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Performance of hybrid maize (*Zea mays* L.) under varying phosphorus and potassium Levels

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Abstract
A field experiment was conducted at Udaipur during *kharif* 2015, with objective to work out optimum phosphorus and potassium levels for maize hybrid. The treatment consisted combinations of four phosphorus levels (30, 45, 60 and 75 kg K_2O_5 ha^{-1}) and four potassium levels (30, 40, 50 and 60 kg K_2O ha^{-1}). The results revealed that application of 60 kg P_2O_5 ha^{-1} significantly enhanced growth and yield attributing parameters. Consequently grain, stover, biological yields, nutrient uptake, protein content of grain and Stover and available P status of soil were significantly higher under 60 kg P_2O_5 ha^{-1} over 45 and 30 kg P_2O_5 ha^{-1}. With highest net returns (`38593 ha^{-1}) and B C ratio (1.75), 60 kg P_2O_5 ha^{-1} proved economically profitable compared to rest of the levels. Application of increasing levels of P_2O_5 significantly decreased soil N status. Likewise application of 40 kg K_2O ha^{-1} significantly improved growth, yield attributes, yield, protein content of grain and stover, profitability and soil K status over 30 kg K_2O ha^{-1}. Further increase in K_2O levels failed to record statistical significance.

Keywords: Maize hybrid, P_2O_5, K_2O and Economics

Introduction

Maize (*Zea may* L.) is one of the most important crop and widely cultivated throughout the country. It is an important for its versatility of adoption under wide range of agro-climatic conditions. Currently maize is cultivated over 9.23 m ha area with 23.67 m t production with average yield of 25.64 q ha^{-1} (Govt. of India, 2015). The maize production has shown a remarkable increase which is mainly associated with significant genetic enhancement from the area of open pollinated composite breeding to double and three way hybrids and recent development in single cross hybrids. These hybrids are nutrient exhaustive and require very high dose of the nutrients (Singh, 2010) [8]. Amongst nutrients, next to nitrogen, phosphorus is of paramount importance in plant system. P stimulates early root
development and essential for energy transfer in living cells by mean of high energy phosphate bonds of ATP which are unstable in water and act as carrier for vital reactions like oxidation of sugars through enhancing enzymatic activities and in initial reaction of photosynthesis and respiration of plants Halvin *et al.* (2005) [4]. Alike this potassium is another important primary nutrient as it activates many enzyme in plant systems, maintains turgor, reduces water loss, aids in photosynthesis and food formation, enhances translocation of sugars and starch, produces grain rich in starch and protect crop against biotic and abiotic stresses (Pettigrew, 2008) [6].

The phosphorus and potassium recommendation for maize developed by researchers is based on crop responses over large areas. These recommendations are periodically revised, although the periodicity may be as long as 5 to 10 years. This often results in over or under fertilization leading to yield and economic losses. Thus considering these facts and paucity of research findings on these aspects in south-east Rajasthan, the present study was carried out with objectives to ascertain economically viable recommendation of phosphorus and potassium for hybrid maize.

The field experiment was carried out during *kharif* 2015 at the Instructional Farm, Rajasthan College of Agriculture, Udaipur, which is situated at 23°34'N latitude and 73°42'E longitude at an altitude of 582.17 meter above the mean sea level. The soil of the experiment site was clay loam having pH 7.5, organic carbon 0.66, available nitrogen 271.4 kg/ha, phosphorus 19.5 kg/ha and potassium 365.5 kg/ha in the plough layer. The well distributed rainfall of 542.0 mm was recorded during crop growth period.

