PHOSPHOROUS EFFECTS ON EARLY GROWTH OF MAIZE (*ZEA MAYS* L.) VARIETIES IN ULTISOLS

Tikaram Pokhrel[1*], Ram Kumar Shrestha[1], Amit Khanal[1], Jiban Shrestha[2]
[1]Institute of Agriculture and Animal Science, Lamjung Campus, Department of Soil Science, Agriengineering and Environmental Science; [2]Nepal Agricultural Research Council, National Commercial Agriculture Research Program, Pakhribas, Dhankuta, Nepal;
**Corresponding author: agripokhtikaram@gmail.com*

Abstract. Soil phosphorus (P) availability is critical for the early growth and development of maize (*Zea mays* L.). The objective of this study was to evaluate the effects of P on early growth of maize varieties. A pot experiment was conducted at Lamjung campus during February to March, 2018 to investigate the effect of P application on early growth of maize plants in Ultisols. The experiment was conducted in two factorial combination of five P level (0 kg ha^{-1}, 15 kg ha^{-1}, 30 kg ha^{-1}, 45 kg ha^{-1} and 60 kg ha^{-1}) and three varieties of maize (Arun-4, Rampur Composite and Manakamana-3). The treatments were laid out on complete randomized design (CRD) with three replications. The effect of P on root biomass, plant height, number of leave and, shoot dry matter of plant was investigated. Results showed that application of 60 kg P ha-1 appeared to be superior to improve the yield attributes. Varietal responses also appeared to be significantly different. Rampur composite responded significantly better in plant height than Manakamana-3 but it did not differ significantly with Arun-4. Although, significant response were found on growth parameters with higher P levels, further investigation is needed to optimize the P rate for enhancing maize yield attributing parameters.

Keywords: Maize (*Zea mays* L.), phosphorous, growth

INTRODUCTION

Phosphorus (P) is one of most essential macronutrient for maize production and its limitation in soil is major problems of soil based cropping system. Maize ranked third highest produced cereals crop in the world. In Nepal it is used as food, feed for animals and fodder in a traditional as well as in improved form whereas, other many developed countries used maize for starch, glucose, corn oil as well as for bio-fuel as ethanol in world. Photosynthesis, energy transfer, transformation of sugars and starches, nutrient movement within the plant and transfer of genetic characteristics are the key plant functions play by P in plant. P also plays key role in structures of cell membranes, cell division, cell enlargement root formation and growth, improves fruit and vegetable quality, vital to seed formation, improves water use and helps hasten maturity (Roberts, 2010). Worldwide, more than 30 % of crop production is affected by lack of macronutrient in soil (Vance *et al.*, 2003). Although cultivation of maize is more in tropical and subtropical part country yield of maize is 2.6835 ton per ha which is very much low in comparisons to other developed countries (MOAD, 2015/16). More than 40% of total cultivated land of Nepal is low in phosphorus which is one of major factor for contributing to low maize production in Nepal. Thus application of P in soil could be solving measures to low productivity of maize. Site specific and soil specific fertilizer and varieties are yet not recommended in Nepal. It can be hypothesized that maize varieties differ in P application on soil for performance of yield attributing characteristics. This study will contribute to breeding to develop soil specific varieties for P efficient. The objective of this study is to assess early performance of maize varieties in P deficient soil.

MATERIALS AND METHOD

Description of the experimental sites and genetic materials. A pot experiment was conducted in farm of Lamjung campus, Sundarbazar Lamjung district (740masl), Nepal during February-March, 2018. The maize varieties was received from National Maize Research Program (NMRP), Rampur, Chitwan, Nepal. The experiment was conducted in pot filled up with soil that was taken from longitude of 84°11'-84°38'E, latitude of 28°3'-28°30'N. The soil type was ultisols and was acidic (pH 4.8) with medium in organic matter and nitrogen, very low in phosphorus and low in potassium.

Table1.

