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Productivity, nutrient acquisition and economics of summer maize (*Zea mays*) under various levels of phosphorus and potash in valley land of Manipur

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Maize (*Zea mays* L.) is the second important food crop of North-Eastern Hill (NEH) region next only to rice. Being a photo-insensitive crop, it can be grown round the year. It occupies an important place in NEH region economy. Besides being a potential source of food for human beings, it is used for feeding poultry, cattle, industries for the production of starch, syrup and alcohol etc. In Manipur, maize is cultivated on an area of 5.0 thousands hectares with a production and productivity of 11.9 thousand tonnes and 2.4 t/ha, respectively,which are about 25-30% less than the national average. There are so many reasons of low productivity of maize in the region but cultivation of traditional varieties with imbalance fertilization is a paramount importance (Babu *et al*. 2016). Apart from that, low nutrient availability in the region also an important case of low productivity. Hybrid maize has high yield potential among the all food grain crops. However, its nutrientsrequirement is too high as compared to traditional genotypes and high yielding varieties (Arunkumar *et al*. 2007).

Phosphorus deficiency is responsible for poor root growth and produce small nubbies ears in maize, while K plays a pivotal role in growth, development, transport of assimilates and also regulate ion of photosynthates in plant system (Demkin and Ageev 1990). Hence, it was hypothesized that cultivation of hybrid maize along with the suitable combination of P and K may enhance the maize productivity in the region.

Therefore, the present study was undertaken to assess the effect of phosphorus and potash on productivity of hybrid maize during summer season of 2014 at Agronomy research farm, CAU, Imphal (Manipur).

The soil of experimental site was acidic in reaction with pH (5.0), clayey in texture, high in organic carbon (0.9%) and medium in available N (285.4 kg/ha), P (18.8 kg/ha) and K (221.0 kg/ha). The experiment consists of four levels of P (P_1= 0, P_2= 40, P_3= 60 and P_4 = 80 kg P_2O_5/ha) and three levels of potash (K_1=0, K_2= 30 and K_3=60 kg K_2O/ha). The experiment was laid down in three time replicated factorial RBD. Half dose of RDN (recommended dose of nitrogen, i.e. 120 kg/ha) plus full dose of various levels of P and K was applied as basal while remaining half RDN 60 kg/ha was given into two equal splits at knee height and tasselling stages. The hybrid maize P 3396 was sown with a spacing 60 cm × 25 cm on 10 February 2014. All the recommended packages and practices of the region were adopted to grow the crop. Maize crop was harvested on 15 June 2014. Data related to productivity, nutrient uptake and economics were analyzed by using standard method and formulas.

Data related to yield attributes and yield are presented in Table 1. In general application of phosphorus and potash exerted beneficial effect on different yield contributing parameters (cob length, cob girth, cobs/plant, grains/cob) and yield. Among the various P levels, the highest cob length (16.0 cm), cob girth (14.4 cm), cobs/plant (1.4), grains/cob (315.6) and grain yield (4.3 t/ha) were observed with application of 80 kg P_2O_5/ha but it remained statically at par with 60 kg P_2O_5/ha. However, it was significantly superior over the other P levels. Similarly, among the different K levels, the highest cob length (17.2 cm), cob girth (14.8 cm), cobs/plant (1.5), grains/cob (355.8) and grain yield (4.8 t/ha) were recorded with 60 K_2O/ha. With regards to interaction effect of P and K, highest cob length (17.7 cm), cob girth (15.1 cm), cobs/plant (1.5), grains/cob (381.9) and grain yield (5.5 t/ha) were recorded with combined application of 80 kg P_2O_5/ha and 60 kg K_2O/ha. However, it was statically at par with the combined application of 60 kg P_2O_5/ha and 30 kg K_2O/ha but significantly superior to other treatment combinations. This might be due to balance supply of P and K, which enhance the plant growth and yield. These results are corroborated with findings of Nanthakumar *et al.* (2014).

