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Effect of Nitrogen, Phosphorus and Potassium on Yield, Quality, Nutrient Content and Uptake on Hybrid Maize (*Zea mays* L.)

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ABSTRACT

Background: Maize (*Zea mays* L.) is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions. Nitrogen though an expensive input is very important as it is intimately involved in the process of photosynthesis and directly reflected in the total dry matter production. Phosphorus is involved in a wide range of plant processes from permitting cell division to the development of a good root system and for ensuring timely and uniform ripening of the crop. Potassium plays a vital role as macronutrient in plant growth and sustainable crop production. The current study aimed to study the effect of nitrogen, phosphorus and potassium on yield, quality, nutrient content and uptake on hybrid maize (*Zea mays* L.) under south Gujarat condition.

Methods: A field experiment was conducted during *rabi* season of the year 2019-20 to study the effect of different levels of nitrogen, phosphorus and potassium on yield, quality, nutrient content and uptake by hybrid maize (*Zea mays* L.). In this experiment twelve treatment combinations consisting of three levels of nitrogen fertilizer, two levels of phosphorus fertilizer and two levels of potassium fertilizer were tried in factorial randomized block design with three replications. The protein content and nitrogen, phosphorus, potassium content and their uptake by seed and stover and available nitrogen, phosphorus, potassium status in the soil after harvest of the crop were determined by different methods.

Result: The result showed that quality parameter *viz*., crude protein content, crude protein yield, nutrient content and uptake by grain and straw of hybrid maize were increased with the increased in nitrogen (180 kg N ha^{-1}), phosphorus (60 kg P_2O_5 ha^{-1}) and potassium (30 kg K_2O ha^{-1}) level.

Key words: Crude protein, Maize, Nitrogen, Nutrient content and uptake, Phosphorus, Potassium, Quality, Yield.

INTRODUCTION

Maize (*Zea mays* L.) is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions. Globally, maize is known as “queen of cereals” because it has the highest genetic yield potential among the cereals (Tollenaar and Lee, 2006). Currently, nearly 1147.7 million MT of maize is being produced together by over 170 countries from an area of 193.7 million ha with average productivity of 5.75 t ha^{-1} (Anonymous, 2020a). The USA has the highest productivity (>9.6 t ha^{-1}) which is double than the global average (4.92 t ha^{-1}). Whereas, the average productivity in India is 2.43 t ha^{-1}. In India, maize is the third most important food crops after rice and wheat. Among the maize growing countries, India rank 4th in area and 7th in production, representing around 4% of the world maize area and 2% of total production. During 2018-19 in India, the maize area has reached to 9.2 million ha (Anonymous, 2020b). The Gujarat state had grown maize in 5.08 lakhs hectare land with production 8.71 million tons and 1714 kg ha^{-1} yield in 2015-16 (Anonymous, 2019).

Among the various agronomic factor determining the crops yield, nutrient management is considered as one of the basic factors. Nitrogen though an expensive input is very important as it is intimately involved in the process of photosynthesis and directly reflected in the total dry matter production. Phosphorus is a fascinating plant nutrient. It is involved in a wide range of plant processes from permitting cell division to the development of a good root system and for ensuring timely and uniform ripening of the crop. Potassium is an essential nutrient for plant growth. Potassium plays a vital role as macronutrient in plant growth and sustainable crop production. Hence, an attempt was made to study the effect of different levels of nitrogen, phosphorus and potassium on yield, quality, nutrient content and uptake on hybrid maize (*Zea mays* l.) under south Gujarat condition.

