
Assessing the effect of phosphorus application on early growth of maize at Sunderbazar, Lamjung, Nepal

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ABSTRACT

Phosphorus (P) is an essential nutrient element for maize production. A pot experiment was conducted during May-June, 2015 to assess the effects of different rates of P on early growth of maize plant at Sunderbazar, Lamjung. Two maize varieties (Rato Makai and Poshilo Makai-1) were subjected to four P levels (0 kg ha⁻¹, 13 kg ha⁻¹, 18 kg ha⁻¹, and 23 kg ha⁻¹) in randomized complete block design with four replications. The effects of different P level on root elongation, root biomass, plant height, root shoot biomass ratio and total dry matter were investigated at 45 days after sowing. For all parameters, the maximum value was obtained when soil was added with 18 kg P ha⁻¹ & the minimum value under the control of 0 kg P ha⁻¹. Maize varieties differed significantly in terms of all the parameters under study, and Poshilo Makai-1 performed better than Rato Makai at all P levels. So, from this result, it can be concluded that Poshilo Makai-1 appeared to be P efficient over Rato Makai at early growth stage. However, it would be necessary to look at the response of crop up to maturity and at wider range of P to have the better insight of their relative performance.

Key words: Early vegetative growth, phosphorus fertilizer, maize, root shoot ratio

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INTRODUCTION

Maize (*Zea mays* L.) is one of the most important staple food crops after rice and contributes 23% of the total cereal production in Nepal (Regmi, 2011). It occupies nearly 1 million ha with an average productivity of 2.32 t ha⁻¹ (KC et al., 2015). Being a constituent of cell constituents, Phosphorus (P) plays an important role in several plant processes such as photosynthesis, respiration, energy storage and transfer, cell division, and cell enlargement etc. Maize requires P for the higher crop yield (Chen et al., 1994). Adequate level of P not only enhances the early root formation and growth (Hajabbasi and Schumacher, 1994) but also enhances crop quality, and is needed for seed formation (IPNI, 1999; Mohan et al., 2015). P deficiency is considered to be one of the most frequently occurring limitations in the productivity

of crops grown in tropical and subtropical ecological regions (Ramaekers et al., 2010) where P can strongly fixed to the soil through adsorption and precipitation thereby reducing its bioavailability to the plants (DoVale & Fritsche-Net, 2013). Being an important constituent of organic compounds in the plants, P deficiency reduces plant growth (Marschner, 1977). Low concentration of soil available P is one of the major constraints to sustain optimal crop production (Wang et al., 2011) and its availability is very important during the early growth stage (Alley, 2009). Absence of the P fertilizer application, especially in the intensive cultivation systems, result in low soil P content (Smaling et al., 1997). Since majority of the Nepalese soils are low in soil available P (Dawadi & Thapa, 2015), P could be limiting factor for the Maize production, especially in the hilly regions of Nepal. The yield of maize, thus, could be increased by the application of soil application of P fertilizer. Existing fertilizer recommendations - including P fertilizer- by government bodies consist of fixed rates without considering the site-specific soil and weather condition. Thus, it is hypothesized that addition of P in the soil would improves the yield attributing parameters of the maize, and its requirement varies with the maize varieties. The objective of this research was to assess the effect of different level of P fertilizer on the early growth of two maize varieties and to screen the P- efficient variety.

MATERIALS AND METHODS

A pot experiment was conducted under diffused light condition in the farm of Lamjung Campus, Sundarbazar, Lamjung (700 masl), Nepal during May-June, 2015. Average daily mean temperature and precipitation during that period were recorded as 17.32°C and 3.19 mm. The experiment included two factors- maize varieties and P levels. Soil was collected from maize field, Lamjung Campus; air dried for 48 hours and filled in poly-pots (5 L) at the rate of 3 kg pot⁻¹. Then soil was treated with nitrogen (N) (40 kg ha⁻¹), potassium (K) (17 kg ha⁻¹) and other nutrients including magnesium (Mg), copper (Cu), manganese (Mn), calcium (Ca), molybdenum (Mo), zinc (Zn), boron (B) and iron (Fe) (30, 2, 0.2, 71, 0.2, 1, 1 & 2 ppm respectively). For treatment application, soil was treated with four P levels (0 kg ha⁻¹, 13 kg ha⁻¹, 18 kg ha⁻¹, and 23 kg ha⁻¹) through sodium phosphate (NaH₂PO₄). In each pot, three pre-germinated seeds of maize varieties [Rato Makai (a local variety) and Poshilo Makai-1(an improved variety)] were sown at 5 cm depth. Those eight treatments were arranged in randomized complete block design with four replications. Seven days after sowing (DAS), only one seedling per pot was left. Water lost due to evapotranspiration was replaced at every alternative day and maintained at pot's maximum water holding capacity against gravity (field capacity). Before harvesting the plants at 45 DAS, plant height was measured. Root and shoot were separated, washed with water and root length was measured. This was followed by oven drying of roots and shoots at 60°C for 72 hours. Oven dried roots and shoots were then weighed. Data were subjected to the ANOVA using SPSS Windows Version 20 and treatment means were separated using Tukey's test to signify the treatments difference at 5% of probability.

