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# Effects of Sulphur and Nitrogen on the Yield and Seed Quality of Maize (cv. Barnali )

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**Abstract:** The experiment was conducted at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh, during the period from November 2000 to May 2001 to find the effect of sulphur and nitrogen on the yield and seed quality of maize (cv. Barnali). The study included three levels of Sulphur, viz., 0, 10 and 20 kg $ha^{-1}$ and four levels of Nitrogen, viz., 0 ,60, 100 and 120 kg $ha^{-1}$. Gypsum and urea were used as the sources of Sulphur and Nitrogen, respectively. The highest grain yield and 1000-grain weight were obtained with 20 kg S $ha^{-1}$. The maximum no of grains/cob, the highest shelling percentage, the highest 1000-gain weight, Maximum grain yield and maximum stover yield were produced by the application of 120 N $ha^{-1}$. Grain yield increased with the increasing rates of both Sulphur and Nitrogen but their interaction effects were not significant for all the quantitative characters under study. Seed quality attributes like germination percentage, vigour index, seedling shoot and root length and shoot and root dry weights were not influenced by Sulphur application. Nitrogen application had significant effect on vigour index, seedling shoot and root dry weights. The interaction between Sulphur and Nitrogen levels showed significant effect on seedling shoot and root dry weights. Maximum vigour index and root dry weights/ seedling of maize were found with 120 kg but the highest shoot dry weight/seedling was obtained with 100 kg N $ha^{-1}$. Maximum shoot and root dry weights/seedling was obtained by applying 120 kg N $ha^{-1}$ in combination with 20 kg S $ha^{-1}$.

**Key words:** Effect, sulphur, nitrogen, yield, seed quality, maize

## Introduction

Maize (***Zea mays*** L.) is one of the most important cereal crops of the world and hence it may be acceptable as a third cereal crop in Bangladesh for its higher productivity. In Bangladesh, the cultivation of maize has been gaining popularity in recent years. It is now becoming an important cereal crop for its higher productivity and diversified uses (Islam and Kaul, 1986). It covers about 2429 ha of land producing 2000 tons of grains annually (BBS, 1999). Maize crop has been included as a major enterprise in the crop diversification and intensive cropping programmes (Kaul and Rahman,1983). The agroclimatic conditions of Bangladesh are favourable for its cultivation round the year. The average yield of maize in the country is not satisfactory. It is rather very low compared with leading maize growing countries of the world The national average yield is only 1.06 t $ha^{-1}$, whereas the newly released varieties have the potential to produce more than 8 t $ha^{-1}$ (BBS, 1995). The problem of low grain yield of maize in our country may be associated with declining productivity of high to medium lands under continuous intensive cropping, soil fertility thus declining at rapid rate. This problem may be overcome by judicious application of fertilizers, especially with Nitrogen and Sulphur. Recently Sulphur deficiency has been found to be widespread in soils of Bangladesh. Use of higher analysis fertilizers like urea, TSP and MP, high yielding varieties (HYV), higher cropping intensity without any replenishment and limited use of organic manures are the most probable reasons for Sulphur deficiency. Sulphur deficiencies affected not only yield of plant but also protein quality through its effects on the synthesis of certain amino acids, cystine, cyseine and methionine as well as plant hormones and vitamins. A few experiments as evidenced in the previous literature reported significant responses of maize to S, generally in the range of 12 to 20% yield increases Allen(1976), Grant and Rowell (1976) and Kang and Osiname (1976). Nitrogen nutrition is a major consideration for increasing grain yield and quality of maize. Nitrogen should be applied in such a way that would maximize its utilization for grain production. In order to achieve this, N should be applied at various phases of plant growth and development. In recent years, emphasis has been given to increase fertilizers use efficiency by top dressing and split applications of nitrogenous fertilizers at critical growth stages of maize (Singh, 1985). It appears that there is a need to find out a fertilizer management system using a combination of Sulphur with Nitrogen fertilizer, for better utilization of the latter. Recently farmers of Bangladesh are advised to use gypsum along with urea for higher yield. But research on examining the best combination of Nitrogen and Sulphur for higher maize yield is still meagre. Therefore, an attempt was made with the objective to identify the suitable doses of Sulphur and Nitrogen in order o achieve both quantitative and qualitative improvement of maize production.

