

ISSN Print: 2664-844X
ISSN Online: 2664-8458
NAAS Rating (2026): 4.97
IJAFS 2026; 8(11): 477-482
www.agriculturaljournals.com
Received: 14-09-2026
Accepted: 27-10-2026
Published: 13-11-2026

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Effect of integrated nutrient management on growth of guava varieties in the Rajnandgaon district of Chhattisgarh plain

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DOI: https://www.doi.org/10.33545/2664844X.2026.v8.i11g.90983

Abstract
The field experiment, titled "Effect of integrated nutrient management on growth of guava varieties in the Rajnandgaon district of the Chhattisgarh plain," was conducted during the 2019-20 *mrig-bahar* season at the Horticulture Farm, Bharregaon, under the Pt. K.L. Shukla College of Horticulture and Research Station, Rajnandgaon, Chhattisgarh.
The study employed a Factorial Randomized Block Design (FRBD) consisting of 24 treatments across three replications. The experiment evaluated two factors: four guava varieties and six levels of integrated nutrient management (INM).
The research aimed to investigate the influence of organic manures, inorganic fertilizers, biofertilizers, and their combinations on the growth of guava under ultra-high-density planting conditions in the Chhattisgarh plains.
The results indicated that all growth parameters—including plant height, trunk girth, and canopy spread (both north-south and east-west)—were superior in the treatment combination V_4N_3 (Lalit variety + 75% RDF + 10 kg FYM + 2.5 kg vermicompost + 50 g Azotobacter).

Keywords: Guava, INM, growth, azotobacter, nutrients

Introduction

Guava (*Psidium guajava* L.), a member of the family Myrtaceae, is one of the most economically important fruit crops cultivated in tropical and subtropical regions worldwide. In India, guava cultivation dates back to the 17th century, and it is regarded as the fourth most important fruit crop after mango, banana, and citrus. The crop occupies a significant position in Indian horticulture, covering an estimated area of approximately 2.51 lakh hectares, with an annual production of about 4,083 thousand tonnes.

Continuous increases in fruit production result in the substantial removal of essential plant nutrients from the soil, thereby accelerating nutrient depletion and gradually reducing soil fertility. Such nutrient imbalances may adversely affect crop productivity as well as the quality of harvested fruits. Moreover, the excessive and indiscriminate application of chemical fertilizers as the primary source of plant nutrients can cause serious environmental degradation, negatively influence plant health, and potentially pose risks to consumers (Shanker *et al*., 2002).

In this context, the integrated application of organic manures and inorganic fertilizers offers a promising approach to maintaining soil health and improving crop productivity. Combining organic substrates with chemical fertilizers can positively influence the physical, chemical, and microbiological properties of soil, thereby creating a favourable environment for plant growth and development. Furthermore, the combined utilization of organic manures, biofertilizers, and crop residues represents an economical and sustainable nutrient management strategy. Such integrated nutrient management practices can improve nutrient availability and contribute to enhanced growth, fruit yield, and quality in various fruit crops (Katiyar *et al*., 2012).

Materials and Methods

The present investigation was carried out during the year 2019–2020 at the Horticulture Farm, Bharregaon, functioning under Pt. K.L. Shukla College of Horticulture and Research Station, Rajnandgaon, Chhattisgarh. Rajnandgaon district is located approximately 85 km from Indira Gandhi Krishi Vishwavidyalaya, Raipur. Geographically, the district lies in the north-eastern part of Chhattisgarh, extending between 20°07′ N and 22°29′ N latitudes and 80°23′ E and 81°24′ E longitudes, with an average elevation of 330.71 metres above mean sea level.

The region falls under the dry moist sub-humid agro-climatic zone and receives an average annual rainfall of approximately 953 mm. The climatic conditions are characterized by considerable seasonal variations in

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temperature, with the maximum temperature reaching up to 45.9 °C during summer and the minimum temperature dropping to approximately 16 °C during winter. These agro-climatic conditions provide the environmental background for conducting horticultural research in the region.

