International Journal of

# Agricultural Research

ISSN 1816-4897

Academic Journals Inc.

www.academicjournals.com

International Journal of Agricultural Research 2 (7): 599-606, 2007
ISSN 1816-4897


# Sulphur Application on Growth and Yield and Quality of Sesame Varieties

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**Abstract:** A field experiment was conducted in sandy clay loam soils to study the importance of sulphur in realizing the better yield and quality viz., crude protein and oil content and yield of sesame crop during summer season of 2005 in Randomized Block Design with three replications. Three sesame varieties (TMV 4, TMV 6 and KS 95010) were tested for the response to five levels of sulphur ($S_0$: 0 kg S ha$^{-1}$; $S_{15}$: 15 kg S ha$^{-1}$; $S_{30}$: 30 kg S ha$^{-1}$; $S_{45}$: 45 kg S ha$^{-1}$ and $S_{60}$: 60 kg S ha$^{-1}$). The positive response between S application up to 60 kg ha$^{-1}$ and growth and yield components and seed yield of sesame was noticed in this study. The plant height was superior with the application of 60 kg S ha$^{-1}$ and TMV 6 recorded the maximum and the highest was in KS95010 with the application of 60 kg S ha$^{-1}$. The number primary and secondary branches per plant, number of capsule in main stem, primary and secondary branch and number of seeds per capsule was found higher with the application of 45 kg S ha$^{-1}$. Application of 60 and 45 kg S ha$^{-1}$ recorded higher seed yield and KS 95010 was significantly superior to other varieties. The highest seed yield was obtained from KS 95010 with the application of 60 kg S ha$^{-1}$. The quality parameters studied viz., crude protein content and oil content and yield was increased with increasing S levels. The crude protein content was higher with higher levels of S viz., 45 and 60 kg S ha$^{-1}$ and TMV 4 registered the highest crude protein content among the varieties. The higher crude protein content was obtained in TMV 4 with the application of 60 and 45 kg S ha$^{-1}$. The oil content was highest with the application 60 kg S ha$^{-1}$ and higher in TMV 4 and TMV 6 than KS 95010. The higher oil content was obtained in TMV 4 with the application of 60 kg S ha$^{-1}$. The oil yield was also recorded higher at 60 kg S ha$^{-1}$ and all the varieties were equally effective. The higher oil content was obtained in KS 95010 with the application of 60 kg S ha$^{-1}$. In general application of 45 and 60 kg S ha$^{-1}$ was found to improve higher growth, yield and quality in different sesame cultivars. The culture KS 95010 performed better than the other varieties.

**Key words:** Sesame, sulphur, branches, capsule, yield

## INTRODUCTION

Sesame is called as Queen of oilseeds. Oilseeds are important constituent in human dietary system next to carbohydrate and protein (Pal and Gangwar, 2004). Among the oilseeds crops, sesame has the highest oil content of 46-64% with 25% protein (Goel and Sanjayakumar, 1994). Sulphur (S) requirement is equal to that of phosphorus (Scherer, 2001) essential for the growth and development, plays a key role in the plant metabolism, indispensable for the synthesis of essential oils, plays a vital role in chlorophyll formation (Ajai Singh *et al*., 2000) required for development of cells and it increases

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cold resistance and drought hardiness (Patel and Shelke, 1995) and constituent of a number of organic compounds (Shamina and Imamul, 2003), oil storage organs particularly oil glands (Jaggi *et al*., 2000) and vitamin $B_1$ (Thirumalaisamy *et al*., 2001).

