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Effects of foliar application of nutrients and plant growth regulators on vegetative growth, fruit yield and quality attributes of guava (*Psidium guajava* L.) cv. L-49

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Abstract

Guava (*Psidium guajava* L.) is an important tropical and subtropical fruit crop, valued for its nutritional quality and economic importance. However, optimising combinations of foliar application of nutrients and plant growth regulators (PGRs) combinations for improving productivity and fruit quality of mature guava fruit (L-49) under subtropical conditions remains an important production objective. The present study was conducted during the rabi seasons of 2023–24 and 2024–25 at Janta College, Bakewar, Etawah, Uttar Pradesh, India to evaluate the effects of foliar application of urea (1.0 %), potassium sulphate (K_2SO_4) (0.3 %), calcium sulphate ($CaSO_4$) (0.4 %), gibberellic acid (GA_3) (20 ppm) and naphthalene acetic acid (NAA) (30 ppm), individually and in combinations. The experiment comprised 26 treatments arranged in a randomised block design (RBD) with 3 replications. Among all the treatments, T_{25} (urea + K_2SO_4 + $CaSO_4$ + GA_3 + NAA) consistently produced the highest vegetative growth, fruit yield and sugar content and the lowest fruit acidity. At 40 days after spraying, T_{25} recorded leaf lengths of 12.18 cm and 13.03 cm, leaf widths of 7.15 cm and 7.65 cm, leaf areas of 87.08 cm² and 99.67 cm² and fruit yields of 66.98 kg tree^{-1} and 68.32 kg tree^{-1} (186.20 and 189.93 q ha^{-1}) in 2023–24 and 2024–25 respectively. It also recorded the highest total sugar content, with values of 9.58 % and 9.76 % and the lowest titratable acidity of 0.32 % in T_{25} in both years. The response is likely associated with complementary effects of nitrogen (N) on vegetative development, potassium (K) on photosynthesis and assimilate transport, calcium on cellular integrity and GA_3 and NAA on cell expansion, fruit retention and sink development. Overall, the combined foliar application represented by T_{25} showed promise as an integrated approach for improving growth, yield and fruit quality of guava cv. L-49 under the agro-climatic conditions of the study area. However, multi-location trials and economic validation are required before wider recommendation.

Keywords: calcium sulphate; fruit quality; fruit yield; gibberellic acid; naphthalene acetic acid; nutrients; potassium sulphate; plant growth regulators; urea; vegetative growth

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1. Introduction

Guava (*Psidium guajava* L.), belonging to the family Myrtaceae, is an economically and nutritionally important fruit crop cultivated extensively in tropical and subtropical regions. It is commonly referred to as the “apple of the tropics” and is valued for its vitamin C, dietary fibre, carotenoids, flavonoids, phenolic compounds and minerals. These constituents contribute to its nutritional and functional food value. Guava is generally well adapted to diverse climatic and soil conditions and can tolerate moderately saline and alkaline environments. Guava performs best in soils with a pH range of 6.5–8.5; however, higher soil pH levels can reduce the availability of

micronutrients such as zinc (Zn) and boron (B), thereby affecting yield and fruit quality (1, 2). The optimum temperature for its growth ranges from 23–26 °C, although the plant can withstand temperatures up to 46 °C, highlighting its resilience under changing climatic conditions (3). India is one of the major guava-producing countries and the crop contributes substantially to the fruit sector. Increasing consumer awareness of the nutritional and health-promoting properties of guava has further stimulated its cultivation and demand. However, productivity and fruit quality are influenced by seasonal climatic variation, nutrient availability, crop load and orchard management practices. In particular, the rainy season crop is often affected by insect pests such as fruit flies, resulting in considerable yield losses (4, 5). Therefore, efficient nutrient management and appropriate physiological regulation are essential for sustaining productivity and improving fruit quality under varying agro-climatic conditions. Among commercially important cultivars, L-49 (Sardar) is widely cultivated because of its semi-dwarf stature, prolific bearing habit, attractive fruit size, adaptability and consumer acceptance. Its fruits are generally large and oblong and are rich in vitamins, particularly vitamins A, B and C, as well as minerals such as iron (Fe) and phosphorus (P) (6, 7). Previous studies have reported significant responses to foliar application of nutrients, particularly Zn and potassium (K), in improving fruit yield and quality (8). The foliar application of K and calcium (Ca) has been reported to improve leaf growth, yield, fruit quality and fruit retention in guava (9). Nitrogen is closely associated with chlorophyll formation, protein synthesis, assimilate synthesis and vegetative growth, whereas K plays an important role in stomatal regulation, photosynthesis, assimilate transport and carbohydrate metabolism. Potassium also facilitates the translocation of photosynthates, thereby promoting sugar accumulation and potentially reducing fruit acidity (10, 11). Calcium is involved in cell wall stability, membrane integrity and cellular signalling, thereby supporting fruit development and quality. Plant growth regulators (PGRs) can further modify physiological and reproductive processes in guava. Gibberellic acid (GA_3) promotes cell elongation and influences flowering, fruit set and fruit development, whereas naphthalene acetic acid (NAA) can affect fruit retention, root development and sink activity depending on its concentration and timing of application (12, 13). The combined application of nutrients and PGRs may therefore influence both source development and sink strength, potentially resulting in improved vegetative growth, fruit retention, yield and biochemical composition. In addition to fruit quality, guava leaves contain several biologically active compounds, including flavonoids such as quercetin and phenolic acids such as ferulic, caffeic and gallic acids, which have been associated with antioxidant, anti-inflammatory and antidiabetic properties (14). Although previous studies have focused either on individual nutrients, selected nutrient combinations, or individual PGRs, comparatively limited information is available on the response of mature L-49 trees to a combined foliar application integrating N, K, Ca, GA_3 and NAA under rabi season conditions of the central Uttar Pradesh region. The scientific rationale of the present study was therefore to determine whether simultaneous foliar application of essential nutrients and PGRs could provide a stronger response than individual or partial combinations. The study specifically evaluated whether the integrated treatment could improve leaf development, yield and biochemical quality in mature L-49 trees.

