



Influence of bioenhancers, biofertilizers and mulching on growth and yield of guava cv. L-49

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ABSTRACT

The present investigation was carried out to evaluate the effect of integrated organic nutrient management practices on growth, flowering and yield attributes of guava. The result revealed that among the treatments, T₉-Vermicompost (1 kg/tree) + Mulching with dry leaves + Panchagavya (5%) + PSB culture (50 g/tree) + Azotobacter (50 g/tree) recorded maximum plant height increment (0.72 m), trunk girth (64.57 cm), shoot length (50.49 cm), number of leaves per shoot (48.83), fruit retention (51.93%) and yield per plant (53.80 kg/tree). Correlation analysis revealed strong positive association of vegetative growth traits and fruit retention with yield. Principal Component Analysis (PCA) indicated that the first three principal components contributed 78.64 per cent of total variability, with plant height increment, trunk girth, shoot length, fruit retention and yield per plant contributing maximum towards PC1. The study concluded that integrated application of vermicompost, bioenhancers, mulching and biofertilizers significantly improved vegetative growth, flowering, fruit retention and yield of guava cv. L-49 under sustainable production systems.

Key words: *Psidium guajava* L., bioenhancers, organic nutrient, PCA, vegetative growth, yield.

INTRODUCTION

Guava (*Psidium guajava* L.) is one of the most important tropical and subtropical fruit crops cultivated widely in India owing to its high nutritional, medicinal and economic value. It is popularly known as the “apple of the tropics” and is an excellent source of vitamin C, antioxidants, minerals, pectin and dietary fibre. Among the commercially cultivated cultivars, cv. L-49 is highly preferred because of its prolific bearing habit, superior fruit quality and high yield potential. However, continuous and excessive use of chemical fertilizers in fruit production has resulted in soil degradation, nutrient imbalance, decline in microbial activity and environmental pollution, thereby necessitating sustainable nutrient management practices in guava cultivation (Chouhan and Tripathi, 2).

In recent years, the use of organic inputs such as vermicompost, mulching materials, bioenhancers and biofertilizers has gained considerable importance for improving crop productivity and maintaining soil fertility. Vermicompost improves soil structure, nutrient availability and microbial activity, ultimately enhancing plant growth and yield (Gupta and Tripathi, 5). Organic mulching materials such as dry leaves and paddy straw help in conserving soil moisture, regulating soil temperature, reducing weed infestation and improving soil organic carbon content. Bioenhancers such as Panchagavya, Amritpani

and Jivamrit are rich in beneficial microorganisms and growth-promoting substances which stimulate plant metabolic activities, flowering and fruiting. Similarly, biofertilizers such as Azotobacter and phosphate-solubilizing bacteria (PSB) improve nutrient availability and enhance soil biological activity by fixing atmospheric nitrogen and solubilizing unavailable phosphorus (Tripathi *et al.*, 17).

The integrated application of organic manures, mulching, bioenhancers and biofertilizers not only improves nutrient use efficiency and crop productivity but also reduces dependence on chemical fertilizers and promotes environmental sustainability (Tripathi *et al.*, 15). Although the beneficial effects of individual organic inputs on fruit crop performance have been widely documented, studies evaluating their integrated application remain limited, particularly in guava under specific agro-climatic conditions. The combined use of bioenhancers, biofertilizers, and mulching may provide synergistic effects by improving nutrient availability, enhancing soil biological activity, and creating favourable microenvironmental conditions for plant growth and productivity. However, comprehensive information regarding their collective influence on growth, flowering, and yield attributes of guava cv. L-49 is still lacking. Therefore, the present study was undertaken to investigate the interactive effects of different organic treatment combinations on guava performance with the aim of developing sustainable and environmentally sound production strategies.

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MATERIALS AND METHODS

The present investigation was carried out during the years 2024-25 and 2025-26 at Kalyanpur Nursery, Department of Fruit Science, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh. Geographically, Kanpur district is situated in the subtropical region between 25.26° to 26.58° North latitude and 79.31° to 80.34° East longitude at an altitude of 135 m above mean sea level. The experimental material consisted of healthy and uniform guava plants cv. L-49 maintained under normal orchard management conditions.

