International Journal of Science, Environment and Technology, Vol. 5, No 5, 2016, 2989 – 2998

ISSN 2278-3687 (O)
2277-663X (P)

EFFECT OF NITROGEN AND SULPHUR LEVELS ON GROWTH, YIELD, QUALITY AND ECONOMICS OF SINGLE CROSS HYBRID MAIZE (Zea mays. L)

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Abstract: Experiment on "Effect of nitrogen and sulphur levels on growth, yield and economics of single cross hybrid maize (Zea mays. L)'' was conducted during *Kharif*, 2013 at College farm, College of Agriculture, Rajendranagar, Hyderabad to evaluate the effect of nitrogen and sulphur on growth, yield and economics of maize. The experiment was carried out with two nitrogen levels (N_1: 180 kg ha^{-1}, N_2: 225 kg ha^{-1}) as first factor and five sulphur levels (S_0: 0 kg ha^{-1}, S_1: 20 kg ha^{-1}, S_2: 40 kg ha^{-1}, S_3: 60 kg ha^{-1} and S_4: 80 kg ha^{-1}) as second factor comprising ten treatment combinations were laid out in randomized block design with factorial concept replicated thrice. With respect to levels of nitrogen growth parameters like plant height (cm), leaf area index and dry matter accumulation (g plant^{-1}), yield attributes like number of grains cob^{-1}, grain weight cob^{-1} and test weight (g) were recorded significantly highest with N_2 (225 kg ha$^{-1)}$. Grain and stover yield were recorded highest and significantly higher than N_1 (180 kg ha^{-1}), the per cent increase in grain and stover yield were 4, 3.2 respectively over N_1. Significantly B: C ratio and crude protein content in grain was observed with N_2 (225 kg ha^{-1}) than N_1 (180 kg ha^{-1}). Application of sulphur levels shows positive effect on growth and yield of maize. In case of yield attributes like number of grains cob^{-1}, grain weight cob^{-1}(g) and test weight (g)were recorded highest with S_3 (60 kg ha^{-1}) and it was significantly higher than S_2 (40 kg ha^{-1}), S_1 (20 kg ha^{-1}) over S_0 (0 kg ha^{-1}) and it was on par with S_4 (80 kg ha^{-1}). With increasing the levels of sulphur the grain and stover yield were increased in decreased rate but it was on par with S_3 (60 kg ha^{-1}). The per cent increase in grain yield was 8.2, 13.8, 23.2 and 20.6 with S_1 (20 kg ha^{-1}), S_2 (40 kg ha^{-1}), S_3 (60 kg ha^{-1}) and S_4 (80 kg ha^{-1}) respectively over S_0 (0 kg ha^{-1}). Due to combined application of N and S improved the growth and yield attributes of maize and ultimately increased the grain and stover yield. Significantly B: C ratio and crude protein content in grain was observed with S_3 (60 kg ha^{-1}). Application of N and S@ 225 and 60 kg ha^{-1} recorded highest grain yield, stover yield , crude protein content and B:C ratio than other nitrogen and sulphur combinations but it was on par with N and S @ 225 and 80 kg ha^{-1}.

Keywords: Maize, Nitrogen, Sulphur, Yield, Crude protein content, B: C ratio.

Introduction

Maize (*Zea mays* L.) is an important food and feed crop among cereals which occupies third rank after wheat and rice in the world. Maize has high production potential

*Received Aug 19, 2016 * Published Oct 2, 2016 * www.ijset.net*

compared to any other cereal crop. Hence, it is called as the "Queen of cereals". India is the fifth largest producer of maize in the world contributing 3% of the global production. Indian Maize programme under the umbrella of Directorate of Maize Research has now focused on single cross hybrids which increased maize production by 31 per cent and productivity by 27 per cent over the last year (DMR, 2009). The area under single cross hybrids is 20% of total maize area during 2010 and likely to increase rapidly.

