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Nutrient Availability and Maize (*Zea mays*) Growth in Soil Amended with Organic Manures

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ABSTRACT

Organic manures help to improve soil physical, chemical and biological properties thus improve nutrient availability to crops. This experiment was conducted to evaluate the beneficial effects (if any) of different sources of organic manures on soil physico-chemical properties and growth of maize. Organic manures viz. farm yard manure, poultry manure and pressmud were added in soil filled earthen pots at10 t ha^{-1}. Four seeds of maize (cv Nilam) were sown in each pot. Six days after emergence, plants were thinned to have two plants per pot. Results revealed that organic matter content, phosphorus and potassium bioavailability in soil and their uptake by plants were increased by organic manure application irrespective of the source. Likewise organic manure substantially improved the plant height, leaf area and shoot and root fresh and dry weights. Similarly shoot phosphorus and potassium contents were also improved by the application of organic manures. This improved growth was mainly due to increased soil nutrient availability and uptake by plants. Comparing different sources, phosphorus and potassium concentration in plants were maximum in poultry manure treatment and farm yard manure, respectively.

Key Words: Poultry manure; Farm yard manure; Pressmud; Maize; Phosphorus availability

INTRODUCTION

Rising demands of population for food impels to produce more grains than past per unit area as all of the available quality soil is under crop production. Use of inorganic fertilizers has substantially increased mainly, because of sustained crop production, awareness about food quality and increased cropping intensities (NFDC, 2003). This has depleted soil of plant nutrients particularly of phosphorus (P), potassium (K) and micronutrients as most of farmers use only nitrogenous fertilizers. This has also resulted in a gradual decrease of organic matter content in the soil (NFDC, 2003).

Low use efficiencies of inorganic fertilizers coupled with their rising costs has directed the attention of farmers towards organic sources. Organic manures may increase soil fertility and thus the crop production potential possibly by changes in soils physical and chemical properties including nutrient bioavailability, soil structure, water holding capacity, cation exchange capacity, soil pH, microbial community & activity etc. (Marschner, 1995; Walker *et al.*, 2004; Clemente & Bernal, 2006; Agbede *et al*., 2008; Muhammad & Khattak, 2009). Soil pH is greatly influenced by addition of organic matter (OM) through different organic amendments and change in pH varies with the nature of OM (Walker *et al.*, 2004).

Addition of organic matter (pressmud) improves soil nutrient availability and uptake by plants (Marschner, 1995). While with the increase in soil organic matter, N and P availability also increases (Chaudhary *et al*., 1998; Ewulo *et al.*, 2008). Phosphorus is generally present in Pakistani soils as insoluble compounds of calcium such as di-calcium phosphate and tri-calcium phosphate with little or no solubility (Rahmatullah *et al.*, 1994). There is need to improve the availability of native soil P. Organic matter decomposition in soils increases the CO_2 concentration leading to the formation of carbonic acid, which dissolute native P minerals and fixed P (Marschner, 1995; Mengel & Kirkby, 2001) thereby increasing the P mobility in soil. Increased microbial activity and resultant biochemical transformations in soil, because of added organic manures may cause mineralization of more recalcitrant P fraction (Nziguheba *et al.*, 1998). Hence plants grown with organic manures accumulate more P than without organic amendments (Mujeeb *et al*., 2008).

A balanced and integrated use of organic and inorganic nutrient sources may help sustain crop production. Integrated use of organic and inorganic fertilizers increases crop yields. Improved yields of various crops have been reported by addition of organic manures (Usman *et al.*, 2003; Khaliq *et al.*, 2004; Muhammad & Khattak, 2009). Nonetheless, little is known on the response of maize to

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application of organic manure of different sources without P fertilizers. It is hypothesized that addition of organic manures will improve the mobility of native P by changing soil chemistry and hence will improve the maize growth even without supplemental P fertilizer.

