

International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
 ISSN Online: 2617-4707
 NAAS Rating (2026): 5.29
 Indexing: Embase
 IJABR 2026; SP-10(9): 2093-2099
www.biochemjournal.com
 Received: 10-07-2026
 Accepted: 20-08-2026
 Published: 23-09-2026

Nisha R Thorat

Ph.D. Scholar, Department of
 Vegetable Science, Dr. PDKV,
 Akola, Maharashtra 444104,
 India

A.P Wagh

Professor, Department of
 Vegetable Science, Dr. PDKV,
 Akola, Maharashtra 444104,
 India

A.M Sonkamble

Professor and Head,
 Department of Vegetable
 Science, Dr. PDKV, Akola,
 Maharashtra 444104, India

V.S Kale

Professor, Department of
 Vegetable Science, Dr. PDKV,
 Akola, Maharashtra 444104,
 India

Suchita V Gupta

Professor and Head,
 Department of Farm Structure,
 COAE, Dr. PDKV, Akola,
 Maharashtra 444104, India

S.D Jadhao

Professor and Head,
 Department of Soil Science
 and Agril. Chemistry, Dr.
 PDKV, Akola, Maharashtra
 444104, India

**Corresponding Author:
Nisha R Thorat**

Ph.D. Scholar, Department
 of Vegetable Science, Dr.
 PDKV, Akola, Maharashtra
 444104, India

Growth dynamics and developmental response of cucumber to graded NPK fertigation under naturally ventilated polyhouse conditions

Nisha R Thorat¹, A.P Wagh², A.M Sonkamble³, V.S Kale⁴, Suchita V Gupta⁵, S.D Jadhao⁶

DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i9Sz.10118>

ABSTRACT

A two-year investigation was conducted during rabi 2024–25 and 2025–26 to evaluate the growth dynamics and flowering response of parthenocarpic cucumber (*Cucumis sativus* L.) to graded NPK fertigation under naturally ventilated polyhouse conditions. Nine NPK combinations, viz., 100:50:50 to 200:100:200 kg N:P:K ha⁻¹, were evaluated in a randomized block design with three replications. Fertigation was initiated five days after transplanting and applied at four-day intervals through 24 split applications using urea, phosphoric acid and sulphate of potash. Growth observations were recorded at 15, 30, 45, 60, 75 and 90 days after transplanting (DAT). Treatment effects were non-significant during the initial establishment phase but became significant from 30 DAT onwards. Among the treatments, 150:75:150 kg N:P:K ha⁻¹ (T_6) consistently recorded superior growth, attaining maximum pooled vine length (199.97 cm), branches (21.55 vine⁻¹) and leaves (70.35 vine⁻¹) at 90 DAT. T_6 also induced earlier first flowering (29.00 days), 50% flowering (35.00 days) and maximum female flowers (31.00 vine⁻¹). The results indicated that balanced NPK fertigation promoted sustained vegetative growth and coordinated reproductive development. Thus, 150:75:150 kg N:P:K ha⁻¹ was identified as the most effective treatment under the experimental conditions.

Keywords: *Cucumis sativus* L., NPK fertigation, Growth dynamics, Vine length, Branching, Leaf production, Flowering, Parthenocarpic cucumber, Naturally ventilated polyhouse, Protected cultivation

1. Introduction

Vegetable farming holds a significant place in Indian agriculture since it contributes to food and nutritional security, boosts farm income, creates employment and helps to diversify agricultural output. It offers the possibility of higher returns per unit area and per unit of time, along with a good opportunity to improve the living standards of small and marginal farmers because of the labor it requires and its suitability for intensive cultivation. The growing demand for high-quality vegetables in both domestic and international markets makes it all the more necessary to increase productivity by means of better production technologies and efficient resource management. Before independence India's vegetable production was thought to be less than 20 million tones and has since increased considerably over the following decades. As the population grows, urbanization takes place and there is greater awareness of the need for healthy diets, demand for vegetables is expected to rise even further (Mengel *et al.*, 2001) [1].

The NITI Aayog Working Group on the Demand and Supply of Crops and Livestock Products and Agricultural Inputs states that the average vegetable productivity in India was 18.37 t ha⁻¹ in 2019-20 and is expected to reach 25.04 t ha⁻¹ by 2047-48 under the business-as-usual scenario, thus underscoring the need to continuously improve productivity through the use of efficient production technologies and careful resource management (NITI Aayog, 2024) [2]. Among vegetable crops, cucumber (*Cucumis sativus* L.) is an important economic crop in the Cucurbitaceae family and is widely grown for fresh eating. It is valued for its high-water content, low caloric value and nutritional qualities and has considerable commercial value because of its short growing period and constant market demand. In 2023–24, cucumber production in India was about 18.06 lakh tones from around 1.03 lakh hectares, giving an average productivity of about 17.50 t ha⁻¹ (National Horticulture Board, 2024) [3]. The crop is also seen as appropriate for intensive and protected production systems due to its fast growth and high productivity potential (Singh *et al.*, 2017; Singh *et al.*, 2018) [4, 5].

