INFLUENCE OF VARIOUS LEVELS OF SULPHUR ON GROWTH AND YIELD OF SINGLE CROSS HYBRID MAIZE

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ABSTRACT

Evaluation on the effect of sulphur on the growth, yield and nutrient uptake of maize was experimented during Kharif season, 2013 at College farm, College of Agriculture, Rajendranagar, Hyderabad. This was on the topic, “Influence of varying levels of sulphur on growth yield and nutrient uptake of single cross hybrid maize (Zea mays. L.)”. An experiment was conducted with five different levels of sulphur (S₀: 0 kg ha⁻¹, S₁: 20 kg ha⁻¹, S₂: 40 kg ha⁻¹, S₃: 60 kg ha⁻¹ and S₄: 80 kg ha⁻¹), which were placed in randomized block design with factorial concept replicating thrice. As a result, the yield of grain and stover were recorded significantly to be higher than N₁ (180 kg ha⁻¹). It was also evidenced that the per cent increase in grain and stover yield were 4, 3.2 over N₁ respectively. When the sulphur levels are increased, the yield of grain and stover were increased in decreased rate but in par with S₃ (60 kg ha⁻¹). With S₁ (20 kg ha⁻¹), S₂ (40 kg ha⁻¹), S₃ (60 kg ha⁻¹) and S₄ (80 kg ha⁻¹), the increase percent in grain yield was 8.2, 13.8, 23.2 and 20.6 respectively over S₀ (0 kg ha⁻¹). It is also observed that the nutrient uptake by grain and stover was significantly higher with N₂ (225 kg ha⁻¹) than N₁ (180 kg ha⁻¹). Positive effect was shown on the growth and yield of maize by the application of sulphur levels. Similarly, there was a positive effect on nutrient uptake by grain and stover at harvest. Grain and stover showed highest level of nutrient uptake with S₃ (60 kg ha⁻¹), which is considerably higher than S₂ (40 kg ha⁻¹), S₁ (20 kg ha⁻¹) over S₀ (0 kg ha⁻¹) and in par with S₄ (80 kg ha⁻¹). Records have shown that the treatments with higher application of nitrogen N₂ (225 kg ha⁻¹) avails higher nitrogen status. When the level of Sulphur is increased, S status of soil is influenced. Potassium and phosphorus availability in soil along with Nitrogen & Sulphur level and sulphur-nitrogen interaction was found to be insignificant.

KEYWORDS: Maize, Nitrogen, Sulphur, Yield, Nutrient Uptake & Soil Nutrients

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INTRODUCTION

Maize (Zea mays L.) is an essential food and an important feed crop among all other cereals. Maize ranks third after wheat ranking first and rice ranking second in the world. When compared to other cereal crops, Maize has high potential for productivity. Hence it is called as the "Queen of cereals". After rice and wheat that supplies fodder, feed, food, which is also a source of raw materials that are used for the development of hundreds of industrial products like protein, starch, food sweeteners, oil, alcoholic beverages, cosmetics, pharma, bio-fuel etc, maize (Zea mays L.) becomes the third most important cereal. Andhra Pradesh leads the list of major maize producing states contributing 17% of the total Indian maize production. By 2030, the demand for maize would be approximately 45MT among which 24-25% of usage will be for human consumption, 60% will be utilized for
poultry and livestock feed and the remaining 15-16% will be used for industrial raw material. The prerequisites for achieving higher productivity of single cross maize hybrids and sustaining their productivity are the balanced and adequate supply of major and secondary plant nutrients. Lakkineni and Abrol, 1994 revealed that Sulphur has a major role in the higher plants’ primary metabolism. In certain groups of plants, it is also found to be involved in the synthesis of secondary metabolic products. It also plays a vital role in protein formation along with nitrogen and phosphorus. Sulphur has an influence on yield and it also improves the quality of crops as it has influence on protein metabolism and oil synthesis (Krishnamoorthy, 1989; Patil et al., 1998). As per Kumar and Yadav 2007, it is also responsible for the synthesis of essential amino acids like cysteine, cysteine and methionine. Crop management is improved by the favorable effect of Sulphur on environmental stress and by its resisting ability against pest and diseases (Kruse et al., 2007). According to Tandon, 1989, maize crop absorbs as much Sulphur as it absorbs Phosphorus. When there is Sulphur deficiency in the soil, we cannot realize the full yield potential of crops irrespective of other available nutrients even under favorable crop husbandry practices. Katyal et al., 1987 says that the determination of nutrition value of cereals can be performed by knowing the proportion of Sulphur containing amino acids. Sulphur has attained global attention due to the frequent sulphur deficiency issues in time and space. Researchers have reported that there are several factors that contributed to sulphur deficiencies. This includes the increased usage of high analysis fertilizers like diammonium phosphate (DAP) instead of single super phosphate (SSP), which are sulphur free. Over the years, there was lack of organic manures addition and this acted as a factor for sulphur deficiency (Bhagyalakshmi et al., 2009). The requirement of sulphur to produce one ton of cereals is low. But the uptake of Sulphur per unit area is almost equal to the amount of oil seeds. This is due to the higher cereal productivity.