MATERIALS AND METHODS

The experiment was conducted at Sub-Campus University of Agriculture, Faisalabad at Depalpur, Dist. Okara. Bulk surface (0-15 cm) sample of soil collected from the experimental farm was air dried, grinded to pass through a 2 mm sieve and mixed thoroughly. The soil was characterized for various physico-chemical properties following USDA Handbook No. 60 (Richards, 1954). Experimental soil was having 64.5% sand, 8.5% silt and 27% clay and was classified as sandy clay with a bulk density of 1.57 Mg m^{-1}. Soil pH in 1:1 soil water suspension was 7.8. Amount of $CaCO_3$ equivalent estimated by acid dissolution was 7.8. Initially bioavailable P in soil as estimated by 0.5 M $NaHCO_3$ extraction according to Olsen *et al.* (1954) was 5.5 mg P kg^{-1} soil.

The soil was thoroughly mixed and 7.5 kg prepared soil was filled in 16 earthen pots. Nitrogen and potassium were added in each pot at the rate of 100 and 50 kg ha^{-1}, respectively using urea and potassium sulfate, while phosphorus was not applied. The pots were arranged in four different groups (treatments), each consisting of four pots (replications). Organic manures; farmyard manure, poultry manure and pressmud were mixed with soil at the rate of 10 t ha^{-1} in each pot, followed by water application. Control pots did not receive any organic manure application. The chemical composition of the organic manure used in this study is presented in Table I. After attaining field capacity, the soil was again mixed thoroughly and four seeds of maize (cv Nilam) were sown in each pot. Six days after emergence, plants were thinned to have two plants per pot. Six weeks after emergence, plants were harvested to record the observations. Plant height was measured by a measuring tape. Roots were taken out by gentle pressure and soil adhering to roots (rhizosphere) was collected. Roots were washed to remove soil particles and stored in paper bags. Bulk soil samples were also collected from pots away from roots. Plant shoot and root fresh weight was recorded using top load balance. Leaf area was recorded for each pot by measuring the leaf length and width. The soil samples collected (after final harvest) were analyzed for EC, pH, organic matter, available P and K using standard laboratory procedures. The data recorded were analyzed statistically using computer based software MSTAT-C and MS Excel®.

RESULTS AND DISCUSSION

Physico-chemical properties of the soil: Organic matter contents were substantially improved by the application of organic manures, maximum being from pressmud followed by poultry manure (Table II). Addition of organic manure increases microbial activity in the soil (Marschner, 1995), which may increase the organic matter contents in soils compared to control. Furthermore, in these treatments, significant amount of organic matter was added, which increased the content of organic matter (Agbede *et al*., 2008). The organic matter contents in soil differed significantly among rhizosphere and bulk soil being significantly higher in rhizosphere soil than the bulk soil (Table II). Increased microbial activity in rhizosphere and released organic substances by plants might be responsible for higher organic matter contents in rhizosphere soil than in bulk soil (Marschner, 1995). While organic manure addition did not change the soil electric conductivity and pH. Nonetheless electric conductivity of rhizosphere soil was less than that of bulk soil. Though several researcher (Marschner, 1995; Walker *et al.*, 2004) observed significant changes in soil pH on addition of organic manure owing to OM oxidation and release of CO_2 in the soil. However, this contradiction may be because of short duration of present study. There are also reports indicating non-significant effect of organic manure on soil pH (Agbede *et al.*, 2008).

