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IMPACT OF NITROGEN AND SULPHUR FERTILIZATION ON YIELD, QUALITY AND UPTAKE OF NUTRIENT BY MAIZE IN SOUTHERN RAJASTHAN

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ABSTRACT

A field experiment was conducted at Udaipur during two kharif seasons of 2010 and 2011 in factorial randomized block design to study effect of nitrogen levels and its scheduling on productivity and quality of maize (Zea mays L.) with and without sulphur application. Three levels of nitrogen (125, 150 and 175 kg N ha^{-1}), three schedules of nitrogen application (3 splits, 4 splits and 5 splits) and 2 levels of sulphur (control and 40 kg S/ha) were tested. The results revealed that the application of 175 kg N ha^{-1} significantly increased yields, quality and nutrient uptake by maize crop over 150 and 125 kg N ha^{-1}. Amongst nitrogen schedules, application of nitrogen in four splits in ratio of 25:25:25:25 at basal, 4 to 6 leaf, knee high and 50 per cent tasseling stages recorded significantly higher yields, quality and nutrient uptake by crop over recommended three split application of nitrogen at basal, knee high and 50 per cent tasseling stages. Further, the application of 40 kg S ha^{-1} significantly increased yields, quality and nutrient uptake by crop over control.

Key words: Maize, nitrogen scheduling, sulphur, quality, nutrient uptake, yield

INTRODUCTION

In India, maize is the third most important cereal crop grown on 8.12 m ha with the production and productivity of 21.29 m tonnes and 25.07 q ha^{-1}, respectively (Eco. Stat., 2011). It has diverse uses in various forms. Out of the total production, 45 % is consumed as staple food in various forms. The traditional recommended maize varieties having low protein content with unbalanced composition of essential amino acids *viz*. lysine and tryptophan are low while leucine and isoleucine are high. In tribal and rural areas where maize is a principlal dietary source these traditional varieties causes several diseases like kwashiorkor and malnutrition. To overcome these nutritional problems the specially bred single cross hybrids (*Opaque*-2 modifier gene) were developed, which improves lysine and tryptophan and reduces the leucine and isoleucine content and provide the quality protein with balanced amino acids. In general, maize is an exhaustive crop and requires very high doses of nitrogen and other nutrients. Optimization of nitrogen doses is essentially required to achieve higher yield of QPM as it can alone contribute 40-60 per cent in crop yield. Nitrogen is also an essential constituent of protoplasm and chlorophyll and is associated with the activity of every living cell. Most of the popular/ recommended varieties of QPM are single cross hybrids and they are very sensitive to nitrogen stress before flowering. Nitrogen stress during flowering stage results in kernel and ear abortion, whereas stress during grain filling accelerates leaf sencence, reduces photosynthesis and kernel weight (Meena, 2010). Thus, for enhancing the productivity of QPM single cross hybrids, optimization of nitrogen fertilization has emerged as a serious concern for maize growers. Apart from amount of application, nitrogen fertilization at critical stages is another important aspect of maize cultivation. At present only three splits of nitrogen *viz*., 1/3 at sowing, 1/3 at knee high stage and 1/3 at initiation of tasseling are recommended. This agronomic recommendation for composite, hybrids and normal maize may not be applicable for nitrogen exhaustive quality protein maize hybrids because of difference in their development pattern. To avoid leaching and other losses of nitrogen, its application should be standardized for QPM (Kumar 2009 and Singh 2010). Sulphur is indispensable for synthesis of certain amino acids and involved in various metabolic enzymatic processes in plants and consequently affects the grain yield quantity and quality both. In India, widespread sulphur deficiency is regarded as one of the major cause for yield plateau or even decline. Therefore, an investigation to find the response of Quality Protein Maize to sulphur fertilization is the need of the hour.

