Effect of Organic and Inorganic Sources of Nitrogen on Maize Yield, Nitrogen Uptake and Soil Fertility

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Abstract
The effect of integrated use of mineral and organic nitrogen sources (farmyard manure) on maize yield, nitrogen uptake and soil fertility was assisted in the field experiment carried out on silty clay loam soil at the new developmental farm of the university of agriculture, Peshawar Pakistanduring 2014. Combined doses of N provided from all sources was applied 150 kg.ha^{-1}. There were four replications and 6 treatments i.e., (T1) Control, (T2) 150 kg N ha^{-1} from mineral sources, (T3) 150 kg ha^{-1} from FYM, (T4) 25% FYM + 75% mineral N, (T5) 50% FYM + 50% N and (T6) 75% FYM + 25% mineral N. Maize variety (Azam) was sown in RCB design. Data on plant height, grain yield and stover yield were recorded in maize. Samples of grain and stover were analyzed for total N to determine its uptake by the crop. Results indicated that the greatest plant height of 221.85 cm, maximum grain yield of 2046.12 kg.ha^{-1} and straw yield of 7004.73kg.ha-^{1} were obtained from treatment 25% N was applied from farm yard manure and 75% of mineral fertilizer. Agronomic efficiency and nitrogen use efficiency were also found higher in the treatment 25% N were applied from farm yard manure and 75% from mineral fertilizer. Soil total N, organic matter and available P were significantly affected by the organic source and there integration with mineral N source. Maximum total N, organic matter and available P were observed in treatment where FYM were applied alone. It was concluded that combination of organic and mineral N sources in ratio 25:75 are the best combination to achieve sustainable yield and soil fertility.

Keywords: Organic Nitrogen, mineral N, N uptake, Maize yield, Integrated use.

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INTRODCUTION

Maize (*Zea mays* L.) is an exhaustive and multipurpose cereal crop that provides food for human, feed for animals, and raw material for the industries. It has greater nutritional value as it contains about 72% starch, 10% protein, 4.8% oil, 8.5% fiber, 3% sugar and 1.7% ash (Chaudhary, 1993). It is the third most important cereal crop after wheat and rice, while in the farming system of Khyber Pukhtunkhwa it ranks second after wheat in importance. In Pakistan it was grown on an area of 1168.5 ha with total production of 4944.2 tons and national average yield of 4231 kg.ha^{-1}, whereas in Khyber Pukhtunkhwa, it is grown on about 509.5 ha with a total production of 957.9 tons and average yield of 1880 kg.ha^{-1} (MINFAL, 2013-14).

Due to high economic return, the area under maize cultivation in KPK is increasing but the yield, on the other hand is stagnant and below than the other advanced countries of the world. The productivity of crops is very low as the 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). Maize is a very exhaustive crop as they deplete soil fertility, but also degrade soil physical properties. Balance application of mineral fertilizers plays a significant role in boosting crop production on alkaline calcareous soils of Pakistan (Ahmad, 2000). Despite increased in use of the chemical fertilizers, per hectare yield has not been increased proportionally rather stagnation occurs (Ali, 2000). This has been attributed to the imbalanced use of mineral fertilizers and also inappropriate method of their application that resulted in low fertilizer nutrient use efficiency. According to Zia *et al*. (2000) continuous use of chemical fertilizers even in balanced proportion will not be able to sustain crop productivity due to deterioration in soil health.

In Pakistan farm yard manure is the most important organic manure. It has been estimated that about 50% of animal droppings are not collected properly. Out of the collected about 50% is used as for fuel and hardly 1/4th of animal dropping are used as organic fertilizer sources. Based on the assumptions and calculation, it is estimated that about 1.5 million tons of nutrients are available from farmyard manure. Of this nitrogen accounts for 726 thousand tons, P_20_5 191 thousand tons and K_20 617 thousand tons (Bari, 2003).

