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Original Research Paper

Effect of foliar application of calcium and potassium on growth, yield and quality of guava (*Psidium guajava* L.)

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ABSTRACT

The present experiment was carried out to evaluate the effect of foliar application of calcium nitrate and potassium sulphate on growth, yield, and fruit quality of guava cv. L-49, during 2022 to 2023, in randomized block design with ten treatments *viz*., T_1 (absolute control), T_2 [$Ca(NO_3)_2$ 2%], T_3 [$Ca(NO_3)_2$ 4%], T_4 [$Ca(NO_3)_2$ 6%], T_5 [K_2SO_4 2%], T_6 [K_2SO_4 4%], T_7 [K_2SO_4 6%], T_8 [$Ca(NO_3)_2$ 2% + K_2SO_4 2%], T_9 [$Ca(NO_3)_2$ 4% + K_2SO_4 4%] and T_{10} [$Ca(NO_3)_2$ 6% + K_2SO_4 6%]. Results revealed that T_9-Ca $(NO_3)_2$ (4%) + K_2SO_4 (4%) significantly enhanced all measured parameters. T_9 [$Ca(NO_3)_2$ 4% + K_2SO_4 4%] exhibited earliest flower bud initiation (24.83 days), flowering (24.17 days) and highest flower count per shoot (20.55). The highest fruit set (8.83 fruits/shoot), lowest fruit drop (2.17 fruits/shoot) and maximum fruit retention (6.33 fruits/shoot) were also recorded under T_9. In terms of physical attributes, fruit weight (148.14 g), length (4.58 cm), width (4.14 cm) and volume (163.20 cm^3) were significantly improved. Yield per plant (45.29 kg) and per hectare (11.87 t) were highest in T_9. Biochemical quality parameters were significantly enhaced under T_9 such as total soluble solids (9.93%), ascorbic acid (235.96 mg/100 g) and total sugars (9.64%) with the lowest acidity (0.28%) and longest shelf-life (13.38 days). These findings highlight the substantial benefits of Ca $(NO_3)_2$ and K_2SO_4 in improving guava productivity and quality, with T_9 emerging as the most effective treatment.

Keywords: Calcium nitrate, flowering, fruit retention, fruit yield, guava potassium sulphate

INTRODUCTION

Guava (*Psidium guajava* L.), often referred to as the 'apple of the tropics', holds immense economic and nutritional significance. Indigenous to tropical America and introduced to India in the 17th century (Menzel & Paxton, 1985). Guava has adapted well to diverse agro-climatic conditions *viz.*, Maharashtra, Uttar Pradesh, Madhya Pradesh, Bihar and Gujarat. India is the leading global guava producer, with a cultivation area of approximately 3.61 lakh hectares and an annual production of 5.37 million tons (Anon., 2024). The fruit acclaimed for its high vitamin C (260 mg/100 g), is extensively utilised in fresh consumption and in fruit processing industry (Bhattacherjee & Tandon, 2021).

Calcium is integral for cell division, elongation and maintaining cell wall integrity. Potassium regulates osmotic balance, enhances enzymatic activity and improves fruit size, colour, sweetness and overall sensory attributes (Afroz et al., 2023; da Silva et al., 2023).

Numerous studies have highlighted the benefits of calcium and potassium supplementation for improving nutrient availability and uptake efficiency in high-density planting systems, closer spacing increases competition for resources and alters the canopy microclimate. Under such intensive conditions, calcium nitrate and potassium are essential for maintaining productivity, fruit quality, and physiological stability (Ganeshamurthy et al., 2023). Application of these nutrients in mitigating oxidative stress, strengthening plant resistance against abiotic stressors and extending post-harvest shelf life (Cavalcante et al., 2018).

The present study aims to evaluate the effect of calcium nitrate and potassium sulphate on vegetative growth, yield, quality and post harvest storability of guava cv. L-49.

