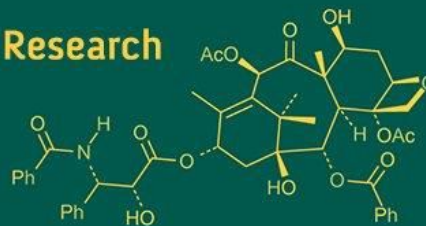


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Effect of integrated nutrient management on growth and flowering of dragon fruit [*Selenicereus costaricensis* (web.) Britton and Rose]

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Abstract

A field experiment was conducted to study the effect of Integrated Nutrient Management (INM) on growth and flowering of dragon fruit (*Selenicereus costaricensis*) at a farmer's field in Maddur, Tiruttani, Thiruvallur district, Tamil Nadu. The experiment was carried out on four-year-old dragon fruit plants (variety Ciyam Red C) using a Randomized Block Design (RBD) with eight treatments and three replications, with five poles per treatment. The treatments consisted of different combinations of Recommended Dose of Fertilizers (RDF), vermicompost, consortium biofertilizer and micronutrients (ZnSO₄ + boric acid). The results revealed that the treatment T₇ (75% RDF + 25% vermicompost + consortium biofertilizer + micronutrients) recorded the highest growth parameters such as plant height (32.40 cm), number of cladodes plant⁻¹ (16.67), cladode length (102.45 cm) and cladode diameter (13.95 cm). The same treatment also produced the maximum number of flowers plant⁻¹ (68.45) and showed better flowering performance compared to other treatments. The control treatment recorded the lowest values for all the parameters studied. The enhanced performance under integrated nutrient management may be attributed to the combined effect of inorganic fertilizers, organic manure, biofertilizers and micronutrients which improved nutrient availability, soil health and nutrient uptake by the plants. The study indicates that integrated application of Recommended Dose of Fertilizers (RDF) at 450:350:300 g N:P:K pole⁻¹, along with vermicompost, consortium biofertilizer at 100 ml pole⁻¹ and micronutrient spray of ZnSO₄ at 0.5% and boric acid at 0.2%, is effective in improving the growth and flowering performance of dragon fruit under tropical conditions.

Keywords: Dragon fruit, integrated nutrient management, vermicompost, consortium, micronutrients, growth

Introduction

Dragon fruit [*Selenicereus costaricensis* (web.) Britton and Rose] belonging to the family Cactaceae is a perennial climbing cactus widely cultivated in tropical and subtropical regions. It is commonly known as pitaya, strawberry pear, night blooming cereus and queen of the night (Martin *et al.*, 1987) [9]. The crop originated in the tropical forest regions of Mexico and Central and South America and later spread to many countries including Vietnam, Thailand, Malaysia, Australia and Israel (Mizrahi and Nerd, 1996; Mizrahi *et al.*, 1997) [10, 11]. In India, dragon fruit cultivation has expanded rapidly in states such as Tamil Nadu, Karnataka, Maharashtra, Gujarat and Andhra Pradesh due to its high economic value, nutritional importance and adaptability to dry climatic conditions. Dragon fruit plants are fast-growing climbing cacti with succulent triangular stems and aerial roots that help the plant attach to support structures. The fruit is a non-climacteric epigenous berry with attractive red or yellow skin and white or red pulp containing numerous edible black seeds. The fruit is rich in vitamin C, minerals, antioxidants and dietary fibre, making it a popular health-promoting fruit (Morton, 1987; Zainoldin and Baba, 2012) [12, 1]. Due to its increasing market demand and export potential, dragon fruit cultivation is gaining importance in many tropical countries. Proper nutrient management plays a vital role in improving the growth and flowering of dragon fruit plants. Adequate and balanced supply of nutrients ensures better vegetative growth, flowering and fruit development, thereby increasing productivity. However, continuous use of chemical fertilizers alone may lead to deterioration of soil health and reduced nutrient use efficiency. Integrated Nutrient Management (INM) is an approach that combines the use of chemical fertilizers, organic manures and consortium biofertilizers

