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Studies on the effect of foliar application of micronutrients on growth and yield attributes of sesame (*Sesamum indicum*) TMV 4

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Abstract
A field experiment was conducted at experimental farm, Department of Agronomy, Imayam Institute of Agriculture and Technology during 2024 to study the effect of foliar application of micronutrients on growth and yield attributes of sesame crop. Sesame variety TMV 4 used as test crop. The field experiments were laid out in a Randomized Block Design with 8 treatments and 3 replications. The treatments are T_1-RDF (Control) 35:23:23 kg NPK/ha, T_2-RDF + Boron (0.3%), T_3-RDF + Zinc (0.5%), T_4-RDF + Sulphur (0.5%), T_5-RDF + Boron (0.3%) + Zinc (0.5%), T_6-RDF + Boron (0.3%) +Sulphur (0.5%), T_7-RDF + Zinc (0.5%) +Sulphur (0.5%), T8-RDF + Boron (0.3%) + Zinc (0.5%) + Sulphur (0.5%). All treatments recorded significantly increased growth and yield over the control. However, T_8 (mixture of all above micronutrient) recorded significantly growth and yield attributes than the other treatments.

Keywords: Sesame, sulphur, boron, zinc

Introduction
Sesame (*Sesamum indicum* L.) is the oldest indigenous oil crop cultivated in world, particularly in Asia and Africa for its excellent nutritional, medicinal, cosmetic and cooking qualities of oil and it belongs to the Pedaliaceae family. Sesame is called as the "Queen of oil Seeds" because of the extra ordinary qualities and rich source of protein (24%), carbohydrates (15%) and excellent source of quality oil (50%). In India, it was cultivated in an area of 16.2 lakh hectares with a production of 7.33 lakh tones and productivity of 450 kg/ha. In Tamil Nadu, sesame production was around 2.79 lakh tonnes from an area of 4.7 lakh hectare during 2021-22. The productivity of sesame in Tamil Nadu is 589 kg/ha in 2022 (Directorate of Economics and Statistics 2023). India occupied 2nd position in production in the world next to Myanmar in Sesame Production. Sesame has antioxidant properties. About 73 percent of the sesame produced in the country is used for oil extraction, 14.5 percent for domestic uses.The sesame oil cake is used as feed for the milch animals as well as manure which contains 6.0 to 6.2% nitrogen, 2.0 to 2.2% phosphorus and 1.0 to 1.2% potash (Yadav *et al*., 2008) [11].
The micronutrients play an important role in increasing crop yield. Rekani (2019) [9] stated that micronutrients increases grain yield up to 50%, and increasing macronutrients use efficiency. Oilseed crops require more sulphur (S) than cereal crops, and S deficiency interferes with plant metabolism and synthesis of S-containing amino acids, thereby adversely affecting both seed and oil yields. S is essential for plant growth and development and plays an important role in plant metabolism, essential oil synthesis and chlorophyll formation. It also improves cell growth, cold resistance, and drought resistance, and components of many organic compounds, oil storage organs (Ahmed El-Sherif *et al* 2016) [1]. Zinc (Zn) plays an important role in various enzymatic and physiological activities in plants. It is also an essential component of synthetic and natural organic complexes of plants. It is estimated that over 30% of agricultural soils worldwide are deficient in available zinc, leading to deficiencies in crops grown on these soils (Behera, 2011) [2]. Boron is one of the essential micronutrients required for normal plant growth. Its deficiency results in large losses in crop production, both qualitatively and quantitatively. In oilseeds, it is important for pollen tube growth, flowering, seed setting, and seed development. It regulates stomata opening and makes plants drought tolerant

(Roul 2015) [10]. This study was conducted to study the effect of foliar application of micronutrients like Sulphur, Zinc, Boron on growth and yield parameters of sesame.

Materials and Methods

The experiment was carried out in July 2024 at Imayam Institute of Agriculture and Technology to study the effect of Foliar application of micronutrients on growth and yield attributes of sesame. The field experiment was carried out at Experimental Farm, Department of Agronomy, Imayam Institute of Agriculture and Technology. The experiment farm is geographically located at 11'17º North Latitude and 78'62º East Longitude with an altitude of 85m above MSL. The mean maximum and minimum temperature ranges from 34.7 to 36ºC and 23 to 27ºC. The highest relative humidity is 86% and lowest is 74.3%. The average rainfall is 670 mm.