**Materials and Methods**

The present piece of research work was carried out at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh, during the period from November 2000 to May 2001 to study the effects of Sulphur and Nitrogen on the yield seed quality of maize (cv. barnali). The soil of the experimental area belongs to the Sonatola Soil Series under the Old Brahmaputra Floodplain Agro-ecological Zone having non calcareous dark grey Floodplain Soil (FAO and UNDP, 1988). The soil of the experimental field was more or less acidic in reaction, low organic matter and its general fertility level was also low . The land was flat, well drained and above the flood level. The topography is medium high with sandy loam texture and pH 6.7 (FAO and UNDP, 1988).the levels of nitrogen and sulphur used in the experimental treatments were as follows: A. Sulphur levels, 3 (kg $ha^{-1}$): i) $S_0$ = 0 (control) , ii) $S_1$= 10 and iii) $S_2$ = 20

B. Nitrogen levels, 4 (kg $ha^{-1}$): i) $N_0$ = 0 (control), ii) $N_1$= 60, iii) $N_2$ = 100, iv) $N_3$ = 120

The other nutrient elements were used as general doses with 50 kg $ha^{-1}$ $P_2O_5$ from triple super phosphate and 60 kg $ha^{-1}$ $K_2O$ from muriate of potash. The treatment combinations for the experiment are given in Table 1. Barnali, a high yielding cultivar of maize was used as test crop

Table 1: The treatment combinations of sulphur and nitrogen fertilizers used in the experiment

| Treatments | Combinations of S and N | |
|---|---|---|
| | S kg ha$^{-1}$ | N kg ha$^{-1}$ |
| $T_1$ | 0 | 0 |
| $T_2$ | 10 | 0 |
| $T_3$ | 20 | 0 |
| $T_4$ | 0 | 60 |
| $T_5$ | 10 | 60 |
| $T_6$ | 20 | 60 |
| $T_7$ | 0 | 100 |
| $T_8$ | 10 | 100 |
| $T_9$ | 20 | 100 |
| $T_{10}$ | 0 | 120 |
| $T_{11}$ | 10 | 120 |
| $T_{12}$ | 20 | 120 |

in the experiment.The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The whole experimental area was first divided into three blocks. Each block was later divided into twelve plots. The size of each unit plot was 4.0 m × 2.5 m. Total number of unit plots were 36. The individual plots and the blocks were separated for irrigation and drainage by 1.5 m and 2.0 m channels, respectively. Seeds were collected from Bangladesh Agricultural Development Corporation (BADC) office, Khagdohor, Mymensingh. The experimental land was opened on 10 November 2000. Individual plots were prepared by repeated spading unit the soil achieved a good tilth and was ready for sowing. Weeds and stubbles were removed and the plots were levelled by small ladder. Sulphur and Nitrogen fertilizer were applied as per treatments specifications and other fertilizers were applied according to the fertilizers recommendation guide (BARC, 1997). Full doses of triple super phosphate (TSP), muriate of potash (MP), gypsum and one-third of the urea were applied at the time of final land preparation. The remaining urea were applied at the time of final land preparation. The remaining urea was applied in two equal splits on 30 and 60 days after sowing (DAS). Seeds were sown on 25 November 2000 by hand drilling at a depth of 4-6 cm in furrows 75 apart. There were 4 rows plot$^{-1}$. Within a row, hills were spaced 25 cm apart and two seeds were sown per hill. A seed rate of 30 kg ha$^{-1}$ was used as per recommendation by Bangladesh Agricultural Research Institute (BARI, 1993). The seedlings of the crop emerged out within 6-8 DAS. Necessary gap filling was done at 12 DAS. Weeding was done three times, at 30, 45 and 70 DAS. Thinning was done after 25 DAS. One healthy plant was retained per hills and the other plant was removed. Earthig up was done by spade at 45 DAS to prevent lodging of plants. Irrigation was applied first after 40 days and second after 70 DAS. The experimental crop was harvested plot wise at full maturity on 16 April 2001. The sample plants were harvested separately for recording data on plant characters and yield and yield components. Data on the following plant characters and yield and yield components were collected from the sample plants of each plot. Number of cobs/plant, number of rows cob$^{-1}$, Number of grains cob$^{-1}$, Weight of 1000-grain (g), Shelling percentage, grain yield (t ha$^{-1}$), Stover yield (t ha$^{-1}$). Number of total cobs were counted from the sample plants and then averaged and recorded. Total number of grains cob$^{-1}$ from the sample plants was counted averaged and recorded. One thousand clean dried grains were counted from the seeds obtained from sample plants of each plot and weighed by using an electrical balance and recorded. It denotes the ration of total grain weight cob$^{-1}$ and total cob weight and was calculated with the following formula:

