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Residual Effect of Poultry Manure and Mineral N Application on Maize Production under Wheat-Maize Cropping System

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ABSTRACT

The study was designed to asses the residual effect of organic N (Poultry Manure) and mineral N on maize crop in field experiments carried out on silty clay loam soil at NIFA, Tarnab, Peshawar, Khyber Pakhtunkhwa (KP) Pakistan during 2014-15. Combined dose of N from both sources were 120 kg ha^{-1} applied to wheat crop alone and in different combination making six treatments. Maize variety (Azam) was sown in Randomized complete block (RCB) design with four replications. Agronomic data, grains ear^{-1}, 1000 grain weight, biomass grain yield data, N-uptake in maize grain and straw were recorded. Results showed that maximum grain ear^{-1}, 1000 grain weight, biomass and grain yield was obtained from treatment where 25% N applied from poultry manure + 75% from mineral N source applied to previous wheat crop. Agronomic efficiency and nitrogen use efficiency were also found maximum in treatment where 75% poultry manure + 25% mineral N was applied. It was concluded from the study that residual effect of organic manure with mineral N in different ratios enhances crop productivity and soil fertility.

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Introduction

Maize grown in rotation with wheat is an important cereal crop of the irrigated area of Pakhtunkhwa, Pakistan. It was planted on area of 516.1 thousand ha with a total production of 918.6 thousand tones and the average yield was about 1.7 t ha^{-1} (MINFAL, 2014-15). Due to high economic return, the area under maize cultivation in is increasing, but the yield on the other hand is stagnant and less than the advanced countries of the world. The crops productivity are very low as majority of the farmers are still practicing traditional farming techniques. Moreover, the cost of production has increased many times due to rising prices of fuel and other agricultural inputs and thus the growth in yields of different crops has started slowing down in the high potential agricultural soils of Pakistan (Gill 2000) Organic matter, nitrogen and phosphorus are deficient in Pakistani soils. it is difficult to obtained high yield from any soil without the application of any fertilizer. Inorganic fertilizer improves the yield of crop significantly but the high prices of the fertilizer lead to imbalance application of fertilizer. In modern agriculture due to high prices of inputs there is lot of stress on low input, sustainable agricultural. Due to which the interest is creating for adoption of old farming practices like the use of organic manure as fertilizer. Organic manures improve crop productivity, soil fertility and reduce inputs cost. Poultry manure (PM) is an excellent organic fertilizer as it contains high N, P, K and other essential nutrients (Farhad et al., 2009). It has been reported to supply P more readily to plants than other organic sources (Garg and Bahla, 2008). Ano and Agwu (2006), Uwah et al. (2011) and Uwah et al. (2012) reported that PM increased soil pH, organic matter content, available P, exchangeable cations and micro nutrients, reduced exchangeable Al and Fe contents and bulk density. Poultry manure application increased soil N levels by 53%, while exchangeable cation contents also increased appreciably (Boateng et al., 2006).

In addition, organic waste can also generate a positive residual effect that should be taken into account when planning the next crop (Eghball et al., 2004). The residual N effect obtained with the organic residues mainly results from the fact that the N becomes part of the clay and organic soil fraction (Jensen et al., 2000) and is immobilized as part of the soil's microbial biomass (Jensen et al., 2000; Jokela and Randall, 1997; Sainz et al., 2004). Eghball et al. (2004) found that, in maize monoculture, the application of beef cattle (Bos taurus) manure and compost over 4 years generated greater amounts of dry matter (DM) and increased the whole plant N concentration in the fifth and sixth years. Decomposition of the manure and mineralization of the nutrients contained in it is fairly slow and may take a few

months to several years depending on environmental factors (Paul and Beauchamp, 1993). As a result, long-term manure addition can have residual effects lasting several years (Lund and Doss, 1980; Dilz et al., 1990). The aim of this study was to investigate the residual effect of organic manure (PM) on the yield and yield component of maize and soil fertility.