The pre-sowing soil samples collected from each treatment plots of the experimental field in three replicates were analyzed for the initial physico-chemical properties. The texture of the soil in the experimental field was sandy loam.

Experimental details

The field Experiment was laid out in Randomized Block Design with three replications with 24 plots in total, each covering 20m^2 (5m X 4m). The experiment was conducted during July 2024 with TMV 4 sesame variety.

Preparation of land: Prepare the soil into a fine tilth by ploughing 2-4 times using a cultivator and break the clods into fine soil by rotovator to facilitate the easy germination of seeds and clear out the stubbles and stones from the field and form the beds according to layout of the experimental field.

- **Sowing of seeds:** A seed rate of 5 kg/ha is needed to achieve the required plant stand. Sesame variety TMV 4 is used to plant in Line sowing method. In order to facilitate easy seeding and even distribution increase the bulk by mixing the seed with either sand or dry soil or well sieved farmyard manure in 1:20 ratio. The optimum depth for seed placement is 2.5 cm. Avoid deep seeding as it adversely affects germination and plant stand.
- **Interculture:** The crop is very sensitive to weed competition during the first 20-25 days. Two weeding, one after 15-20 days of sowing and other at 30-35 days after sowing are required to keep the field weed free and to make moisture and nutrients available to the crop. Use herbicides to control the emergence of weeds. When the plants are about 15 cm in height, thin the crop so as to give a proper spacing between plants.
- **Irrigation:** A single watering was administered right after the seedlings were dibbled. Depending on the soil and weather circumstances, life irrigation was administered on the third day, followed by irrigation at intervals of 7 to 10 days. Sesame's flowering and pod-formation periods are when irrigation is most important. At all stages of crop growth, water stagnation was avoided.
- **Fertilizer Application:** As a base application, the recommended dose of 35:23:23 kg of NPK ha^{-1} was used. Nitrogen should be given in split doses. Urea (46 percent nitrogen), Single Super Phosphate (16 percent P_2O_5), and Muriate of Potash (60 percent K2O) were the commercial fertilizer sources used to supply NPK.
- **Harvesting:** Harvest the crop, when the leaves turn yellow and start drooping and the bottom capsules are lemon yellow by pulling out the plants. Harvest during the morning hours. Cut the root portion and stack the plants in bundles for 3-4 days when the leaves will fall off. Spread in the sun and beat with sticks to break open the capsules. Repeat this for 3 days. Clean and sundry for about 7 days before storing and stored it in separate plot wise lots.

Sampling procedures and measurements

The collected soil samples were analyzed for pH, EC and available macro nutrients. In the laboratory, standard protocols for nutritional analysis were used. Five plants from each net plot area were tagged and used for recording all biometric observations for growth attributes (plant height, leaf area Index, number of leaves per plant)and yield attributes (pod length, number of pods per plant, number of seeds per pod) were recorded.

Statistical analysis

According to Gomez and Gomez (1984) [4], the data collected from numerous observations was statistically evaluated using the Randomized Block Design approach and standard analysis of variance (ANOVA) procedures. Wherever the 'F' test was significant, the critical difference was calculated at a 5% level of probability to examine the significance of the difference between any two means. The difference between the treatments was significant whenever the calculated 'F-value' exceeded the tabulated value.