The experiment comprised ten treatment combinations, T₁-Control, T₂-Vermicompost (1.5 kg/ tree) + Mulching with dry leaves + Amritpani (20%) + Azotobacter (50 g/tree), T₃-Vermicompost (1 kg/ tree) + Mulching with dry leaves + Panchagavya (5%) + Azotobacter (50 g/tree), T₄-Vermicompost (1 kg/tree) + Mulching with paddy straw + Jivamrit (20%) + Azotobacter (50 g/tree), T₅-Vermicompost (1.5 kg/tree) + Mulching with dry leaves + Amritpani (20%) + PSB culture (50 g/tree), T₆-Vermicompost (1 kg/tree) + Mulching with dry leaves + Panchagavya (5%) + PSB culture (50 g/tree), T₇-Vermicompost (1 kg/tree) + Mulching with paddy straw + Jivamrit (20%) + PSB culture (50 g/tree), T₈-Vermicompost (1.5 kg/tree) + Mulching with dry leaves + Amritpani (20%) + PSB culture (50 g/tree) + Azotobacter (50 g/tree), T₉-Vermicompost (1 kg/tree) + Mulching with dry leaves + Panchagavya (5%) + PSB culture (50 g/tree) + Azotobacter (50 g/tree) and T₁₀- Vermicompost (1 kg/tree) + Mulching with paddy

straw + Jivamrit (20%) + PSB culture (50 g/tree) + Azotobacter (50 g/tree).

The experiment was laid out in Randomized Block Design (RBD) with three replications. Vermicompost and biofertilizers were applied uniformly in the root zone of the plants according to the treatment combinations and thoroughly mixed with the soil. Organic mulching materials namely dry leaves and paddy straw were applied uniformly around the basin area of plants for moisture conservation and weed suppression. Foliar application of Panchagavya and drenching of Amritpani and Jivamrit were carried out before flowering and during fruit setting stages using a pneumatic foot sprayer during morning hours. Observations were recorded on growth, flowering and yield parameters (Table 1,2). Plant height increment, canopy spread and trunk girth were measured after final harvest using measuring tape. Shoot length and shoot diameter were recorded from five randomly selected shoots per plant using measuring scale and vernier calipers, respectively. The number of shoots per plant was recorded after the final harvest and average was calculated. Shoot diameter (10 cm from base) was measured using vernier calipers on five randomly selected shoots per plant and the average was calculated. The number of fruits per plant was recorded at harvest and total fruit yield per plant was expressed in kilograms using a balance. Leaves from five randomly selected shoots per plant were counted after the final harvest and the average number of leaves per shoot was calculated.

Table 1: Influence of different treatment on growth characteristics of L-49 guava (Pooled mean for two season).

Treatment	Plant height increment (m)	Trunk girth (cm)	Canopy spread (N-S) M	Canopy spread (E-W) M	Shoot length (cm)	Number of shoots/ plants
T ₁	0.42 ^g	51.41 ^d	4.70 ^b	4.76 ^a	37.34 ^e	26.65 ^c
T ₂	0.53 ^{ef}	56.32 ^{cd}	5.09 ^{ab}	4.84 ^a	42.24 ^d	28.48 ^{bc}
T ₃	0.51 ^f	58.53 ^{bc}	5.33 ^a	4.81 ^a	44.45 ^{cd}	27.32 ^{bc}
T ₄	0.56 ^e	59.53 ^{abc}	5.02 ^{ab}	4.88 ^a	45.46 ^{bcd}	28.48 ^{bc}
T ₅	0.55 ^{ef}	56.56 ^{cd}	5.10 ^{ab}	4.87 ^a	42.48 ^d	28.48 ^{bc}
T ₆	0.62 ^{cd}	59.48 ^{abc}	4.93 ^{ab}	4.94 ^a	45.41 ^{bcd}	27.15 ^{bc}
T ₇	0.58 ^{de}	60.44 ^{abc}	5.09 ^{ab}	4.92 ^a	46.37 ^{abcd}	27.82 ^{bc}
T ₈	0.66 ^{bc}	62.34 ^{ab}	5.06 ^{ab}	4.98 ^a	48.27 ^{abc}	29.15 ^{bc}
T ₉	0.72 ^a	64.57 ^a	5.00 ^{ab}	5.04 ^a	50.49 ^a	32.15 ^a
T ₁₀	0.68 ^{ab}	62.61 ^{ab}	4.97 ^{ab}	5.00 ^a	49.21 ^{ab}	29.98 ^{ab}
SE(d) ±	0.02	2.42	0.20	0.23	1.88	1.24
C.D. _(0.05)	0.05	5.09	0.41	0.48	3.95	2.61

