

EFFECT OF INTEGRATED ORGANIC INORGANIC NUTRIENT MANAGEMENT ON VEGETATIVE GROWTH OF LOW-CHILLING APPLE (*MALUS × DOMESTICA* BORKH.) CV. HRMN-99 UNDER SUBTROPICAL CONDITIONS

Anurag Raj¹, Saket Mishra^{*2}, Sneha Sandilya³, Saurav Kumar⁴, Ravi Kumar Singh⁵, Jitendra Chaurasia⁶, Hemant Kumar⁷ and Rishant Shukla⁷

¹, 3, 4 & 5 Research Scholar, Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh 211007, India

²Associate Professor, Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh 211007, India

⁶ Research Scholar, College of Horticulture, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, India

⁷ Department of Fruit Science, Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya (U.P.)

^{*}Corresponding author's: Saket Mishra, E-mail id: mishrasaket1@gmail.com & ravi.singhknit@gmail.com

ABSTRACT

A field experiment was conducted during 2023-24 and 2024-25 to evaluate the effect of integrated nutrient management on the vegetative growth of apple (*Malus × domestica* Borkh.) cv. HRMN-99. The experiment comprised eleven treatments laid out in a randomized block design with three replications. Observations on plant height, plant spread, number of primary and secondary branches, stem girth, leaf area and leaf area index (LAI) were recorded at 30, 60, 90 and 120 days after treatment application, and the data were analysed for individual years and pooled over the two years. Treatment effects on plant height, plant spread and the number of primary and secondary branches were non-significant at 30 days, but became significant from 60 days onwards and persisted up to 120 days in both years and in the pooled data. Stem girth and leaf area were also significantly influenced by the treatments, whereas LAI did not differ significantly. Among the treatments, T₁₁ consistently recorded the best growth performance. At 120 days, it recorded the maximum plant height (3.94 m), plant spread (279.42 cm), number of primary branches (6.77), number of secondary branches (68.49), stem girth (31.48 cm) and leaf area (42.68 cm²) on a pooled basis. It was statistically at par with T₁₀ for most of these parameters. The minimum values were recorded under T₁ for all parameters (2.88 m, 211.90 cm, 5.41, 54.12, 23.17 cm and 36.93 cm², respectively). The results indicate that the integrated nutrient management practice followed in T₁₁ was the most effective in promoting vegetative growth of apple cv. HRMN-99.

KEYWORDS: Apple, HRMN-99, vegetative growth, low-chilling, subtropical, organic manures

INTRODUCTION

Apple (*Malus × domestica* Borkh.) belongs to the family Rosaceae and is one of the most widely cultivated temperate fruit crops in the world, valued both for its economic importance and its nutritional and therapeutic properties. Botanically an allopolyploid ($2n = 2x = 34$) pome fruit believed to have originated in Central Asia, apple has since spread across temperate regions of Europe, Asia and North America and today numbers several thousand cultivars grown for fresh consumption, processing and cider production (Kumar et al., 2026). Beyond its dietary role, the fruit is a rich source of dietary fibre, vitamins, minerals and phenolic antioxidants, and has been associated with several health benefits, which has sustained its position as one of the most economically significant fruit crops globally (Kumar et al., 2026). In India, apple cultivation is concentrated in the Himalayan states of Jammu and Kashmir, Himachal Pradesh and Uttarakhand, which together account for the bulk of the country's apple area and production and where favourable temperate climate and chilling conditions support high-quality fruiting (Kumar et al., 2026).

Despite this concentration in traditional hill regions, the requirement for adequate winter chilling has historically restricted apple cultivation to temperate tracts, limiting its expansion into the vast subtropical plains of the country. Conventional apple cultivars fail to break dormancy properly and show poor flowering and fruit set when chilling hours are inadequate, which is a major concern for diversifying apple cultivation into non-traditional, warmer regions (Choudhary et al., 2020; Pundir and Satpathy, 2024). The development of low-chilling cultivars such as HRMN-99, bred by Shri Hariman Sharma of Himachal Pradesh has addressed this constraint to a considerable extent, as the cultivar is self-pollinating, tolerant of high summer temperatures, and capable of satisfactory growth and fruiting under tropical and subtropical conditions where conventional cultivars cannot be grown (Choudhary et al., 2020; Pundir and Satpathy, 2024). However, successful

establishment of such cultivars under subtropical environments depends not only on climatic adaptability but equally on adequate nutritional management to support vigorous vegetative growth, since attributes such as plant height, spread, branching, stem diameter and leaf area determine the canopy framework and photosynthetic surface on which subsequent flowering and yield depend (Sharma et al., 2024).