Results and Discussion

Growth attributes

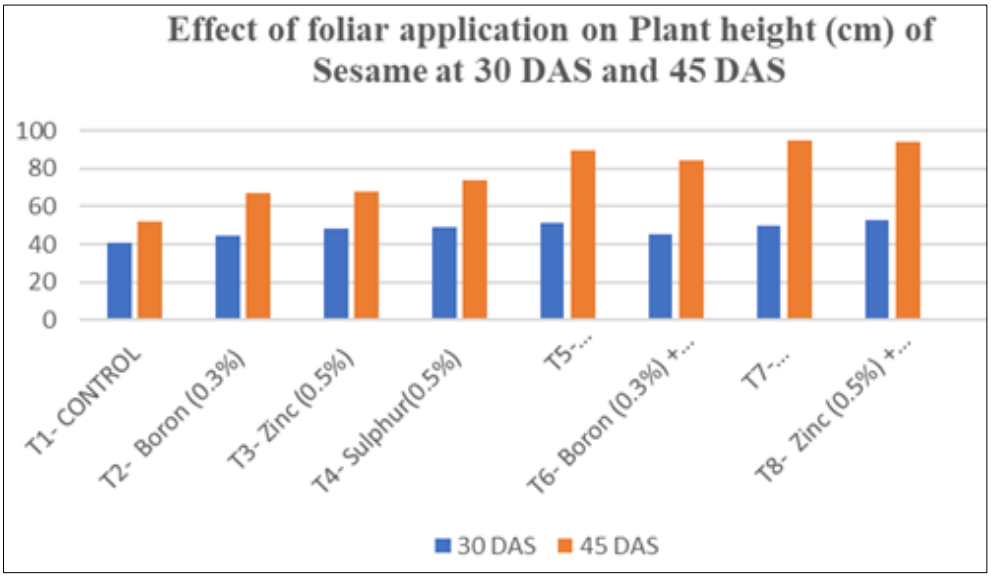
The results of the field study on sesame crop indicated significant influence of foliar spray on the growth attributes *viz*., plant height, leaf area index, No. of leaves per plant observed to be significant when compared to control treatment. Among the treatments, (T8) foliar application of Zinc (0.3%) + Boron (0.5%) + Sulphur (0.5%) on 30 and 45 DAS recorded highest growth parameters. The growth parameters *viz*., plant height, dry weight was significantly influenced by Sulphur and boron treatments. Reason for increasing plant height was mainly due to the addition of boron as it escalated chlorophyll content of leaf which in turn increased Photosynthetic activity and new tissue growth. Similar findings were reported earlier by Maheshwari *et al*. (2023) [7].

Foliar application of micronutrients also helped translocation of nutrients or minerals made easily absorbable by the plants for better photosynthetic activity and reflected in a significant increase in plant height. The similar research reports were observed by Movahhedi Dehnavi et al. (2017) [8]. The application of Zinc as foliar spray proved to increase the plant height and number of leaves per plant due to somatic growth of tissues. The results are in agreement with the experimental findings of Mahdi, (2014) [6]. The application of Zinc as foliar spray proved to increase the plant height and number of leaves per plant due to somatic growth of tissues. The results are in agreement with the findings of Mahdi, (2014) [6]. The mixture of all micronutrients (Boron, Zinc, and Sulphur) recorded significantly higher plant height. These results are in accordance with the findings of Dinesh Seervi *et al*., (2017) [3].

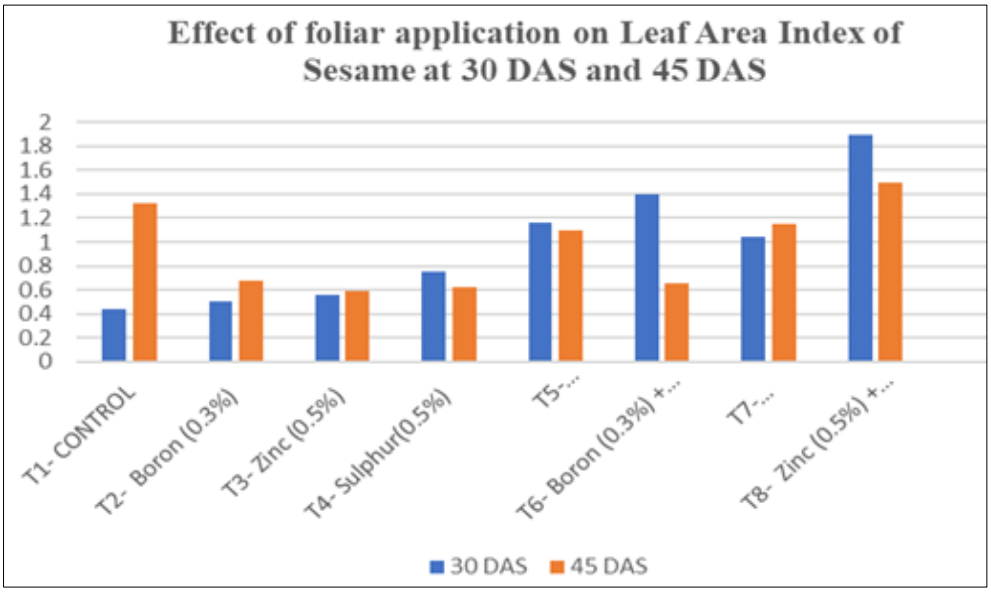
Plant height: The foliar nutrition recorded significant

enhancement in the plant height of Sesame. The plant height (cm) data was recorded at 30 DAS and 45 DAS of the crop. Different treatments of foliar application significantly influenced the plant height at various growth stages. The data on plant height (cm) is presented in the Table. The plant height was significantly enhanced by foliar application of Zinc (0.5%) + Boron (0.3%) + Sulphur (0.5%) on 30 DAS (T8). This treatment recorded the highest plant height of 52.47 at 30 DAS and 45 DAS and it was on par with foliar application of Foliar Application of Zinc (0.5%) + Sulphur (0.5%) on 30 DAS and 45 DAS (T_7).

