

Fertilizer-induced Variations in Growth and Yield of *Eryngium foetidum* L.

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Received: 27 Aug 2025; Revised accepted: 06 Oct 2025

Abstract

Spiny coriander (*Eryngium foetidum* L.), an emerging nutritious herbal spice, was evaluated for its response to various fertilizer doses in a field experiment conducted at Kerala Agricultural University during September 2024 to March 2025. The study assessed the effect of seven fertilizer levels on growth, yield, and biochemical properties using a randomized block design with three replications. The traits such as plant height (21.14 cm), leaf area (76.52 cm²), and green leaf yield (3346.95 g plot⁻¹) were significantly enhanced with the application of treatment containing FYM at 5.00 t ha⁻¹ combined with 25:10:10 kg ha⁻¹ NPK and a 1.50% urea foliar spray (T₄). Treatments incorporating vermicompost at 2.50 t ha⁻¹ along with 25:10:10 kg ha⁻¹ NPK and foliar sprays of 1.00% or 1.50% urea, excelled in essential oil (0.55-0.57%), total chlorophyll content (2.12 mg g⁻¹), carotenoid content (0.74 mg g⁻¹), and secondary metabolite production (total phenols: 13.27 mg GE g⁻¹; flavonoids: 45.65 mg QE g⁻¹). The absolute control consistently underperformed. These findings point out the importance of combined organic and inorganic fertilizer application in enhancing the growth, yield, and biochemical content, with T₄ being optimal for biomass and T₆/T₇ for medicinal properties, supporting sustainable cultivation and economic potential.

Key words: *Eryngium foetidum*, Fertilizer, Growth, Yield, Biochemical

Herbal spices have long been valued for their various roles in human life, such as enhancing the sensory qualities of food while also providing therapeutic benefits. Although major spices have received significant scientific attention, a large number of minor spices remain underexplored, despite their well-established roles in traditional cuisine and folk medicine. Spiny coriander, botanically known as *Eryngium foetidum* L., is one such lesser-known but highly valuable herb belonging to the Apiaceae family. Indigenous to Tropical America and the Caribbean islands, this plant is now grown in various regions of South-East Asia, such as India, Bangladesh, Singapore, Thailand, Myanmar, Sri Lanka, Indonesia, Malaysia, and Vietnam, due to its spicy flavour and pungent aroma resembling that of *Coriandrum sativum* L., a widely used spice belonging to the same family [3], [11]. In India, this biennial herb with long, dark green, and nutrient-rich fleshy leaves is cultivated in northeastern states like Assam, Manipur, Mizoram, Nagaland, and Tripura, some pockets of southern states like Kerala, Karnataka, and Tamil Nadu, mainly for household consumption and also in the Andaman and Nicobar Islands [14].

Rather than its use as a spice, the herb is a promising remedy for various ailments such as fevers, burns, earache, asthma, epilepsy, vertigo, bone fractures, snake bites, scorpion

stings, and diarrhoea due to its anti-helminthic, anti-inflammatory, analgesic, and anti-bacterial properties [5]. In addition to their pharmacological properties, their cultivation offers opportunities for diversifying agricultural systems and supporting local livelihoods.

The productivity and quality of the green leaves are greatly influenced by nutrient availability, as fertilizers not only determine biomass accumulation but also affect the synthesis of secondary metabolites responsible for flavour and medicinal properties. However, the standardized nutrient management practices for *Eryngium foetidum* are lacking, resulting in inconsistent yields and variable quality. Optimizing fertilizer doses is therefore critical to enhance both the green leaf yield and the biochemical composition of this crop, ensuring its wider acceptance and economic potential.

To address this gap, the present study was conducted to evaluate the effect of different fertilizer doses on the green leaf yield and biochemical content of *Eryngium foetidum*.