At present, the average yields of seeds are just about 421 kg $ha^{-1}$, which needs to be increased to at least 1.2 and 1.5 tones by 2010 and 2015 as reported by Hedge (2005). The growth parameters like leaf area, crop growth rate and net assimilation rate index and yield parameters like branches per plant, capsules per plant, seeds per capsule and 1000 seed weight was improved increased sulphur in sesame (Thakur and Patel, 2004; Sarkar and Panik, 2002; Tiwari *et al*., 2000). The response of sesame to sulphur for producing higher yield was up to 40 kg $ha^{-1}$ according to Nagwani *et al.* (2001) and Kathiresan (2002) and up to 50 kg $ha^{-1}$ (Sarkar and Panik, 2002). Sulphur application not only improved the grain yield but also improved the quality of crops (Tiwari and Gupta, 2006). At present, the average yields of seeds are just about 421 kg $ha^{-1}$, which needs to be increased to at least 1.2 and 1.5 tones by 2010 and 2015 as reported by Hedge (2005). The response of sesame to sulphur for producing higher yield was up to 40 kg $ha^{-1}$ according to Nagwani *et al.* (2001) and Kathiresan (2002) and up to 50 kg $ha^{-1}$ (Sarkar and Panik, 2002). The response of sesame crop varies with sulphur levels to produce crude protein and oil content and yield was reported by Singh and Tiwari (1985). As the intensity of cropping is gradually increasing, the response of oilseeds to sulphur is also increasing (Ghosh *et al*., 2002). Use of high analysis sulphur free fertilizers, heavy sulphur removal by the crops under intensive cultivation and neglect of sulphur replenishment contributed to widespread sulphur deficiencies in arable soils. Hence this study was attempted to study the importance of sulphur in realizing the better growth, yield and quality of sesame crop.

## MATERIALS AND METHODS

### Experimental Site, Design and Treatment Details

The experiment was conducted in a sandy clay loam soil of Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, Union Territory of Pondicherry, India during the year 2004-05. The experimental site is situated 12 km from Bay of Bengal, lies between 10°49′ and 11°01’ North latitude and 78°43’ and 79°52’ East longitude with an altitude of 4 m above Mean Sea Level (MSL). The initial soil analyses show that the soil was sandy clay loam in texture falls in *Fluventic Haplustept* taxonomic class. The soil is optimum in bulk density (1.25 Mg $m^{-3}$) and particle density (2.20 Mg $m^{-3}$) with the porosity of 43.18%. The soil reaction was neutral (pH: 7.61) and the Electrical Conductivity is low (0.35 dS $m^{-1}$). The soil was low in available nitrogen ($KMnO_4$-N: 146 kg $ha^{-1}$) and available potassium ($NH_4OAc$-K: 145 kg $ha^{-1}$), medium in available phosphorous (Olsen-P: 12.6 kg $ha^{-1}$) and high in organic carbon content (0.88%). The sulphur content was 16.9 kg $ha^{-1}$.

The experiment was conducted during summer season between March and June of the year 2005 in Randomized Block Design (RBD) with three replications. Three sesame varieties (TMV 4, TMV 6 and KS 95010) were tested for the response to five levels of sulphur ($S_0$: 0 kg S $ha^{-1}$; $S_{15}$: 15 kg S $ha^{-1}$; $S_{30}$: 30 kg S $ha^{-1}$; $S_{45}$: 45 kg S $ha^{-1}$ and $S_{60}$: 60 kg S $ha^{-1}$). The sulphur (S) was supplied through Gypsum as per the treatments to the corresponding plots. The nitrogen was supplied through Di-Ammonium Phosphate (@ 35 kg N $ha^{-1}$) in three splits half at basal and remaining half in two equal splits at vegetative stage and at flower initiation stage; Phosphorous (@ 23 kg $P_2O_5$ $ha^{-1}$) was supplied through Di-Ammonium Phosphate as basal; potassium (@ 23 kg $K_2O$ $ha^{-1}$) through muriate of potash as basal. Thinning was done twice at 15 and 30 days after sowing. A hand weeding was done at 25 days after transplanting to remove the competitive weeds in the field. A pesticide spray of monocrotophos @ 250 mL $ha^{-1}$ was given at 30 days after transplanting to control leaf folders and sucking pests. The plant height, number of branches per plant, number of capsules per plant, number of seeds per capsule was recorded at harvest stage. The crop was harvested separately from the plots, harvested and winnowed and grain yield and test weight were recorded. The nitrogen content of seeds was estimated by Kjeldahl's method by 1030 auto analyzer (Bremner, 1965) and crude protein content was derived by multiplying the seed nitrogen content with the factor 6.25 (Humphries, 1956). The oil content was estimated by Soxhlet apparatus method following the procedure of Singh *et al*. (1960). The oil yield was calculated by multiplying oil content with seed yield. The observations collected from the experiment and the data on the results of analysis of plant samples were subjected to statistical scrutiny as per the procedure of Gomez and Gomez (1984).

