Indian Journal of Agronomy **58** (3): 340–343 (September 2013)

Research Paper

Productivity and economics of quality protein maize (*Zea mays*) as influenced by nitrogen levels, its scheduling and sulphur application

ROSHAN CHAUDHARY[1], D. SINGH[2] AND V. NEPALIA[3]

Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan 313 001

Received : February 2013; Revised accepted : July 2013

ABSTRACT

A field experiment was conducted during rainy season of 2010 and 2011 at Udaipur to ascertain suitable nitrogen level (125, 150 and 175 kg N/ha), appropriate schedule of nitrogen application (3, 4 and 5 splits) with and without sulphur (control and 40 kg S/ha) for quality protein maize (*Zea mays* L.) in soils having medium fertility status. Results pooled over two years indicated that dry matter accumulation recorded under 175 kg N/ha was significantly higher over 150 and 125 kg N/ha at successive growth stages, while crop growth rate increased significantly upto 150 kg N/ha. Application of 175 kg N/ha significantly increased yield attributing parameters consequently yield and nutrient uptake, N status of soil and proved economically profitable to 150 and 125 kg N/ha. Staggering of nitrogen application in 4 equal splits as 25% at sowing + 25% at 4–6 leaf stage + 25% at knee high stage + 25% at 50% tasseling stages showed marked improvement in growth, yield attributes, yield, nutrient uptake, N status of soil and proved economically beneficial compared to recommended 3 splits of nitrogen application. Application of 40 kg S/ha affirmed potential role in enhancing productivity of quality protein maize and also proved economically profitable compared to control.

Key words : Nitrogen levels, Nitrogen scheduling, Quality protein maize, Sulphur

In India maize is an important cereal crop and grown on 8.49 mha with production and productivity of 21.29 mt and 2.51 t/ha. Out of total production 45% is consumed as staple food in various forms. Beside this maize is a main ration for poultry birds. Forage maize is used as fresh or dry fodder. 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 tryptophane and reduced leucine and isoleucine contents and produce quality protein with balanced composition of amino acids (Prasanna *et al.*, 2001). 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). Most popular variety of quality protein maize 'HQPM 1' is having slow initial growth and thereafter vigorous growth, thus its nitrogen requirement is high compared to other hybrids (Singh, 2010). 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). 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). 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. In addition to nitrogen, deficiency of sulphur has been reported over the past several years and high attention is required on the importance of the element in plant nutrition (Nader and Nadia, 2011). Therefore to standardize nitrogen level, its scheduling and to find response of quality protein maize to sulphur fertilization is need of the hours.

[2]**Corresponding author Email:** dilipagron@gmail.com
[1]Subject Matter Specialist; [2&3]Professor, Rajasthan College of Agriculture, MPUAT, Udaipur

MATERIALS AND METHODS

A field experiment was carried out during *kharif* 2010 and 2011 at Rajasthan College of Agriculture, Udaipur, Rajasthan which is situated at 23°34'N latitude and 73°42'E longitude at an altitude of 582.17 meter above the mean sea level. The soil of the experiment site was clay loam having pH 7.5 and 7.7, organic carbon 0.66 and 0.67, available nitrogen 268.4 and 270.18 kg/ha, available phosphorus 19.5 and 18.7 kg/ha, available potassium 365.5 and 370.5 kg/ha and available sulphur 9.4 and 9.2 ppm in the plough layer. The well distributed rainfall of 758.0 and 642.0 mm was recorded during crop growth period of 2010 and 2011, respectively. The treatment, combination of 3 nitrogen levels (125, 150 and 175 kg N/ha), 3 scheduling (3 splits as 33.3 % at sowing + 33.3% at knee high + 33.3% at 50% tasseling, 4 splits as 25% at sowing + 25% at 4–6 leaf stage + 25% at knee high stage + 25% at 50% tasseling and 5 splits as 10% at basal + 20% at 4–6 leaf stage + 30% at knee high stage + 30% at 50% tasseling + 10% at grain filling stage) and two sulphur levels (control and 40 kg sulphur/ha) were tested in three times replication factorial randomized block design. The full maturing single cross quality protein maize hybrid 'HQPM 1', which was released by All India Coordinated Research Project on maize for commercial cultivation throughout India during 2004 was used as test variety. The crop was sown manually by placing two seeds a depth of 5–6 cm maintaining rows and plants spacing at a 60×25 cm on 3 July, 2010 and 5 July, 2011, respectively. The crop was harvested during second fortnight during both the years. The experimental plot size was 15 m^2. Thinning was carried out at 15 days after sowing to maintain required plant population. Nitrogen as per treatments was top dressed in 3, 4 and 5 splits. The recommended and uniform dose of 30 kg P_2O_5/ha was also given through DAP as basal application. In order to minimize weed competition, pre-emergence application of atrazine at 0.5 kg/ha followed by one hoeing and earthing up at 20 days after owing was carried out. Net returns and B:C ratio were evaluated on basis of prevailing market prices of inputs and produce. Leaf area index (LAI), Chlorophyll, protein content, nutrient uptake, crop growth rate (CGR) and soil status of different nutrient were worked out by using standard methods for analysis and formula. Data of each character collected were statistically analyzed using standard procedure of variance analysis.