Varieties used in study and its characteristics

Varieties	Origin	Parentage	Plant height (cm)	Maturity days	Recommended domain	Varietal characteristics
Arun-4	Nepal	Formed using elite introduced germplasm and local landraces	143-247	113-115	Winter and spring in terai, summer in mid hills	Yellow seed, short plant height, internodes green not swollen
Rampur composite	Thailand	Thai Composite-1×Suwan-1	210-220	115-130	Terai, inner terai and lower hills	Orange yellow seed color, tight husk cover
Manakamana-3	CIMMYT (Mexico)	Population 22 C8	220-240	135-150	Mid hills	White seed color, tight husk cover, stay green character

Experimental design and treatments. Collected soil was subjected to air dried for 48 hours and filled in perforated plastic pots with 3 kg soil. Then soil was treated with nitrogen 45 kg ha^{-1} and potassium 45 kg ha^{-1}along with 250 gm well rotten FYM. For treatment application five level of P (0, 15, 30, 45 and 60) kg ha^{-1} in the form of single super phosphate (SSP) was treated in soil. The seeds of maize was obtained from agro vets. In each pot three seeds of maize (Arun-4, Rampur composite and Manakamana-3) varieties were sown at depth of 4 cm. these fifteen treatment were arranged in complete randomized design with three replications. Thinning was done ten days after sowing (DAS) to left one plant per pots. Water loss was replaced at two days interval and maintains field capacity in the pots.

Data collection and analysis. Plant height and number of leaves were counted at 45 DAS before plant was harvested. Root and shoot was separated and root was washed and weight was taken. This was followed by oven drying of root and shoot at 65 °C for 48 hours. Data were analyzed by using R- studio 1.1.423 and figures were made by MS Excel 2007.

RESULTS AND DISCUSSION

Root biomass. In terms of fresh root mass (Table 2) significantly different results was found with P application. Irrespective of maize varieties, maximum (20.054g) fresh root weight was obtained when P was applied as 60 kg ha^{-1}, statistically similar with fresh root mass obtained by 45 kg P ha^{-1}, whereas minimum(6.97 gm per plant) was recorded in 0 kg P ha^{-1}. This observation is in agreement with the findings of Kumari, (2017) who stated increase in root biomass with increase in P application. Kim and Li (2016) also reported increase in biomass of root with increase in phosphorus in lantana. P plays major role in cell enlargement, cell division and formation of new tissue thus increase root biomass. Increased

root weight due to P application could be due to the direct effect of P on root growth and development (Srivastava and Ahlawat, 1995). Increase in root mass may also be due to increase in lateral root or root branching regulated by P availability. The result was contradictory with Gaume et al.(2001). Shrestha et al, (2016) also reported increase in root biomass upto certain level of P and decrease thereafter. The mean value of fresh root mass showed, the interaction between P and varieties as well as varieties alone was insignificant.

Table 2.
Root biomass, plant height and number of leaves on maize varieties as affected by added P in soil.

Treatments	Root biomass (g)	Plant height (cm)	Number of leaves
P levels			
60kg/ha	20.054[a]	72.556[a]	9.00[a]
45kg/ha	17.762[a]	67.267[a]	8.889[ab]
30kg/ha	14.634[b]	60.244[b]	8.3334[bc]
15kg/ha	11.734[b]	44.977[c]	7.882[c]
0kg/ha	6.972[c]	33.533[d]	7.667[c]
Sem(±)	1.076	2.26	0.2049
L.S.D.	3.109	6.53	0.5917
F-test	**	**	**
Varieties			
Arun-4	15.61	57.12[a]	8.133
Rampur composite	13.97	58.12[a]	8.333
Manakamana-3	13.11	51.433[b]	8.600
Sem(±)	0.834	1.75	0.1587
L.S.D.	2.408	5.06	0.4584
F-test	*ns*	*	*ns*
CV%	22.69	12.168	7.776

Means in same column followed by similar lowercase are not significantly different by Duncan test.
**= significant at 0.01%, *=significant at 0.05% and ns= non significant