Among major nutrients, nitrogen is the motor of plant growth and it is a component of protein and nucleic acids and when N is sub-optimal, growth is reduced (Haque *et al.*, 2001). Nitrogen serves as the source for the dark green colour in the leaves of various crops. This is a result of a high concentration of chlorophyll. The nitrogen is also a component of energy-transfer compounds, such as ATP (adenosine triphosphate) which allows cells to conserve and use the energy released in metabolism. It is being realized that apart from the major nutrients, the role of secondary nutrients in general and sulphur in particular increasing cereal production is well established (Jamal *et al.*, 2005). In recent years, sulphur deficiency has become an increasing problem in agriculture, which limits the crop production (Wells and Darts, 1986). Maize has higher sulphur requirement and is sensitive to its deficiency (Pandey and Girish, 2002). Saalbach (1973) reported yield loss in maize to an extent of 10 to 30% and Pal and Singh (1992) up to 35% due to sulphur deficiency. The sulphur requirement to produce one ton of cereals is rather low but its uptake per unit area becomes almost equal to that of oilseeds mainly due to higher productivity of cereals (Bhagyalakshmi *et al.*, 2009). Several factors contributing to sulphur deficiencies were reported by many researchers includes, the increased use of sulphur free high analysis fertilizers like diammonium phosphate (DAP) in place of single super phosphate (SSP) and lack of addition of organic manures over the years resulted in emergence of S deficiency.

1. Materials and Methods

The field experiment entitled was conducted at College farm, Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad during *kharif* 2013. The experimental soil was sandy loam in texture, neutral in reaction. The fertility status of the experimental soil was low in organic carbon and available nitrogen, medium in available phosphorous, sulphur and high in potassium.

The experiment was laid out in randomized block design (Factorial) with two nitrogen levels (N_1: 180 kg ha^{-1}, N_2: 225 kg ha^{-1}) as factor one and five sulphur levels (S_0: 0 kg ha^{-1}, S_1: 20 kg ha^{-1}, S_2: 40 kg ha^{-1}, S_3: 60 kg ha^{-1} and S_4: 80 kg ha^{-1}) as second factor comprising 10 treatment combinations and replicated thrice. Single cross hybrid maize (DHM-117) was sown in *kharif*-2013 at a spacing of 60 cm x 20 cm. A uniform dose of 60 kg ha^{-1} P_2O_5 as Diammonium phosphate, potassium @ 50 kg ha^{-1} as Murate of potash was applied to all the treatments. The entire dose of P_2O_5 and half of K_2O were applied at the time of sowing. DAP is also supplied some amount of nitrogen and remaining amount of nitrogen was applied as per the treatments in the form of urea (46% N) in three equal splits (one third each at basal, at knee-high and tasseling stages). Similarly the remaining potassium was applied along with nitrogen during second top dressing at tasseling stage. Sulphur was applied in the form of gypsum at the time of sowing as per the treatment.

2.1 *Statistical analysis*

The data generated were subjected to analysis of variance (ANOVA) and separation of means was obtained using Factorial Randomized Block Design (FRBD), according to the methods described by Gomez and Gomez (1984).

2. Results and Discussion

2.1 Effect of nitrogen on growth, yield and economics of maize

The data pertaining to growth and yield attributes was presented in Table 1. The highest plant height (174cm), leaf area index (2.6) and dry matter accumulation (231.7 g $plant^{-1}$) at harvest was observed with N_2 than N_1. This might be due to increase in cell division, cell elongation and nucleus formation (Wajid *et al*., 2007). The nitrogen was an integral part of protein, the blocks of the plant and it also helps in maintaining higher auxin level which might have resulted in better plant height (Singh *et al*., 2000). The increase in LAI with increasing nitrogen level might be due to more number of leaves per plant which might be due to lesser senescence and leaf retention for longer period with higher nitrogen application (Aulakh *et al*., 2013). Dry matter accumulation is one of the important parameter reflecting the growth of the crop. The optimum accumulation of dry matter, followed by partitioning of assimilates to the sink leads to higher yields. Increase in nitrogen level produced more number of leaves per plant, more LAI resulting in more dry matter. The increase in dry matter per plant at harvesting stage due to combined increase in nitrogen and sulphur application was ascribed to its positive effects, though non-significant on plant height and LAI by Rasheed *et al*. (2004). The data pertaining to yield attributes was presented in Table 2., Yield attributes *viz.,* total number of grains cob^{-1}, test weight (g), grain weight cob^{-1}(g) were significantly higher with increasing level of nitrogen @ 225 kg ha^{-1}. Higher dry matter accumulation and efficient translocation to the reproductive parts due to supply of adequate nitrogen levels might be responsible for realizing more number of rows cob^{-1}. Similar results also reported by Dawadi and Sah (2012) who observed increased number of rows cob^{-1} with increase in levels of nitrogen. Higher accumulation of photosynthates with increasing levels of nitrogen resulted in relatively higher accumulation of photosynthates in individual grain and thereby increased test weight and ultimately grain weight of cob at higher levels of nitrogen (Joshi *et al*., 2014).