Experimental details

The experiment comprised 24 treatment combinations involving different sources of organic manures (farmyard manure and vermicompost), inorganic fertilizers, and biofertilizers. These treatments were formulated to evaluate the effects of integrated nutrient management on the growth, productivity, and quality of guava. The details of the various treatment combinations are presented below:

Table 1. Factor A: Varieties: 4 levels

V_1	Allahabadsafeda
V_2	L-49
V_3	Shweta
V_4	Lalit

Table 2. Factor B: INM: 6 levels

N0	Control
N_1	100% RDF
N_2	75% RDF+ 10 kg FYM + 2.5 kgvermicompost + 50 gm Trichoderma Trichoderma
N_3	75% RDF + 10 kg FYM + 2.5 kgvermicompost +50 gm Azotobactor Azotobactor
N_4	Allahabadsafeda + 75% RDF + 10 kg FYM + 2.5 kg vermicompost + 50 gm Azosprillium vermicompost+ 50 gm Azosprillium
N_5	Allahabadsafeda + 75% RDF + 10 kg FYM + 2.5 kg vermicompost + 50 gm PSB vermicompost+ 50 gm PSB

Observation

1. **Plant height (cm):** Plant height can be measured by using measuring scale. It can be measured from lowest point crown to highest point of canopy. Plant height is express in centimeter.
2. **Girth of the primary branch (cm):** The circumference of the primary branch was measured with the help of a vernier caliper and was expressed in cm.
3. **Canopy spread (*N*-S):** The canopy extension was measured in a north-south direction by using a measuring scale and the mean canopy extension was expressed in meters in the direction (*N*-S).
4. **Canopy spread (*E*-W):** The canopy extension was measured in the east-west with the help of a measuring scale and the mean canopy extension was calculated in meters in the (*E*-W) direction.

Results and Discussion

Plant height

Among the different guava varieties evaluated, V_4 (Lalit) recorded the significantly maximum plant height (244.5 cm), followed by V_3 (Shweta), with a plant height of 239.2 cm. In contrast, the minimum plant height (230.8 cm) was observed in V_1 (Allahabad Safeda). These findings are in agreement with the results reported by Paikra *et al.* (2015) [1].

The superior plant height observed in the guava variety Lalit may be attributed to its inherent genetic characteristics and varietal potential, along with its better adaptability to the prevailing agro-climatic conditions. The favourable interaction between the genetic makeup of the variety and the local environmental conditions might have contributed to enhanced vegetative growth. These findings are in accordance with the observations reported by Singh *et al.* (2016) [2, 3, 4].

Different integrated nutrient management (INM) treatments had a significant influence on plant height in guava. Among the treatments, N_3 (75% RDF + 10 kg FYM + 2.5 kg vermicompost + 50 g Azotobacter) recorded the maximum plant height (243.9 cm), followed by N_4 (75% RDF + 10 kg FYM + 2.5 kg vermicompost + 50 g *Azospirillum*). In contrast, the minimum plant height (220.1 cm) was recorded under N_0 (control). The superior performance of N_3 may be attributed to the combined and complementary effects of inorganic fertilizers, organic manures, and biofertilizers, which might have improved nutrient availability and supported better vegetative growth.

The enhancement in plant height under integrated nutrient management treatments may be attributed to the production of plant growth-promoting substances, particularly indole-3-acetic acid (IAA), which stimulates cell division and elongation. The application of biofertilizers, especially *Azotobacter* spp., may have contributed to increased IAA production, improved nutrient availability in the rhizosphere and rhizoplane, and enhanced nitrogen fixation. Furthermore, the combined application of inorganic fertilizers, organic manures, and *Azotobacter* might have ensured a balanced and continuous supply of essential nutrients, particularly nitrogen. Improved nitrogen availability could have enhanced photosynthetic activity and assimilate production, thereby promoting vegetative growth and increasing plant height. Similar findings were also reported by Sharma *et al.* (2017) [5].

The interaction effect of integrated nutrient management and guava varieties on plant height, as presented in Table 4, was found to be significant. Among the different treatment combinations, V_4N_3 (Lalit + 75% RDF + 10 kg FYM + 2.5 kg vermicompost + 50 g *Azotobacter*) recorded the maximum plant height (263.7 cm), followed by V_4N_4 (Lalit + 75% RDF + 10 kg FYM + 2.5 kg vermicompost + 50 g *Azospirillum*), which recorded a plant height of 250.3 cm. In contrast, the minimum plant height (212.3 cm) was observed under V_1N_0 (Allahabad Safeda + control). The superior performance of V_4N_3 may be attributed to the combined effects of the genetic potential of the Lalit variety and the synergistic contribution of organic manures, inorganic fertilizers, and *Azotobacter* in improving nutrient availability and promoting vegetative growth.