$$\text{Shelling percentage} = \frac{\text{Total grain weight cob}^{-1}\text{ (g)}}{\text{Total cob weight (g)}} \times 100$$

Grains obtained from each unit plot were sun-dried at 14% moisture and weighed carefully. The dry weight of grains of five sample plants were added to the respective plot yield to record the final grain yield plot$^{-1}$(kg). The grain yield was converted to t ha$^{-1}$. Stover obtained from each unit plot including the stover of the sample plants of respective unit of plot were dried in sun and weighed to record the final stover yield plot$^{-1}$ (kg) and finally converted to t ha$^{-1}$. The quality of the harvested maize seed of each treatment was tested in the laboratory. The following quality attributes were recorded, germination percentage (%), vigour index, shoot length seedling$^{-1}$ (cm), root length seedling$^{-1}$ (cm), shoot dry weight seedling$^{-1}$(mg), root dry weight seedling$^{-1}$ (mg). Germination test of the harvested seeds of maize was done in petridish using sand. The petridishes were filled with sand leaving 2 cm from the top. Adequate moisture level was maintained in the germination media (sand). Three hundred seeds were taken randomly from each sample and divided into three equal replication i.e.; each petridish received 100 seeds. Vigour test of the harvested seeds was done in pot using brick gravels and soil. One hundred and fifty seeds were taken randomly from each sample and divided into three replications i.e.; each pot received 50 seeds. The tests were conducted at Agronomy Department from 9 to 15 June 2001. The number of germinated seeds were counted in each day. After 7 days the total number of germinated seedlings were counted for calculation of the germination percentage. From the daily record of germinated seedlings vigour index of the seed was calculated by the following formula (Agarwal, 1991).

$$\text{Vigour index} = \frac{\text{Number of seeds germinated at first count}}{\text{Number of days to first count}} + \ldots\ldots\ldots\ldots + \frac{\text{Number of seeds germinated at last count}}{\text{Number of days to first count}}$$

After completion of germination test, 5 seedling were selected randomly from each pot and then carefully uprooted in such a way that no root part had left in the spot. Then they were washed in tap water properly and the root portions of the seedlings were separated carefully.

finally, the length of shoot and root were measured by a centimeter scale. Root and shoot portions of seedlings were placed in an electric oven at $65^0$C temperature for overnight. Thus dry matters of shoot and root were weighed. The collected data were analyzed statistically using the "Analysis of variance" technique and mean differences among the treatment were adjudged by using the Duncun's Multiple Range Test (DMRT) and Least Significance Difference (LSD) test where necessary (Gomez and Gomez, 1994).