Increased the grain and stover yields with increasing levels of nitrogen was due to significant increase in plant height, LAI, dry matter accumulation and yield attributing characters, *viz.,* number of grains per cob, test weight with application of nitrogen was mainly responsible for increasing the grain and stover yields. Grain yield of maize was function of yield attributes which are favourably influenced by N-application (Singh *et al*., 2003). The per cent increase in crude protein content with N_2 (225 kg ha^{-1}) over N_1 (180 kg ha^{-1}) was 4.9%. The increase in crude protein content in grain might be due to the fact that nitrogen is an integral constituent of amino acids, which are the basic units of the protein. The increased nitrogen application increases the gross returns, net returns and B: C ratio (3.06), this might be due to increased nitrogen increases the grain, stover yield and quality of maize. These results are in accordance with the findings of Choudary *et al*. (2013).

2.2 Effect of sulphur on growth, yield and economics of maize

The growth parameters like plant height(180 cm), leaf area index (3.0) and drymatter (234.7 g $plant^{-1}$) were increased significantly with increasing levels of sulphur up to S_3 (60 kg ha^{-1}) thereafter though the sulphur level increases up to S_4 (80 kg ha^{-1}) the growth parameters were decreased slightly but it was comparable with S_3 (60 kg ha^{-1}). Better growth and development of maize plants due to higher levels of sulphur dose would have been due to multiple role of S in protein and carbohydrate metabolism of plants by activating a number of enzymes which participate in dark reaction of photosynthesis hence increases the plant height and dry matter was observed with increased dose of S application. The increase in total dry matter with application of S was due to better crop growth which gave maximum plant height, LAI and ultimately produced more dry matter. These results were in conformity with the findings of Tanveer *et al*. (2013).

With respect to sulphur levels, yield attributes, grain and stover yield were recorded highest with S_3 (60 kg ha^{-1}) and it was significantly higher than S_2 (40 kg ha^{-1}), S_1 (20 kg ha^{-1}), and S_0 (0 kg ha^{-1}), however increasing S level beyond 60 kg ha^{-1} increased the grain and stover yield was decreased. Improvement of vegetative structures for nutrients absorption and photosynthesis, strong sink strength through development of reproductive structures and production of assimilates under influence of applied S maintained and balanced source to sink ratio which might have resulted in increased yield attributes of maize. More number of bigger size cobs might have accommodated number of grains providing sufficient space for development of individual grain, leading to higher test weight with sulphur application resulting in higher grain weight cob^{-1}.

Increased grain yield of maize with higher sulphur application could be owing to higher availability of nutrients and development of strong source-sink relationship manifested in realization of higher productivity of maize in terms of seed yield (Tandon, 1999). Similar findings also reported by Jaggi and Raina (2008). The higher stover yield was associated with higher dose of sulphur due to better vegetative growth as indicated by more dry matter production in maize (Mehta *et al*, 2005).

The per cent increase in crude protein content was 3.7, 10.3, 18.1 and 15.5% with S_1 (20 kg ha^{-1}), S_2 (40 kg ha^{-1}), S_3 (60 kg ha^{-1}) and S_4 (80 kg ha^{-1}) respectively over S_0 (0 kg ha^{-1}). It might be due to the fact that sulphur is constituent of amino acids and participates in several bio-chemical processes for the metabolism of carbohydrate, fats and proteins in plant system. The results were in accordance with Jaliya *et al*. (2012). The increased sulphur application rates upto 60 kg ha^{-1} increases the gross returns, net returns and B: C ratio (3.30), this might be due to synergistic effect of sulphur and nitrogen increases the grain, stover yield and quality of maize. These results were in accordance with the findings of Shivran *et al*. (2013).