MATERIALS AND METHODS

The experiment was carried out at Rajasthan College of Agriculture, Udaipur, having sub-tropical climate. The experiment consisted of 18 treatment combination, viz three N levels (125, 150 and 175 kg ha^{-1}) and three nitrogen scheduling (3 splits: 33.3 % at sowing + 33.3 % at knee high stage + 33.3 % at 50 % tasseling, 4 splits: 25 % at sowing + 25 % at 4- 6 leaf stage + 25 % knee high stage + 25 % at 50 % tasseling and 5 splits: 10 % basal + 20 % at 4- 6 leaf stage + 30 % knee high stage + 30 % at 50% tasseling + 10 % at grain filling stage) and two sulphur levels (control and 40 kg S ha^{-1}) were evaluated under factorial randomized block design with three replications. The soil of experimental site was medium in available nitrogen (268 kg ha^{-1}) and available phosphorus (19.5 kg ha^{-1}), high in available potassium (365.5 kg ha^{-1}). The QPM single cross hybrid variety "Haryana Quality Protein Maize-1" (HQPM-1) was used as test crop. The test variety "HQPM-1" was sown with onset of rain on 3 and 5 July, during both the years using 20 kg seed ha^{-1}. In well prepared field, furrows were opened at 60 cm apart and two seeds were placed manually using 25 cm spacing at a depth of 3-4 cm. The crop was harvested on 15 and 20 October during both the years. Observations were recorded on grain yield from net plot area of 15 m^2. The uptake of N, P, K and S at harvest by grain and stover were computed by multiplying content value with yield data. The grain and stover samples collected at harvest were oven dried at 65°C to a constant weight and ground in laboratory mill. These samples were analysed for N by modified Kjeldal method (Jakson, 1973). Phosphorus content was determined in diacid (HNO_3 $HClO_4$) digest by molybdvanadate yellow colour method, K bu flame photometer and S turbidimetric method (Chesnin and Yien 1951).

RESULTS AND DISCUSSION

Effect on yield

It is evident from Table 1 that application of 175 kg N ha^{-1} significantly improved grain and stover yields over 125 kg N ha^{-1}. Amongst nitrogen schedules, application of nitrogen in four splits in ratio of 25:25:25:25 at basal, 4 to 6 leaf, knee high and 50 % tasseling stages recorded significantly higher grain, stover and biological yields over recommended three split application of nitrogen at basal, knee high and 50 % tasseling stages, respectively on pooled analysis basis and the extent of increase under four splits over three splits were 14.14, 14.34 and 14.25 %, respectively. Significant increase in grain yield due to application of higher nitrogen could be ascribed to the low status of available N in soil. It has been well emphasized that higher N fertilization to QPM plays vital role in improving three major aspects of yield determination i.e., formation of vegetative structure for nutrient absorption, photosynthesis and strong sink length through development of reproductive structure and production of assimilates to fill economically improved sink (source strength). Thus, cumulative influence of N application and other nutrients through synergetic effect Sreelatha *et.al.* (2012) seems to have maintained balanced source sink through improving both the events of crop development (vegetative and generative), ultimately resulted in increased grain yield. Positive response of QPM to higher nitrogen is in close conformity with the findings of Meena (2011). The significant increase in straw yield with application of increasing nitrogen levels seems to be due to its direct effect in improving biomass plant^{-1} at successive growth stages as well as at harvest of the crop, while the indirect effect might be on account of increase in various photosynthetic parameters *viz.*, LAI, chlorophyll and CGR at grand growth phase. Further, biological yield is a function of grain and straw yield representing reproductive and vegetative growth of the crop. Application of 40 kg S ha^{-1} significantly enhanced grain, stover and biological yields over control. The magnitude of increase was 13.3, 13.9 and 13.4 %, respectively on pooled basis. Significant increase in grain and stover yield due to application of 40 kg sulphur ha^{-1}could be ascribed its affect in improving biomass plant^{-1}at successive stages as well as in plant part at the harvest of the crop and might be on account of increase in plant height at successive stages. Further biological yield is a function of grain and stover yield representing reproductive and vegetative growth of the crop. The profound influence of S fertilization on both these events ultimately led to production of higher biological yield under its application. Jaga and Sharma (2013) reported similar results in wheat.

N nutrient uptake and quality

The results (Table 1) revealed that the uptake of N, P, K and S in grain and stover showed positive influence under application of 125 to 150 and 150 to 175 kg N ha^{-1}. The marked improvement in uptake of nutrients by grain and straw (N and P) could be ascribed to greater availability of N along with P and K to the level of sufficiency in soil environment through direct application of N and its synergetic effect on P and K. Amongst nitrogen application schedules, application of nitrogen in three equal splits registered the lowest N uptake by the crop. The application of nitrogen in four equal splits enhanced

Table 1: Effect of levels and scheduling of nitrogen, and sulphur on yields and nutrient uptake (kg ha^{-1}) by maize (Mean of 2 year)

