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Influence of Foliar Application of NAA, Zinc Sulphate and Calcium Nitrate on Flowering, Yield and Quality Attributes of Winter Season Guava

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ABSTRACT

The present experiment was conducted from June to December, 2024 at Guava Orchard, Department of Fruit Science, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, U.P., India. This study aimed to improve the fruiting attributes, physical attributes, fruit yield, and quality of the L-49 cultivar of guava. The experiment was laid out in RBD with three replicates of each treatment. Total 10 treatments including one control, viz., NAA at 25 ppm, NAA at 50 ppm, NAA at 75 ppm, $ZnSO_4$ at 0.50%, $ZnSO_4$ at 0.50 %, $ZnSO_4$ at 0.75%, $ZnSO_4$ at 1.0%, Calcium nitrate at 0.50%, Calcium nitrate at 1.0%, Calcium nitrate at 1.50%, and Control, i.e. water spray. The present investigation, it was reported that the application of $ZnSO_4$ at 1.0% with significantly increased flowers (59.60) shoot^{-1}, fruit set (59.73%), and decreased fruit drop (41.67%), increased fruit retention (58.33%), fruit weight (152.40 g), fruit length (7.68 cm), fruit width (7.25 cm), fruit volume (156.84 cc), specific gravity (1.19 g cc^{-1}), and fruit yield (56.84 kg) plant^{-1}, pulp (96.56%), pulp: seed ratio (28.14) and minimum number of seeds (253) fruit^{-1} and seed weight (5.23 g) fruit^{-1} and quality parameters like: TSS (12.09°Brix), total sugars (8.02%), reducing sugars (3.84%), non-reducing sugars (4.18%), and decreased titratable acidity (0.43%) content. Hence, plants treated with $ZnSO_4$ at 1.0% could also be used to improve fruiting, overall yield, and quality characteristics of the L-49 cultivar of guava.

KEYWORDS: Guava, NAA, zinc sulphate, calcium nitrate, yield, quality

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1. INTRODUCTION

Guava (*Psidium guajava* L.) is an important fruit crop grown in both tropical and subtropical regions of the world. It is often known as the "apple of the tropics" due to its high nutritional properties, particularly its rich vitamin C content. Guava comprises approximately 140 genera and 3,000 species, while the genus *Psidium* has around 150 species; only *Psidium guajava* holds commercial significance. The guava tree is believed to have originated in tropical America, likely ranging from Mexico to Peru, and was brought to India by the Portuguese as early as the 17th century. In India, Guava is the fourth most important fruit crop, after mango, banana, and citrus, in terms of area, and fifth in terms of production (Anonymous, 2021). A cooler winter is beneficial for promoting heavy fruiting and improving fruit quality. The optimal climate for guava cultivation includes approximately 100 cm of evenly distributed rainfall, a temperature range of 23–28°C, and the trees can grow at altitudes of up to 1500 m above sea level.

Guava fruit is considered one of the most delicious and luscious, with a higher nutritional value. It is a rich source of vitamin C and pectin content. This fruit stands out for its excellent aroma and distinct flavour, making it a year-round favorite, except during the peak summer months. Mostly eaten raw or consumed in the form of juice, jam, and jellies (Parvez et al., 2018).

Plant bio-regulators and micronutrients play an important role in fruit set, fruit yield, and quality improvement (Tripathi and Kumar, 2022a). In the majority of fruit plants, fruit drop is controlled by spraying of NAA at different concentrations (Patel and Tripathi, 2024). The application of zinc resulted in a significant reduction in fruit drop, improvement in flowering, growth, and fruit quality parameters (Vivekanand et al., 2023). NAA helps to induce flowering, to prevent shedding of buds, Flowers, and unripe fruits (Verma et al., 2023). The application of NAA 20 ppm significantly reduced fruit drop and increased fruit retention in aonla (Tiwari et al., 2017). NAA reduces the number of seeds in the fruits, also induces heavier fruiting and promotes better flowering (Sharma and Tiwari, 2015). Application of NAA at 40 ppm was found to be more effective in enhancing fruit set, and also increased fruit retention (Radha et al., 2023). The NAA has been shown to greatly increase cellulose ber formation and synthetic auxin in plants (Mohit et al., 2023). The application of NAA at 40 ppm with $ZnSO_4$ at 0.5% can significantly increase the number of fruits per plant (Kumar et al., 2018b). The increased TSS, total sugars, titratable acidity, TSS: acid ratio, TSS: sugar ratio and ascorbic acid content by the application of NAA at 50 ppm and zinc sulphate at 0.4% in litchi (Rawat and Tripathi, 2024a).