## Results and Discussion

### Effect on yield and components

#### Number of cobs plant$^{-1}$

Different sulphur levels did not significantly influence the number of cobs per plant. The maximum number of cobs per plant (1.14) was found 20 kg S ha$^{-1}$ and minimum number of cobs per plant (1.09) with 0 kg S ha$^{-1}$ (Table 2). The number of cobs per plant was not significantly influenced by different nitrogen levels. The maximum number of cobs per plant (1.22) was obtained with 120 kg N ha$^{-1}$ and minimum number of cobs per plant (1.02) with 0 kg N ha$^{-1}$ (Table 2). Therefore it was observed that number of cobs per plant increased with increasing nitrogen levels. Nimje and Seth (1998) also reported a similar result. The interaction of sulphur and nitrogen levels showed no significant influence on the number of cobs per plant. However, numerically the number of cobs per plant (1.26) in the treatment combination of $S_2 \times N_3$ and the lowest number of cobs per plant (1.00) in the combinations of $S_0 \times N_0$ (Table 3).

#### Number of grains cob$^{-1}$

The number of grains per cob was not significantly influenced by Sulphur levels. The maximum number of grains per cob (405.52) was found with 20 kg S ha$^{-1}$ and minimum number of grains peer cob (399.39) with 10 kg S ha$^{-1}$ (Table 2). The number of grains per cob was significantly affected by Nitrogen levels. The highest number of grains per cob (437.20) was found with 120 kg N ha$^{-1}$ which was statistically identical to 100 kg N ha$^{-1}$ (Table 2). The lowest number of grains per cob (349.30) was obtained with 0 kg N ha$^{-1}$ . This might be due to larger cob size proper pollination, translocation of sugars and starch and finally proper grain set due to N fertilizer, which develop more leaf area index (LAI). The findings of the present study was in agreement with that of Bouquet ***et al.*** (1987) and Sanjeev and Bangarwa (1997) who observed increased number of grains per cob by Nitrogen fertilization. The interaction between sulphur and Nitrogen fertilizers failed to show the significant effect on number of grains per cob. However, numerically the highest number of grains per cob (444.80) was obtained in the combination S1 $\times N_3$ and the lowest one (322.22) in the combination $S_1 \times N_0$ (Table 3), the result indicated that grain formation was the physiological factor than nutritional.

#### Weight of 1000-grain

There was a significant influence on weight of 1000-grain by Sulphur application. The highest 1000-grain weight (282.30 g) was recorded with 20 kg S ha$^{-1}$ which was statistcally identical to 10

Table 2: Effects of sulphur and nitrogen on the yield and yield components of maize

| Treatment | No. of cobs/plant | | No. of grains/cob | | 1000-grain weight (g) | | Shelling percentage (%) | | Grain yield (t ha$^{-1}$) | | Stover yield (t ha$^{-1}$) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | S | N | S | N | S | N | S | N | S | N | S | N |
| 0 | 1.09 | 1.01 | 405.37 | 349.3b | 263.10b | 258.00b | 66.75 | 64.39c | 4.36b | 3.17d | 6.44 | 5.09c |
| 10 | 1.11 | | 399.39 | | | | | | | | | |
| 20 | 1.14 | | 405.52 | | 282.30a | | 71.22 | | 4.71a | | 6.82 | |
| 60 | | 1.09 | | 402.1ab | | 264.90b | | 67.17bc | | 4.16c | | 6.22b |
| 100 | | 1.14 | | 425.2a | | 274.30ab | | | 70.12ab | 5.18b | | 7.37a |
| 120 | | 1.22 | | 437.2a | | 287.90a | | 73.15a | | 5.63a | | 7.86a |
| Sx | - | - | - | 19.54 | 4.76 | 5.50 | - | 1.74 | 0.05 | 0.06 | - | 0.12 |
| Level of signi. | NS | NS | NS | 0.05 | 0.05 | 0.01 | NS | 0.05 | 0.01 | 0.01 | NS | 0.01 |

Figures in a column having similar letter(s) do not differ significantly wheras, figures having dissimilar letters differ significantly at 5% of probability as per DMRT