RESULTS AND DISCUSSION

Effect on root length

The mean values of the root length, root dry matter and plant height for maize varieties and P levels are presented in Table 1. When added to the soil, P showed significant effect on root length in maize varieties under study. Irrespective of the maize varieties, length of root was

highest when they were grown at 18 kg P ha⁻¹ (Table 1). This might be due to the P stimulated utilization of assimilates in root system thereby enhancing root length. Root length at 23 kg P ha⁻¹ did not significantly differ than at 18 kg P ha⁻¹. Poshilo Makai-1 again expressed longer roots than the Rato Makai when no P was applied. The observed effect of P application on root elongation is consistent with the results of Hajabbasi and Schumacher (1994) and Rosoem et al. (1994), but disagrees the finding of Anuradha and Narayanan (1991).

Effect on root biomass

Initially, increase in level of P appeared to be positively correlated with root biomass. Maize varieties produced least biomass when no P was applied, and highest value was obtained at 18 kg P ha⁻¹. Application of P enhances root elongation and in turn increases root biomass. Amijee et al. (1989) stated that P inflow have direct effect in root weight which in turn increases density of root branching. These effects lead to increase P acquisition as well as other nutrients. This is the reason that plant grown under control of no P application accumulated least root biomass. The root weight, however, was found to be greater in Poshilo Makai-1 than that of Rato Makai.

Effect on plant height

Different level of applied P showed significant effect on plant height (Table 1). Plant height was least at 0 kg P ha⁻¹ and the highest value was recorded at 18 kg P ha⁻¹, followed by P at the rate of 23 kg ha⁻¹. This result reveals that P at the rate of 18 kg ha⁻¹ might be the optimum rate for the maize and could trigger plant growth. Amin et al. (1989) also observed similar effects of P on plant height in maize. P induced plant growth is strongly associated with the better root growth and nutrient uptake (Hussain et al., 2006). Babatola et al. (2002) also observed the positive effect of P on plant growth. Decreased plant height at 23 kg P ha⁻¹ may be due to the antagonistic effect of high soil P on uptake and assimilation of other elements that would have positive role on plant growth (Uguru, 1996). At control treatment, plant height was greater for Poshilo Makai-1 than that of Rato Makai, and could be related to the genetic effect. This result, however, is in contrary to the finding of Eltelib et al. (2006) who reported that plant height of the maize decreased at increasing P levels.

Table 1. Plant height, root length and root biomass of maize varieties as affected by added P in soil

P Level (kg ha ⁻¹)	Root length (cm)		Root biomass (g)		Plant height (cm)	
	Rato Makai	Poshilo Makai-1	Rato Makai	Poshilo Makai-1	Rato Makai	Poshilo Makai-1
0	13.12 ^d	19.17 ^c	0.165 ^c	0.20 ^c	57.20 ^b	62.42 ^b
13	20.55 ^c	29.32 ^b	0.34 ^b	0.40 ^b	58.00 ^b	65.60 ^b
18	50.82 ^a	62.02 ^a	0.47 ^a	0.53 ^a	73.72 ^a	78.85 ^a
23	44.37 ^b	57.57 ^a	0.42 ^{ab}	0.46 ^{ab}	66.7 ^{ab}	71.00 ^{ab}

Mean values followed by the same lowercase letter in the column are not significantly different by Tukey test ($\alpha=0.05$; n=4)

