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Effect of nitrogen and phosphorus fertilizers on growth and quality of high quality protein maize (*Zea mays* L.) to under South Saurashtra agroclimatic zone of Gujarat

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ABSTRACT

An experiment was conducted to assess the "effect of nitrogen and phosphorus fertilizers on growth and quality of high quality protein maize (*Zea mays* L.) to under South Saurashtra agroclimatic zone of Gujarat" during summer, 2016 at the department of agronomy, college of agriculture, JAU, Junagadh. The results revealed that application of 150 kg N ha^{-1} significantly higher plant height, dry matter accumulation, number of leaves per plant and protein content over control and 90 kg N ha^{-1}, while at par with 120 kg N ha^{-1}. Result showed that application of 60 kg P2O5 ha^{-1} significantly higher plant height, dry matter accumulation, number of leaves per plant and protein content, being remained at par with 45 kg P2O5 ha^{-1} over control

***Key words:** Quality protein maize, Nitrogen and phosphorus, Growth parameters and protein.*

Introduction

Maize (*Zea mays* L.) is an annual plant belongs to the family *Gramineae.* Among the cereals, maize ranks third in total world production of cereal after wheat and rice and it is principal staple food in many countries, particularly in the tropics and subtropics of the word. Maize is considered as the "Queen of cereals". Being a C_4 plant, it is capable to utilize solar radiation more efficiently even at lower radiation intensity. Globally, maize is known as queen of cereals because of its highest genetic yield potential. Maize is the only food cereal crop that can be grown in diverse seasons, ecologies and uses. Beside this maize have many types like normal yellow/white grain, sweet corn, baby corn, popcorn, waxy corn, high amylase corn, high oil corn, quality protein maize, *etc*. Apart from this, maize is an important industrial raw material and provides large opportunity for value addition.

Globally, it is cultivated on more than 160 million hectares (mha) area across 166 countries having wider diversity of soil, climate and management practices. Maize contributes maximum among the

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food cereal crops *i.e.* 40% annually (>800 million tonnes) in the global food production. Among the maize growing countries, USA is the largest producer and contributes nearly 35% of the total maize produced, followed by China with more than 20% production with same acreage as of USA. Maize is the driver of US food safety with highest productivity (>10 t ha^{-1}) which is double than the global productivity (5.3 t ha^{-1}). Whereas, productivity of India is just half than the world productivity (DMR, 2012).

In Indian agriculture, maize assumes a special significance on account of its utilization as food, feed and fodder besides several industrial use. Gujarat occupies an area of 0.50 million ha, with production of 0.82 million tonnes and productivity of 1525 kg ha^{-1} (Anon., 2013). In India, it is grown on 8.67 mha area with the production and productivity of 21.75 mt and 2566 kg ha^{-1}, respectively (Anon., 2014). The high yielding single cross hybrid of quality protein maize developed by breeders popularly known as 'HQPM' assumes a great significance in overcoming problem of malnutrition in tribal population of Gujarat as well as in many parts of country where maize is raised as a staple food crop. There is enormous scope to increase cultivation of HQPM due to its increasing global demand, value addition potential and better prices in market compared to its traditional varieties of maize. The HQPM is a hybridized variety of maize specially bread by addition of *Opaque*-2 mutant gene, which improve lysine and tryptophan and reduce leucine and isoleucine contents and produce quality protein with balanced composition of amino acids (Prasanna *et al.,* 2001). The most important goal of HQPM research is to reduce malnutrition through direct human consumption (Sofi *et al.,* 2009).