NS = Not significant

Table 3: Effect of interaction of sulphur and nitrogen on the yield and yield components of maize

| Interaction (S×N`) | Number of cobs/plant | Number of grains/cob | 1000-grain weight (g) | Shelling percent (%) | Grain yield (t ha$^{-1}$) | Stover yield (t ha$^{-1}$) |
|---|---|---|---|---|---|---|
| $S_0N_o$ | 1.00 | 353.03 | 250.89 | 63.36 | 3.00 | 4.91 |
| $S_0N_1$ | 1.07 | 402.04 | 257.05 | 65.28 | 4.01 | 6.04 |
| $S_0N_2$ | 1.10 | 430.78 | 266.17 | 67.39 | 5.02 | 7.19 |
| $S_0N_3$ | 1.20 | 435.33 | 278.24 | 70.96 | 5.40 | 7.61 |
| $S_1N_o$ | 1.01 | 322.22 | 256.91 | 62.02 | 3.16 | 5.12 |
| $S_1N_1$ | 1.08 | 401.13 | 262.98 | 66.73 | 4.16 | 6.23 |
| $S_1N_2$ | 1.16 | 429.40 | 268.55 | 71.29 | 5.20 | 7.38 |
| $S_1N_3$ | 1.20 | 444.80 | 285.01 | 73.11 | 5.61 | 7.88 |
| $S_2N_o$ | 1.02 | 372.53 | 266.20 | 68.37 | 3.34 | 5.25 |
| $S_2N_1$ | 1.13 | 402.67 | 274.55 | 69.50 | 1.32 | 6.41 |
| $S_2N_2$ | 1.16 | 415.32 | 288.05 | 71.65 | 5.33 | 7.54 |
| $S_2N_3$ | 1.26 | 431.56 | 300.29 | 75.37 | 5.87 | 8.20 |
| Level of Significance | NS | NS | NS | NS | NS | NS |

NS= Not Significant $S_0$ = 0 kg S ha$^{-1}$, $N_0$ = 0 kg N ha$^{-1}$, $S_1$ = 10 kg S ha$^{-1}$, $N_1$ = 60 kg N ha$^{-1}$, $S_2$ = 20 kg S ha$^{-1}$, $N_2$ = 100 kg N ha$^{-1}$, $N_3$ = 120 kg N ha$^{-1}$

kg S ha$^{-1}$ and the lowest one (263.10) was recorded with 0 kg S ha$^{-}$ (Table 2). Nitrogen had significant effect on the weight 1000-grain. The highest weight of 1000-grain (287.9o g ) was obtained by the application of 120 kg N ha$^{-1}$ which was statistically identical to 100 kg N ha$^{-1}$ and the lowest one (258.oo g) by the application of 0 kg N ha$^{-1}$ (Table 2). This might be due to proper translocation of sugar and starch in the grain by nitrogen fertilization. The result was in agreement with the findings of Nimje and Seth (1998) and Sanjeev and Bangarwa (1997). The interaction of Sulphur and Nitrogen had no significant effect on the weight of 1000-grain (300.29 g) was found in the treatment combination of $S_2 \times N_3$ and the lowest one (250.89 g) in the combination of $S_0 \times N_0$ (Table 3).

Table 4: Effects of sulphur and nitrogen on germination percentage, vigour index, shoot length, root length, shoot and root dry weight of maize

| | Germination (%) | | Vigouur index | | Shoot length/ seedling (cm) | | Root length/ seedlinng (cm) | | Shoot dry weight/ seedling (mg) | | Root dry weight/ seedling (mg) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Treatment | S | N | S | N | S | N | S | N | S | N | S | N |
| 0 | 97.90 | 97.66 | 11.38 | 10.96b | 32.22 | 31.19 | 24.24 | 23.58 | 74.50 | 68.66c | 40.50 | 33.11b |
| 10 | 96.50 | - | 11.20 | - | 31.40 | - | 21.9o | - | 76.50 | - | 35.33 | - |
| 20 | 97.91 | - | 11.65 | - | 32.42 | - | 25.42 | - | 79.83 | - | 42.50 | - |
| 60 | - | 96.33 | - | 11.53a | | 32.31 | | 23.46 | | 74.00bc | | 38.66ab |
| 100 | - | 97.77 | - | 11.57a | | 32.29 | | 22.16 | | 84.22ab | | 40.89ab |
| 120 | - | 98.00 | - | 11.58a | | 33.58 | | 26.20 | | 80.89ab | | 45.11a |
| Sx | | - | | 0.16 | | - | | - | | 2.09 | | 2.64 |
| Lev. of sig. | | NS | | 0.05 | | NS | | NS | | 0.01 | | 0.05 |