Cucumber hybrids that are gynoeccious and parthenocarpic are especially well suited to cultivation in protected environments since they are capable of producing seedless fruits without the need for pollination. Polyhouses with natural ventilation create a growing environment that has been only partly altered, allowing for better control of temperature, relative humidity, irrigation and the supply of nutrients than is possible in

open field conditions. Protected cultivation thus has great potential for off-season production, greater productivity and better fruit quality (Sharma *et al.*, 2011) [6]. It has already been shown in earlier studies that the performance of cucumbers under protected conditions is greatly affected by the growing medium, irrigation, fertigation, the microclimate and the availability of nutrients.

Cucumber is a crop that thrives in warm seasons and does so best at a temperature of about 18 to 34 °C; it can be grown on a wide variety of well-drained soils, although loam and clay-loam soils are especially appropriate for good growth. In India the crop is grown in a number of states, such as West Bengal, Haryana, Madhya Pradesh, Karnataka, Andhra Pradesh, Uttar Pradesh, Punjab, Assam, Telangana and Maharashtra. For the 2023–24 horticultural estimates, Maharashtra produced around 65.37 thousand tonnes of cucumber on 5.38 thousand hectares, the yield being approximately 12.40 t ha⁻¹ (NHB, 2024). The relatively low level of productivity shows that there is room for improvement by means of suitable varieties, protected cultivation and more efficient management of water and nutrients.

Nutrient management is especially important in the case of cucumber since it has a fast vegetative growth and produces fruit continuously. Nitrogen, phosphorus and potassium are fundamental for vegetative development, for root growth, for flowering, for fruit development and for yield formation. On the other hand, applying fertilizers in an unbalanced or excessive manner may raise production costs and lead to nutrient losses and environmental problems, while insufficient nutrient availability can hinder crop growth and yield. Fertigation offers an effective method of supplying nutrients directly to the root zone through the use of irrigation water, thus improving the match between the availability of nutrients and the crop's demand. Research carried out under protected cultivation has shown that fertigation management can have a substantial effect on cucumber growth, yield, fruit quality and nutrient-use efficiency (Sharma *et al.*, 2011) [6].

The efficiency of fertigation is not just a function of the total amount of nutrients provided, but also depends on the concentration, how often the applications are made and when they take place. Singh *et al.* (2018) [5] found that the level of fertigation had a significant effect on cucumber yield and on the efficiency with which nutrients were used in a greenhouse environment that was only partly controlled, while Li (2019) [7] showed that optimized irrigation combined with nitrogen fertigation increased cucumber yield, quality and efficiency in the use of both water and nitrogen. More recently, Babal *et al.* (2024) [8] stated that irrigation and fertigation practices had significant effects on cucumber growth and productivity in protected conditions. A lot of research has been carried out concerning the production of protected cucumbers, but there is still very little information available on the reaction of parthenocarpic cucumbers to gradually increasing NPK fertigation levels under naturally ventilated polyhouse conditions, especially in the agro-climatic conditions of Maharashtra. Furthermore, it is necessary to adjust the supply of nutrients in accordance with the needs of the crop if a balance is to be achieved between productivity, fruit quality, nutrient-use efficiency and economic returns. That is why the present study was carried out to assess the effect of different NPK fertigation levels on the growth, yield and quality of cucumbers under naturally ventilated polyhouse conditions and to establish an efficient nutrient-management strategy aimed at increasing productivity and profitability (Anjanappa *et al.*, 2012; Al-Rubaie *et al.*, 2025) [9, 10].

2. Materials and methods

2.1 Experimental site

The investigation was conducted during rabi seasons 2024-25 and 2025-26 at the Instructional Farm, Department of Vegetable Science, College of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, under naturally ventilated polyhouse conditions.

2.2 Treatments and fertigation schedule

Nine graded NPK fertigation treatments were evaluated to study the growth and developmental response of parthenocarpic cucumber under naturally ventilated polyhouse conditions. The treatments comprised different combinations of nitrogen (N), phosphorus (P) and potassium (K) levels to assess the response of cucumber to increasing nutrient supply and different N:P balances.

