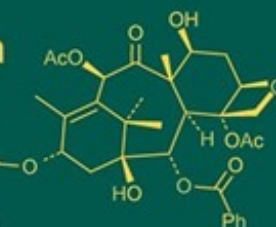
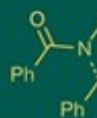


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Response of seed yield and quality parameters of sesame (*Sesamum indicum* L.) to foliar application of micronutrients

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ABSTRACT

A field experiment entitled “Effect of foliar application of micronutrients on seed yield and seed quality parameters in sesame (*Sesamum indicum* L.)” was conducted at the Experimental Farm of the Quality Seed Production Unit, Khanapur-A, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, during the summer season of 2025–26, using sesame variety ‘TLT-10’. The experiment was conducted to determine the effects of different micronutrient treatments on growth, yield-attributing characters and seed quality parameters in sesame. The experiment was laid out in a Randomized Block Design (RBD) with three replications. The treatments consisted of T_1 – Control, T_2 – Boron (Borax) @ 0.3 g L⁻¹, T_3 – Zinc (zinc sulphate) @ 0.3 g L⁻¹, T_4 – Iron (ferrous sulphate) @ 0.4 g L⁻¹, T_5 – Manganese (manganese sulphate) @ 0.2 g L⁻¹, T_6 – Boron + Iron @ 0.3 + 0.4 g L⁻¹, T_7 – Zinc + Iron @ 0.3 + 0.4 g L⁻¹, T_8 – Iron + Manganese @ 0.4 + 0.2 g L⁻¹ and T_9 – $T_2 + T_3 + T_4 + T_5$. Among the different micronutrient treatments, T_9 recorded the significantly earliest days to 50 per cent flowering compared with the other treatments and the control. Treatment T_9 recorded the highest plant height, maximum number of branches per plant, leaves per plant, capsules per plant, capsule length, capsule width, seeds per capsule and 1000-seed weight compared with the other treatments. Treatment T_9 also recorded the highest seed yield per plant and seed yield per plot. With respect to seed quality parameters, treatment T_9 recorded the highest germination percentage, Seedling Vigour Index-I, Seedling Vigour Index-II and oil content compared with the other micronutrient treatments.

Keywords: Sesame, foliar micronutrients, zinc, zinc sulphate, borax, manganese, Fe-Ferrous, B-Boron, seed yield, seed quality, svi-seedling vigour index

Introduction

Sesame (*Sesamum indicum* L.) is one of the most ancient and important oilseed crops cultivated in the tropical and subtropical regions of the world. It is often referred to as the “Queen of Oilseeds” due to its high-quality edible oil, which is rich in natural antioxidants such as sesamin, sesamol and sesamolins. These compounds not only impart stability to the oil but also enhance its nutritional and medicinal value (Namiki, 2007) [1].

The productivity of sesame in India is often constrained by improper nutrient management, particularly micronutrient deficiencies. Micronutrients such as zinc (Zn), boron (B), iron (Fe) and manganese (Mn) play a crucial role in plant metabolism, enzyme activation, chlorophyll synthesis, pollen viability and seed formation. The deficiency of these elements can significantly impair plant growth, flowering and seed development, resulting in reduced yield and poor quality of produce (Marschner, 2012) [2].

Foliar application of micronutrients has emerged as an effective and economical approach to enhance crop yield and quality, particularly in oilseed crops like sesame (Fageria *et al.*, 2009) [3]. Foliar application ensures quick and efficient absorption of nutrients by bypassing soil limitations and improving the physiological activities of the plant during critical growth stages (Fernández *et al.*, 2013) [4]. Several researchers have demonstrated that foliar application of zinc and iron improves chlorophyll synthesis and photosynthetic efficiency, leading to better growth and higher yield. Similarly, boron enhances pollen germination and seed set, while manganese contributes to enzyme activation and metabolic regulation (Havlin *et al.*, 2014) [5].