Table I: Chemical composition of the farm yard manure (FM), poultry manure (PM) and pressmud (PrM)

Organic manure	N (%)	P (mg g^{-1})	K (mg g^{-1})
FYM	0.46	0.46	0.89
PM	1.08	0.60	0.79
PrM	0.42	0.48	1.32

Soil K and P contents were significantly improved by organic manure application (Table II). Cavigelli and Thien (2004) also found increased bioavailability of P in soils by addition of organic matter. Here higher P contents were observed in soil previously added with poultry manure, while higher K contents were recorded in soil receiving pressmud. This happened possibly due to the higher contents of respective mineral in the respective source (Table I). Phosphorus is relatively immobile nutrient in soil and diffusion is the major process controlling its movement. Hence indirectly soil moisture regulates soil P mobility (Marschner, 1995). Addition of organic manure increased soil moisture contents (Boateng *et al.*, 2006), which may be the reason of improved P availability in soil. Nonetheless organic manures after decomposition may also have played role in carbonic acid driven increased P bioavailablity (Marschner, 1995; Mengel & Kirkby, 2001). Production of organic legends in soil by increased microbial activity (Marschner, 1995) might be responsible for desorption of P from mineral compounds.

Plant growth: Organic manure application substantially influenced the plant growth (Table III). Addition of organic manure significantly improved plant height than control treatment. Maximum plant height was observed in treatment receiving press mud followed by poultry manure and farm yard manure. Though there was substantial increase in leaf

Table II: Physico-chemical characteristics of soil after harvesting maize. Values are mean of four replicates ± standard error

Treatments	Soil	Organic matter	EC (dSm^{-1})	pH	Phosphorus (mg kg^{-1})	Potassium (mg kg^{-1})
C	Rhizosphere	0.39 ± 0.03	1.45 ± 0.32	8.4 ± 0.45	3.22 ± 0.34	70 ± 5
	Bulk soil	0.25 ± 0.04	1.60 ± 0.12	8.4 ± 1.10	5.02 ± 0.12	65 ± 7
FYM	Rhizosphere	0.78 ± 0.02	1.45 ± 0.21	8.3 ± 0.34	6.4 ± 0.11	110 ± 9
	Bulk soil	0.62 ± 0.07	1.74 ± 0.14	8.3 ± 0.32	8.10 ± 0.08	136 ± 11
PM	Rhizosphere	0.87 ± 0.05	1.45 ± 0.32	8.2 ± 0.12	7.72 ± 0.05	89 ± 3
	Bulk soil	0.70 ± 0.03	1.50 ± 0.19	8.2 ± 0.42	10.24 ± 1.1	121 ± 9
PrM	Rhizosphere	1.19 ± 0.09	1.65 ± 0.12	8.4 ± 0.89	5.6 ± 0.26	130 ± 11
	Bulk soil	1.10 ± 0.12	1.73 ± 0.14	8.4 ± 0.21	8.91 ± 0.45	150 ± 21
Probability		*	NS	NS	*	*

Table III: Plant height (cm) and leaf area (cm^2 $plant^{-1}$) of maize plants. All treatments values are mean of four replicates

Treatments	Plant height (cm)	Leaf area (cm^2 $plant^{-1}$)
C	88 ± 1.26	2512 ± 132
FYM	94 ± 3.19	5062 ± 118
PM	99 ± 3.52	4297 ± 132
PrM	103 ± 1.00	4182 ± 81
Probability	*	**

Table IV: Shoot and root fresh and dry weights (g pot^{-1}) of maize plants grown with different sources of organic manures. Values are means of four replicates

Treatments	Shoot weight (g/pot)		Root weight (g/pot)		Plant weight (g/pot)	
	Fresh	Dry	Fresh	Dry	Fresh	Dry
C	49.3 ± 2.6	6.70 ± 0.37	24.0 ± 1.22	6.82 ± 0.45	73 ± 1.55	13.52 ± 0.38
FYM	79.8 ± 2.3	11.44 ± 1.01	27.3 ± 1.70	7.50 ± 0.42	133 ± 2.10	18.94 ± 0.86
PM	84.3 ± 2.6	10.48 ± 0.54	28.0 ± 1.35	9.95 ± 1.10	109 ± 2.43	20.43 ± 1.63
PrM	82.0 ± 1.6	9.77 ± 0.18	32.0 ± 2.38	9.57 ± 0.59	101 ± 2.48	17.33 ± 0.71
Probability	*	*	*	*	*	*