MATERIALS AND METHODS

A field experiment was conducted from September 2024 to March 2025 at Plantation farm, College of Agriculture,

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Vellanikkara, Kerala Agricultural University, Thrissur (10 ° 31' N latitude, 76 ° 13' E longitude and 22.5 metres above mean sea level) to evaluate the effect of various fertilizer doses on the growth, yield, and biochemical properties of *Eryngium foetidum*. The soil in the experimental plot was classified as lateritic with pH 6.11, EC 0.07 Ds m⁻¹, OC 1.12%, available N (442 kg ha⁻¹), available P₂O₅ (40.73 kg ha⁻¹), and available K₂O (99.90 kg ha⁻¹) at the initiation of the experiment. The experiment was laid out in a randomized block design comprising seven treatments (Table 1) and three replications. The crop was planted at a spacing of 15 × 10 cm with a plot size of 1 m². Fertilizer doses were calculated based on the soil test results, and urea, rajphos, and muriate of potash were used as the inorganic sources of fertilizers. The entire quantity of FYM or vermicompost, phosphorus, and half the dose of nitrogen and potassium were applied as basal. The remaining half dose of nitrogen and potassium was applied as top dressing at 45 days after planting (DAP), followed by application of urea as foliar spray at 90 DAP. Weeding and inflorescence removal were carried out periodically.

Table 1 Fertilizer doses for standardization of fertilizer schedule of spiny coriander

Treatment	Fertilizer doses
T ₁	: Absolute control
T ₂	: FYM 5.00 t ha ⁻¹ + 20:10:10 kg ha ⁻¹ NPK + foliar spray of 1.50% urea (control)
T ₃	: FYM 5.00 t ha ⁻¹ + 25:10:10 kg ha ⁻¹ NPK + foliar spray of 1.00% urea
T ₄	: FYM 5.00 t ha ⁻¹ + 25:10:10 kg ha ⁻¹ NPK + foliar spray of 1.50% urea
T ₅	: Vermicompost 2.50 t ha ⁻¹ + 20:10:10 kg ha ⁻¹ NPK + foliar spray of 1.50% urea
T ₆	: Vermicompost 2.50 t ha ⁻¹ + 25:10:10 kg ha ⁻¹ NPK + foliar spray of 1.00% urea
T ₇	: Vermicompost 2.50 t ha ⁻¹ + 25:10:10 kg ha ⁻¹ NPK + foliar spray of 1.50% urea

Recording observations on growth, yield and biochemical parameters

The data on plant growth and yield-related characters were recorded at the time of harvest (120 DAP). Five plants were randomly selected and tagged from each experimental plot to record observations on plant height, collar girth, number of leaves per plant, leaf length, leaf width, leaf area, plant spread, number of suckers per plant, leaf area index (LAI), green leaf yield, and total biomass yield per plant. Entire plants were uprooted and used for quantifying data related to total biomass yield and green leaf yield per plot. Other parameters like volatile oil content, chlorophyll, carotenoid, total phenols, and flavonoids were assessed using the respective methods outlined below:

Determination of essential oil content (%)

The volatile oil of *Eryngium foetidum* was estimated using Clevenger distillation method [4] and expressed as % (v/w) on dry weight basis.

Determination of chlorophyll content (mg g⁻¹)

Fresh leaf tissue (0.25 g) was placed into test tubes to which 15 mL of DMSO (dimethyl sulfoxide) was introduced, and the mixture was then incubated at 60°C for one hour until the leaf tissue lost all pigmentation. The extract was subsequently decanted into a volumetric flask and diluted to a final volume of 25 ml with additional DMSO (dimethyl sulfoxide). Absorbance readings were obtained using a

spectrophotometer at wavelengths of 645 nm and 663 nm, using pure DMSO (dimethyl sulfoxide) as the reference blank [8]. To quantify chlorophyll a, chlorophyll b, and total chlorophyll content Arnon's equation was used [2].

Determination of carotenoid content (mg g⁻¹)

Carotenoid levels in the fresh leaves were quantified using DMSO extraction [8]. The same preparations utilized for chlorophyll quantification served for carotenoid determination as well. Absorbance values were recorded at 480 nm and 510 nm, and carotenoid concentrations were computed according to the equations given by [2].

Determination of total phenols (mg GE g⁻¹)

Fresh leaf sample (0.50 g) was ground in a mortar and pestle using 10 mL of 80% ethanol. The homogenate was subjected to centrifugation at 10,000 rpm for 20 minutes and the supernatant was decanted into a test tube. The remaining residue underwent a second extraction, after which the supernatants were combined and concentrated to dryness by evaporation. The dried extract was then resuspended in 5 mL of distilled water and 0.20 mL aliquots were pipetted into test tubes for analysis. For both the blank and sample tubes, 3 mL of distilled water was added along with 0.50 mL Folin-Ciocalteu reagent. Following a 3 minutes incubation at ambient temperature, 2 mL of 20% sodium carbonate was added to each tube and thoroughly mixed. The samples were incubated in the dark for 60 minutes prior to absorbance measurement at 650 nm using a spectrophotometer. Gallic acid served as the reference standard for constructing a calibration curve and the results were reported as milligrams of gallic acid equivalent per gram [13].