MATERIALS AND METHODS

The entitled field experiment was conducted at College farm, Acharya N. G. Ranga Agricultural University, Rajendranagar, Hyderabad during Kharif 2013. The soil used for this experiment was sandy loam in texture and neutral in reaction. It had low organic carbon, available nitrogen and sulphur. Additionally, it was medium in available phosphorous and high in potassium.

Experiment was conducted in randomized block design with factorial concept. For this, two nitrogen levels (N1: 180 kg ha-1, N2: 225 kg ha-1) and five sulphur levels (S0: 0 kg ha-1, S1: 20 kg ha-1, S2: 40 kg ha-1, S3: 60 kg ha-1 and S4: 80 kg ha-1) were used as factor one and factor two, comprising ten different treatment combinations replicating thrice. At a spacing of 60 cm x 20 cm, single cross hybrid maize (DHM-117) was sown in Kharif-2013. To all the treatments, a uniform dose of 60 kg ha-1 Phosphorus pentoxide (P2O5) as Diammonium phosphate, 50 kg ha-1 Potassium as Murate of potash were applied. At the time of sowing, an entire dose of Phosphorus pentoxide (P2O5) and half of Potassium oxide (K2O) were applied. Some amount of nitrogen is supplied as Diammonium Phosphate (DAP) and the remaining amount of Nitrogen is supplied as per the treatments in urea form (46% N). This is applied in three equal splits – one third each at basal, knee-high and tasseling stages). The remaining potassium was applied during second top dressing along with nitrogen at tasseling stage. At the time of sowing, sulphur was applied in the form of gypsum as per the treatment.

Statistical Analysis

Data generated through these experiments were subjected to ANOVA (analysis of variance). According to the methods described by Gomez and Gomez (1984), separation of means was also obtained using Factorial Randomized
RESULTS AND DISCUSSIONS

Effect of Sulphur Levels on Plant Height (in cm)

At S₃ (60 kg ha⁻¹), a maximum plan height was recorded, which was 28, 174, 180 and 180 cm at six leaf, dough, silking and harvesting stages respectively. This is significantly superior to S₁ (20 kg ha⁻¹), S₂ (40 kg ha⁻¹) and S₀ (0 kg ha⁻¹). Nevertheless, the maximum height was reached with S₃ (60 kg ha⁻¹) during all the stages, which is on par with S₄ (80 kg ha⁻¹) statistically. The lowest plan height was evidenced with S₀ (0 kg ha⁻¹).

With the increased dose of Sulphur application, increase in plant height and dry matter is observed. This is because Sulphur plays multiple roles in protein and carbohydrate metabolism of plants by activating much number of enzymes that play an essential role in dark reaction of photosynthesis. When sulphur dose is provided at higher levels, maize plants show better development and growth. Barsoom (1996) reported that when higher dose of Sulphur is administrated, maize plan height reaches the maximum height.

![Figure 1: Plant Height (in cm) of Maize at Different Growth Stages as Influenced by Sulphur Levels](image)

**Effect of Sulphur Levels on Leaf Area Index (LAI)**

With the increasing levels of sulphur up to S₃ (60 kg ha⁻¹), the leaf area index (LAI) was found to be increased significantly. When the sulphur level is increased up to S₄ (80 kg ha⁻¹), the LAI was found to be decreased slightly, but on par with S₃ (60 kg ha⁻¹). The increase of per cent in LAI with S₃ (60 kg ha⁻¹) over S₀ (0 kg ha⁻¹) during the stages six leaf, silking, dough and physiological maturity was 43.2, 41.4, 34.2 and 109.0% respectively.

Increased level of Sulphur application results in the progressive increase in LAI. Increase in Sulphur application leads to rise in the nutrient uptake level that will enhance the rate of photosynthesis, enzymatic reactions and metabolism (Mengal and Kirkby, 2001). Daniel et al. (2008) supported the findings and reported that the increase in Sulphur application significantly affected LAI and showed the highest value.
Effect of Sulphur Levels on Dry Matter Production

Production of total dry matter increased gradually and steadily after crop establishment until the stage of physiological maturity in all the levels of Sulphur. Significant application of Sulphur affected dry matter accumulation during the growth of maize.