Nutrient availability is thus a critical determinant of vegetative growth and canopy development in apple, with nitrogen primarily governing shoot and leaf development and phosphorus and potassium supporting root activity, energy metabolism and nutrient transport (Kumar et al., 2018). Integrated nutrient management (INM), combining organic manures with inorganic fertilizers, has been widely advocated as a means of improving nutrient-use efficiency while sustaining soil fertility, since organic sources such as FYM and vermicompost improve soil structure, moisture retention and microbial activity, whereas inorganic fertilizers meet the immediate nutrient demand of the actively growing plant (Kumar et al., 2018; Kishor and Debnath, 2024). This synergy has been demonstrated repeatedly in apple: Das et al. (2016) reported that combining FYM and vermicompost with inorganic NPK under mulching substantially improved productivity in spur-type apple cv. Starkrimson over recommended inorganic fertilization alone, while Raturi et al. (2018) found that partial substitution of inorganic fertilizer with vermicompost produced the highest shoot growth and tree height increment in cv. Red Delicious. In HRMN-99 specifically, Padhan et al. (2019) showed that organic growing media significantly improved early establishment and growth under Prayagraj conditions, and Vats et al. (2022) reported improved height and branching with integrated NPK, biocapsule and nanozeolite application at the same location, while Sharma et al. (2024) recorded significant variation in height, girth, branching, leaf area and LAI among low-chilling cultivars under different organic-inorganic nutrient levels in Assam.

Given the growing interest of subtropical-plains farmers in HRMN-99 as a diversification and income option, a clear understanding of its response to systematically combined organic and inorganic nutrient sources is of direct practical value. Findings from such an investigation would allow growers to identify a nutrient management regime that maximizes vegetative vigour and, in turn, canopy establishment, flowering potential and yield, without excessive dependence on costly inorganic fertilizers. This would support more sustainable, cost-effective and regionally adapted orchard management practices for smallholder and marginal farmers seeking to cultivate apple in non-traditional, subtropical tracts of India. Therefore, the present investigation was undertaken to evaluate the effect of integrated organic–inorganic nutrient management on the vegetative growth of low-chilling apple cv. HRMN-99 under subtropical conditions of Prayagraj, Uttar Pradesh, with particular emphasis on plant height, plant spread, primary and secondary branches, stem diameter, leaf area and leaf area index.

MATERIALS AND METHODS

The present investigation was conducted on the low-chilling apple (*Malus domestica* Borkh.) cv. HRMN-99 at the Research Farm of the Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj, Uttar Pradesh, India. The experiment was carried out for two consecutive growing seasons, 2023-24 and 2024-25. The climate of Prayagraj is subtropical, with hot summers, a distinct monsoon period and relatively mild winters. The experimental site therefore provided suitable conditions for evaluating the performance and nutrient response of a low-chilling apple cultivar under subtropical conditions.

Six-year-old apple trees were selected for the experiment. The experiment was laid out in a randomized block design (RBD) with 11 nutrient management treatments and three replications. Each tree was considered an experimental unit, resulting in a total of 33 trees. The trees were planted at a spacing of 2 × 2 m, with one tree representing each replication of a treatment. Thus, each experimental unit occupied an area of 4 m².

Before the initiation of the experiment, representative soil samples were collected from the experimental site and analyzed for their physical and chemical properties. The soil was sandy loam, with sand, clay and silt contents of 57.41, 18.89 and 22.35%, respectively, during 2023-24, and 57.38, 18.93 and 22.36%, respectively, during 2024-25. The soil pH was 6.5 and 6.2, while electrical conductivity was 0.38 and 0.35 dS m⁻¹, respectively, in the two seasons. Soil organic carbon was 0.21 and 0.20%, respectively. The available nitrogen, phosphorus and potassium contents were 171.48, 13.60 and 215.40 kg ha⁻¹, respectively, during 2023-24, compared with 173.54, 15.41 and 218.34 kg ha⁻¹, respectively, during 2024-25.