Table 1 : Effect of calcium and potassium on flowering and fruiting parameters of guava cv. L-49

Treatment	Days to flower bud initiation	Days to first flower	No. of flowers/shoot	Fruit set/ shoot	Fruit drop/ shoot	Fruit retention/ shoot
T_1-Absolute control	38.83±0.49a	45.50±0.36a	10.83±0.10g	5.85±0.06g	4.83±0.10a	1.02±0.03h
T_2-Ca $(NO_3)_2$ (2%)	30.58±0.33c	30.40±0.53fg	16.51±0.08cd	7.83±0.03de	3.54±0.04c	5.05±0.05d
T_3-Ca $(NO_3)_2$ (4%)	27.83±0.52b	30.83±0.28f	16.83±0.17c	8.59±0.10b	3.17±0.01d	5.66±0.05c
T_4-Ca $(NO_3)_2$ (6%)	32.52±0.05d	35.83±0.12c	15.83±0.15e	8.17±0.03c	4.50±0.05b	3.67±0.00f
T_5-K_2SO_4 (2%)	28.52±0.38b	32.17±0.62e	16.17±0.14de	8.03±0.08cd	3.17±0d	5.02±0.11d
T_6- K_2SO_4 (4%)	27.53±0.07b	28.50±0.22h	18.17±0.15b	8.77±0.14ab	2.83±0.01e	5.85±0.04b
T_7- K_2SO_4 (6%)	32.83±0.22d	33.83±0.32d	15.83±0.06e	7.73±0.08e	2.83±0.01e	4.63±0.07e
T_8-Ca $(NO_3)_2$ (2%) + K_2SO_4 (2%)	30.52±0.02c	29.50±0.30gh	16.61±0.16c	8.06±0.04cd	3.50±0.04c	5.15±0.03d
T_9-Ca $(NO_3)_2$ (4%) + K_2SO_4 (4%)	24.83±0.32a	24.17±0.19i	20.55±0.15a	8.83±0.05a	2.17±0.03f	6.33±0.06a
T_{10}-Ca $(NO_3)_2$ (6%) + K_2SO_4 (6%)	36.50±0.50b	42.50±0.33b	11.83±0.16f	6.50±0.07f	4.83±0.05a	1.67±0g
SE(m)±	0.24	0.46	0.20	0.08	0.03	0.07
CD at 5%	0.69	1.33	0.58	0.23	0.09	0.20

MATERIALS AND METHODS

The experiment was conducted at the Horticulture Garden, Department of Fruit Science, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, during July 2022 to October 2023. The region has a semi arid subtropical climate with annual rainfall of 80-85 cm mainly during July-September and temperature ranging from 9.0°C-44.8°C.

The experiment was carried out on 15 years old uniform and healthy plants of guava cv. L-49, in randomized block design replicated three times with ten treatments including T_1- absolute control, T_2-Ca $(NO_3)_2$ (2%), T_3-Ca $(NO_3)_2$ (4%), T_4-Ca $(NO_3)_2$ (6%), T_5-K_2SO_4 (2%), T_6- K_2SO_4 (4%), T_7- K_2SO_4 (6%), T_8-Ca $(NO_3)_2$ (2%) + K_2SO_4 (2%), T_9-Ca $(NO_3)_2$ (4%) + K_2SO_4 (4%) and T_{10}-Ca $(NO_3)_2$ (6%) + K_2SO_4 (6%). A recommended dose of 180 g N, 90 g P, 90 g K per plant was applied through urea, single super phosphate and muriate of potash, respectively. The full dose of P_2O_5 and K_2O along with 50% nitrogen was applied as basal through soil application around the tree basin, whereas the remaining nitrogen was applied in two equal splits during active vegetative growth and fruit development stages followed by irrigation. Foliar sprays of calcium nitrate and potassium sulphate (10 L/tree, respectively) were applied twice at fruit set stages, one month after fruit setting during evening hours. Solutions of 2%, 4% and 6% (200, 400, 600 g/10 L) and combinations (2% + 2% + 4% + 4% + 6% + 6%) were used. Tween 20 was added as a surfactant.

Physical traits *viz*., size, weight, volume, specific gravity and yield, were measured using vernier caliper, digital balance and water displacement method. Yield per plant was extrapolated to hectare basis. Biochemical quality included total soluble solids (TSS, °Brix ERMA hand refractometer, titratable acidity, AOAC, 2000), TSS: acid ratio, ascorbic acid (Ranganna, 1977), total sugar (Lane & Eynon, 1943). The fruit's shelf-life was recorded at 0 days and 2-day intervals.

