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GROWTH AND YIELD RESPONSE OF HYBRID MAIZE (*Zea mays* L.) TO PHOSPHORUS LEVELS IN SANDY LOAM SOIL OF CHITWAN VALLEY, NEPAL

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Abstract

To evaluate the phosphorus response on winter hybrid maize, a field experiment was conducted at farm land of National Maize Research Program, Rampur, Chitwan, Nepal on 2012 and 2013. Seven levels of Phosphorus i.e. 0, 20, 40, 60, 80, 100 and 120 kg P_2O_5 ha^{-1} were applied along with 160:40 kg N:K_2O ha^{-1}. The experiment was laid out in randomized complete block design with three replications. Hybrid maize RML 32 × RML 17 was used for this study. Analysis of variance showed that plant height (cm), dry matter accumulation (g), number of kernels per row, 1000 grain weight (g) and grain yield (ton ha^{-1}) were significantly affected with Phosphorus level. The results showed that the trend of increment was positive for grain yield with increased P level from 0 to 80 kg P_2O_5 ha^{-1}. The highest grain yield (10.77 ton ha^{-1}) was measured when 120 kg P_2O_5 ha^{-1} is applied. It is concluded that 80 kg P_2O_5 ha^{-1} can be applied in winter season for hybrid maize RML-32 × RML-17 in Chitwan valley low land irrigated condition. Further studies are necessary on different soil types, seasons, management system and varieties to get more information about the most proper addition of P on maize.

Key Words: Hybrid maize, phosphorus, Growth and yield traits.

Introduction

Maize (*Zea mays* L.) is the main stay of hill people and is the leading crop in the national economyin Nepal. The improved maize varieties need large amounts of nutrients, and their production potentiality could be exploited through the use of balanced and adequate nutrients. The nitrogen requirement of maize is very high as compared to other essential plant nutrients. Its demand of Phosphorus (P) is also high and it is sensitive to a low phosphate supply particularly at the early stages of growth. Inorganic phosphorus is one of the least available plant nutrients in soils, even though it is essential for plant growth and development (Vance et al., 2003).

Phosphorus is involved in photosynthesis, energy transfer, cell division and enlargement, root formation and growth, improves fruit and vegetable quality, vital to seed formation, improves water use and helps hasten maturity (Roberts, 2010). The central role of P in the energy transfer processes therefore hardly allows for a decrease in the rate of P application (Vadez et al., 1999) since low P availability will delay crop vigour and maturity (Havlin et al., 1999).For production to be sustainable it is important that P removed from the soil is balanced by a plant available form of P input. This is not always the case as there is often a net export of soil P from production systems, where P is either not supplied at rates and in forms to balance P removal by plant products or simply not applied (Oehl et al., 2002; Burkitt et al., 2007).Phosphorus is frequently found fixed with Al, Fe and Mn minerals in acidic condition and fixed with Ca in alkaline condition. In well-drained soils, phosphate ions normally do not move very far from their place of origin. Applying P in a band near the developing roots is most effective since phosphates generally move short distances from their point of placement. Phosphorus fixation is reduced when the extent of contact between the phosphate and the soil fixing particles is reduced (Lafond et al., 2003).In order to ensure sustainable and profitable agriculture that has a minimal impact on the environment (Richardson et al., 2009), the application of P-based fertilizers is routinely used to overcome soil deficiencies and to maintain the productivity of agricultural systems.The formation of insoluble compounds due to soil chemical reactions limits the plant available P making phosphate fertilization use efficiency very low by crops. This will not only increase efficiency and decrease the cost of production, but also reduce runoff of soil applied P, which is responsible for eutrophication of many of lakes and streams (Sharpley et al., 1994). Therefore, appropriate management of phosphate fertilizers is a major concern. It is important to use judiciously P fertilizer. In Nepal, very limited studies were done to study the effect of p level on hybrid maize. Therefore, a field experiment was conducted to evaluate the response of growth and productivity traits of hybrid maize by the addition of different phosphorus levels.

Materials and Methods

The experiment was conducted at the farm land of National Maize Research Program (NMRP), Rampur, Chitwan, Nepal NMRP is located in between 27°40'N latitude and

84°19'E longitude and an altitude of 228 m above mean sea level in the inner terrain (Siwalik Dun Valley). The experiment was carried out during winter season of 2012 and 2013. The experiment was laid out in randomized complete block design (RCBD) with three replications. Hybrid maize RML 32 × RML 17 was planted in 12 sq. m plot with the row to row spacing 60 cm and 25 cm plant to plant spacing. The sources of chemical fertilizer were Urea, single super phosphate (SSP) and muriate of potash (MOP). Soil sampling was done before sowing and analyzed for total N, available P, available K, Soil Organic matter and pH.

