

Effect of foliar nutrition on the yield characters, yield attributes and yields of irrigated sesame in Cauvery Delta zone of Tamil Nadu

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ABSTRACT

A field experiment was carried out at the Experimental Farm of the Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai Nagar, Tamil Nadu during 2024 to study the effect of foliar nutrition on the yield characters, yield attributes, and yields of sesame in an irrigated condition. The field experiment was laid out in a randomized block design with eleven treatments, each replicated three times. The sesame variety TMV 4 was chosen for the study. The treatments include foliar application of macronutrients such as DAP, KCl, NPK (19:19:19) and micronutrients ($ZnSO_4$, $MnSO_4$) (30 & 45 DAS) alone and in combinations. The results of the experiment showed that the yield characters, yield attributes, and seed and stalk yields of sesame, including the number of capsules per plant (131.46), capsule length (2.58 cm), number of seeds per capsule (64.32), seed weight per plant (8.98 g), seed yield (877 kg/ha) and stalk yield (1885 kg/ha) were notably enhanced with the foliar application of 2% DAP, 0.5% KCl, 0.5% $ZnSO_4$ and 0.5% $MnSO_4$ at 30 and 45 days after sowing (DAS) (T_8). The same treatment also resulted in a higher harvest index value of 31.75%.

Key words: DAP, Foliar Nutrition, KCl, $MnSO_4$, NPK, Sesame, Yield, Yield Attributes and $ZnSO_4$.

Introduction

Sesame (*Sesamum indicum* L.) is a significant oil seed crop with ancient origins. Sesame is poetically known as the "Queen of Oilseeds" because of its high-quality polyunsaturated stable fatty acids, such as palmitic acid (16%), stearic acid (18%), oleic acid (18.1%), and linoleic acid (18.2%), which offer resistance to rancidity (Taware *et al.*, 2006). Sesame is cultivated globally on 12.84 million hectares, producing 6.74 million tonnes with a productivity of 525 kg per hectare. In India, sesame is cultivated on 1.62 million hectares, yielding 7.89 lakh tonnes with a productivity of 485 kg per hectare. In Tamil Nadu, sesame is cultivated on 4.72 lakh hectares, produc-

ing 2.79 lakh tonnes with a productivity of 585 kg per hectare (FAOSTAT, 2023). Despite its importance as an oilseed crop, the average productivity remains low compared to sesame-producing countries like China (1,393 kg per hectare), Egypt (1,315 kg per hectare), and Nigeria (1,063 kg per hectare). Sesame yields are often low due to inadequate cultivation practices and suboptimal growing conditions, particularly in areas with poor soil fertility. Yield is a complex outcome influenced by various plant physiological processes, which are significantly impacted by management practices and the surrounding environment. Among these practices, proper nutrient management, especially through foliar applications, plays a crucial role in maximiz-

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ing sesame production.

The foliar application of DAP at critical stages of the crop has been shown to improve the growth and yield of the crop, as reported by Ramesh *et al.* (2015). Potassium (K) is one of the essential nutrients necessary for plant growth and physiological processes. Potassium is a part of the plant's structure and regulates various biochemical processes (Hasanuzzaman *et al.*, 2018). Recently, a new generation of specialty fertilizers have been developed for foliar feeding. The NPK (19:19:19) fertilizer is a fully water-soluble, balanced fertilizer with nitrogen in three forms: $\text{NO}_3\text{-N}$ (45.0%), $\text{NH}_4\text{-N}$ (4.5%), and $\text{NH}_2\text{-N}$ (10.5%). It also contains 19 per cent water-soluble phosphorus and potassium, with a low salt index. Foliar application of NPK (19:19:19) significantly enhanced the growth and yield of crops (Asanul Hoque and Labani Sarkar, 2022).

Zinc is a crucial micronutrient that acts as a structural component or regulatory cofactor for many enzymes and proteins involved in various essential biochemical processes and protection against pathogens (Gupta *et al.*, 2006). Bagci (2007) observed that zinc enhances the yield and quality of oil seeds. Manganese is a key micronutrient in plants, essential for the functioning of enzymes involved in photosynthesis, protein synthesis, lipid metabolism, and other crucial processes (Monreal *et al.*, 2015). Foliar application of manganese is particularly advantageous for crops when the roots are unable to obtain the necessary nutrients to fulfil the crop's needs at critical stages (Brar and Brar, 2004). Based on the above considerations, this study aimed to investigate the effects of foliar applications of macronutrients (NPK fertilizers) and micronutrients (zinc and manganese) on sesame yield, yield components, and overall productivity under irrigated conditions.