Note: The results are presented mean value ± standard error. Mean value with same letter indicate non significant and different letter as significant value.

Table 2: Influence of different treatments on growth and yield of L-49 guava (Pooled mean for two season).

Treatment	Shoot diameter (cm)	Number of leaves/shoots	Number of flowers/shoots	Number of fruits/plants	Fruit retention %	Fruit drop %	Yield (Kg/tree)
T ₁	2.94 ^c	32.84 ^g	22.89 ^{ab}	200.12 ^c	33.34 ^h	66.66 ^a	35.03 ^e
T ₂	3.32 ^b	35.50 ^{fg}	21.65 ^b	199.93 ^c	37.23 ^g	62.77 ^{ab}	37.35 ^{de}
T ₃	3.56 ^a	36.83 ^{ef}	22.96 ^{ab}	205.88 ^c	42.75 ^{ef}	57.26 ^{cd}	39.16 ^{de}
T ₄	3.25 ^b	38.17 ^{ef}	22.06 ^b	207.98 ^{bc}	40.02 ^f	59.95 ^{bc}	39.93 ^d
T ₅	3.33 ^b	40.00 ^{de}	22.83 ^{ab}	235.08 ^a	44.87 ^{de}	55.13 ^{cde}	45.17 ^c
T ₆	3.16 ^b	44.67 ^{bc}	24.96 ^a	228.51 ^{ab}	49.62 ^{abc}	50.37 ^{ef}	45.08 ^c
T ₇	3.33 ^b	42.00 ^{cd}	23.85 ^{ab}	239.05 ^a	47.14 ^{cd}	52.87 ^{def}	47.92 ^{bc}
T ₈	3.30 ^b	45.00 ^{bc}	23.86 ^{ab}	239.52 ^a	48.72 ^{bc}	51.27 ^{ef}	50.21 ^{ab}
T ₉	3.24 ^b	48.83 ^a	22.79 ^{ab}	246.75 ^a	51.93 ^a	48.07 ^f	53.80 ^a
T ₁₀	3.21 ^b	46.50 ^{ab}	23.64 ^{ab}	244.58 ^a	50.50 ^{ab}	49.50 ^f	51.55 ^{ab}
SE(d) ±	0.10	1.72	1.17	10.18	1.30	2.33	2.13
C.D. _(0.05)	0.21	3.61	2.45	21.39	2.73	4.89	4.47

Note: The results are presented mean value ± standard error. Mean value with same letter indicate non significant and different letter as significant value.

The percentage of fruit drop was determined using the following formula:

$$\text{Fruit drop (\%)} = \frac{(\text{Number of fruits at initial stage} - \text{Number of fruits retained at maturity})}{\text{Number of fruits at initial stage}} \times 100$$

The percentage of fruit retention was worked out using the formula:

$$\text{Fruit retention (\%)} = \frac{\text{Total number of fruits retained per shoot till maturity}}{\text{Number of fruits set per shoot}} \times 100$$

The number of fruits per plant was recorded at harvesting stage. Fruits harvested from each treatment were weighed using a balance and the total yield per plant was worked out in kilograms. The recorded data were subjected to statistical analysis following the procedure suggested by (Panse and Sukhatme, 8) under Randomized Block Design. Analysis of variance (ANOVA), correlation analysis and Principal Component Analysis (PCA) were performed using R Studio software (2026.04.0.). The significance of treatment differences was tested through 'F' test at 5% level of significance. Duncan's Multiple Range Test (DMRT) was employed for comparison of treatment means at p≤0.05.

