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EFFECT OF NITROGEN, PHOSPHORUS AND POTASSIUM ON GROWTH, YIELD AND ECONOMICS OF HYBRID MAIZE (*Zea mays* L.) UNDER SOUTH GUJARAT CONDITION

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ABSTRACT

A field experiment was conducted at College Farm, Navsari Agricultural University, Navsari (Gujarat) during *rabi* season of the year 2019-20 to study the effect of nitrogen, phosphorus and potassium on growth, yield and economics of hybrid maize (*Zea mays* L.) under south Gujarat condition. The results revealed that application of nitrogen @ 180 kg ha^{-1} recorded significantly the higher growth parameters, yield attributes and grain (51.58 q ha^{-1}) and straw (103.69 q ha^{-1}) yields as well as net realization (Rs. 88,379 ha^{-1}) with BCR value (2.68) of maize. Application of phosphorus @ 60 kg ha^{-1} dominated and established its superiority in respect to almost all growth parameters, yield attributes and yields (49.05 q ha^{-1} of grain and 98.33 q ha^{-1} of straw) with highest net realization (Rs. 81,803 ha^{-1}) and BCR of (2.44). All the growth, yield attributes, grain yield (49.16 q ha^{-1}) and straw yield (96.68 q ha^{-1}) as well as highest net realization (Rs. 83,469 ha^{-1}) and BCR (2.64) were recorded with the application of potassium 30 kg ha^{-1}. Profitable yield of maize can be obtained by the application of 180 kg nitrogen ha^{-1} (50 % at basal, 25 % at knee high stage and 25 % at pre-flowering stage), 60 kg phosphorus ha^{-1} and 30 kg potassium ha^{-1} under south Gujarat condition.

(Key words: Maize, nitrogen, phosphorus, potassium, yield, yield attributes, economics)

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, 2020$_a$). The USA has the highest productivity (> 9.6 t ha^{-1}) which is double than the global average (4.92 t ha^{-1}). Whereas, average productivity in India is 2.43 t ha^{-1}. In India, maize is the third most important food crop 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, 2020$_b$). The Gujarat state had grown maize in 5.08 lakhs hectare land with the production of 8.71 million tons and 1714 kg ha^{-1} productivity (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 nitrogen, phosphorus and potassium on maize in *rabi* season.

MATERIALS AND METHODS

A field experiment was conducted at College Farm, 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 growth, yield and economics of 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. 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

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(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 muriate 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 treatments 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 five plants from each plot was randomly selected and tagged for measuring the plant height (cm) and number of leaves $plant^{-1}$ at 60, 90 days after sowing and at harvest. At harvesting, 5 plants from each plot were selected for recording yield components. Total number of matured cobs (from 5 plants) were recorded and averaged to get the number of cobs $plant^{-1}$. Length and girth of matured cobs (from 5 plants) were recorded using a measuring tape, weighed using an electronic weighing machine and then averaged to get mean cob weight. Other yield components i.e. number of grain rows cob^{-1} was counted from each of 5 cobs separately and averaged to get mean value. After proper sun drying, grains were de-shelled and the number of grains cob^{-1} and 100 grain weight (test weight) were recorded. Plants from the demarked net plot area were harvested and tied in bundles after removing all the matured cobs from them. Grains were de shelled from the cob (de husked) and then dried properly to reduce the moisture content at 14.0 %. Weight of grains was recorded as kg $plot^{-1}$ and then converted into q ha^{-1}. The plants (without grain) were dried in the Sun and finally weighed to get straw yield in kg $plot^{-1}$ and converted into q ha^{-1}. 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 maize.