2.3 Interaction effect of nitogen and sulphur on growth, yield and economics of maize

Application of N and S @ 225 and 60 Kg ha^{-1} respectively showed significantly higher dry matter production at maturity stage than other N and S combinations but it was statistically on par with N and S @ 225 and 80 Kg ha^{-1}.The larger photosynthetic area and prolonged photosynthesis due to leaf area index and number of leaves per plant led to higher dry matter production probably because of higher and balanced supply of N and S fertilizers.

Combined Application of N and S show positive effect on increasing the grain weight cob^{-1} due to nitrogen and sulphur fertilization results in greater translocation of photosynthates from vegetative parts to developing grains. Moreover, nitrogen and sulphur nutrients have synergistic effects on growth and yield attributes resulting in greater translocation of photosynthates from source to sink (Channabasamma *et al*., 2013).

Application of N and S combinely increased the grain and stover yield (shown in fig 1 & 2)due to nitrogen and sulphur application is attributed to enhanced crop growth rate, net assimilation rate and dry matter production per plant which ultimately increased grain number per ear and grain weight per ear, grain and stover yield of maize (Rasheed *et al.*, 2004).

Application of N and S @ 225 and 60 Kg ha^{-1} showed significantly higher gross returns, net returns and B: C ratio than the other N and S combinations but it was statistically on par with N and S @ 225 and 80 Kg ha^{-1} and shown in Table 1.2. Combined application of nitrogen and sulphur increases the grain yield, stover yield and quality of maize which ultimately increases the gross returns and net returns. These results were in line with the results of Jeet *et al*. (2013).

Conclusions

With respect to levels of nitrogen growth parameters like plant height (cm), leaf area index and dry matter accumulation (g plant^{-1}), yield attributes , grain and straw yield were recorded significantly highest with N_2 (225 kg ha$^{-1)}$.. Significantly highest B: C ratio and crude protein content in grain was observed with N_2 (225 kg ha^{-1}) than N_1 (180 kg ha^{-1}). Application of sulphur levels shows positive effect on growth and yield of maize. In case of yield attributes like number of grains cob^{-1}, grain weight cob^{-1}(g) and test weight (g)were recorded highest with S_3 (60 kg ha^{-1}) and it was significantly higher than S_2 (40 kg ha^{-1}), S_1 (20 kg ha^{-1}) over S_0 (0 kg ha^{-1}) and it was on par with S_4 (80 kg ha^{-1}). With increasing the levels of sulphur the grain and stover yield were increased in decreased rate but it was on par with S_3 (60 kg ha^{-1}). Significantly B: C ratio and crude protein content in grain was observed with S_3 (60 kg ha^{-1}). Application of N and S @ 225 and 60 kg ha^{-1} recorded highest grain yield, stover yield , crude protein content and B:C ratio than other nitrogen and sulphur combinations but it was on par with N and S @ 225 and 80 kg ha^{-1}.

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Table 1: Effect of nitrogen and sulphur levels on growth and yield attributing characters of single cross hybrid maize

	Plant height at harvest (cm)	Leaf area index at harvest	Dry matter at harvest (g $plant^{-1}$)	Total number of grains cob^{-1}	Grain weight cob^{-1} (g)	Test weight (g)
Nitrogen levels (N)						
N_1 (180 kg ha^{-1})	171	1.9	220.3	321	140.6	26.5
N_2 (225 kg ha^{-1})	174	2.6	231.7	333	146.3	28.3
SEm±	0.7	0.1	0.66	3.58	0.64	0.47
CD (p=0.05)	2.0	0.3	1.05	10.8	1.92	1.43
Sulphur levels (S)						
S_0 (0 kg ha^{-1})	163	1.4	211.7	297	130.0	24.5
S_1(20 kg ha^{-1})	167	1.9	223.3	312	138.3	26.5
S_2 (40 kg ha^{-1})	175	2.1	228.3	331	142.9	28.8
S_3 (60 kg ha^{-1})	180	3.0	234.7	349	154.3	31.2
S_4 (80 kg ha^{-1})	178	2.5	231.9	345	151.7	29.9
SEm±	1.0	0.16	1.05	4.20	1.01	0.55
CD (p=0.05)	3.2	0.50	3.16	12.6	3.04	1.65
Interaction (NxS)						
SEm±	1.5	0.23	1.49	5.06	1.43	1.06
CD (p=0.05)	NS	NS	4.47	15.2	4.30	NS

