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EFFECT OF PHOSPHORUS FERTILIZER ON THE YIELD AND QUALITY OF MAIZE (*Zea mays* L) FODDER ON CLAY LOAM SOIL

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ABSTRACT

Maize is an important Kharief (summer) fodder for animals in Pakistan. Phosphorus is a quality nutrient for fodders. The use of P for maize fodder is negligible. Thus a field study was conducted to evaluate the effect of Phosphorus fertilizer on the yield and quality of maize fodder on a clay loam (calcareous) soil. Adsorption isotherm was constructed by equilibrating 2.5 g soil with 25 ml of 0.01 M $CaCl_2$ solution containing 0, 20, 40, 60, 80, 100, 200,300,400 and 500 µg P mL^{-1} as KH_2PO_4 and shaking for 24 hour at 20 ^{0}C. Phosphorus fertilizer doses were computed by using empirically derived Freundlich equation to adjust soil solution Phosphorus levels of 0.05, 0.1, 0.15, 0.20, 0.25, 0.30, 0.35, 0.40, and 0.50 mg P L^{-1}. It was observed that different Phosphorus fertilizer doses were required to adjust different soil solution Phosphorus levels. Adsorption of Phosphorus increased with phosphorus application rate but marginal adsorption decreased significantly. Yield and quality of maize fodder were improved with Phosphorus application. Yield increased upto T_8 where Phosphorus was applied @ 53 kg ha^{-1} but quality traits (P concentration, dry matter, crude protein, crude fiber and ash contents (%) improved with the highest rate of Phosphorus use i.e. 57 kg ha^{-1}. Phosphorus application showed non-significant affect on NDF and ADF contents (%). External and internal Phosphorus requirements of maize fodder to obtain 95 % relative yield were 0.25 mg L^{-1} and 0.23 mg L^{-1} respectively.

Key word: - P fertilization, derived Freundlich equation, maize fodder yield and quality.

INTRODUCTION

Maize grown for green fodder is a short-duration crop and is ready for harvesting in about 8-10 weeks after sowing. No research in the recent past has been carried out to find out the profitability of maize as green fodder in Punjab in-spite of the ever-increasing demands and its economic importance. Based on area and production, maize is the 3rd most important cereal crop after wheat and rice in world (Tollenaar and Dwyer 1999). The yield of maize in Pakistan is very low as compared to other maize producing countries. Maize is a nutritious fodder and is the richest source of livestock feed. This crop can be grown under irrigated areas with wide range of climate throughout the year for fodder purpose in the province of Punjab. Forage maize (*Zea mays* L.) can also be grown in winter which had a significant role in livestock production, particularly in the tropical zone where feed stuffs could not meet animal requirements due to many factors such as poor soil fertility, drought and others (Eltelib *et al* 2006). The production of maize fodder could be increased by the application of balanced fertilizer in particular with the use of phosphorus fertilizer as its quality can be considerably improved with this nutrient.

The purpose of the present investigation was to determine the effect of rates of Phosphorus fertilizer on the Nutritive value of maize (*Zea mays*) fodder in conditions of Okara Pakistan.

MATERIALS AND METHODS

A clay loam soil was selected. The soil samples were collected from 0-30 cm depth. The soil was alkaline in reaction (pH 8.0), non-saline (ECe 0.75 dSm^{-1}), calcareous ($CaCO_3$ 10.0 %) and low in organic matter (0.8 %), available P (5.6 ppm) and K (71 ppm).