## RESULTS AND DISCUSSION

### Effect of Sulphur on Growth Parameters

#### Plant Height

Plant height at harvest stage increased with increased S levels. This might be due to more synthesis of amino acids, increase in chlorophyll content in growing region and improving the photosynthetic activity, ultimately enhancing cell division and thereby increased the crop growth rate (Table 1). This was evinced through the studies of Intodia and Tomar (1997) and Dubey and Khan (1993). Application of 60 kg S $ha^{-1}$ recorded highest plant height of 140.9 cm among the S levels and in varieties TMV 6 recorded the maximum. Higher dose of 60 kg S $ha^{-1}$ to KS 95010 produced highest height (144.7 cm).

#### Number of Branches per Plant

Application of 45 kg S $ha^{-1}$ produced more primary (8.4) and secondary (8.1) branches per plant (Table 1). Primary and secondary branches per plant indicated that sulphur application increased the number. These findings are in line with the result obtained through the study of Vishwakarma *et al*. (1998). The increased number of branches by sulphur application is attributed to the stimulatory effect of sulphur in cell division. The importance of sulphur in cell division, cell elongation and setting of cell structure has been reported by Hadvani *et al*. (1993). Among the varieties TMV 6 produced more number of primary and secondary branches of 8.5 and 7.3 per plant, respectively.

### Effect of Sulphur on Yield Parameters

#### Number of Capsules per Plant

Application of S significantly increased the number of capsules per plant in main stem, primary branches and secondary branches (Table 1). Similar results were reported by Devakumar and Giri (1998) and Subramaniyan *et al.* (1999). Among the different S levels, application of S at 45 kg $ha^{-1}$ recorded higher number of capsules in main stem, primary and secondary branches per plant. Beyond this level, there was a decline in the number of capsules per plant. The possible reason for this kind of result may be due to the nutritional imbalance caused by the highest level of S i.e., 60 kg $ha^{-1}$. Among the varieties tested, KS 95010 produced higher number of capsules in both primary and secondary branches of plants. The promising performance of KS 95010 in producing higher number of capsules per plant was well-established through the study of Govindarasu *et al.* (1998).

#### Number of Seeds per Capsule

Positive relationship was observed between the levels of sulphur and the number of seeds per capsule. Among the different S levels, application of S at 45 kg $ha^{-1}$ recorded higher number of seeds per capsule (48.3) (Table 1). Enhanced performances of reproductive parameters was due to the role of S in better absorption of nutrients and also due to higher rate of assimilate partitioning towards the sink. These findings are in conformity with those reported by Devakumar and Giri (1998) and Subramaniyan *et al*. (1999), who observed that the application of sulphur significantly influenced the

Table 1: Influence of Sulphur levels on growth and yield components and seed yield of sesame varieties