Table V: Shoot potassium and phosphorus concentration (mg g^{-1}) of maize grown with different organic sources. Values are means of four replicates

Treatments	Potassium concentration (mg g^{-1})	Phosphorus concentration (mg g^{-1})
C	20 ± 1.7	4.7 ± 0.02
FYM	33 ± 3.1	7.6 ± 0.01
PM	47 ± 3.5	8.2 ± 0.03
PrM	62 ± 7.3	6.9 ± 0.06
Probability	*	*

Whereas C is control, FYM is farm yard manure, PM is poultry manure, PrM is pressmud, * Significant at 5% probability, ** significant at 1% probability, NS non-significant

area by all the organic manures; about two fold increase in leaf area by the application of farm yard manure. Improved plant height and leaf area in plants by organic manure application has been reported (Boateng *et al.*, 2006; Muhammad & Khattak, 2009). Likewise substantial improvement in root and shoot fresh and dry weights was observed by the application of organic manures (Table IV). Here increase in shoot fresh weight was higher from press mud and poultry manure than farmyard manure. This improved plant growth by addition of organic manure may be attributed to improved mineral nutrition of plants particularly phosphorus as phosphorus was not applied to plants. Likewise maximum increase in root fresh matter was observed from press mud application. Addition of organic matter also improved root dry matter. Root dry matter was significantly more in plants grown with Press mud. Similarly plant fresh as well dry weight was improved by addition of organic matter sources. The improved shoot and root growth by addition of organic manure (Muhammad & Khattak, 2009; Boateng *et al*., 2006; Hirzel *et al.*, 2007) might be attributed to improved soil P and K availability (Table III) (Marschner, 1995).

Potassium and phosphorus concentration in shoots of maize: Potassium concentration in shoots was significantly more in plants grown with either source of organic manure than in plants grown without organic manure addition (Table V). Maximum increase in shoot K concentration was observed when press mud was added at the rate of 10 tons ha^{-1} followed by poultry manure and farm yard manure. The increase in K concentration, because of added organic matter may be attributed to K concentration of organic matter and improved root growth. Better root growth is responsible increased nutrient uptake in plants (Aziz *et al*., 2006).

Phosphorus concentration in plants grown without organic matter was significantly more when organic matter was added with either source. Phosphorus was not applied to the soil in any pot, hence the P uptake was attributed to the native P in the soil. The higher P concentration in plant shoots, because of added organic matter in soil was attributed to the increased P availability (Mohanty *et al*., 2006; Hirzel *et al*., 2007; Ewulo *et al.*, 2008; Garg & Bahl, 2008). Root growth was more in plants receiving organic manures; hence, it may be the reason for increased P uptake (Aziz *et al*., 2006) of plants receiving organic manure.

CONCLUSION

Addition of organic matter through all sources significantly improved the soil properties and maize growth. Improvement in maize growth was principally due to increase in P and K availability in soil. Hence integrated use of organic manure with chemical fertilizers would be a better and practical approach to sustain soil fertility and productivity.

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REFERENCES

Agbede, T.M., S.O. Ojeniyi and A.J. Adeyemo, 2008. Effect of poultry manure on soil physical and chemical properties, growth and grain yield of sorghum in southwest, Nigeria. *American-Eurasian J. Sustainable Agric.*, 2: 72–77

Aziz, T., Rahmatullah, M.A. Maqsood, M.A. Tahir, I. Ahmad and M.A. Cheema, 2006. Phosphorus utilization by six *Brassica cultivars* (*Brassica juncea* L.) from tri-calcium phosphate; a relatively insoluble P compound. *Pakistan J. Bot.,* 38: 1529–1538

Boateng, S.A., J. Zichermann and M. Kornahrens, 2006. Poultry manure effect on growth and yield of maize. *West Africa J. Appl. Ecol.*, 9: 1–11

