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Response of quality protein maize hybrids (*Zea mays* L.) on growth parameters under different plant population and nutrient management practices

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Abstract
A field experiment was conducted at Udaipur during *Kharif* season of 2016 to study the Response of Quality Protein Maize Hybrids (*Zea mays* L.) on Growth parameters under Different Plant Population and Nutrient Management Practices. Results revealed that hybrid HQPM-5 recorded higher plant population, plant height, dry matter accumulation at 25, 50 75 DAS and at harvest (19.70, 60.94, 197.51 and 214.47 g plant^{-1}), CGR between 25-50 DAS (15.00 g m^{-2} day^{-1}) and 50-75 DAS (50.07 g m^{-2} day^{-1}), RGR, LAI over PQMH-1. Maize hybrid HQPM-5 attend significantly early tasseling and silking than PQMH-1. 1,00,000 plants ha^{-1} recorded higher DMA, CGR, RGR, LAI over 83,333 plants ha^{-1}. Among various nutrient management practices STCR recorded highest plant height, DMA, CGR, RGR, LAI over SSNM and RDF, respectively.

Keywords: STCR (soil test crop response), SSNM (Site specific nutrient management), RDF, LAI (leaf area index), CGR (crop growth rate), RGR (relative growth rate)

Introduction
Maize, the queen of cereals, occupies a pride place among cereal crops in India. It has emerged as third most important food crop after rice and wheat as it represents 24% of total cereal production. It is a staple food for vast rural population of our country particularly in the southern parts of Rajasthan. The maize varieties have low protein content with unbalanced composition of essential amino acids. The low protein and unbalanced amino acid content in maize (QPM) cause protein deficiency diseases like kwashiorkor and malnutrition. To overcome this problem, quality protein maize (QPM) was developed. The QPM is hybridized variety of maize specially bred by Opaque-2 modifier gene, which improves lysine and tryptophan, reduces leucine and isoleusine content and produces quality protein with balanced composition of amino acids.

Growth and grain yield of maize is remarkably influenced by nutrient management, but inadequate use of major nutrients (N, P) is responsible for limiting maize yields. Hence proper nutrition of QPM hybrid is important to get high crop yields. Nitrogen is a component of protein and nucleic acid which determines plant growth and development (Onasanya *et al*., 2009) [2]. Phosphorus is needed for growth, utilization of sugar and starch, photosynthesis, metabolic process which leads to higher yield potential (Ayub *et al.*, 2002) [1]. Maize with higher productive potential, being heavy feeder of nutrients requires continuous and assured nutrient supply throughout the growing period from germination to grain filling stages to realize good yields. Hence, for better dissemination and adaptation of QPM hybrids the present experiment on nutrient management practices under varying plant populations with nitrogen and phosphorus levels was initiated as an endeavor to make QPM a real potential use.

Material and Method
The field experiment was conducted during *Kharif* 2016 at Instructional Farm, Department of Agronomy, Rajasthan College of Agriculture, Udaipur. The soil of the experimental site was clay loam in texture slightly alkaline in reaction, medium in available nitrogen and phosphorus, while high in potassium. The treatment consisted combinations of two QPM hybrids (HQPM-5 and PQMH-1), plant population (83,333 and 1,00,000 plants ha^{-1}) with three nutrient management practices RDF (90 kg N + 30 kg P_2O_5 ha^{-1}),

STCR (157.8 kg N + 87.11 kg P_2O_5 + 81.7 kg K_2O ha^{-1}) and SSNM (113 kg N + 39 kg P_2O_5 ha^{-1}). These treatments were evaluated under split plot design with three replications. QPM hybrids and plant populations are taken in main plots and nutrient management practices are placed in sub plots. QPM hybrids were sowm on 4th july 2016 at varying plant populations with a seed rate of 25 kg ha^{-1}. Half dose of nitrogen and full dose of phosphorus were applied as per treatment at sowing time and rest of nitrogen was top dressed at knee high stage.

Result and discussion

Growth Parameters

Plant height

It is evident from the data (Table 1) that plant height recorded under application of STCR was significantly superior by 3.29 and 4.79 per cent over SSNM and RDF, respectively.