Zinc sulphate plays an essential role in plant growth and development. It helps prevent low yields, spotted leaves, and stunted growth. It is one of the essential elements for the formation of chlorophyll and hence useful towards photosynthetic activity (Tripathi and Viveka Nand, 2022b). It is involved in chlorophyll synthesis and plays a positive role in photosynthesis and nitrogen metabolism (Babu and Tripathi, 2022). Zinc is used to induce early blossoming, growth and quality in many fruits (Gupta et al., 2022).

Calcium plays an important role in maintaining the quality of fruits and calcium treatments help to retain fruit firmness, increase vitamin-C content, decrease storage breakdown, and rotting (Tripathi et al., 2018). As mentioned above, this study aimed to improve the fruiting attributes, physical attributes, fruit yield, and quality of the L-49 cultivar of guava.

2. MATERIALS AND METHODS

The experiment was carried out during June to December, 2024 in the Guava Orchard, Department of Fruit Science, C. S. Azad University of Agriculture and Technology, Kanpur, comprising of foliar application of NAA (25, 50, and 75, ppm), zinc (0.50, 0.75 and 1.0%) and Calcium (0.50, 1.0 and 1.5%) along with control (water spray), before flowering and after fruit set, during winter season with randomized block design on 16 year old guava plants cv. L-49 spaced at 6×6 m^2. All the treatments were replicated thrice. The observations on flowering and fruiting (flowers $shoot^{-1}$, fruit set, fruit drop, and fruit retention), physical and yield (fruit length, fruit width, fruit weight, fruit volume, fruit yield $plant^{-1}$, number of seed $fruit^{-1}$, seed weight $fruit^{-1}$, pulp %, pulp: seed ratio and specific gravity), and quality parameters (TSS, titratable acidity, reducing sugars, non-reducing sugars and total sugars) of guava plants were recorded as per standard procedures. The data recorded on various parameters during experimentation were statistically analyzed.

3. RESULTS AND DISCUSSION

A perusal of the data presented in the following tables indicated that flowering and fruiting characteristics with quality parameters were significantly influenced by the foliar application of different nutrients.

3.1. Flowering and fruiting parameters

3.1.1. Number of flowers $shoot^{-1}$

Data presented in Table 1 revealed that the number of flowers per branch was significantly improved with the foliar application of different nutrients. The maximum number of flowers (59.60) $branch^{-1}$ was recorded with the foliar application of $ZnSO_4$ at 1.00%, which was significantly higher than all other treatments but statistically at par

Table 1: Effect of foliar spray of NAA, zinc, and calcium on flowering, fruiting, and physical parameters of winter season Guava cv L–49

Treatment	Number of flowers shoot^{-1}	Fruit set (%)	Fruit drop (%)	Fruit retention (%)	Fruit length (cm)	Fruit width (cm)	Fruit weight (g)	Fruit volume (cc)	Specific gravity (g cc^{-1})
T_1: Control)	42.40	40.00	57.67	42.33	6.08	5.87	121.49	101.58	1.06
T_2: NAA 25 ppm	56.80	54.80	46.93	53.07	6.98	6.85	144.22	128.23	1.09
T_3: NAA 50 ppm	57.60	57.40	43.93	56.07	7.08	6.96	150.47	133.21	1.15
T_4: NAA 75 ppm	59.60	59.73	41.67	58.33	7.68	7.25	152.40	56.84	1.19
T_5: Zinc sulphate 0.50%	52.26	42.66	50.95	49.05	6.40	6.26	126.56	109.88	1.13
T_6: Zinc sulphate 0.75%	53.20	44.99	49.05	50.95	6.55	6.31	130.61	113.78	1.12
T_7: Zinc sulphate 1.0%	54.40	47.86	48.05	51.95	6.63	6.47	134.32	118.58	1.13
T_8: Calcium nitrate 0.50%	55.40	49.86	48.26	51.74	6.72	6.61	137.61	122.33	1.10
T_9: Calcium nitrate 1.0%	56.20	53.53	47.80	52.20	6.86	6.73	140.22	126.42	1.11
T_{10}: Calcium nitrate 1.5%	57.00	56.26	44.73	55.27	7.06	6.91	147.31	131.62	1.14
SEm±	0.57	0.37	0.36	0.36	0.17	0.16	2.52	1.77	0.02
CD (p=0.05)	1.72	1.12	1.07	1.07	0.52	0.47	7.54	5.31	0.05