Figures in a column having similar letter(s) do not differ significantly wheras, figures having dissimilar letters differ significantly at 5% of probability as per DMRT

NS = Not significant

Table 5: Effect of interaction between sulphur and nitrogen on germination percentage, vigour index, shoot length, root length, shoot and root dry weight of maize

| Interaction (S×N`) | Germination (%) | Vigour index | Shoot length/ seedling (cm) | Root length/ seedling (cm) | Shoot dry weight/ seedling (mg) | Root dry weight/ seedling (mg) |
|---|---|---|---|---|---|---|
| $S_0N_o$ | 98.33 | 10.76 | 32.03 | 23.09 | 69.33b | 26.66d |
| $S_0N_1$ | 96.00 | 11.98 | 34.71 | 22.14 | 83.33b | 32.00cd |
| $S_0N_2$ | 98.00 | 11.59 | 31.62 | 24.18 | 70.00b | 40.00cd |
| $S_0N_3$ | 99.33 | 11.20 | 34.51 | 27.56 | 82.00b | 41.33abcd |
| $S_1N_o$ | 96.00 | 10.77 | 30.11 | 22.79 | 70.00b | 30.00cd |
| $S_1N_1$ | 96.66 | 11.12 | 32.15 | 22.03 | 75.33b | 32.66cd |
| $S_1N_2$ | 96.66 | 11.43 | 31.73 | 18.49 | 83.33b | 38.00bcd |
| $S_1N_3$ | 96.66 | 11.47 | 31.59 | 24.29 | 77.33b | 40.67bcd |
| $S_2N_o$ | 98.66 | 11.84 | 31.42 | 24.87 | 66.66b | 44.00abc |
| $S_2N_1$ | 96.33 | 11.00 | 30.08 | 26.20 | 80.66b | 43.33abc |
| $S_2N_2$ | 98.66 | 11.71 | 33.53 | 23.82 | 68.66b | 48.67abc |
| $S_2N_3$ | 98.00 | 12.05 | 34.64 | 26.76 | 86.67a | 56.00ab |
| SX | - | - | - | - | - | - |
| Level of Significance | NS | NS | NS | NS | NS | NS |

Figures in a column having similar letter (s) do not differ significantly whereas, figures having dissimilar letters differ significantly at 5% level of probability as per DMRT, NS = Not significant

### Shelling percentage

Sulphur levels did not significantly influence shelling percentage. The highest shelling percentage (71.22 %) was found with 20 kg S ha$^{-1}$ and the lowest shelling percentage (66.75 %) was obtained 0 kg S ha$^{-1}$ (Table 2). Nitrogen fertilizer showed significantly variable effect on shelling percentage. The highest shelling percentage (73.15 %) was observed by the application of 120 kg N ha$^{-1}$ and the lowest one (64.59%) by no Nitrogen application, which was statistically identical to 60 kg N ha$^{-1}$ (Table 2). Therefore, it was observed that increased shelling percentage with the increasing level of Nitrogen. Similar result was also reported by Hammam (1995).The interaction between Sulphur Nitrogen levels failed to show the significant effect on shelling percentage. The highest shelling percentage (75.37 %) was found in the treatment combination of $S_2 \times$ N3 and the lowest one (62.02 %) was obtained in the combination of $S_1 \times N_0$ (Table 3).