RESULTS AND DISCUSSION

Effect of nitrogen

The data given in Table 1 indicated that application of 180 kg N ha^{-1} (N_3) recorded significantly highest plant height (143.8, 181.8 and 191.2 cm at 60, 90 DAS and harvest, respectively) but it was at par with treatment N_2 (150 kg N ha^{-1}). The difference in number of leaves $plant^{-1}$ was non-significantly influenced at all stages of crop growth due to different nitrogen levels, but numerically the maximum number of leaves $plant^{-1}$ was recorded at 60, 90 DAS and harvest with the application of 180 kg N ha^{-1} (N_3). The increase in plant height and number of leaves $plant^{-1}$ with increasing level of nitrogen is quite obvious because nitrogen influences favorably the meristematic activity, which increases the number and length of internodes ultimately resulting better growth. The increase in leaf number was result of increased and balanced availability of nutrient with higher levels of nitrogen. The enhanced vegetative growth in term of plant height due to nitrogen application had also reported by Amanullah and Khan (2017). They reported that maize crop fertilized with 150 kg N ha^{-1} produced taller plants (184 cm) as compared to other nitrogen levels (60, 90 and 120 kg N ha^{-1}).

Karki *et al.* (2020) reported that plant height increased with increased level of nitrogen and found the highest at 120 kg N ha^{-1} which were statistically similar with 90 kg N ha^{-1} in maize.

The data given in Table 2 reported that difference in test weight (g) was non-significantly influenced due to different nitrogen levels. Numerically the highest test weight was recorded under treatment N_3 (180 kg N ha^{-1}) *i.e.* 23.42 g, while, the lowest test weight of 21.86 g was recorded under treatment N_1 (120 kg N ha^{-1}). Application of 180 kg N ha^{-1} (N_3) recorded significantly the highest number of cobs $plant^{-1}$ (1.69), number of grains cob^{-1} (476.8), cob length (20.71 cm) and cob girth (14.63 cm). Whereas, the lowest number of cobs $plant^{-1}$ (1.44), number of grains cob^{-1} (375.3), cob length (17.69 cm) and cob girth (12.48 cm) were noted under treatment N_1 (120 kg N ha^{-1}). This might be due to fact that nitrogen might have hastened vigorous vegetative growth of the maize which might have stimulate the rate of photosynthesis and resulted into higher diversification of photosynthesis from vegetative to reproductive sink. These results are similar to those reported by Pal *et al.* (2017). They recorded significantly the highest values of yield attributes with the application of 120 kg N ha^{-1} and the lowest values were recorded under 60 kg N ha^{-1} in maize.

Ezung and Zamir (2019) recorded the highest number of grains (464.43) and test weight (80.54 g) through application of 100 % RD of N through vermicompost as compared to other levels of nitrogen and control in maize.

The data given in Table 3 indicates 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^{-1}). While, the lowest grain yield (42.61 q ha^{-1}) and straw yield (87.04 q ha^{-1}) was recorded under treatment N_1 (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 Soujanya *et al.* (2018). They recorded increase in grain yield of maize with the increasing nitrogen levels from 90 kg N ha^{-1} to 240 kg N ha^{-1}. The crop applied with 240 kg N ha^{-1} recorded more grain yield of 7647 kg ha^{-1} which was on par with 180 kg N ha^{-1} (7635 kg ha^{-1}) and significantly superior over 90 kg N ha^{-1} (6511 kg ha^{-1}) in maize.

Yadav *et al.* (2017) reported that seed yield (54.15 q ha^{-1}) and straw yield (81.25 q ha^{-1}) of maize were significantly more in 100 % N through neem coated urea followed by 50 % N through urea + 50 % N through neem coated urea.

The application of 100 % RD of N through vermicompost recorded the highest number of grain yield (25.78 q ha^{-1}) and stover yield (75.42 q ha^{-1}) as compared to other levels of nitrogen and control in maize (Ezung and Jamir (2019)

The data given in Table 3 indicated that the maximum gross realization (^{1} 1,21,346 ha^{-1}), net realization (Rs. 88,379 ha^{-1}) and BCR (2.68) was recorded with the application of 180 kg N ha^{-1} (N_3). While, the minimum gross realization (Rs. 1,00,589 ha^{-1}), net realization (Rs. 68,342 ha^{-1}) and BCR (2.12) observed with the application of 120 kg N ha^{-1} (N_1). The results of present investigation are accordance with the findings of Pal *et al.* (2017). They reported highest values of net return and B:C ratio with the application of 120 kg N ha^{-1} and the lowest values were recorded under 60 kg N ha^{-1} in maize.

