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Response of nitrogen and sulphur levels on productivity and profitability of QPM hybrid (*Zea mays*) under dryland condition of Eastern Uttar Pradesh

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ABSTRACT

A field experiments was conducted during, 2009-2010 and 2010-2011 at Varanasi , under dryland condition to assess the growth, yield, quality, nutrient content and economics of QPM hybrids (*Zea mays* L.) under different nitrogen and sulphur levels. Twenty four treatment combination arranged in split plot design replicated three times with four nitrogen levels control, 50 kg N/ha, 100 kg N/ha and 150 kg N/ha in main plot treatments, two QPM hybrids Shaktiman-2 and Shaktiman-4 and three sulphur levels 15 kg S/ha, 30 kg S/ha and 45 kg S/ha as sub-plot treatments. Significant differences were observed among the treatments for all the parameters studied. Dry matter accumulation (g/plant), cob diameter (cm), test weight, protein content (%), protein yield (q/ha), N, P_2O_5, K_2O and S content in plant was increased significantly as a result of nitrogen and sulphur levels. Application of 150 kg N/ha recorded significantly higher grain yield 43.94% and 43.43% over 0 kg N/ha in 1st and 2nd years, respectively. The highest net return (65.76% and 64.07%) and B: C ratio (39.08% and 38.72%) was recorded under 150 kg N/ha in 1st and 2nd years, respectively over 0 kg N/ha. QPM hybrid, Shaktiman-4 proved significantly higher growth, yield attributes, quality, net return and B: C ratio compared to Shaktiman-2. Shaktiman-4 recorded 3.55% and 2.62% higher grain yield over Shaktiman-2 in 1st and 2nd years, respectively. Application of 45 kg S/ha obtained 10.77% and 10.25% highest grain yield during 1st and 2nd years, respectively over 15 kg S/ha. The highest net return (12.56% and 11.69%) and B: C ratio (3.15% and 3.52%) was recorded under 45 kg S/ha in 1st and 2nd years, respectively over 15 kg S/ha.

Key words: Grain yields, Net return, Protein content, Protein yields and QPM hybrids

Among cereals, maize (*Zea mays* L.) is an important food and feed crop which ranks third after wheat and rice in the world while it stand fourth ranks next to rice, wheat and jowar in India. Hybrid maize is a heavy feeder and more responsive to nutrients and required amount of nutrients may be supplied through balanced inorganic fertilizers to grow it and to maintain soil fertility on a sustained manner. Maize cultivation in India is being practiced on 6.0 million hectare (about 67%) area mainly as rainfed crop during rainy season and only 20.8% grown under irrigated conditions while contributing about 42% in National Food Grain Production. Because its expanded use in the agro-industries it is recognized as a leading commercial crop of great economic value. Among the primary maize growing countries of the world, with respect of area and production USA rank first while India rank fifth both in terms of area and production. Productivity is tremendously lower than other growing countries of the world and many reasons of low productivity. Among the management of plant nutrition is considered to be the major one. Hence there is need to improve this major component of the production technology for getting higher maize production of better quality. Balanced nutrition is an essential component of nutrient management and plays a significant role in increasing crop production and its quality. Maize being highly exhaustive, demands good nutrient management. Among the essential nutrients nitrogen is most important limiting factor for plant growth and make up 1-4% of dry matter of the plant and its application increases the nitrogen, crude protein content and metabolizable energy (Mahdi *et al*. 2012). Sulphur is essential for many growth functions in plant including nitrogen metabolism, enzyme activity, protein and oil synthesis. When sulphur is deficient in soil, full yield potential of the crop cannot be realized regardless of other nutrients even under good crop husbandry practices (Rasheed *et al*. 2004) and wide spread deficiency of sulphur and nitrogen also leads to low productivity of dryland crops (Sahrawat *et al*. 2007).