P adsorption isotherms and application of Freundlich equation to compute P doses: Phosphorus adsorption capacity of the soil was determined by shaking 2.5g soil with 25ml 0.01M $CaCl_2$ containing P concentrations 0, 20, 40, 60, 80, 100, 200,300,400 and 500 µg P ml^{-1} prepared from KH_2PO_4 for 24 hours at 20^{o}C.The soil solutions were filtered through Whatman No.41 filter paper and P concentration was measured using Ascorbic Acid Method (Murphy and Riley, 1962) and adsorption isotherms were constructed according to the methods described by (Rowell 1994). The amount of P adsorbed was calculated from the difference of P added and P remained in solution after P equilibrium was established. The adsorption data was fitted to the empirically derived Freundlich equation (Pant and Reddy 2001) as under to compute P fertilizer doses.

$$X/m = K_f (EPC)^{1/n}$$

Linear form of the equation $= \text{Log } X/m = \text{Log } K_f + 1/n \text{ (Log EPC)}$

X/m = Amount of P adsorbed per unit of soil (ug g^{-1})

EPC = Equilibrium P concentration in soil solution (ug ml^{-1})

K_f is proportionality constant for Freundlich equation (mg P kg^{-1})
1/n is empirical constant expressed in L kg^{-1}.

P doses were computed (table-I) by putting the adsorption data into the linear form of the derived Freundlich equation to attain soil solution P levels of 0.05, 0.10, 0.15, 0.20, 0.25, 0.30, 0.35, 0.40, and 0.50 mg L-1.

Table I: - P fertilizer doses computed by Freundlich equation

Treatments	Soil solution P levels	Clay loam	
		P	P_2O_5
	mg L^{-1}	← kg ha^{-1} →	
T_1	0.00	0	0
T_2	0.05	26	59
T_3	0.10	37	84
T_4	0.15	43	99
T_5	0.20	47	108
T_6	0.25	51	118
T_7	0.30	56	129
T_8	0.35	53	120
T_9	0.40	55	126
T_{10}	0.50	57	131

Field experiment: The field experiment was conducted on clay loam soil at farmer's field. There were ten treatments and three replications layed-out in Randomized Complete Block Design (RCBD). Whole P (calculated) table 1 and recommended K (60 kg ha^{-1}) were applied at the time of sowing. Nitrogen @ 60 kg ha^{-1} was applied in two splits i.e. half at sowing and half with first irrigation. The crop was harvested at silking stage of growth, fodder yield and dry matter contents (%) data were recorded. Plant samples were analyzed for P concentration, crude protein, crude fiber and ash content (%). Data thus generated was statistically analyzed (M-state) according to (Steel *et al*, 1997). The comparisons among the treatment means were made by using Duncan's Multiple Range Test at 5 % probability level (Duncan, 1955).

RESULTS AND DISCUSSION

Green fodder yield (Mg ha^{-1}) of maize as affected by P fertilizer: The fodder yield data of maize presented in table 2 indicated that maize fodder yield was increased significantly over control with all the P application rates. Similarly the maximum green fodder yield of 42.35 and 42.18 Mg ha^{-1} was obtained with T_8 and T_7 where P was applied @ 53 and 55 kg ha^{-1} against soil solution P levels of 0.35 and 0.30 mg L^{-1}.The yield from control plots was 11.24 Mg ha^{-1}. The increase in fodder yield over that of control plots with P application was upto 0.35 mg L^{-1} soil solution P level. The increase in fodder yield is attributed to the increase in plant height and number of plants with P application. The increase in plant height due to P had also been reported by (Aslam, 1986). It is concluded from the results that P adsorption capacities influenced supply of P differently to the plants. The plant height has positive correlation with the soil solution P. The maize plant height was greater, even at low level of soil solution P if the P adsorption parameters of the soil were low. The increase in yield was mainly due to greater plant height, stem diameter and leaf area $plant^{-1}$ (Ayub *et al.* 2002). Similarly, (Alias *et al*., 2003) reported that Stover yield of maize increased significantly with increasing level of P upto 125 kg ha^{-1} further increase of P rate (150 kg ha^{-1}) decreased the Stover yield. (Eijk *et al*., 2006) also obtained similar results.

Table II: - Effect of P on green fodder yield (Mg ha^{-1}), P concentration (%) and dry matter contents (%) of maize fodder.