Keeping in view the importance of integrated plant nutrients for sustained soil fertility and crop productivity this study was designed to assess the effect of Farm yard manure (FYM) along with mineral nitrogen on maize yield, nutrient uptake and soil fertility.

MATERIALS AND METHODS

A field experiment was conducted at the Research Farm of The University Agricultural, Peshawar during summer 2014 to assess the influence organic and inorganic sources of Nitrogen on maize yield, N uptake and soil fertility.Nitrogen was applied at 150 kg.ha^{-1} to maize from organic (FYM) and mineral N sources alone or in different proportion. The experimental design was a randomized complete block with four replications. The treatment details are shown in table 3. Wellrotten FYM was obtained from the University Dairy Farm and analyzed for total N, P and K are presented in Table 1. Composite soil samples at 0-30 cm depth was collected and analyzed for soil characteristics. Physico-chemical properties of the experimental field are given in Table. 2.

The field was thoroughly prepared. Lay-out was carried out according to the experimental plan, with treatment plot size of 5 x 3 sq.m. The organic N sources (FYM) were uniformly distributed in relevant treatment plots and thoroughly mixed into the soil at sowing time and the mineral N (urea) was applied in three splits i.e. sowing, tillering and at booting stages of the crop. Phosphorus 90 kg.ha^{-1} and K 60 kg.ha^{-1} were applied in the form of single super phosphate and potassium sulfate as basal dose to the crop and adjusted on the basis of P and K present in the organic sources.

After thorough seed-bed preparation and fertilizer application, maize (variety: Azam) was planted in rows 60 cm apart on June 30, 2014. The crop was irrigated from the canal when needed and recommended cultural and plant protection measures were adopted throughout the experimental period. The crop was harvested at maturity, and data were recorded. After each crop harvest soil samples were taken from each plot and analyzed for total N, available Phosphorus and organic matter. Grain and stover samples were analyzed for total N to determine N uptake by the crop.

Soil and plant analysis:

Soil texture was determined by the hydrometer method as described by Koehler *et al*., 1984. 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 the method outlined by Mclean, 1982. Organic matter was

determined by the method given by Nelson and Sommer, 1982. 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 N was determined by Kjeldhal digestion method and total P and K were determined by method given in (A.O.A.C, 1979). The N content in maize grain and stover were determined by Kjeldhal digestion method.

N-uptake: N concentration in Grain/Stover sample x grain/ Stover yield100

N use efficiency: N use efficiency was derived by the following formula (Zia *et al*., 1998).
N-uptake (fertilized plot)- Nuptake (control plot) x 100
Rate of N applied

Agronomic efficiency: was calculated by the following formula (Zia *et al*., 1998).
Grain yield (fertilized) - grain yield (control) x 100
Rate of fertilizer applied

Statistical Analysis

The procedures of Steel *et al.* (1997) were followed for statistical analysis of the dat.

Table 1. Composition of FYM used in the experiment

Characteristics	Value (%)
N	0.6
P	0.44
K	1.0

Table 2. Basic properties of the experimental soil

Texture	pH	ECe	$CaCO_3$	Organic matter	Extractable P	Total N
Silty clay loam	8.10	0.62 dS m^{-1}	18 %	0.82%	3.5 mg kg^{-1}	0.04%

Table 3.Treatments detail

T_1= control (no-nitrogen)
T_2= 150 kg N ha^{-1} from mineral source
T_3= 150 kg N ha^{-1} from Farm yard manure
T_4= 25% FYM+ 75% mineral nitrogen (MN)
T_5= 50% FYM+ 50% mineral nitrogen (MN)
T_6= 75% FYM+ 25% mineral nitrogen (MN)

FYM= Farm Yard Manure

RESULTS AND DICUSSION

The results obtained on the effect of organic and Inirganic sources of niitrogen on Maize yield, N uptake and soil fertility are presented and discussed below:

Plant Height

Data regarding plant height of maize as affected by the application of farm yard manure (FYM) and mineral nitrogen applied alone and in different combination are presented in table 4. Statistical analysis of the data showed that effect of different treatments was significant ($P<0.05$). Maximum plant height of 221.85 cm was obtained in treatment receiving 75% N from mineral source and 25% N from organic source (FYM) followed by the treatment receiving 100% N from mineral source. The smallest height of 171.80 cm was

found in control treatment receiving no mineral or organic source of N. The treatment receiving 100% N from FYM produced significantly lower plant height compared with other fertilized treatments. Plant height is considered as the appearance of full vegetative potential and initiation of reproductive phase. The reason for highest plant height in treatment of combined application of organic N source with mineral N might be due to availability and uptake of sufficient quantity of N from mineral source at early growth stages and FYM provided better nutrition to the crop in later stages while combined application of mineral Na long with organic N nourished the crop during both early and later stages. Application of mineral N alone or with organic N increases plant height significantly (Iqbal *et al*., 2002; Idris and Wisal, 2001; Singh and Agarwal, 2001 and Mohsin *et al*., 2012).

Grain Yield

Data regarding grain yield kg.ha^{-1}of maize as affected by the application of farm yard manure (FYM) and mineral nitrogen applied alone and in different combination are presented in table 4. Statistical analysis of the data showed that grain yield of maize was significantly (P<0.05) higher in N fertilized treatments compared with control. Highest grain yield of 2046.12 kg.ha^{-1} was obtained from treatment receiving 75% N from mineral source and 25% from FYM followed by the treatment receiving N from mineral source and FYM at 50:50 ratio, and these two treatments were statistically same. The results indicated that treatments receiving N solely from urea or FYM produced significantly lower yield compared with treatment receiving N from combined contribution. 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 the growth parameters. The fertilizer nitrogen serves not only as a nutrient source but also provide energy for microbial activities in order to mineralize the organic nitrogen of organic manure and makes it available to crop. Our results are also in line with Shah *et al*. (2007) who reported significantly increased in grain yield of maize with integrated use of urea and compost as compared to their sole application.

Stover Yield

Data regarding stover yield kg.ha^{-1}of maize as affected by the application of farm yard manure (FYM) and mineral nitrogen applied alone and in different combination are presented in table 4. Statistical analysis of the data showed that stover yield of maize was significantly (P<0.05) affected by N fertilized treatments over the control. The result showed that stover yield of 7004.73 kg.ha^{-1} was obtained from the treatment receiving 75% N from mineral source and 25% from FYM**,** followed by the treatment where N was applied at 50:50 ratio from mineral and organic source. These results suggested that the influence of combined application of N from mineral source with organic N source was much stronger than their sole application. These results are in agreement with Shilpashree *et al*. (2012) who reported significantly increased in stover yield of maize in all that treatments which received nitrogen in integrated form. Asadu and Unagwu (2012) also reported that the combined use of organic and inorganic fertilizers is required for sustainable maize crop productivity. These results are also in line with Shah *et al.* (2007) who reported increased instover yield because of combined application of organic and mineral fertilizers.

Agronomic efficiency kg.kg^{-1}

Agronomic efficiency as affected by organic and mineral N sources alone and their combined effect is presented in table 4. Maximum agronomic efficiency of 7.24 kg.kg^{-1} was observed in the treatment in which 25% N from FYM and 75% mineral N was applied and followed by the treatment where N in 50:50 ratio were applied. The high agronomic efficiency might be due to the reason that organic manure change soil quality after manure application, which is linked to the effect the OM content, soil structure and biological activity (Bronick and Lal, 2005; Tisdall and Oades, 1982). Soil quality and superior soil management are fundamental components of sustainable crop production because soil supports basic physical, chemical and biological processes that must take place in order to support plant growth and ultimately yield.