Flavonoid content (mg QE g⁻¹)

A 100 mg sample of leaf tissue was extracted with 10 mL of 80% ethanol. The extract was centrifuged at 10000 rpm for 15 minutes and the supernatant was collected. The residue was re-extracted twice, and the supernatants were combined, followed by dilution to a final volume of 50 mL using 80% ethanol. For analysis, 0.50 mL of the leaf extract was transferred to a test tube and 3 mL of 5% (w/v) sodium nitrate along with 2.50 mL of distilled water was added. The mixture was incubated at ambient condition for 3 minutes, after which 0.30 mL of 10% (w/v) aluminium chloride was added and incubation continued for another 6 minutes. Subsequently, 2 mL of 1M sodium hydroxide was added and the final volume was adjusted to 10 mL with distilled water. The mixture was incubated in the dark at room temperature for 60 minutes. Using a spectrophotometer, the absorbance was measured at 415 nm against blank. Using Quercetin as standard, a standard curve was generated and results were expressed in milligrams of Quercetin equivalent per gram [18].

For identifying significant trends and variations, all the data recorded from the study were subjected to analysis of variance by using GRAPES software [6]. This tool enabled to get accurate and reliable results.

RESULTS AND DISCUSSION

The quantity and quality of the fleshy dark green leaves produced by the *Eryngium foetidum* varied among different fertilizer trials. The results highlight significant differences in the efficiency of seven different treatments on plant growth, yield, and biochemical parameters. Across the various growth parameters measured (Table 2-4), application of farmyard manure (FYM) at 5.00 t ha⁻¹ combined with 25:10:10 kg ha⁻¹

NPK and 1.50% urea foliar spray consistently outperformed other treatments by recording the highest plant height (21.14 ± 0.47 cm), plant spread at east-west (40.51 ± 0.85 cm) and north-south (40.02 ± 0.73 cm), collar girth (2.12 ± 0.06 cm), number of leaves per plant (19.07 ± 0.30), leaf length (21.59 ± 0.31 cm), leaf width (4.72 ± 0.08 cm), leaf area (76.52 ± 1.72 cm²), leaf area index (4.01 ± 0.03), and number of suckers per plant (2.00 ± 0.08). In contrast, the absolute control exhibited the lowest

growth metrics: plant height (17.01 ± 0.47 cm), east-west spread (29.79 ± 0.85 cm), north-south spread (29.62 ± 0.73 cm), collar girth (1.67 ± 0.06 cm), number of leaves per plant (13.80 ± 0.30), leaf length (18.01 ± 0.31 cm), leaf width (4.00 ± 0.08 cm), leaf area (64.26 ± 1.72 cm²), leaf area index (3.06 ± 0.03), and number of suckers per plant (0.53 ± 0.08). The treatments T₃, T₆, and T₇ exhibited comparable results, followed by treatments T₂ and T₅, which showed intermediate results.

Table 2 Variation of growth parameters in response to different fertilizer regimes

Treatment	Plant height (cm)	East-west spread (cm)	North-south spread (cm)	Collar girth (cm)
T ₁	17.01 ^c	29.79 ^c	29.62 ^c	1.67 ^c
T ₂	18.97 ^{cd}	35.67 ^b	32.11 ^d	1.89 ^b
T ₃	20.11 ^{abc}	34.66 ^b	35.09 ^{bc}	1.97 ^{ab}
T ₄	21.14 ^a	40.51 ^a	40.02 ^a	2.12 ^a
T ₅	18.35 ^{de}	33.27 ^b	33.86 ^{cd}	1.92 ^b
T ₆	19.45 ^{bcd}	34.58 ^b	35.06 ^{bc}	1.92 ^{ab}
T ₇	20.44 ^{ab}	34.25 ^b	36.20 ^b	1.94 ^{ab}
SE (m)	0.47	0.85	0.73	0.06
CV (%)	4.17	4.27	3.64	5.84