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to maintain soil fertility and improve crop productivity in a sustainable manner (Sharvesh *et al.*, 2026) [22]. The combined application of inorganic fertilizers with organic sources such as vermicompost improves soil physical, chemical and biological properties while ensuring the availability of essential nutrients to plants. Organic manures also enhance microbial activity and nutrient mineralization, thereby supporting better plant growth and yield (Sharvesh *et al.*, 2026) [22]. Consortium biofertilizers play an important role in INM by improving nutrient availability and uptake. A consortium biofertilizer contains beneficial microorganisms such as nitrogen-fixing bacteria, phosphate-solubilizing bacteria (PSB) and potassium-solubilizing bacteria (KSB), which enhance nutrient mobilization and availability in the rhizosphere. These microorganisms help in biological nitrogen fixation and solubilization of insoluble forms of phosphorus and potassium, thereby improving nutrient uptake and plant growth. Similarly, micronutrients such as zinc and boron are essential for several physiological processes including enzyme activation, pollen viability, fruit set and overall plant metabolism. Deficiency of these micronutrients may adversely affect growth, flowering and fruit quality. Although the individual effects of chemical fertilizers, organic manures and consortium biofertilizers are well documented, limited information is available on their combined use in dragon fruit cultivation. Therefore, the present study was undertaken to evaluate the effect of different combinations of Recommended Dose of Fertilizers (RDF), vermicompost, consortium biofertilizer and micronutrients (ZnSO_4 and boric acid) on the growth and flowering of dragon fruit, with the aim of identifying an efficient and sustainable nutrient management practice.

Materials and Methods

The present investigation entitled “Effect of Integrated Nutrient Management on growth and flowering of dragon fruit (*Selenicereus costaricensis*)” was carried at a farmer’s field located at Maddur, Tiruttani, Thiruvallur district, Tamil Nadu. The experimental site is geographically situated at

13.24° N latitude and 79.56° E longitude at an altitude of 92 m above mean sea level and falls under a tropical agro-climatic region. The experiment was conducted on four-year-old dragon fruit plants (variety Ciyam Red C) to study the Effect of Integrated Nutrient Management on growth and flowering of Dragon Fruit (*Selenicereus costaricensis*). The experiment was laid out in a Randomized Block Design (RBD) with eight treatments and three replications, with five poles per treatment. The treatments consisted of different combinations of Recommended Dose of Fertilizers (RDF), vermicompost, consortium biofertilizer and micronutrients (ZnSO_4 + Boric acid). The treatments were: T₁: Control, T₂: 100% RDF, T₃: 75% RDF + 25% Vermicompost, T₄: 50% RDF + 50% Vermicompost, T₅: 75% RDF + 25% Vermicompost + Consortium Biofertilizer, T₆: 50% RDF + 50% Vermicompost + Consortium Biofertilizer, T₇: 75% RDF + 25% Vermicompost + Consortium Biofertilizer + Micronutrients and T₈: 50% RDF + 50% Vermicompost + Consortium Biofertilizer + Micronutrients. The application of Recommended Dose of Fertilizers (RDF) at 450:350:300 g N:P:K pole⁻¹, along with vermicompost, consortium biofertilizer at 100 ml pole⁻¹ and micronutrient spray of ZnSO_4 at 0.5% and boric acid at 0.2%. The required inputs were applied as per the treatment combinations and all experimental units were maintained under uniform cultural practices. Observations on growth and flowering parameters were recorded and the data were statistically analyzed using ANOVA for RBD as suggested by Panse and Sukhatme (1997) [14] using OPSTAT software (version 6.0.81.69) at 5% level of significance.

Results and Discussion

The effect of integrated nutrient management on growth parameters of dragon fruit was found to be significant (Table 1). Among the treatments, the application of 75% RDF + 25% vermicompost + consortium biofertilizer + micronutrients (ZnSO_4 + boric acid) recorded the highest plant height (32.40 cm), number of cladodes plant⁻¹ (16.67), cladode length (102.45 cm) and cladode diameter (13.95 cm).

Table 1: Effect of INM on growth parameters of dragon fruit cv. Ciyam Red C

Treatment details		Plant height	No of cladodes plant ⁻¹	Cladode length	Cladode diameter
T ₁	Control	15.13	6.43	83.97	11.19
T ₂	100% RDF	21.70	8.62	87.93	11.78
T ₃	75% RDF + 25% Vermicompost	18.37	8.32	87.39	11.70
T ₄	50% RDF + 50% Vermicompost	25.47	12.55	95.01	12.84
T ₅	75% RDF + 25% Vermicompost + Consortium Biofertilizer	22.51	10.78	91.83	12.36
T ₆	50% RDF + 50% Vermicompost + Consortium Biofertilizer	25.78	12.73	95.34	12.89
T ₇	75% RDF + 25% Vermicompost + Consortium Biofertilizer + Micronutrients (ZnSO_4 + Boric acid)	32.40	16.67	102.45	13.95
T ₈	50% RDF + 50% Vermicompost + Consortium Biofertilizer + Micronutrients (ZnSO_4 + Boric acid)	28.99	14.64	98.79	13.40
C.D		1.69	0.81	6.58	0.89
S.Ed		0.78	0.37	3.04	0.41