Materials and Methods

The present investigation was carried out at the Experimental Farm of the Quality Seed Production Unit, Khanapur-A, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, during the summer season of 2025–26. The experimental site had uniform, well-ploughed black cotton soil and was levelled and maintained to ensure uniform fertility. The sesame variety ‘TLT-10’ was used as the seed material. Sowing was carried out

in the field using the dibbling method, with a row-to-row spacing of 30 cm and a plant-to-plant spacing of 15 cm. The net plot size was 1.2×3 m. A basal fertilizer dose of 60:40:20 kg N:P:K ha^{-1} was applied. The experiment was laid out in a Randomized Block Design (RBD) with nine treatments and three replications. Foliar application of micronutrients was carried out at 30 and 60 days after sowing (DAS). The treatment details were as follows: T₁ – Control; T₂ – Boron (borax) @ 0.3 g L⁻¹; T₃ – Zinc (zinc sulphate) @ 0.3 g L⁻¹; T₄ – Iron (ferrous sulphate) @ 0.4 g L⁻¹; T₅ – Manganese (manganese sulphate) @ 0.2 g L⁻¹; T₆ – Boron + Iron (borax + ferrous sulphate) @ 0.3 + 0.4 g L⁻¹; T₇ – Zinc + Iron (zinc sulphate + ferrous sulphate) @ 0.3 + 0.4 g L⁻¹; T₈ – Iron + Manganese (ferrous sulphate + manganese sulphate) @ 0.4 + 0.2 g L⁻¹; and T₉ – (T₂ + T₃ + T₄ + T₅).

The following observations were recorded: days to 50 per cent flowering, plant height (cm), number of branches per plant, number of leaves per plant, number of capsules per plant, capsule length (cm), capsule width (mm), number of seeds per capsule, 1000-seed weight (g), seed yield per plant (g), seed yield per plot (g), and seed quality parameters, viz., germination percentage, Seedling Vigour Index-I, Seedling Vigour Index-II, and oil content (%). The germination test was conducted using the top-of-paper (TP) method (ISTA, 1985) [6]. Seedling Vigour Index-I was calculated as germination percentage $\times$ seedling length, as described by Abdul-Baki *et al.* (1973) [7]. Seedling Vigour Index-II was calculated as germination percentage $\times$ seedling dry weight. Oil content was estimated using the nuclear magnetic resonance (NMR) method with 25 g of clean seeds.

Layout of plot – 11×13.20 m

R1	R2	R3
T ₁	T ₃	T ₅
T ₂	T ₄	T ₆
T ₃	T ₅	T ₇
T ₄	T ₆	T ₈
T ₅	T ₇	T ₉
T ₆	T ₈	T ₁
T ₇	T ₉	T ₂
T ₈	T ₁	T ₃
T ₉	T ₂	T ₄

Results and Discussion

Days to 50 per cent flowering

The treatment differences were found to be significant for days to 50 per cent flowering. The number of days required to attain 50 per cent flowering ranged from 46.00 to 49.73 days. Treatment T₉ recorded the earliest 50 per cent flowering, requiring 46.00 days, followed by T₈ (46.53 days) and T₆ (46.60 days). In contrast, treatment T₁ recorded the latest 50 per cent flowering, requiring 49.73 days, followed by T₅ (48.20 days) and T₄ (48.00 days). The data pertaining to the effect of foliar application of micronutrients on days to 50 per cent flowering in sesame are presented in Table 1.

Plant height (cm)

The data indicated that plant height was significantly influenced by different micronutrient treatments. Treatment T₉ recorded the maximum plant height of 100.70 cm, followed by T₇ (98.07 cm) and T₈ (96.30 cm), whereas treatment T₁ recorded the minimum plant height of 82.50 cm, followed by T₃ (85.90 cm) and T₅ (86.30 cm). The grand mean for plant height was 91.58 cm. These results corroborate the findings of Hamideldin *et al.* (2014) [8], Bakhtiari *et al.* (2020) [9], and Khan *et al.* (2021) [10] in sesame.

Number of branches per plant

Significant variation among treatments was observed for the number of branches per plant. Treatment T₉ recorded the maximum number of branches per plant (4.52), followed by T₇ (4.20) and T₆ (4.00),

whereas the minimum number was recorded in T₁ (2.93), followed by T₂ (3.13) and T₅ (3.47). The grand mean was 3.72 branches per plant. These findings are in conformity with the findings of Bakhtiari *et al.* (2020) [9] and Sangeetha *et al.* (2022) [11] in sesame.

Number of leaves per plant

The treatments exhibited significant differences in the number of leaves per plant. Treatment T₉ recorded the highest number of leaves per plant (59.87), followed by T₈ (56.27) and T₇ (56.23), whereas the lowest number was recorded in T₁ (46.57), followed by T₂ (49.67) and T₅ (50.50). The grand mean for the number of leaves per plant was 52.89. The present findings are in agreement with those of Khuong *et al.* (2022) [12], who observed that foliar application of boron increased the number of leaves in sesame.