Treatments	Soil solution P levels	Fodder yield	Dry matter	P concentration
	mg L^{-1}	Mg ha^{-1}	← % →	
T_1	0.00	11.24^{E}	12.45^{G}	0.116^{I}
T_2	0.05	16.81^{D}	15.47^{F}	0.176^{H}
T_3	0.10	21.74^{C}	18.34^{E}	0.182^{G}
T_4	0.15	24.21^{C}	19.21^{D}	0.196^{F}
T_5	0.20	31.83^{B}	20.25^{C}	0.214^{E}
T_6	0.25	40.80^{A}	20.38^{C}	0.225^{D}
T_7	0.30	42.03^{A}	22.19^{B}	0.226^{D}
T_8	0.35	42.35^{A}	22.58^{AB}	0.230^{C}
T_9	0.40	42.18^{A}	22.65^{AB}	0.254^{B}
T_{10}	0.50	41.95^{A}	22.72^{A}	0.264^{A}

Means sharing the same letters are statistically significant at 5 % level of Probability.

Dry matter yield: The data regarding dry matter contents data of maize fodder are presented in table 2. The DM contents increased with increasing P application rates. The higher P rates could not improve DM contents. Maximum dry matter contents of 22.72 % were obtained with T_{10} where P was applied @ 57 kg ha^{-1} against soil solution P levels of 0.50 mg L^{-1}. The role of P in modifying soil and plant environment is conducive for better growth. The dry matter contents of maize from control plots were 12.45%. The trend in dry matter contents was similar to that of green fodder yield. The dry matter contents increased significantly upto T_{10}.but at par with T_8 and T_9. The results are in conformity with those of (Khattak and Iqbal 1992). (Rashid, 1992) also reported 13% less dry matter yield for maize with no P fertilizer application. The results are also in line with the findings of (Singh and Bishnoi, 1993) who observed that there was significant increase in dry matter yield of maize upto P application @ 40 mg P_2O_5 ha^{-1}. At successive levels of P application the significant increase in dry matter yield of maize was not observed (Eltelib *et al*, 2006). (Pholsen and Suksri, 2007) reported that dry matter yield of sorghum increased upto 75 Kg P_2O_5 ha^{-1} but at higher rate of P application i.e. 150 Kg P_2O_5 ha^{-1} there was decrease in dry matter yield. In the present study the decrease in dry matter yield at higher P application rates might be due to dilution effect and imbalanced nutrition. The plant growth might be affected due to deficiency of Zn induced by high P levels (Sinha *et al*., 1995).

P Concentration in maize fodder: Data regarding P concentration in maize fodder (table 2) showed that P concentration increased with its application. It increased significantly in maize fodder upto 0.50 mg L^{-1} soil solution P level. The maximum P concentration in maize fodder was 0.264 % where P was applied @ 57 kg ha^{-1} (against soil solution P level of 0.50mg L^{-1}). Fodder produced on clay loam soil can meet better the P requirement of the animals. The minimum P concentration 0.116 % was observed in maize fodder harvested from the control plots, which showed poor quality of fodder. The results are in agreement with the findings of (Chaudhary *et al*., 2003), who observed that P contents in maize fodder increased significantly with increasing soil solution P levels in all the soil series. (Rashid, 1992) reported that maize leaf tissue require 0.26 percent P for optimum crop growth. P deficiencies occur in animals when forages containing 0.10-0.12 % P are fed (Pinchak *et al*., 1989).

Quality of maize fodder: Quality fodder is needed for better performance of animals. The parameters used to describe forage quality are crude protein, crude fiber, ash, ADF and NDF contents (%) (Soest, 1985). Addition of P fertilizer is necessary as it improves both quality and quantity of the green fodder (Dhillon *et al*., 1998). P application to soil regulates Mg uptake, which prevent tetany (a disease) in animals (Lock *et al*., 2000).

The effect of P on crude protein content in maize fodder is presented in table 3. The crude protein, crude fiber and ash contents in maize fodder increased with increase in P application rate. The maximum crude protein, crude fiber and ash contents were 10.55, 21.63 and 7.26 % respectively, in maize fodder with T_{10} where P was applied @57 kg P ha^{-1} against soil solution P level of 0.50 mg L^{-1}. This indicated better utilization of N with increasing P inputs. The increase in crude protein content was due to the fact that P is an important structural component of DNA and RNA. The Phosphate group in nucleic acids bridges the RNA or DNA. DNA is the carrier of genetic information and RNAs function in protein synthesis (Mengel and Kirkby, 2001). Similarly, (Hussain, 1991) reported that crude protein content in sorghum fodder was increased with P application.