2. Materials and Methods

Experimental site

The present investigation was carried out during the rabi seasons of 2023–24 and 2024–25 in a guava orchard at the Department of Horticulture, Janta College, Bakewar, Etawah, Uttar Pradesh, India. The study aimed to evaluate the response of mature guava cv. L-49 to foliar application of nutrients and PGRs. The experimental site is located in the middle of the north alluvial plains in central Uttar Pradesh with the Yamuna River to its right and has a subtropical climate.

Location and climatic conditions

Geographically, the guava orchard is located at approximately 26–28° N latitude and 80.34° E longitude, at an elevation of 149.5 m above mean sea level. The average rainfall of the area varies from 80–100 cm per annum. A major part of the rain is received between 25 June and 25 September. There are distinct summer and winter seasons and the temperature ranges between 30 °C in January and 48 °C in May–June. Occasional frost may occur during the winter season and dry hot winds are usual during the summer seasons.

Plant material and experimental design

The experimental material consisted of 20-year-old, healthy and uniformly maintained guava trees of cv. L-49 planted at a spacing of 6 × 6 m. A total of 78 plants were selected. The experiment was conducted in a randomised block design (RBD) with 26 treatments and 3 replications. The experimental unit consisted of one tree per treatment per replication.

Treatments details

The treatments consisted of foliar application of three nutrient sources, namely urea (1.0 %), potassium sulphate (K_2SO_4) (0.3 %) and calcium sulphate ($CaSO_4$) (0.4 %), along with two PGRs, GA_3 at 20 ppm and NAA at 30 ppm. These treatments were applied either alone or in combination, along with a water spray and an untreated control for comparison (Table 1).

Table 1. Treatment details

Treatments	Treatment combination	Doses quantity
T_1	Urea	1.0 %
T_2	K_2SO_4	0.3 %
T_3	$CaSO_4$	0.4 %

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T_4	GA_3	20 ppm
T_5	NAA	30 ppm
T_6	Urea + K_2SO_4	1.0 % + 0.3 %
T_7	Urea + $CaSO_4$	1.0 % + 0.4 %
T_8	Urea + GA_3	1.0 % + 20 ppm
T_9	Urea + NAA	1.0 % +30 ppm
T_{10}	K_2SO_4+ $CaSO_4$	0.3 % + 0.4 %
T_{11}	K_2SO_4+ GA_3	0.4 % + 20 ppm
T_{12}	K_2SO_4+ NAA	0.4 % + 30 ppm
T_{13}	$CaSO_4$+ GA_3	0.3 % + 20 ppm
T_{14}	$CaSO_4$+ NAA	0.3 % + 30 ppm
T_{15}	Urea + K_2SO_4+ $CaSO_4$	1.0 % + 0.3 % + 0.4 %
T_{16}	Urea + K_2SO_4 + GA_3	1.0 % + 0.4 % + 20 ppm
T_{17}	Urea+ K_2SO_4 + NAA	1.0 % + 0.4 % + 30 ppm
T_{18}	Urea + $CaSO_4$+ GA_3	1.0 % + 0.3 % + 20 ppm
T_{19}	Urea + $CaSO_4$+ NAA	1.0 % + 0.3 % + 30 ppm
T_{20}	Urea + GA_3+ NAA	1.0 % + 20 ppm + 30 ppm
T_{21}	K_2SO_4+ $CaSO_4$+ GA_3	0.4 % + 0.3 % + 20 ppm
T_{22}	K_2SO_4+ $CaSO_4$ + NAA	0.4 % + 0.3 % + 30 ppm
T_{23}	$CaSO_4$+ GA_3+ NAA	0.4 % + 20ppm + 30 ppm
T_{24}	GA_3+ NAA + K_2SO_4	20 ppm + 30 ppm + 0.3 %
T_{25}	Urea + K_2SO_4+ $CaSO_4$+ GA_3 + NAA	1.0 + 0.3 % + 0.4 % + 20 ppm + 30 ppm
T_{26}	Control (RDF) N : P : K	500 g N + 200 g P + 500 g K $tree^{-1}$

N: nitrogen; P: phosphorus; K: potassium; K_2SO_4: potassium sulphate; $CaSO_4$: calcium sulphate; GA_3: gibberellic acid; NAA: naphthalene acetic acid; RDF: recommended dose of fertiliser.