Similarly, P and K acquisition was significantly influenced by different levels of P and K (Table 1).Among the various levels of P and K, application of 80 kg P_2O_5/

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Table 1 Effect of phosphorus and potash on productivity and nutrient acquisition of hybrid maize

Treatment	Yield attributes				Grain yield (t/ha)	Nutrients uptake (kg/ha)	
	Cob length (cm)	Cob girth (cm)	Cobs/ plant	Grains/ cob		P	K
Phosphorus (P_2O_5 kg/ha)							
P1 = 0	14.80	13.70	1.27	271.83	3.10	13.24	64.05
P2 = 40	15.35	13.80	1.31	286.66	3.50	14.00	66.05
P3= 60	15.50	14.02	1.36	299.22	3.80	15.16	74.90
P4 = 80	16.07	14.35	1.41	315.64	4.20	16.04	76.06
SEd ±	0.31	0.15	0.02	6.09	1.30	0.34	3.76
CD (P=0.05)	0.65	0.32	0.04	12.63	2.71	0.71	7.80
Potash (K_2O kg/ha)							
K1 = 0	13.84	13.02	1.15	230.51	2.56	11.46	61.5
K2 = 30	15.26	14.05	1.37	293.66	3.70	14.10	70.04
K3 = 60	17.20	14.83	1.49	355.83	4.80	18.28	79.69
SEd ±	0.27	0.13	0.02	5.27	1.13	0.29	3.26
CD (P=0.05)	0.56	0.27	0.04	10.94	2.34	0.61	6.75

ha resulted in maximum P uptake (16.0 kg/ha), which was significantly higher over the other. The addition of potash remarkably enhanced the K uptake by maize. Significantly higher potassium uptake (79.69 kg/ha) was observed with 60 kg K_2O/ha followed by 30 and 0 kg K_2O/ha. The interaction of P and K on uptake of both phosphorus and potassium was significant and the combined application of P and K resulted in maximum P and K uptake by crop. Among the various P and K levels the highest phosphorus (20.3 kg/ha) and potassium (97.6 kg/ha) uptake was recorded with the combined application of 80 kg P_2O_5/ha and 60 kg K_2O/ha. This might be due to high amount of dry matter production and nutrients accumulation in different parts of plant with sound development of root system. These results confirm the findings of Jing *et al.* (2014) and Mahala *et al.* (2006).The economics of hybrid maize under various levels of P and K was also worked out (Table 2). Critical appraisal of data showed that the highest cost of cultivation, gross return, net return and B: C ratio were with treatment received 80 kg P_2O_5/ha plus 60 kg K_2O/ha. This was due to the fact that this treatment had corresponding produce higher economic yield higher input involvement which resulted in higher returns and B: C ratio. These results are in close conformity with the findings of Wakeel *et al.* (2002), Jiagui *et al.* (2004) and Singh *et al.* (2013).

Table 2 Effect of phosphorus and potash on economics of hybrid maize

Treatment	Cost of cultivation (₹ × 10^3/ha)	Gross income (₹ × 10^3/ha)	Net return (₹ × 10^3/ ha)	B:C ratio
P1K1	23.3	22.5	-0.68	-0.03
P1K2	25.0	36.9	11.9	0.48
P1K3	25.8	41.8	15.9	0.62
P2K1	27.0	45.0	18.0	0.66
P2K2	28.8	48.6	19.8	0.67
P2K3	29.7	53.8	24.1	0.81
P3K1	29.0	49.7	20.7	0.72
P3K2	30.7	56.7	26.0	0.85
P3K3	31.6	61.5	29.9	0.95
P4K1	30.9	59.8	28.9	0.94
P4K2	32.6	71.5	38.9	1.19
P4K3	33.5	77.4	43.8	1.3

P1 = 0 kg ha^{-1}, P2 = 40 kg ha^{-1}, P3 = 60 kg ha^{-1}, P4 = 80 kg ha^{-1}, K1 = 0 kg ha^{-1}, K2 = 30 kg ha^{-1} and K3 = 60 kg ha^{-1}

SUMMARY

The productivity, nutrient acquisition and economics of hybrid maize (*Zea mays* L.) was influenced by various doses of P and K. Among the P levels, application of 80 kg P_2O_5/ha recorded the highest values of yield attributes, grain yield, nutrient uptake and net returns. It was superior to other P levels. Similarly, the higher value of yield attributing parameters and yield of maize was obtained with 60 kg K_2O/ha. Significantly highest interaction effect of 80 kg P_2O_5/ha plus 60 kg K_2O/ha was recorded as compared to remaining treatment combinations. The study suggested that the combined application of P_2O_5 and K_2O @ (80 + 60 kg/ ha) is optimum for producing the optimum yield of hybrid maize in Manipur. Hence, it may be recommended to the farmer of the region for harvesting maximum economic returns.

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