| | Plant height | | | | No. of primary branches plant$^{-1}$ | | | |
|---|---|---|---|---|---|---|---|---|
| | Varieties | | | | Varieties | | | |
| S-levels | TMV4 | TMV6 | KS95010 | Mean | TMV4 | TMV6 | KS95010 | Mean |
| $S_0$ | 103.3 | 111.9 | 118.5 | 111.2 | 6.4 | 7.4 | 6.90 | 6.9 |
| $S_{15}$ | 126.5 | 121.7 | 127.3 | 125.2 | 7.5 | 8.3 | 7.40 | 7.7 |
| $S_{30}$ | 131.9 | 132.7 | 133.3 | 132.6 | 7.9 | 8.4 | 7.90 | 8.1 |
| $S_{45}$ | 136.0 | 136.1 | 138.0 | 136.7 | 8.4 | 8.9 | 8.00 | 8.4 |
| $S_{60}$ | 138.4 | 139.5 | 144.7 | 140.9 | 7.1 | 7.7 | 7.00 | 7.3 |
| Mean | 127.2 | 128.4 | 132.3 | 129.3 | 7.5 | 8.5 | 7.40 | |
| | S | V | S×V | | S | V | S×V | |
| SED | 1.4 | 1.1 | 2.5 | | 0.16 | 0.13 | 0.28 | |
| CD | 2.9 | 2.3 | 5.1 | | 0.33 | 0.26 | NS | |
| | **No. of capsules in main stem** | | | | **No. of capsules in primary branch** | | | |
| $S_0$ | 14.8 | 15.6 | 16.9 | 15.8 | 39.1 | 39.8 | 39.7 | 39.5 |
| $S_{15}$ | 18.3 | 16.7 | 17.7 | 17.6 | 41.0 | 43.5 | 44.4 | 42.9 |
| $S_{30}$ | 19.5 | 17.8 | 20.0 | 19.1 | 46.8 | 44.9 | 46.6 | 46.1 |
| $S_{45}$ | 20.3 | 20.2 | 22.1 | 20.9 | 49.2 | 51.2 | 51.9 | 50.8 |
| $S_{60}$ | 18.8 | 18.9 | 22.6 | 20.1 | 42.7 | 49.9 | 53.9 | 47.2 |
| Mean | 18.4 | 17.8 | 19.9 | | 43.8 | 45.9 | 47.3 | |
| | S | V | S×V | | S | V | S×V | |
| SED | 0.30 | 0.23 | 0.52 | | 0.29 | 0.46 | 1.02 | |
| CD | 0.62 | 0.48 | 1.06 | | 1.21 | 0.94 | 2.09 | |

| | No. of secondary branches plant$^{-1}$ | | | | No. of seeds per capsule | | | |
|---|---|---|---|---|---|---|---|---|
| | Varieties | | | | Varieties | | | |
| S-levels | TMV4 | TMV6 | KS95010 | Mean | TMV4 | TMV6 | KS95010 | Mean |
| $S_0$ | 5.4 | 6.2 | 6.1 | 5.9 | 41.3 | 40.3 | 41.0 | 40.9 |
| $S_{15}$ | 6.6 | 7.1 | 7.2 | 7.0 | 42.5 | 41.9 | 43.7 | 43.0 |
| $S_{30}$ | 7.2 | 7.2 | 8.1 | 7.2 | 44.3 | 45.3 | 47.3 | 45.7 |
| $S_{45}$ | 7.8 | 8.5 | 8.1 | 8.1 | 47.3 | 48.1 | 49.7 | 48.3 |
| $S_{60}$ | 7.3 | 7.6 | 7.5 | 7.5 | 47.0 | 46.3 | 50.1 | 46.8 |
| Mean | 6.8 | 7.3 | 7.2 | | 44.4 | 44.7 | 45.7 | 44.9 |
| | S | V | S×V | | S | V | S×V | |
| SED | 0.12 | 0.09 | 0.21 | | 0.4 | 0.3 | 0.8 | |
| CD | 0.25 | 0.19 | 0.42 | | 0.9 | 0.7 | NS | |
| | **No. of capsules in secondary branch** | | | | **Test weight (g)** | | | |
| $S_0$ | 12.3 | 13.2 | 13.0 | 12.9 | 2.65 | 2.44 | 2.37 | 2.49 |
| $S_{15}$ | 14.3 | 17.3 | 16.7 | 16.1 | 2.78 | 2.67 | 2.57 | 2.67 |
| $S_{30}$ | 19.2 | 20.4 | 21.1 | 20.2 | 2.83 | 2.77 | 2.73 | 2.78 |
| $S_{45}$ | 22.4 | 23.9 | 24.3 | 23.5 | 2.97 | 2.87 | 2.80 | 2.88 |
| $S_{60}$ | 20.0 | 20.5 | 20.7 | 20.4 | 3.06 | 2.93 | 2.86 | 2.96 |
| Mean | 17.7 | 19.1 | 19.2 | | 2.86 | 2.73 | 2.67 | |
| | S | V | S×V | | S | V | S×V | |
| SED | 0.40 | 0.31 | 0.69 | | 0.05 | 0.04 | 0.08 | |
| CD | 0.80 | 0.64 | NS | | 0.09 | 0.07 | NS | |

NS: Non Significant

yield components in sesame. All the varieties showed variation in increasing the number of seeds per capsule with sulphur application. Among the S levels, 45 kg S ha$^{-1}$ recorded the highest number of seeds per capsule in the case of TMV 4 and TMV 6, whereas number of seeds was increased up to 60 kg S ha$^{-1}$ in the case of KS 95010. Here again, the culture KS 95010 is proved to be more fertilizer responsive as claimed by Govindarasu *et al.* (1998).