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MATERIALS AND METHODS

Varanasi falls in the belt of semi-arid to sub-humid climate receiving a mean annual rainfall of 1100 mm and potential evapo-transpiration of about 1525 mm thus there is a moisture deficit of 425 mm. The normal period of onset for the monsoon in this region is 3rd week of June which lasts up to the month end of September or sometimes extends to the 1st week of October. The coldest month is January, with minimum temperature varying from 7°C to 10°C with occasional extremes. The maximum temperature ranged in *kharif* 25°C to 38°C. The other parameters were normal during rainy season. Field experiment were conducted at Agronomy Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during *kharif* 2009-2010 and 2010-2011. Twenty four treatment combinations arranged in split plot design replicated three times with four nitrogen levels (0 kg N/ha, 50 kg N/ha, 100 kg N/ha and 150 kg N/ha) in main plot, two QPM hybrids (Shaktiman 2 and Shaktiman 4) and three sulphur levels (15 kg S/ha, 30 kg S/ha and 45 kg S/ha) as sub-plot. The total rainfall received during crop period 484.2 mm and 722 mm during June 2009 to December 2009 and June 2010 to December 2010, respectively. Crop was sown on bed; bed was prepared with tractor drawn bed maker cum planter with the distance of 67.5 cm between centre to centre of bed and bed size including 37.5 cm bed top and 30 cm furrows. One row/bed of crop was sown with maintaining 22.5 cm of plant to plant distance. Nitrogen and sulphur were applied as per treatments while P (60 kg/ha) and K (40 kg/ha) were applied uniformly across the treatments and hybrids. Geographly experimental site falls under the sub-tropical zone of Indo-Gangetic plains lies on the left bank of river Ganga. It is located on 25^0 18'N lactitude, 83^0 3´ E longitude and at an altitude of 75.70 meters above mean sea levels in the Northern Gangetic Alluvial plains. The soil was slightly alkaline (pH 7.6) determined by Glass electrode pH meter (Jaction 1973). The soil was sandy loam with initial available N content (183.00 kg/ha) determined by Alkaline paramagnet method (Subbiah and Asija 1973), P content (21.00 kg/ha) determined by Olsen's, method (Olsen *et al*. 1954), K content (228.00 kg/ha) determined by Flame photometer method (Jaction 1973) and available sulphur content (14.32 kg/ha) determined by Spectrophotometer method (Black 1965). Observations, viz. green leaf/plant, dry matter accumulation (g/plant), number of cobs/plant, cob diameter (cm) and test weight (g), grains and biological yield (q/ha), net return (₹/ha), B:C ratio, protein content (%), protein yield (q/ha), N, P, K and S content in plant was observed under crop parameters. Protein content (%) in grain was worked out by multiplying the nitrogen content in grain with the factor 6.25. The economics was computed by using the prevalent prices of inputs and outputs. To test the significance, the experimental data collected on various aspects were analysed with the procedure described by Cochran and Cox (1967) and adopted by Cheema and Singh (1991) in statistical package CPCS 1.

RESULTS AND DISCUSSION

Growth and yield attributes of QPM hybrids

The statistical analysis of data (Table 1) revealed that plant attained maximum number of green leaf/plant, dry matter accumulation (g/plant), number of cobs/plant, cob diameter (cm) and test weight (g) under application of 150 kg N/ha as compared to 100 kg N/ha, 50 kg N/ha and 0 kg N/ha during both years. Supply of adequate quantity of

Table 1 Growth and yield attributes of quality protein maize (QPM) hybrids as affected by nitrogen and sulphur levels