The nine treatments were T₁ = 100:50:50, T₂ = 100:50:75, T₃ = 100:50:100, T₄ = 150:75:75, T₅ = 150:75:100, T₆ = 150:75:150, T₇ = 200:100:100, T₈ = 200:100:150 and T₉ = 200:100:200 kg N:P:K ha⁻¹. Among the treatments, T₆ (150:75:150 kg N:P:K ha⁻¹) represented an intermediate N and P supply combined with a comparatively higher K level, whereas T₉ (200:100:200 kg N:P:K ha⁻¹) represented the highest overall NPK combination evaluated.

The fertilizers were applied via the drip irrigation system, using water-soluble fertilizer sources such as urea as the main source of nitrogen, phosphoric acid as the source of phosphorus and sulphate of potash (SOP) as the source of potassium. The amounts of each individual fertilizer needed were determined on the basis of the respective NPK treatment and then applied by means of the fertigation system. Fertigation began five days after the plants were transplanted and was then carried out every four days, which meant that there were 20 split fertigation applications in total throughout the crop period. The amount of nitrogen, phosphorus and potassium specified for each treatment was delivered through these split applications so as to ensure a steady supply of nutrients in the active root zone. All the treatments followed the same fertigation schedule and method of irrigation, although the amounts and combination of nutrients differed depending on the treatment.

The experiment included nine NPK fertigation treatments, each of which was replicated three times, giving a total of 27 experimental plots. Apart from the NPK fertigation, all the other cultural practices - such as transplanting, irrigation, training, plant protection and inter-cultural operations-remained the same throughout the different treatments. Hence, the main variable in the experiment was the combination of NPK fertigation, enabling an evaluation of its effect on the various stages of vegetative growth and reproductive development.

2.3 Growth observations

Growth observations were taken at 15, 30, 45, 60, 75 and 90 DAT (days after transplanting). Vine length (cm), number of branches per vine and number of leaves per vine were measured. Flowering was evaluated in terms of days to first flower, days to 50% flowering and number of female flowers per vine. All measurements were done consistently across the trial period.

2.4 Stage-wise increment

In order to describe the progress over time, the stage-wise increment was calculated from the treatment means:

- Increment = value at later stage – value at earlier stage

The increments are used as descriptive values to indicate the amount of change between two subsequent measurements and are not considered as additional independent observations.

3. Results and discussion

3.1 Temporal dynamics of vine length

The response of cucumber vine length to NPK fertigation differed considerably with crop age. At 15 DAT, differences among treatments were statistically non-significant in both years and in pooled analysis. However, from 30 DAT onwards, the influence of NPK treatments became significant and hence, treatment differentiation became apparent as the crop entered active vegetative development. In pooled analysis, the vine length at 15 DAT ranged from 24.60 cm in T₅ (150:75:100 Kg ha⁻¹) to 29.56 cm in T₂ (100:50:75 Kg ha⁻¹). Treatment effects were not significant. However, at 30 DAT, T₆ (150:75:150 Kg ha⁻¹) recorded the maximum vine length of 75.54 cm, statistically at par

with T_8 (200:100:150 Kg ha⁻¹) (75.03 cm), T_7 (200:100:100 Kg ha⁻¹) (74.94 cm) and T_9 (200:100:200 Kg ha⁻¹) (74.84 cm), whereas T_1 (100:50:50 Kg ha⁻¹) recorded the minimum vine length of 61.42 cm. At 45 DAT, T_6 (150:75:150 Kg ha⁻¹) was still superior with a vine length of 99.22 cm with T_7 (200:100:100 Kg ha⁻¹) recording 97.81 cm compared with 85.18 cm in T_1 (100:50:50 Kg ha⁻¹). At 60 DAT, T_6 (150:75:150 Kg ha⁻¹) recorded 129.35 cm whereas it was statistically comparable with T_7 (200:100:100 Kg ha⁻¹), T_8 (200:100:150 Kg ha⁻¹) and T_5 (150:75:100 Kg ha⁻¹). At 75

DAT, T_6 (150:75:150 Kg ha⁻¹) recorded 159.25 cm compared with 132.55 cm in T_1 (100:50:50 Kg ha⁻¹). Finally, at 90 DAT, T_6 (150:75:150 Kg ha⁻¹) produced the maximum pooled vine length of 199.97 cm whereas T_1 (100:50:50 Kg ha⁻¹) recorded 170.27 cm. The superiority of T_6 (150:75:150 Kg ha⁻¹) was therefore not confined to the final observation. It was consistent from 30 DAT and persisted to 90 DAT. Similar findings were reported by *Surve et al. (2002)* [11] and *Kumari et al. (2020)* [12].