RESULTS AND DISCUSSION

Growth characters

Application of 150 kg N/ha significantly increased plant height over 125 kg N/ha at 90 days after sowing (DAS). Further increase in N rate fail to record statistical significance over 150 kg N/ha. Increasing rate from 125 to 175 kg N/ha significantly increased dry matter accumulation at 90 DAS, chlorophyll content and LAI at 50 per cent tasseling stage. The crop growth rate between 60–90 days after sowing significantly responded upto 150 kg N/ha. On medium nitrogen status soil, these significant improvement with increasing level of nitrogen might be on account of high uptake of required nutrients, chlorophyll and increased LAI for growth and development of plant (Sreelatha *et al.*, 2012). Staggering of nitrogen application in four equal splits at sowing, 4–6 leaf stage, knee high and 50% stages significantly increased plant height, dry matter accumulation at 90 DAS, CGR between 60-90 DAS, chlorophyll content and LAI at 50% tasseling stage, compared to recommended three splits of nitrogen application. Further staggering its application in five splits failed to record statistical significance. In present experiment urea was used as source of fertilizer, which hydrolyses in presence of urease enzyme in ammonium carbonate which is an unstable compound and decompose to ammonia and nitrate and in these form nitrogen is absorbed by plants within a week period of time. Some of ammonia may be lost through leaching and denitrification and cause low recovery of nitrogen. Thus under four splits of nitrogen application these losses may be negligible and it becomes available for longer period and increased its use efficiency and efficient uptake (Bindhani *et al.*, 2008).

Sulphur application significantly improved plant growth in terms of plant height, dry matter, LAI, chlorophyll content and CGR. With addition of sulphurs its availability increase in plant system as a consequence of lower hydration of (SO_4^{-2}-S) ions, the plant cell colloids, get swollen which reduce turgor pressure thereby increase transpiration and ultimately led to higher extraction of nutrient from soil environment towards plant system. Further sulphur involved in synthesis of S containing amino acids, various enzymatic processes and various oxidation reduction reaction of plant resulting in greater meristamatic activities and apical growth thereby improving overall plant growth (Jaliya *et al.*, 2012).

Yield attributes and yield

Yield attributes of quality protein maize showed marked improvement with successive increase in nitrogen levels upto 175 kg N/ha, consequently highest grain and fodder yields were recorded under 175 kg N/ha which were significantly higher over 150 and 125 kg N/ha. The variation in yield attributes, grain and fodder yields correspond to improvement in growth of crop due to increasing levels of nitrogen (Singh, 2010).

Application of nitrogen in 4 splits significantly increased most of yield attributing consequently grain and stover yields over three split application of nitrogen. This appears to be on accounts of vigorous growth of plant as reflected by higher plant height, CGR, chlorophyll and LAI of plant. Under four splits of nitrogen application, higher availability of nitrogen coincided with three critical stages of crop growth namely pre-knee high, knee high and 50% tasseling *i.e.*, during complete grand growth phase of crop. This eventually suggest observed longer available period of nitrogen under four splits in soil accentuating greater content and uptake of N, P, K and S in grain and stover, thus increasing yield attributes and yield compared to three splits (Singh, 2010).

Application of 40 kg S/ha significantly improved yield attributes consequently productivity estimated in terms of grain and stover yield. The effect of sulphur fertilization appears to be due to vigorous growth of plant as its presence in plant system suggest greater availability of metabolites and nutrients (Singh, 2010) synchronized to demand for growth and development of each reproductive structure (Jaliya *et al.,* 2012).

Nutrient uptake

Highest uptake of N, P and K were recorded under 175 kg N/ha, which were significantly higher over 150 and 125 kg N/ha. Similarly application of nitrogen in four splits significantly enhanced total accumulation of N, P, K and S over recommended three split application of nitrogen. Sulphur application also enhanced total N, P, K and S uptake over no sulphur application. The marked improvement in uptake of nutrient could be ascribed to greater availability of N and S in soil environment through direct application, improvement in dry matter and its synergistic effect on P and K (Jaliya *et al.,* 2012).