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MATERIALS AND METHODS

A field experiment was conducted at College Farm, Deptt. of Agronomy, Navsari Agricultural University, Navsari (Gujarat) during *rabi* season of the year 2019-20 to study the effect of different levels of nitrogen, phosphorus and potassium on yield, quality, nutrient content and uptake by

hybrid maize (*Zea mays* L.) under south Gujarat condition. The soil of the experimental field was clayey in texture and showed low, medium and high rating of available nitrogen (197.36 kg ha^{-1}), phosphorus (52.32 kg ha^{-1}) and potassium (481.40 kg ha^{-1}), respectively. The soil was found slightly alkaline (pH 7.8) with normal electric conductivity. The maximum temperature ranged between 27.5 to 34.9°C, while minimum temperature ranged between 8.4 to 19.5°C during period of experimentation. Similarly, maximum relative humidity ranged between 76.4 to 91.3% whereas minimum relative humidity ranged between 39.4 to 68.6% during period of experimentation. Sunshine hours per day ranged between 2.5 to 9.0 during the year 2019-20. Twelve treatment combinations consisting of three levels of nitrogen fertilizer *i.e.* N_1 (nitrogen 120 kg ha^{-1}), N_2 (nitrogen 150 kg ha^{-1}) and N_3 (nitrogen 180 kg ha^{-1}), two levels of phosphorus fertilizer *i.e.* P_1 (phosphorus 30 kg ha^{-1}) and P_2 (phosphorus 60 kg ha^{-1}) and two levels of potassium fertilizer *i.e.* K_1 (potassium 00 kg ha^{-1}), K_2 (potassium 30 kg ha^{-1}) were tried in factorial randomized block design with three replications. Nitrogen, phosphorus and potassium were given in the form of urea, single super phosphate and murate of potash, respectively. Nitrogen was applied in three splits (50% at basal, 25% at knee stage and 25% at pre-flowering stage) and the entire dose of phosphorus and potassium were applied as basal application at just before sowing in the furrows. Organic manure FYM @ 10 t ha^{-1} was applied as common for all treatment before sowing by broadcasting and mixed in the soil. Seeds of hybrid maize GAYMH 3 was dibbled on 20 Nov. 2019 and harvested at 12 March 2020.

The data on seed and stover yield was recorded from the net plot and converted on a hectare basis. The nitrogen content in green gram seed was estimated by micro Kjeldahl's method as described by Jackson (1973). The protein content of the seed was computed by multiplying the nitrogen percentage with 6.25 for each treatment. Chemical studies about nitrogen, phosphorus, potassium content and their uptake by seed and stover and available nitrogen, phosphorus, potassium status in the soil after harvest of the crop were determined as per different methods *viz.*, Modified Kjeldahl's method (For N), Wet digestion (Diacid) Vanado molybdo phosphoric acid yellow colour method (for P) and Flame photometric method (for K). The data were analyzed statistically by adopting the standard procedures described by Panse and Sukhatme (1985). The purpose of the analysis of variance was to determine the significant effect of treatments on green gram. Uptake of nutrients by seed and plant was calculated by using following formula:

Nutrient uptake (kg ha^{-1}) =

$$\frac{\text{Nutrient content (\%)} \times \text{Seed yield (kg ha}^{-1}\text{)}}{100}$$

RESULTS AND DISCUSSION

Effect of nitrogen

The data given in Table 3 indicated that application of 180 kg N ha^{-1} (N_3) recorded significantly the highest grain yield (51.58 q ha^{-1}) and straw yield (103.69 q/ha). While, the lowest grain yield (42.61 q ha^{-1}) and straw yield (87.04 q ha^{-1}) was recorded under treatment N1 (120 kg N ha^{-1}). Higher grain and straw yield under high level of nitrogen was evidently due to different levels of nitrogen was related to the differences in size of photosynthetic surface and to the relative efficiency of total sink activity, possibly a function of yield attributes and higher plant height, respectively. These results are in conformity with the results of Singh *et al.* (2015). They reported that application of 150 kg N ha^{-1} resulted 21.71 and 2.58% higher grain and stover yield over 100 kg N ha^{-1} in maize.

The data given in Table 1 indicated that different levels of nitrogen exhibited their non-significant influence on crude protein content in grain, while application of 180 kg N ha^{-1} (N_3) reported significantly the highest crude protein yield (703.6 kg ha^{-1}). The increase in crude protein content in grain might be due to the fact that nitrogen is an integral constituent of amino acids, which are the basic units of the protein. The results of present investigation are accordance with the findings of Thirupathi *et al.* (2016). They reported that significantly the highest crude protein content (8.5 %) was recorded with application of 225 kg N ha^{-1} as compared to 180 kg N ha^{-1} in maize.