with $ZnSO_4$ at 0.75% (T_3) and Calcium nitrate 1.5% (T_{10}), while the minimum number of flowers (42.40) branch^{-1} was recorded under control. Improvement in the number of flowers shoot^{-1} as a result of foliar application of zinc might be due to enhanced photosynthetic and other metabolic activity, which led to an increase in various plant metabolites responsible for cell division and elongation. These findings align with the reports of Babu and Tripathi (2022), who applied 1% zinc application, Pratap et al. (2022) $ZnSO_4$ 1.0%+Borax 1.0%, and Singh and Mishra (2024) zinc at 0.35%+GA_3 100 ppm in Guava, found the maximized number of flower plant^{-1}.

3.1.2. Fruit set (%)

A perusal of Table 1 showed that the effect of foliar application of NAA, zinc, and calcium on the fruit set in guava cv. L-49 was found to be significant during the present investigation. Maximum fruit set (59.73%) was recorded under $ZnSO_4$ at 1.00%, which was significantly higher than all other treatments but statistically at par with $ZnSO_4$ at 0.75% (T_3) and calcium nitrate at 1.5% (T_{10}), and the minimum (40.00%) was recorded under the control. Zinc appeared to have helped increase fruit set, either by improving pollen germination or by facilitating the growth of pollen tubes that enabled timely fertilization before the stigma loses its receptivity or the style becomes nonfunctional. These findings were in agreement with those of Babu and Tripathi (2022), application of 1% zinc, Badal and Tripathi (2021), boron at 0.6%, and Pratap et al. (2022) $ZnSO_4$ 1.0%+Borax 1.0% in guava found maximum fruit set.

3.1.3. Fruit drop and retention (%)

It was quite apparent from the data presented in Table 1 that all treatments in the present experiment were significant in minimizing fruit drop. Minimum fruit drop (41.67%) with maximum fruit retention (58.33%) were observed with the spray of $ZnSO_4$ at 1.00%, which was statistically at par with (T_3) $ZnSO_4$ at 0.75%, and (T_{10}) calcium nitrate at 1.50%, while the maximum fruit drop (57.67%) with minimum fruit retention (42.33%) were recorded under control (T_1). Fruit drop reduction might be due to the reason that zinc supported fruit retention by stimulating the production of endogenous auxins, which prevented abscission and helped the ovary remain attached to the shoot, thereby reducing overall fruit drop and ultimately increasing fruit retention. These findings were in agreement with the reports of Pratap et al. (2022) with the application of $ZnSO_4$ 1.0%+Borax 1.0%, Babu and Tripathi (2022) 1.0% zinc sulphate; Verma et al. (2025) NAA20 ppm+$ZnSO_4$ 0.4% application, Tiwari et al. (2017) NAA at 20 ppm and Mohit et al. (2023) NAA @ 75 ppm in Aonla, and Gupta et al. (2022) can significantly reduce the percentage of fruit drop with increased fruit retention.

3.1.4. Fruit size {length and width (cm)}

The size of the fruit was recorded by measuring the fruits with vernier callipers, and an average value was obtained. The plants which were treated with zinc sulphate at 1.00% significantly hastened the length of fruits, registering 7.68 cm and fruit width (7.25 cm), closely followed by (T_3) zinc sulphate at 0.75% (Table 1). In this regard, untreated plants (control) exhibited a minimum of 6.08 cm fruit length and 5.87 cm of fruit width. This enlargement in fruit size with zinc sulphate application might also have a substantial impact on fruit size enhancement due to its role in promoting cell elongation and expansion, which led to a desired increase in fruit size. These findings were in agreement with the reports of Baloda et al. (2023) applied $ZnSO_4$ at 125 g plant^{-1}; Singh and Mishra (2024) applied Zinc at 0.35%+GA_3 at 100 ppm in Guava; and Vivekanand et al. (2023) applied GA_3 at 60 ppm+zinc 0.7% in Litchi, found increased fruit size (length and width).