Materials and Methods

The field experiment entitled the effect of nitrogen and phosphorus fertilizers on growth and yield of high quality protein maize (*Zea mays* L.) to under south saurashtra agroclimatic zone of Gujara was conducted during summer 2016 at Instructional Farm, Department of Agronomy, Junagadh Agricultural University, Junagadh (Gujarat), which is situated in South Saurashtra Agro-climatic region of Gujarat state and enjoys a typically subtropical climate characterized by fairly cold and dry winter, hot and dry summer as well as warm and moderately humid monsoon. This is situated at 221.50 N latitude and 70.50 E longitudes with an altitude of 60 m above the mean sea level. The soil was clayey in texture and slightly alkaline in reaction with pH 7.9 and EC 0.38 dS m^{-1}. The soil was low in available nitrogen (241.00 kg ha^{-1}) and available phosphorus (31.60 kg ha^{-1}) while medium in available potash (245.36 kg ha^{-1}). The experiment comprising of total twelve treatment combinations consisting four levels of nitrogen viz., N_0: Control, N_1: 90 kg N ha^{-1}, N_2: 120 kg N ha^{-1}, N_3: 150 kg N ha^{-1} and three levels of phosphorus viz., P_0: Control, P_1: 45 kg P_2O_5 ha^{-1}, P_2: 60 kg P_2O_5 ha^{-1} laid out in Factorial Randomized Block Design replicated thrice. The crop was sown in 60 cm × 20 cm spacing with seed rate of 25 kg/ha. The variety HQPM-1 was shown on 10th February and all other recommended practices were adopted according to as per needed of crop requirement. Statistical analysis of the individual data of various characters studied in the experiment was carried out using standard statistical procedures as described by Panse and Sukhatme (1985). Standard error of mean, critical difference (C.D.) at 5 per cent level of probability and coefficient of variance were worked out for the interpretation of the results.

Results and Discussion

Effect on growth parameters

An assessment of data (Table 1 & 3) indicated that different levels of nitrogen did not exert their significant influence on plant height and dry matter accumulation at 30 DAS. However, at 60 DAS and harvest application of 150 kg N ha^{-1} recorded significantly higher plant height (152.44 cm and 196.79 cm), dry matter accumulation (79.96 and 148.61 g plant^{-1}) and numbers of leaves per plant (13.17 and 14.56), which was found statistically at par with 120 kg N ha^{-1}. Whereas, significantly the lowest plant height was observed under treatment control. The application of 150 kg N ha^{-1} recorded 8.02 and 7.17 per cent higher plant height at 60 DAS and 6.62 and 5.17 per cent at harvest and dry matter accumulation per plant by 23.52 and 13.43 per cent at 60 DAS and 10.27 and 7.4 per cent at harvest and numbers of leaves per plant by 26.51and 16.24 per cent at 60 DAS, 29.76 and18.08 per cent at harvest over control, which was found statistically at par with 120 kg N ha^{-1}, respectively.

The improvement in growth parameter with application of 150 and 120 kg N ha^{-1} might have resulted in better and timely availability of N for their utilization by plant as judged from nitrogen content of straw. Nitrogen is considered a vitally important plant nutrient. In addition to its role in the formation of proteins, nitrogen is an integral part of chlorophyll which is the primary absorber of light energy needed for photosynthesis. Besides these, it is also a constituent of certain organic compounds of physiological importance. Under the present investigation, profound influence of N as component of fertility management, on crop growth seen to be due to maintaining congenial nutritional environment of plant system on account of their greater availability from soil media. The significant improvement in nutrient status of plant parts might have resulted in greater synthesis of amino acids, proteins and growth promoting hormones, which leads to enhanced the meristematic activity and increased cell division and their elongation. The results are in close conformity with the findings of Thakur *et al.*, (1997), Mishra (2005), Chiller and Kumar (2006) and Bindhani *et al.*, (2007). An examination of data showed that different levels of phosphorus did not execute their significant influence on plant height at 30 DAS. However, at 60 DAS and harvest application of 60 kg P_2O_5 ha^{-1} resulted in significantly the higher plant height (151.51 cm and 196.67 respectively), which was found statistically at par with treatment 45 kg P_2O_5 ha^{-1}. Whereas, significantly the lowest plant height was observed under control. Application of 60 kg P_2O_5 ha^{-1} recorded significantly higher dry matter accumulation (29.95, 76.84 and 148.11 g $plant^{-1}$**)** and numbers of leaves per plant (4.42, 12.91 and 13.83) at 30 DAS, at 60 DAS and harvest over control, which was found statistically at par with 45 kg P_2O_5 ha^{-1} over control, respectively. The application of 60 kg P_2O_5 ha^{-1} recorded 7.72 per cent higher plant height at 60 DAS and 6.29 per cent at harvest and dry matter accumulation per plant by 16.99 per cent at 30 DAS, 9.56 per cent at 60 DAS and 9.08 per cent at harvest and numbers of leaves per plant 23.46 per cent at 30 DAS, 21.22 per cent at