The data given in Table 2 indicated that N, P and K content in grain and straw were found non-significant by different nitrogen levels. Numerically the highest value of N, P and K content of 2.187, 0.310 and 1.471 per cent, respectively in grain and N, P and K content of 0.581, 0.205 and 1.103 per cent, respectively in straw was recorded with the application of 180 kg N/ha (N_3) and the lowest value of N, P and K content of 2.124, 0.299 and 1.451 per cent, respectively in grain and N, P and K content of 0.558, 0.195 and 1.074 per cent, respectively in straw was recorded with the application of 120 kg N ha^{-1} (N_1). The present findings are within the close vicinity of those reported by Der (2014) in maize. They reported that numerically higher value of N, P and K content in grain and straw of 1.606 and 0.401%, 0.307 and 0.206% and 0.469 and 0.884%, respectively, were observed with higher application of nitrogen (150 kg ha^{-1}).

Significantly the highest N, P and K uptake of 112.58, 15.99 and 75.91 kg/ha, respectively in grain and N, P and K uptake of 60.33, 21.25 and 114.39, respectively in straw was recorded with application of 180 kg N ha^{-1} (N_3) over application of 150 and 120 kg N ha^{-1}. This may be due to increasing nutrient levels increases nutrient uptake in grain and straw. Similar results were recorded by Jadhav *et al.* (2011). They recorded significantly higher uptake of N (71.74 kg ha^{-1}), P (10.00 kg ha^{-1}) and K (13.147 kg ha^{-1}) by grain and N (56.62 kg ha^{-1}), P (6.14 kg ha^{-1}) and K (59.59 kg ha^{-1}) by stover was recorded by application of nitrogen @ 120 kg ha^{-1} in pearl millet.

The mean data pertaining to available N, P_2O_5 and K_2O in soil after harvest of crop were presented in Table 3. The individual effect of nitrogen, phosphorus and potassium levels and interaction effect on available N in soil were found non-

significant. However, numerically higher available N, P_2O_5 and K_2O was recorded with application of 180 kg N ha^{-1} (N_3) and lower available N, P_2O_5 and K_2O was recorded with application of 120 kg N ha^{-1} (N_1). Similar results were recorded by Sangtam *et al.* (2017). They reported that significantly higher available N (325.16 kg ha^{-1}) was recorded under application of 80 kg N ha^{-1}, however, available phosphorus and available potassium in did not record any significant variations among the different nitrogen doses in maize.

Effect of phosphorus

The data given in Table 3 indicated that application of 60 kg P_2O_5 ha^{-1} (P_2) recorded significantly highest grain yield (49.05 q ha^{-1}), whereas, the lower grain yield (45.13 q ha^{-1}) was recorded under treatment P_1 (30 kg P_2O_5 ha^{-1}). While, different levels of phosphorus do not impart their significant influence on straw yield. This increase in grain yield with the increase in phosphorus level may be attributed probably to the development of extensive root system. Which enabled the plants to absorb more nutrients from the depth and might have growth of the plant enhanced photosynthetic activities. These findings are in conformity with the results of Pandey *et al.* (2016). They reported that crop was fertilized up to 80 kg ha^{-1} of phosphorus application enhanced more growth and seed yield than the 40 kg ha^{-1} and control in lentil.

The data given in Table 1 indicated that different levels of phosphorus exhibited their non-significant influence on crude protein content in grain, while application of 60 kg P_2O_5 ha^{-1} (P_2) recorded significantly highest crude protein yield (664.5 kg ha^{-1}). This finding closely associated with those of Raskar *et al.* (2013) and Khan and Singh (2017) in maize.