Table 1. Effect of graded NPK fertigation on pooled vine length of cucumber

Treatments	15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT
T_1 100:50:50	26.92	61.42	85.18	117.73	132.55	170.27
T_2 100:50:75	29.56	63.38	86.79	118.95	135.40	172.13
T_3 100:50:100	26.38	65.62	87.63	120.73	137.84	176.49
T_4 150:75:75	28.64	68.17	92.34	123.63	146.10	184.10
T_5 150:75:100	24.60	72.41	94.08	125.28	149.94	190.01
T_6 150:75:150	24.72	75.54	99.22	129.35	159.25	199.97
T_7 200:100:100	25.78	74.94	97.81	127.82	155.50	192.92
T_8 200:100:150	27.95	75.03	95.47	125.91	154.42	192.27
T_9 200:100:200	26.73	74.84	91.14	120.77	146.94	180.38
'F' test	NS	Sig	Sig	Sig	Sig	Sig
SE (m) ±	0.19	0.45	0.63	1.62	1.98	1.68
CD at 5%	----	1.35	1.88	4.86	5.94	5.04

3.2 Stage-wise increment in vine length

The stage-wise analysis gives a more informative picture of the developmental trajectory.

Table 2. Derived stage-wise increment in pooled vine length

Treatments	15 - 30	30 - 45	45 - 60	60 - 75	75 - 90
T_1 100:50:50	34.50	23.76	32.55	14.82	37.72
T_2 100:50:75	33.82	23.41	32.16	16.45	36.73
T_3 100:50:100	39.24	22.01	33.10	17.11	38.65
T_4 150:75:75	39.53	24.17	31.29	22.47	38.00
T_5 150:75:100	47.81	21.67	31.20	24.66	40.07
T_6 150:75:150	50.82	23.68	30.13	29.90	40.72
T_7 200:100:100	49.16	22.87	30.01	27.68	37.42
T_8 200:100:150	47.08	20.44	30.44	28.51	37.85
T_9 200:100:200	48.11	16.30	29.63	26.17	33.44

The biggest increment under T_6 was recorded between 15 and 30 DAT (50.82 cm). This implies that the stage is very critical for rapid vine elongation. T_6 also registered relatively high increments in the periods 60-75 DAT and 75-90 DAT, suggesting that the canopy was also expanding. The dynamic pattern is very interesting since the superiority of T_6 (150:75:150 Kg ha⁻¹) was not determined by a single outlier. Instead, the treatment sustained a relatively good growth curve. The growth from 15 to 90 DAT in T_6 (150:75:150 Kg ha⁻¹) was 175.25 cm against 143.35 cm in T_1 (100:50:50 Kg ha⁻¹). Thus, the difference between the two treatments became more evident as the crop developed. This response can be related to the synergistic effect of balanced nutrients as provided in T_6 (150:75:150 Kg ha⁻¹). The original thesis related nitrogen to chlorophyll, amino-acids, proteins and vegetative growth; phosphorus to root proliferation and energy transfer; and potassium to stomatal regulation, enzyme activation and assimilate translocation. Importantly, the response was not linear. Hence, despite receiving the highest NPK dose, T_9 (200:100:200 Kg ha⁻¹) registered 180.38 cm at 90 DAT against 199.97 cm for T_6

(150:75:150 Kg ha⁻¹). This suggests that the cucumber growth was responsive to optimum nutrition and not just quantity of nutrients.

3.3 Branch development

The number of branches per vine followed a pattern similar to vine elongation. Treatment effects were non-significant at 15 DAT but became significant from 30 DAT onward. In pooled analysis, T_6 (150:75:150 Kg ha⁻¹) recorded the maximum number of branches at 30 DAT (7.25), 45 DAT (11.21), 60 DAT (16.73), 75 DAT (18.02) and 90 DAT (21.55). T_1 (100:50:50 Kg ha⁻¹) consistently recorded the minimum values. At 90 DAT, T_6 (150:75:150 Kg ha⁻¹) gave 21.55 branches vine⁻¹ which is nearly twice the value recorded for T_1 (100:50:50 Kg ha⁻¹) (11.11). Indeed, a 93.97% increase was calculated. This large response in branching is biologically important, as branching contributes to the expansion of the photosynthetically active canopy. The original discussion attributes the enhanced branching to improved availability of N, P and K increased metabolic activity, photosynthesis, protein synthesis and assimilate translocation. The present findings are consistent with the observations of *Tekale et al. (2014)* [13] and *Arinderpal et al. (2019)* [14].