The experimental data were subjected to ANOVA (Gomez & Gomez,1996) and treatment means compared using (DMRT) at 5% level of significance ($p \leq 0.05$).

RESULTS AND DISCUSSION

Flowering and fruiting parameters

The pooled data (Table 1) revealed that T_9-[Ca$(NO_3)_2$ 4% + K_2SO_4 4%] recorded early flower bud (24.83 days), which was statistically at par with T_6-[K_2SO_4 6%] with (27.53 days) and T_3-[Ca$(NO_3)_2$ 4%] (27.83 days). The T_1-absolute control (38.83 days) exhibited the most delayed flower bud. The improvement may be attributed to the role of calcium in cell division and membrane stability while potassium enhanced carbohydrate translocation and floral initiation. Jaime-Guerrero et al. (2024) and Chouhan et al. (2025) also observed a positive impact of calcium and potassium on floral initiation.

Table 2 : Effect of calcium and potassium on physical parameters of guava cv. L-49

Treatment	TSS (%)	Acidity (%)	Ascorbic acid	Reducing sugars (%)	Non-reducing sugars (%)	Total sugars (%)	Shelf life (days)
T_1-Absolute control	7.94±0.09e	0.52±0a	153.86±0.66h	3.77±0.01h	2.27±0f	3.47±0.01h	7.40±0.05g
T_2-Ca $(NO_3)_2$ (2%)	8.61±0.16d	0.50±0bc	185.11±0.40g	4.82±0.06g	2.70±0.03c	4.61±0.05g	9.41±0.09f
T_3-Ca $(NO_3)_2$ (4%)	8.77±0.14cd	0.49±0.01c	193.69±1.19f	6.09±0.06d	2.72±0.02c	5.76±0.08f	9.85±0.15de
T_4-Ca $(NO_3)_2$ (6%)	8.84±0.03cd	0.51±0ab	199.48±1.76e	5.71±0.05e	2.47±0.01e	5.84±0.06f	9.41±0.11f
T_5-K_2SO_4 (2%)	8.76±0.01cd	0.33±0ef	216.22±2.80d	5.50±0.04f	2.59±0.01d	6.40±0.09e	9.65±0.11ef
T_6- K_2SO_4 (4%)	9.07±0.12bc	0.34±0e	225.27±1.92bc	6.96±0.04c	2.81±0.04b	7.95±0.07c	11.22±0.12b
T_7- K_2SO_4 (6%)	8.90±0.01bcd	0.36±0.01d	224.11±1.27c	4.95±0.06g	2.67±0.02cd	7.16±0.06d	10.34±0.07c
T_8-Ca $(NO_3)_2$ (2%) + K_2SO_4 (2%)	9.63±0.17a	0.29±0g	234.60±0.69a	7.38±0.04b	2.81±0.06b	8.74±0.05b	11.15±0.12b
T_9-Ca $(NO_3)_2$ (4%) + K_2SO_4 (4%)	9.93±0.04a	0.28±0g	235.96±2.43a	7.66±0.06a	2.92±0.03a	9.64±0.23a	13.38±0.10a
T_{10}-Ca $(NO_3)_2$ (6%) + K_2SO_4 (6%)	9.19±0.09b	0.32±0.01f	229.50±1.83b	4.89±0.02g	2.42±0.01e	8.51±0.11b	10.16±0.12cd
SE(m)±	0.10	0.01	1.86	0.05	0.02	0.08	0.12
CD at 5%	0.28	0.02	5.38	0.14	0.07	0.23	0.34

The earliest first flowering was recorded under T_9-Ca$(NO_3)_2$ at 4% + K_2SO_4 at 4% (24.17 days), which was significantly earlier than the T_1-absolute control (45.50 days). Early flowering may be attributed to improved photosynthesis, nutrient mobility, enzymatic activity, and assimilate translocation induced by calcium and potassium application. Kumari et al. (2022) and Nodal et al. (2026) in guava also reported similar results.