Preparation and application of spray

The spray solutions of various strengths were prepared separately for each treatment using distilled water and the pH of the solution was maintained as required by the formulation. The spraying was done with a 15 L capacity knapsack sprayer fitted with a hollow cone nozzle. Approximately, 8–10 L of spray solution per tree was used to achieve uniform wetting of the foliage and adequate coverage of both the upper and lower leaf surfaces without excess runoff. The same spray volume and application procedure were followed for all treatments. Foliar sprays were applied at three crop phenological stages, namely 15 days before flowering, during flowering and 15 days after flowering. The spraying was performed during the morning hours (09:00 –10:00 am) under relatively calm and dry weather conditions. During application, the air temperature was approximately 24–28 °C, relative humidity 70–75 % and wind speed below 10 km hr^{-1}.

Orchard management

All experimental trees received uniform orchard management practices, including irrigation, weed management, pruning, pest and disease management and basal nutrient application according to standard recommendations followed at the experimental site.

Morphological parameters

The observations of vegetative growth, like leaf length (cm), leaf width (cm) and leaf area (cm^2), were recorded at 20 and 40 days after spraying (DAS) using a digital vernier scale and a leaf-area meter. Yield parameters were assessed in terms of total fruit yield (kg $tree^{-1}$) and (q ha^{-1}). Fruit yield per hectare was calculated using the experimental planting density of 6 × 6 m, corresponding to approximately 278 trees ha^{-1}.

Biochemical analysis

Biochemical quality, viz., titratable acidity, sugar contents like reducing sugars, total sugars and non-reducing sugars of harvested guava fruits *P. guajava* cv.L-49 were analysed by standard procedures (15).

Titratable acidity (%)

Fresh guava fruits were washed and the edible portion was separated and homogenised thoroughly. A 10 g of fruit pulp was weighed and transferred to a 100 mL volumetric flask. Distilled water was added, the sample was thoroughly mixed and the volume was made up to 100 mL. The extract was filtered through Whatman No. 1 filter paper. A 10 mL aliquot of the filtrate was transferred to a conical flask and 2–3 drops of 1 % phenolphthalein were added. The aliquot was titrated against standardised 0.1 N NaOH until a persistent faint pink colour appeared. Titratable acidity was expressed as a percentage of citric acid.

$$\text{Titratable acidity} = \frac{V \times N \times E \times D \times 100}{W \times A \times 1000}$$

Where,

V = Volume of sodium hydroxide (NaOH) used (mL)

N = Normality of NaOH

E = Equivalent weight of citric acid (64.04)

D = Total volume of extract (mL)

W = Weight of sample (g)

A = Aliquot volume (mL)

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Reducing sugar (%)

Reducing sugars were estimated by the Lane and Eynon volumetric method (15). Approximately 5 g of homogenised guava pulp was weighed and extracted with distilled water. The extract was clarified using suitable clarification reagents and filtered. The clarified extract was diluted to a known volume. For estimation, a known volume of Fehling's solution A and Fehling's solution B was mixed and boiled. The fruit extract was then added gradually from a burette while boiling. Methylene blue indicator was added near the end point and titration was continued until the blue colour disappeared, leaving a brick-red precipitate of cuprous oxide. The amount of reducing sugar was calculated from the titre value and expressed as a percentage of fresh fruit weight.

$$\text{Reducing sugar (\%)} = \frac{\text{Dilution factor} \times \text{Fehling factor} \times 100}{\text{Titre value} \times \text{Weight of sample}}$$

Total sugar (%)

For estimation of total sugars, the prepared fruit extract was subjected to acid hydrolysis to convert non-reducing sugars, principally sucrose, into reducing sugars. A measured quantity of the clarified extract was treated with dilute hydrochloric acid and heated under controlled conditions. After hydrolysis, the solution was cooled and neutralised with NaOH using an appropriate indicator. The volume was made up to a known volume and filtered if necessary. The hydrolysed extract was titrated against standardised Fehling's solution using the Lane and Eynon procedure described above. The titre value was used to calculate total sugars, which were expressed as a percentage.

Non-reducing sugars

Non-reducing sugars were calculated by subtracting the reducing sugar content from the total sugar content and expressed as a percentage.