Nitrogen Concentration in Grain

Data on N concentration in maize grain are shown in Table 5. The N concentration in maize grain was significantly (P<0.05) greater for N fertilized treatments over the control. The maximum N concentration of 1.43% was found in the treatment receiving 75% N from mineral source and remaining 25% from FYM followed by 1.39% in treatment receiving N in 50:50 ratio. These findings are also in agreement with the results of Azam *et al*. (2010) who reported that increase of N concentration in grain might be the efficient use of all available nitrogen sources for plant and roots growth because of continued supply of nutrients. Shah and Ishaq (2006) also reported increased in N

concentration of wheat grain in treatment where FYM integrated with urea.

Nitrogen concentration in Maize Stover

Data on N concentration in maize straw are presented in Table5 . Mean values of the table showed that N concentration in maize stover was not affected by any of the fertilizer treatments. However, N concentration in maize straw was greater in fertilized treatments compared with control treatment and the differences between them were statistically non significant. Similar results were obtained by Idris *et al.* (2001), Idris and wisal (2001) and Shah and Ishaq (2006) who reported maximum nitrogen concentration in wheat straw by integration of organic manure and mineral fertilizer.Our results are in agreement with the findings of Shah *et al*. (2007) who reported that the N concentration in stover showed little variability among treatments probably most of the N from stover has been translocated to grains by the time of crop maturity.

Nitrogen uptake by Maize crop

Nitrogen uptake in maize grain and stover (total uptake) followed similar trend of response to various N fertilized treatments. The results showed that N uptake by maize crop significantly ($P<0.05$) affected by organic and mineral N. The maximum N uptake of 49.72 $kg.ha^{-1}$ was obtained in treatment receiving 75% N from urea and 25% from FYM. The next highest uptake of 42.57 $kg.ha^{-1}$ was recorded in treatment receiving N in 50:50 ratio. Significantly lowest N uptake of 23.82 kg ha^{-1} was observed in treatment receiving100% N from FYM comparing with other fertilized treatments.These results are in agreement with the Iqbal *et al.* (2008), Shah and Ishaq (2006), Idris *et al.* (2001) who reported that the combination of organic N and inorganic N resulted in greater N-uptake than sole N application. Soil fertility building in organic systems improves soil biological properties, which subsequently influence nitrogen availability to crop (Watson *et al*., 2002). Nyamangara *et al*. (2003) also reported that inorganic N fertilizer could be used to overcome the deficiency caused by low N manure fertilizers. This implies that the presence of a small amount of manure increased N recovery from mineral N fertilizers.

Table 4. Plant height, grain yield, stover yield and agronomic efficiency of Maize as affected by the combine application of farm yard manure and mineral N.

Treatments	Plant height	Grain yield	Stover yield	Agronomic efficiency
	cm	$Kg.ha^{-1}$	$Kg.ha^{-1}$	$Kg.kg^{-1}$
Control	171.80d	960.82d	2325.44e	
100% N from urea	206.75ab	1386.70bc	4677.87cd	2.83
100% N from FYM	185.50cd	1162.64cd	3777.55d	1.34
75% N urea + 25% N FYM	221.85a	2046.12a	7004.73a	7.24
50% N urea + 50% N FYM	199.78bc	1751.77ab	6138.18ab	5.27
25% N urea + 75% FYM	197.05bc	1586.41b	5187.91cd	4.17
LSD P<0.05	18.773	366.45	1156.2	

Mean in same column followed by different letters are significantly different at 5% level of probability using LSD test

Table 5. N concentration in maize grain and stover as affected by the combine application farm yard manure and mineral N

Treatments	N Grain (%)	N stover (%)
Control	1.11c	0.22a
100% N from urea	1.22b	0.26a
100% N from FYM	1.22b	0.24a
75% N urea + 25% N FYM	1.43a	0.26a
50% N urea + 50% N FYM	1.39a	0.27a
25% N urea + 75% FYM	1.27b	0.24a
LSD P<0.05	0.073	0.071

Mean in same column followed by different letters are significantly different at 5% level of probability using LSD test

Table 6. N uptake and Nitrogen Use Efficiency of maize as affected by the combine application farm yard manure and mineral N