Materials and Methods

A field experiment was carried out from January to April 2024 at the Experimental Farm of the Department of Agronomy, Faculty of Agriculture, Annamalai University, located in Annamalai Nagar, Tamil Nadu, to investigate the effect of foliar nutrition on the growth and yield of sesame. The experimental field is situated in the North Eastern Agro-Climatic Zone of Tamil Nadu. The Experimental Farm is positioned at $11^\circ 38' \text{ N}$ latitude and $79^\circ 72' \text{ E}$ longitude, with an altitude of +5.79 meters above mean sea level (MSL). The weather in Annamalai

Nagar is moderately warm, with particularly hot summer months. The soil of the experimental field was classified as clay loam, with a pH of 7.4 and an electrical conductivity (EC) of 0.46 dS m^{-1} . The soil was low in available nitrogen (215.6 kg/ha), moderate in available phosphorus (18.84 kg/ha), and rich in available potassium (316.4 kg/ha). The field experiment was laid out in a randomized block design with eleven treatments, each replicated three times. The treatments included T_1 - Control (water spray), T_2 - Foliar spray of 2% DAP + 0.5% KCl, T_3 - Foliar spray of 2% NPK (19:19:19), T_4 - Foliar spray of 0.5% MnSO_4 , T_5 - Foliar spray of 0.5% ZnSO_4 , T_6 - Foliar spray of 2% DAP + 0.5% KCl + 0.5% ZnSO_4 , T_7 - Foliar spray of 2% DAP + 0.5% KCl + 0.5% MnSO_4 , T_8 - Foliar spray of 2% DAP + 0.5% KCl + 0.5% ZnSO_4 + 0.5% MnSO_4 , T_9 - Foliar spray of 2% NPK (19:19:19) + 0.5% ZnSO_4 , T_{10} - Foliar spray of 2% NPK (19:19:19) + 0.5% MnSO_4 and T_{11} - Foliar spray of 2% NPK (19:19:19) + 0.5% ZnSO_4 + 0.5% MnSO_4 . The promising sesame variety TMV 4 was selected for the study. In this experiment, the recommended seed rate of 5 kg per hectare and a spacing of $30 \times 30 \text{ cm}$ were followed. The sesame crop was fertilized with the recommended schedule of 35:23:23 kg N, P_2O_5 and $\text{K}_2\text{O ha}^{-1}$. According to the treatment schedule, DAP (2%), KCl (0.5%), NPK (19:19:19) (2%), MnSO_4 (0.5%), and ZnSO_4 (0.5%) were sprayed at 30 and 45 days after sowing (DAS). The application was done using a hand-operated knapsack sprayer with a spray volume of $500 \text{ liters ha}^{-1}$, during the morning hours. In each treatment, five samples per net plot were randomly tagged. Various biometric observations were recorded at different stages of crop growth. Matured sesame crop from the net plot area was harvested, cured, threshed and seeds were separated, cleaned, dried and finally seed yield was recorded at 10 per cent moisture content. The data collected on various traits during the field study were statistically analyzed using the method described by Panse and Sukhatme (1978). When significant results were observed, the critical differences were calculated at a five percent probability level to make statistical inferences. Treatment differences that were not significant were indicated as "NS".

Results and Discussion

Yield Characters and Yield Attributes of Sesame

Analyzing yield characters and yield attributes pro-

vides a better understanding of the physiological basis and source-sink relationship of the crop as influenced by the foliar application of macro and micronutrients. All yield attributes, such as the number of capsules per plant, capsule length, number of seeds per capsule and seed weight per plant were significantly affected by the macro and micronutrients. In this experiment, foliar application of 2% DAP, 0.5% KCl, 0.5% ZnSO₄, and 0.5% MnSO₄ at 30 and 45 DAS (T₈) resulted in the highest number of capsules per plant of 131.46, capsule length of 2.58 cm, number of seeds capsule⁻¹ of 64.32 and seed weight per plant of 8.98 g which were 52.96 per cent, 91.11 per cent, 55.73 per cent and 48.92 per cent, respectively over control (Table 1).

The foliar application of NPK fertilizer may have contributed to reduce flower drop, which significantly increased the number of capsules per plant, as observed by Omer and Abd-Elnaby (2017). A reduction in flower drop could also be attributed to the prolonged assimilatory activity of leaves, which may have led to a higher number of capsules per plant, according to Avinasha *et al.* (2019). Furthermore, foliar feeding of essential nutrients, particularly phosphorus, led to the development of healthy capsules, which in turn significantly increased the capsule length and capsule weight per plant and enhanced the seed filling capacity. These findings align with those of Swain *et al.* (2020).