Treatment	Number of green leaf/plant		Dry matter (g/plant)		Cobs/plant		Cob diameter (cm)		Test weight (g)	
	2009-2010	2010-2011	2009-2010	2010-2011	2009-2010	2010-2011	2009-2010	2010-2011	2009-2010	2010-2011
Nitrogen levels										
0 kg/ha	6.98	7.78	170.73	177.81	1.02	1.05	3.17	3.21	220.64	220.86
50 kg/ha	8.32	9.39	230.3	239.96	1.12	1.12	3.69	3.74	226.97	227.66
100 kg/ha	9.34	10.03	247.76	251.97	1.33	1.39	4.01	4.11	225.84	238.07
150 kg/ha	10.53	11.06	275.96	282.34	1.47	1.56	4.38	4.48	246.69	247.33
CD (P=0.05)	1.34	1.87	13.04	15.90	0.09	0.16	0.30	0.34	4.48	5.43
QPM hybrids										
Shaktiman-2	8.67	9.43	229.94	236.04	1.22	1.26	3.75	3.82	228.75	232.35
Shaktiman-4	8.91	9.70	232.43	240.00	1.25	1.30	3.87	3.94	231.31	234.61
CD (P=0.05)	0.21	0.24	2.02	3.16	0.02	0.02	0.07	0.09	2.13	2.22
Sulphur levels										
15 kg/ha	8.58	9.26	225.19	230.59	1.18	1.24	3.67	3.71	227.81	230.75
30 kg/ha	8.87	9.63	228.33	237.83	1.24	1.27	3.81	3.88	229.45	233.63
45 kg/ha	8.92	9.80	240.03	245.64	1.29	1.32	3.96	4.05	232.85	236.06
CD (P=0.05)	0.25	0.28	5.73	6.23	0.04	0.04	0.11	0.15	2.33	2.40

nitrogen might have enhanced the availability of nitrogen due to its quick release and mineralization, which in turn may enhance the growth and developmental process. The findings are in corroboration with those reported by Meena *et al.*(2011). Similar observations were also reported by Choudhary *et al*. (2007). Among QPM hybrids Shaktiman 4 recorded higher number of green leaf/plant, dry matter accumulation (g/plant), number of cobs/plant, cobs diameter (cm) and test weight (g) than Shaktiman 2 in both the years. The application of sulphur enhanced the growth and yield attributes, significantly. Number of green leaf/plant, dry matter accumulation (g/plant), number of cobs/plant, cob diameter (cm) and test weight (g) was found to be significantly higher under the application of 45 kg S/ha followed by 30 kg S/ha and 15 kg S/ha in both the years.

Grain and biological yield of QPM hybrids

Application of 150 kg N/ha recoded significantly 43.94%, 43.43% higher grain yield and 38.16%, 37.06% higher biological yield over control during 1st and 2nd year, respectively (Table 2). The beneficial effect of N application on growth, yield attributes, yield and than their cumulative effects are responsible for enhancing productivity at higher N levels. The results are in close conformity with those of Bhat *et al*. (2008) and Khan *et al*. (2005). QPM hybrids could significantly affect the grain and biological yield. Shaktiman-4 recorded significantly 3.55 %, 2.62 % higher grain yield and 2.33 %, 3.04 % higher biological yield in 1st and 2nd years, respectively as compared to Shaktiman 2. The considerable improvement due to Shaktiman 4 might be due to growth and yield attributing characters. The results are in close conformity with those of Hamidi and Nasab (2001). Sulphur levels have also significant effect on the grain and biological yield of QPM hybrids during each year's (Table 2). Application of 45 kg S/ha resulted significantly higher grain yield to the tune of 10.77%, 10.25% higher grain yield and 6.17%, 6.12% higher biological yield than 15 kg S/ha in 1st and 2nd year, respectively. The considerable improvement in grain yield, due to application of 45 kg S/ha might be attributed to the fact that sulphur nutrients had the positive and cumulative effect of growth and yield attributes that's responsible for higher yield with the application of 45 kg S/ha the findings are in close conformity to those of Mehta *et al*. (2005).