Number of capsules per plant

A significant effect of treatments was observed on the number of capsules per plant. Treatment T₉ recorded the maximum number of capsules per plant (60.20), followed by T₆ (54.00) and T₇ (52.40), whereas the minimum number was recorded in T₁ (35.13), followed by T₅ (39.80) and T₄ (40.33). The grand mean was 46.92 capsules per plant. These results are in close agreement with the findings of Dinesh *et al.* (2018) [13], Patil *et al.* (2020) [14], Ramya *et al.* (2023) [15], and Pravalika *et al.* (2023) [16] in sesame.

Capsule length (cm)

Capsule length was significantly affected by the foliar treatments. Treatment T₉ recorded the maximum capsule length (3.31 cm), followed by T₂ (3.30 cm), while T₃, T₆, and T₇ recorded an equal capsule length of 3.29 cm. The minimum capsule length was recorded in T₁ (3.11 cm), followed by T₅ (3.19 cm) and T₄ (3.21 cm). The grand mean for capsule length was 3.25 cm. This finding is in agreement with the findings of Jeberson *et al.* (2025) in sesame.

Capsule width (mm)

Significant differences among treatments were recorded for capsule width. Treatment T₉ recorded the maximum capsule width (9.92 mm), followed by T₇ (9.82 mm) and T₆ (9.70 mm), whereas the minimum capsule width was recorded in T₁ (Control) (9.10 mm). The grand mean for capsule width was 9.62 mm.

Number of seeds per capsule

The treatments differed significantly for the number of seeds per capsule. Treatment T₉ recorded the highest number of seeds per capsule (59.90), followed by T₆ (58.83) and T₂ (57.60), whereas the lowest number was recorded in T₁ (50.00), followed by T₅ (55.13) and T₄ (55.17). The grand mean was 56.30 seeds per capsule. These results are in conformity with the findings of Seervi *et al.* (2018) [17], Jeberson *et al.* (2025), and Pravalika *et al.* (2023) [16] in sesame.

1000 seed weight (g)

1000-seed weight differed significantly among the treatments. Treatment T₉ recorded the maximum test weight (3.70 g), followed by T₇ (3.58 g) and T₃ (3.56 g), whereas the minimum test weight was recorded in T₁ (3.27 g), followed by T₅ (3.29 g) and T₄ (3.20 g). The grand mean for 1000-seed weight was 3.45 g. The present findings are supported by Habimana *et al.* (2016) [18], Maheshwari *et al.* (2023) [19], Khan *et al.* (2021) [10], Sangeetha *et al.* (2022) [11], and Pravalika *et al.* (2023) [16] in sesame.

Seed yield per plant (g)

The data revealed highly significant differences among treatments for seed yield per plant. Treatment T₉ recorded the maximum seed yield per plant (9.20 g), followed by T₇ (9.06 g) and T₆ (8.51 g), whereas the minimum seed yield per plant was recorded in T₁ (4.90 g), followed by T₅ (5.57 g) and T₄ (5.99 g). The grand mean for seed yield per plant was 7.31 g. The increase in seed yield due to the combined application of micronutrients could be attributed to enhanced synthesis of carbohydrates and proteins and their translocation to the devel

opening seeds. These findings corroborate the reports of Dinesh *et al.* (2018) [13] and Ramya *et al.* (2023) [15] in sesame.

Seed yield per plot (g)

A significant effect of treatments was recorded on seed yield per plot. Treatment T₉ recorded the maximum seed yield per plot (438.47 g), followed by T₇ (427.62 g) and T₆ (424.83 g), whereas the minimum seed yield per plot was recorded in T₁ (304.66 g), followed by T₅ (322.66 g) and T₄ (347.81 g). The grand mean for seed yield per plot was 378.40 g. These results are in agreement with the findings of Sangeetha *et al.* (2022) [11], Pravalika *et al.* (2023) [16], Dhaliwal *et al.* (2021) [20], Jeberson *et al.* (2025), and Purushothaman *et al.* (2024) [21] in sesame.

The present investigation was undertaken to study the effect of foliar application of micronutrients (B, Zn, Fe, and Mn), applied singly and in combination, on growth, seed yield, yield-contributing characters, and seed quality parameters of sesame (*Sesamum indicum* L.).