Additionally, applying ZnSO₄ along with MnSO₄

enabled the rapid absorption of zinc, sulphur and manganese during the reproductive stage, when nutrient demand is highest due to the crop's indeterminate growth habit. This application reduced flower drop and ultimately increased the number of capsules per plant, capsule length, seeds per capsule and seed weight per plant (Elayaraja and Singaravel, 2017). Moreover, foliar application of micronutrients (zinc, sulphur, and manganese) enhanced the number of flower buds and prevented flower drop by maintaining optimal bio-physiological conditions, which contributed to higher yield attributes in sesame. These findings are consistent with those reported by Haritha *et al.* (2022).

In this study, there was no significant difference in thousand seed weight among the treatments. However, the plots treated with foliar application of 2% DAP + 0.5% KCl + 0.5% ZnSO₄ + 0.5% MnSO₄ (applied at 30 and 45 DAS) (T₈) recorded numerically higher values. This could be because genetic characteristics were not greatly affected by agronomic practices. Similar findings were reported by Reddy *et al.* (2020) and Dhayanethi *et al.* (2024a). The next best treatment in the ranking was the foliar application of 2% NPK (19:19:19) along with 0.5% ZnSO₄ + 0.5% MnSO₄ at 30 and 45 DAS (T₁₁), resulting in 126.95 capsules per plant, 2.42 cm long capsule, 61.54 seeds capsule⁻¹ and seed weight plant⁻¹ of 8.64 g. The lowest values for the number of capsules per plant, capsule length, seeds per capsule and

Table 1. Effect of foliar nutrition on yield characters and yield attributes in sesame

Treatments	No. of capsules/ plant	Capsule length (cm)	No. of seeds/ capsule	Seed weight/ plant (g)	Test weight (g)
T ₁ -Control (Water spray)	85.94	1.35	41.30	6.03	2.87
T ₂ - Foliar spray of 2% DAP + 0.5% KCl(30 & 45 DAS)	104.40	1.83	51.10	7.27	2.92
T ₃ - Foliar spray of 2% 19:19:19 (NPK) (30 & 45 DAS)	98.72	1.69	48.03	6.84	2.90
T ₄ - Foliar spray of 0.5% MnSO ₄ (30 & 45 DAS)	90.24	1.49	43.69	6.35	2.89
T ₅ - Foliar spray of 0.5% ZnSO ₄ (30 & 45 DAS)	94.33	1.54	45.42	6.49	2.89
T ₆ - Foliar spray of 2% DAP+0.5% KCl+0.5% ZnSO ₄ (30 & 45 DAS)	121.35	2.25	58.89	8.23	2.96
T ₇ - Foliar spray of 2%DAP+0.5%KCl+ 0.5% MnSO ₄ (30 & 45 DAS)	117.38	2.19	57.37	8.16	2.96
T ₈ - Foliar spray of 2% DAP+0.5% KCl+0.5% ZnSO ₄ +0.5% MnSO ₄ (30 & 45 DAS)	131.46	2.58	64.32	8.98	3.00
T ₉ - Foliar spray of 2% 19:19:19 (NPK) + 0.5% ZnSO ₄ (30 & 45 DAS)	112.99	2.04	54.96	7.72	2.94
T ₁₀ - Foliar spray of 2% 19:19:19 (NPK) + 0.5% MnSO ₄ (30 & 45 DAS)	109.29	1.99	53.76	7.64	2.94
T ₁₁ - Foliar spray of 2% 19:19:19 (NPK) + 0.5% ZnSO ₄ +0.5% MnSO ₄ (30 & 45 DAS)	126.95	2.42	61.54	8.64	2.98
S.Ed	2.01	0.04	0.98	0.14	0.05
CD(P=0.05)	4.22	0.08	2.06	0.29	NS

DAS: Days After Sowing NS : Not Significant

seed weight per plant were observed in the water spray treatment (T_1).