Treatments consisted of different combinations of organic manures, viz., farmyard manure, vermicompost, and poultry manure, in combination with inorganic fertilizers applied at different proportions of the recommended dose of fertilizer RDF: 140:70:140g N:P:K plant⁻¹. The treatment combinations were as follows:

Treatments	Description
T ₁	100% RDF
T ₂	FYM 10 kg plant ⁻¹
T ₃	FYM 5 kg + 100% RDF
T ₄	Vermicompost 10 kg plant ⁻¹
T ₅	Vermicompost 5 kg + 100% RDF
T ₆	Poultry manure 3 kg plant ⁻¹
T ₇	Poultry manure 1.5 kg + 100% RDF
T ₈	FYM 2.5 kg + vermicompost 2.5 kg + poultry manure 1.5 kg plant ⁻¹
T ₉	FYM 2.5 kg + vermicompost 2.5 kg + 50% RDF
T ₁₀	FYM 2.5 kg + vermicompost 2.5 kg + poultry manure 1.5 kg + 50% RDF
T ₁₁	FYM 2.5 kg + vermicompost 2.5 kg + poultry manure 1.5 kg + 100% RDF

Observations recorded

Morphological observations were recorded individually for each experimental plant during both growing seasons. Plant height (cm) was measured from the ground level to the highest growing point of the plant using a measuring scale. Plant spread (cm) was determined by measuring the canopy spread in two perpendicular directions and calculating the mean value. Number of primary branches plant⁻¹ was recorded by counting the branches arising directly from the main stem, whereas secondary branches plant⁻¹ were counted from the primary branches. Stem girth of six-year-old apple trees was measured in centimetres using a measuring tape at a uniform height of 30 cm above ground level. Leaf area (cm²) was determined from representative fully expanded leaves using the adopted leaf-area measurement method. Leaf area index (LAI) was calculated as the ratio of total leaf area per plant to the corresponding ground area occupied by the plant.

Statistical Analysis

Data recorded for individual years were subjected to analysis of variance appropriate for a randomized block design. For the combined analysis across the two years, year, treatment and year × treatment interaction were considered as sources of variation. Treatment means were compared using the critical difference (C.D.) at the 5% level of probability. The standard error of mean (SEm±) and coefficient of variation (C.V.) were also calculated. All statistical analyses were performed using OPSTAT (Sheoran et al., 1998).

4. RESULTS

4.1 Plant height

Data pertaining to the effect of integrated nutrient management on plant height at 30, 60, 90 and 120 days after treatment application are presented in Table 1. The results revealed a non-significant effect of treatments on plant height at 30 days during both years of study as well as in pooled analysis, indicating a uniform initial growth response across treatments. However, from 60 days onward, a significant influence of nutrient management practices on plant height was recorded and persisted through 120 days in both individual years and pooled data. At 120 days, T₁₁ recorded the maximum plant height (3.90, 3.97 and 3.94 m in 2023-24, 2024-25 and pooled, respectively). It was statistically at par with T₁₀ in the individual years and significantly superior to all other treatments in the pooled analysis, including T₁₀ (3.63 m) and T₉ (3.58 m). The minimum plant height was recorded under T₁ (2.88 m pooled).

Table 1. Effect of integrated nutrient management on Plant height at 30,60,90 and 120 days in apple cv. HRMN-99 during the both years and pooled.