RESULTS AND DISCUSSION

The results revealed that plant height increment and trunk girth of guava plants significantly influenced by different organic nutrient management. Among the treatments, T₉ recorded the maximum plant height increment (0.72 m) and trunk girth (64.57 cm) whereas the minimum plant height increment (0.42 m)

and trunk girth (51.41 cm) were observed under the control T₁. The superior performance under T₉ might be due to combined application of vermicompost, Panchagavya, PSB culture and Azotobacter, which enhanced nutrient availability, microbial activity and synthesis of growth-promoting substances, resulting in better root development and efficient nutrient absorption (Sarfaraj and Tripathi, 14). Furthermore, use of organic manures and mulching might have improved soil moisture conservation, aeration thereby promoting vigorous vegetative growth (Chouhan and Tripathi, 3) in guava.

The results revealed among the treatments, T₃ recorded the maximum canopy spread in the North-South direction (5.33 m), while the minimum (4.70 m) was observed under the control treatment T₁. In the East-West direction, the maximum canopy spread (5.04 m) was recorded under T₉, whereas the minimum was observed under T₁. The increased canopy spread might be attributed to the synergistic effect of vermicompost, Panchagavya, PSB culture and Azotobacter on nutrient availability, soil fertility and plant metabolism. Panchagavya supplied growth-promoting hormones, while Azotobacter and PSB enhanced nitrogen fixation and phosphorus availability, thereby improving vegetative growth (Sourabh *et al.*, 11). Similar findings were also reported by Bhadauria and Tripathi (1) in mango.

Among the treatments, T₉ recorded the maximum shoot length (50.49 cm) and number of shoots per plant (32.15), whereas the minimum under the control treatment T₁ (37.34 cm and 26.65, respectively). The

superior performance of T₉ might be attributed to the combined effect of vermicompost, Panchagavya, PSB culture and Azotobacter, which possibly enhanced nutrient mineralization, microbial activity and endogenous hormone production (Sumbul *et al.*, 12; Ram *et al.*, 10; Mishra and Tripathi, 7).

The results revealed that maximum shoot diameter was recorded in T₃ (3.56 cm), whereas the minimum was observed under the control treatment T₁ (2.94 cm) (Table 2). In contrast, T₉ produced the highest number of leaves per shoot (48.83), followed by T₁₀ (46.50) and T₈ (45.00), while the lowest number was recorded in T₁ (32.84). The enhanced vegetative growth might be attributed to improved nutrient availability, microbial activity and hormonal balance due to combined application of vermicompost, Panchagavya, PSB culture and Azotobacter, thereby promoting better plant vigour in guava (Chauhan and Tripathi, 2).

The data presented in Table 2 revealed treatments, T₆ recorded the highest number of flowers per shoot (24.96), while T₉ produced the maximum number of fruits per plant (246.75) and minimum number of flowers per shoot and fruits per plant was recorded under T₂ (21.65) and T₁ (200.12), respectively. The improved flowering and fruiting under integrated organic treatments might be attributed to balanced nutrient availability, enhanced microbial activity and increased synthesis of endogenous growth regulators and synergistic influence of Azotobacter and PSB culture possibly improved nitrogen fixation and phosphorus mobilization, thereby enhancing photosynthetic efficiency, assimilate partitioning and reproductive development (Pathak and Ram, 9; Swaminathan *et al.*, 13). The present experiment findings align with in strawberry (Tripathi *et al.*, 16).

The results presented in Table 2 for Fruit retention and fruit drop revealed among the treatments, T₉ recorded the highest fruit retention (51.93%) and the lowest fruit drop (48.07%), whereas the control treatment T₁ exhibited minimum fruit retention (33.34%) and maximum fruit drop (66.66%). The improved fruit retention under integrated organic treatments might be attributed to balanced nutrient availability, enhanced photosynthetic efficiency and better hormonal regulation due to combined application of vermicompost, Panchagavya, PSB culture, Azotobacter and mulching, thereby reducing fruit drop in guava (Sourabh *et al.*, 11).