Seed and Stalk Yields

The yield potential of sesame is determined by yield attributes, which are closely related to growth parameters. Among the treatments, the foliar application of 2% DAP + 0.5% KCl + 0.5% $ZnSO_4$ + 0.5% $MnSO_4$ (applied at 30 and 45 DAS) (T_8) significantly resulted in higher seed yield of 877 kg ha⁻¹ and stalk yield of 1885 kg ha⁻¹, which were 68.00% and 53.25%, respectively over control (Table 2). This improvement can be attributed to the combined effects of macronutrients (NPK) and micronutrients (zinc and manganese). The substantial increase in seed and stalk yields was mainly due to enhanced dry matter accumulation, a higher number of branches per plant and more capsules per plant (Mahajan *et al.*, 2016). The crop's improved nutrient uptake, facilitated by effective translocation of nutrients from the source to the reproductive parts, might be the key factor contributing to these higher parameter values, as also reported by Dhayanethi *et al.* (2024b). Moreover, the foliar application of zinc and manganese activated various enzymes and boosted basic metabolic rates in plants, aided in the synthesis of nucleic acids and hormones, and mitigated the adverse effects of water stress, which likely contributed positively. This led to an increased conversion of photosynthates into yield-attributing traits, ultimately enhancing both seed and stalk yields. These results are consistent with those reported by Elayaraja *et al.* (2019).

This treatment was followed by the foliar application of 2% NPK (19:19:19) combined with 0.5% $ZnSO_4$ + 0.5% $MnSO_4$ at 30 and 45 DAS (T_{11}), resulting in a seed yield of 841 kg ha⁻¹ and stalk yield of 1812 kg ha⁻¹. The water spray treatment (T_1) resulted in the lowest values for growth attributes, yield attributes and seed and stalk yields. This outcome can be attributed to the absence of NPK, zinc and manganese supplied to the crop, leading to the poorest growth and yield attributes observed in the control, which resulted in a lower yield compared to the other treatments. These findings are consistent with those reported by Siva *et al.* (2017).

In this research, the treatment involving the application of 2% DAP + 0.5% KCl + 0.5% $ZnSO_4$ + 0.5% $MnSO_4$ at 30 and 45 DAS (T_8) showed higher harvest index values. This increase in harvest index could be due to the foliar application of a combination of macro and micronutrients, which enhances the leaf area index (LAI) and photosynthetic efficiency. Consequently, there is an improved translocation of photosynthates from the source to the sink and more effective allocation towards the reproductive parts, leading to a higher harvest index. These findings align with the studies by Modak and Mallick (2017), and Abdul-Qader and Ali (2021). The lowest harvest index was observed in the control (T_1).

Conclusion

Based on the result of experiment, it was concluded that foliar application of 2% DAP + 0.5% KCl + 0.5%

Table 2. Effect of foliar nutrition on seed yield, stalk yield and harvest index in sesame

Treatments	Seed yield (kg/ha)	Stalk yield (kg/ha)	Harvest index (%)
T1 - Control (Water spray)	522	1230	29.79
T ₂ - Foliar spray of 2% DAP + 0.5% KCl (30 & 45 DAS)	645	1480	30.35
T3 - Foliar spray of 2% 19:19:19 (NPK) (30 & 45 DAS)	608	1405	30.20
T4 - Foliar spray of 0.5% $MnSO_4$ (30 & 45 DAS)	560	1309	29.96
T5 - Foliar spray of 0.5% $ZnSO_4$ (30 & 45 DAS)	569	1329	29.98
T6 - Foliar spray of 2% DAP+0.5% KCl+ 0.5% $ZnSO_4$ (30 & 45 DAS)	780	1734	31.03
T7 - Foliar spray of 2% DAP+0.5% KCl+ 0.5% $MnSO_4$ (30 & 45 DAS)	756	1681	31.02
T8 - Foliar spray of 2% DAP+0.5% KCl+ 0.5% $ZnSO_4$ +0.5% $MnSO_4$ (30 & 45 DAS)	877	1885	31.75
T9 - Foliar spray of 2% 19:19:19 (NPK) + 0.5% $ZnSO_4$ (30 & 45DAS)	719	1606	30.92
T10-Foliar spray of 2% 19:19:19(NPK)+ 0.5% $MnSO_4$ (30 & 45 DAS)	696	1556	30.91
T11-Foliar spray of 2% 19:19:19 (NPK)+ 0.5% $ZnSO_4$ +0.5% $MnSO_4$ (30 & 45 DAS)	841	1812	31.70
S.Ed	12.12	28.74	0.01
CD(p=0.05)	25.46	60.37	0.03

ZnSO₄ + 0.5% MnSO₄ at 30 and 45 days after sowing (DAS) was the optimum agronomic nutrient management treatment for performing higher yield attributes and yield of sesame under irrigated condition in the Cauvery Delta zone of Tamil Nadu.

Conflict of Interest - None

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