## Test Weight

The test weight was significantly superior in 60 kg S ha$^{-1}$ than the other levels compared, but was not much conspicuous (Table 1). Among the varieties, TMV 4 recorded higher test weight. However,

Table 2: Sulphur application on seed yield and quality of sesame varieties

| | Seed yield (kg ha$^{-1}$) | | | | Crude protein (%) | | | |
|---|---|---|---|---|---|---|---|---|
| | Varieties | | | | Varieties | | | |
| S-levels | TMV 4 | TMV 6 | KS 95010 | Mean | TMV 4 | TMV 6 | KS 95010 | Mean |
| $S_0$ | 424 | 431 | 433 | 430 | 19.12 | 16.24 | 13.57 | 16.31 |
| $S_{15}$ | 509 | 532 | 501 | 514 | 23.12 | 17.81 | 16.34 | 19.09 |
| $S_{30}$ | 588 | 562 | 593 | 581 | 24.20 | 19.97 | 21.36 | 21.85 |
| $S_{45}$ | 598 | 610 | 597 | 601 | 25.54 | 21.89 | 21.41 | 22.86 |
| $S_{60}$ | 554 | 591 | 617 | 587 | 26.77 | 22.81 | 22.29 | 23.96 |
| Mean | 535 | 545 | 548 | | 23.75 | 19.65 | 19.04 | |
| | S | V | S×V | | S | V | S×V | |
| SED | 7 | 5 | 11 | | 0.60 | 0.47 | 1.05 | |
| CD | 14 | 10 | 23 | | 1.24 | 0.96 | NS | |
| | Oil content (%) | | | | Oil yield (kg ha$^{-1}$) | | | |
| $S_0$ | 38.3 | 39.0 | 38.5 | 38.6 | 162.3 | 167.9 | 166.6 | 165.6 |
| $S_{15}$ | 43.0 | 42.5 | 42.6 | 42.7 | 219.3 | 227.7 | 213.1 | 220.0 |
| $S_{30}$ | 46.0 | 43.8 | 45.2 | 45.0 | 267.3 | 246.2 | 268.3 | 260.6 |
| $S_{45}$ | 49.0 | 49.0 | 48.0 | 48.7 | 289.9 | 298.9 | 288.7 | 292.5 |
| $S_{60}$ | 51.5 | 50.7 | 49.8 | 50.7 | 293.7 | 299.8 | 305.4 | 299.6 |
| Mean | 45.6 | 45.0 | 44.8 | | 246.5 | 248.1 | 248.4 | |
| | S | V | S×V | | S | V | S×V | |
| SED | 0.3 | 0.67 | 0.47 | | 1.69 | 1.31 | 2.94 | |
| CD | 0.6 | 1.37 | NS | | 3.47 | NS | 6.02 | |

NS: Non Significant

the differences were not that much conspicuous. This might be attributed to the intrinsic characters of the varieties. This finds support from Prabhu (2004).

**Effect of Sulphur on Seed Yield**

The effect due to S levels, varieties and their interactions was seen very conspicuously in realizing the seed yield (Table 2). Among the different S levels compared 45 and 60 kg S ha$^{-1}$ recorded the highest seed yield of 601 and 587 kg ha$^{-1}$, respectively. With respect to the varieties, the highest yield (548 kg ha$^{-1}$) was recorded in KS 95010 with, followed by TMV 6 and TMV 4. Application of 60 kg S ha$^{-1}$ to KS 95010 produced highest seed yield of 617 kg ha$^{-1}$ but it was comparable with the yield of TMV 6 (610 kg ha$^{-1}$) with 45 kg S ha$^{-1}$. Supply of S in addition to N, P and K might act as a lifting factor behind the increased seed yield. Application of sulphur resulted in improved growth and yield parameters and therefore, finally increased the seed yield. These findings are in accordance with the earlier reports of Devakumar and Giri (1998) and Tiwari *et al.* (2000). The lowest yield recorded under control treatment might be due to the limited availability of nutrient in soil and uptake of nutrient by the crop, which ultimately reflected on these results. This finds support from the study of Singh *et al.* (1997) and Ansari *et al.* (1998). The interaction of S with varieties revealed that, application of S at 60 kg ha$^{-1}$ performed better in KS 95010 (617 kg ha$^{-1}$) which was followed by TMV 6 and TMV 4, respectively at 45 kg S ha$^{-1}$ and the lower yields in the variety of TMV 4 at different levels of S are ascribed due to their intrinsic characters and growth potential (Govindarasu *et al.*, 1998).