Treatments	30 Das	45 Das
T_1-RDF (Control) 35:23:23 kg NPK/ha	40.76	52.11
T_2-FoliarApplicationof Boron (0.3%)	44.28	66.99
T_3-FoliarApplicationof Zinc (0.5%)	48.30	67.78
T_4-FoliarApplicationof Sulphur (0.5%)	49.10	73.67
T_5-Foliar Application of Boron (0.3%) + Zinc (0.5%)	51.23	89.32
T_6-FoliarApplicationof Boron (0.3%) + Sulphur (0.5%)	44.89	84.22
T_7-FoliarApplicationof Zinc (0.5%) +Sulphur (0.5%)	49.47	94.56
T_8-FoliarApplicationof Zinc (0.3%) + Boron (0.5%) + Sulphur (0.5%)	52.47	93.87
CD(P=0.05)	0.71	1.35



Leaf Area Index (LAI): The foliar nutrition recorded significant enhancement in LAI of sesame. The data on LAI was recorded at 30 DAS and 45 DAS of the crop. Different treatments of foliar application significantly influenced the LAI at different growth stages. The LAI was significantly enhanced by foliar application of Zinc (0.5%) +Boron (0.3%) + Sulphur (0.5%) on 30 DAS (T_8). This treatment recorded the highest leaf area index of 1.89 and 1.49 at 30 and 45 DAS respectively and it was on par with Foliar Application of Zinc (0.5%) + Sulphur (0.5%) (T_7) on 30 DAS and 45 DAS.



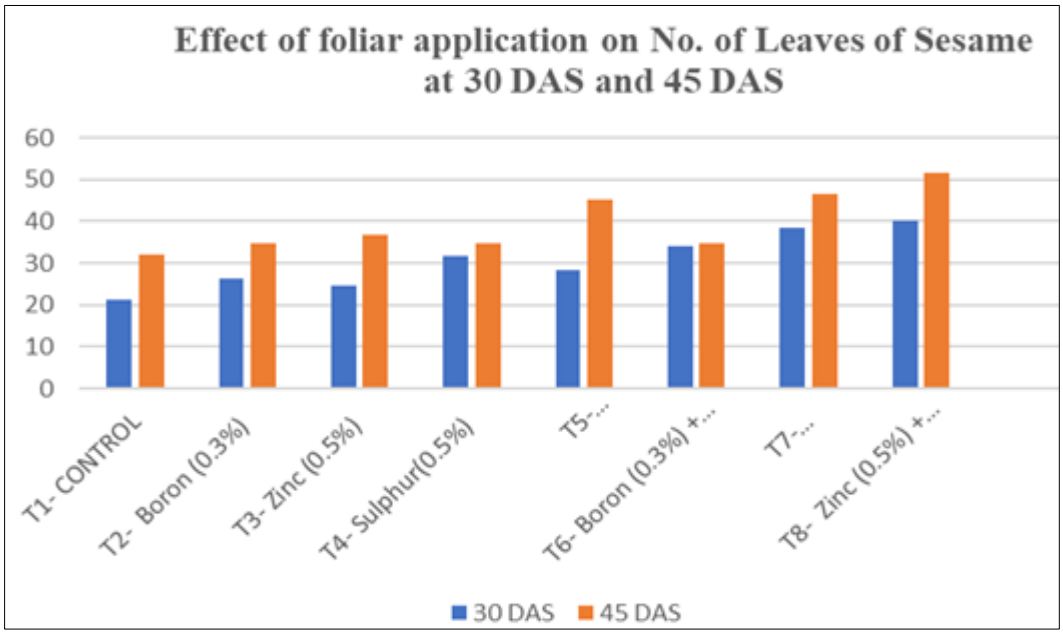
Treatments	30 Das	45 Das
T_1-RDF (Control) 35:23:23 kg NPK/ha	0.44	1.32
T_2-Foliar Application of Boron (0.3%)	0.50	0.68
T_3-Foliar Application of Zinc (0.5%)	0.56	0.59
T_4-Foliar Application of Sulphur (0.5%)	0.75	0.62
T_5-Foliar Application of Boron (0.3%) + Zinc (0.5%)	1.16	1.10
T_6-Foliar Application of Boron (0.3%) + Sulphur (0.5%)	1.04	0.66
T_7-Foliar Application of Zinc (0.5%) + Sulphur (0.5%)	1.40	1.15
T_8-Foliar Application of Zinc (0.3%) + Boron (0.5%) + Sulphur (0.5%)	1.89	1.49
CD(P=0.05)	0.59	0.89