Table 2: Effect of nitrogen and sulphur levels on yield, quality and economics of single cross hybrid maize

	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Crude protein (%)	Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	B:C ratio
Nitrogen levels (N)						
N_1 (180 kg ha^{-1})	6521	8726	8.1	84773	57104	3.06
N_2 (225 kg ha^{-1})	6789	9007	8.5	88257	60014	3.12
SEm±	34.2	32.9	0.07	446	445	
CD (p=0.05)	102	99	0.23	1334	1333	

Sulphur levels (S)						
S_0 (0 kg ha^{-1})	5881	8120	7.9	76543	49857	2.84
S_1(20 kg ha^{-1})	6366	8557	8.2	82753	55357	3.02
S_2 (40 kg ha^{-1})	6697	8917	8.5	87056	59105	3.11
S_3 (60 kg ha^{-1})	7246	9450	9.1	94202	65685	3.30
S_4 (80 kg ha^{-1})	7096	9286	8.9	91855	62794	3.16
SEm±	54.2	52.2	0.07	704	704	
CD (p=0.05)	162	157	0.22	2108	2108	
Interaction (NxS)						
SEm±	76.5	73.8	0.10	996	995	
CD (p=0.05)	229	221	NS	2981	2981	

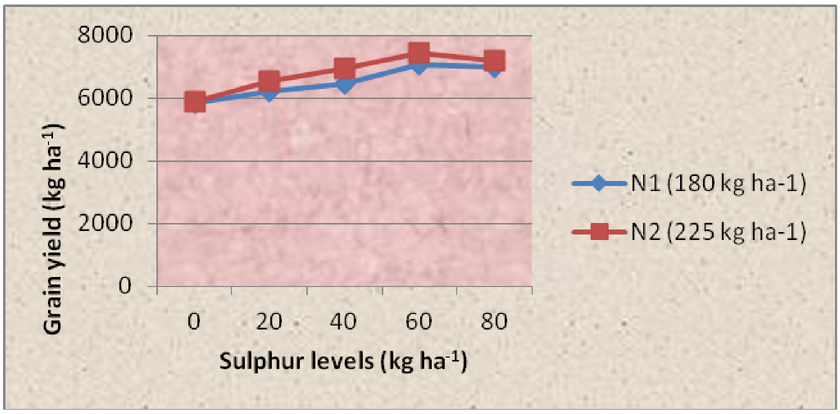

Fig 1. Interaction effect of nitrogen and sulphur levels on grain yield (kg ha^{-1}) of maize

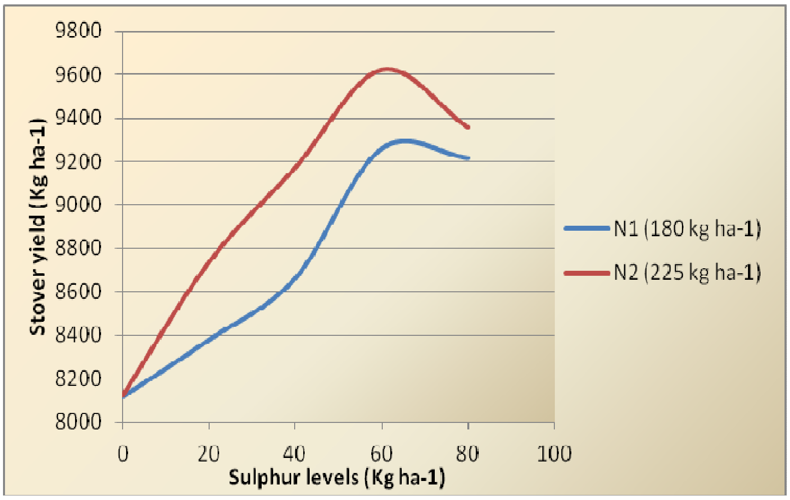

Fig 2. Interaction effect of nitrogen and sulphur levels on stover yield (kg ha^{-1}) of maize