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Productivity, nitrogen balance and economics of winter maize (*Zea mays*) as influenced by QPM cultivars and nitrogen levels

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Earlier efforts to improve the nutritional value of maize achieved success however, the developed composites could not become popular because of poor yield and soft kernel making them vulnerable to pests. The maize carrying Opaque-2 gene in homozygous condition with hard endosperm and vitreous kernel is referred as quality protein maize (QPM) Prasanna *et al*. (2001). It is an open pollinated variety or hybrid of maize containing lysine and tryptophan twice than the normal maize varieties along with low amount of leucine. Maize (*Zea mays* L.) is utilized in diverse ways ranging from human to livestock and the quality protein maize has a greater potential in human nutrition specially for the malnourished children and is also a good source of protein requirement for pre-school children (Srivastava *et al.* 2005). Maize is gaining popularity as an important crop of winter season because of its high yield potential, minimum losses due to biotic factors and greater responses to applied nutrients. Simultaneously to exploit such high potential of winter maize (QPM), a proper knowledge and information on crop nutrition and suitable cultivars are needed. The QPM cultivars developed so far are at different stages of evaluation. Optimum nitrogen application is important in quality protein maize since, the grain of crop produced under conditions of low nitrogen supply has poor protein content. Worku *et al*. (2007) examined the effect of low N stress on protein quantity and grain yield of QPM and non-QPM cultivars under three N levels and observed significant genotypic differences for grain protein content and grain yield. Since, the information on above aspects are fragmentary and scanty, therefore, the present investigation was carried to find out the optimum level of nitrogen and efficient cultivars for winter season maize (QPM) under the conditions of eastern Uttar Pradesh.

The field experiment was conducted during winter (*rabi*) season of 2007-08 at the Agricultural Research Farm, Banaras Hindu University, Varanasi. The soil was sandy clay loam in texture, neutral in reaction (pH 7.51), low in organic carbon content (0.26%) and available nitrogen (182 kg N/ ha) and medium in available phosphorus (13.86 kg P/ ha) and available potassium (149.2 kg K/ ha). Three nitrogen levels, viz. 80 kg (50% RD), 160 kg (100% RD) and 240 kg/ha (150% RD) formed the main plot (14 × 10 m^2) treatments. Four hybrid cultivars, viz. two QPM (HQPM-1, HQPM-4) and two non-QPM of full season maturity (BIO-9681 and SEEDTEC-2324) were assigned to sub plots (3.5 × 2.5 m^2) replicated thrice in a split plot design. Nitrogen for all the three levels were applied in 3 equal splits at sowing, knee high and tasseling stage in their respective treatments. However, a common dose of phosphorus and potassium each @ 60 kg/ ha were applied uniformly at the time of sowing. The test crop was sown adopting 60 cm × 25 cm spacing. Recommended cultural practices were adopted for raising the experimental crop. Mean maximum and minimum temperatures and total rainfall during the crop period was 31.5°C, 15.5°C and 37.8 mm, respectively. Nitrogen concentration in grain and stalk was estimated by modified Kjeldhal's method (Jackson 1958).

The growth, yield attributes and yield were influenced significantly by different nitrogen levels. However, cobs/ plant, days to 50% silking, shelling percentage and test weight were not affected significantly due to nitrogen levels (Table 1 and 2). The plant height, dry matter accumulation and number of green leaves/ plant increased significantly up to 100 per cent recommended dose of nitrogen (160 kg/ha) further increase in nitrogen level though increased the value but could not reach to the level of significance. Increase in plant height of winter maize due to nitrogen was noted by Mehta *et al*. (2011) and stimulated vegetative growth enhanced the number of green leaves. Length of cob, girth of cob and weight of grains/cob showed significant improvement due to application of highest nitrogen dose of 240 kg over 80 kg while at par with the recommended N level of 160 kg/ha. Higher values of these growth and yield attributing characters

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Table 1 Effect of QPM cultivars and N levels on growth and yield attributes of winter maize

Treatment	Plant height (cm)	No. of green leaves at 120 DAS	Dry matter production/ plant (g)	Days to 50% silking	Cobs/ plant	Length of cob (cm)	Girth of cob (cm)	Shelling percentage (%)	Weight of grains/ cob (g)	1000-grain weight (g)
Nitrogen level (kg/ha)										
80	158.4	10.88	141.1	118.2	1.04	14.5	4.20	67.7	75.4	220.1
160	177.3	11.65	159.7	116.7	1.04	16.0	4.33	71.5	90.9	226.0
240	182.6	11.88	167.4	118.2	1.05	16.4	4.51	72.8	101.7	233.3
SEm ±	4.1	0.26	3.4	0.7	0.01	0.6	0.11	1.8	5.8	11.9
CD (*P*=0.05)	11.5	0.71	9.5	NS	NS	1.6	0.30	3.2	16.0	NS
Cultivars										
HQPM 4	175.8	11.24	171.9	116.8	1.02	16.6	4.39	66.9	96.8	239.4
HQPM 1	172.2	12.03	141.6	120.2	1.08	15.1	4.04	71.9	74.7	191.4
BIO 9681	180.7	11.29	138.3	117.1	1.03	15.2	4.44	71.5	84.3	227.3
SEEDTEC 2324	162.8	11.32	152.6	116.6	1.04	15.8	4.51	71.7	101.5	247.9
SEm ±	7.1	0.26	3.1	0.6	0.01	0.5	0.08	2.0	6.3	10.2
CD (*P*=0.05)	18.5	0.55	8.9	1.5	NS	1.0	0.18	4.2	13.2	21.4