The highest number of flowers per shoot was recorded under T_9-Ca$(NO_3)_2$ at 4% + K_2SO_4 at 4% (20.55 flowers/shoot), followed by T_6-K_2 SO_4 at 4% (18.17 flowers/shoot), whereas, the T_1-bsolute control (10.83 flowers/shoot) had the lowest floral production. Higher flower production may be due to enhanced cell division, photosynthesis, and metabolic activity under calcium and potassium application (Chouhan et al., 2025).

The number of fruit set per shoot was significantly higher under T_9-Ca$(NO_3)_2$ at 4% + K_2SO_4 at 4% (8.83 fruits/shoot), statistically at par with T_6-K_2SO_4 at 4% (8.77 fruits/shoot) and T_3-Ca$(NO_3)_2$ at 4% (8.59 fruits/shoot), while the T_1-absolute control (5.85 fruits/shoot) recorded the lowest fruit set. Improved fruit set may be due to enhanced pollen germination and carbohydrate translocation under calcium and potassium application in guava (Thiruezhirselvan et al., 2024).

The lowest fruit drop per shoot was recorded in T_9-Ca$(NO_3)_2$ at 4% + K_2SO_4 at 4% (2.17), followed by T_6-K_2SO_4 at 4% (2.83) and T_3-Ca$(NO_3)_2$ at 4% (3.17), whereas, the highest fruit drop was observed in T_1 and T_{10} (4.83). Reduced fruit drop may be attributed to improved cell wall strength, auxin regulation, and enhanced photosynthetic activity under calcium and potassium application (Dangwal et al., 2026).

The highest fruit retention per shoot was observed under T_9-Ca$(NO_3)_2$ at 4% + K_2SO_4 at 4% (6.33 fruits/shoot), followed by T_6-K_2SO_4 at 4% (5.85 fruits/shoot) and T_3-Ca$(NO_3)_2$ at 4% (5.66 fruits/shoot), while the T_1-absolute control (1.02 fruits/shoot) recorded the lowest fruit retention. Enhanced fruit retention may be attributed to improved carbohydrate metabolism, auxin stabilization, and cell division under calcium and potassium application (Shruti et al., 2025).

Physical parameters

Data presented in Table 2 revealed that the maximum fruit weight (148.14 g) was recorded in T_9-Ca$(NO_3)_2$ at 4% + K_2SO_4 at 4%, while minimum was observed in T_1-absolute control (99.45 g). Increased fruit weight may be attributed to enhanced cell division, membrane stability, and carbohydrate translocation under calcium and potassium application (Wan-Li et al., 2022) in guava.

Fruit width was highest in T_9 (4.14 cm), followed by T_8 (4.13 cm) and T_3 (3.96 cm), while the lowest was recorded in T_1 (3.13 cm). Improved fruit width may be attributed to enhanced carbohydrate metabolism,

Table 3 : Effect of calcium and potassium on bio-chemical parameters of guava cv. L-49

Treatment	Fruit weight (g)	Fruit width (cm)	Fruit length (cm)	Fruit volume (cm^3)	Fruit specific gravity	Fruit yield (kg/tree)	Fruit Yield (t/ha)
T_1-Absolute control	99.45±0.68f	3.13±0.01e	2.18±0.01h	101.56±1.44g	0.98±0.01b	32.95±0.49f	8.45±0.00f
T_2-Ca $(NO_3)_2$ (2%)	124.46±0.51c	3.43±0.05d	3.09±0.04f	128.72±2.22c	0.97±0.02b	33.94±0.48f	8.73±0.12f
T_3-Ca $(NO_3)_2$ (4%)	119.13±1.18d	3.96±0.05b	3.72±0.03c	148.20±2.20b	0.80±0.02d	38.65±0.32d	10.03±0.11de
T_4-Ca $(NO_3)_2$ (6%)	116.90±1.35d	3.40±0.02d	2.78±0.04g	122.47±0.91de	0.96±0.02 bc	37.20±0.60e	9.63±0.15e
T_5-K_2SO_4 (2%)	139.57±1.20b	3.46±0.02d	3.12±0.03f	124.43±0.43cd	0.91±0.01c	40.60±0.03c	10.57±0.22cd
T_6- K_2SO_4 (4%)	141.51±1.15b	3.77±0.05c	3.70±0.04cd	149.53±3.21b	0.95±0.03bc	40.61±0.15c	10.58±0.03cd
T_7- K_2SO_4 (6%)	110.13±0.66e	3.23±0.03e	3.60±0.05d	116.21±1.81f	0.95±0.02bc	40.32±0.17c	10.50±0.27cd
T_8-Ca $(NO_3)_2$ (2%) + K_2SO_4 (2%)	147.79±1.35a	4.13±0.03a	4.18±0.05b	153.29±0.58b	0.97±0.01b	42.93±0.73b	11.22±0.23b
T_9-Ca $(NO_3)_2$ (4%) + K_2SO_4 (4%)	148.14±0.97a	4.14±0.02a	4.58±0.03a	163.20±1.34a	1.13±0.01a	45.29±0.81a	11.87±0.28a
T_{10}-Ca $(NO_3)_2$ (6%) + K_2SO_4 (6%)	113.10±0.69e	3.49±0.03d	3.36±0.00e	117.98±1.22ef	0.96±0.01bc	42.20±0.26b	11.02±0.14bc
SE(m)±	1.39	0.03	0.04	1.60	0.01	0.42	0.20
CD at 5%	4.04	0.09	0.10	4.65	0.02	1.22	0.57