Table 1. Effect of N and P levels on plant height of high quality protein maize

Treatments	Plant height (cm) at		
	30 DAS	60 DAS	Harvest
Nitrogen levels (kg N ha^{-1})			
Control	39.52	141.11	184.56
90	39.90	142.23	187.10
120	40.80	149.57	193.57
150	41.79	152.44	196.79
S.Em.±	1.40	3.16	3.18
C.D. (P = 0.05)	NS	9.27	9.33
Phosphorus levels (kg P_2O_5 ha^{-1})			
Control	39.39	140.65	185.03
45	40.93	146.86	189.81
60	41.19	151.51	196.67
S.Em.±	1.21	2.74	2.76
C.D. (P = 0.05)	NS	8.02	8.08
C.V. (%)	10.34	6.48	5.01
Interaction (N×P)	NS	NS	NS

Table 2. Effect of N and P levels on dry matter accumulation of high quality protein maize

Treatments	Dry matter accumulation ($g\ plant^{-1}$) at		
	30 DAS	60 DAS	Harvest
Nitrogen levels (kg N ha^{-1})			
Control	25.86	64.73	134.76
90	26.62	70.49	138.37
120	28.61	76.12	143.92
150	30.27	79.96	148.61
S.Em.±	1.12	2.19	3.46
C.D. (P = 0.05)	3.28	6.42	10.16
Phosphorus levels (kg P_2O_5 ha^{-1})			
Control	25.60	70.13	135.78
45	27.97	71.50	140.36
60	29.95	76.84	148.11
S.Em.±	0.97	1.90	3.00
C.D. (P = 0.05)	2.84	5.56	8.80
C.V. (%)	12.06	9.02	7.35
Interaction (N×P)	NS	NS	NS

Table 3. Effect of N and P levels on number of leaves per plant of high quality protein maize

Treatments	Number of leaves $plant^{-1}$ at		
	30 DAS	60 DAS	Harvest
Nitrogen levels (kg N ha^{-1})			
Control	3.44	10.41	11.22
90	3.78	11.33	12.33
120	4.11	12.45	14.22
150	4.56	13.17	14.56
S.Em.±	0.25	0.62	0.59
C.D. (P = 0.05)	0.72	1.82	1.72
Phosphorus levels (kg P_2O_5 ha^{-1})			
Control	3.58	10.65	11.92
45	3.92	11.96	13.50
60	4.42	12.91	13.83
S.Em.±	0.21	0.54	0.51
C.D. (P = 0.05)	0.62	1.58	1.49
C.V. (%)	18.55	15.72	13.42
Interaction (N×P)	NS	NS	NS

60 DAS and 16.02 per cent at harvest over control, which was found statistically at par with 45 kg P_2O_5 ha^{-1}, respectively. Phosphorus fertilization improves the various metabolic and physiological processes and thus known as "energy currency" which is subsequently used for vegetative and reproductive growth through photo-phosphorylation. In addition to its vital metabolic role, P is an important structural component of nucleic acid, phytein, phospholipids and enzymes. An adequate supply of phosphorus early in the life cycle of plant is important in laying down the primordia of its reproductive part. It also increases the initiation of both first and second order rootlets and their development. The extensive root system helps in exploiting the maximum nutrients and water from the soil. Under the present investigation, profound influence of P, a component of fertility management, on crop growth seem to be due to maintaining congenial nutritional environment of plant system on account of their greater availability from media. The significant improvement in nutrient status of plant parts might have resulted in greater synthesis of amino acids, proteins and growth substances, which seems to have enhanced the meristematic activity and increased cell division and their elongation. The enhanced growth with phosphorus was also reported by Ramamurthy and Shivashankar (1996), Patel *et al*., (2000), Arya and Singh (2001), Banerjee *et al*., (2006) and Amhakhian and Osemwota (2012).