Table 3. Effect of different INM and guava varieties on plant height

Treatment	Plantheight(cm)
Factor A. Varieties (4 Level)	

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	Treatment	Plantheight(cm)
V_1	Allahabad Safeda	230.8
V_2	L-49	235.7
V_3	Shweta	239.2
V_4	Lalit	244.5
	S. Em.	0.699
	C.D at5%	1.997
	Factor B. INM (6 Level)	
N_0	Control	220.1
N_1	100% RDF	237.7
N_2	75% RDF+ 10 kg FYM+ 2.5 kg vermicompost + 50 gm *Trichoderma*	232.7
N_3	75% RDF+ 10 kg FYM+ 2.5 kg vermicompost + 50 gm Azotobacter	250.3
N_4	75% RDF+ 10 kg FYM+ 2.5 kg vermicompost + 50 gm *Azospirillum*	243.9
N_5	75% RDF+ 10 kg FYM + 2.5 kg vermicompost + 50 gm PSB	240.7
	S. Em.	0.857
	C.D at 5%	2.446

Table 4. Interaction effect of different INM and guava varieties on plant height (cm)

	N0	N1	N2	N_3	N4	N5
V_1	212.3	234	225.7	240.3	237.3	235
V_2	218.7	236.3	231	247.3	242.7	238.3
V_3	222.3	241	235.7	250	245.3	241
V_4	227	239.3	238.3	263.7	250.3	248.3
S. Em.			1.713			
C.D at5%			4.892			
C.V. (%)			1.249			

Trunk girth

Among the different guava varieties evaluated, V_4 (Lalit) recorded the significantly maximum trunk girth (7.002 cm), followed by V_3 (Shweta), with a trunk girth of 6.894 cm. In contrast, the minimum trunk girth (6.699 cm) was observed in V_1 (Allahabad Safeda). These results are in agreement with the findings of Gurjar *et al.* (2015) [2]. The superior trunk girth observed in Lalit may be attributed to its inherent genetic characteristics and better adaptability to the prevailing agro-climatic conditions. Similar observations were reported by Paikra *et al.* (2015) [1].

Different integrated nutrient management (INM) treatments exerted a significant influence on trunk girth. Among the treatments, N_3 (75% RDF + 10 kg FYM + 2.5 kg vermicompost + 50 g *Azotobacter*) recorded the maximum trunk girth (7.278 cm), followed by N_4 (75% RDF + 10 kg FYM + 2.5 kg vermicompost + 50 g *Azospirillum*), with a trunk girth of 6.977 cm. However, the minimum trunk girth (6.480 cm) was recorded under N_0 (control). The superior performance of N_3 may be attributed to the combined effects of organic manures, inorganic fertilizers, and nitrogen-fixing biofertilizers, which might have enhanced nutrient availability and promoted better vegetative growth.

The increased trunk girth under biofertilizer treatments may be associated with enhanced nitrogen availability through biological nitrogen fixation, which could contribute to improved chlorophyll synthesis and photosynthetic activity. Additionally, the production of plant growth-promoting substances by beneficial rhizobacteria in the rhizosphere may stimulate root development, nutrient uptake, and overall vegetative growth. Improved nutritional status and photosynthetic efficiency might have ultimately contributed to increased trunk girth. Similar findings were reported by Mishra *et al.* (2011) [6].

The interaction effect of integrated nutrient management and guava varieties on trunk girth, as presented in Table 6, was found to be significant. Among the different treatment combinations, V_4N_3 (Lalit + 75% RDF + 10 kg FYM + 2.5 kg vermicompost + 50 g *Azotobacter*) recorded the maximum trunk girth (7.470 cm), followed by V_3N_3 (Shweta + 75% RDF + 10 kg FYM + 2.5 kg vermicompost + 50 g *Azotobacter*), with a trunk girth of 7.303 cm. In contrast, the minimum trunk girth (6.347 cm) was observed under V_1N_0 (Allahabad Safeda + control). The superior performance of V_4N_3 may be attributed to the combined influence of the genetic potential of Lalit and the beneficial effects of integrated nutrient management, particularly the synergistic contribution of organic manures, inorganic fertilizers, and *Azotobacter* in promoting vegetative growth and stem development.