Treatments	Grain N uptake (kg ha^{-1})	Stover N uptake (kg ha^{-1})	Total uptake (kg ha^{-1})	NUE (%)
Control	10.67d	5.36d	15.55d	-
100% N from urea	16.89c	12.34c	29.48bc	9.28
100% N from FYM	14.19cd	8.63cd	23.83c	5.52
75% N urea + 25% N FYM	29.56a	18.67a	49.72a	22.78
50% N urea + 50% N FYM	24.40ab	16.71ab	42.57a	18.01
25% N urea + 75% FYM	20.06bc	13.09bc	33.57b	12.01
LSD P<0.05	5.94	4.67	8.07	-

Mean in the same column followed by different letters is significantly different at 5% level of probability using LSD test

Nitrogen use efficiency

Nitrogen use efficiency is the recovery of the applied fertilizer N by the harvested crop. Nitrogen use efficiency as affected by organic (FYM) and mineral N and their combined effect are presented in Table 6. Significant differences were observed in N use efficiency and maximum nitrogen use efficiency of 22.78% was observed in the treatment where 25% FYM and 75% mineral N was applied. This is followed by the treatment where 50% N from FYM and 50% mineral N was used. These results are in agreement with Idris *et al*. (2001), Yaduvashi (2003) who reported that a combined application of urea and FYM resulted in the increased fertilizer N recovery relative to other treatments.

Soil Fertility Status after Harvesting

Soil organic matter content

The soil analysis after the maize harvest showed that organic matter content was significantly affected by application of organic and mineral N (Table 7). The maximum organic matter content of 0.93% was found in the treatment receiving 100% N from FYM followed by 0.91% of organic matter content in the treatment receiving 75% N from FYM and remaining 25% from urea. Organic matter was increased with the application of organic manures after crop harvest. This may be due to the composition of N sources where some N sources were comparatively more quickly mineralized than other sources because of difference in organic compounds of various N sources. These findings are in agreement with Yadvinder*et al*. (2004) and Zhang *et al*. (2009) who reported that the application of organic manure alone or in combination with mineral fertilizers increased soil organic matter content compared with the control treatment.

Soil total N content

Like organic matter content the similar pattern was followed by total N content (Table 7). The highest nitrogen content was found in the treatment receiving 100% N from FYM followed by the treatment receiving 75% N from FYM and 25% from urea. N content was highest in N fertilized treatments than control. Our results in Table 7 further showed that application of FYM increased soil organic matter and total N contents over the control. Total nitrogen was more in soil after maize harvest. This may be due to the built up effects of the fertilizer and manure applied to soil. Similar results were reported by Islam *et al*. (2013)and Manoj *et al*. (2012) who revealed that the application of organic manure alone or integrated with mineral fertilizers increased available N, P and K contents as compared to control treatment.

Extractable P content

The data on extractable P as affected by mineral N and organic N alone and different combinations are presented in Table 7 The results showed that available P after maize harvest significantly (P<0.05) affected by organic and mineral N. The maximum available phosphorus of 4.39 $mg.kg^{-1}$ was obtained in treatment receiving 100% N from FYM followed by the treatment receiving N in 25:75 mineral and organic ratio.Similar results were revealed by Bhandari *et al*. (2002) who reported an increase in available P in the treatments where FYM was applied as compared to mineral fertilizers alone. These results are also in agreement with Yaduvanshi (2003) and Wiqar *et al*. (2013) who 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 fixation adsorption and solubilize insoluble P in soils.

Table 7. Soil organic matter, Total N and Extractable P after maize harvest as affected by the combine application farm yard manure and mineral N.