Effect of phosphorus

The data given in Table 1 indicated that potassium did not show any significant effects on plant height and number of leaves $plant^{-1}$ at 60, 90 DAS and at harvest. The data given in Table 2 indicated that different levels of phosphorus don't impart their significant influence on number of grains cob^{-1} and test weight, but numerically the highest grains cob^{-1} (430.90) and test weight (23.09 g) was recorded with 60 kg P_2O_5 ha^{-1} and the lowest grains cob^{-1} (406.16) and test weight (22.10 g) was recorded with 30 kg P_2O_5 ha^{-1}. Application of 60 kg P_2O_5 ha^{-1} (P_2) recorded significantly the highest number of cobs $plant^{-1}$ (1.61), cob length (19.81 cm) and cob girth (14.05 cm), whereas, the lowest number of cobs $plant^{-1}$ (1.51), cob length (18.58 cm) and cob girth (13.17 cm) was noted under treatment P_1 (30 kg P_2O_5 ha^{-1}). It might be due to beneficial effect of phosphorus on prolification and elongation of roots thereby more absorption of moisture and nutrient from deeper soil layer which improves crop growth and development. Phosphorus is also one of the most important plant nutrients essential for the improvement of reproductive part of cob. It confirms the findings of Pal *et al.* (2017). They recorded significantly highest values of yield attributes with application of 60 kg P_2O_5 ha^{-1}, where the lowest values were recorded with 40 kg P_2O_5 ha^{-1} in maize.

Marbaniang *et al.* (2020) reported that treatment receiving 30 kg ha^{-1} of phosphorus recorded the highest number of pods $plant^{-1}$ (17.33), number of seeds pod^{-1} (14.33) as compared to control in green gram.

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 enhanced growth and photosynthetic activities. These findings are in conformity with the results of Pal *et al.* (2017). They reported that significantly the highest values of grain and straw yield were observed with the application of 60 kg P_2O_5 ha^{-1} and the lowest values were recorded under 40 kg P_2O_5 ha^{-1} in maize.

Marbaniang *et al.* (2020) reported that treatment receiving 30 kg ha^{-1} of phosphorus recorded the highest seed yield (350 kg ha^{-1}) as compared to control in green gram.

The data given in Table 3 indicated that the maximum gross realization (Rs. 1,15,325 ha^{-1}), net realization (Rs. 81,803 ha^{-1}) and BCR (2.44) was recorded with the application of 60 kg P_2O_5 ha^{-1} (P_2). While, the minimum gross realization (Rs. 1,06,588 ha^{-1}), net realization (Rs. 74,424 ha^{-1}) and BCR (2.31) observed with the application of 30 kg P_2O_5 ha^{-1} (P_1). The results of present investigation are accordance with the findings of Punse *et al.* (2018). They recorded highest gross monetary returns (Rs. 73.613 ha^{-1}) and net monetary returns (Rs. 54,931 ha^{-1}) with the application of 60 kg P ha^{-1} which was significantly superior over 30 and 40 kg P ha^{-1}, but remained at par with 50 kg P ha^{-1}. Highest B:C ratio was obtained with the application of phosphorus @ 60 kg ha^{-1} followed by the application of 50 kg P ha^{-1} in green gram.

Effect of potassium

The data given in Table 1 indicated that potassium did not show any significant effects on plant height and number of leaves $plant^{-1}$ at 30, 60, 90 DAS and at harvest. The data given in Table 2 indicated that different levels of potassium don't impart their significant influence on number of grains cob^{-1} and test weight, but numerically the highest grains cob^{-1} (426.69) and test weight (23.05 g) was recorded with 30 kg K_2O ha^{-1} and the lowest grains cob^{-1} (410.36) and test weight (22.14 g) was recorded with control, whereas, significantly the highest cobs $plant^{-1}$ (1.61), cob length (19.84 cm) and cob girth (14.08 cm) observed with the application of 30 kg K_2O ha^{-1} (K_2). This might be due to continuous filling of grains by sufficient photosynthesis and its lead to increase number of cobs, cob length and girth. Gnanasundari *et al.* (2018) reported that cob length was significantly influenced up to 120 kg K_2O ha^{-1}, whereas, cob girth responded only up to 80 kg K_2O ha^{-1}. Kalpana and Krishnarajan (2002) reported significantly higher cobs $plant^{-1}$ of baby corn with 50 kg K ha^{-1} as compared to 40 kg K ha^{-1}. Sadiq *et al.* (2017) reported that test weight (315 g) was increased in plots where K was applied at the rate of 120 kg ha^{-1}, whereas, the minimum test weight (293 g) was recorded in control plots. Hussain *et al.* (2007) reported that maximum number of grains ear^{-1} (324) was obtained by the application of 90 kg K_2O ha^{-1}, while minimum number of grains ear^{-1} (271) obtained with 30 kg K_2O ha^{-1}.