The results presented in Table 2 indicated that treatments, T₉ recorded the highest yield (53.80 kg/tree), which was statistically at par with T₁₀ (51.55 kg/tree) and T₈ (50.21 kg/tree), whereas the minimum yield was observed under the control treatment T₁ (35.03 kg/tree). The enhanced yield under T₉ might

be attributed to the synergistic effect of vermicompost, Panchagavya, PSB culture and Azotobacter, which possibly improved nutrient availability, microbial activity and hormonal balance within the plant system (Kumar *et al.*, 6).

Furthermore, enhanced nitrogen fixation and phosphorus solubilization might have increased photosynthetic efficiency, assimilate production and translocation towards developing fruits, thereby improving fruit set, retention and overall productivity. In addition, mulching possibly conserved soil moisture and maintained favourable rhizosphere conditions, resulting in better nutrient uptake and reduced physiological stress. Similar findings have also been reported in guava (Dwivedi, 4).

The data on traits association presented in Fig. 1 revealed that most of the vegetative, flowering and yield parameters exhibited positive correlation with each other, whereas fruit drop showed negative association with almost all the traits. Canopy spread (North-South and East-West), shoot diameter, number of shoots per plant, trunk girth, shoot length, plant height increment and number of leaves per plant were positively associated with fruit retention and yield per plant. Likewise, number of fruits per plant exhibited strong positive correlation with trunk girth, shoot length, plant height increment, number of leaves per plant, fruit retention and yield per plant, while fruit drop remained negatively correlated. Trunk girth and shoot length also showed positive association with plant height increment, fruit retention and yield per plant. Similarly, plant height increment and number of leaves per plant were

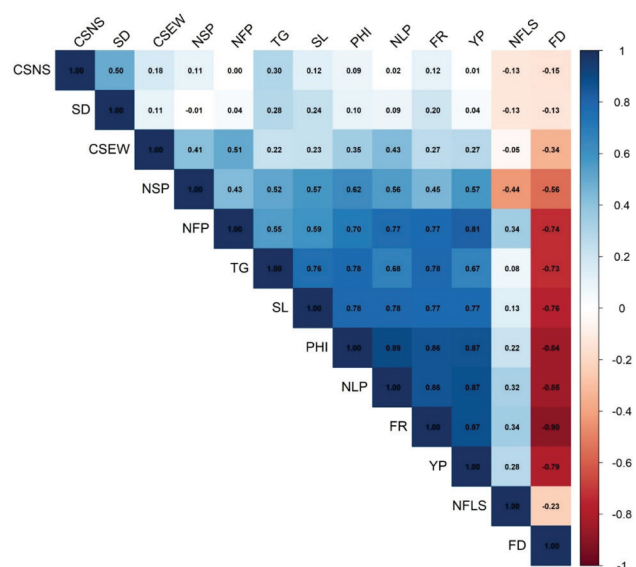


Fig. 1. Character association among vegetative and yield characteristics.

positively correlated with fruit retention and yield. Fruit retention exhibited strong positive association with yield per plant, whereas fruit drop showed highly negative correlation with most of the growth and yield contributing traits. The number of flowers per shoot also showed positive association with yield and fruit retention, but negative correlation with fruit drop. Overall, the correlation analysis indicated that vegetative growth traits such as trunk girth, shoot length, plant height increment, number of leaves per plant and fruit retention played an important role in improving yield per plant, while reduction in fruit drop could be a key factor for enhancing productivity in guava.

Principal component analysis revealed that out of thirteen principal components observed in the present investigation, only three PCs were found significant due to Eigen values greater than 1, contributing 78.64 per cent of the total variation, whereas the remaining PCs showed Eigen values less than 1 and were considered non-significant for the study (Table 3). Among the significant principal components, PC1 contributed maximum variability (54.76%), followed by PC2 (13.53%) and PC3 (10.36%).