Treatment	Plant Height (m.) at 30 days			Plant Height (m.) at 60 days			Plant Height (m.) at 90days			Plant Height (m.) at 120days		
	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled
T ₁	2.63	2.67	2.65	2.71	2.75	2.73	2.80	2.82	2.81	2.85	2.9	2.88
T ₂	2.64	2.68	2.66	2.92	2.96	2.94	3.02	3.04	3.03	3.07	3.13	3.1
T ₃	2.68	2.73	2.7	3.16	3.21	3.18	3.27	3.29	3.28	3.32	3.38	3.35
T ₄	2.66	2.7	2.68	3.04	3.09	3.07	3.15	3.17	3.16	3.2	3.26	3.23
T ₅	2.71	2.76	2.73	3.29	3.34	3.32	3.40	3.43	3.42	3.46	3.52	3.49
T ₆	2.65	2.69	2.67	3	3.04	3.02	3.10	3.12	3.11	3.15	3.21	3.18
T ₇	2.7	2.75	2.72	3.24	3.29	3.27	3.35	3.38	3.36	3.41	3.47	3.44
T ₈	2.67	2.72	2.69	3.11	3.16	3.14	3.22	3.24	3.23	3.28	3.33	3.3

T ₉	2.72	2.77	2.74	3.37	3.43	3.4	3.49	3.52	3.50	3.55	3.61	3.58
T ₁₀	2.74	2.79	2.77	3.42	3.48	3.45	3.54	3.57	3.55	3.6	3.67	3.63
T ₁₁	2.75	2.8	2.78	3.7	3.77	3.74	3.83	3.87	3.85	3.9	3.97	3.94
SEm (±)	0.08	0.08	0.06	0.1	0.12	0.07	0.11	0.11	0.08	0.11	0.12	0.08
C.D. (5%)	NS	NS	NS	0.3	0.35	0.21	0.32	0.34	0.23	0.34	0.35	0.23
C.V. (%)	5.08	5.19	5.13	5.51	6.02	5.58	5.79	6	5.9	5.88	6.02	5.95

4.2 Plant spread

As with plant height, plant spread did not differ significantly at 30 days, but differed significantly from 60 to 120 days (Table 2). At 120 days, T₁₁ recorded the maximum spread (276.77, 282.07 and 279.42 cm in 2023-24, 2024-25 and pooled, respectively). It was statistically at par with T₁₀ (270.34 cm) and T₉ (262.85 cm) and significantly superior to the remaining treatments. The minimum spread was recorded under T₁ (211.90 cm pooled).

Table 2. Effect of integrated nutrient management on Plant spread at 30,60,90 and 120 days in apple cv. HRMN-99 during the both years and pooled.

Treatment	Plant Spread (cm.) at 30 days			Plant Spread (cm.) at 60 days			Plant Spread (cm.) at 90days			Plant Spread (cm.) at 120days		
	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled
T ₁	176.02	177.81	176.92	185.41	186.81	186.11	197.39	199.31	198.35	205.10	208.08	206.59
T ₂	185.58	188.32	186.95	205.31	207.55	206.43	219.77	222.52	221.15	229.21	232.92	231.07
T ₃	180.15	182.81	181.48	212.83	214.78	213.81	226.72	229.89	228.31	236.61	240.85	238.73
T ₄	187.31	190.41	188.86	214.62	218.10	216.36	231.50	236.14	233.82	243.00	247.40	245.20
T ₅	182.49	185.51	184.00	220.06	222.31	221.19	234.59	238.26	236.43	244.25	248.51	246.38
T ₆	186.45	189.36	187.91	211.12	212.48	211.80	226.06	229.07	227.57	235.97	239.95	237.96
T ₇	181.66	184.50	183.08	218.01	220.13	219.07	232.32	235.76	234.04	242.67	247.18	244.93
T ₈	188.17	191.46	189.82	219.22	221.82	220.52	234.88	238.40	236.64	245.61	250.10	247.86
T ₉	183.32	186.52	184.92	226.74	229.17	227.96	241.78	245.77	243.78	252.98	258.02	255.50
T ₁₀	185.67	189.25	187.46	238.90	241.72	240.31	256.47	261.56	259.02	268.75	273.86	271.31
T ₁₁	193.92	198.18	196.05	245.01	248.32	246.67	262.92	267.95	265.44	276.15	282.16	279.16
SEm (±)	5.34	5.83	3.95	6.41	6.8	4.67	7.66	8.08	5.57	8.45	8.76	6.09
C.D. (5%)	NS	NS	NS	18.92	23.83	13.35	22.61	23.83	15.92	24.93	25.84	17.39
C.V. (%)	5	5.37	5.19	5.09	5.9	5.21	5.69	5.9	5.8	6	6.1	6.05

4.3 Number of primary branches

Both branching parameters were non-significant at 30 days and significant from 60 to 120 days (Tables 3 and 4). At 120 days, T₁₁ recorded the maximum number of primary branches (6.77 pooled) and secondary branches (68.49 pooled). It was statistically at par with T₁₀ (6.43 and 66.68, respectively). The minimum values were recorded under T₁ (5.41 and 54.12, respectively).