The soil type was Ustic Psamments (USDA classification) and was alluvial sandy loam in texture. The initial total N content was low (0.122%), available P was high (104 kg ha^{-1}), available K was medium (155 kg ha^{-1}), soil organic matter was low (2.4%) and very slightly acidic in pH (6.4). Farm yard manure (FYM), Potash(K) and half doses of N were applied during final land preparation and remaining doses of N was applied in two split at knee height and before tasseling as per treatment designed. Weeding was done one month after planting. Irrigation was given as need. The growth, yield and yield attributes were measured and analysis of variance (ANOVA) was carried out by using Genstat 13.2. The significance differences among the means were tested using least significance difference (LSD) at 5% significance level.

Results and Discussion

Plant height (cm) and dry matter accumulation (g):

Plant height was significantly affected by the different levels of P fertilizer. The highest value of plant height measured at 105 DAS (Days after sowing) (101.6 cm), with the addition of 120 kg P_2O_5 $ha^{-}1$. This trait was significantly different with the addition of P, but the plant height measured at 45, and 75 DAS, and at maturity did not influenced significantly by P levels (Table 1). The increase in plant height may due to the increment in proliferation of roots, which significantly increases the uptake of moisture and P (Aikins and Afukwa, 2010). The accumulation of dry matter per plant was significantly influenced by the levels of P (Table 2). The dry matter accumulation per plant that measured at 45 and 75 DAS were influenced by the addition of P, but dry matter at 105 DAS was not affected significantly by P levels. The maximum dry matter measured at 45 DAS (3.17g $plant^{-1}$) when P applied with 120 kg P_2O_5 ha^{-1}. Increased P level had a significant increased in dry matter per plant at 45 DAS. The highest dry matter per plant (22.6 g $plant^{-1}$) was recorded when 100 kg P_2O_5 ha^{-1} was applied. The results showed a significant effect of P levels on the days to 50% tasseling, which decreased with the increased of P levels. Same results were obtained for the trait days to 50% silking which decreased with the increased of P levels. Days to 50% silking at 0 kg P_2O_5 ha^{-1} treatment was 90 days, while with the application of 120 kg P_2O_5 ha^{-1} the days to silking was 85.

Table 1: Effect of phosphorus levels on plant height (cm) in hybrid maize during winter 2012 and 2013 during different growth stages

Treatment	45 DAS			75 DAS			105 DAS			maturity		
(kg P_2O_5 ha^{-1})	2012	2013	Mean	2012	2013	Mean	2012	2013	Mean	2012	2013	Mean
0	4.38	6.56	5.47	16.07	18.52	17.29	87.64	102.76	95.2	139	156	147.5
20	5.47	7.48	6.47	16	19.14	17.57	79.82	104.98	92.4	148	150	149
40	5.64	7.55	6.6	16.67	18.92	17.79	89.53	110.07	99.8	141	156	148.5
60	5.8	7.27	6.53	15.67	18.62	17.14	90.82	99.98	95.4	148	151	149.5
80	5.87	7.87	6.87	16.47	19.36	17.91	82.84	98.16	90.5	144	154	149
100	5.58	7.43	6.5	14.8	18.7	16.75	78.56	95.04	86.8	148	153	150.5
120	5.67	7.67	6.67	16.6	18.94	17.77	92.44	110.76	101.6	145	150	147.5
F-test	NS	NS		NS	NS		**	*		NS	NS	
$LSD_{0.05}$							5.7	9.3				
CV%	6.8	7.9		10.5	9.8		4.8	5.6		6.8	5.7	

*,** denote the level of significance at 0.05 and 0.01 %, respectively

Table 2: Effect of Phosphorus levels on dry matter (g/plant) and days to flowering in hybrid maize during winter 2012 and 2013 during different growth stages