Non-reducing sugar (%) = Total sugars (%) - Reducing sugar (%)

Statistical analysis of data

The field experiment was conducted in a RBD with 3 replications of each treatment. The data obtained from the experiments were analysed through one-way analysis of variance (ANOVA). Treatment means were compared using the critical difference (CD) at the 5 % level of significance and the *F*-value was tested for comparing treatment means. Critical difference was calculated by the following formula:

$$C.D = \frac{\sqrt{2VE}}{r} \times 't' \text{ at } 5\ \%$$

Where,

CD = critical difference, VE = error variance and r = number of replications is the value at 5 % level of significance for error degree of freedom. The significance and non-significance of the treatments at 5 % level of probability were calculated by multiplying the S. Ed. with the appropriate tabulated value for error degrees of freedom.

3. Results

Morphological parameters

The results presented in Table 2 revealed that the foliar application of nutrients and PGRs had a significant effect on vegetative growth parameters of guava cv. L-49 during the rabi season of both years (2023–24 and 2024–25). The observations were recorded in terms of leaf length (cm), leaf width (cm) and leaf area (cm²) at 20 and 40 DAS.

Leaf length (cm)

A perusal of the data indicates that leaf length was significantly influenced by different treatments at both stages of observation. At 20 DAS, the maximum leaf length was recorded under treatment T25 (urea + K_2SO_4 + $CaSO_4$ + GA_3 + NAA) with values of 11.90 cm in both years, which was statistically superior to all other treatments. At 40 DAS, the same treatment again recorded the highest leaf length with values of 12.18 cm and 13.03 cm during 2023–24 and 2024–25 respectively. Among all the treatments, T17 (urea + K_2SO_4 + NAA) and T16 (urea + K_2SO_4 + GA_3) also showed significantly higher leaf length compared to individual applications. The minimum leaf length was observed under control (RDF), indicating the beneficial effect of foliar nutrition and growth regulators over conventional fertilisation. The increase in leaf length might be due to enhanced cell elongation and division caused by GA_3, along with improved N availability from urea, which plays a key role in vegetative growth.

Table 2. Foliar application of plant growth regulators (PGRs) and nutrients on vegetative growth of *Psidium guajava* cv. L-49 during rabi season of 2023–24 and 2024–25

Treatments	Treatments combination	Length of leaf (cm)				Width of leaf (cm)				Leaf area (cm^2)			
		20 DAS		40 DAS		20 DAS		40 DAS		20 DAS		40 DAS	
		2023-24	2024-25	2023-24	2024-25	2023-24	2024-25	2023-24	2024-25	2023-24	2024-25	2023-24	2024-25
T_1	Urea	7.96	8.57	9.26	9.39	5.30	6.12	5.93	6.44	42.18	52.44	54.91	60.47
T_2	K_2SO_4	7.85	7.59	8.48	7.82	5.60	5.69	5.96	6.07	43.96	43.18	50.54	47.46
T_3	$CaSO_4$	8.00	7.38	8.37	8.04	5.20	5.83	5.68	6.19	41.60	43.02	47.54	49.76
T_4	GA_3	7.85	8.22	9.01	8.70	4.96	6.15	6.02	6.71	38.93	50.55	54.24	58.37