Effect on root shoot ratio

Different level of P showed significant effect on root shoot ratio (Fig 1). Addition of P was positively correlated with root shoot ratio up to a certain P level, and above that, negative effect on root shoot ratio was observed. While the lowest root shoot ratio (0.5) was observed at control of no P application, the highest value was at 18 kg P ha⁻¹ (1.6). When no P was applied, root shoot ratio was found to be higher for Poshilo Makai-1 (0.5) than that for Rato Makai (0.4). P induced higher root biomass relative to that of shoot biomass in the maize plant might be due to the roles of P on root growth at early vegetative stage. The opposite effect, however, can be expected at later stage of plant growth and at higher P application. Reduction of root shoot ratio is also associated with higher level of P in growing medium (Wilson & Haydock, 1971). On contrast, P- induced lower root shoot ratio have also been reported (Rychter & Randall, 1994; Ciereszko et al., 1996) and was associated with the partitioning of higher proportion of photosynthetes to the above ground plant part. According to Gregory and Richards (1929) plants grown at low soil P tend to produce a higher photosynthetic rate. This higher photosynthetic rate causes increased leaf biomass. Hence, root shoot ratio is lower.

Effect on dry matter

Soil application of P significantly increased the total biomass yield as compared to the control of no P application; but only up to a level. Maize plants accumulated the least dry matter (0.5g) when no P is applied, while this value reached to 0.8 g at 18 kg P ha⁻¹, and this value did not differ significantly when grown at 13 kg P ha⁻¹ (0.73g) & 23 kg P ha⁻¹ (0.75g). Irrespective of the P level, Poshilo Makai-1 produced higher biomass (0.74 g) than Rato Makai (0.68 g). This may be attributed to the role of P for the cell division at meristematic tissue and other physiological activities (Russel, 1973). Pellerin et al. (2000) have reported that the soil applied P induced dry matter yield is associated with improvement of root system, increased leaf area index and, in turn, its positive effect on photosynthesis and carbohydrate nutrition of plant. The higher P level (23 kg P ha⁻¹) did not result in increase in dry matter production. This may be due to the Fe accumulation in the roots under higher soil P level (Holmes, 1960).

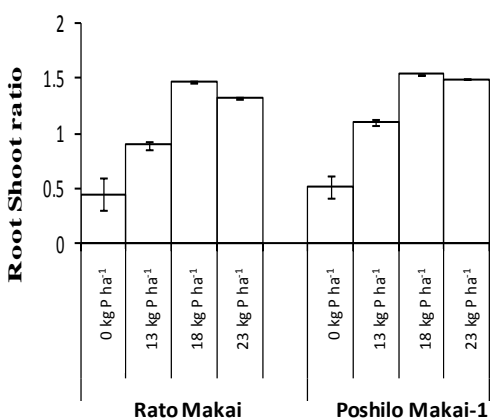


Figure 1. Effect of additional level of P in soil on root shoot ratio at 45 DAS in maize varieties.

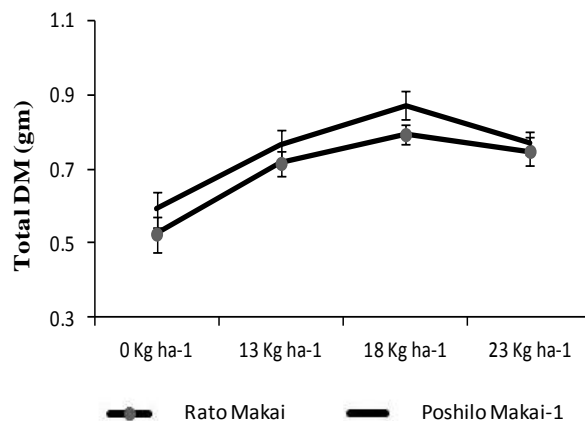


Figure 2. Effect of additional level of P in soil on total dry matter at 45 DAS in maize varieties.

CONCLUSION

The findings of this experiment have revealed that application of P to the soil significantly affects maize growth. At early growth stage, increasing concentration of P to certain level increases root length, root biomass, plant height and root shoot ratio and total dry matter, and 18 kg P ha⁻¹ appear to be optimum in context of Lamjung, Nepal. Plant showed relatively poor growth if P is not applied to the soil. Poshilo Makai-1 (improved variety) performs better over Rato Makai (local variety) even for same level of soil P including control of no P application. These conclusions can only be preliminary and further studies need to compare the P response of different genotypes at field condition as well as to the maturity level.

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