Table 3. Effect of NPK fertigation on pooled branches per vine

Treatments	15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT
T ₁ 100:50:50	1.70	3.23	5.06	7.57	9.02	11.11
T ₂ 100:50:75	1.38	4.07	6.71	9.83	11.09	13.98
T ₃ 100:50:100	1.97	4.59	7.77	10.76	12.54	14.93
T ₄ 150:75:75	1.80	5.56	9.05	12.16	13.88	17.20
T ₅ 150:75:100	1.78	6.46	9.51	14.25	16.05	18.84
T ₆ 150:75:150	1.33	7.25	11.21	16.73	18.02	21.55
T ₇ 200:100:100	1.66	7.02	10.54	15.50	17.07	20.09
T ₈ 200:100:150	1.90	6.65	10.03	14.58	16.32	19.20
T ₉ 200:100:200	1.88	6.25	9.66	13.82	14.17	16.92
'F' test	NS	Sig	Sig	Sig	Sig	Sig
SE (m) ±	0.18	0.36	0.71	0.63	0.58	0.65
CD at 5%	----	1.08	2.14	1.89	1.74	1.95

3.4 Stage-wise increment in branching

Table 4. Derived stage-wise increment in branches per vine

Treatments	15 - 30	30 - 45	45 - 60	60 - 75	75 - 90
T ₁ 100:50:50	1.53	1.83	2.51	1.45	2.09
T ₂ 100:50:75	2.69	2.64	3.12	1.26	2.89
T ₃ 100:50:100	2.62	3.18	2.99	1.78	2.39
T ₄ 150:75:75	3.76	3.49	3.11	1.72	3.32
T ₅ 150:75:100	4.68	3.05	4.74	1.80	2.79
T ₆ 150:75:150	5.92	3.96	5.52	1.29	3.53
T ₇ 200:100:100	5.36	3.52	4.96	1.57	3.02
T ₈ 200:100:150	4.75	3.38	4.55	1.74	2.88
T ₉ 200:100:200	4.37	3.41	4.16	0.35	2.75

The largest increase under T₆ (150: 75: 150 Kg ha⁻¹) was during 15-30 DAT followed by another large increase during 45-60 DAT. This is an indication of two major periods of lateral development. The relatively smaller increment under T₉ (200: 100: 200 Kg ha⁻¹) during 60-75 DAT is of particular interest. While T₉ (200: 100: 200 Kg ha⁻¹) re-

ceived more nutrients than T₆ (150: 75: 150 Kg ha⁻¹), it was not able to maintain the same rate of branch accumulation as T₆ (150: 75: 150 Kg ha⁻¹) during this period. This is additional evidence that an optimum has been reached.

3.5 Leaf development

Table 5. Effect of NPK fertigation on pooled number of leaves per vine

Treatments	15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT
T ₁ 100:50:50	7.57	11.61	16.81	24.69	37.11	50.61
T ₂ 100:50:75	6.30	12.27	17.39	27.00	38.42	53.36
T ₃ 100:50:100	6.02	12.39	18.16	28.31	40.86	57.11
T ₄ 150:75:75	5.95	12.81	19.37	29.14	43.19	61.16
T ₅ 150:75:100	6.83	15.22	20.63	30.22	45.78	65.59
T ₆ 150:75:150	6.17	18.06	24.36	35.39	50.82	70.35
T ₇ 200:100:100	6.94	16.99	21.83	33.00	48.51	67.88
T ₈ 200:100:150	7.83	16.04	20.83	31.93	47.85	66.04
T ₉ 200:100:200	6.72	15.89	19.17	29.06	41.69	64.99
'F' test	NS	Sig	Sig	Sig	Sig	Sig
SE (m) ±	0.47	0.94	0.38	0.87	1.26	0.85
CD at 5%	----	2.82	1.15	2.61	3.78	2.55

Leaf production is one of the most critical indicators that show if the plant has successfully established a canopy. This is because leaves are the main photosynthetic surface of the plant. The pooled data did not show any significant treatment differences at 15 DAT; however, there were significant differences from 30 DAT. T₆ (150: 75: 150 Kg ha⁻¹) consistently produced the highest number of leaves throughout the experiment. At 90 DAT, T₆ (150: 75: 150 Kg ha⁻¹) produced 70.35

leaves vine⁻¹, compared with 50.61 in T₁ (100: 50: 50 Kg ha⁻¹). Thus, T₆ (150: 75: 150 Kg ha⁻¹) increased leaf number by 39.00%. The consistency among vine length, branching and leaf production is significant. Rather than increasing only one growth parameter, T₆ (150: 75: 150 Kg ha⁻¹) promoted several components of plant architecture simultaneously. Similar findings were reported by [Surve et al. \(2002\)](#) [11] and [Feleafel et al. \(2014\)](#) [15].