Effect on yield

An appraisal of data (Table 4) showed that different levels of nitrogen imparted their significant influence on grain yield and straw yield of QPM. Application of 150 kg N ha^{-1} recorded significantly the higher grain yield (4201 kg ha^{-1}) and straw yield (6194 kg ha^{-1}) and remained statistically at par with 120 kg N ha^{-1}. Significantly, the lowest grain and straw yield was recorded under no nitrogen application. Result that various levels of phosphorus manifested their significant influence on grain yield and straw yield. Application of 60 kg P_2O_5 ha^{-1} recorded significantly higher of grain yield (3774 kg ha^{-1}) and straw yield (5694 kg ha^{-1}) and remained statistically at par with 45 kg P_2O_5 ha^{-1}. Where, no application of phosphorus produced significantly the lowest grain and straw yield. The findings are in close agreement with the results obtained by Bindhani (2007), Dibaba *et al*., (2013) and Om *et al.*, (2014).

Table 4. Effect of N and P levels on grain and straw yield of high quality protein maize

Treatments	Yield (kg ha^{-1})	
	Grain	Straw
Nitrogen levels (kg N ha^{-1})		
Control	2419	3556
90	3795	5594
120	3904	6038
150	4201	6194
S.Em.±	134.10	199.78
C.D. (P = 0.05)	393.31	585.92
Phosphorus levels (kg P_2O_5 ha^{-1})		
Control	3323	5055
45	3642	5289
60	3774	5694
S.Em.±	116.14	173.01
C.D. (P = 0.05)	340.62	507.42
C.V. (%)	11.24	11.21
Interaction (N×P)	NS	NS

Effect on quality

The perusal of data (Table 5) revealed that different levels of nitrogen exerted their significant influence on protein content of grains. Application of 150 kg N ha^{-1} recorded significantly the higher protein content of grains (11.05%) and remained statistically at par with 120 kg N ha^{-1} (10.68%). In contrast, significantly the lowest protein content of grains (10.28%) was recorded under no nitrogen application. This could also be explained on the basis of better availability of desired and required nutrients in crop root zone and

Table 5. Effect of N and P levels on protein content in grain of high quality protein maize

Treatments	Protein content in grain (%)
Nitrogen levels (kg N ha^{-1})	
Control	10.28
90	10.43
120	10.68
150	11.05
S.Em.±	0.19
C.D. (P = 0.05)	0.55
Phosphorus levels (kg P_2O_5 ha^{-1})	
Control	10.11
45	10.74
60	10.99
S.Em.±	0.16
C.D. (P = 0.05)	0.47
C.V. (%)	5.27
Interaction (N×P)	NS

enhanced photosynthetic and metabolic activity resulting in better partitioning of photosynthates to sinks, which reflected in quality enhancement in terms of protein content. The finding are closely associated with those of reported earlier Jena *et al.*, (2013) and Choudhary *et al.*, (2013). Result that various levels of phosphorus exerted their significant influence on protein content of grains. Application of 60 kg P_2O_5 ha^{-1} recorded significantly higher of protein content of grains (10.99%) and remained statistically at par with 45 kg P_2O_5 ha^{-1} (10.74%). In contrast, significantly the lowest of protein content of grains (10.11%) was recorded under control plots. This results are closely associated with Yogananda *et al.*, (2000) and Arya and Singh (2001).

Conclusion

On the basis of one year field experimentation, it may be concluded that to application 150 kg N ha^{-1} and 60 kg P_2O_5 ha^{-1} recorded significant higher plant growth parameter, grain yield and straw yield and protein content, remained statistically at par with 120 kg N ha^{-1} and 45 kg P_2O_5 ha^{-1}.

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