Treatment	45 DAS			75 DAS			105 DAS			Days to tasseling			Days to silking		
(kg P_2O_5 ha^{-1})	2012	2013	Mean	2012	2013	Mean	2012	2013	Mean	2012	2013	Mean	2012	2013	Mean
0	1.3	2.3	1.8	15.4	18.1	16.8	62.8	77.6	70.2	86	82	84	92	88	90
20	1.4	2.0	1.7	15.8	13.3	14.6	69.6	83	76.3	86	84	85	90	88	89
40	1.3	2.4	1.9	16.9	14.8	15.9	71.4	85.6	78.5	84	83	83	87	87	87
60	1.4	2.5	2	16.5	17.4	17	73.2	74	73.6	83	81	82	86	86	86
80	1.8	3.2	2.5	19.8	22.9	21.4	72.2	86.3	79.2	82	83	83	86	87	87
100	2.1	3.2	2.7	20.6	24.5	22.6	78.6	79.6	79.1	82	83	83	86	87	87
120	2.5	3.7	3.1	19.3	19.0	19.2	86.4	94.3	90.3	80	81	81	84	86	85
F-test	*	**		*	*		*	NS		*	*		*	*	
$LSD_{0.05}$	1.0	1.2		4.8	5.2		9.8			3.6	4.2		4.3	4.6	
CV%	6.8	5.9		12.8	13.9		12.8	9.3		1.4	1.2		1.6	1.4	

*,** denote the level of significance at 0.05 and 0.01 %, respectively

Yield attributes

Ear length and number of kernels rows per ear were not significantly differed with P doses (Table 3). Number of kernels per row was significantly affected by P doses. Increased P doses had increased no. of kernels per row. Highest no. of kernels per row (30.8) was recorded with 60 kg P_2O_5 ha^{-1} and the lowest no. of kernels per row was obtained in 0 kg P_2O_5 ha^{-1} treatment. Highest 1000 grain wt was affected by P doses. Increased P doses had increased 1000 grain wt. from 0 to 80 kg P_2O_5 ha^{-1}. Highest 1000 grain wt. of 375 g was recorded when 80 kg P_2O_5 ha^{-1} applied and lowest 1000 grain wt. of 342g was recorded in 0 kg P_2O_5 ha^{-1} applied treatment.

Table 3: Effect of Phosphorus levels on yield attributes and grain yield in hybrid maize during winter 2012 and 2013

Treatment (kg P_2O_5 ha^{-1})	1000 grain wt (g)			Kernels rows per ear			Kernels per row			Stover yield (ton ha^{-1})			Grain yield (ton ha^{-1})		
	2012	2013	Mean	2012	2013	Mean	2012	2013	Mean	2012	2013	Mean	2012	2013	Mean
0	326	358	342	11.2	11.6	11.4	24.4	30	27.2	5.9	9.86	7.92	5.92	6.48	6.2
20	344	358	351	11.6	10.4	11	26.6	30	28.3	6.8	9.85	8.34	6.89	8.55	7.72
40	337	363	350	11.2	10.8	11	25.5	33.1	29.3	8.1	*8.95*	8.57	8.34	8.86	8.6
60	356	388	372	11.5	11.5	11.5	28.8	32.8	30.8	7.8	8.12	7.99	8.9	10.24	9.57
80	349	401	375	11.6	10	10.8	28.2	28.2	28.2	8.5	8.38	8.46	9.88	10.84	10.36
100	367	375	371	10.8	11	10.9	29.4	31.8	30.6	7.8	10	8.91	10.24	8.26	9.25
120	359	375	367	10.8	10.8	10.8	28.8	31.4	30.1	8.2	9.22	8.72	9.96	11.58	10.77
F-test	*	*		NS	NS		*	*		NS	NS		**	**	
$LSD_{0.05}$	26.9	28.6					2.8	2.1					1.96	1.77	
CV%	6.8	5.1		3.6	2.9		5.8	4.5		21.6	16.5		12.9	11.2	

*,** denote the level of significance at 0.05 and 0.01 %, respectively

Grain and stover yield

Phosphorus doses had significant influenced on the grain yield of maize but did not influence on the stover yield (Table 3). There was increasing trend on grain yield with increased P level from 0 to 80 kg P_2O_5 ha^{-1} (Fig. 1a).The highest grain yield of 10.77 ton ha^{-1} was measured when 120 kg P_2O_5 ha^{-1} applied which was at par with 80 kg P_2O_5 ha^{-1} applied treatment. At 100 kg P_2O_5 ha^{-1} doses, the grain yield slightly decreased than the grain yield of 80 kg P_2O_5 ha^{-1} and again at 120 kg P_2O_5 ha^{-1} slightly increased. This trend indicates that for Rampur low land irrigated condition up to 80 kg P_2O_5 ha^{-1} can go for hybrid maize variety RML- 32 × RML -17.