Treatments	Yields (kg ha^{-1})		Nitrogen		Phosphorus		Potassium		Sulphur	
	Grain	Stover	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Nitrogen levels (kg ha^{-1})										
125	3724	5712	61.1	35.9	13.2	8.9	15.5	64.5	4.5	17.7
150	4424	6824	73.9	45.1	15.7	10.6	18.4	77.0	5.4	21.2
175	4855	7532	82.1	51.9	17.3	11.8	20.3	85.1	5.9	23.7
S. Em. ±	104.6	170.0	2.09	1.26	0.46	0.41	0.54	2.25	0.17	0.55
C.D. (P=0.05%)	295.3	479.8	5.91	3.56	1.31	1.16	1.53	6.37	0.48	1.57
Nitrogen scheduling										
3 Splits	3924	6047	64.5	38.6	13.9	9.4	16.4	68.3	4.7	18.7
4 Splits	4479	6914	75.3	46.4	15.9	10.8	18.7	78.0	5.5	21.6
5 Splits	4600	7107	77.4	47.9	16.4	11.1	19.2	80.3	5.7	22.3
S.Em. ±	104.6	170.0	2.09	1.26	0.46	0.41	0.54	2.25	0.17	0.55
C.D. (P=0.05%)	295.3	479.8	5.91	3.56	1.31	1.16	1.53	6.37	0.48	1.57
Sulphur levels (kg ha^{-1})										
Control	4063	6244	67.7	41.4	14.4	9.7	16.9	70.7	4.8	18.8
40	4606	7115	77.1	47.2	16.4	11.1	19.2	80.4	5.8	22.9
S. Em. ±	85.4	138.8	1.71	1.03	0.38	0.33	0.44	1.84	0.14	0.45
C.D. (P=0.05%)	241.1	391.7	4.83	2.91	1.07	0.95	1.25	5.20	0.39	1.28

N uptake significantly over three splits of nitrogen application on pooled basis. Thus greater availability of nutrients (Table 1) with higher nitrogen fertilization seems to have synergistic interactions between these nutrients to maintained critical concentration at cellular level, fulfilled their requirements for profuse plant growth and their efficient translocation towards sink component (stover and grain).

Table 2: Effect of levels and scheduling of nitrogen, and sulphur on protein content and economics (Mean of 2 year)

Treatments	Protein content (%)	Net returns (Rs.)	B C ratio
Nitrogen levels (kg ha^{-1})			
125	10.24	38000	2.05
150	10.43	48356	2.58
175	10.55	54709	2.88
S. Em. ±	0.050	1912	0.085
C.D. (P=0.05%)	0.140	5394	0.240
Nitrogen scheduling			
3 Splits	10.24	40697	2.20
4 Splits	10.49	48931	2.62
5 Splits	10.50	51436	2.69
S. Em. ±	0.050	1912	0.085
C.D. (P=0.05%)	0.140	5394	0.240
Sulphur levels (kg ha^{-1})			
Control	10.29	43017	2.30
40	10.53	51026	2.71
S. Em. ±	0.041	1561	0.069
C.D. (P=0.05%)	0.120	4404	0.196

The results are in accordance with the findings of Das *et al.,* (2010) and Joshi (2011). On pooled analysis basis, minimum protein content was recorded with application of 125 kg N ha^{-1}. Application of 150 kg N ha^{-1} significantly enhanced protein content over 125 kg N ha^{-1} by 1.86 %. Staggering of nitrogen in four splits significantly increased protein content of grain over recommended three splits of nitrogen application by 2.44 %. Sulphur application significantly increased N, P, K and S uptake in grain and stover over control. Application of 40 kg S ha^{-1} significantly enhanced protein content of grain. It might be due to the fact that S is constituent of amino acids and participates in several bio-chemical processes for the metabolism of carbohydrate, fat and protein in plant system. The results confirmed the findings of Jaliya *et al.* (2012).

Economics

The highest net returns (Rs. 54709 ha^{-1}) and BC ratio (2.88) were recorded under 175 kg N ha^{-1} which was significantly higher over preceding levels. Application of nitrogen in four equal splits in ratio of 25:25:25:25 at basal, 4 to 6 leaf, knee high and 50 % tasseling stages proved economically beneficial as it recorded significantly higher net returns and BC ratio over three splits of nitrogen application. Sulphur application significantly increased net returns and BC ratio over control. On the basis of results, it is inferred that application of 175 kg N ha^{-1} produced significantly higher grain yield and also proved economically beneficial with highest net retirns and BC. Amongst nitrogen schedules, application of nitrogen in four equal splits (25:25:25:25) produced significantly higher grain yield, net returns and BC ratio. Application of 40 kg S ha^{-1} affirmed potential role in enhancing productivity of quality protein maize and also proved economically profitable compared to control.

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