At all the growth stages, maximum dry matter was recorded (13.3, 79.5, 126.7 and 234.7 g plant\(^{-1}\)) with S\(_3\) (60 kg ha\(^{-1}\)), which was significantly higher than S\(_2\) (40 kg ha\(^{-1}\)), S\(_1\) (20 kg ha\(^{-1}\)), and S\(_0\) (0 kg ha\(^{-1}\)) but in par with S\(_4\) (80 kg ha\(^{-1}\)). With the increase of sulphur levels up to S\(_3\) (60 kg ha\(^{-1}\)), a significant increase of dry matter has been observed. When the sulphur level was increased up to S\(_4\) (80 kg ha\(^{-1}\)), the dry matter level was observed to be slightly decreased.

With the application of Sulphur, there was an increase in total dry matter. This was the resultant of better crop growth, which aided plant height to the maximum. The better crop growth also gave maximum LAI, which obviously produced more dry matter. Findings of Poonia (2000) supported these results.

Effect of Sulphur Levels on Yield Attributes of Maize

The characteristics of yield attribute are number of grains row\(^{-1}\), total number of grains cob\(^{-1}\), cob weight(g) and grain weight cob\(^{-1}\) (g). The highest yield was recorded with S\(_3\) @ 60 kg ha\(^{-1}\) and the values were 25.6, 349, 210.7 and 154.3.
respectively. This was significantly higher than $S_1$ (20 kg ha$^{-1}$), $S_2$ (40 kg ha$^{-1}$) and $S_0$ (0 kg ha$^{-1}$) statistically, but on par with $S_4$ (80 kg ha$^{-1}$).

Gahlout et al. (2010) reported that the improvement of vegetative structures for photosynthesis and nutrients absorption, strong sink strength attainment through the development of reproductive structure, assimilates production under the influence of applied Sulphur, balanced and maintained source to sink ratio have contributed to the increased yield attributes of maize.

Table 1: Yield Attributes of Maize as Influenced by Various Sulphur Levels

<table>
<thead>
<tr>
<th>Sulphur Levels (S)</th>
<th>Number of Grains Row$^{-1}$</th>
<th>Total Number of grains Cob$^{-1}$</th>
<th>Cob Weight (g)</th>
<th>Grain Weight Cob$^{-1}$ (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S_0$ (0 kg ha$^{-1}$)</td>
<td>22.8</td>
<td>297</td>
<td>185.5</td>
<td>130.0</td>
</tr>
<tr>
<td>$S_1$ (20 kg ha$^{-1}$)</td>
<td>23.6</td>
<td>312</td>
<td>192.2</td>
<td>138.3</td>
</tr>
<tr>
<td>$S_2$ (40 kg ha$^{-1}$)</td>
<td>24.5</td>
<td>331</td>
<td>202.7</td>
<td>142.9</td>
</tr>
<tr>
<td>$S_3$ (60 kg ha$^{-1}$)</td>
<td>25.6</td>
<td>349</td>
<td>210.7</td>
<td>154.3</td>
</tr>
<tr>
<td>$S_4$ (80 kg ha$^{-1}$)</td>
<td>25.5</td>
<td>345</td>
<td>207.4</td>
<td>151.7</td>
</tr>
<tr>
<td>SEm</td>
<td>0.22</td>
<td>4.20</td>
<td>2.12</td>
<td>1.01</td>
</tr>
<tr>
<td>CD (p=0.05)</td>
<td>0.65</td>
<td>12.6</td>
<td>6.37</td>
<td>3.04</td>
</tr>
</tbody>
</table>

Effect of Sulphur Levels on Grain and Stover Yield of Maize

Maximum stover yield of 9450 kg ha$^{-1}$ and maximum grain yield of 7246 kg ha$^{-1}$ were recorded with $S_3$ (60 kg ha$^{-1}$), which is significantly superior to $S_1$ (20 kg ha$^{-1}$), $S_2$ (40 kg ha$^{-1}$), and $S_0$ (0 kg ha$^{-1}$). But this was statistically on par with $S_4$ (80 kg ha$^{-1}$). 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$^{-1}$), the increase in percent of grain yield was 8.2, 13.8, 23.2 and 20.6% respectively over $S_0$ (0 kg ha$^{-1}$). Tandon, 1999 reported that with higher sulphur application, increase seed yield of maize could be due to increased availability of nutrients and also due to development of heavy source-sink relationship established with the awareness of maize higher productivity in terms of yield of seeds.