The increase in absorption of nutrient by harvestable plant part seems to have promoted greater leaf formation. Thus, increase in this component of photosynthesis process seems to have increased interception, absorption and utilization of radiant energy there by higher plant height, higher accumulation of photosynthates and finally dry matter, CGR, and LAI by hybrid HQPM-5. The correlation studies further substantiates positive relationship between plant height and dry matter accumulation, ($r = 0.844^{*}$).

Dry matter accumulation (DMA)

HQPM-5 at 25 (19.70 g $plant^{-1}$), 50 (60.94 g $plant^{-1}$), 75 DAS (197.51 g $plant^{-1}$), and at harvest (214.47 g $plant^{-1}$) accumulated higher dry matter $plant^{-1}$ which was significantly higher over PQMH-1. Dry matter accumulation 25 and 50 DAS was found significantly higher in plant population 83,333 plants ha^{-1} by 9.00 and 8.47 per cent, respectively over 1,00,000 plants ha^{-1}. An application of STCR significantly enhanced dry matter accumulation 25, 50, 75 DAS and at harvest by 10.20 and 11.17, 3.35 and 5.84, 3.16 and 4.70 and 3.70 and 6.07 per cent, respectively over SSNM and RDF.

As the number of plants increased in a given area the competition among the plants for nutrients uptake and sunlight interception also increased and due to this dry matter accumulation during early stage of crop found highest in lower plant density. The correlation studies further substantiates positive relationship between grain yield and cobs $plant^{-1}$ ($r = 0.551^{**}$), grain yield and dry matter accumulation at harvest ($r = 0.962^{**}$) dry matter at harvest and Stover yield (0.925^{**}) and plant height at harvest and Stover yield (0.877^{**}) and DMA at harvest and biological yield (0.947^{**}). The results are also in conformity with the findings of Saini *et al*., (2014) [3] and Sinha, (2016) [4].

Crop growth rate

Data presented in (Table 2) showed that HQPM-5 recorded higher crop growth rate between 25-50 DAS (15 g m^{-2} day^{-1}) and 50-75 DAS (50.07 g m^{-2} day^{-1}). 1,00,000 plants ha^{-1} recorded significantly higher CGR (53.31 g m^{-2} day^{-1}) by 21.29 per cent over 83,333 plants ha^{-1}between 50-75 DAS. Among various nutrient management practices application of STCR recorded highest crop growth rate (49.75 g m^{-2} day^{-1}) between 50-75 DAS which was significantly higher by 2.88 and 4.03 per cent over SSNM and RDF, respectively.

The overall improvement in crop growth under the influence of optimum nutrition involving nutrient management practices could be ascribed to their potential role in modifying soil and plant environment conducive for better development of both morphological and biochemical components of the plant growth that increase efficiency of physiological processes of plant system.

Relative growth Rate

1,00,000 plants ha^{-1} recorded significantly higher RGR (between 50-75 DAS) over 83,333 plants ha^{-1}.

Leaf area index

It is evident from the data (table 2) that HQPM-5 recorded higher leaf area index at 25 DAS which was significantly superior over PQMH-1 by 29.88 per cent but found non significant at 50 DAS and 75 DAS. STCR recorded highest LAI 25, 50, 75 DAS and at harvest over SSNM and RDF and similarly SSNM also recorded higher LAI 25, 50, 75 DAS and at harvest over RDF.

Days to 50 % tasseling and days to 50 % silking

The data reveal that (Table 3) Hybrid HQPM-5 significantly attaind early tasseling and silking than PQMH-1 by 3.5 and 3.49 days, respectively.

Table 1: Effect of hybrids, plant populations and nutrient management practices on plant population, plant height and DMA