**The Response Function and Optimization of Sulphur**

Response function between levels of S and seed yield of varieties were characterized by quadratic relationship. The results indicated that the physical optimal rate was 41.25 kg S ha$^{-1}$ for TMV 4, 48.74 kg S ha$^{-1}$ for TMV 6, 56.25 kg S ha$^{-1}$ for KS95010 and as a whole 47.27 kg S ha$^{-1}$ for sesame. The economic optimal rate was 40.32 kg S ha$^{-1}$ for TMV 4, 47.39 kg S ha$^{-1}$ for TMV 6, 54.66 kg S ha$^{-1}$ for KS95010 and as a whole 46.09 kg S ha$^{-1}$ for sesame. From this investigation, the optimum level of S can be fixed as 48 kg ha$^{-1}$ for irrigated sesame.

**Effect of Sulphur on Quality Parameters**

**Crude Protein**

The crude protein content of seeds was increased with increasing in S levels. The higher crude protein contents of 23.96 and 22.86% were registered at 60 and 45 kg S $ha^{-1}$ than the other levels. The lowest content of 16.31 was observed at S control. Among the varieties tested, TMV 4 registered the highest crude protein content of 23.75% followed by TMV 6 (19.65%). The highest crude protein of 26.77 and 25.54% was produced by the variety TMV 4 with 60 and 45 kg S $ha^{-1}$. The substantial increase in crude protein content with gypsum application might be due to increased availability of sulphur for subsequent synthesis of oil and crude protein. This kind of interpretation is in consonance to the report of Chitkala and Reddy (1991).

**Oil Content**

The oil content of sesame seeds was significantly influenced by S application. Increasing the S levels increased the oil content considerably (Table 2). This was in line with the reports of FAO (2004). The maximum oil content of 50.7% was recorded with the highest dose of sulphur (60 kg S $ha^{-1}$) and followed by 45 kg S $ha^{-1}$ (48.7%). This same result was reported by Singh and Tiwari (1985). This could be attributed to the influence of sulphur in rapid conversion of nitrogen to crude protein and finally to oil. The acetic thiolinase, a sulphur based enzyme in the presence of S convert acetyl Co-A to melonyl Co-A, rapidly resulting in higher oil content in seed crops (Krishnamurthy and Mathan, 1996). Among the varieties TMV 4 recorded highest oil content of 45.6% and it was on par with TMV 6 (45.0%) but superior than KS 95010 (44.8%). The highest oil content (51.5%) was recorded by TMV 4 with the application of 60 kg S $ha^{-1}$. The increase in oil content due to S application might be due to its key role in biosynthesis of oil in plants (Mudd, 1967).

**Oil Yield**

Oil yield was significantly influenced by S application. The application of S at 60 kg $ha^{-1}$ registered the higher oil yield of 299.6 kg $ha^{-1}$ (Table 2). Though there were slight variations in the oil yields among the varieties, it was not significant. However, the interaction between varieties and S levels showed significant variation in the oil yield. The higher oil yield of 305 kg $ha^{-1}$ was registered in KS 95010 at 60 kg S $ha^{-1}$. Full utilization of carbohydrate for the synthesis of oil with sulphur might be increased the oil yield (Yadav and Harishankar, 1980).