might be due to improved N supply which more rapidly converted the synthesized carbohydrates to proteins and protoplasm, this extra protein allows the plant to grow faster. The application of 240 kg N recorded significantly higher seed and stover yield over 80 kg N and registered an increase in yield by 48.4 and 26.1%, respectively which was at par with the application of 160 kg N/ha. Similar results have also been reported at several locations in testing of pre-release QPM germplasms with varying nitrogen levels (Anonymous 2007). Protein content in grain increased with nitrogen levels and the highest values were recorded when 240 kg N/ha was applied, however, the highest nitrogen level proved significantly superior to only 80 kg N/ha and was at par with moderate N level (160 kg/ha). Protein yield increased significantly with increasing N levels up to highest dose of 240 kg N/ha. Greater values of growth, yield attributes and yield at highest nitrogen rate indicate probably 160 kg N/ha was not adequate to meet the requirement of hybrid maize. Economically, a dose of 240 kg N/ha proved better over other doses and claimed highest net returns and benefit: cost ratio of ₹ 30 119/ ha and 2.09, respectively (Table 2).

Perusal of data (Table 1 and 2) clearly indicates that

Table 2 Effect of QPM cultivars and N levels on yield, quality, economics and nitrogen balance in soil after harvest of winter maize

Treatment	Grain yield (tonnes /ha)	Stover yield (tonnes /ha)	Protein content (%)	Protein yield (kg/ha)	Net returns (₹/ha)	B:C ratio	Total available N (initial + applied) (kg/ha)	N removal (kg/ha)	Computed N balance (kg/ha)	Actual N balance (kg/ha)	Net N balance (kg/ha)
Nitrogen level (kg/ha)											
80	4.32	8.13	11.36	491.2	13842	1.54	262	112.3	149.7	209.8	60.1
160	5.62	9.37	11.68	656.4	24084	1.91	342	143.4	198.6	289.2	90.6
240	6.42	10.25	11.83	759.0	30119	2.09	422	172.5	249.5	265.5	16.0
SEm ±	0.34	0.77	0.13	10.6				3.9		5.1	
CD (*P*=0.05)	0.94	2.12	0.36	32.8				11.6		14.5	
Cultivars											
HQPM-4	5.96	10.16	11.68	696.4	30565	2.31	342	155.2	186.8	269.2	82.4
HQPM-1	4.13	8.93	11.11	459.4	15267	1.65	342	117.4	224.6	335.6	111.0
BIO-9681	5.10	8.42	11.61	480.1	22395	1.96	342	131.4	210.6	300.3	89.7
SEEDTEC-2324	6.62	9.50	12.09	800.0	35318	2.50	342	159.7	182.3	244.6	62.3
SEm ±	0.27	0.69	0.18	11.8				3.3		4.4	
CD (*P*=0.05)	0.56	1.45	0.32	30.1				9.7		12.8	

Note: Selling price ('/kg) of produce: Maize grain 8.00, maize stover 0.60

different cultivars brought significant variation on growth, yield attributes and yield of winter maize, though the cultivars exhibited varied responses for different parameters studied. Genotype BIO 9681 produced significantly taller plants than SEEDTEC 2324 but was at par with other two QPM cultivars. Significantly higher number of green leaves produced by genotype HQPM 1 compared to others, besides it recorded significantly higher shelling percentage than HQPM 4 and found at par with non-QPM cultivars (BIO-9681 and SEEDTEC 2324). Genotype HQPM 4 registered significantly higher cob length over HQPM-4 and BIO-9681 and stover yield than BIO 9681. SEEDTEC 2324 proved superior in respect of higher dry matter production, maximum number of yield attributing characters, grain yield as well as net return and benefit: cost ratio. This genotype claimed significantly higher girth of cob, weight of grains/cob and test weight than HQPM 1 but was at par with rest of the cultivars. It also registered significantly higher grain yield, protein content and protein yield as compared to other cultivars. The data revealed that no genotype was superior for all the characters and different cultivars reflected the degree of genetic variability for growth, yield attributes and yield according to the inherent character of that particular genotype. Yields of currently available QPM germplasm are competitive with some regional cultivars although they are lower than that of the best available non-QPM cultivars Pixley (2001). SEEDTEC 2324 gave highest net return and benefit: cost ratio (₹ 35 317/ ha and 2.50) closely followed by HQPM 4 (₹ 30 565/ ha and 2.31) while HQPM 1 was least profitable (₹ 15 267/ha and 1.65). The nitrogen removal differed significantly due to different treatments. Nutrient removal being a function of dry matter production and partly due to increase in its concentration, application of 240 kg N/ ha gave more total dry matter, registered significantly higher removal of nitrogen. This might be due to higher nitrogen concentration and yield at higher level of nitrogen application. Singh *et al.* (2012) in sweet corn also observed the increased removal of nitrogen at higher N level. Among the four cultivars, SEEDTEC 2324 showed in more N removal but being at par with HQPM 4 and significantly higher than HQPM 1 and BIO 9681. The availability of nitrogen was increased with graded level of nitrogen up to 240 kg/ha, whiles it similar at each genotype. The computed nitrogen balance was highest at 240 kg N compared to lower doses of nitrogen. The higher net N balance was noticed with BIO-9681 might be due to less removal of nitrogen. Net nitrogen balance also increased only up to 160 kg N/ ha, thereafter it decreased. These findings supported those of Singh *et al*. (2012).

The absence of interaction between nitrogen levels and cultivars for yield attributes and yield indicated that grain yield response to applied nitrogen doses for optimum yield were not affected by cultivars. Similar findings were also reported by Buah *et al.* (2009).

SUMMARY

The experimental findings suggests that SEEDTEC 2324 proved superior over other cultivars for increasing yield of winter maize and application of 240 kg N/ha was found most suitable for achieving higher yield and profitability of winter maize in eastern Uttar Pradesh conditions. Further investigations are required to bring yields of QPM cultivars at par with the best normal endosperm cultivars.

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