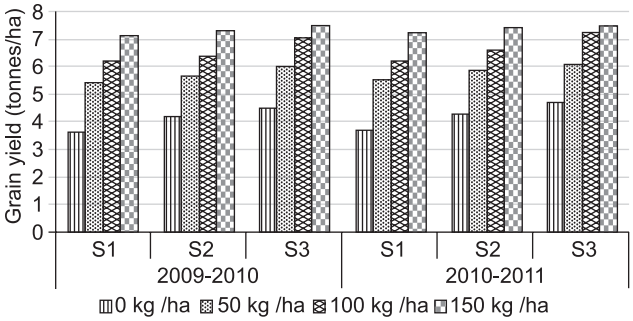

Fig 1 Interaction of nitrogen × sulphur on grain yield (tonnes/ha) of QPM hybrids.

The grain yield of QPM hybrids varied significantly due to levels of N and S during both the years (Fig 1). The significantly highest grain yield was obtained with the combined use of 150 kg N/ha with 45 kg S/ha, which were significantly higher than all the remaining combination of nitrogen and sulphur. The application of 150 kg N/ha with 30 kg S/ha was second best treatment combination (Fig. 1) The results are in close conformity with those of Maurya *et al*. (2005).

Economics

The net return (₹ 48 598.54/ha and ₹ 50 091.04/ha) and

Table 2 Yield and economics of QPM hybrids as affected by nitrogen and sulphur levels

Treatment	Grain yield (tonne/ha)		Biological yield (tonne/ha)		Net return (₹/ha)		B: C ratio	
	2009-2010	2010-2011	2009-2010	2010-2011	2009-2010	2010-2011	2009-2010	2010-2011
Nitrogen levels								
0 kg/ha	4.12	4.23	11.46	11.93	16 638.08	17 997.29	1.59	1.63
50 kg/ha	5.71	5.84	15.45	16.10	33 041.29	34 663.3	2.14	2.19
100 kg/ha	6.58	6.68	16.63	16.91	40 960.63	42 027.46	2.38	2.42
150 kg/ha	7.36	7.49	18.52	18.95	48 598.54	50 091.04	2.61	2.66
CD (P=0.05)	0.48	0.50	1.05	1.58	1 498.52	2 578.20	0.20	0.23
QPM hybrids								
Shaktiman-2	5.79	5.94	15.33	15.84	33 616.60	35 185.79	2.15	2.21
Shaktiman-4	6.01	6.10	15.70	16.10	35 328.85	36 513.90	2.20	2.24
CD (P=0.05)	0.11	0.11	0.24	0.25	612.00	795.00	0.02	0.02
Sulphur levels								
15 kg/ha	5.59	5.69	15.11	15.47	32 472.99	33 566.96	2.15	2.19
30 kg/ha	5.85	6.04	15.32	15.96	33 879.93	36 022.91	2.16	2.21
45 kg/ha	6.27	6.34	16.10	16.48	37 139.20	38 013.15	2.22	2.27
CD (P=0.05)	0.12	0.17	0.67	0.70	785.00	1 102.00	0.03	0.04

B: C ratio (2.61 and 2.66) was higher with application of 150 kg N/ha in 1st and 2nd years, respectively as compared to 100 kg N/ha, 50 kg N/ha and 0 kg N/ha (Table 2). The higher net return was attributed to the higher grain yield. The results are in close conformity with that of Ram *et al*. (2006). Shaktiman 4 resulted higher net return (₹ 35 328.85/ ha and ₹ 36 513.90/ha) and B: C ratio (2.20 and 2.24) over Shaktiman 2. Each successive increment of S levels from 15 to 45 kg S/ha improved the values of net return during both the years (Table 2). Application of 45 kg S/ha observed highest net return (₹ 37 139.20/ha and ₹ 38 013.15/ha) and B: C ratio (2.22 and 2.27) during 1st and 2nd years, respectively followed by 30 kg S/ha and 15 kg S/ha (Table 2). The findings are in corroboration with those reported by Patel *et al*. (2004).