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T_5	NAA	8.40	8.36	8.44	8.39	5.15	5.89	6.04	6.50	43.26	49.24	50.97	54.53
T_6	Urea + K_2SO_4	9.15	9.27	9.60	9.35	5.88	6.63	6.27	6.89	53.80	61.46	60.19	64.42
T_7	Urea + $CaSO_4$	8.75	9.25	8.95	10.23	5.28	6.28	6.32	6.72	46.20	58.09	56.56	68.74
T_8	Urea + GA_3	8.97	8.98	9.10	9.36	5.40	6.57	6.47	6.68	48.43	58.99	58.60	62.52
T_9	Urea + NAA	9.04	9.47	9.43	9.92	6.03	6.51	6.60	6.77	54.51	61.64	62.23	67.15
T_{10}	K_2SO_4 + $CaSO_4$	8.87	9.11	9.47	9.64	5.58	6.01	6.12	6.43	49.49	54.75	57.95	61.98
T_{11}	K_2SO_4 + GA_3	8.36	9.33	9.54	9.61	5.48	6.57	5.97	6.65	45.81	61.29	56.95	63.90
T_{12}	K_2SO_4 + NAA	9.14	9.82	10.33	9.88	5.85	6.36	6.49	6.77	53.46	62.45	67.04	66.88
T_{13}	$CaSO_4$ + GA_3	8.83	11.19	10.43	11.90	5.83	6.08	6.40	6.69	51.47	68.03	66.75	79.61
T_{14}	$CaSO_4$ + NAA	8.69	11.35	10.90	12.20	5.53	6.24	6.53	6.50	48.05	70.82	71.17	79.30
T_{15}	Urea + K_2SO_4 + $CaSO_4$	10.88	11.42	11.26	12.36	5.78	6.66	6.53	6.90	62.88	76.05	73.52	85.28
T_{16}	Urea + K_2SO_4 + GA_3	11.07	11.57	11.50	12.70	5.56	6.87	6.94	7.20	61.45	79.48	79.81	91.44
T_{17}	Urea+ K_2SO_4 + NAA	11.45	11.42	11.77	12.86	5.95	6.97	7.07	6.93	68.12	79.59	83.21	89.11
T_{18}	Urea + $CaSO_4$ + GA_3	10.04	10.07	10.83	10.18	6.31	6.52	6.55	6.96	63.35	65.65	70.93	70.85
T_{19}	Urea + $CaSO_4$ + NAA	10.27	9.97	11.30	10.20	5.92	6.30	6.55	6.70	60.79	62.81	74.01	68.34
T_{20}	Urea + GA_3 + NAA	10.82	10.16	11.30	10.46	6.05	6.43	6.64	6.90	65.46	65.32	75.03	72.17
T_{21}	K_2SO_4+ $CaSO_4$ + GA_3	10.21	10.38	11.10	10.83	6.52	6.27	6.35	6.88	66.56	65.08	70.48	74.51
T_{22}	K_2SO_4+ $CaSO_4$ + NAA	10.42	10.49	11.50	10.74	6.38	6.44	6.48	6.80	66.47	67.55	74.52	73.03
T_{23}	$CaSO_4$+ GA_3 + NAA	10.73	10.78	11.60	11.20	6.47	6.44	6.58	6.92	69.42	69.42	76.32	77.50
T_{24}	GA_3+ NAA + K_2SO_4	11.19	10.91	12.16	11.26	6.69	6.38	6.72	6.80	74.86	69.60	81.71	76.56
T_{25}	Urea + K_2SO_4 + $CaSO_4$ + GA_3 + NAA	11.90	11.90	12.18	13.03	6.52	7.12	7.15	7.65	77.58	84.72	87.08	99.67
T_{26}	Control (RDF)	7.34	6.29	8.10	6.84	6.31	6.39	6.43	6.83	46.31	40.19	52.08	43.98
	C.D. at 5 %	0.60	0.64	0.68	0.82	0.91	0.51	0.37	0.43	5.24	4.85	4.29	4.83
	SE(m)	0.31	0.22	0.24	0.29	0.31	0.18	0.13	0.15	1.84	1.70	1.51	1.70

N: nitrogen; P: phosphorus; K: potassium; K_2SO_4: potassium sulphate; $CaSO_4$: calcium sulphate; GA_3: gibberellic acid; NAA: naphthalene acetic acid; RDF: recommended dose of fertiliser.

Leaf width (cm)

Leaf width was also significantly affected by the application of nutrients and PGRs. At 20 DAS, treatment T_{25} recorded the maximum leaf width represented as 6.52 and 7.12 cm, while at 40 DAS, it maintained superiority with values of 7.15 and 7.65 cm during both 2023–24 and 2024–25 years. The treatments involving combined application of nutrients and growth regulators performed better than their individual applications. Treatments such as T_{17} and T_{21} (K_2SO_4 + $CaSO_4$ + GA_3) also exhibited comparatively higher leaf width values. The increase in leaf width may be attributed to the role of K in regulating stomatal activity and photosynthesis, Ca in strengthening cell walls and auxins (NAA) in promoting cell expansion.

Leaf area (cm²)

Leaf area is an important parameter reflecting the photosynthetic capacity of the plant. The data clearly show that leaf area increased significantly with the application of combined treatments. The maximum leaf area was recorded under T_{25}, with values of 77.58 and 84.72 cm² at 20 DAS and 87.08 and 99.67 cm² at 40 DAS during 2023–24 and 2024–25, respectively. The next best treatments were T_{17} and T_{16}, which also recorded higher leaf area compared to other treatments. The lowest leaf area was recorded under control (RDF), confirming the effectiveness of foliar feeding. The increase in leaf area could be due to the combined effect of N, K and Ca along with growth regulators. Nitrogen enhances chlorophyll content and vegetative growth, K improves translocation of photosynthates, while GA_3 and NAA promote cell enlargement and division, leading to larger leaf surface area.

Fruit yield and quality parameters

The data presented in Table 3 clearly indicate that the foliar application of nutrients in combination with PGRs significantly influenced fruit yield and quality parameters of guava cv. L-49 during the rabi season of both experimental years (2023–24 and 2024–25).

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Table 3. Foliar application of plant growth regulators (PGRs) and nutrients on fruit yield, quality of *Psidium guajava* cv. L-49 during rabi season of 2023–24 and 2024–25