Table 3 Variation of growth parameters in response to different fertilizer regimes

Treatment	Number of leaves per plant	Leaf length (cm)	Leaf width (cm)	Leaf area (cm ²)
T ₁	13.80 ^d	18.01 ^d	4.00 ^c	64.26 ^c
T ₂	16.13 ^c	19.35 ^c	4.31 ^b	68.19 ^{bc}
T ₃	18.40 ^{ab}	20.39 ^b	4.39 ^b	69.94 ^b
T ₄	19.07 ^a	21.59 ^a	4.72 ^a	76.52 ^a
T ₅	17.80 ^b	19.73 ^{bc}	4.24 ^b	68.47 ^{bc}
T ₆	18.07 ^b	19.12 ^c	4.30 ^b	69.38 ^{bc}
T ₇	18.60 ^{ab}	19.61 ^{bc}	4.40 ^b	71.10 ^b
SE (m)	0.30	0.31	0.08	1.72
CV (%)	3.00	2.71	3.06	4.28

Table 4 Variation of growth parameters in response to different fertilizer regimes

Treatment	Leaf area index	Number of suckers per plant
T ₁	3.06 ^f	0.53 ^e
T ₂	3.51 ^e	0.93 ^d
T ₃	3.70 ^e	1.33 ^c
T ₄	4.01 ^a	2.00 ^a
T ₅	3.61 ^d	1.07 ^d
T ₆	3.78 ^{bc}	1.40 ^{bc}
T ₇	3.80 ^b	1.60 ^b
SE (m)	0.03	0.08
CV (%)	1.46	11.16

Table 5 Variation of yield parameters in response to different fertilizer regimes

Treatment	Total biomass yield per plant (g)	Total biomass yield per plot (g)	Green leaf yield per plant (g)	Green leaf yield per plot (g)	Essential oil content (%)
T ₁	55.91 ^c	3347.93 ^t	38.98 ^c	2521.65 ^e	0.08 ^e
T ₂	72.48 ^{bc}	3941.07 ^e	48.15 ^b	3069.49 ^d	0.32 ^{cd}
T ₃	72.26 ^{bc}	4155.39 ^d	50.89 ^b	3167.45 ^{bc}	0.27 ^d
T ₄	85.69 ^a	4627.57 ^a	62.64 ^a	3346.95 ^a	0.37 ^c
T ₅	67.59 ^d	4355.17 ^c	48.69 ^b	3051.63 ^d	0.47 ^b
T ₆	70.77 ^{cd}	4453.84 ^b	49.98 ^b	3132.41 ^c	0.55 ^{ab}
T ₇	74.85 ^b	4496.42 ^b	53.37 ^b	3207.81 ^b	0.57 ^a
SE (m)	1.30	20.412	2.24	14.05	0.03
CV (%)	3.15	0.842	7.70	0.79	13.00

In terms of yield parameters (Table 5), total biomass yield per plant and per plot was highest in the fertilizer trial involving farmyard manure (FYM) at 5.00 t ha⁻¹ with 25:10:10 kg ha⁻¹ NPK and foliar spray of 1.50% urea (85.69 ± 1.30 g and 4627.57 ± 20.41 g, respectively), followed by T₇ (74.85 ± 1.30

g and 4496.42 ± 20.41 g) and T₆ (70.77 ± 1.30 g and 4453.84 ± 20.41 g). Green leaf yield per plant and per plot followed a similar trend, with T₄ achieving 62.64 ± 2.24 g and 3346.95 ± 14.05 g, respectively, significantly higher than T₁ (38.98 ± 2.24 g and 2521.65 ± 14.05 g). Treatments T₂, T₃, and T₆ recorded

intermediate yields with T₂ (48.15 ± 2.24 g and 3069.49 ± 14.05 g) and T₅ (48.69 ± 2.24 g and 3051.63 ± 14.05 g) showing comparable green leaf yields. The essential oil content was highest in T₇ ($0.57 \pm 0.03\%$), followed closely by T₆ ($0.55 \pm$

0.03%) and T₅ ($0.47 \pm 0.03\%$), while T₁ recorded the lowest content ($0.08 \pm 0.03\%$). The essential oil content of T₄ was moderate ($0.37 \pm 0.03\%$) but significantly lower than that of T₇ and T₆.