Table 5. Influence of different INM and guava varieties on trunk girth (cm)

	Treatment	Trunkgirth (cm)
	Factor A. Varieties (4 Level)	
V_1	AllahabadSafeda	6.699
V_2	L-49	6.796
V_3	Shweta	6.894
V_4	Lalit	7.002
	S. Em.	0.003

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	Treatment	Trunkgirth (cm)
	C.D at5%	0.008
	Factor B. INM (6 Level)	
N_0	Control	6.480
N_1	100% RDF	6.777
N_2	75% RDF+ 10 kg FYM + 2.5 kg vermicompost+ 50 gm *Trichoderma*	6.672
N_3	75% RDF+ 10 kg FYM + 2.5 kg vermicompost + 50 gm Azotobacter	7.298
N_4	75% RDF+ 10 kg FYM + 2.5 kg vermicompost + 50 gm *Azospirillum*	6.977
N_5	75% RDF+ 10 kg FYM + 2.5 kg vermicompost+ 50gm PSB	6.883
	S. Em.	0.003
	C.D at5%	0.010

Table 6. Interaction effect of different INM and guava varieties on trunk girth (cm)

	N0	N1	N2	N_3	N4	N5
V_1	6.347	6.637	6.503	7.160	6.830	6.720
V_2	6.443	6.730	6.617	7.260	6.907	6.817
V_3	6.500	6.833	6.733	7.303	7.047	6.947
V_4	6.630	6.907	6.833	7.470	7.123	7.047
S. Em.			0.007			
C.D at5%			0.019			
C.*V*. (%)			0.176			

Canopy spread N-S

Among the different guava varieties evaluated, V_4 (Lalit) exhibited the significantly maximum canopy spread in the north-south (*N*-S) direction (1.244 m), followed by V_3 (Shweta), with a canopy spread of 1.212 m. In contrast, the minimum canopy spread (1.169 m) was recorded in V_1 (Allahabad Safeda). These findings are in agreement with the results reported by Paikra *et al.* (2015) [1].

The variation in canopy spread among the different guava varieties might be attributed to their inherent genetic makeup and varietal characteristics, along with differences in physiological processes such as photosynthetic efficiency, translocation of photosynthates from source to sink, and photorespiration. These physiological activities may have contributed to differences in vegetative growth and canopy development among the varieties. Similar findings were reported by Singh *et al.* (2013) [2, 3, 4].

Different integrated nutrient management (INM) treatments had a significant influence on canopy spread in the north-south (*N*-S) direction. Among the treatments, N_3 (75% RDF + 10 kg FYM + 2.5 kg vermicompost + 50 g *Azotobacter*) recorded the maximum canopy spread (1.311 m), followed by N_4 (75% RDF + 10 kg FYM + 2.5 kg vermicompost + 50 g *Azospirillum*), with a canopy spread of 1.251 m. However, the minimum canopy spread (1.107 m) was observed under N_0 (control). The improved canopy development under integrated nutrient management treatments might be attributed to better soil health and improvements in the physical, chemical, and biological properties of the soil. The addition of organic manures, along with inorganic fertilizers and biofertilizers, may have improved nutrient availability and created a favourable nutritional environment for enhanced vegetative growth. Similar observations were reported by Singh *et al.* (2003) [2, 3, 4].

The interaction effect of integrated nutrient management and guava varieties on canopy spread in the north-south (*N*-S) direction, as presented in Table 8, was found to be significant. Among the different treatment combinations, V_4N_3 (Lalit + 75% RDF + 10 kg FYM + 2.5 kg vermicompost + 50 g *Azotobacter*) recorded the maximum canopy spread (1.357 m), followed by V_3N_3 (Shweta + 75% RDF + 10 kg FYM + 2.5 kg vermicompost + 50 g *Azotobacter*), with a canopy spread of 1.337 m. In contrast, the minimum canopy spread (1.043 m) was recorded under V_1N_0 (Allahabad Safeda + control). The superior performance of V_4N_3 may be attributed to the combined influence of the genetic potential of the Lalit variety and the beneficial effects of integrated nutrient management, which might have improved nutrient availability and promoted greater vegetative growth and canopy expansion.