Quality of QPM hybrids

Quality parameters, ie protein content (%) and protein yield (q/ha) of QPM hybrids improved significantly with each successive increase in N level up to 150 kg N/ha during both the years (Table 3). Supply of adequate quantity of N might have enhanced the availability and N content due to its quick release and mineralization, which in turn may enhance the protein content (%). The findings are in corroboration with those reported by Bhat *et al*. (2008). QPM hybrids, proved the significant effect in respect of protein content and protein yield (kg/ha). The highest value of protein content (%) was recorded under Shaktiman 4 as compared to Shaktiman 2. The results are in findings with those of Gupta *et al*. (2009). Application of 45 kg S/ha enhanced protein content (%) and protein yield (kg/ha) significantly followed by 30 kg S/ha and 15 kg S/ha. The sulphur might have released the sufficient amount of available S at constant levels which resulted higher amount of residual contents of available nutrients particularly N and better environment for increased uptake of nutrients and consequently enhance protein content (%).The results are in consonance with those of Ram *et al*. (2006).

Nutrient content

Nitrogen, phosphorus, potassium and sulphur content was significantly higher under application of 150 kg N/ha as compared to 100 kg N/ha, 50 kg N/ha and 0 kg N/ha during both the years (Table 3). Supply of adequate quantity of N might have enhanced the availability of nutrient content in plant. The results are in close conformity with those of Maurya *et al*. (2005). QPM hybrid, Shaktiman 2 recorded highest nitrogen, phosphorus, potassium and sulphur content than Shaktiman 4 during both the years; because of yielding ability of any crop plant is inversely proportional to the mean dry matter content in genotypes. Significantly highest nitrogen, phosphorus, potassium and sulphur content was recorded under 45 kg S/ha followed by 30 kg S/ha and 15 kg S/ha (Table 3). Supply of adequate quantity of sulphur might have enhanced the availability of nutrients resulting higher nutrient content in plants. The nutrient content is the function of yield with nutrient concentration and yield is

Table 3 Quality and nutrient content (%) in plant of QPM hybrids as affected by nitrogen and sulphur levels

Treatment	Protein content (%)		Protein yield (kg /ha)		N content (%)		P content (%)		K content		S content	
	2009-2010	2010-2011	2009-2010	2010-2011	2009-2010	2010-2011	2009-2010	2010-2011	2009-2010	2010-2011	2009-2010	2010-2011
Nitrogen levels												
0 kg/ha	9.14	9.19	376.93	389.28	2.182	2.231	0.336	0.340	1.592	1.600	0.259	0.262
50 kg/ha	10.19	10.30	581.95	601.31	2.542	2.606	0.345	0.350	1.639	1.646	0.267	0.269
100 kg/ha	10.91	11.06	718.20	734.80	2.790	2.829	0.368	0.379	1.774	1.787	0.278	0.282
150 kg/ha	11.17	11.20	821.66	838.76	2.866	2.872	0.396	0.416	1.859	1.869	0.286	0.290
CD (P=0.05)	0.21	0.23	8.95	9.65	0.040	0.075	0.040	0.110	0.074	0.148	0.008	0.020
QPM hybrids												
Shaktiman-2	10.26	10.36	554.87	615.48	2.601	2.639	0.363	0.378	1.721	1.725	0.273	0.277
Shaktiman-4	10.44	10.52	627.65	641.82	2.589	2.635	0.359	0.376	1.712	1.720	0.271	0.275
CD (P=0.05)	0.08	0.10	4.89	5.65	NS	NS	NS	NS	NS	NS	NS	NS
Sulphur levels												
15 kg/ha	10.25	10.36	574.81	589.00	2.564	2.605	0.339	0.344	1.614	1.619	0.269	0.271
30 kg/ha	10.371	10.43	607.06	630.18	2.602	2.643	0.365	0.372	1.717	1.725	0.273	0.275
45 kg /ha	10.439	10.52	654.27	666.86	2.620	2.659	0.382	0.397	1.819	1.836	0.277	0.283
CD (P=0.05)	0.10	0.12	6.42	7.89	0.030	0.037	0.020	0.040	0.032	0.082	0.006	0.010