enzyme activity, and fruit development under calcium and potassium application.

The longest fruits were recorded in T_9 (4.58 cm), followed by T_8 (4.18 cm) and T_3 (3.72 cm), with the shortest in T_1 (2.18 cm). Enhanced fruit elongation resulted from improved carbohydrate metabolism, middle lamella integrity, and stomatal regulation under calcium and potassium application. These findings support Kanpure (2019) and Afroz et al. (2023) in guava.

Fruit volume was highest in T_9 (163.20 cm³), followed by T_8 (153.29 cm³) and T_3 (148.20 cm³), while T_1 had the lowest (101.56 cm³). The highest fruit-specific gravity was recorded in T_9 (1.13), while the lowest was noted in T_3 (0.80). Higher specific gravity resulted from increased dry matter accumulation and improved mineral utilization under calcium and potassium application. These findings agree with Kanpure (2019) and Afroz et al. (2023) in guava.

The highest yield per plant (45.29 kg) was obtained in T_9, followed by T_8 (42.93 kg) and T_6 (40.61 kg), while, lowest recorded in T_1 (32.95 kg). Higher yield resulted from improved fruit size and fruit production under calcium and potassium application in guava (Moradinezhad & Dorostkar, 2021; Kumari et al., 2022).

Similarly, the highest yield per hectare (11.87 t) was recorded in T_9, followed by T_8 (11.22 t) and T_6 (10.50 t), while, lowest (8.45 t/ha) was observed in T_1. Improved yield resulted from enhanced cell division, chlorophyll synthesis, and photosynthetic activity under calcium and potassium application in guava (Moradinezhad & Dorostkar, 2021).

Biochemical quality parameters

The highest total soluble solids (TSS) content was recorded in fruits treated with T_9-Ca$(NO_3)_2$ at 4% + K_2SO_4 at 4% (9.93%), followed by T_8-Ca$(NO_3)_2$ at 2% + K_2SO_4 at 2% (9.63%) and T_6-K_2SO_4 at 4% (9.07%) (Table 3), whereas, lowest TSS (7.94%) was recorded in absolute control (T_1). The increase in TSS may be due to enhanced carbohydrate metabolism, nutrient uptake, and starch-to-sugar conversion under calcium and potassium application. These findings align with Afroz et al. (2023) and Jaime-Guerrero et al. (2024).

The lowest acidity (0.28%) recorded in T_9 and the highest (0.52%) in T_1. Reduced acidity may be due to lower anaerobic respiration and enhanced acid-to-sugar conversion under calcium application.The findings corroborate Jaime-Guerrero et al. (2024) and Shruti et al. (2025) in guava.

The highest ascorbic acid (235.96 mg/100 g) recorded was recorded in T_9, followed by T_5-K_2SO_4 at 4%, while, lowest (153.86 mg/100 g) in T_1. Higher ascorbic acid content resulted from enhanced metabolic activity and nutrient translocation under calcium and potassium application (Hanafi et al., 2024; Haider et al., 2024).