This treatment was followed by 50% RDF + 50% vermicompost + consortium biofertilizer + micronutrients, which recorded plant height of 28.99 cm, 14.64 cladodes plant⁻¹, cladode length of 98.79 cm and cladode diameter of 13.40 cm. The lowest values for all the growth parameters were observed in the control treatment, which recorded plant height of 15.13 cm, 6.43 cladodes plant⁻¹, cladode length of 83.97 cm and cladode diameter of 11.19 cm.

Plant height is an important indicator of vegetative growth and reflects the plant's ability to efficiently utilize available nutrients. In the present study, increased plant height may be attributed to the combined application of RDF (NPK), vermicompost, microbial consortium and micronutrients, which improved nutrient availability and soil biological activity. Nitrogen promotes vegetative growth through enhanced chlorophyll formation and photosynthetic activity,

while phosphorus improves root development and energy transfer in plant cells and Vermicompost improves soil structure, microbial activity and nutrient mineralization processes, leading to better nutrient uptake (Sharvesh *et al.* 2026) [22]. The microbial consortium consisting of nitrogen fixing bacteria and phosphorus solubilizing bacteria also enhances nutrient availability in the rhizosphere. Similar findings were reported in dragon fruit by Kumar *et al.* (2019) [6], who observed increased plant height with integrated nutrient management. Rawat *et al.* (2022) [17] also reported improved vegetative growth in red dragon fruit (*Hylocereus costaricensis*) under combined application of fertilizers and organic manures. Similar enhancement in plant height due to integrated nutrient application was reported in guava (*Psidium guajava*) by Dutta *et al.* (2009) [3] and in mango (*Mangifera indica*) by Yadav *et al.* (2011) [25] and Jawahar Srinith *et al.* (2025) [5] in guava.

The number of cladodes pole⁻¹ determines the photosynthetic surface area and directly influences the productivity of dragon fruit plants. Increased cladode production observed in the present study may be attributed to improved nutrient supply and enhanced metabolic activity resulting from integrated nutrient application. Nitrogen promotes vegetative growth and branching, while phosphorus enhances root growth and nutrient uptake. Vermicompost also improves soil microbial population and enzymatic activity, leading to increased vegetative growth and cladode formation (Sharvesh *et al.*, 2026) [21]. Similar results were reported in dragon fruit by Prajapati *et al.* (2021) [16], who observed a significant increase in vegetative segments with balanced nutrient supply. Rawat *et al.* (2022) [17] also reported increased cladode production in red dragon fruit with integrated nutrient management. Comparable findings were also reported in banana (*Musa spp.*) by Sabarad *et al.* (2004) [18], where the application of vermicompost and biofertilizers significantly enhanced vegetative growth.

Cladode length reflects the vigor and growth potential of dragon fruit plants. In the present study, increased cladode length may be attributed to improved nutrient availability and enhanced physiological activity resulting from integrated nutrient application. Nitrogen promotes cell

division and elongation, while phosphorus and potassium improve metabolic activity and carbohydrate translocation (Muruganandam *et al.*, 2025) [13]. Vermicompost also improves soil aeration and moisture retention, which supports root growth and nutrient absorption. Similar results were reported in dragon fruit (*Hylocereus costaricensis*) by Samant *et al.* (2023) [19], who observed increased cladode length under adequate fertilizer application. Rawat *et al.* (2022) [17] also reported enhanced cladode growth in red dragon fruit with combined organic and inorganic nutrient sources.

Cladode diameter is associated with structural strength and physiological activity of the plant. Increased cladode thickness observed in the present study may be attributed to better nutrient uptake and improved accumulation of photosynthates in vegetative tissues (Sharvesh *et al.*, 2025) [23]. Potassium plays a crucial role in carbohydrate translocation and enzyme activation, which promotes the development of thicker cladodes. Vermicompost and microbial inoculants enhance soil microbial activity and nutrient availability, resulting in improved vegetative growth. Similar observations were reported in dragon fruit by Chauhan *et al.* (2024) [1], who observed increased cladode thickness with organic manure and biofertilizer application. Similar improvements in shoot diameter were also reported in guava (*Psidium guajava*) by Godage *et al.* (2013) [4] and Sharvesh *et al.* (2026) [22] in avocado.