The treatment consisted combinations of four phosphorus levels (30, 45, 60 and 75 kg K_2O/ha) and four potassium levels (30, 40, 50 and 60 kg K_2O/ha). These sixteen treatment combinations were evaluated under factorial randomized block design with three replications. Maize hybrid "Pratap Hybrid Makka-3" released by MPUAT, Udaipur was used as test variety. The crop were sown manually on 7th July, 2015 by placing two seeds at a depth of 5-6 cm maintaining rows and plants spacing at 60 x 25 cm, respectively. The experimental plot size was 15 m^2. Thinning was carried out at 15 days after sowing to maintain required plant population. Phosphorus and potassium were applied as basal, through DAP and MOP as per treatments, whereas recommended nitrogen (90 kg/ha) was applied in 3 equal splits viz., 1/3 as basal, 1/3 at knee high stage and remaining 1/3 at initiation of tassel stage. In order to minimize weed competition, pre-emergence application of atrazine at 0.5 kg/ha followed by one hoeing and earthing up at 20 days after sowing was carried out. Net returns and BC ratio were calculated on basis of prevailing market prices. LAI, chlorophyll, protein content, nutrient uptake, crop growth rate (CGR) and relative growth rate (RGR) were worked out by using standard methods for analysis and formula.

Enriching P_2O_5 level from 30 to 60 kg P_2O_5 ha^{-1} significantly increased plant height at harvest, dry matter at harvest, LAI at 60 days after sowing compared to 45 and 30 kg P_2O_5 ha^{-1}. Days to 50 per cent silking was not significantly influenced by phosphorus levels. Between 30 to 60 days after sowing and 60 days after sowing to harvest, the CGR and RGR were significantly higher under application of 60 kg P_2O_5 ha^{-1} compared to 45 and 30 kg P_2O_5 ha^{-1}. Application of 60 kg P_2O_5 ha^{-1} improved yield attributing components consequently grain, stover, biological yields and N, P and K uptake. Significant improvement in growth, yield attributes and yield appears to be on account of enrichment of soil with P along with N to the level of sufficiency through synergistic interactions between these nutrients. These improvements might have contributed to higher root growth and its proliferation which help in better uptake of required nutrient from soil. The improvement in the nutrient status of plant (P and N) resulted in better availability of nutrient for growth and development of the plant right from early stage which promoted improvement in these parameters (Paramasivan *et al.* (2011) [5] and Sepat and Rai, (2013) [7].

Likewise the plant height, dry matter accumulation and LAI increased significantly by applying 40 kg K_2O ha^{-1} over 30 kg K_2O ha^{-1}. Days to 50 per cent silking failed to record significant variation under increasing K_2O levels. Increasing K_2O level from 30 to 40 kg K_2O ha^{-1} significantly increased CGR between 30 to 60 days after sowing. The K_2O levels had no significant bearing on RGR between 60 days after sowing to harvest. Application of 40 kg K_2O ha^{-1} improved the yield attributing characters *viz.*, grains/cob, test weight, shelling percentage and length of cob consequently grain, stover, biological yields, N, P, and K up takeand protein content of grain and stover over preceding K_2O level and proved economically profitable. In plant system potassium act primarily as catalytic in nature. The enzyme activation is regarded as potassium's single most important function and these enzymes are involved in so many plant physiological process. Further potassium provide much of the osmotic "Pull" that draws water in plant roots thus make full use of water and withstand water stress and plays an important role in photosynthesis. Potassium plays special role in activating various metabolites like chlorophyll, enzymes, harmones and these metabolites influence various other secondary physiological process which in turn affect growth and productivity of plant and also protect them against biotic and abiotic stresses (Das, 2012) [1].

Table 1: Effect of phosphorus level and potassium level on growth, yield attributes, yield and economics