4.4 Number of secondary branches

Data on secondary branch number are presented in Table 4. As with the other vegetative parameters, no significant differences were detected at 30 days after treatment, whereas significant variation among treatments

was observed from 60 to 120 days.

Table 4. Effect of integrated nutrient management on No. of secondary branches at 30,60,90 and 120 days in apple cv. HRMN-99 during the both years and pooled.

Treatment	No. of Secondary branches at 30 days			No. of Secondary branches at 60 days			No. of Secondary branches at 90 days			No. of Secondary branches at 120 days		
	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled
T ₁	22.61	23.38	23	32.19	34.08	33.13	40.98	42.3	41.64	52.99	55.25	54.12
T ₂	22.92	23.68	23.3	33.79	35.07	34.43	42.13	43.6	42.86	55.23	56.56	55.89
T ₃	23.44	24.7	24.07	37.01	38.99	38	46.71	48.82	47.77	60.15	61.76	60.96
T ₄	23.29	24.2	23.75	35.4	37.03	36.21	45.29	46.7	46	58.68	59.75	59.22
T ₅	23.46	25.25	24.35	37.96	40.25	39.11	49.23	51.69	50.46	62.2	64.27	63.23
T ₆	23.14	23.95	23.54	34.59	36.04	35.32	43.27	44.9	44.08	56.45	57.85	57.15
T ₇	23.46	24.99	24.22	37.97	40.14	39.06	48.05	50.34	49.2	61.63	63.32	62.48
T ₈	23.39	24.45	23.92	36.21	38.01	37.11	45.57	47.52	46.54	58.92	60.46	59.69
T ₉	23.47	25.5	24.48	39.63	42.17	40.9	50.42	53.04	51.73	64.18	66.01	65.09
T ₁₀	23.47	25.54	24.51	40.63	43.37	42	53.03	55.99	54.51	65.72	67.64	66.68
T ₁₁	24.6	26.89	25.75	41.46	44.39	42.93	54.71	57.35	56.03	67.99	68.99	68.49
SEm (±)	0.7	0.89	0.24	1.16	1.29	0.37	1.42	1.44	0.43	1.81	1.47	0.5
C.D. (5%)	NS	NS	NS	3.42	3.81	2.48	4.18	4.24	2.88	5.33	4.34	3.33
C.V. (%)	5.19	6.19	5.74	5.42	5.73	5.59	5.19	5.05	5.12	5.19	4.11	4.67

Treatment T₁₁ produced the highest number of secondary branches at 60 days (41.46, 44.39 and 42.93 for 2023-24, 2024-25 and pooled, respectively), 90 days (54.71, 57.35 and 56.03) and 120 days (67.99, 68.99 and 68.49), and was statistically at par with T₁₀ (66.68 pooled at 120 days) but significantly superior to all remaining treatments. T₁ recorded the lowest number of secondary branches at every stage (54.12 pooled at 120 days), and the increase in T₁₁ over T₁ was 26.5 per cent on pooled basis at 120 days.

4.5 Stem girth, leaf area and leaf area index

The data on stem girth, leaf area and leaf area index are presented in Table 5. Stem girth and leaf area were significantly influenced by the treatments in both years and in the pooled analysis, whereas leaf area index (LAI) was not.

Table 5. Effect of integrated nutrient management on Stem girth, leaf area and leaf area index in apple cv. HRMN-99 during the both years and pooled.