No of Leaves/Plant

The foliar nutrition recorded significant enhancement in No of leaves/plant of sesame. The data on LAI was recorded at 30 DAS and 45 DAS of the crop. Different treatments of foliar application significantly influenced the LAI at different growth stages.

The No. of leaves/plant was significantly enhanced by foliar application of Zinc (0.5%) + Boron (0.3%) + Sulphur (0.5%) on 30 DAS and 45 DAS (T_8). This treatment recorded the highest leaf area index of 1.89 at 30 it was on par with foliar application of Zinc (0.5%) + Sulphur (0.5%) on 30 DAS and 45 DAS (T_7).

Treatments	30 Das	45 Das
T_1-RDF (Control) 35:23:23 kg NPK/ha	21.40	32.10
T2-Foliar Application of Boron (0.3%)	26.26	34.78
T3-Foliar Application of Zinc (0.5%)	24.70	36.67
T4-Foliar Application of Sulphur (0.5%)	31.70	34.89
T5-Foliar Application of Boron (0.3%) + Zinc (0.5%)	28.40	45.11
T6-Foliar Application of Boron (0.3%) + Sulphur (0.5%)	34.20	34.67
T7-Foliar Application of Zinc (0.5%) + Sulphur (0.5%)	38.53	46.57
T8-Foliar Application of Zinc (0.3%) + Boron (0.5%) + Sulphur (0.5%)	40.20	51.67
CD(P=0.05)	0.87	1.23



Yield attributes

Number of pods per plant differed significantly among the treatments. It varied from a minimum of 18.00 to maximum of 34.67 pods per plant among the treatments. Foliar application of all micronutrients significantly increased the number of pods per plant over the control. The higher number of pods was found in T_8 followed by T5. Similar findings was reported by Dinesh Seervi et al., (2017) [3]. The highest seed yield was obtained by combined nutrients. Number of seeds per pod varied from a minimum of 40.91 to a maximum of 54.55. Therefore, foliar application of all the micronutrients alone or in combination as well as their commercial mixture significantly increased number of seeds per pod. This result is in accordance with Dinesh Seervi *et al.*, (2017) [3]. Treatment 7 (Zinc 0.5% + Sulphur 0.5%) significantly recorded higher number of capsules per plant which is on par with treatment 8, that includes the application of all micronutrient as foliar Spray. The increased number of capsules per plant was due to a significant improvement in sulphur application, attributed to the overall improvement in vigour and plant growth as a result of a balanced nutrient development. Adequate supply of sulphur also aids in flower primordial development. The reproductive part of a plant that gives rise to capsule and seed development. This results were similar to the findings of Kosgi Pravalika *et al.* (2023) [5].