Material and Methods

The experiments were conducted during 2014 and 2015 at research farm of Nuclear Institute for Food and Agriculture (NIFA), Tarnab Peshawar, Khyber Pakhtunkhwa (KP) Pakistan. Soil of the experimental site was silty clay loam soil. Physico-chemical properties of the experimental field are given in (Table. 1). The experimental design was a randomized complete block with four replications. There were six treatments. The plot size was 4 x 3.5 m having. Nitrogen was applied to wheat crop at the rate of 120 kg ha^{-1} from mineral N and organic source (PM) applied alone and in combinations. And their residual effect was studied on maize crop. Maize variety Azam were sown, Phosphorus and potassium were applied to maize crop at the rate of 90 and 50 kg ha^{-1}. The row to row distance was 70 cm and plant to plant distance was 6 cm apart. Recommended cultural and plant protection measures were adopted through out the experimental period. At maturity the crops was harvested. After crop harvest soil samples were taken from each plot and analyzed for total N available Phosphorus, and organic matter.

In the chemical analysis soil texture 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) with the help of pH and conductivity meters according to method outlined by Richard, (1954). Organic matter was determined by the method given by Walkley and Black (Black, 1965). In composite soil sample total nitrogen was determined by Kjeldhal digestion method and available P was determined by $NaHCO_3$ extractable Method. In the organic manures total nitrogen was determined by Kjeldhal digestion method and total P and K were determined by method given in (A.O.A.C, 1979) (Table 2) The samples of stover and grains of maize were ground to 40 mesh powder in the wiley mill and nitrogen was determined by Kjeldhal digestion method.

$$NU = NCTS \times \frac{Grain}{Straw\ yield\ in\ plot}$$

Where;
NU :N-uptake
NCTS :N concentration in treatment sample

N use efficiency (NUE) was derived by the following formula. (Zia et al., 1998).

$$NUE = \frac{NU(Fertilized\ plot) - NU(Control\ plot)}{Rate\ of\ N\ applied} \times 100$$

Agronomic efficiency (AE) was calculated by the following formula (Zia et al. 1998).

$$AE = \frac{Grain\ yield\ (fertilized) - grain\ yield\ (control)}{Rate\ of\ fertilizer\ applied}$$

The data collected were statistically analyzed through MSTATC statistical package

Table 1 Basic properties of the experimental soil before the start of the experiment.

Texture	Silty clay loam
pH (1:25 suspension)	8.10
EC (1:25 suspension)	0.62 dS m^{-1}
$CaCO_3$ equivalent	18 %
Organic matter	0.82%
$NaHCO_3$ extra-P	3.5 mg kg^{-1}
% N	0.05%

Table 2 Composition of organic materials.

Organic Manure	Poultry Manure
%N	2.87
% P	1.30
% K	1.75
% OC	33.8
C:N	11.7

Table 3 Treatments details.

T_1= control (no-nitrogen)
T_2= 120 kg N ha^{-1} from mineral source (100% MN)
T_3= 120 kg N ha^{-1} from Poultry manure (100% PM)
T_4= 25% PM+ 75% mineral nitrogen (MN)
T_5= 50% PM+ 50% mineral nitrogen (MN)
T_6= 75% PM+ 25% mineral nitrogen (MN)

Results and discussion

Number of Grains Ear^{-1}

Grain number per ear affected by the residual effect of poultry manure and mineral nitrogen sources and these combination presented in Table 4 showed that different treatments have significant effect on the maximum grains number of per ear (423.5) were obtained in the treatment where 25% N applied from Poultry manure and 75% from mineral source. It was followed by the treatment where 100% N applied from PM to the previous wheat crop. Data further revealed that year have significant effect on the grain per ear. Maximum grain per ear was obtained in first year 2014 due to more available environment to the crop. The interaction between treatment x year was also significant the terms of maximum number of grain per ear was obtained in the treatments in first year 2014. More grain's number ear^{-1} of maize were due to the residual effect of organic manure which have favorably affected the balance of macro and micronutrients which increased plant growth and increased assimilates for producing more grains ear^{-1}. Our results are in agreement with those of Talathi (2001) who reported maximum grain number

ear^{-1} caused by residual effect of integrated use of organic manure. Sharma et al. (1988) showed that nutrient from organic sources did not prove beneficial to the rice, but their residual effect in increasing the grain yield of succeeding wheat crop was clearly evident.