**Grain yields**

Sulphur treatment had a significant influence on grain yield. The maximum grain yield (4.71 t $ha^{-1}$) was obtained by the application of 20 kg S $ha^{-1}$ which was statistically identical to 10 kg S $ha^{-1}$ (Table 2). The minimum grain yield (4.36 t $ha^{-1}$) was found by no Sulphur application . Therefore, it was observed that increased grain yield with increasing level of Sulphur. This result was in agreement with Sinha ***et al.*** (1995) who reported that grain yield increased with S application. Similar result was reported by Talukder and Islam(1982).Grain yield varied significantly due to levels of Nitrogen application. It was noted that application of increased the grain yield significantly over no Nitrogen application. Among the treatments, the highest grain yield (5.63 t $ha^{-1}$) was obtained by the application of 120 kg N $ha^{-1}$ and the lowest yield (3.17 t $ha^{-1}$) achieved with 0 kg N $ha^{-1}$ (Table 2). Application of 120 kg N $ha^{-1}$ produced maximum number of grains/cob, 1000-grain weight, shelling percentage which resulted the highest grain yield compared with other treatments. This finding corroborate with the results obtained by Oikeh ***et al.*** (1988), Maidl and Fishbeck (1990), Gupta and Gautam (1994), Sharma and Thakur (1995), Shanti ***et al.*** (1996), Oliveira (1997), Thakur ***et al.***(1998), Shiraji ***et al.*** (2000) and Pandey ***et al.*** (2000).

The interaction between Sulphur and Nitrogen had no significant influence on grain yield. This result was in agreement with O'Leary and Rehm (1990) who reported that ther was no N×S interaction for grain yield.

**Stover yield**

Sulphur treatment had no significant influence on stover yield. The highest stover yield (6.82) t $ha^{-1}$ was found with 20 kg S $ha^{-1}$ and the lowest stover yield (6.44 t $ha^{-1}$) was found with 0 kg S$ha^{-1}$ (Table 2). Stover yield significantly varied due to Nitrogen application. The highest stover yield (7.86 t $ha^{-1}$) was obtained by the application of 120 kg N $ha^{-1}$ which statistically identical with 100kg N $ha^{-1}$ and the lowest (5.09 t $ha^{-1}$) with 0 kg N $ha^{-1}$ (Table 2). Sanjeev and Bangarwa (1997) also reported that increased stover yield due to Nitrogen application, which has the similarity wit the present findings. Stover yield was not significantly varied due to the ineraction effect of Sulphur and Nitrogen levels. The highest stover yield (8.20 t $ha^{-1}$) was obtained in the treatment combination of $S_2 \times N_3$ and the lowest stover yield (4.91 t $ha^{-1}$) was obtained in the combination of $S_0 \times N_0$ (Table 2).

**Seed quality parameters**

**Germination percentage**

Germination percentage was not significantly affected by sulphur levels. The highest germination percentage (97.91) was found with 20kg S $ha^{-1}$ and the lowest one (96.50) with 10 kg S $ha^{-1}$ (Table 4). Germination percentage was not significantly affected by Nitrogen levels. The highest germination percentage (98.00) was found with 120kg S $ha^{-1}$ and the lowest one (96.33) with 60 kg N $ha^{-1}$ (Table 4).Similar results were also observed by Khot and Umrani (1992).The interaction between sulphur and nitrogen levels failed to show the significant effect on germination percentage (Table 5).

**Vigour index**

Vigour index was not significantly affected by sulphur levels. The highest vigour index (11.65) was recorded with 20 kg S $ha^{-1}$ and the lowest one (11.20 ) with 10 kg S $ha^{-1}$ (Table 4). Vigour index significantly affected by nitrogen levels. The highest vigour index (11.58) was recorded with 120 kg N $ha^{-1}$ which was statistically identical to 60 kg N $ha^{-1}$ and 100 kg N $ha^{-1}$ (Table 4). The lowest vigour index (10.96) was found with 0 kg N $ha^{-1}$. The interaction effect of sulphur and nitrogen levels on vigour index was not significant (Table 5).