Table III: - Effect of P fertilization on the quality of maize fodder.

Treatments	Soil solution	Crude protein	Crude fiber	ash	NDF	ADF
	mg L^{-1}	←		%	→	
T_1	0.00	5.85H	21.00NS	6.28 G	52.63 NS	28.84 NS
T_2	0.05	6.14G	21.35	6.32 G	52.59	28.71
T_3	0.10	6.52F	21.38	6.58 F	52.55	28.60
T_4	0.15	6.70F	21.46	6.72 E	52.54	28.54
T_5	0.20	7.07E	21.49	6.86 D	52.52	28.51
T_6	0.25	7.34D	21.52	6.98 C	52.52	28.50
T_7	0.30	8.35C	21.52	7.02 C	52.46	28.45
T_8	0.35	9.10B	21.55	7.07 BC	52.43	28.42
T_9	0.40	10.30A	21.59	7.18 AB	52.40	28.36
T_{10}	0.50	10.55A	21.63	7.26 A	52.44	28.36

Means sharing the same letters are statistically significant at 5 % level of Probability.

The increase in crude fiber contents was due to more dry matter accumulation with P application (Chand *et al*., 1992). Similarly, (Ayub *et al*., 2002) reported that crude fiber content was increased with P application along with N. Increase in ash % is due to increase in mineral matter (Soest, 1985). ADF and NDF are composed of cellulose plus lignin and cellulose plus hemicellulose plus lignin, respectively and are the structural carbohydrates in plants, which play an important role in the digestibility of forage. The decrease in ADF and NDF (cell wall components) is an indication in improvement of the quality of fodders. On the other hand high values of both the parameters indicate poor digestibility due to more lignification (Soest 1985). P application showed non-significant effect on ADF and NDF contents in maize fodder. However, there was slight decrease in the quantity of these parameters and increase in soluble carbohydrates in fodder by P fertilization, which showed quality improvement (Reid and Jung 1965). The results of this study are also in agreement with those of (Karwasra *et al*., 1984) and (Chand *et al*., 1992) who reported that ADF and NDF contents of sorghum fodder did not change significantly with P application. (Pholsen and Sukseri 2007) reported that P and K fertilizers application had no effect on ADF and NDF contents in forage sorghum.

P requirements of maize fodder: The soil solution P level and P concentration in maize fodder at head initiation stage were plotted against 95 % relative yield of maize fodder for the determination of P requirement by the Boundary Line Technique (Webb, 1972) as shown in the Fig 1 and 2