Treatments	Soil total N (%)	Organic Matter (%)	Extractable P ($mg.kg^{-1}$)
control	0.040c	0.795c	3.35c
100% N from urea	0.0453b	0.905b	3.74bc
100% N from FYM	0.0469a	0.938a	4.39a
75% N urea + 25% N FYM	0.0452b	0.903b	3.98ab
50% N urea + 50% N FYM	0.0454b	0.909b	4.09ab
25% N urea + 75% FYM	0.0459ab	0.918ab	4.13ab
LSD P<0.05	0.005	0.028	0.519

Mean in same column followed by different letters are significantly different at 5% level of probability using LSD test

Conclusion

Integrated use of organic and inorganic nitrogen performed better than the use of organic and inorganic nitrogen sources alone in terms of improving crop yields of maize and soil fertility status.The integration of organic nitrogen and mineral nitrogen in the ratio of 25:75 enhanced the yield of maize. For higher grain yield the mineral fertilizer must be applied and their ratio should not be less than 75% of mineral N. The agronomic efficiency and nitrogen use efficiency increased with the use of organic and mineral N the ratio of 25:75 for sustainable yield of Maize and its residual effect on soil fertility.

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اثرات منابع آلی و معدنی نیتروژن بر عملکرد ذرت، جذب نیتروژن و حاصلخیزی خاک

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چکیده

اثر استفاده تلفیقی منابع معدنی و آلی نیتروژن (کود دامی مزرعه) بر عملکرد ذرت، جذب نیتروژن و حاصلخیزی خاک مدیریت شده در آزمایش مزرعه‌ای بر خاک سیلتی رسی لومی در مزرعه تازه توسعه یافته دانشگاه کشاورزی پیشاور پاکستان در طی سال ۹۳ اجرا شد. دزهای ترکیب شده نیتروژن فراهم شده از تمامی منابع به کار رفته ۱۵۰ کیلوگرم در هکتار می‌باشد. در این‌جا ٤ تکرار و ٦ تیمار شامل T1 (شاهد)، T2 (۱۵۰ کیلوگرم نیتروژن در هکتار از منابع معدنی)، T3 (۱۵۰ کیلوگرم در هکتار کود دامی مزرعه‌ای)، T4 (۲۵٪ کود دامی مزرعه‌ای + ۷۵٪ نیتروژن معدنی)، T5 (۵۰٪ کود دامی مزرعه‌ای+ ۵۰٪ نیتروژن) و T6 (۷۵٪ کود دامی مزرعه‌ای+ ۲۵٪ نیتروژن معدنی) به‌کار گرفته شد. رقم Azam در طرح بلوک کامل تصادفی کاشته شد. داده‌های ارتفاع بوته، عملکرد دانه و عملکرد کاه در ذرت اندازه‌گیری شد. پس از تجزیه نمونه‌های دانه و کاه مقدار نیتروژن کل جذب شده توسط گیاه تعیین شد. نتایج نشان داد که بالاترین ارتفاع بوته (۲۲۱/۸۵ سانتی‌متر)، حداکثر عملکرد دانه (۲۰٤٦/۱۲ کیلوگرم در هکتار) و عملکرد کاه (۷۰۰٤/۷۳ کیلوگرم در هکتار) از تیمار کود دامی مزرعه‌ای و ۷۵٪ کود معدنی به‌دست آمد. کارایی زراعی و کارایی مصرف نیتروژن با بالاترین میزان در تیمار ۲۵٪ نیتروژن معدنی به‌کار رفته از طریق کود دامی مزرعه‌ای و ۷۵٪ کود نیتروژن معدنی حاصل شد. کل نیتروژن خاک، ماده آلی و فسفر قابل دسترس، به‌طور معنی‌داری تحت تأثیر منابع آلی و تلفیق با منبع معدنی نیتروژن قرار گرفت. حداکثر نیتروژن کل، ماده آلی و فسفر قابل دسترس در تیمار کود دامی مزرعه‌ای به تنهایی مشاهده شد. نتیجه‌گیری می‌شود که ترکیبی از نیتروژن آلی و معدنی با نسبت ۲۵ به ۷۵ درصد بهترین ترکیب برای دستیابی به عملکرد و حاصلخیزی خاک می‌باشد.

کلمات کلیدی: نیتروژن آلی، نیتروژن معدنی، جذب نیتروژن، عملکرد ذرت، مصرف تلفیقی.

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