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Nupur Sharma
Department of Agronomy, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan, India

MK Kaushik
Department of Agronomy, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan, India

Sunita kumari
Department of Agronomy, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan, India

Vinod Kumar Yadav
Department of Agricultural chemistry and soil science. Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan, India

Correspondence
Nupur Sharma
Department of Agronomy, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan, India

Effect of QPM hybrids (*Zea mays* L.) on nutrient uptake and quality under different plant population and nutrient management practices

Nupur Sharma, MK Kaushik, Sunita Kumari and Vinod Kumar Yadav

Abstract
A field experiment was conducted at Udaipur during *Kharif* season of 2016 to study the effect of varying plant population and nutrient management on the nutrient uptake and quality of QPM hybrids. Results revealed that highest nitrogen and phosphorus content and grain and Stover their uptake was found with the application of STCR which was followed by SSNM and RDF. N and P uptake in grain and total uptake of N and P was found significantly higher in HQPM-5 over PQMH-1. Hybrid HQPM-5, 1, 00, 000 plants ha-1 and application of STCR was found better in terms of chlorophyll content. Protein content was found highest with application of STCR over SSNM and RDF.

Keywords: STCR, SSNM, RDF, QPM, Nutrient uptake

Introduction
In India maize is an important cereal crop. Out of total production 45% is consumed as staple food in various forms. In recent past high yielding single cross hybrid of quality protein maize were bread by addition of opaque- 2 mutant gene, which improved lysine and tryptophan and reduced leucine and isoleucine contents and produce quality protein with balanced composition of amino acids. The most important goal for enhancing productivity of quality protein maize is to reduce malnutrition through direct human consumption in tribal dominated area, where maize is a staple food (Sofi *et al*., 2009) [5]. Most popular variety of quality protein maize 'HQPM 1' is having slow initial growth and there after vigorous growth, thus its nitrogen requirement is high compared to other hybrids. Hence higher yield of quality protein maize can be obtained through judicious use of nitrogen as it can alone contribute 45–60% crop yield (Das *et al*., 2010) [1]. In quality protein maize nitrogen stress during flowering stage results in kernel and ear abortion and stress during grain filling accelerates leaf senescence reduce photosynthesis and kernel weight (Zaidi *et al*., 2005) [6]. Thus, the recommended 3 split application of nitrogen for hybrids and composite may not be applicable to nitrogen exhaustive quality protein maize 'HQPM 1' because of difference in its growth and development pattern. Soil test based fertilizer application techniques, site specific nutrient management (SSNM) and soil test crop response (STCR) are cost effective and plant need based approaches with specific yield target. The SSNM and STCR approaches not only aim to reduce or increase fertilizer use and also the effective tools for supplying crop nutrients as and when needed to achieve higher yield, besides this they also aims to increase system nutrient use efficiency, leading to more net returns per unit of fertilizer invested. So it was felt to standardize nutrient management practices for quality protein maize hybrids with different plant populations.

Materials and methods
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.

Table 1: Effect of QPM hybrids under varying plant population and nutrient management practices on nutrient content and their uptake

Treatments	Nitrogen (%)		Phosphorous (%)		Nitrogen uptake (kg ha^{-1})			Phosphorus uptake (kg ha^{-1})		
	Grain	Stover	Grain	Stover	Grain	Stover	Total	Grain	Stover	Total
Hybrids										
HQPM-5	1.841	0.292	0.308	0.160	97.21	23.24	120.44	16.31	12.65	28.96
PQMH-1	1.848	0.303	0.300	0.150	86.42	22.03	108.44	14.07	10.92	24.99
CD (P=0.05)	NS	NS	NS	NS	8.39	NS	8.90	1.49	0.75	1.59
Plant Population (Plants ha^{-1})										
83,333	1.883	0.299	0.307	0.158	88.67	21.65	110.33	14.52	11.42	25.94
1,00,000	1.805	0.297	0.301	0.153	94.95	23.61	118.56	15.87	12.15	28.02
CD (P=0.05)	NS	NS	NS	NS	NS	1.88	NS	NS	NS	1.59
Nutrient management practices										
RDF	1.764	0.278	0.280	0.148	79.41	18.86	110.33	12.64	10.07	22.71
STCR	1.934	0.323	0.324	0.163	105.30	26.87	118.56	17.66	13.59	31.24
SSNM	1.834	0.292	0.309	0.154	90.73	22.16	110.33	15.28	11.70	26.98
CD (P=0.05)	0.042	0.004	0.025	0.005	3.48	1.02	3.64	1.22	0.66	1.10

Result and discussion

N and P content

It was evident from the data (Table 1) that among various nutrient management practices STCR recorded highest N and P content in grain and Stover which was significantly higher over SSNM and RDF, respectively.