3.2. Physical and yield attributes

3.2.1. Fruit weight (g) and fruit volume (cc)

Fruit weight and volume significantly increased with the application of zinc sulphate at 1% (152.40 g and 56.84 cc, respectively), closely followed by zinc sulphate at 0.75% (T_3), respectively (Table 1), against the poorest fruit weight and fruit volume were revealed under control (121.49 g and 101.58cc, respectively). An increase in fruit weight and volume was due to the reason that zinc regulates metabolic activities, which increased the accumulation of food materials in the tissue Similar results were also obtained by Babu and Tripathi (2022) 1.0% zinc application, and Meena et al. (2023) borax 0.2%+zinc sulphate 0.2% in Guava; Verma et al. (2025) NAA at 20 ppm+$ZnSO_4$ at 0.4%, and Tripathi and Kumar (2022a) GA_3 at 60 ppm+$ZnSO_4$ at 1.0% in Mango can signicantly increased fruit weight and volume.

3.2.2. Specific gravity of fruit (g cc^{-1})

Guava plants treated with 1% zinc sulphate produced fruits with the highest specific gravity, i.e., 1.19 g cc^{-1} (Table 1). In contrast, plants in the control treatment produced fruits having the lowest specific gravity, i.e., 1.06 g cc^{-1}. This increase in specific gravity with the use of zinc might be due to the increase in fruit pulp and decrease in seed weight. The results obtained during the experimentation period were reported in the studies by Mohit et al. (2023) NAA at 75 ppm in Aonla, Khan et al. (2022), $ZnSO_4$ at 0.8% application in mango, and Tripathi and Kumar (2022a) GA_3 at 60 ppm+$ZnSO_4$ at 1.0%, in Mango, can signicantly increased specific gravity of fruit.

3.2.3. Fruit yield (kg) plant^{-1}

The plants treated with zinc sulphate at 1.00% yielded the maximum fruit, 56.84 kg plant^{-1}, closely followed by treatment (T_3) $ZnSO_4$ at 0.75% (Figure 1). Untreated plants, i.e., control (T_1), produced significantly less fruit yield of 35.60 kg plant^{-1}. The maximum yield in the treatment of zinc sulphate at 1% might be attributed to the production of the maximum number of fruits in this treatment, resulting in more yield. The increase in fruit count tree^{-1} might be attributed to the role of zinc in catalyzing oxidation-reduction reactions and its critical involvement in sugar metabolism, promoting fruit development and consequently increasing yield. These findings aligned with the reports of Meena et al. (2023) applied borax 0.2%+zinc sulphate 0.2%, Gangwar et al. (2023) applied NAA @ 75 ppm, and Singh and Mishra (2024) applied Zn 0.35%+GA_3 100 ppm in guava, Verma et al. (2025) NAA at 20 ppm+$ZnSO_4$ at 0.4% significantly and Kumar et al. (2018a) GA_3 at 40 ppm+$ZnSO_4$ (1.0%) in mango, and Rawat and Tripathi (2024b) applied NAA @ 50 ppm and zinc sulphate @ 0.4% found the highest fruit yield tree^{-1}.

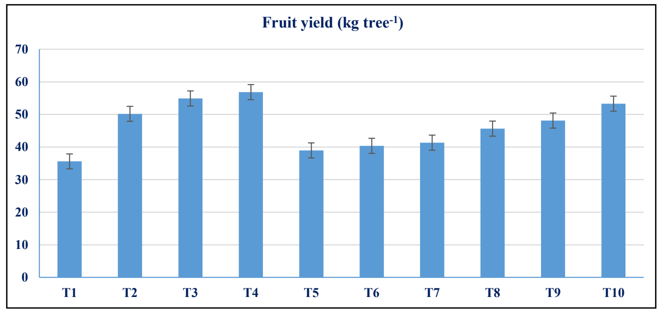

Figure 1: Effect of foliar spray of NAA, zinc, and calcium on fruit yield of winter season Guava cv L-49

3.2.4. Number and weight (g) of seeds fruit^{-1}

The application of NAA, Zinc sulphate, and calcium nitrate could significantly influence data in Table 2 regarding the number and weight of seeds fruit^{-1}. The minimum number of seeds fruit^{-1} (253) and seed weight (5.23 g) were recorded in fruits that were produced from the plants treated with zinc sulphate at 1% (T_4), which was closely followed by the application of 0.75% of zinc sulphate (T_3) and (T_{10}) calcium nitrate at 1.5%. The maximum number of seeds (320) and seed weight (6.87 g) fruit^{-1} were recorded under the control treatment. The application of high levels of zinc sulphate could lead to reduced pollen germination and tube growth, thereby limiting the successful fertilization of ovules. Similar findings were also obtained by Hada et al. (2017), spray of Borax 0.4%+zinc sulfate 0.8% in guava, and Vivekanand et al. (2023) application of GA_3 at 60 ppm+Zinc at 0.7% in litchi, which increases the number and fruit weight.