Treatment	Stem girth (cm)			Leaf area (cm ²)			LAI		
	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled
T ₁	21.6	24.74	23.17	36.55	37.3	36.93	0.3	0.31	0.31
T ₂	22.31	25.62	23.96	37.89	38.66	38.27	0.31	0.33	0.32
T ₃	25.13	29.15	27.14	39.19	40.07	39.63	0.33	0.34	0.33
T ₄	23.71	27.38	25.55	38.54	39.37	38.96	0.32	0.33	0.33
T ₅	26.37	31.07	28.72	40	40.94	40.47	0.34	0.35	0.34
T ₆	23.01	26.49	24.75	38.22	39.01	38.61	0.32	0.33	0.32
T ₇	25.95	30.16	28.05	39.67	40.58	40.12	0.33	0.34	0.34
T ₈	24.42	28.27	26.35	38.87	39.72	39.3	0.32	0.34	0.33
T ₉	27.41	31.99	29.7	40.34	41.3	40.82	0.34	0.35	0.35
T ₁₀	28.26	33.05	30.65	40.84	41.83	41.34	0.34	0.36	0.35
T ₁₁	28.99	33.96	31.48	42.16	43.19	42.68	0.36	0.37	0.36
SEm (±)	0.78	0.96	0.62	0.68	0.72	0.5	0.02	0.02	0.01
C.D. (5%)	2.31	2.83	1.77	2.01	2.13	1.42	NS	NS	NS

C.V. (%)	5.38	5.68	5.57	3.02	3.11	3.06	8.72	8.59	8.66
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Maximum stem girth was recorded under T₁₁ (28.99, 33.96 and 31.48 cm in 2023-24, 2024-25 and pooled, respectively), which was statistically at par with T₁₀ (30.65 cm pooled) and significantly superior to the remaining treatments. The minimum stem girth was recorded under T₁ (23.17 cm pooled). Leaf area followed a similar trend, with T₁₁ recording the maximum value (42.16, 43.19 and 42.68 cm² in 2023-24, 2024-25 and pooled, respectively), statistically at par with T₁₀ (41.34 cm² pooled) and significantly higher than the other treatments. The minimum leaf area was recorded under T₁ (36.93 cm² pooled). In contrast, LAI did not differ significantly among treatments in either year or in the pooled analysis, although it was numerically highest under T₁₁ (0.36 pooled) and lowest under T₁ (0.31 pooled).

DISCUSSION

Integrated nutrient management significantly influenced the vegetative growth of apple cv. HRMN-99, with T₁₁ (FYM + vermicompost + poultry manure + 100% RDF) consistently recording the highest values for plant height, plant spread, primary and secondary branches, stem diameter and leaf area, whereas T₁ (100% RDF) generally recorded the lowest values. Treatment differences were comparatively small during the initial growth stage but became more pronounced from 60 days onward, indicating a progressive response of the trees to integrated nutrient supply. Similar enhancement of apple growth through integrated application of organic and inorganic nutrients was reported by Das et al. (2016), who recorded superior growth and productivity with FYM, vermicompost and mineral NPK integration.

The greater plant height, canopy spread and branching under T₁₁ are consistent with the findings of Sharma et al. (2024), who reported maximum plant height, stem girth, branches, leaf area and leaf area index in low-chilling apple, including HRMN-99, under combined FYM and NPK application. Similar findings were reported by Vats et al. (2022) and Gupta and Mishra (2024) in HRMN-99 under Prayagraj conditions, where nutrient supplementation in combination with NPK significantly improved plant height, primary and secondary branches, stem girth and leaf area. Padhan et al. (2019) also observed significant improvement in plant height, branching, leaf number and plant spread of HRMN-99 with organic growing-media combinations containing vermicompost, leaf compost and FYM.

The positive response of stem diameter and canopy development to integrated nutrient supply is further supported by Kumar et al. (2018), who reported improved growth and productivity of apple through integration of organic and inorganic fertilizers with biofertilizers. Likewise, Das et al. (2016) demonstrated that partial supplementation of mineral nutrient requirements through FYM and vermicompost improved plant growth and productivity compared with recommended fertilizer application alone. Recent work on high-density apple by Abd-Allah et al. (2024) also showed significant increases in tree height, plant spread, trunk girth, extension growth and leaf area with improved NPK fertigation. These findings are further supported by recent research demonstrating positive effects of integrated organic amendments, biofertilizers and mineral fertilization on nutrient balance and apple productivity.