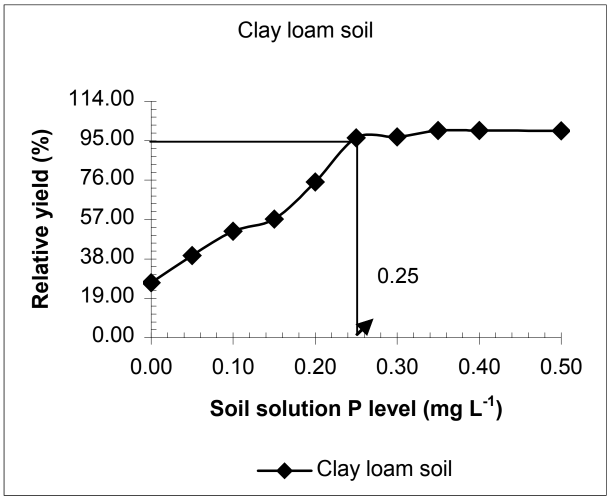

Fig1: External P requirement of maize fodder

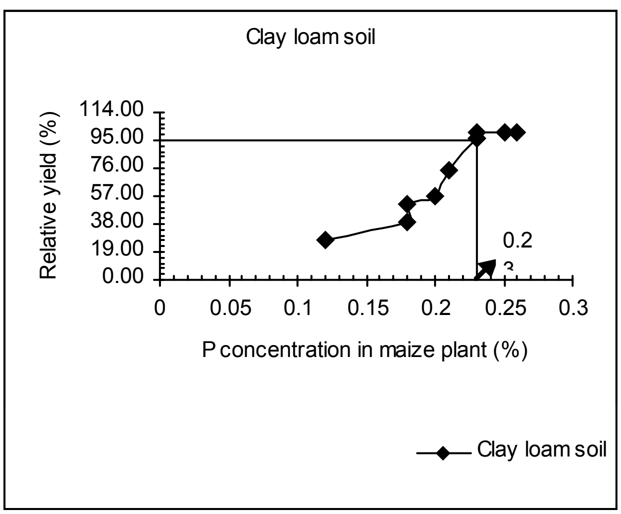

Fig 2:- Internal P requirement of maize fodder

Maximum soil solution P level of 0.25 mg L^{-1} was required for 95 % relative yield on this soil. (Hassan *et al*., 1994) calculated P fertilizer requirement using adsorption isotherms as 83, 51,50 and 8 mg P kg^{-1} for the Missa, Gujranwala, Abbotabad and Risalpur soil series to adjust soil solution P level of 0.2 mg P L^{-1} and soil solution P requirement of corn for near maximum (95 %) biomass production was 0.3 mg PL^{-1}. Internal P requirement in maize fodder to obtain 95 % relative yield was 0.23 %. Chaudhary *et al*., (2003) reported that the critical phosphorus concentration ranged from 0.22 to 0.26 % for 40-60 cm tall maize plants. Similarly, (Rehman *et al*., 2007) stated that internal P requirement in sorghum fodder harvested from Typic Camborthid soil was 0.326%.

REFERENCES

Alias, A., M. Usman, E. Ullah, and E. A. Waraich (2003). Effects of different Phosphorus levels on the growth and yield of two cultivars of maize (*Zea mays* L.).Int.J.Agric. and Biolo.5 (4):632-634.

Aslam, M. (1986). Response of wheat (Pb-81) to fertilizer and irrigation interaction. M.Sc. Thesis Uni. Agri. Faisalabad.

Ayub, M., M. A. Nadeem, M. S. Shara, and N. Mahmood (2002). Response of Maize (Zea mays L) fodder to different levels of Nitrogen and Phosphorus.Asian.J.plant Sci.1 (4):352-354.

Chand, K., M. L. Dixit, and S. K. Arora (1992). Yield and quality of forage sorghum as affected by phosphorus fertilization.J.Indian Soc.Soil Sci.40:302-306.

Chaudhry, E. H., A. M. Ranjha, M. A. Gill and S. M. Mehdi (2003). Phosphorus requirement of maize in relation to soil characteristics. Int. J. Agric. Bio. 5(4):625-629.

Dhillon, N. S., T. S. Dhesi, and B. S. Brar (1998). Extractants for assessing P availability to Berseem in flood-plain soils of Punjab.J.Indian Soc.Soil Sci.46 (3):402-406.

Duncan, D. B. (1955).Multiple Range and Multiple F-Test. Biometrics.11:13-15.

Eijk, D. V. D., B. H. Janssen, and O. Oenema (2006). Initial and residual effects of fertilizer phosphorus on soil phosphorus and maize yields on phosphorus fixing soils. Agri. Ecosys. and Environ.116(1-2):104-120.

Eltelib, H. A., M. A. Hamad, and E. E. Ali (2006). The effect of Nitrogen and Phosphorus fertilization on growth,yield and quality of forage maize (*Zea mays* L.) J.Agrono.5(3):515-518.

Hassan, M. M., A. Rashid, and M. S. Akhtar (1994). Phosphorus requirement of maize and sunflower on selected bench mark soils of Pakistan. In Proc. 4th Nat. Cong. Soil Sci. May 24-26, 1992 at NARC, Islamabad. p. 327-332.