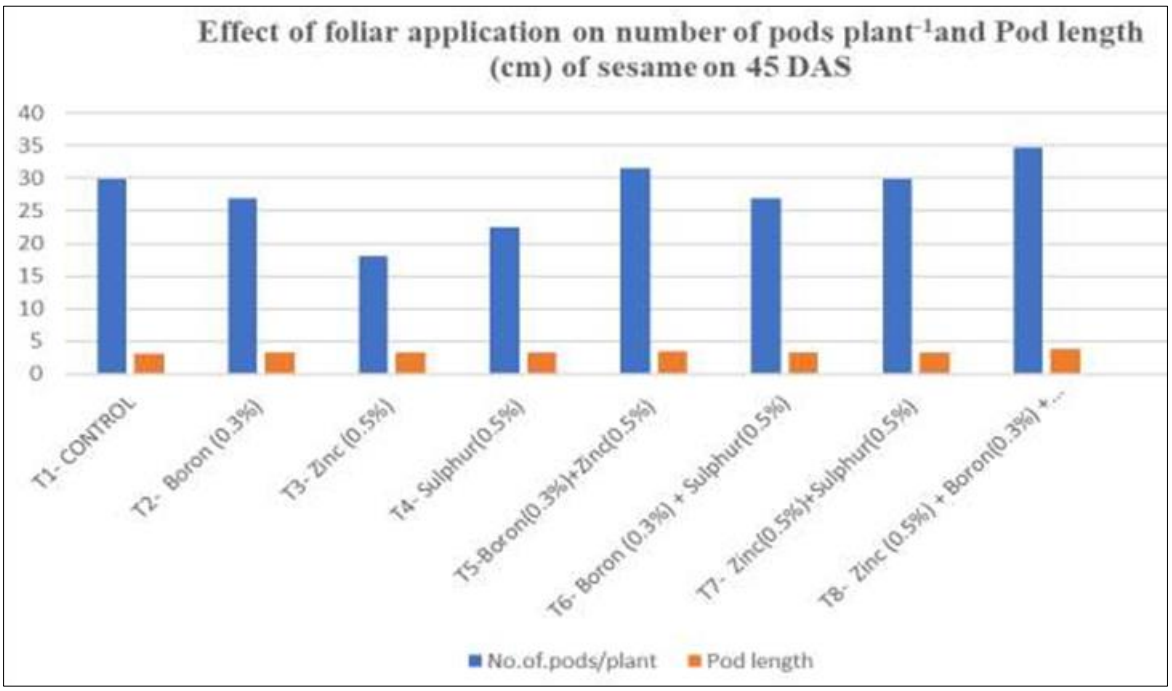
No of pods plant^{-1}

The data regarding number of pods plant^{-1} was recorded at

harvest stage of the crop. The number of pods plant^{-1} was significantly enhanced by different treatment of foliar application practices. The number of pods plant^{-1} was significantly influenced by Foliar Application of Zinc (0.5%) + Boron (0.3%) + Sulphur (0.5%) on 45 DAS which recorded maximum of 34.67 pods plant^{-1} at harvest and it was statistically on par with the Foliar Application of Boron (0.3%) + Zinc (0.5%) on 45 DAS.

The pod length was significantly influenced by Foliar Application of Zinc (0.5%) + Boron (0.3%) + Sulphur (0.5%) (T_8) on 45 DAS which recorded maximum of 3.20 cm at harvest and it was statistically on par with the Foliar Application of Boron (0.3%) + Zinc (0.5%) on 45 DAS is 2.50 cm.

Treatments	No of pods/plant	Pod Length
T_1-RDF (Control) 35:23:23 kg NPK/ha	18.00	2.15
T_2-Foliar Application of Boron (0.3%)	26.89	2.27
T_3-Foliar Application of Zinc (0.5%)	29.97	2.22
T_4-Foliar Application of Sulphur (0.5%)	32.57	2.32
T_5-Foliar Application of Boron (0.3%) + Zinc (0.5%)	31.56	2.55
T_6-Foliar Application of Boron (0.3%) + Sulphur (0.5%)	26.89	2.38
T_7-Foliar Application of Zinc (0.5%) + Sulphur (0.5%)	29.80	2.43
T_8-Foliar Application of Zinc (0.3%) + Boron (0.5%) + Sulphur (0.5%)	34.67	3.20
CD(P=0.05)	0.76	0.12



Number of Seeds pod^{-1}

The data regarding number of seeds pods^{-1} was recorded at harvest stage of the crop. The number of seeds pods^{-1} was significantly enhanced by different treatment of foliar application practices.

Among the treatments tested the Foliar Application of Zinc (0.5%) + Boron (0.3%) + Sulphur (0.5%), (T_8) and it was on par with foliar application of Sulphur (0.5%), (T_4).

Conclusion

From this investigation, it may be concluded that was foliar application of Zinc (0.5%) + Boron (0.3%) + Sulphur (0.5%) (T_8) suggested to get profitably higher yield in Sesame. It is also recommended foliar Application of Foliar Application of Zinc (0.5%) + Sulphur (0.5%) (T_7) that may be the alternate for Zinc (0.5%) + Boron (0.3%) + Sulphur (0.5%) (T_8) in order to achieve maximum yield and returns in Sesame.

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