**Shoot length**

Shoot length per seedling was not significantly varied by Sulphur levels. The highest shoot length per seedling(32.42 cm) was obtained with 20 kg S $ha^{-1}$ and the lowest one (31. 40 cm) with 10 kg S $ha^{-1}$ (Table 4). Shoot length per seedling was not significantly influenced by Nitrogen fertilization. The longest shoot length per seedling (33.58 cm) was found with 120 kg N $ha^{-1}$ (Table 4). Analysis of variance indicated that interaction of Sulphur and Nitrogen levels was not significant for shoot length/seedling.

**Root length/seedling**

Root length/seedling was not significantly affected influenced by different by sulphur levels. The longest root (25.42 cm) was found with 20 kg S $ha^{-1}$ and the lowest one (21.90 cm) was recorded with 10 kg S $ha^{-1}$ (Table 4). Root length/seedling was not significantly influenced by different nitrogen levels. The maximum root length/seedling (26.20 cm) was found with 120 kg N $ha^{-1}$ and minimum root length/seedling (22.16 cm) was found with 100 kg N $ha^{-1}$ (Table 4). Interaction between Sulphur and Nitrogen levels showed no significant effect on root length/ seedling (Table 5).

**Shoot dry weight/seedling**

Shoot dry weight/seedling was not significantly influenced by sulphur levels. Shoot dry weight/seedling varied significantly due to the different Nitrogen levels. The highest shoot dry weight/seedling (84.22 mg) was obtained with 100kg N $ha^{-1}$ which was statistically identical to 120 kg N $ha^{-1}$ (Table 4). The lowest one (68.66 mg) was obtained with 0 kg N $ha^{-1}$. From the table 4, it was observed that increased shoot dry weight/seedling with increasing Nitrogen levels up to 100-kg $ha^{-1}$. Application of 120 kg N $ha^{-1}$ produced lower shoot dry weight/seedling than that of 100-kg $ha^{-1}$. Analysis of variance indicated that interaction of Sulphur and Nitrogen levels was significant for shoot dry weight/seedling. The highest shoot dry weight/seedling (86.67 mg) was recorded in the treatment combination of $S_2 \times N_3$ which was statistically identical to the combinations of $S_0 \times N_1$, $S_0 \times N_3$ and $S_1 \times N_2$ and the lowest shoot dry weight. seedling (66.66 mg) was found due to combination of $S_2 \times N_0$ which was statistically similar to the combinations of $S_0$

$\times N_0$, $S_0 \times N_2$, $S_1 \times N_0$, $S_1 \times N_1$, $S_1 \times N_3$, $S_2 \times N_0$, $S_2 \times N_1$ and $S_2 \times N_2$ (Table 5).

**Root dry weight/seedling**

Root dry weight/seedlings was not significantly influenced by Sulphur levels. However, numerically the highest root dry weight/seedling (42.50 mg) was found with 20 kg S $ha^{-1}$and the lowest one (35.33 mg) with 10 kg S $ha^{-1}$ (Table 4). Root dry weight/seedlings was not significantly influenced by Nitrogen levels. The highest root dry weight/seedling (45.11 mg) was recorded with 120 kg N $ha^{-1}$ and the lowest root dry weight/seedling (33.11 mg) was found with0 kg N $ha^{-1}$ (Table 4). Application of 60 kg N $ha^{-1}$ and 100 kg N $ha^{-1}$ produced statistically similar (40.88 mg and 38.66 mg) root dry weight/seedling. From the table 4, it was revealed that increased rooot dry weight/seedling with increasing nitrogen levels. Interaction between Sulphur and Nitrogen levels showed significant effect on root dry weight/seedling. Maximum root dry weight/seedling (56.00 mg) was obtained due to combination of $S_2 \times N_3$ and the minimum one (26.66 mg) due to combination of $S_0 \times N_0$ (Table 5). From the table 5, it was observed that increased root dry weight/seedling root dry weight/seedling with increasing the Nitrogen level with Sulphur level.

It may be concluded that application of 20 kg S $ha^{-1}$ and 120 kg N $ha^{-1}$ recommended to obtain high yield and to get the best quality of maize seed to the maize growers, but nitrogen and sulphur did not show significantly dependence on each other for grain and stover yield.

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