Soil status

Application of 175 kg N/ha retained significantly higher nitrogen in soil over 150 and 125 kg N/ha. Likewise N retained under 5 splits of N application was significantly higher over 3 splits but proved statistically at par with 4 splits of nitrogen application. Similarly, sulphur application also improved sulphur status in soil compared to control. This might be on account of direct application of nutrients in soil.

Protein content

Application of 150 kg N/ha significantly increased protein content of grain over 125 kg N/ha. Similarly, 4 splits proved better over 3 splits in terms of protein synthesis. Sulphur application significantly increased protein over no sulphur application. Improvement in protein content under N and S application is expected as N and S are constituents of protein, enzymes and chlorophyll (Jaliya *et al.,* 2012).

Economics

The pooled data inferred that application of 175 kg N/ha produced significantly higher grain yield

Table 1. Effect of nitrogen, its scheduling and sulphur application on growth parameters, yield attributes, yield and economics of quality protein maize (Pooled data of two years)

Treatment	Plants at harvest (×10³/ha)	LAI at 50% tasseling	At 90 DAS		Chl* 50 % tasseling	CGR* at 60-90 DAS	Yield attributes				Yields (t/ha)		Economics	
			Plant height (cm)	DM (g/plant)			Grains/ cob	Grains weight/ plant	Test weight (g)	Shelling (%)	Grain	Stover	Net returns (×10³ ₹/ha)	B:C ratio
Nitrogen levels (kg/ha)														
125	64.2	3.62	193.8	193.8	2.28	12.0	313	65.5	185.8	75.9	3.72	5.71	38.0	2.05
150	64.3	3.98	203.9	203.9	2.31	12.4	325	69.0	191.8	78.2	4.42	6.82	48.3	2.58
175	64.1	4.30	209.1	209.1	2.37	12.6	339	73.6	196.9	80.2	4.85	7.53	54.7	2.88
SEm±	0.50	0.072	1.93	1.93	0.013	0.10	4.42	0.95	1.593	0.70	0.104	0.170	1.91	0.085
CD (P=0.05)	NS	0.202	5.45	5.45	0.036	0.28	12.46	2.69	4.497	1.97	0.295	0.479	5.39	0.240
Nitrogen scheduling														
3 splits	64.2	3.79	194.6	194.6	2.29	12.1	317	66.0	187.5	76.5	3.92	6.047	40.6	2.20
4 splits	64.2	4.04	204.7	204.7	2.33	12.5	328	70.2	193.4	78.8	4.47	6.914	48.9	2.62
5 splits	64.2	4.06	207.5	207.5	2.35	12.5	332	71.8	193.6	79.0	4.60	7.107	51.4	2.69
SEm±	0.50	0.072	1.93	1.93	0.013	0.10	4.42	0.95	1.593	0.7	0.104	0.170	1.91	0.085
CD (P=0.05)	NS	0.202	5.45	5.45	0.036	0.28	12.46	2.69	4.497	1.9	0.295	0.479	5.39	0.240
Sulphur levels (kg/ha)														
Control	64.3	3.87	197.0	197.0	2.30	12.2	318	68.1	189.1	77.0	4.06	6.44	43.0	2.30
40	64.1	4.06	207.5	207.5	2.34	12.5	333	70.6	193.9	79.2	4.60	7.11	51.0	2.71
SEm±	0.41	0.059	1.57	1.57	0.010	0.08	3.61	0.78	1.301	0.57	0.085	0.138	1.56	0.069
CD (P=0.05)	NS	0.165	4.45	4.45	0.030	0.23	10.18	2.20	3.672	0.16	0.241	0.391	4.40	0.196

CGR: Crop growth rate in (g/m²/day) Chl: Chlorophyll content

Table 2. Effect of nitrogen, its scheduling and sulphur application on nutrient uptake, grain protein content and available soil nutrients status (Pooled data of two years)