Cavigelli, M.A. and S.J. Thien, 2004. *Phosphorus Bioavailability Following Incorporation of Green Manure Croporation*. AG Professional Magazine, pp: 46–48

Chaudhary, M.A., M. Shafiq and A.U. Rehman, 1998. Effect of organic and inorganic fertilizer on maize crop response under eroded loess soil. *Pakistan J. Soil Sci*., 15: 39–43

Clemente, R. and M.P. Bernal, 2006. Fractionation of heavy metals and distribution of organic carbon in two contaminated soils amended with humic substances. *Chemosphere*, 64: 1264–1273

Elsayed, M.T., M.H. Babiker, M.E. Abdelmalik, O.N. Mukhtar and D. Montange, 2008. Impact of filter mud application on the germination of sugarcane and small seeded plants and on soil and sugarcane nitrogen contents. *Bioresource Technol.,* 99: 4164–4168

Ewulo, B.S., O.S. Ojeniyi and D.A. Akkani, 2008. Effect of poultry manure on selected soil physical and chemical properties, growth, yield and nutrient status of tomato. *African J. Agric. Res.,* 3: 612–616

Garg, S. and G.G. Bahl, 2008. Phosphorus availability to maize as influenced by organic manures and fertilizer phosphorus associated with phosphatase activity in soils. *Bioresource Technol.,* 99: 5773–5777

Hirzel, J., I. Matus, F. Novoa and I. Walter, 2007. Effect of poultry litter on silage maize (*Zea mays* L.) production and nutrient uptake. *Spanish J. Agric. Res*., 5: 102–109

Khaliq, T., T. Mahmood, J. Kamal and A. Masood, 2004. Effectiveness of farmyard manure, poultry manure and nitrogen for corn (*Zea mays* L.) productivity. *Int. J. Agric. Biol.,* 6: 260–263

Marschner, H., 1995. *Mineral Nutrition of Higher Plants*. Academic Press International, San Diego, CA, USA

Mengel, K. and E.A. Kirkby, 2001. *Principles of Plant Nutrition,* 5th edition. Kluwer Academic Publishers, London

Mohanty, S., N.K. Paidaray and A.R. Rajan, 2006. Availability and uptake of phosphorus from organic manures in groundnut-corn sequence using radio tracer techniques. *Geoderma*, 133: 225–230

Mujeeb, F., Rahmatullah, A. Hannan and M. Aamer Maqsood, 2008. Response of maize to di-ammonium phosphate and farmyard manure application on three different soils. *Pakistan J. Agric. Sci.,* 45: 13–18

Muhammad, D. and R.A. Khattak, 2009. Growth and nutrient concentration of maize in pressmud treated saline-sodic soils. *Soil Environ.,* 28: 145–155

Nziguheba, G., C.A. Palm, R.J. Buresh and P.C. Smithson, 1998. Soil phosphorus fractions and adsorption as affected by organic and inorganic sources. *Plant Soil* 198: 159–168

NFDC, 2003. *Fertilizer Use in Pakistan*. National Fertilizer Development Centre, Islamabd

Olsen, S.R., C.V. Cole, F.S. Watanabe and L.A. Dean, 1954. *Estimation of Available Phosphorus in Soils by Extraction with Sodium Bicarbonate*. Circular 939, USDA, Washington, D.C

Richards, A.L., 1954. *Diagnosis and Improvements of Saline and Alkaline Soils*. USDA, Hand book No. 60, Washington, D.C

Usman, M., E. Ullah, E.A. Warriach, M. Farooq and A. Liaqat, 2003. Effect of organic and inorganic manures on growth and yield of rice variety Basmati 2000. *Int. J. Agric. Biol.,* 5: 481–483

Walker, D.J., R. Clemente and M.P. Bernal, 2004. Contrasting effects of manure and compost on soil pH, heavy metal availability and growth of *Chenopodium album* L. in a soil contaminated by pyritic mine waste. *Chemosphere*, 57: 215–224

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