Hussain, A. (1991). Effects of different phosphorus application on growth and yield behaviour of maize. M.Sc. (Hons.) Agric. Thesis, Dept. Agron. Univ. Agric. Faisalabad,Pakistan.

Karwasra, S. P. S., S. L. Chaudhary and A. P. Khera (1984). Forages Res. in India. .9, 57.

Khattak, J. K., and J. Iqbal (1992). Calibration of phosphorus on calcareous soils by $NaHCO_3$ and NH_4HCO_3- DTPA extracting using maize as a test crop. In proc. "Role of Phosphorus in Crop Production." NFDC, Islamabad, Pakistan. p. 311-320.

Lock, T. R., R. L. Kallenbach, D. G. Blevins, T. M. Reinbott, R. J. Crawford, Jr., M. D. Massie, and G. J. Bishop-Hurley (2000). Phosphorus fertilization of tall Fescue may prevent grass tetany.Better crops.84 (3):12-13.

Mengel, K and E. A. Kirkby (2001). Principles of plant nutrition.5th (ed.).Kluwer Academic Publishers,London.

Murphy, J. and H. P. Riley (1962). A modified single solution method for the determination of phosphate in natural waters. Anal. Chim. Acta. 27: 31-36.

Pant, H .K. and K. R. Reddy (2001). Phosphorus sorption characteristics of Estuarine sediments under different redox conditions.J.Environ.Qual.30:1474-1480.

Pholsen, S. and A. Suksri (2007). Effects of phosphorus and potassium on growth, yield and fodder quality of IS 23585 Forage sorghum cultivar (*Sorghum bicolor* L. Moench). Pak.J.Biolo.Scie.ISSN.1028-8880.

Pinchak, W. E., L. W. Greene and R. K. Heitschmidt (1989). Mineral dynamics in beef cattle diets from a southern mixed-grass prairie. J. Range Manage. 42:431–433.

Rashid, A., (1992). Phosphorus use efficiency in soils of Pakistan. In Proc. "Efficient use of Plant Nutrients". Soil Sci. Soc. Pakistan. p. 115-128.

Rehman, O., S. M. Mehdi, A. M. Ranjha and M. Sarfraz (2007). Phosphorus requirement of cereal crops and fertility buildup factor in a Typic Camborthid soil. J. Biolo. Sci. 7 (7) 1072-1081.

Reid, R. L. and C. A. Jung (1965). Influence of fertilizer treatment on the intake,Digestibility,and palatability of tall fescue hay. J. Anim. Sci., 24:615-625.

Rowell, D. L., (1994). Soil Science. Methods and applications Longman Scientific and Technical.Harlow.Essex.UK.

Singh, B. and S. R. Bishnoi (1993). Determination of critical level of available soil phosphorus for maize. J. Indian Soc. Soil Sci.41(3):501-503.

Sinha, R. B., R. Sakal, and S. Kumar (1995). Sulpher and phosphorus nutrition of winter maize in calcareous soils. J. Indian Soc. Soil Sci.43(3):413-418.

Soest, P. J. V. (1985). Composition, Fiber quality, and Nutritive value of forages. In: Forages, The Science of grassland Agriculture. Maurice, E.H., B.F.Robert, and M.S.Darrel (4th Ed), Iowa state Univ.press Ames, Iowa, USA.p. 413-421.

Steel, R. G. D., J. H. Torrie and D. A. Dicky (1997). Principles and procedures of Statistics, a biometric approach. 3rd Ed. Mc Graw-Hill, Inc. Book Co. N.Y. USA.

Tollenaar, M. and Dwyer, L. M. (1999). Physiology of maize. In Smith, D. L. and Hamel, C. (eds). Crop Physiology and Processes. Springer-Verlag, Berlin Heidelberg, pp. 169-199.

Webb, R. A. (1972). Use of boundary line technique in the analysis of biology data. J. Hort. Sci. 47: 309-319.