Treatments	Treatments combination	Fruit yield (kg tree^{-1})		Fruit yield (q ha^{-1})		Acidity (%)		Reducing (%)		Non- reducing (%)		Total sugar (%)	
		2023–24	2024–25	2023–24	2024–25	2023–24	2024–25	2023–24	2024–25	2023–24	2024–25	2023–24	2024–25
T_1	Urea	52.78	55.93	146.74	155.50	0.51	0.50	3.36	3.24	2.57	2.46	5.92	5.71
T_2	K_2SO_4	47.97	52.36	133.35	145.55	0.53	0.53	3.08	3.09	2.05	2.14	5.16	5.23
T_3	$CaSO_4$	46.87	51.42	130.29	142.94	0.54	0.54	2.94	3.02	1.97	1.98	4.86	5.00
T_4	GA_3	47.53	53.89	132.14	149.83	0.52	0.52	3.09	3.15	2.23	2.25	5.32	5.40
T_5	NAA	47.58	56.32	132.29	156.57	0.52	0.51	3.30	3.22	2.33	2.37	5.63	5.59
T_6	Urea + K_2SO_4	47.39	61.23	131.74	170.23	0.45	0.47	4.19	3.85	3.38	2.94	7.57	6.79
T_7	Urea + $CaSO_4$	49.68	59.73	138.11	166.06	0.47	0.48	3.70	3.58	3.27	3.19	6.98	6.78
T_8	Urea + GA_3	48.82	60.13	135.73	167.15	0.47	0.47	3.85	3.79	3.36	3.37	7.21	7.16
T_9	Urea + NAA	50.62	60.75	140.73	168.89	0.46	0.46	4.14	3.72	3.62	3.23	7.76	6.96
T_{10}	K_2SO_4 + $CaSO_4$	53.72	57.27	149.35	159.20	0.51	0.52	3.63	3.38	3.16	2.81	6.79	6.19
T_{11}	K_2SO_4 + GA_3	53.45	58.62	148.59	162.96	0.49	0.51	3.90	3.52	3.00	2.98	6.90	6.50
T_{12}	K_2SO_4 + NAA	53.07	59.05	147.53	164.16	0.48	0.49	3.92	3.67	3.05	3.34	6.97	7.01
T_{13}	$CaSO_4$ + GA_3	48.47	57.77	134.76	160.59	0.50	0.50	3.70	3.44	2.93	2.99	6.63	6.43
T_{14}	$CaSO_4$ + NAA	50.11	58.55	139.31	162.77	0.49	0.41	4.03	3.46	3.81	3.82	7.85	7.28
T_{15}	Urea + K_2SO_4 + $CaSO_4$	63.39	66.61	176.22	185.18	0.36	0.36	4.65	4.58	4.40	4.46	9.05	9.03
T_{16}	Urea + K_2SO_4 + GA_3	64.48	67.27	179.26	187.02	0.35	0.35	4.73	4.68	4.51	4.61	9.24	9.29
T_{17}	Urea+ K_2SO_4 + NAA	65.13	67.84	181.07	188.61	0.33	0.33	4.79	4.79	4.61	4.72	9.40	9.52
T_{18}	Urea + $CaSO_4$ + GA_3	59.62	64.49	165.74	179.29	0.39	0.42	4.49	4.47	4.03	4.07	8.52	8.55
T_{19}	Urea + $CaSO_4$ + NAA	61.18	65.68	170.08	182.60	0.38	0.40	4.50	4.39	4.21	4.19	8.71	8.58
T_{20}	Urea + GA_3 + NAA	62.32	66.45	173.24	184.73	0.37	0.38	4.58	4.47	4.30	4.30	8.89	8.77
T_{21}	K_2SO_4+ $CaSO_4$ + GA_3	56.25	61.84	156.38	171.90	0.44	0.45	4.25	3.48	3.93	3.60	8.18	7.08
T_{22}	K_2SO_4+ $CaSO_4$ + NAA	55.86	62.53	155.29	173.85	0.43	0.45	4.36	4.23	3.79	3.74	8.15	7.97
T_{23}	$CaSO_4$+ GA_3 + NAA	56.04	63.42	155.78	176.30	0.41	0.43	4.39	4.11	3.88	3.88	8.28	7.99
T_{24}	GA_3+ NAA + K_2SO_4	56.97	64.20	158.39	178.48	0.40	0.42	4.37	4.22	3.92	3.92	8.28	8.14
T_{25}	Urea + K_2SO_4 + $CaSO_4$ + GA_3 + NAA	66.98	68.32	186.20	189.93	0.32	0.32	4.85	4.90	4.73	4.86	9.58	9.76
T_{26}	Control (RDF)	46.54	48.30	129.37	134.28	0.56	0.56	2.91	2.98	1.60	1.86	4.53	4.82
	C.D. at 5 %	2.50	1.39			0.02	0.03	0.23	0.39	0.38	0.37	0.53	0.56
	SE(m)	0.88	0.49			0.01	0.01	0.08	0.14	0.13	0.13	0.19	0.20

N: nitrogen; P: phosphorus; K: potassium; K_2SO_4: potassium sulphate; $CaSO_4$: calcium sulphate; GA_3: gibberellic acid; NAA: naphthalene acetic acid; RDF: recommended dose of fertiliser.