3.6 Stage-wise increment in leaves

Table 6. Derived stage-wise increment in leaves per vine

Treatments	15 - 30	30 - 45	45 - 60	60 - 75	75 - 90
T ₁ 100:50:50	4.20	5.04	7.88	12.42	13.50
T ₂ 100:50:75	5.97	5.12	9.61	11.42	14.94
T ₃ 100:50:100	6.37	5.77	10.15	12.55	16.25
T ₄ 150:75:75	6.85	6.57	9.77	14.05	17.97
T ₅ 150:75:100	8.39	5.41	9.59	15.56	19.81
T ₆ 150:75:150	11.89	6.30	11.03	15.43	19.53
T ₇ 200:100:100	10.05	4.84	11.17	15.51	19.37
T ₈ 200:100:150	8.21	4.79	11.10	15.92	18.19
T ₉ 200:100:200	9.17	3.28	9.89	12.63	23.30

T₆ (150: 75: 150 Kg ha⁻¹) increased most rapidly in terms of leaf number in the interval 15-30 DAT (11.89 leaves vine⁻¹). The treatment also recorded high leaf numbers throughout the rest of the observation period and maintained the trend. The large early increase implied that nutrients were adequate to encourage rapid canopy development after establishment. The maintenance of growth at later stages demonstrated that the treatment also sustained canopy growth. Thus, it was not only effective at the onset but throughout the growth period.

3.7 Flowering transition

The vegetative response was associated with considerable variation in reproductive development. The treatment T₆ (150: 75: 150 Kg ha⁻¹) took 29.00 days to attain the first flower, while the treatment T₁ (100:

50: 50 Kg ha⁻¹) took 39.50 days to reach the same stage. This suggests that the duration needed for the first flower in T₆ (150: 75: 150 Kg ha⁻¹) is lesser by 26.58%. In addition, the treatment T₆ (150: 75: 150 Kg ha⁻¹) attained 50% flowering in 35.00 days, while the same was achieved in 48.67 days for the treatment T₁ (100: 50: 50 Kg ha⁻¹), implying a 28.08% decrease in the former. This analysis is critical since it demonstrates that the treatment which showed tremendous vegetative advancement did not compromise the flowering period, instead, it hastened the process. As a result, it can be concluded that the treatment T₆ (150: 75: 150 Kg ha⁻¹) promotes an accelerated transition from canopy development to reproductive maturity. Similar findings were reported by Kaur *et al.* (2019) [16], Kumar *et al.* (2020) [17] Kumari *et al.* (2020) [12].

Table 7. Flowering response under graded NPK fertigation (Pooled data)

Treatments	First flower initiation (Days)	Days to 50 % flowering	Number of female flowers per vine
T ₁ 100:50:50	39.50	48.67	23.93
T ₂ 100:50:75	38.00	47.00	24.08
T ₃ 100:50:100	36.83	45.50	25.45
T ₄ 150:75:75	32.16	39.17	28.38
T ₅ 150:75:100	31.33	37.17	29.53
T ₆ 150:75:150	29.00	35.00	31.00
T ₇ 200:100:100	34.00	41.17	30.37
T ₈ 200:100:150	34.50	42.00	28.48
T ₉ 200:100:200	35.16	43.00	27.36
'F' test	Sig	Sig	Sig
SE (m) ±	0.45	0.45	0.34
CD at 5%	1.34	1.35	1.01

3.8 Female flower production

T₆ (150: 75: 150 Kg ha⁻¹) produced the greatest numbers of female flowers in both pooled analysis (31.00 flowers vine⁻¹) and individual years, followed by T₇ (200: 100: 100 Kg ha⁻¹) (30.37). T₁ (100: 50: 50 Kg ha⁻¹) produced the least number of female flowers (23.93 flowers vine⁻¹). The effect of treatment was significant in both years and in the pooled analysis. **The calculated increase of T₆ (150: 75: 150 Kg ha⁻¹) over T₁ (100: 50: 50 Kg ha⁻¹) was 29.54%.** The increased production of leaves, branches and female flowers associated

with an earlier flowering in T₆ (150: 75: 150 Kg ha⁻¹) suggested that a more favorable developmental balance was achieved with this treatment. Thakur *et al.* (2024) [18] reported number of fruits increased with the increment of potassium in cucumber.