The data given in Table 2 indicated that N, P and K content in grain and straw was found non-significant effect due to different phosphorus levels. However, numerically the highest value of N, P, K content of 2.168, 0.307 and 1.470 per cent, respectively in grain and N, P, K content of 0.575, 0.202 and 1.097 per cent, respectively in straw was recorded with application of 60 kg P_2O_5 ha^{-1} (P_2) and the lowest value of N, P, K content of 2.143, 0.302 and 1.451 per cent, respectively in grain and N, P, K content of 0.564, 0.197 and 1.083 per cent, respectively in straw was recorded with application of 30 kg P_2O_5 ha^{-1} (P_1). This finding closely associated with those of Singh *et al.* (2015). The results of the study indicated the application of phosphorus upto 40 kg P_2O_5 ha^{-1} recorded significantly higher nitrogen, phosphorus and potassium content in seed and straw and their uptake as compared to absolute control and 20 kg P_2O_5 ha^{-1} but was at par with 60 kg P_2O_5 ha^{-1} in mung bean.

However, N, P, K uptake by grain and N, P uptake by straw was recorded significantly higher with application of 60 kg P_2O_5 ha^{-1} (P_2), while, K uptake by straw was found non-significant by phosphorus levels. This may be due to increasing nutrient level increases nutrient uptake in grain and straw. Singh *et al.* (2015). The results of the study indicated the application of phosphorus upto 40 kg P_2O_5 ha^{-1} recorded significantly higher nitrogen, phosphorus and potassium uptake by seed and straw as compared to absolute control and 20 kg P_2O_5 ha^{-1} but was at par with 60 kg P_2O_5 ha^{-1} in mung bean.

The mean data pertaining to available N, P_2O_5 and K_2O in soil after harvest of crop were presented in Table 3.

Table 1: Yield and quality of maize as influenced by nitrogen, phosphorus and potassium levels.

Treatments	Grain yield (q/ha)	Straw yield (q/ha)	Crude protein content (%)	Crude protein yield (kg/ha)
Levels of nitrogen (N)				
N_1 = 120 kg N ha^{-1}	42.61	87.04	13.27	566.7
N_2 = 150 kg N ha^{-1}	47.08	95.34	13.48	634.8
N_3 = 180 kg N ha^{-1}	51.58	103.69	13.67	703.6
SEm (±)	1.49	2.77	0.18	21.63
CD (P=0.05)	4.38	8.13	NS	63.45
Levels of phosphorus (P)				
P_1 = 30 kg P_2O_5 ha^{-1}	45.13	92.39	13.39	605.6
P_2 = 60 kg P_2O_5 ha^{-1}	49.05	98.33	13.55	664.5
SEm (±)	1.22	2.26	0.14	17.66
CD (P=0.05)	3.57	NS	NS	51.81
Levels of potassium (K)				
K_1 = 00 kg K_2O ha^{-1}	45.02	94.04	13.39	603.4
K_2 = 30 kg K_2O ha^{-1}	49.16	96.68	13.55	666.7
SEm (±)	1.22	2.26	0.14	17.66
CD (P=0.05)	3.57	NS	NS	51.81
Interaction				
N × P	NS	NS	NS	NS
N × K	NS	NS	NS	NS
P × K	NS	NS	NS	NS
N × P × K	NS	NS	NS	NS
CV (%)	10.98	10.07	4.54	11.80

The individual effect of nitrogen, phosphorus and potassium levels and interaction effect on available P in soil were found non-significant. There is numerically high phosphorus present in soil with respect of application of high dose of phosphorus. The present findings are within the close vicinity of those reported by Der (2014) in maize. They observed that significantly higher available P_2O_5 (30.70 kg ha^{-1}) was recorded under application of 75 kg P_2O_5 ha^{-1}, however, available nitrogen and available potassium in did not record any significant variations among the different phosphorus doses in maize.