Table 7. Influence of different INM and guava Varieties on canopy spread (*N*-S) (m)

	Treatment	Canopyspread(*N*-S)
	FactorA.Varieties(4 Level)	
V_1	AllahabadSafeda	1.169
V_2	L-49	1.196
V_3	Shweta	1.212
V_4	Lalit	1.244
	S. Em.	
	C.D at5%	
	FactorB.INM(6Level)	
N_0	Control	1.107
N_1	100% RDF	1.217
N_2	75% RDF+ 10 kg FYM+ 2.5 kg vermicompost+ 50 gm *Trichoderma*	1.154

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	Treatment	Canopyspread(*N*-S)
N_3	75% RDF+ 10 kg FYM+ 2.5 kg vermicompost+ 50 gmAzotobacter	1.311
N_4	75% RDF+ 10 kg FYM+ 2.5 kg vermicompost+ 50gm *Azospirillum*	1.251
N_5	75% RDF+ 10 kg FYM + 2.5 kg vermicompost+ 50gm PSB	1.192
	S. Em.	0.003
	C.D at5%	0.019

Table 8. Interaction effect of different INM and guava varieties on canopy spread (*N*-S) (m)

	N0	N1	N2	N_3	N4	N5
V_1	1.043	1.170	1.113	1.260	1.227	1.200
V_2	1.090	1.207	1.133	1.290	1.243	1.213
V_3	1.133	1.227	1.167	1.337	1.247	1.160
V_4	1.160	1.263	1.203	1.357	1.287	1.193
S. Em.			0.006			
C.D at5%			0.016			
C.V. (%)			0.825			

Canopy spread (E-W)

Among the different guava varieties evaluated, V_4 (Lalit) recorded the significantly maximum canopy spread in the east-west (*E*-W) direction (1.443 m), followed by V_3 (Shweta), with a canopy spread of 1.431 m. In contrast, the minimum canopy spread (1.369 m) was observed in V_1 (Allahabad Safeda). These findings are in agreement with the results reported by Paikra *et al.* (2015) [1].

The variation in canopy spread among the different guava varieties might be attributed to their inherent genetic characteristics and varietal potential, along with differences in various physiological processes, such as photosynthetic efficiency, translocation of photosynthates from source to sink, and photorespiration. These physiological activities may have contributed to differences in vegetative growth and canopy development. Similar findings were reported by Singh *et al.* (2013) [2, 3, 4].

Different integrated nutrient management (INM) treatments had a significant influence on canopy spread in the east-west (*E*-W) direction. Among the treatments, N_4 (75% RDF + 10 kg FYM + 2.5 kg vermicompost + 50 g *Azospirillum*) recorded the maximum canopy spread (1.466 m), followed by N_3 (75% RDF + 10 kg FYM + 2.5 kg vermicompost + 50 g *Azotobacter*), with a canopy spread of 1.418 m. In contrast, the minimum canopy spread (1.393 m) was recorded under N_0 (control). The improvement in canopy development under integrated nutrient management treatments might be attributed to enhanced soil health and improvements in the physical, chemical, and biological properties of the soil. The combined application of organic manures, inorganic fertilizers, and biofertilizers may have improved the nutritional environment and nutrient availability, thereby promoting vegetative growth. Similar findings were reported by Singh *et al.* (2013) [2, 3, 4].

The interaction effect of integrated nutrient management and guava varieties on canopy spread in the east-west (*E*-W) direction, as presented in Table 10, was found to be significant. Among the different treatment combinations, V_4N_3 (Lalit + 75% RDF + 10 kg FYM + 2.5 kg vermicompost + 50 g *Azotobacter*) recorded the maximum canopy spread (1.557 m), followed by V_3N_3 (Shweta + 75% RDF + 10 kg FYM + 2.5 kg vermicompost + 50 g *Azotobacter*), with a canopy spread of 1.523 m. However, the minimum canopy spread (1.243 m) was observed under V_1N_0 (Allahabad Safeda + control). The superior performance of V_4N_3 might be attributed to the combined effects of the genetic potential of the Lalit variety and the improved nutritional environment provided by integrated nutrient management, which may have facilitated greater vegetative growth and canopy expansion.