Table 4 : Effect of calcium and potassium on economics of guava cv. L-49

Treatment	Total cost (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B: C ratio
T_1-Control	41522.00	118150.00	76628.00	2.85
T_2-Ca $(NO_3)_2$ (2%)	48611.00	305800.00	257189.00	6.29
T_3-Ca $(NO_3)_2$ (4%)	50522.00	328040.00	277518.00	6.49
T_4-Ca $(NO_3)_2$ (6%)	48002.00	273830.00	225828.00	5.70
T_5-K_2SO_4 (2%)	49622.00	283560.00	233938.00	5.71
T_6-K_2SO_4 (4%)	51947.00	371130.00	319183.00	7.14
T_7-K_2SO_4 (6%)	47642.00	212670.00	165028.00	4.46
T_8-Ca $(NO_3)_2$ (2%) + K_2SO_4 (2%)	47360.00	321090.00	273730.00	6.78
T_9-Ca $(NO_3)_2$ (4%) + K_2SO_4 (4%)	53198.00	389200.00	336002.00	7.32
T_{10}-Ca $(NO_3)_2$ (6%) + K_2SO_4 (6%)	41522.00	134830.00	93308.00	3.25

The Reducing sugar content was significantly higher in T_9 (7.66%) compared to the absolute control (3.77%). Similarly, non-reducing sugar content was highest in T_9 (2.92%) and lowest in T_1 (2.27%). The increase in non-reducing sugars may be linked to calcium nitrate's role in amino acid synthesis and enzyme activation (Ali et al., 2019; Wan-Li et al., 2022) in guava. Total sugar content was highest in T_9 (9.64%), followed by T_8 (8.74%), while the lowest was recorded in T_1 (3.47%).

The longest shelf-life (13.38 days) was observed in T_9, followed by T_5 (11.22 days) and T_7 (11.15 days), while the shortest (7.40 days) was recorded in T_1. Extended shelf-life resulted from maintained fruit firmness, reduced respiration, and delayed biochemical changes under calcium and potassium application (Bhooriya et al., 2020; Ganeshamurthy et al., 2023).

Benefit-cost ratio (B: C ratio)

Among the various treatments T_9-Ca $(NO_3)_2$ at 4% + K_2SO_4 at 4% registered the maximum gross return (Rs.389200.00/ha) followed by T_6-K_2SO_4 at 4% (Rs.371130.00/ha) and T_3-Ca $(NO_3)_2$ at 4% (Rs.321090.00/ha), however, T_0-control (Rs.118150.00/ha) recorded lowest B:C ratio (Table 4). Treatments, T_9-Ca $(NO_3)_2$ at 4% + K_2SO_4 at 4% registered the maximum net return (Rs.336002.00/ha), closely followed by T_6-K_2SO_4 at 4% (Rs.319183.00/ha) and T_3-Ca $(NO_3)_2$ at 4% (Rs.273730.00/ha). The T_1-control recorded a minimum value of the gross return (Rs.76628.00/ha), while, T_9-Ca $(NO_3)_2$ at 4% + K_2SO_4 at 4% recorded maximum (7.32) B:C ratio. The B: C ratio was closely followed by T_6-K_2SO_4 at 4% (7.14) and T_3-Ca $(NO_3)_2$ at 4% (6.78), whereas, control recorded minimum B:C ratio (2.85).

CONCLUSION

Application of calcium nitrate and potassium sulphate significantly influenced the vegetative growth, fruiting, yield and fruit quality of guava (*Psidium guajava* L.) cv. L-49. Among the treatments, T_9 [$Ca(NO_3)_2$ 4% + K_2SO_4 4%] was found to be the most effective, promoting early flower bud initiation, enhanced flowering, higher fruit set, and reduced fruit drop. Treatment T_9 also resulted in the highest yield per plant (45.29 kg) and per hectare (11.87 t), along with superior fruit weight, size and volume. Moreover, Reduced acidity and extended shelf-life improved fruit quality attributes (TSS, ascorbic acid, and total sugars), highlighting the effectiveness of calcium and potassium. The treatment T_9 [$Ca(NO_3)_2$ 4% + K_2SO_4 4%] recorded the highest gross return, net return and B:C ratio, proving to be the most profitable treatment.

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