Effect of potassium

The data given in Table 3 indicated that application of 30 kg K_2O ha^{-1} (K_2) recorded significantly the highest grain yield (49.16 q ha^{-1}), whereas, the lowest grain yield (45.02 q ha^{-1}) was accumulated under treatment K_1 (00 kg K_2O ha^{-1}). Different levels of potassium did not influence significant on straw yield. Improvement in grain and straw yield might be attributed to an overall improvement in growth and yield attributes at all the stages of crop growth. The present finding of increase in grain yield was in accordance with the research findings of Mandal *et al.* (2020) recorded higher grain yield (7.86 t ha^{-1}) was obtained with 150 kg K_2O ha^{-1} which was statistically similar to 120 kg K_2O ha^{-1} (7.78 t ha^{-1} of grain) in maize.

The data given in Table 1 indicated that different levels of potassium exhibited their non-significant influence on crude protein content in grain, while application of 30 kg K_2O ha^{-1} (K_2) reported significantly the highest crude protein yield (666.7 kg ha^{-1}). The results of present investigation are conformity with results observed by Balpande *et al.* (2016). They reported that significantly high protein yield was observed due to application 30 kg K_2O ha^{-1} in pigeon pea.

The data given in Table 2 indicated that N, P and K content in grain and straw was found non-significant by different potassium levels. However, numerically the highest value of N, P, K content of 2.169, 0.308 and 1.470 per cent, respectively in grain and N, P, K content 0.581, 0.205 and 1.097 per cent, respectively in straw was recorded with application of 30 kg K_2O ha^{-1} (K_3) and the lowest value of N, P, K content of 2.143, 0.302 and 1.451 per cent, respectively in grain and N, P, K content of 0.562, 0.197 and 1.083 per cent, respectively in straw was recorded by control (K_1). The results of present investigation are conformity with results observed by Patil *et al.* (2017). They reported that no significant difference in primary nutrients content (N, P and K) in grain and stover of maize with varied levels of K_2O *i.e.*, 50, 75, 100 and 125 per cent of recommended dose of K_2O.

The data given in Table 2 indicated that N, P and K uptake by grain was found significant due to different potassium levels. Significantly the highest N, P and K uptake by grain of 106.7, 15.2 and 1.81 kg ha^{-1}, respectively was recorded with application of 30 kg K_2O ha^{-1} (K_2), while, N, P and K uptake by straw was found non-significant due to different potassium levels. Increased uptake of nitrogen might have resulted in vigorous growth and higher photosynthetic rate which led to

Table 2: N, P and K content and uptake by grain and straw of maize as influenced by nitrogen, phosphorus and potassium levels.

Treatments	Nutrient content (%)						Nutrient uptake (kg/ha)					
	Grain			Straw			Grain			Straw		
	N	P	K	N	P	K	N	P	K	N	P	K
Levels of nitrogen (N)												
N_1 = 120 kg N ha^{-1}	2.124	0.299	1.451	0.558	0.195	1.074	90.7	12.8	61.8	48.6	17.0	93.5
N_2 = 150 kg N ha^{-1}	2.157	0.305	1.460	0.569	0.200	1.093	101.6	14.4	68.8	54.3	19.0	104.1
N_3 = 180 kg N ha^{-1}	2.187	0.310	1.471	0.581	0.205	1.103	112.6	16.0	75.9	60.3	21.3	114.4
SEm (±)	0.03	0.00	0.02	0.01	0.00	0.01	3.46	0.51	2.21	1.84	0.59	3.35
CD (P=0.05)	NS	NS	NS	NS	NS	NS	10.15	1.49	6.49	5.41	1.74	9.84
Levels of phosphorus (P)												
P_1 = 30 kg P_2O_5 ha^{-1}	2.143	0.302	1.451	0.564	0.197	1.083	96.9	13.7	65.6	52.1	18.3	100.3
P_2 = 60 kg P_2O_5 ha^{-1}	2.168	0.307	1.470	0.575	0.202	1.097	106.3	15.1	72.1	56.7	19.9	107.7
SEm (±)	0.02	0.00	0.01	0.01	0.00	0.01	2.83	0.42	1.81	1.51	0.49	2.74
CD (P=0.05)	NS	NS	NS	NS	NS	NS	8.29	1.22	5.30	4.42	1.42	NS
Levels of potassium (K)												
K_1 = 00 kg K_2O ha^{-1}	2.143	0.302	1.451	0.562	0.197	1.083	96.6	13.6	65.2	52.9	18.5	102.1
K_2 = 30 kg K_2O ha^{-1}	2.169	0.308	1.470	0.577	0.203	1.097	106.7	15.2	72.4	55.9	19.7	105.9
SEm (±)	0.02	0.00	0.01	0.01	0.00	0.01	2.83	0.42	1.81	1.51	0.49	2.74
CD (P=0.05)	NS	NS	NS	NS	NS	NS	8.29	1.22	5.30	NS	NS	NS
Interaction												
N × P	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
N × K	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
P × K	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
N × P × K	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	4.54	4.27	4.26	5.73	5.12	4.65	11.80	12.26	11.15	11.75	10.79	11.17