Table 6 Variation of biochemical parameters in response to different fertilizer regimes

Treatment	Total phenols (mg GE g ⁻¹)	Flavonoids (mg QE g ⁻¹)
T ₁	6.76 ^g	29.36 ^f
T ₂	10.04 ^e	36.76 ^d
T ₃	12.11 ^b	34.30 ^e
T ₄	11.58 ^c	36.27 ^{de}
T ₅	9.03 ^f	39.98 ^c
T ₆	13.27 ^a	42.69 ^b
T ₇	10.66 ^d	45.65 ^a
SE (m)	0.08	0.77
CV (%)	1.24	3.50

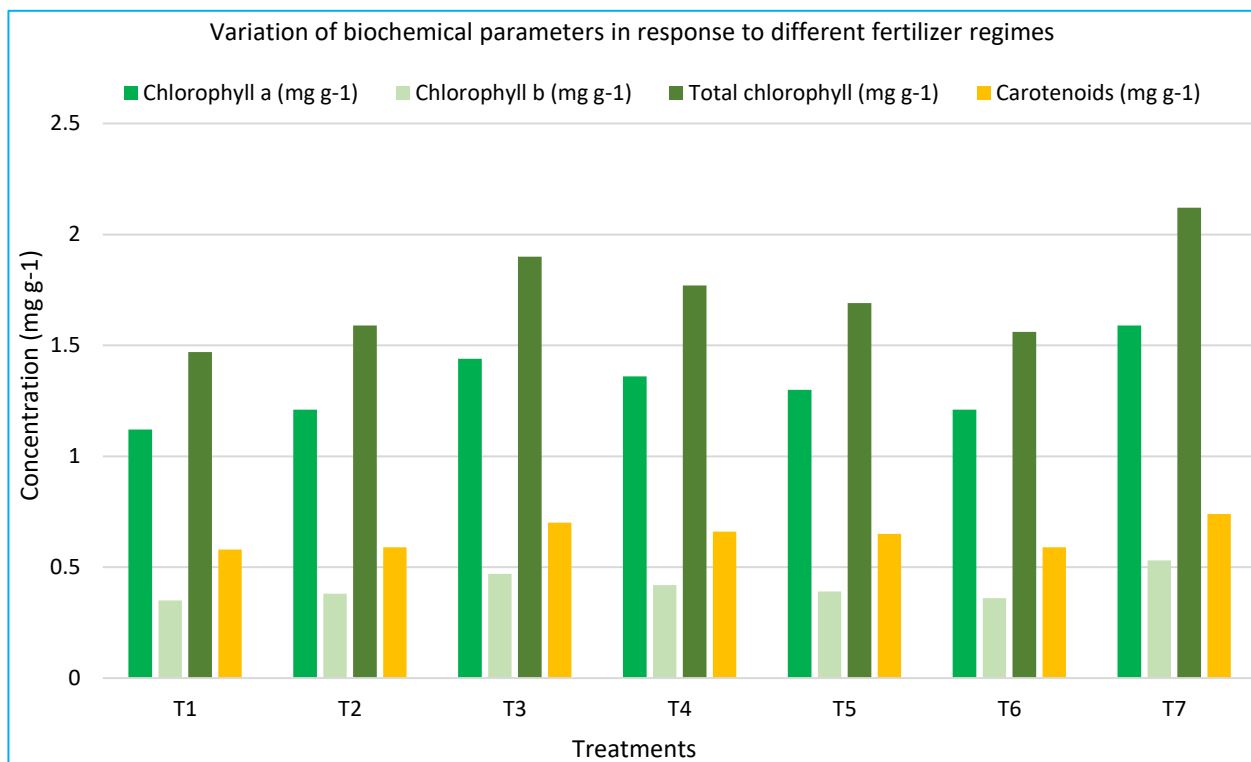


Fig 1 Variation of biochemical parameters in response to different fertilizer regimes