Table 4 Nitrogen and sulphur balance sheet as influenced by nitrogen and sulphur levels of QPM hybrids

Treatment	Total available N (Initial + added fertilizers) through (kg/ha)		Total N harvest (kg/ha)		Expected N balance after last harvest/Net loss or gain (kg/ha)		Total available S (Initial + added through fertilizer) (kg/ha)		Total S harvest (kg/ha)		Expected S balance after last harvest/ Net loss or gain (kg/ha)	
	2009-2010	2010-2011	2009-2010	2010-2011	2009-2010	2010-2011	2009-2010	2010-2011	2009-2010	2010-2011	2009-2010	2010-2011
Nitrogen levels												
0 kg/ha	183	181	113.83	120.85	69.17	60.15	14.32	17.32	14.35	15.62	–0.03	1.7
50 kg/ha	233	231	181.97	194.12	57.03	36.88	14.32	17.32	24.05	26.14	–9.73	–8.82
100 kg/ha	283	281	218.81	226.58	64.19	54.42	14.32	17.32	29.75	31.34	–15.43	–14.02
150 kg/ha	333	331	238.00	245.00	95.00	86.00	14.32	17.32	32.93	36.75	–18.61	–19.43
QPM hybrids												
Shaktiman-2	183	181	185.89	194.92	–2.89	–13.92	14.32	17.32	23.60	26.39	–9.28	–9.07
Shaktiman-4	183	181	190.12	198.29	–7.12	–17.29	14.32	17.32	26.18	28.42	–11.86	–11.10
Sulphur levels												
15 kg/ha	183	181	179.72	187.00	3.28	–6.00	29.32	32.32	23.94	25.33	5.38	6.99
30 kg/ha	183	181	186.42	197.07	–3.42	–16.07	44.32	47.32	24.98	26.75	19.34	20.57
45 kg/ha	183	181	198.20	205.72	–15.2	–24.72	59.32	62.32	26.78	30.50	32.54	31.82

more deciding factor for higher nutrient uptake. The results are in consonance with those of Sakal *et al*. (2000).

Nitrogen and sulphur balance

Addition of N to the soil was the highest with 150 kg N/ha. Increasing N levels improved N uptake and maximum value was recorded at 150 kg N/ha (Table 4). Among the two QPM hybrids Shaktiman 4 recorded higher N uptake as compared to Shaktiman 2. Sulphur application also enhanced the N availability and N uptake with increasing levels from 15 kg S/ha to 45 kg S/ha in both the years. Based on the initial N of the soil and addition and depletion of the N, the expected N balance/net loss or gain was negative with QPM hybrids and sulphur treatments in both the years. In general, the expected balance/net loss or gain of N was positive among N treatments and recorded more with the application of 150 kg N/ha during both the years. These findings supported those of Meena *et al*. (2011). Sulphur addition to the soil was the highest with 45 kg S/ha. Increasing sulphur levels improved sulphur uptake and maximum value was recorded at 45 kg S/ha (Table 4). Among the two QPM hybrids Shaktiman 4 recorded higher sulphur uptake as compared to Shaktiman 2. Sulphur application also enhanced the sulphur availability and sulphur uptake with increasing levels from 15 kg S/ha to 45 kg S/ha in both the years. Based on the initial sulphur of the soil and addition and depletion of the S, the expected sulphur balance/net loss or gain was negative with nitrogen levels and QPM hybrids in both the years. In general, the expected balance/net loss or gain of sulphur was positive among sulphur treatments and recorded more with the application of 45 kg S/ha during both the years. Similar findings also reported by Sakal *et al*. (2000).

With the results of above findings, it may be concluded that QPM hybrid Shaktiman 4 along with the application of 150 kg N/ha with 45 kg S/ha recorded significantly highest grain yield, quality, net return and B: C ratio under dryland conditions of Eastern Uttar Pradesh, India.

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