Treatments	Plant height at harvest (cm)	Days to 50% silking	DM at 60 DAS (g/plant)	LAI at 60 DAS	CGR 30-60 DAS	RGR 30-60 DAS	Grains /cob	Length of cob (cm)	Test weight (cm)	Shelling per cent	Yield (q/ha)		Net returns (₹/ha)	B:C ratio
											Grain	Stover		
P_2O_5 kg/ha														
30	192.6	52.5	68.2	2.56	14.15	0.091	261	15.13	160.9	75.8	29.72	45.62	24753	1.19
45	206.4	52.5	83.4	2.89	17.01	0.100	376	17.03	200.8	77.5	34.60	53.24	31593	1.48
60	216.8	52.0	95.7	3.08	19.29	0.105	397	18.68	210.5	79.5	39.59	60.97	38593	1.75
75	217.6	52.0	96.6	3.08	19.50	0.105	398	18.91	210.6	79.0	39.87	61.69	38408	1.69
SEm±	1.08	0.20	0.50	0.02	0.11	0.003	2.28	0.11	1.77	0.40	0.31	0.48	472	0.02
CD (P = 0.05)	3.12	NS	1.46	0.05	0.32	0.008	6.60	0.32	5.10	1.15	0.89	1.40	1364	0.06
K_2O kg/ha														
30	198.6	52.3	75.5	2.63	15.56	0.100	328	16.48	178.1	75.4	31.74	48.81	27020	1.25
40	210.3	52.1	88.6	2.99	17.95	0.100	368	17.75	200.8	78.8	36.89	56.81	34827	1.64
50	212.1	52.3	90.0	2.99	18.25	0.100	368	17.76	201.5	78.7	37.59	57.90	35812	1.63
60	212.3	52.3	89.8	3.00	18.20	0.101	368	17.76	202.4	78.8	37.55	58.01	35687	1.60
SEm±	1.08	0.20	0.50	0.02	0.11	0.003	2.28	0.11	1.77	0.40	0.31	0.48	472	0.02
CD (P = 0.05)	3.12	NS	1.46	0.05	0.32	NS	6.60	0.32	5.10	1.15	0.89	1.40	1364	0.06

Table 2: Effect of P_2O_5 levels on protein content, nutrient uptake and available N, P, K status of soil at harvest.

Treatments	Protein content (%)		Nutrient uptake (kg/ha)			Soil nutrient status at harvest (kg/ha)		
	Grain	Stover	N	P	K	N	P	K
P_2O_5 kg/ha								
30	9.8	4.0	75.66	16.78	68.07	280.3	17.2	303.6
45	10.2	4.2	92.26	20.45	79.71	273.4	17.6	302.1
60	10.6	4.3	109.00	24.14	90.83	270.2	18.3	302.0
75	10.7	4.3	110.12	24.36	91.92	270.2	19.7	302.1
SEm ±	0.03	0.01	0.84	0.21	0.73	0.47	0.08	0.74
CD (P=0.05%)	0.07	0.02	2.44	0.61	2.10	1.35	0.22	NS
K_2O kg/ha								
30	10.3	4.2	85.51	18.93	68.57	273.5	18.2	293.3
40	10.3	4.2	99.15	22.02	86.02	273.5	18.2	297.5
50	10.3	4.2	101.08	22.39	88.04	273.5	18.1	304.7
60	10.3	4.2	101.30	22.39	87.89	273.5	18.2	314.4
SEm ±	0.03	0.01	0.84	0.21	0.73	0.47	0.08	0.74
CD (P=0.05%)	NS	NS	2.44	0.61	2.10	NS	NS	2.13

After harvest of crop, N retained in soil under application of 30 kg P_2O_5 ha^{-1} was significantly higher compared to 45, 60 and 75 kg P_2O_5 ha^{-1}. Contrary increase in P_2O_5 level from 30 to 75 kg P_2O_5 ha^{-1} and K_2O levels from 30 to 60 kg K_2O ha^{-1} significantly improved P and K status of soil, respectively. The decrease in available nitrogen status of soil under application of higher level of phosphorus could be ascribed that higher availability of P seems to have promoted root growth and its proliferation resulting in higher mining of available nitrogen right from early stage to harvesting of crop. Whereas added phosphorus and potassium are used for maintaining their critical concentration, which could be used for growth of developing plant and capable of sustaining higher yields on one hand and assured restoration of soil fertility on other (Gill *et al.*, 2008) [2].

It is therefore concluded that under prevailing agro climatic conditions maize hybrid fertilized with 60 kg P_2O_5/ha and 40 kg K_2O/ha proved most efficient and economically profitable.

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