## CONCLUSIONS

The positive response between S application and growth, yield and quality of sesame was noticed in this study. The plant height was superior with the application of 60 kg S $ha^{-1}$ and TMV 6 recorded the maximum and the highest was in KS95010 with the application of 60 kg S $ha^{-1}$. The number primary and secondary branches per plant, number of capsule in main stem, primary and secondary branch and number of seeds per capsule was found higher with the application of 45 kg S $ha^{-1}$. The branching was higher in TMV 6, capsule count in KS 95010 and seeds per capsule with TMV 4 and TMV 6. The seed yield was much influenced by the application of S and among the varieties. At 60 and 45 kg S $ha^{-1}$ seed yield and KS 95010 was significantly superior. The highest seed yield was obtained from KS 95010 with the application of 60 kg S $ha^{-1}$. The physical optimal rate was 47.27 kg S $ha^{-1}$ and economic optimal rate was 46.09 kg S $ha^{-1}$ for sesame. The higher levels of S viz., 45 and 60 kg S $ha^{-1}$ recorded higher crude protein content and TMV 4 registered the highest crude protein content among the varieties. The higher crude protein content was obtained in TMV 4 with the application of 60 and 45 kg S $ha^{-1}$. The oil content of sesame seeds increased conspicuously with increased supply of S. Application 60 kg S $ha^{-1}$ recorded higher oil content and higher with TMV 4 and TMV 6. The higher oil content was obtained in TMV 4 with the application of 60 kg S $ha^{-1}$. The oil yield was also recorded higher at 60 kg S $ha^{-1}$ and all the varieties were equally effective. The higher oil content was obtained in KS 95010 with the application of 60 kg S $ha^{-1}$. From this investigation, the optimum level of S can be fixed as 48 kg $ha^{-1}$ for better growth, yield and quality of sesame crop and KS 951010 will be the more suitable varieties.

## REFERENCES

Ajai Singh, S.P., R.S. Singh, Katiyar and P.P. Singh, 2000. Response of nitrogen and sulphur on economic yield of sunflower under sodic soil condition. Indian J. Agric. Sci., 70: 536-537.

Ansari, M.M., A. Ramesh and S.D. Billore, 1998. Effect of different organic manures on the collar rot incidence and yield in soybean. J. Oilseeds Res., 15: 368-370.

Bremner, J.M., 1965. In: Methods of Soil Analysis. Part 2, Black, C.A. (Ed.), Am. Soc. Agron., 9: Inc., Publishers. USA.

Chitkala, T.D. and M.G. Reddy, 1991. Effect of gypsum and P fertilizers on groundnut. Indian J. Agron., 36: 265-266.

Devakumar, M. and Giri, 1998. Influence of weed control and doses and time of gypsum application on yield attributes, pod and oil yields of groundnut. Indian J. Agron., 43: 453-458.

Dubey, O.P. and R.A. Khan, 1993. Effect of nitrogen and sulphur content in Indian mustard and their residual balance in soil. Indian J. Agron., 38: 582-587.

FAO., 2004. Report on sulphur in agriculture. Fert. News, 49: 1-5.

Ghosh, P.K., K.G. Mandal, K.K. Bandhyopadhyay, K.M. Hati, S. Rao and A.K. Tripathi, 2002. Role of plant nutrient management in oilseed production. Fert. News, 47: 67-77.

Goel, P.D. and S. Sanjayakumar, 1994. A great ancient oilseed sesamum. Farmer and Parliament, 12: 6-7.

Gomez, K.A. and A.A. Gomez, 1984. Statistical Procedures for Agricultural Research. 2nd Edn., Int. Rice Res. Inst., Manila, Philippines and John Wiley and Sons, New York, USA., pp: 680.

Govindarasu, R., P. Sivasubramanian and K. Manian, 1998. Analysis of seed yield and yield components in sesame at coastal Karaikal. J. Indian Soc. Coastal Agric. Res., 7: 95-97.

Hadvani, R.G., R.P.S. Ahlawat and S.J. Trivedi, 1993. Effect of methods of sowing and levels of sulphur on growth and yield of groundnut (*Arachis hypogea*). Indian J. Agron., 38: 325-327.

Hedge, D.M., 2005. Oil seeds-measures to turn self-reliant. The Hindu-Survey of Indian Agriculture, pp: 71-76.