Biomass (kg ha^{-1})

Data on the biological yield of maize as affected by the residual effect organic source (PM) and mineral nitrogen sources are presented in Table 4. Different treatments have significant effect on the maximum biological yield of maize crop 7511 kg ha^{-}1 obtained from the treatment where 25% N applied from poultry manure and 75% from mineral source. It was followed by the treatment where 100% N applied from poultry manure to the previous wheat crop. Years have significant effect on the biological yield obtained 2014 and 2015. The maximum biological was higher in 2014 than in 2015. The interaction between treatment x year was also significant the terms of maximum biological yield of 9142.9 kg ha^{-1} from applied 75% N and 25% PM in the year 2014, due to mineralization from the organic manure applied to previous wheat crop. These results were supported by those of Ramamurthy and Shivahanker (1996) who reported that residual effect of organic and mineral N fertilizers were superior in terms of growth, yield attributes, grain yield and stover yield than either one alone. Rao and Shaktawat (2002) stated that dry matter and yield of maize were significantly increased by residual effect of organic manure and mineral fertilizer. Talathi (2001) stated that residual effect of 50% recommended NPK + 50% N through farm yard manure (FYM) was more pronounced resulting in increased dry matter stover yield of succeeding maize.

Grain Yield (kg ha^{-1})

Maize grain yield affected by the residual effect of poultry manure and mineral N and these combination are presented in Table 4 revealed that similar trend were found during both the years Maximum grain yield of 1877.4 kg ha^{-1} obtained in treatment where 25% N was applied from poultry manure and 75% mineral source. It was followed by the treatment where 75% N from PM and 25% from MN source. Year have significant effect on grain yield maximum yield recorded in 2015 than 2014. Among the treatments the higher grain yield of maize was found in the treatment 25: 75 ratio of poultry manure and mineral nitrogen was due to the greater carry over effect of the treatment which increases the maize grain yield. This may also be due to the availability of nitrogen and other nutrients and the physical properties of the soil which were improved by the addition of organic manures. Residual effect of integrated use of nitrogenous commercial fertilizer and organic manure resulted in maximum grain cob^{-1}, grain weight, harvest index and increase in grain yield as reported by Ramamurthy and Shivashankar (1996). Rao and Shaktawat (2002), Silva et al. (2006) and Rathore et al. (1995) reported that residual effect of farm yard manure (FYM) with inorganic fertilizers was significant on grain yield of succeeding wheat crop. Sharma et al. (1995) also reported the beneficial residual effect of sesbania and mung straw applied to rice on succeeding wheat crop and reported an increase in wheat yield by 0.6 and 0.7 t ha^{-1}, respectively as compared to control treatment.

Table 4 Yield (kg ha^{-1}) and yield component of maize affected by residual effect of poultry manure and mineral N sources in wheat-maize cropping system 2014-15.

T	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean
	Grain Ear^{-1}	Grain Ear^{-1}		Biomass	Biomass		Grain yield	Grain yield	
T1	361.53ABC	280.00CD	320.76C	5660.7BCD	4035.7D	4848.2B	875.7C	866.1C	870.9C
T2	429.81AB	286.75CD	358.28BC	7571.4AB	4642.9CD	6107.1AB	1220.7BC	1367.9BC	1294.3B
T3	417.54AB	351.00BC	384.27AB	8964.3A	4167.9D	6566.1A	1280.6BC	1385.7BC	1333.1B
T4	454.30A	392.75AB	423.52A	9142.9A	5878.6BCD	7510.7A	1603.1AB	2151.8A	1877.4A
T5	420.79AB	254.50D	337.64BC	7125.0ABC	4919.6CD	6022.3AB	1312.1BC	1467.9BC	1390.0B
T6	438.96AB	246.75D	342.85BC	8750.0A	4116.1D	6433.0A	1293.0BC	1535.7B	1414.3B
L			19.270			508.44			122.97