Plant height. We found that highly significant effect of Phosphorus on plant height (table 2). Irrespective of the maize varieties, plant was tallest (72.566cm) when P was applied at 60 kg ha^{-1} whereas significantly short (33.533cm) plant height was recorded in 0 kg P ha^{-1} levels. Umeri *et al.* (2016), Shrestha *et al.* (2016) and Ayub *et al.* (2002) also observed similar effect of P on plant height. Materecnera and Morutse (2009) also reported increment of P for dry land maize production in a soil with very low P level increase in maize plant height. Although P ranks second to nitrogen as limiting factor for growth in plant height among different nutrient, but the application of P fertilizer has found essential for improvement of vegetative elongation of maize (Withers *et al.*, 2001). Increase on plant height with increase in P may be probably due to increase in root development and nutrient uptake. Soil very low in P adsorb large amounts of P leaving very little for plant growth due to which addition of P will made higher availability of P to plants and might help in promotion of plant height.. However some consequence was accounted by Masood *et al.* (2011), who reported increase in plant height upto certain level of P application whereas further increase did not have increment in height. Rampur composite expressed tallest plant

height but it was statistically similar with Arun-4. Lower plant height was recorded in Manakamana-3 which was similar to Arun-4, but significantly differs with Rampur composite. Increase in plant height might be due to genotypic difference between varieties. Interaction effect between P and varieties was not found significant in terms of plant height.

Number of leaves. In terms of leaf number (table 2), significant effect was found with Phosphorus level. Regardless of varieties, the number of leaf count are found higher in 45 and 60 kg P ha^{-1} as compared to lower level of P and control. The plants treated with 15 and 30 kg P ha^{-1} did not differ significantly from control 0 kg P ha^{-1} in number of leaves. Highest (9) number of leaves was found in 60 kg P ha^{-1}. Amanullah *et al.* (2010), Arya and Singh (2001) also reported increase in leaf number with increase in P. Plenet et al. (2000) reported delay in 4^{th} to 9^{th} leaf appearance in P deficient soil. The importance of P in leaf development may be attributed due to P demand in cell division. Also the P plays major roles in new tissue formation. Neither the varieties nor the interaction between varieties and P showed non-significant effect on leaf counts.

Shoot dry matter. Effect of P was found highly significant on dry shoot weight of maize. The dry matter accumulation increases with increase in phosphorus application rates. Irrespective to varieties, shoot dry matter increased by more than 7 times in 60 kg P ha^{-1} in comparisons to control. The highest (7.908 g per plant) dry shoot was observed in 60 kg P ha^{-1} whereas, lowest(1.197 g per plant) dry plant mass was obtained when 0 kg P was applied. This increase in mass can be attributing to number of leaf, leaf size and plant height. The result is in confirmatory with those of Farroq *et al.* (2016), Kumari (2017) also reported increase in dry matter accumulation of shoot with increase in P levels. Pholsen and Suksri, (2007) reported that increase in dry matter yield upto P application of 75 kg ha^{-1} while further increase in P application i.e. 150 Kg P_2O_5 ha^{-1} there was decrease in dry matter yield of sorghum. Increased in dry matter with increase in P levels was due to increase uptake of minerals, nutrients, carbohydrate assimilation.Varieties were found not significant in terms of dry matter yield in shoot also the interaction between varieties and P level was not significant. However maximum shoot dry matter recorded Arun-4 with 60 kg ha^{-1} P application and minimum in makamana-3 in no application of P.

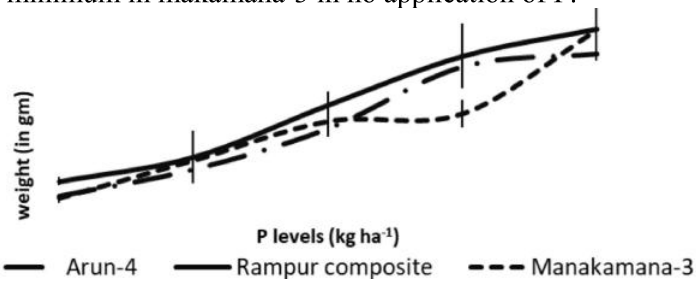

Figure 1. Dry shoot matter in maize varieties as affected by added Phosphorus

CONCLUSION

The present study concluded that application of P in soil significantly affects maize growth. At early growth stage, increase in P level in soil increase root biomass, number of leaves, shoot dry matter and plant height and highest is obtained at 60 kg P ha^{-1}. Rampur composite responded better than Manakamana-3 in plant height. However Arun-4 and Rampur composite are similar in all parameter taken. These conclusions are only the preliminary and further investigations with higher P application in various maize varieties at field condition upto later stage.

Acknowledgements. The authors would also like to thank National Maize Research Program Rampur (NMRP), Rampur,Chitwan for the provision of research materials and Institute of Agriculture and Animal Science (IAAS), Lamjung Campus, Lamjung, Nepal for technical and financial supports.