The data given in Table 3 indicated that application of 30 kg K_2O ha^{-1} (K_2) recorded significantly highest grain yield (49.16 q ha^{-1}), whereas, the lowest grain yield (45.02 q ha^{-1}) was found under treatment K_1 (00 kg K_2O ha^{-1}). Different levels of potassium did not influence significance on straw yield. Improvement in grain and straw yield might be

Table 1. Growth attributes of maize as influenced by nitrogen, phosphorus and potassium levels

Treatments	Plant height (cm)			No. of leaves plant^{-1}		
	60 DAS	90 DAS	At harvest	60 DAS	90 DAS	At harvest
Levels of Nitrogen (N)						
N_1 =120 kg N ha^{-1}	130.6	166.9	175.0	11.35	11.97	11.43
N_2 =150 kg N ha^{-1}	137.5	174.5	183.7	11.68	12.26	11.88
N_3 =180 kg N ha^{-1}	143.8	181.8	191.2	11.93	12.50	12.00
S Em. ±	3.53	3.93	4.35	0.23	0.26	0.24
C D at 5 %	10.36	11.52	12.76	-	-	-
Levels of Phosphorus (P)						
P_1 = 30 kg P_2O_5 ha^{-1}	134.7	172.4	179.2	11.38	12.04	11.57
P_2 = 60 kg P_2O_5 ha^{-1}	139.9	176.4	187.4	11.92	12.44	11.97
S Em. ±	2.88	3.21	3.55	0.19	0.21	0.20
C D at 5 %	-	-	-	-	-	-
Levels of Potassium (K)						
K_1 = 00 kg K_2O ha^{-1}	136.3	172.2	179.1	11.48	12.09	11.69
K_2 = 30 kg K_2O ha^{-1}	138.3	176.6	187.5	11.83	12.39	11.86
S Em. ±	2.88	3.21	3.55	0.19	0.21	0.20
C D at 5 %	-	-	-	-	-	-
C V %	8.91	7.80	8.23	6.80	7.38	7.12
Interaction						
N X P						
S Em. ±	5.00	5.56	6.16	0.32	0.34	0.34
C D at 5 %	-	-	-	-	-	-
N X K						
S Em. ±	5.00	5.56	6.16	0.32	0.34	0.34
C D at 5 %	-	-	-	-	-	-
P X K						
S Em. ±	4.08	4.54	5.03	0.26	0.28	0.28
C D at 5 %	-	-	-	-	-	-
N X P X K						
S Em. ±	7.07	7.86	8.71	0.46	0.48	0.48
C D at 5 %	-	-	-	-	-	-

Table 2. Yield attributes of maize as influenced by nitrogen, phosphorus and potassium levels