T: Treatments, T1: Control, T2: 100% MN, T3: 100% PM, T4: 25% PM+ 75% MN, T5: 50% PM+ 50% MN, T6: 75% PM+ 25% MN, L: LSD $_{0.05}$

Table 5 1000 grain weight N uptake in grain and straw of maize affected by residual effect of poultry manure and mineral N sources in wheat-maize cropping system 2014-15

T	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean
	GW	GW	(gm)	NU	NU	(kg ha^{-1})	NUG	NUG	(kg ha^{-1})
C	187.88AB	168.03B	177.95C	11.157BCD	6.098D	8.627B	9.735C	9.670C	9.702C
T1	216.30A	212.28A	214.29AB	16.047ABC	7.617D	11.832AB	14.925BC	16.135BC	15.530B
T2	215.35A	215.20A	215.27A	19.313A	6.643D	12.977AB	15.100BC	16.725BC	15.913B
T3	199.40AB	214.47A	206.94AB	20.350A	9.160CD	14.755A	19.945AB	26.277A	23.111A
T4	211.07A	205.78A	208.42AB	16.188ABC	7.280D	11.734AB	14.963BC	17.152B	16.057B
T5	181.95AB	205.15A	193.55BC	17.455AB	5.357D	11.406AB	14.945BC	17.985B	16.465B
L			719.05			1.4991			1.4368

T: Treatments, T1: Control, T2: 100% MN, T3: 100% PM, T4: 25% PM+ 75% MN, T5: 50% PM+ 50% MN, T6: 75% PM+ 25% MN L: LSD $_{0.05}$,
GW: 1000 grain weight (gm), NU: N-uptake straw (kg ha^{-1}), NUG: N-uptake grain (kg ha^{-1})

Table 6 Agronomic efficiency (kg/kg) and nitrogen use efficiency of maize affected by residual effect of poultry manure and urea sources in wheat-maize cropping system 2014-15.

Treatments	Agronomic efficiency kg/kg	NUE
Control	-	-
100% M N	3.53	4.86
100% PM	3.85	5.18
25% PM+ 75% MN	8.39	11.17
50% PM+ 50% MN	4.33	5.30
75% PM+ 25% MN	4.53	5.64

1000-Grains Weight (gm)

Data of the 1000 grain weight affected by the residual effect of poultry manure and mineral nitrogen sources and there combinations are presented in Table 5. Data revealed that year have non significant effect on the 1000 grain weight. 100% N from PM produce maximum 1000 grain weight of (215 gm). It was followed by the treatment where 100% N applied from mineral source (MN) to the previous wheat crop. Higher 1000 grains weight due to the residual effect of poultry manure. Similar results were reported by Iqbal et al. (2008) and Silva et al. (2006) reported a positive residual effect of organic plus NPK fertilizers on 1000 grains weight. Soni and Sikarwar (1991) observed that residual effect of applied FYM at varying fertilizer levels on succeeding wheat crop

Nitrogen Uptake by Maize Grain kg ha^{-1}

N-uptake of maize grain affected by poultry manure and mineral nitrogen source and these combinations are presented in Table 5. Data revealed that in 2015 N-uptake maize grain was maximum than 2014. Maximum N uptake of 26.27 kg ha^{-1} was obtained from the treatment where 25% N applied from poultry manure and 75% from mineral was applied. It was followed by the treatment where 75% N applied from PM and 25% from mineral source was applied to previous wheat crop. Rao and Shaktwat (2002) and Iqbal et al. (2008) reported that residual effect of organic manure improved growth yield and nutrient uptake of maize. Rathore et al (1995) reported that residual effect of farm yard manure (FYM) with inorganic fertilizers was significant on grain yield of succeeding wheat crop and NPK uptake.