REFERENCES

1. Manullah, J., Zakirullah, M., Tariq, M., Nawab, K., Khan, A. Z. , Farhatullah, Shah, Z., Jan, A., Khalil, S. K. , Jan, M. T., Sajid, M. , Hussain, Z. , Rahman, H. (2010). Levels and time of Phosphorus application influence growth, dry matter partitioning and harvest index in maize. Pak. J. Bot., 42(6), 4051-4061.
2. Arya, K.C., Singh, S.N. (2001). Productivity of maize as influenced by different levels of phosphorus, zinc and irrigation. Indian J. of Agric. Sci., 71, 57-59.
3. Ayub, M., Nadeem, M.A. , Sharar, M.S., Mahmood, N. (2002). Response of maize (*Zea mays* L.) fodder to different levels of nitrogen and phosphorus. Asian J. Pl. Sci. 1, 352-354.
4. Farooq, M.U., Iqbal, A., Akhter, M.J. , Waqas, M.A., Masqsood, M., Usma, A. (2016). Impact of phosphorus levels and application methods on growth, quality and quality of biomass produced by forage maize. Int. J. Biol. BIOTECH, 13(2), 241-246.
5. Gaume, A., Machler, F., Carlos, D.L. , Narro, L., Frossard, E. (2001). Low-P tolerance by maize (*Zea mays* L.) genotypes: Significance of root growth, and organic acids and acid phosphatase root exudation. Plant and Soil, 228, 253–264.
6. Kim. H. J., li, X.(2016). Effects of Phosphorus on Shoot and Root Growth, Partitioning, and Phosphorus Utilization Efficiency in Lantana. Hort Science, 51(8), 1001-1009.
7. Kumari, S. (2017). Effect of Nitrogen and Phosphorus level on dry matter yield at different growth stages of popcorn in south saurashtra region of Gujarat, India. Int.J.Curr.Microbiol.App.Sci., 6(8), 547-553.
8. Masood, T., Gul, R. , Munsif, F., Jalal, F. , Hussain, Z., Noreen, N., Khan, H., Din, N. , Khan, H. (2011). Effect of different phosphorus levels on the yield and yield compojnents of maize. Sarhad J. Agric., 27(2), 167-170
9. Materechera, S.A., Morutse, H.M. (2009). Response of maize to Phosphorus from fertilizer and chicken manure in a semi-arid environment of south Africa. Exp. Agric pp. 261-273.
10. MOAD. (2015/16). Statistical information on Nepalese agriculture. From http://www.moad.gov.np/en/publication (Accessed 06/04/2018)
11. Plenet, D., Mollier, A., Pellerin, S. (2000). Growth analysis of maize field crops under phosphorus deficiency. Radiation use efficiency, biomass accumulation and yield components. Soil Science Journal, 165, 259–272.
12. Roberts, T. (2010). Importance of phosphorus in plant and human nutrition. http://www.ipni.net/html (Accessed 04/04/2018).
13. Shrestha, R.K., Amgain, L. P., Aryal, S. (2016). Assessing the effect of phosphorus application on early growth of maize at Sunderbazar, Lamjung, Nepal. Journal of Maize Research and Development, 2(1), 117-122.
14. Srivastava, T. K., Ahlawat, I.P.S. (1995). Response of Pea (*Pisum sativum*) to phosphorus,molybdenum and biofertilizers. Ind.J.Agron., 40, 630-635.
15. Umeri. C., Moseri, H., Onyemekonwu, R.C. (2016). Effects of Nitrogen and Phosphorus on the Growth Performance of Maize (*Zea mays* L.) in Selected Soils of Delta State, Nigeria. Adv Crop Sci Tech, 4, 207p.
16. Vance, C.P., Uhde-Stone, C. Allan, D. L. (2003). Phosphorus Acquisition and Use: Critical Adaptations by Plants for Securing a Nonrenewable Resource. New Phytologist, 157, 423-447.
17. Withers, P.J.A., Edwards, A.C., Foy, R.H.(2001). Phosphorus cycling in UK agriculture and implications for phosphorus loss from soil. Soil Use Manag, . 17, 139-149.