Treatments	Number of cobs $plant^{-1}$	Number of grains cob^{-1}	Cob Length (cm)	Cob Girth (cm)	Test weight (g)
Levels of Nitrogen (N)					
N_1 =120 kg N ha^{-1}	1.44	375.3	17.69	12.48	21.86
N_2 =150 kg N ha^{-1}	1.56	403.5	19.18	13.73	22.51
N_3 =180 kg N ha^{-1}	1.69	476.8	20.71	14.63	23.42
S Em. ±	0.04	10.48	0.46	0.29	0.42
C D at 5 %	0.11	30.73	1.36	0.86	-
Levels of Phosphorus (P)					
P_1 = 30 kg P_2O_5 ha^{-1}	1.51	406.2	18.58	13.17	22.10
P_2 = 60 kg P_2O_5 ha^{-1}	1.61	430.9	19.81	14.05	23.09
S Em. ±	0.03	8.56	0.38	0.24	0.35
C D at 5 %	0.09	-	1.11	0.71	-
Levels of Potassium (K)					
K_1 = 00 kg K_2O ha^{-1}	1.51	410.4	18.54	13.14	22.14
K_2 = 30 kg K_2O ha^{-1}	1.61	426.7	19.84	14.08	23.05
S Em. ±	0.03	8.56	0.38	0.24	0.35
C D at 5 %	0.09	-	1.11	0.71	-
C V %	8.04	8.67	8.36	7.50	6.51
Interaction					
N X P					
S Em. ±	0.05	14.82	0.66	0.42	0.60
C D at 5 %	-	-	-	-	-
N X K					
S Em. ±	0.05	14.82	0.66	0.42	0.60
C D at 5 %	-	-	-	-	-
P X K					
S Em. ±	0.04	12.10	0.54	0.34	0.49
C D at 5 %	-	-	-	-	-
N X P X K					
S Em. ±	0.08	20.96	0.93	0.59	0.85
C D at 5 %	-	-	-	-	-

Table 3. Yield and economics of maize as influenced by nitrogen, phosphorus and potassium levels

Treatments	Yield ($q\ ha^{-1}$) Grain	Yield ($q\ ha^{-1}$) Straw	Gross realization ($Rs.\ ha^{-1}$)	Net realization ($Rs.\ ha^{-1}$)	BCR
Levels of Nitrogen (N)					
N_1 =120 kg N ha^{-1}	42.61	87.04	100589	68342	2.12
N_2 =150 kg N ha^{-1}	47.08	95.34	110933	78326	2.40
N_3 =180 kg N ha^{-1}	51.58	103.69	121346	88379	2.68
S Em. ±	1.49	2.77			
C D at 5 %	4.38	8.13			
Levels of Phosphorus (P)					
P_1 = 30 kg P_2O_5 ha^{-1}	45.13	92.39	106588	74424	2.31
P_2 = 60 kg P_2O_5 ha^{-1}	49.05	98.33	115325	81803	2.44
S Em. ±	1.22	2.26			
C D at 5 %	3.57	-			
Levels of Potassium (K)					
K_1 = 00 kg K_2O ha^{-1}	45.02	94.04	106797	75990	2.47
K_2 = 30 kg K_2O ha^{-1}	49.16	96.68	115116	83469	2.64
S Em. ±	1.22	2.26			
C D at 5 %	3.57	-			
C V %	10.98	10.07			
Interaction					
N X P					
S Em. ±	2.11	3.92			
C D at 5 %	-	-			
N X K					
S Em. ±	2.11	3.92			
C D at 5 %	-	-			
P X K					
S Em. ±	1.72	3.20			
C D at 5 %	-	-			
N X P X K					
S Em. ±	2.99	5.54			
C D at 5 %	-	-			

Selling price : Grain - 18.5 Rs. kg^{-1} and straw -2.5 Rs Kg^{-1}

attributed to an overall improvement in growth and yield attributes at all the stages of crop growth. Gnanasundari *et al*. (2020) recorded significantly more grain yield of hybrid maize up to 120 kg K_2O ha^{-1}. Mandal *et al*. (2020) recorded higher grain yield (7.86 t ha^{-1}) with 150 kg K_2O ha^{-1} which was statistically similar to 120 kg K_2O ha^{-1} (7.78 t ha^{-1}) in maize.

The data given in Table 3 indicated that the maximum gross realization (Rs. 1,15,116 ha^{-1}), net realization of (Rs. 83,469 ha^{-1}) and BCR (2.64) was recorded with the application of 30 kg K_2O ha^{-1} (K_2). The application of K_1 (00 kg K_2O ha^{-1}) gave the minimum gross realization (Rs. 1,06,797 ha^{-1}), net realization (Rs. 75,990 ha^{-1}) and BCR (2.47). The results of present investigation are accordance with the findings of Mandal *et al.* (2020). They recorded significantly more net return and B:C ratio with the increased potash level up to 90 kg K_2O ha^{-1} in maize.

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

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