Table 9. Influence of different INM and guava varieties on canopy spread (*E*-W)

	Treatment	Plantcanopy spread(E-W)
	Factor A. Varieties (4 Level)	
V_1	Allahabad safeda	1.369
V_2	L-49	1.398
V_3	Shweta	1.431
V_4	Lalit	1.443
	S. Em.	0.003
	C.D at 5%	0.008
	Factor B. INM (6 Level)	
N_0	Control	1.305
N_1	100% RDF	1.393
N_2	75% RDF + 10 kg FYM + 2.5 kg vermicompost + 50 gm Tricoderma	1.366
N_3	75% RDF+ 10 kg FYM + 2.5 kg vermicompost+ 50 gm Azetobactor	1.514
N_4	75% RDF+ 10 kg FYM + 2.5 kg vermicompost + 50 gm Azosprillium	1.466
N_5	75% RDF + 10 kg FYM + 2.5 kg vermicompost + 50gm PSB	1.418
	S. Em.	0.003
	C.D at5%	0.009

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Table 10. Interaction effect of different INM and guava varieties on canopy spread (*E*-W)

	N0	N1	N2	N_3	N4	N5
V_1	1.243	1.370	1.317	1.473	1.420	1.390
V_2	1.303	1.370	1.353	1.503	1.450	1.410
V_3	1.333	1.407	1.383	1.523	1.490	1.447
V_4	1.340	1.423	1.410	1.557	1.503	1.427
S. Em.			0.007			
C.D at5%			0.019			
C.V. (%)			0.811			

Conclusion

The vegetative growth parameters, viz., plant height, trunk girth, canopy spread in the north-south (*N*-S) direction, and canopy spread in the east-west (*E*-W) direction, were significantly influenced by different guava varieties. Among the varieties evaluated, V_4 (Lalit) exhibited the significantly maximum vegetative growth, recording a plant height of 2.445 m, trunk girth of 7.002 cm, canopy spread (*N*-S) of 1.244 m, and canopy spread (*E*-W) of 1.443 m. The variety V_4 (Lalit) was closely followed by V_3 (Shweta) and V_2 (L-49), whereas V_1 (Allahabad Safeda) recorded the minimum values for all the vegetative growth parameters during the experimental period of 2019–2020. The superior vegetative performance of Lalit might be attributed to its inherent genetic potential and better adaptability to the prevailing agro-climatic conditions.

Different integrated nutrient management (INM) treatments also exerted a significant influence on the vegetative growth of guava. Among the treatments, N_3 (75% RDF + 10 kg FYM + 2.5 kg vermicompost + 50 g *Azotobacter*) recorded the maximum plant height (2.503 m), trunk girth (7.298 cm), canopy spread (N-S) (1.311 m), and canopy spread (E-W) (1.514 m). This treatment was closely followed by N_4 (75% RDF + 10 kg FYM + 2.5 kg vermicompost + 50 g *Azospirillum*), N_5 (75% RDF + 10 kg FYM + 2.5 kg vermicompost + 50 g PSB), N_1 (100% RDF), and N_2 (75% RDF + 10 kg FYM + 2.5 kg vermicompost + 50 g *Trichoderma*). In contrast, the minimum vegetative growth was recorded under N_0 (control). The superior performance of N_3 might be attributed to the synergistic effects of inorganic fertilizers, organic manures, and *Azotobacter*, which may have improved nutrient availability, soil health, and overall plant growth.

The interaction between guava varieties and integrated nutrient management treatments also showed significant effects on vegetative growth parameters. Among the different treatment combinations, V_4N_3 (Lalit + 75% RDF + 10 kg FYM + 2.5 kg vermicompost + 50 g *Azotobacter*) recorded the maximum plant height (263.7 cm), trunk girth (7.470 cm), canopy spread (N-S) (1.357 m), and canopy spread (E-W) (1.557 m). Conversely, the minimum values for these vegetative growth parameters were observed under V_1N_0 (Allahabad Safeda + control). The superior performance of V_4N_3 may be attributed to the combined influence of the genetic potential of the Lalit variety and the beneficial effects of integrated nutrient management, particularly the complementary contribution of organic manures, inorganic fertilizers, and biofertilizers in improving nutrient availability and promoting vegetative growth.

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How to cite this article: Parihar N, Tamrakar P, Paikra DM. Effect of integrated nutrient management on growth of guava varieties in the Rajnandgaon district of Chhattisgarh plain. *International Journal of Agriculture and Food Science*. 2026;8(11):477-482. doi: https://www.doi.org/10.33545/2664844X.2026.v8.i11g.90983

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