The flowering parameters of dragon fruit were significantly influenced by the different nutrient management treatments (Table 2). Among the treatments, the application of 75% RDF + 25% vermicompost + consortium biofertilizer + micronutrients (ZnSO₄ + boric acid) recorded the maximum number of days to bud initiation (202.15 days) and days to first flowering (221.15 days). This treatment also produced the highest number of flowers plant⁻¹ (68.45). It was followed by 50% RDF + 50% vermicompost + consortium biofertilizer + micronutrients, which recorded 209.43 days for bud initiation, 228.43 days for first flowering and 63.87 flowers plant⁻¹. The control treatment recorded the minimum number of days to bud initiation (238.91 days) and days to first flowering (257.91 days), along with the lowest number of flowers plant⁻¹ (45.33).

Table 2: Effect of INM on flowering parameters of dragon fruit cv. Ciyam Red C

Treatment details		Days to bud initiation	Days to first flowering	No of flowers plant ⁻¹
T ₁	Control	238.91	257.91	45.33
T ₂	100% RDF	231.03	250.03	50.29
T ₃	75% RDF + 25% Vermicompost	232.11	251.11	49.61
T ₄	50% RDF + 50% Vermicompost	216.95	235.95	59.14
T ₅	75% RDF + 25% Vermicompost + Consortium Biofertilizer	223.27	242.27	55.17
T ₆	50% RDF + 50% Vermicompost + Consortium Biofertilizer	216.29	235.29	59.56
T ₇	75% RDF + 25% Vermicompost + Consortium Biofertilizer + Micronutrients (ZnSO ₄ + Boric acid)	202.15	221.15	68.45
T ₈	50% RDF + 50% Vermicompost + Consortium Biofertilizer + Micronutrients (ZnSO ₄ + Boric acid)	209.43	228.43	63.87
C.D		15.68	17.03	4.00
S.Ed		7.24	7.86	1.85

Days to first flowering is an important phenological parameter indicating the transition from vegetative to reproductive growth. In the present study, integrated nutrient management reduced the number of days required for flowering. Adequate nutrient supply enhances carbohydrate accumulation and promotes synthesis of plant

growth regulators involved in floral initiation (Madhavan *et al.*, 2025a and Sathappan *et al.*, 2025 in papaya) [7, 21]. Nitrogen improves vegetative growth while phosphorus plays a key role in flower bud differentiation. Similar results were reported in dragon fruit by Perween and Hasan (2018) [15], who observed earlier flowering with balanced fertilizer

application. Siddiqua *et al.* (2024) ^[24] also reported reduced days to flowering in dragon fruit with integrated nutrient management practices.

Flower and bud production is closely associated with plant nutrition and vegetative growth. In the present investigation, increased number of flowers pole⁻¹ may be attributed to improved nutrient uptake and enhanced carbohydrate accumulation resulting from integrated nutrient management (Madhavan *et al.*, 2025b) ^[8]. Biofertilizers improve nutrient availability and stimulate plant growth regulators which enhance floral initiation and development. Similar findings were reported in dragon fruit (*Hylocereus undatus*) by Chauhan *et al.* (2024) ^[1], who observed increased flowering with organic manure and biofertilizer application. Comparable results were reported in mango (*Mangifera indica*) by Yadav *et al.* (2011) ^[25] and in guava (*Psidium guajava*) by Dheware and Waghmare (2009) ^[2] and Sathappan *et al.* (2024) ^[20] in papaya

Conclusion

The integrated nutrient management treatment that produced the best growth and flowering response consisted of the application of Recommended Dose of Fertilizers (RDF) at 450:350:300 g N:P:K pole⁻¹, along with vermicompost, consortium biofertilizer at 100 ml pole⁻¹ and micronutrient spray of ZnSO₄ at 0.5% and boric acid at 0.2%. The combined application of inorganic fertilizers, organic manure, beneficial microbial consortium and micronutrients improved nutrient availability, enhanced soil microbial activity and promoted efficient nutrient uptake by the plants. This integrated approach resulted in improved vegetative growth, increased cladode development and enhanced flowering performance of dragon fruit indicating the effectiveness of balanced nutrient management for sustainable crop production.

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Conflict of Interests

The authors declare that there is no conflict of interest.

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