Table 3: Effect of various levels of nitrogen, phosphorus and potassium on available N, P and K in soil after harvest of maize.

Treatment	Available nutrient in soil (kg ha^{-1}) After harvest		
	N	P_2O_5	K_2O
Levels of nitrogen (N)			
N_1 = 120 kg N ha^{-1}	196.11	29.90	462.22
N_2 = 150 kg N ha^{-1}	203.25	30.43	467.45
N_3 = 180 kg N ha^{-1}	207.06	30.78	471.45
SEm ±	3.05	0.57	4.44
CD (P=0.05)	NS	NS	NS
Levels of phosphorus (P)			
P_1 = 30 kg P_2O_5 ha^{-1}	200.80	30.04	463.67
P_2 = 60 kg P_2O_5 ha^{-1}	203.49	30.70	470.41
S Em ±	2.49	0.47	3.63
CD (P=0.05)	NS	NS	NS
Levels of potassium (K)			
K_1 = 00 kg K_2O ha^{-1}	201.78	29.99	463.01
K_2 = 30 kg K_2O ha^{-1}	202.51	30.75	471.08
SEm ±	2.49	0.47	3.63
CD (P=0.05)	NS	NS	NS
Interaction			
N × P	NS	NS	NS
N × K	NS	NS	NS
P × K	NS	NS	NS
N × P × K	NS	NS	NS
CV%	5.23	6.54	3.30

better uptake of N throughout the crop growth period, increased uptake of phosphorus might be due to availability of sufficient potassium at different stages of crop growth which favoured the better root growth and dry matter production and increased uptake of potassium by maize may be ascribed to more availability of potassium at critical stages from the added fertilizer sources and native soil potassium. This finding closely associated with those of Balpande *et al.* (2016). They reported that high N and P uptake was observed due to application of 30 kg K_2O ha^{-1} and Potassium uptake was increased significantly with increasing the levels of K in pigeon pea.

Alam *et al.* (2021) recorded significantly higher N, P and K uptake of 513.74, 105.03 and 491.72 mg kg^{-1}, respectively by application of K_{90} mg kg^{-1} level by fodder maize over control (K_0 mg kg^{-1}).

The mean data pertaining to available N, P_2O_5 and K_2O in soil after harvest of crop were presented in Table 3. The individual effect of nitrogen, phosphorus and potassium levels and interaction effect on available K_2O in soil were found non-significant. There are high potassium present in soil with respect of application of high dose of potassium. The present findings are within the close vicinity of those reported by Ranpariya *et al*. (2017) in green gram. They observed that significantly higher available K_2O (216 kg ha^{-1}) was recorded under application of 60 kg K_2O ha^{-1}, however, available nitrogen and available phosphorus in did not record any significant variations among the different potassium doses in green gram.

CONCLUSION

From the results of one year experimentation, it can be concluded that *rabi* hybrid maize (GAYMH 3) should be fertilized with 180 kg N ha^{-1} (50% at basal, 25% at knee high stage and 25% at pre-flowering stage), 60 kg P_2O_5 ha^{-1} and 30 kg K_2O ha^{-1} for getting higher yield and monetary returns under south Gujarat condition.

Conflict of interest: None.

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