Humphries, E.C., 1956. Mineral Components and Ash Analysis. Modern Method of Plant Analysis. Springer-Verlag, Berlin, 1: 468-502.

Intodia, S.K. and O.P. Tomar, 1997. Effect of sulphur application on growth and yield of sunflower. Indian J. Agric. Sci., 67: 46-47.

Jaggi, R., C. Rakesh, K. Sharma and S.S. Paliyal, 2000. Sulphur as second major nutrient in cruciferous oilseeds. Indian Farming, 12: 14-18.

Kathiresan, 2002. Response of sesame genotypes to levels of nutrient and spacing under different season. Indian J. Agron., 47: 537-540.

Krishnamurthy, V.V. and K.K. Mathan, 1996. Effect of sulphur on yield of groundnut. Madras. Agric. J., 83: 640-642.

Mudd, J.B., 1967. Fat metabolism in plants. Ann. Rev. Plant Physiol., 18: 229-252.

Nagwani, A.V. Sumathi, Chandrika and Muneendra, 2001. Effect of nitrogen and sulphur of yield and oil content of sesame. J. Oilseed Res., 18: 73-77.

Pal, S.S. and B. Gangwar, 2004. Nutrient management in oilseed based cropping systems. Fert. News. 49: 37-38, 41-45.

Patel, J.R. and V.B. Shelke, 1995. Effect of farmyard manure, phosphorus and sulphur on growth, yield and quality of Indian mustard. Indian J. Agron., 43: 713-717.

Prabhu, V., 2004. Optimization of nitrogen requirement to rice fallow sesame (*Sesamum indicum*) for Cauvery delta region. M.Sc. Thesis, Tamil Nadu Agricultural University Coimbatore, India.

Sarkar and Panik, 2002. Effect of planting geometry direction of planting and sulphur application on growth and productivity of sesame. Indian J. Agric. Sci., 72: 70-73.

Scherer, H.W., 2001. Sulphur in crop production. Eur. J. Agron., 14: 81-111.

Shamina and Imamul, 2003. Mineralization pattern of added sulphur in some Bangladesh soils under submerged condition. Indian J. Agric. Chem., 36: 13-21.

Singh, M.L.G. and N.K. Anant, 1960. Effect of N, P and S on the yield and oil content of sesame. Indian J. Agron., 4: 176-181.

Singh, M. and R.C. Tiwari, 1985. Response of oilseed and pulse crops to fertilizers in dry land agriculture. Proc. FAI-NRC, Seminar, Varanasi, pp: 147-159.

Singh, G.R., S.S. Parihar, N.K. Chaure, K.K. Choudhary and R.B. Sharma, 1997. Integrated nutrient management in summer sesame (*Sesamum indicum* L.). Indian J. Agron., 42: 699-701.

Subramaniyan, P.S. and Arulmozhi, 1999. Response of sesame to sulphur and micronutrient and without FYM under irrigated condition. Indian J. Agron., 44: 826-829.

Thakur, D.S. and S.R. Patel, 2004. Response of sesame to different levels of potassium and sulphur in light textured inceptisols of eastern part of Chattisgarh. Indian J. Agric. Sci., 74: 496-98.

Thirumalaisamy, K., P.S. Srinivasan, U. Pangarusamy, M. Thangaraj, V. Mallika and S. Kannaiyan, 2001. Nutrient Deficiency and Remedial Management in Crops. 1st Edn., Sigar Graphics Pub. Coimbatore, pp: 10-11.

Tiwari, R.C., K. Namdeo and K.N. Girisha, 2000. Effect of nitrogen and sulphur on growth, yield and quality of sesame varieties. Res. Crops, 1: 163-167.

Tiwari, K.N. and B.R. Gupta, 2006. Sulphur for sustainable high yield Agriculture in Uttar Pradesh. Indian J. Fert. News, 1: 37-52.

Vishwakarma, S.K., R.S. Sharma and S.K. Kharik, 1998. Influence of varying source and levels of sulphur on root characteristics and nodulation activity in soybean. J. Soil Crop, 8: 116-118.

Yadav, A.S. and Harishankar, 1980. Sulphur role on oilseed crops. Oilseed J., 10: 58-62.