The significant increase in nitrogen and phosphorus content of grain and Stover at harvest seems to be on account of capabilities of hybrid HQPM-5 for efficient absorption, translocation and utilization of mineral nutrients. Moreover, the increased dry matter accumulation by plants of hybrid HQPM-5 subscribe to the view that there was adequate supply of metabolites from shoot to roots. This might have facilitated better root growth thus higher extraction of nutrients from soil environment. These findings are in close agreement with the result reported by Singh *et al*. (2011) [3].

Nitrogen uptake

The results (Table 1) showed that HQPM-5 recorded nitrogen uptake in grain and total uptake was significantly higher by 12.48 and 11.06 per cent over PQMH-1. It is obvious from the data presented in Table 1 that application of STCR increased nitrogen content as well as its uptake by grain, Stover and total uptake as compared to SSNM and RDF. Nitrogen uptake in Stover was found maximum under plant population of 1, 00,000 plants ha^{-1} over 83,333 plants ha^{-1}. Maximum nitrogen uptake was observed under STCR which was 16.05, 21.25 and 17.06 per cent higher over SSNM, whereas it was 32.60, 42.47 and 34.47 per cent higher over RDF, in case of grain, Stover and total nitrogen uptake, respectively.

This may be attributed to better crop growth and higher uptake of nutrients in the above treatment and may be improved nitrogen use efficiency with more appropriate nitrogen rates and better timing of nitrogen application practiced in the STCR treatments. The correlation studies further substantiates positive relationship between N uptake by grain and grain yield (r = 0.951**), and N uptake by Stover and Stover yield (r = 0.923**) and total N and biological yield (r = 0.962**).

Phosphorus uptake

Phosphorus uptake by grain, Stover and total uptake was significantly higher in hybrid HQPM-5 compared to PQMH-1 (Table 1). Total phosphorus uptake was found maximum under plant population of 1, 00,000 plants ha^{-1} over 83,333 plants ha^{-1}. Application of STCR also enhanced phosphorus content in grain and Stover at harvest compared to SSNM and RDF. Maximum phosphorus uptake was obtained under STCR which was 15.57, 16.15, and 15.88 per cent higher over SSNM, and 39.71, 34.95 and 37.56 per cent higher over RDF, respectively in grain, Stover and total phosphorus uptake by maize crop. This may be due to increased concentration of phosphorus in soil solution. Phosphorus application enhances the soil microbial activities which are helpful in the solubilization of native phosphorus and increase content and uptake of phosphorus by maize crop (Kumar *et al*., 2014 and Singh *et al*., 2014) [2, 4].

The correlation studies further substantiates positive relationship between P uptake by grain and grain yield (r = 0.925**), and P uptake by Stover and Stover yield (r = 0.951**) and total P and biological yield (r = 0.953**).

Grain Protein and Chlorophyll content

Further, Data presented in table 3 revealed that highest grain protein recorded with STCR application which was significantly higher over SSNM and RDF. It could be ascribed to direct effect on nitrogen content in seed. Hybrid HQPM-5, 1, 00,000 plants ha^{-1} and application of STCR was found highest in terms of chlorophyll content.

Table 2: 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	N uptake by grain	Grain yield	0.951**	0.905	Y= -12.927 + 0.021
2	P uptake by grain	Grain yield	0.925**	0.855	Y= -5.214 + 0.004
3	N uptake by Stover	Stover yield	0.923**	0.852	Y= -8.591 + 0.004
4	P uptake by Stover	Stover yield	0.951**	0.904	Y= -3.790 + 0.002
5	Total N uptake	Biological yield	0.962**	0.925	Y= -26.131 + 0.011
6	Total P uptake	Biological yield	0.953**	0.909	Y= -10.208 + 0.003

** Significant at 1% level of significance

Table 3: Effect of QPM hybrids under different plant population and nutrient management on protein and chlorophyll content

Treatments	Grain protein (%)	Chlorophyll content at 50 % silking (mg g^{-1} fresh wt.)
Hybrids		
HQPM-5	11.50	1.15
PQMH-1	11.55	1.07
CD (P=0.05)	NS	0.03
Plant Population (Plants ha^{-1})		
83,333	11.77	1.09
1,00,000	11.28	1.12
CD (P=0.05)	NS	0.03
Nutrient management practices		
RDF	11.02	0.93
STCR	12.09	1.25
SSNM	11.46	1.15
CD (P=0.05)	0.26	0.02

Conclusion

It can be concluded that hybrid HQPM-5 found superior in terms of N and P content and uptake, protein and chlorophyll content. Application of STCR significantly increase nutrient content and their uptake, protein and chlorophyll content.

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