The results of the present investigation clearly established the superiority of treatment T₉ over the other treatments, including the absolute control (T₁), for the characters studied. The consistent superiority of T₉ across the growth, yield, and seed quality parameters may indicate

a synergistic effect of the four micronutrients when applied in combination. Boron may have contributed to pollen germination and reproductive development, zinc to auxin synthesis and enzyme activation, iron to chlorophyll synthesis and photosynthetic efficiency, and manganese to photosynthetic electron transport and enzyme activation. Collectively, these functions may have improved source–sink relationships and assimilate translocation towards the reproductive sinks, thereby contributing to enhanced growth and yield. This finding is in close agreement with the findings of Ramya *et al.* (2023) [15] and Elayaraja *et al.* (2020) [22] in sesame.

Germination percentage

Germination percentage was significantly influenced by foliar application of micronutrients. Treatment T₉ recorded the maximum germination percentage (89.00%), followed by T₇ (88.00%) and T₈ (87.00%), whereas the minimum germination percentage was recorded in T₁ (82.33%), followed by T₂ (84.00%) and T₅ (84.00%), which recorded an equal germination percentage. The grand mean for germination percentage was 85.78%. These findings are supported by the findings of Parsaei *et al.* (2017) [23] and Elayaraja *et al.* (2020) [22] in sesame.

Table 1. Effect of foliar application of micronutrients on growth, seed yield and yield contributing characters in sesame (*Sesamum indicum* L.)

Treatment	Days to 50% Flowering	Plant height (cm)	No. of Branches/ Plant	No. of Leaves/ Plant	No. of Capsules/ Plant	Capsule Length (cm)	Capsule Width (mm)	No. of Seeds/ Capsule	1000 Seed weight (g)	Seed Yield/ Plant (g)	Seed Yield/ Plot (g)
T ₁ - Control	49.73	82.50	2.93	46.57	35.13	3.11	9.10	50.00	3.27	4.90	304.66
T ₂ - Boron	47.47	88.60	3.13	49.67	50.53	3.30	9.63	57.60	3.43	7.30	368.28
T ₃ - Zinc	47.68	85.90	3.73	51.57	45.47	3.29	9.64	56.67	3.56	7.35	382.85
T ₄ - Ferrous	48.00	93.90	3.67	53.47	40.33	3.21	9.59	55.17	3.32	5.99	347.81
T ₅ - Manganese	48.20	86.30	3.47	50.50	39.80	3.19	9.59	55.13	3.29	5.57	322.66
T ₆ - B+Fe	46.60	92.00	4.00	51.83	54.00	3.29	9.70	58.83	3.52	8.51	424.83
T ₇ - Zn+Fe	47.46	98.07	4.20	56.23	52.40	3.29	9.82	57.00	3.58	9.06	427.62
T ₈ - Fe+Mn	46.53	96.30	3.80	56.27	44.40	3.23	9.61	56.40	3.42	7.91	388.50
T ₉ - T ₂ +T ₃ +T ₄ +T ₅	46.00	100.70	4.52	59.87	60.20	3.31	9.92	59.90	3.70	9.20	438.47
General Mean	47.52	91.58	3.72	52.89	46.92	3.25	9.62	56.30	3.45	7.31	378.40
S.Em.±	0.55	1.92	0.18	2.04	2.04	0.03	0.09	1.30	0.05	0.35	16.59
C.D. at 5%	1.65	5.75	0.54	6.13	6.11	0.09	0.26	3.89	0.16	1.06	49.73
C.V. (%)	2.00	3.63	8.43	6.70	7.53	1.66	1.57	4.00	2.60	8.37	7.59

Seedling Vigour Index-I

Data revealed significant differences among treatments for Seedling Vigour Index-I. Treatment T₉ recorded the maximum Seedling Vigour Index-I (1775.3), followed by T₃ (1687.2) and T₇ (1574.3), whereas the minimum was recorded in T₁ (1183.0), followed by T₆ (1396.1) and T₅ (1491.2). The grand mean for Seedling Vigour Index-I was 1520.0. These results are in conformity with the findings of Parsaei *et al.* (2017) [23] and Hamsaveni *et al.* (2002) [24].

Seedling Vigour Index-II

Significant variation among treatments was recorded for Seedling Vigour Index-II. Treatment T₉ recorded the maximum Seedling Vigour Index-II (304.39), followed by T₇ (289.51) and T₈ (282.75), whereas the minimum was recorded in T₁ (241.24), followed by T₅ (252.01) and T₂ (254.52). The grand mean for Seedling Vigour Index-II was 269.92. These findings are consistent with the findings of Parsaei *et al.* (2017) [23] and Zaman *et al.* (2019) [25] in sesame.