Treatment	Nutrient uptake (kg/ha)								Grain protein content (%)	Available nutrient status (kg/ha)			PPM
	N		P		K		S						
	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover		N	P_2O_5	K_2O	S
Nitrogen levels (kg/ha)													
125	61.1	35.8	13.2	8.8	15.5	64.4	4.4	17.7	10.2	260.6	17.3	290.6	12.5
150	73.9	45.0	15.7	10.6	18.4	77.0	5.4	21.2	10.4	264.2	17.3	291.1	12.5
175	82.0	51.8	17.2	11.7	20.2	85.1	5.9	23.6	10.5	268.4	17.3	293.2	12.5
SEm±	2.09	1.26	0.46	0.41	0.54	2.25	0.17	0.55	0.05	1.02	0.12	1.97	0.09
CD (P=0.05)	5.91	3.56	1.31	1.16	1.53	6.37	0.48	1.57	0.14	2.89	NS	NS	NS
Nitrogen scheduling													
3 Splits	64.4	38.6	13.9	9.3	16.3	68.3	4.7	18.7	10.2	262.2	17.2	290.6	12.6
4 Splits	75.3	46.3	15.9	10.8	18.6	78.0	5.4	21.6	10.4	264.6	17.3	292.4	12.5
5 Splits	77.3	47.8	16.3	11.0	19.1	80.3	5.6	22.3	10.5	266.4	17.3	292.0	12.4
SEm±	2.09	1.26	0.46	0.41	0.54	2.25	0.17	0.55	0.05	1.02	0.12	1.97	0.09
CD (P=0.05)	5.91	3.56	1.31	1.16	1.53	6.37	0.48	1.57	0.14	2.89	NS	NS	NS
Sulphur levels (kg/ha)													
Control	67.6	41.3	14.4	9.7	16.9	70.6	4.7	18.8	10.2	264.0	17.2	290.7	12.0
40	77.1	47.2	16.3	11.1	19.2	80.4	5.8	22.9	10.5	264.7	17.3	292.6	13.0
SEm±	1.71	1.03	0.38	0.33	0.44	1.84	0.14	0.45	0.04	0.83	0.10	1.61	0.07
CD (P=0.05)	4.83	2.91	1.07	0.95	1.25	5.20	0.39	1.28	0.12	NS	NS	NS	0.21

and also proved economically beneficial with highest net returns (₹54,709/ha) and B:C ratio (2.88). Amongst nitrogen schedules, application of nitrogen in four splits produced significantly higher net returns and B:C ratio by ₹8,234/ha and 0.42 respectively over recommended three split application of nitrogen. Alike this application of 40 kg S/ha affirmed potential role in enhancing productivity of quality protein maize and proved economically profitable compared to control. This might be on account of higher productivity of quality protein maize under judicious use of nitrogen and sulphur.

Based on findings of present investigation, it may be concluded that quality protein maize 'HQPM-1' should be fertilized with 175 kg N/ha in four splits at basal, 4-6 leaf, knee high and 50 per cent tasseling stages along with 40 kg S/ha.

REFERENCES

Bindhani, A., Barik, K.C., Garnayak, I.M. and Mahapatra, P.K. 2008. Productivity and nitrogen use efficiency of baby corn (*Zea mays*) at different levels and timing of nitrogen application under rainfed conditions. *Indian Journal of Agricultural Sciences* **78**(7): 629–31.

Das, A., Patel, D.P., Munda, G.C. and Ghosh, P.K. 2010. Effect of organic and inorganic sources of nutrients on yield, nutrient uptake and soil fertility of maize (*Zea mays*)-mustard (*Brassica campestris*) cropping system. *Indian Journal of Agricultural Sciences* **80**(1): 85–88.

Jaliya, M.M., Chiezey, U.F., Tanimu, B., Odunze, A.C., Othman, M.K., Babaji, B.A., Sani, B.M., Mani, H. 2012. Effect of nitrogen and sulphur fertilizers on nitrogen content in soil, ear leaf, flag leaf and grain of QPM maize varieties at Samaru Zaria. *Journal of Agricultural Sciences* **4**(5): 217–22.

Nader, R.H. and Nadia M.H. 2011. Effect of elemental sulphur and partial substitution of N-Mineral fertilizer by organic amendments on some properties of slight saline soils. *Journal of Applied Sciences Research* **7**(12): 2102–11.

Prassanna, B.M., Vasal, S.K., Kassahun, B. and Singh, N.V. 2001. Quality protein maize. *Current Science* **81**: 1308–19.

Shreelatha, D., Shivalaxmi, Y., Anuradha, M. and R. Ranghaswamy. 2012. Productivity and profitability of rice——maize cropping system as influenced by site-specific nutrient management. *Maize Journal* **1**: 58–60.

Singh, D. 2010. Impact of scheduling on nitrogen on productivity of single cross maize (*Zea mays* L.) hybrids. *Indian Journal of Agricultural Sciences* **80**(7): 649–51.

Sofi, P.A., Wani, S.A., Rathore, A.G. and Wani, S.H. 2009. Quality protein maize (QPM): Genetic manipulation for the nutritional fortification of maize. *Journal of Plant Breeding and Crop Science* **1**: 244–53.

Zaidi, P.H., Mani, P., Selvan, R.S., Singh, R.P. and Singh, N.N. 2005. Problem of low nitrogen stress tolerance in tropical maize. Chapter in book '*Stresses on Maize in Tropics*' Directorate of Maize Research, New Delhi, pp. 137–7.