P content in plant and soil

Plant, leaf and grain as well as soil available P content showed variation in P content in leaf, total plant, grain and in soil. Increased P doses increased leaf and grain P content but not much varied with total P concentration in Plant (Table 4). There was strong correlation between soil available P and grain yield (Fig 2b).Increasing soil available phosphorus grain yield was also increased. Furthermore, increased P fertilizer doses had increased soil available P.

Table 4: Mean soil and plant nutrient content after harvesting maize and before conducting experiment

Treatments (kg P_2O_5 ha^{-1})	Soil				Plant			
	pH	Organic matter %	Total Nitrogen%	Available Phosphorus (kg ha^{-1})	Leaf P content (P%)	Plant P content (P%)	Grain P content (P%)	Plant P uptake (kg P ha^{-1})
0	6.5	2.5	0.127	90	0.38	0.24	0.38	37.05
20	6.5	2.5	0.13	122	0.34	0.15	0.32	34.15
40	6.4	2.7	0.135	134	0.45	0.12	0.22	23.04
60	6.5	2.6	0.133	136	0.73	0.19	0.46	49.27
80	6.5	2.5	0.127	163	0.43	0.12	0.42	46.46
100	6.5	2.5	0.132	174	0.62	0.18	0.37	45.97
120	6.4	2.4	0.12	184	0.4	0.23	0.31	48.64
Composite sample	6.4	2.4	0.122	104				

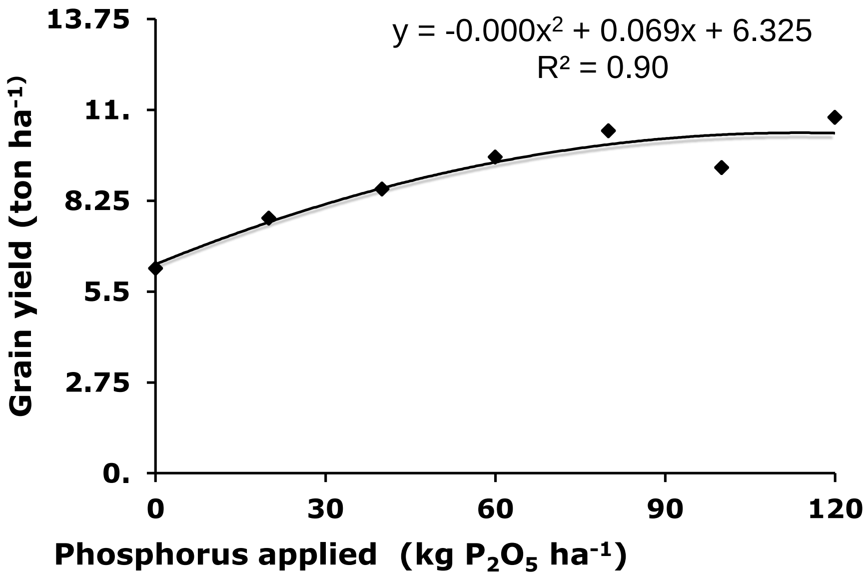

Fig. 1 (a)

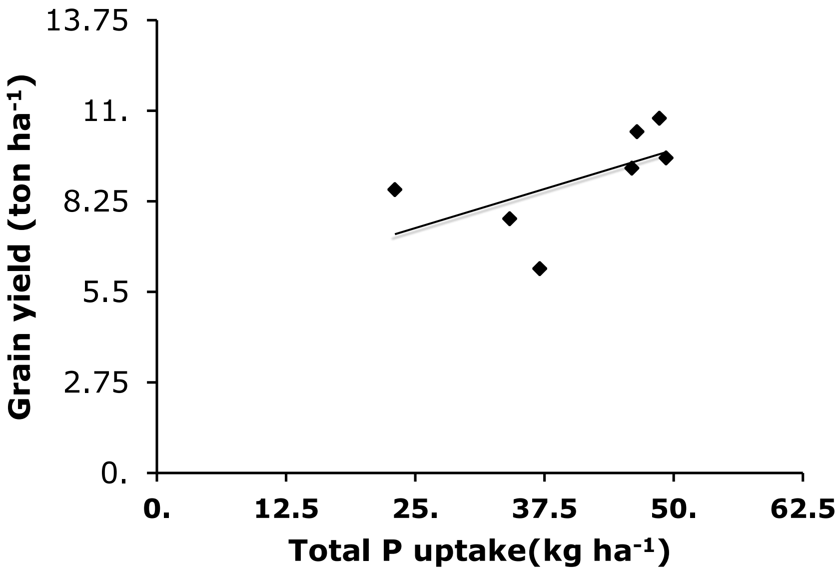

Fig. 1 (b)