Fruit yield (kg tree^{-1} and q ha^{-1})

Among all the treatments, the combined application of urea + K_2SO_4 + $CaSO_4$ + GA_3 + NAA (T_{25}) recorded the highest fruit yield in both years (66.98 and 68.32 kg tree^{-1}, equivalent to 186.20 and 189.93 q ha^{-1}) respectively. This was closely followed by treatments involving multiple nutrient combinations with growth regulators such as T_{17} and T_{20}. In contrast, the lowest yield was observed under the control (RDF), indicating the positive role of foliar feeding. The improvement in yield may be attributed to enhanced photosynthetic efficiency, better nutrient translocation and hormonal balance, which collectively promote flowering, fruit set and fruit retention.

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Acidity (%)

Fruit acidity showed a decreasing trend with the application of combined treatments. The lowest acidity (0.32 %) was recorded under T_{25} during both 2023–24 and 2024–25 years, whereas the highest acidity (0.56 %) was observed in the control. This reduction in acidity may be due to increased conversion of organic acids into sugars during fruit maturation, facilitated by growth regulators and balanced nutrition.

Reducing sugars (%)

Reducing sugar content increased significantly with combined applications of treatments. The maximum reducing sugars (4.85 % and 4.90 %) were noted in T_{25}, followed by T_{17} and T_{20}. The lowest values were recorded in the control treatment. This increase may be due to enhanced enzymatic activity and conversion of complex carbohydrates into simple sugars under the influence of growth regulators like GA_3 and NAA.

Non-reducing sugars (%)

A similar increasing trend was observed in non-reducing sugars, where T_{25} recorded the highest values (4.73 % and 4.86 %). Improved carbohydrate metabolism and efficient translocation of assimilates from source to sink might have contributed to this enhancement.

Total sugars (%)

The total sugar content was also significantly influenced by combined application of treatments. The maximum total sugar content (9.58 % and 9.76 %) was recorded in T_{25}, while the control showed the minimum values. The combined effect of nutrients and PGRs likely improved sugar accumulation through enhanced photosynthesis and metabolic activity.

4. Discussion

The present study revealed that foliar application of nutrients and PGRs significantly improved vegetative growth, fruit yield and quality parameters of mature guava cv. L-49 during both years of experimentation. Among the treatments, T_{25} (urea + K_2SO_4 + $CaSO_4$ + GA_3 + NAA) proved to be most effective, recording maximum leaf length, leaf width, leaf area and fruit yield, represented as 12.18 cm and 13.03 cm, 7.15 cm and 7.65 cm, 87.08 cm² and 99.67 cm² and 66.98 kg tree^{-1} (186.20 q ha^{-1}) and 68.32 kg tree^{-1} (189.93 q ha^{-1}) at 40 DAS, during 2023–24 and 2024–25 respectively. The improvement in vegetative growth might be due to the combined effects of N, K, Ca, GA_3 and NAA. Nitrogen promotes chlorophyll formation, protein synthesis and vegetative development, K may contribute to stomatal regulation, photosynthetic activity and assimilate translocation, while Ca may support cell-wall stability and membrane functions. The GA_3 promotes cell elongation, whereas NAA can improve fruit retention and sink development when applied at appropriate concentrations and developmental stages. Therefore, simultaneous availability of N, K and Ca through foliar application may have improved both source capacity and physiological efficiency of the treated trees. Similar findings were reported for improved vegetative growth and fruit yield in guava with foliar application of urea and K nutrients (16). The significantly increased leaf area (72.25 cm²) and fruit yield (41.44 kg tree^{-1}) with foliar spray of K and Ca in guava were previously reported (17). The similar finding was also supported by the synergistic effect of N, K, Ca and growth regulators that likely improved metabolic activities and reduced fruit drop (9, 18–20). Fruit quality parameters were also positively influenced by foliar sprays of nutrients and PGRs. The lowest acidity (0.32 and 0.32 %), highest reducing sugars (4.85 % and 4.90 %), non-reducing sugars (4.73 % and 4.86 %) and total sugar content (9.58 % and 9.76 %) were recorded under T_{25} during both 2023–24 and 2024–25 years respectively. Similar findings were reported and significantly higher total soluble solids (12.88 °Brix), total sugars (8.64 %) and lower acidity (0.41 %) in guava following foliar application of urea and K nutrients (16). The foliar spray of K and Ca significantly improved fruit quality by increasing total soluble solids (11.70 °Brix), total sugars (9.21 %) and reducing acidity (0.36 %) in guava under subtropical conditions (17). These above results are in close conformity with the earlier findings, which reported that the reduction in acidity and increase in sugar content may be attributed to enhanced metabolic activity and conversion of organic acids into sugars during fruit ripening (21). Furthermore, the increase in total sugars observed in the present study may be attributed to improved photosynthesis and carbohydrate metabolism, which corroborates the findings reported earlier (9). Overall, the combined foliar application of urea + K_2SO_4 + $CaSO_4$ + GA_3 + NAA (T_{25}) was found to be most beneficial for improving growth, yield and fruit quality of mature guava cv. L-49 under rabi season conditions.