Treatments	Plant population (000 ha^{-1})		Plant height (cm)		Dry matter accumulation (g $plant^{-1}$)			
	25 DAS	At harvest	25 DAS	At harvest	25 DAS	50 DAS	75 DAS	At harvest
Hybrids								
HQPM-5	91.83	89.83	52.06	234.49	19.70	60.94	197.51	214.47
PQMH-1	92.07	90.72	51.37	230.42	17.89	56.18	184.80	206.89
SEm±	1.06	0.78	0.92	3.45	0.36	1.09	3.58	3.32
CD (P=0.05)	NS	NS	NS	NS	1.27	3.79	12.38	NS
Plant Population (Plants ha^{-1})								
83,333	83.61	81.77	50.72	227.49	19.61	62.35	194.25	207.57
1,00,000	100.30	98.78	52.70	237.43	17.99	54.78	188.06	213.79
SEm±	1.06	0.78	0.93	3.45	0.36	1.09	3.58	3.32
CD (P=0.05)	3.68	2.73	NS	NS	1.26	3.79	NS	NS
Nutrient management practices								
RDF	91.22	89.86	49.83	227.73	18.07	57.00	187.28	204.97
STCR	93.28	91.44	53.72	238.63	20.09	60.33	196.10	217.43
SSNM	91.36	89.53	51.58	231.01	18.23	58.37	190.09	209.64
SEm±	0.85	0.62	1.07	2.83	0.32	0.86	1.95	2.62
CD (P=0.05)	NS	NS	NS	8.50	0.97	2.58	5.86	7.87

Table 2: Effect of hybrids, plant populations and nutrient management practices on CGR, RGR and LAI

Treatments	Crop growth rate (g m^{-2} day^{-1})		Relative growth rate (g g^{-1} day^{-1})		Leaf area index		
	Between 25-50 DAS	Between 50-75 DAS	Between 25-50 DAS	Between 50-75 DAS	25 DAS	50 DAS	75 DAS
Hybrids							
HQPM-5	15.00	50.07	0.0452	0.0471	2.26	3.75	4.07
PQMH-1	13.96	47.19	0.0458	0.0478	1.74	3.57	3.97
SEm±	0.15	0.76	0.0010	0.0006	0.09	0.11	0.17
CD (P=0.05)	0.50	2.63	NS	NS	0.33	NS	NS
Plant Population (Plants ha^{-1})							
83,333	14.24	43.95	0.0464	0.0454	1.97	3.60	3.94
1,00,000	14.72	53.31	0.0447	0.0494	2.03	3.71	4.08
SEm±	0.15	0.76	0.0010	0.0006	0.09	0.11	0.17
CD (P=0.05)	NS	2.63	NS	0.0019	NS	NS	NS
Nutrient management practices							
RDF	14.19	47.82	0.0460	0.0477	1.52	3.42	3.63
STCR	14.65	49.75	0.0438	0.0473	2.50	4.00	4.43
SSNM	14.60	48.33	0.0467	0.0473	1.99	3.56	3.98
SEm±	0.17	0.50	0.0009	0.0008	0.08	0.10	0.07
CD (P=0.05)	NS	1.50	NS	NS	0.26	0.31	0.22

Table 3: Effect of hybrids, plant populations and nutrient management practices on days to 50 % tasseling and days to 50 % silking

Treatments	Days to 50 % tasseling	Days to 50 % silking
Hybrids		
HQPM-5	46.00	51.35
PQMH-1	49.50	54.84
SEm±	0.82	0.75
CD (P=0.05)	2.86	2.58
Plant Population (Plants ha^{-1})		
83,333	48.06	53.32
1,00,000	47.44	52.87
SEm±	0.82	0.75
CD (P=0.05)	NS	NS
Nutrient management practices		
RDF	47.75	52.82
STCR	47.25	52.99
SSNM	48.25	53.48
SEm±	0.36	0.46
CD (P=0.05)	NS	NS

Table 4: Correlation coefficient and regression equation between dependent variable (Y) and independent variable (X).

S. No.	Dependent (y)	Independent (x)	Correlation coefficient (r)	R^2	Regression equation (Y = a + bX)
1	Plant height at harvest	DMA at harvest	0.844**	0.712	Y= 53.37 + 0.850
2	Grain yield	DMA at harvest	0.962**	0.925	Y= -10522.442 + 73.535
3	DMA at harvest	Stover yield	0.925**	0.855	Y= 146.954 + 0.008
4	Plant height at harvest	Stover yield	0.877**	0.770	Y= 171.544 + 0.008
5	DMA at harvest	Biological yield	0.947**	0.896	Y= 146.528 + 0.005

Conclusion

It can be concluded that maize hybrid HQPM-5 appears to be better suited as it gave the higher plant height, DMA, CGR, RGR, LAI and early days to 50 % tasseling and days to 50 % silking. Plant population 1,00,000 plants ha-1 appears to be better suited as it gave higher plant height, DMA, CGR, RGR, LAI with application of STCR (Soil test crop response).

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