Oil content (%)

The treatments differed significantly for oil content. Treatment T₉ recorded the maximum oil content (46.99%), followed by T₅ (46.90%) and T₄ (46.50%), whereas the minimum oil content was

recorded in T₁ (45.00%), followed by T₇ (45.20%) and T₆ (45.30%). The grand mean for oil content was 45.94%. It is notable that T₇, despite recording high values for most yield-contributing characters, recorded comparatively lower oil content. This may indicate that the zinc–iron combination favoured vegetative growth and yield formation without a proportionate increase in oil accumulation. This observation is consistent with the findings of Rekani (2019) [26]. The present results are in agreement with the findings of Habimana *et al.* (2016) [18], Dhaliwal *et al.* (2021) [20], Khuong *et al.* (2022) [12], Dey (2023) [27], and Saudy *et al.* (2022) [28] in sesame.

An interesting trend observed in the present study was the consistently strong performance of treatment T₇, which ranked second to T₉ for the majority of the characters, including plant height (98.07 cm), number of branches per plant (4.20), 1000-seed weight (3.58 g), seed yield per plant (9.06 g), and Seedling Vigour Index-II (289.51). This performance suggests that the combined application of zinc and iron may have had a complementary effect on vegetative growth and reproductive development in sesame, as also indicated by Kakhki *et al.* (2017) [29] and Haritha *et al.* (2022) [30]. However, T₇ recorded one of the lowest oil contents (45.20%) among the treatments, indicating that the zinc–iron combination favoured growth and yield formation but did not result in a proportionate increase in oil content. This pattern is in line with the observations of Rekani (2019) [26].

Table 2. Effect of foliar application of micronutrients on seed quality parameters in sesame (*Sesamum indicum* L.)

Treatment	Germination (%)	Seedling Vigour Index-I	Seedling Vigour Index-II	Oil Content (%)
T ₁ - Control	82.33	1183.0	241.24	45.00
T ₂ - Boron	84.00	1494.7	254.52	46.10
T ₃ - Zinc	86.67	1687.2	273.01	45.80
T ₄ - Ferrous	85.00	1509.1	261.79	46.50
T ₅ - Manganese	84.00	1491.2	252.01	46.90
T ₆ - B+Fe	86.00	1396.1	270.03	45.30
T ₇ - Zn+Fe	88.00	1574.3	289.51	45.20
T ₈ - Fe+Mn	87.00	1568.9	282.75	45.70
T ₉ - T ₂ +T ₃ +T ₄ +T ₅	89.00	1775.3	304.39	46.99
General Mean	85.78	1520.0	269.92	45.94
S.Em.±	0.97	79.58	8.53	0.36
C.D. at 5%	2.91	238.58	25.57	1.09
C.V. (%)	1.96	9.07	5.47	1.38

The improvement in seed quality parameters under T₉, viz., germination percentage (89.00%), Seedling Vigour Index-I (1775.3), Seedling Vigour Index-II (304.39), and oil content (46.99%), compared with T₁ (82.33%, 1183.0, 241.24, and 45.00%, respectively), demonstrates the beneficial effect of balanced and combined micronutrient nutrition on seed quality in sesame. The superior performance of T₉ may be attributed to the complementary roles of boron, zinc, iron, and manganese in physiological and metabolic processes associated with seed development and maturation. These findings are consistent with the observations of Parsaei *et al.* (2017) [23] and Maheshwari *et al.* (2023) [19], who reported that combined foliar application of micronutrients improved yield and quality-related attributes in sesame.

Conclusion

Among all the micronutrient treatments evaluated in sesame at the Quality Seed Production Unit, VNMKV, Parbhani, treatment T₉ was found to be the most effective treatment compared with the control for the growth, seed yield, yield-contributing, and seed quality characters studied. It recorded the earliest 50 per cent flowering (46.00 days), maximum plant height (100.70 cm), maximum number of branches per plant (4.52) and leaves per plant (59.87), maximum number of capsules per plant (60.20), highest capsule length (3.31 cm), capsule width (9.92 mm), number of seeds per capsule (59.90), 1000-seed weight (3.70 g), seed yield per plant (9.20 g), seed yield per plot (438.47 g), germination percentage (89.00%), Seedling Vigour Index-I (1775.3), Seedling Vigour Index-II (304.39), and oil content (46.99%). Treatment T₇ was found to be the second most effective treatment for most of the growth and yield-related parameters. On the basis of the present findings, foliar application of boron, zinc, iron, and manganese in combination (T₉) may be considered a promising agronomic practice for enhancing seed yield and seed quality of sesame under the conditions of the present investigation.

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