Figure 1: (a) Relationship of grain yield with applied P and fig. 1 (b) relationship with P uptake and grain yield

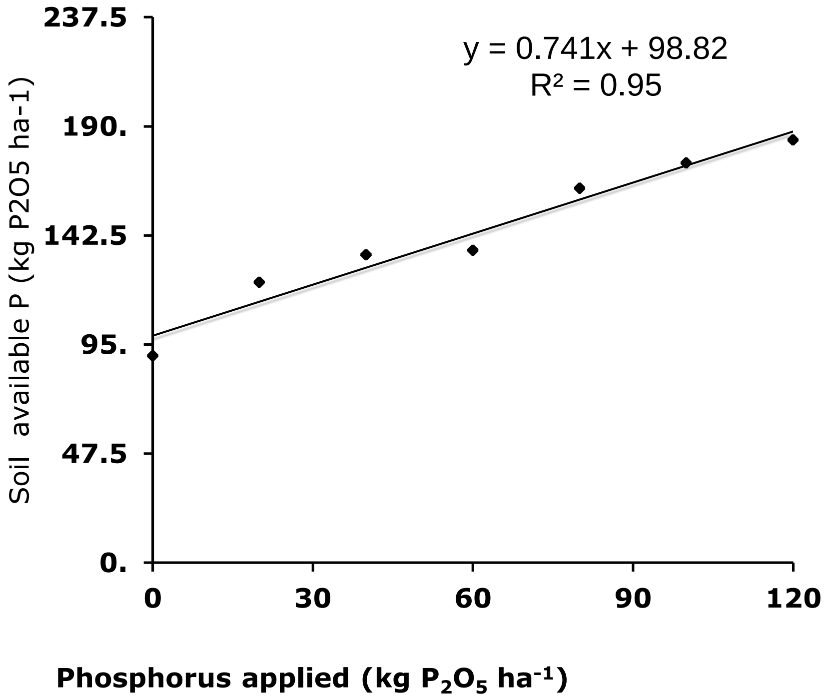

Fig. 2 (a)

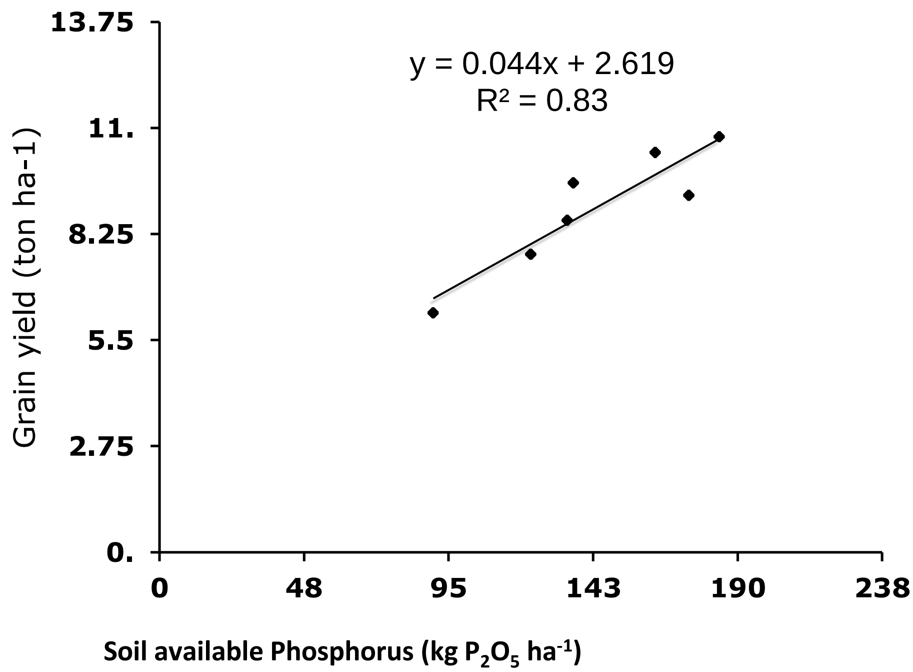

Fig. 2 (b)

Figure 2: (a) Relationship of soil available P and applied P and fig. 2.(b) relationship with soil available P and grain yield

Conclusion

From this study, it can be concluded that 80 kg P_2O_5 ha^{-1} can be applied for winter season growing hybrid maize variety RML-32 × RML-17 in Chitwan valley low land irrigated condition in Nepal. Further studies are necessary on different soil types, seasons, management system and varieties to get further information on P response.

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