5. Conclusion

From the above findings, it can be concluded that the foliar application of nutrients in combination with plant growth regulators (PGRs), particularly the treatment comprising urea + potassium sulphate (K_2SO_4) + calcium sulphate ($CaSO_4$) + gibberellic acid (GA_3) + naphthalene acetic acid (NAA) (T_{25}), significantly enhanced vegetative growth, fruit yield and fruit quality attributes of guava cv. L-49 during the rabi season of both 2023–24 and 2024–25 years. Treatment (T_{25}) consistently recorded the highest values for growth parameters, fruit yield, along with higher sugar contents and lower fruit acidity compared with the control. Therefore, the integrated application of foliar nutrients and PGRs may be considered a promising approach for improving productivity and fruit quality in guava cv. L-49 under similar agro-climatic conditions. However, T_{25} should not be presented as a universal recommendation until its performance is validated through multi-location and multi-season trials and its economic feasibility is established. Future studies should evaluate these components using a factorial experimental design across multiple locations and seasons, together with measurements of nutrient uptake,

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photosynthetic activity, fruit retention, carbohydrate partitioning and economic returns. Such validation will be necessary to establish the agronomic and economic feasibility of T_{25} before recommending its wider adoption.

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Authors' contributions

K carried out the experiment, took observations and analysed the data. SKV guided the research by formulating the research concept and SK approved the final manuscript. SK, PT, NKS participated in the design of the study and performed the statistical analysis reviewed the SP, AKS contributed by imposing the experiment and helped edit, summarise and revise the manuscript. SK, DB and MR summarised and revised the manuscript. All authors have read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest

Authors do not have any conflict of interests to declare.

Ethical issues

None

References

1. Patel H, Patel N. Effect of foliar nutrition on yield and quality attributes of guava under semi-arid conditions. J Appl Hortic. 2024;26(1):65–70.
2. Sharma R, Yadav S, Verma D. Micronutrient deficiency and its impact on guava productivity. Plant Nutr Fert Sci. 2023;29(2):234–42.
3. Rana A, Singh B, Kaur P. Climate resilience of guava under abiotic stress conditions. Agric Rev. 2022;43(4):389–95.
4. Sharma RR, Nagaraja A. Overcoming fruit fly incidence in guava. Indian Hortic. 2016;61(5).
5. Chandana MR, Menaka M, Singh SK, Goswami AK, Ramya Sree M. Eco-friendly management of fruit fly for quality guava production. Indian Hortic. 2023;68(1):43–6.
6. Meena KC. Integrated nutrient management in guava. Sci Hortic. 2024;3(10):111–9.
7. Singh A, Patel R, Kumar S. Pest dynamics and management strategies in guava orchards. J Entomol Zool Stud. 2023;11(3):150–6.
8. Choudhary R, Meena NK, Yadav L. Evaluation of guava cultivars for growth, yield and fruit quality under subtropical conditions. Indian J Hortic. 2022;79(3):345–50.
9. Reddy ML, Kumar N, Rao P. Performance of guava cv. Sardar under different agro-climatic conditions. Indian J Hortic. 2023;80(1):89–95.
10. Kumar R, Yadav P, Mehta S. Role of macro- and micronutrients in improving fruit quality of guava. Hortic Plant J. 2024;10(1):45–53.
11. Yadav P, Kumar R, Singh A. Influence of potassium on fruit quality attributes in guava. Int J Plant Sci. 2023;18(2):145–50.
12. Gupta S, Verma P, Singh A. Effect of plant growth regulators on flowering and fruit set in guava. J Appl Hortic. 2023;25(1):55–60.
13. Singh R, Kumar P, Yadav L. Effect of plant growth regulators on yield and quality of guava. Hortic Int J. 2024;8(2):101–7.
14. Shabbir MA, Khan MR, Saeed F. Functional and nutraceutical properties of guava leaves. Food Biosci. 2023;5(3):102–24.
15. Ranganna S. Handbook of analysis and quality control for fruit and vegetable products. 2nd ed. New Delhi: Tata McGraw-Hill Publishing Company; 1986.
16. Kumar R, Meena RS. Influence of foliar nutrition on guava fruit quality. J Plant Nutr. 2022;45(6):897–905.
17. Patel V, Kumar S, Singh R. Soil pH and micronutrient dynamics affecting guava production. Arch Agron Soil Sci. 2024;70(3):412–25.
18. Verma M. Influence of foliar sprays on carbohydrate metabolism in guava. Hortic Plant J. 2021;7(3):210–8.
19. Sharma A. Effect of GA3 and NAA on biochemical composition of guava. Indian J Hortic. 2020;77(2):245–50.
20. Yadav S, Meena RS, Kumar V. Influence of micronutrients and growth regulators on flowering, fruit set and yield of guava. Indian J Agric Res. 2022;56(3):310–5.
21. Baloda S, Sharma JR, Sharma S, Malik A, Prince, Tokas J, et al. Assessment of foliar application of nutrients on yield and quality of guava (*Psidium guajava* L.). Indian J Agric Sci. 2024;94(4):382–6. http://doi.org/10.56093/ijas.v94i4.144539

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