CONCLUSION

The two-year investigation demonstrated that integrated nutrient management significantly influenced the vegetative growth of low-chilling apple cv. HRMN-99 under subtropical conditions. Treatment effects were non-significant during the initial stage, reflecting uniform early growth, but became pronounced from 60 days onwards and were sustained up to 120 days in both years and in the pooled data. Plant height, plant spread, branching, stem girth and leaf area responded significantly to the nutrient regimes, whereas leaf area index remained unaffected. Treatment T₁₁ (FYM @ 2.5 kg + vermicompost @ 2.5 kg + poultry manure @ 1.5 kg + 100% RDF plant⁻¹) consistently showed the best growth performance across stages and seasons, followed by T₁₀, whereas the T₁ recorded the poorest performance. The combined use of organic manures with the recommended dose of fertilizers appears to support better plant growth than either source alone, probably through a sustained supply of nutrients and improved soil conditions.

On this basis, T₁₁ is recommended for apple growers in the subtropical region for cultivation of cv. HRMN-99, as it promoted vigorous and balanced vegetative growth consistently over two seasons. T₁₀ may be considered a suitable alternative where the full T₁₁ combination is difficult to adopt, since it performed statistically at par with T₁₁ for most growth parameters. These findings should be validated through multi-location trials across different soil types and subtropical agro-climatic zones. Future studies should also examine the long-term effects of integrated nutrient management on orchard productivity, fruit quality, soil physico-chemical and biological properties, and nutrient use efficiency. Economic analysis and studies on microbial consortia and bio-inoculants would further help develop sustainable and cost-effective nutrient management packages for low-chilling apple cultivation.

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Conflict of Interest

The authors declare that they have no competing interests or conflict of interest.

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Table 3. Effect of integrated nutrient management on No. of primary branches at 30,60,90 and 120 days in apple cv. HRMN-99 during the both years and pooled.

Treatment	No. of Primary branches at 30 days			No. of Primary branches at 60 days			No. of Primary branches at 90 days			No. of Primary branches at 120 days		
	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled
T ₁	4.65	4.7	4.68	4.85	4.9	4.88	5.21	5.27	5.24	5.35	5.47	5.41
T ₂	4.67	4.73	4.7	5.01	5.06	5.04	5.43	5.45	5.44	5.54	5.66	5.6
T ₃	4.74	4.81	4.78	5.34	5.4	5.37	5.78	5.83	5.81	5.98	6.1	6.04
T ₄	4.71	4.77	4.74	5.15	5.21	5.18	5.71	5.77	5.74	5.91	6.04	5.98

T ₅	4.8	4.87	4.83	5.44	5.5	5.47	5.89	5.95	5.92	6.12	6.25	6.19
T ₆	4.69	4.75	4.72	5.1	5.16	5.13	5.52	5.55	5.54	5.66	5.78	5.72
T ₇	4.78	4.85	4.81	5.41	5.47	5.44	5.86	5.91	5.89	6.07	6.2	6.13
T ₈	4.73	4.79	4.76	5.32	5.38	5.35	5.76	5.8	5.78	5.94	6.06	6
T ₉	4.82	4.89	4.85	5.56	5.62	5.59	6.02	6.09	6.06	6.28	6.4	6.34
T ₁₀	4.85	4.93	4.89	5.62	5.69	5.65	6.09	6.17	6.13	6.36	6.49	6.43
T ₁₁	4.87	4.95	4.91	5.91	5.98	5.95	6.4	6.49	6.45	6.71	6.84	6.77
SEm (±)	0.14	0.15	0.1	0.15	0.15	0.11	0.16	0.16	0.11	0.17	0.18	0.12
C.D. (5%)	NS	NS	NS	0.45	0.43	0.3	0.46	0.47	0.32	0.51	0.52	0.35
C.V. (%)	5.03	5.28	5.16	4.91	4.7	4.8	4.65	4.76	4.71	4.99	5.04	5.01