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$^{-1}$), the stover yield’s increase in per cent was 5.3, 9.8, 16.3 and 14.3% respectively over $S_0$ (0 kg ha$^{-1}$). When the dose of sulphur is high, it reflects in higher stover yield. As stated in Mehta et al., 2005, this is due to better vegetative growth as specified by more dry matter maize production.

Figure 4: Grain Yield and Stover Yield (kg ha$^{-1}$) of Maize as Influenced by Sulphur Levels

Effect of Sulphur Levels on Sulphur Uptake of Maize

Studies have found that the highest sulphur uptake by grain at 16.2 kg ha$^{-1}$ and stover at 15.6 kg ha$^{-1}$ in $S_3$ (60 kg ha$^{-1}$).
ha\(^{-1}\)). This is significantly higher to S\(_2\) (40 kg ha\(^{-1}\)), S\(_1\) (20 kg ha\(^{-1}\)) and S\(_0\) (0 kg ha\(^{-1}\)). But statistically this was on par with S\(_4\) (80 kg ha\(^{-1}\)). Sulphur uptake by stover and maize grain was significantly increased by the application of Sulphur. Dwidevi et al. (2002) says that the increase in Sulphur concentration in plant and dry matter yield could result in increased uptake in Sulphur. These results were also found be in line with Sakal et al. (2000).

**Effect of Sulphur Levels on Net Return and B: C Ratio of Maize**

Increased application of sulphur rates up to 60 kg ha\(^{-1}\) leads to the increase in the gross returns, net returns and B: C ratio. This could also be because of dry matter production and increase in grain, synergistic effect of sulphur on plant growth, quality of maize and stover yield. With the increased level of sulphur up to 60 kg ha\(^{-1}\), highest net returns of about Rs. 65685/- and B:C ratio of 3.30 were obtained. These results were in line with the reports of Shivranet al. (2013).

**Table 2: Nutrient Uptake, Net Returns and B: C Ratio of Maize as Influenced by Various Sulphur Levels**

<table>
<thead>
<tr>
<th>Sulphur Levels (S)</th>
<th>Sulphur Uptake by Grain(kg ha(^{-1}))</th>
<th>Sulphur Uptake by Stover(kg ha(^{-1}))</th>
<th>Net returns((\text{Rs. ha}^{-1}))</th>
<th>B:C Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>S(_0) (0 kg ha(^{-1}))</td>
<td>8.7</td>
<td>6.8</td>
<td>49857</td>
<td>2.84</td>
</tr>
<tr>
<td>S(_1) (20 kg ha(^{-1}))</td>
<td>11.2</td>
<td>9.1</td>
<td>55357</td>
<td>3.02</td>
</tr>
<tr>
<td>S(_2) (40 kg ha(^{-1}))</td>
<td>13.1</td>
<td>11.1</td>
<td>59105</td>
<td>3.11</td>
</tr>
<tr>
<td>S(_3) (60 kg ha(^{-1}))</td>
<td>16.2</td>
<td>15.6</td>
<td>65685</td>
<td>3.30</td>
</tr>
<tr>
<td>S(_4) (80 kg ha(^{-1}))</td>
<td>15.2</td>
<td>14.4</td>
<td>62794</td>
<td>3.16</td>
</tr>
<tr>
<td>SEm±</td>
<td>0.59</td>
<td>0.68</td>
<td>704</td>
<td></td>
</tr>
<tr>
<td>CD (p=0.05)</td>
<td>1.80</td>
<td>2.06</td>
<td>2108</td>
<td></td>
</tr>
</tbody>
</table>

**CONCLUSIONS**

Positive effect is shown on the growth and yield of maize by the application of sulphur levels. In addition, nutrient uptake by grain and stover during harvest was also favorable. With the increasing levels of sulphur upto S\(_4\) (80 kg ha\(^{-1}\)) the yield of the maize and the growth parameters have also increased. But this is on par with S\(_3\) (60 kg ha\(^{-1}\)) due to synergistic effect of sulphur on dry matter production and on plant growth. When the sulphur level is increased further, there was an increase in the grain and stover yield in decreased rate. But again this was on par with S\(_3\) (60 kg ha\(^{-1}\)). 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\(^{-1}\)), the per cent increase in grain yield was 8.2, 13.8, 23.2 and 20.6 respectively over S\(_0\) (0 kg ha\(^{-1}\)). With S\(_3\) (60 kg ha\(^{-1}\)), the nutrient uptake by stover and grain were recorded to be in highest levels, which on par with S\(_4\) (80 kg ha\(^{-1}\)) is significantly higher than S\(_2\) (40 kg ha\(^{-1}\)), S\(_1\) (20 kg ha\(^{-1}\)) over S\(_0\) (0 kg ha\(^{-1}\)).

**REFERENCES**