3.9 Optimum NPK versus excessive nutrient supply

One of the most surprising findings coming out of the dataset is the absence of a simple positive linear relationship between fertilizer dose and vegetative growth. T₆ provided 150:75:150 kg N: P: K ha⁻¹, yet T₉ provided 200:100:200 kg ha⁻¹. Nevertheless, at 90 DAT:

Parameter	T ₆	T ₉	Advantage of T ₆
Vine length (cm)	199.97	180.38	+19.59 cm
Branches vine ⁻¹	21.55	16.92	+4.63
Leaves vine ⁻¹	70.35	64.99	+5.36
Female flowers vine ⁻¹	31.00	27.36	+3.64
First flowering (days)	29.00	35.16	6.16 days earlier
50% flowering (days)	35.00	43.00	8.00 days earlier

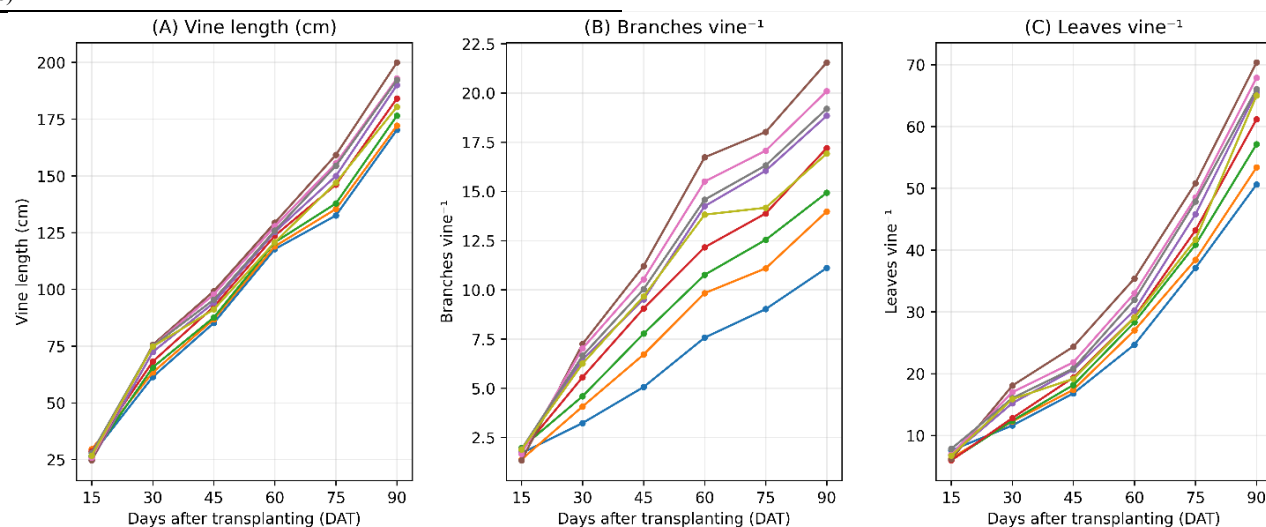


Figure 1. Growth response of cucumber to graded NPK fertigation

This pattern suggests that increased fertilizer application did not necessarily lead to improved crop development. The reduction observed under T₉ (200: 100: 200 Kg ha⁻¹) may be attributed to an imbalance or decreased efficiency in nutrient utilization at the higher nutrient concentration. Due to the absence of direct measurements of nutrient uptake, tissue nutrient content or physiological stress levels in the current experiment, the mechanism should be cautiously described. therefore, that T₆ (150: 75: 150 Kg ha⁻¹) represented the optimum tested NPK combination under the experimental conditions, rather than claiming that T₆ (150: 75: 150 Kg ha⁻¹) was universally optimum for all polyhouse cucumber systems.

Conclusion

On the basis of results summarized above, it can be concluded that out of different treatments evaluated application of T₆ (150: 75: 150 kg ha⁻¹) gave best results with respect to growth and flowering attributing traits for both the years. Fertigation has improved fruit growth particularly the treatment T₆ (150: 75: 150 kg ha⁻¹). Thus, it can be recommended for enhancing growth and early flowering in cucumber under polyhouse conditions.