Nitrogen Uptake by Maize Stover kg ha^{-1}

Data on nitrogen uptake by maize stover affected by residual effect of poultry manure and mineral nitrogen source and these combinations are presented in Table 5. Different combinations have showed that higher N uptake was obtained during 2014 than 2015 due to higher stover yield obtained during 2014. Among the treatment maximum N uptake of 14.755 kg ha^{-1} was obtained in the treatment where 25% N applied from poultry manure and 75% from mineral source. It was followed by the treatment where only PM was applied. Studies have shown that organic materials (compost, manures) enhanced nutrient use efficiency by slow releasing of nutrients (Chang and Janzen, 1996; Paul and Clark, 1996; Muneshwar et al. 2001; Nevens and Reheul, 2003). The addition of organic fertilizer increases nutrients mobilization and soil microbial activities; it also contribute in improving nutrition as well as crop root system. The present findings are in agreement with those of Iqbal et al. (2008) who reported that increase in soil nitrogen level may affect positively N-uptake by maize stover.

Agronomic Efficiency of Maize kg kg^{-1}

Residual effect of poultry manure and mineral nitrogen source and these combinations on agronomic efficiency (AE) of maize crop are presented in Table 6. Data showed that maximum agronomic efficiency of 8.39 kg kg^{-1} was recorded in the treatment where 25% N applied from PM and 75% N from mineral source. It was followed by the treatment where 75% N applied from PM and 25% N from mineral source. These results are in agreement with Kumar and Puri (2001) who reported that Maximum agronomic efficiency was recorded with application of 45 kg nitrogen and 15 tones farm yard manure ha^{-1} (FYM). Individual application of poultry manure (PM) performs best than the mineral fertilizer applied alone due to the mineralization of the organic manures which makes the nitrogen available to the subsequent maize crop. The ratios of 25:75 organic and mineral nitrogen and 75:25 of the organic and mineral nitrogen applied to the wheat crop produce maximum agronomic efficiency of the maize crop than the treatment where only mineral fertilizer was applied alone to the wheat crop.

Nitrogen Use Efficiency (NUE) in Maize

Nitrogen use efficiency (NUE) affected by the residual effect of poultry manure and mineral nitrogen source and these combination presented in Table 6. Data showed that maximum nitrogen use efficiency (NUE) of 11.17 % was observed in the treatment where 25% N was applied from PM and 75% N from mineral source. It was followed by the treatment where 75% N was applied from PM and 25% N from mineral nitrogen (MN) source. NUE was maximum in plots where Poultry manure (PM) was applied alone than mineral fertilizer (MN) due to the mineralization of the organic manures. The ratio of 25:75 and 75:25 organic and mineral sources gives maximum NUE than the plots where mineral fertilizer (MN) was applied alone to the previous wheat crop. Our results are in agreement with Iqbal et al. (2008) who reported that residual effect of poultry litter gave significant improvement in growth yield and nutrient uptake of maize. Ramamurthy and Shivashankar (1996) found that residual effect of organic manure significantly improved the yield contributing characters and nutrient uptake of maize this might be due to enrichment of soil with nutrients.

Conclusion

Residual effect poultry manure combined with mineral fertilizer increased growth and grain yield of maize and nitrogen uptake of maize according to mineral fertilizer applied alone especially on residual basis. The integrated application of poultry manure and mineral nitrogen fertilizer at the ration of 25:75 N basis increased maize yield for the two years of study when compared with single application of mineral N fertilizer**.** This experiment shows that integrated application of poultry manure and mineral N fertilizer was more effective in increasing nutrient availability and maize performance than sole application of any of the fertilizer materials. Addition of mineral fertilizer to poultry manure increased soil nutrients and performance of maize even one year after their application.

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