Biochemical content also showed significant variations among treatments (Fig 1, Table 6). Chlorophyll a, chlorophyll b, and total chlorophyll content were highest in T₇ (1.59 ± 0.02 mg g⁻¹, 0.53 ± 0.02 mg g⁻¹, and 2.12 ± 0.03 mg g⁻¹), with T₁ showing the lowest (1.12 ± 0.02 mg g⁻¹, 0.36 ± 0.02 mg g⁻¹, and 1.47 ± 0.03 mg g⁻¹). Carotenoid content followed a similar pattern, with T₇ at 0.74 ± 0.01 mg g⁻¹ and T₁ at 0.58 ± 0.01 mg g⁻¹. Total phenols were highest in T₆ (13.27 ± 0.08 mg GE g⁻¹), while flavonoids peaked in T₇ (45.65 ± 0.77 mg QE g⁻¹), with T₁ showing the lowest values (6.76 ± 0.08 mg GE g⁻¹ and 29.36 ± 0.77 mg QE g⁻¹).

The results demonstrated that application of FYM at 5.00 t ha⁻¹ combined with 25:10:10 kg ha⁻¹ NPK and 1.50% urea foliar spray was most effective in promoting vegetative growth and biomass yield, likely due to its balanced nutrient supply, which enhanced nitrogen availability for cell division, elongation, and photosynthesis. Similar results were obtained on the combined application of farmyard manure (FYM) and NPK fertilizers on coriander and celery [1], [16]. The

significantly higher plant height, canopy spread, collar girth, number of leaves, leaf area, and LAI under the same treatment suggest optimized nutrient uptake and allocation. It is also evident from the result that the treatment maximized carbon assimilation and biomass accumulation. For active growth and productivity, the combined application of farmyard manure (FYM) and NPK was a critical agronomic practice [7].

The treatments involving vermicompost at 2.50 t ha⁻¹ along with 25:10:10 kg ha⁻¹ NPK and foliar spray of either 1.50% or 1.00% urea performed comparably with the farmyard manure (FYM) 5.00 t ha⁻¹ + 25:10:10 kg ha⁻¹ NPK + 1.50% urea for several parameters, particularly yield and biomass traits, suggesting that vermicompost-based formulations with higher NPK doses are effective alternatives. This aligns with the findings of [15] on sweet basil. Notably, the vermicompost based combinations with 25:10:10 kg ha⁻¹ NPK (1.50% and 1.00% urea foliar sprays) recorded higher essential oil content (0.57% and 0.55%, respectively) compared to the farmyard manure (FYM) based combination (0.37%), confirmed with the

results of [10]. Enhanced levels of total chlorophyll (2.12 mg g⁻¹), carotenoids (0.74 mg g⁻¹), phenols (13.27 mg GE g⁻¹), and flavonoids (45.65 mg QE g⁻¹) under vermicompost treatments further indicate that organic amendments, particularly vermicompost, may enhance the biosynthesis of these compounds, possibly due to its rich organic matter stimulating secondary metabolic pathway. The higher phenol and flavonoid content also highlighted the potential to enhance stress tolerance and medicinal properties. Previous research conducted on coriander proved the role of vermicompost in improving the phenol and flavonoid content [17]. Similar results were also obtained on spearmint [9]. In contrast, the treatments with lower NPK supplementation showed relatively weaker performance, suggesting that reduced nutrient availability constrained their effectiveness in supporting vigorous vegetative growth and yield. The FYM 5.00 t ha⁻¹ + 25:10:10 kg ha⁻¹ NPK + 1.00% urea treatment, although promising, has lower urea concentration, which may have reduced nitrogen availability. The absolute control consistently underperformed, reflecting the critical role of nutrient

supplementation in promoting growth, yield, and biochemical content. A study by [12] stresses the need for the combined application of organic and inorganic fertilizers on *E. foetidum*, as the former resulted in greater biomass and the latter enhanced the oil yield.

CONCLUSION

The experiment demonstrates the significant influence of fertilizer regimes on growth, yield, and biochemical properties of *E. foetidum* L. Maximizing vegetative growth and biomass production were achieved with the application of FYM at 5.00 t ha⁻¹ combined with 25:10:10 kg ha⁻¹ NPK and a 1.50% urea foliar spray due to the high nitrogen availability. Conversely, vermicompost at 2.50 t ha⁻¹ along with 25:10:10 kg ha⁻¹ NPK and foliar sprays of 1.00% or 1.50% urea proved superior for enhancing essential oil yield and secondary metabolite accumulation due to the enriched nutrient status of vermicompost. These results underscore the need for balanced nutrient management for optimizing both yield and quality.

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