References

- Mengel K, Kirkby EA. Principles of plant nutrition (5th ed.). Kluwer Academic Publishers; 2001.
- NITI Aayog. Report of the Working Group on Demand and Supply of Crops and Livestock Products and Agricultural Inputs for 2025–26, 2030–31, 2035–36, 2040–41 and 2047–48. Government of India; 2024.
- National Horticulture Board. Final estimates of area and production of horticultural crops: 2023–24. Ministry of Agriculture and Farmers Welfare, Government of India; 2024.
- Singh MC, Singh JP, Pandey SK, Mahay D, Shrivastva V. Factors affecting the performance of greenhouse cucumber cultivation—A review. *International Journal of Current Microbiology and Applied Sciences*. 2017;6(10):2304–2323.
- Singh MC, Singh KG, Singh JP. Performance of soilless cucumbers under partially controlled greenhouse environment in relation to deficit fertigation. *Indian Journal of Horticulture*. 2018;75(2):259–264.
- Sharma MK, Negi S, Kumari S. Effect of different growing media and fertigation levels on production of cucumber (*Cucumis sativus*) under protected conditions in the hills. *The Indian Journal of Agricultural Sciences*. 2011;79(11).
- Li Y. Optimal drip fertigation management improves yield, quality, water and nitrogen use efficiency of greenhouse cucumber. *Scientia Horticulturae*. 2019;243:357–366.
- Babal B, Sandal SK, Sankhyan NK, Priksit. Impact of different irrigation and fertigation practices on the growth and productivity of cucumber (*Cucumis sativus* L.) under protected environment. *International Journal of Plant & Soil Science*. 2024;36(2):275–281.
- Anjanappa M, Venkatesha J, Kumara BS. Growth, yield and quality attributes of cucumber (Cv. Hassan local) as influenced by integrated nutrient management grown under protected condition. *Vegetable Science*. 2012;39(1):47–50.
- Al-Rubaie OAF, Mawlood GM, Asr OJ, Najm MR, Saadi AM. The effect of organic and chemical fertilization on the growth and yield of cucumbers (*Cucumis sativus* L.) under protected cultivation conditions: Comprehensive review. *Pharaonic Journal of Science*. 2025;1(2):169–183.
- Surve US, Shinde SH, Dusane SM. Efficacy of liquid fertilizer through drip irrigation on growth and yield of cucumber (Cv. Himangi). *Agriculture science Digest*. 2002;22(4):228–231.
- Kumari S, Paramveer S, Sharma RK. Effect of fertigation levels and spacing on growth and yield of cucumber (*Cucumis sativus* L.) cv. KPCH-1 grown under polyhouse. *International Journal of Chemical Studies*. 2020;8:1065–1070.

13. Tekale CD, Tumbare AD, Tekale GS, Danawale NJ, Tambe ST. Effect of different fertigation levels and schedules on growth and yield of cucumber under polyhouse condition. *International Journal of Current Research*. 2014;6(7):7353-7355.
14. Arinderpal K, Raturi HC, Kachwaya DS, Singh SK, Singh T. Effect of fertigation on growth and fruit yield of cucumber (*Cucumis sativus* L.) grown under open ventilated polyhouse condition. *J. of Pharmacognosy and Phytochemistry*. 2019;1:202-204.
15. Feleafel MN, Mirdad ZM, Hassan AS. Effect of NPK Fertigation Rate and Starter Fertilizer on the Growth and Yield of Cucumber Grown in Greenhouse. *Journal of Agricultural Science*. 2014;6(9):1916-9752.
16. Kaur A, Raturi HC, Kachwaya DS, Singh SK, Singh T. Effect of fertigation on growth and fruit yield of cucumber (*Cucumis sativus* L.) grown under open ventilated polyhouse condition. *Journal of Pharmacognosy and Phytochemistry*. 2019;1:202-204.
17. Kumar P, Ansari AM, Swapnil, Sinha A. Effect of fertigation on growth and fruit yield of cucumber (*Cucumis sativus* L.) grown under naturally ventilated polyhouse conditions. *Journal of Pharmacognosy and Phytochemistry*. 2020;9(6):124-126.
18. Thakur M, Jaswal R, Sandal SK. Standardization of drip-based fertigation scheduling in cucumber grown under protected conditions. *Journal of Soil and Water Conservation*. 2024;23(2).
19. Singh MC, Kachwaya DS, Kalsi K. Soilless cucumber cultivation under protective structures in relation to irrigation coupled fertigation management, economic viability and potential benefits-A review. *International Journal of Current Microbiology and Applied Sciences*. 2018;7(3):2451–2468.

How to cite this article: Thorat NR, Wagh AP, Sonkamble AM, Kale VS, Gupta SV, Jadhao SD. Growth dynamics and developmental response of cucumber to graded NPK fertigation under naturally ventilated polyhouse conditions. *International Journal of Advanced Biochemistry Research*. 2026;SP-10(9):2093-2099. doi: <https://www.doi.org/10.33545/26174693.2026.v10.i9Sz.10118>