PCA biplot analysis (Fig. 2) grouped the growth, flowering and yield parameters into different clusters based on their similarity and dissimilarity. Most of the

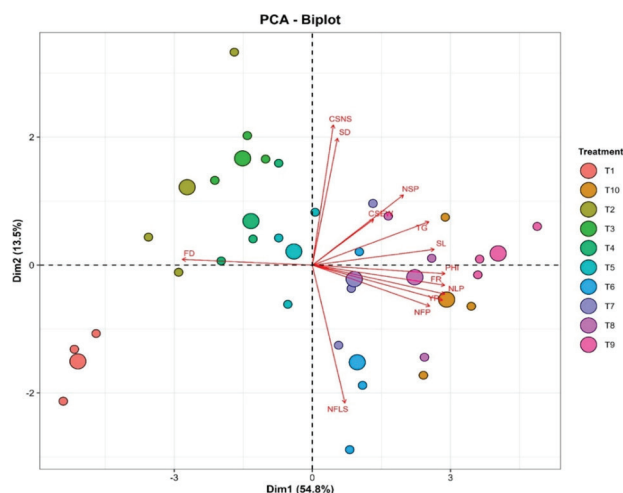


Fig. 2. Principal component analysis for vegetative and yield characteristics.

vegetative and yield contributing traits such as plant height increment, trunk girth, shoot length, number of leaves per plant, number of fruits per plant, fruit retention and yield per plant were highly associated with PC1 and exhibited strong positive loading values. In contrast, fruit drop showed strong negative association with PC1. Traits such as canopy spread

Table 3: Extracted eigenvalues and correlation values for growth, flowering and yield parameters with the first three principal components in guava.

Variables	Principles components		
	PC1	PC2	PC3
Eigen value	7.119	1.759	1.346
Explained variance (%)	54.758	13.528	10.357
Cumulative variance (%)	54.758	68.286	78.643
Characters			
PHI: Plant height increment	0.936	-0.044	-0.047
TG: Trunk girth	0.823	0.220	0.135
CSNS: Canopy spread (North-South)	0.148	0.712	0.432
CSEW: Canopy spread (East-West);	0.432	0.232	-0.280
SL: Shoot length	0.860	0.080	0.040
NSP: Number of shoots per plant	0.643	0.357	-0.613
SD: Shoot diameter	0.177	0.644	0.551
NLP: Number of leaves per plant	0.935	-0.147	-0.025
NFLS: Number of flowers per shoot	0.230	-0.700	0.587
NFP: Number of fruits per plant	0.828	-0.208	-0.024
FR: Fruit retention	0.934	-0.102	0.178
FD: Fruit drop	-0.918	0.029	-0.036
YP: Yield per plant	0.919	-0.179	-0.043

(North-South), shoot diameter and number of shoots per plant were mainly associated with PC2, whereas number of flowers per shoot showed negative association with PC2. Under PC3, canopy spread (North-South), shoot diameter and number of flowers per shoot exhibited comparatively higher positive loading values. The PCA biplot further revealed that the length and direction of vectors indicated the magnitude of contribution of individual traits towards total variability and the angles between vectors explained the relationship among the parameters. Traits grouped closely together exhibited positive association, while traits positioned opposite to each other showed negative association. The PCA biplot revealed that treatments T₈ and T₉ were highly associated with most of the vegetative, flowering and yield traits, whereas the control treatment (T₁) was associated with higher fruit drop. Treatment T₉ showed superior association with growth and yield parameters, indicating that integrated application of organic manures, mulching, bioenhancers and biofertilizers improved productivity and sustainability in guava cultivation.

The present study demonstrated that integrated organic nutrient management practices significantly enhanced growth, flowering, fruit retention, and yield attributes of guava cv. L-49. Among the treatments, T₉ [Vermicompost (1 kg/tree) + mulching with dry leaves + Panchagavya (5%) + PSB culture (50 g/tree) + Azotobacter (50 g/tree)] exhibited superior performance in improving vegetative growth and fruit yield. Correlation and principal component analyses further confirmed the strong contribution of growth and fruit retention parameters toward yield improvement. Therefore, the integrated use of organic nutrient sources and bioinputs can be recommended as a sustainable and effective strategy for enhancing productivity and maintaining ecological sustainability in guava

AUTHORS' CONTRIBUTION

Conceptualization of research (VKT); Designing of the experiments (VKT); Contribution of experimental materials (VKT); Execution of field/lab experiments and data collection (MP); Analysis of data and interpretation (MP); Preparation of the manuscript (MP).

DECLARATION

The authors should declare that they do not have any conflict of interest.

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