3.2.5. Fruit pulp (%) and pulp: seed ratio

The maximum pulp (96.56%) and pulp: seed ratio (28.14) were significantly recorded in fruits that were produced from the plants treated with zinc sulphate at 1% (T_4), and the minimum pulp (94.34%) and pulp: seed ratio (16.68) fruit^{-1} was recorded under the control (T_1) treatment (Table 2). When the application of zinc was at a higher concentration, it could enhance the activity of enzymes involved in nutrient assimilation and protein synthesis, resulting in better fruit filling and mesocarp growth, also increased pulp percentage, and high levels of zinc sulphate could lead to reduced pollen germination and tube growth, thereby limiting the successful fertilization of ovules. These findings aligned with

Table 2: Effect of foliar spray of NAA, zinc sulphate, and calcium nitrate on quality parameters of winter season guava cv L-49

Treatment	Number of seed fruit^{-1}	Seed weight fruit^{-1} (g)	Pulp (%)	Pulp: seed ratio	TSS (°Brix)	Titratable acidity (%)	Reducing sugars (%)	Non-reducing sugars (%)	Total sugars (%)
T_1: Control)	320.00	6.87	94.34	16.68	10.11	0.78	3.45	3.76	7.21
T_2: NAA 25 ppm	281.00	5.95	95.87	23.23	11.48	0.58	3.75	4.04	7.79
T_3: NAA 50 ppm	267.00	5.62	96.26	25.77	11.89	0.48	3.80	4.13	7.93
T_4: NAA 75 ppm	253.00	5.23	96.56	28.14	12.09	0.43	3.84	4.18	8.02
T_5: Zinc sulphate 0.50%	310.00	6.57	94.80	18.25	10.73	0.74	3.53	3.79	7.32
T_6: Zinc sulphate 0.75%	305.00	6.41	95.08	19.37	10.84	0.72	3.58	3.81	7.39
T_7: Zinc sulphate 1.0%	297.00	6.26	95.33	20.45	11.11	0.70	3.62	3.51	7.13
T_8: Calcium nitrate 0.50%	291.00	6.17	95.51	21.30	11.37	0.69	3.66	3.89	7.55
T_9: Calcium nitrate 1.0%	287.00	6.10	95.64	21.98	11.42	0.62	3.72	3.97	7.69
T_{10}: Calcium nitrate 1.5%	276.00	5.81	96.05	24.35	11.50	0.56	3.79	4.09	7.87
SEm±	1.69	0.04	0.07	0.36	0.12	0.01	0.05	0.11	0.13
CD (p=0.05)	5.05	0.12	0.21	1.09	0.35	0.02	0.16	0.34	0.38

the reports of Hada et al. (2017) by the foliar spray of borax 0.4%+zinc sulfate 0.8% in Guava, Kumar et al. (2018b) applied GA_3 (40 ppm)+$ZnSO_4$ (1.0%), and Mohit et al. (2023) NAA at 75 ppm in Aonla can signicantly increases pulp content and pulp: seed ratio.

3.3. Quality attributes

3.3.1. Total soluble solids (Brix) and titratable acidity (%)

The maximum total soluble solids (12.09°Brix) were recorded with the foliar application of zinc sulphate at 1% (T_4), followed by (T_3) zinc sulphate at 0.75% and (T_{10}) Calcium nitrate 1.5%, which was significantly superior to the rest of the treatments (Table 2). While the minimum TSS content (10.11 Brix) was found under control. The increase in TSS due to zinc treatment was a fact that demonstrated zinc's role in the hydrolysis of complex polysaccharides into simple sugars, the synthesis of metabolites, and the rapid translocation of photosynthetic products and minerals from other parts of the plant to developing fruits. Similar results were also obtained by Verma et al. (2025) NAA at 20 ppm+$ZnSO_4$ at 0.4% and, Kumar et al. (2018a) GA_3 (40 ppm)+$ZnSO_4$ (1.0%), and Tripathi and Kumar (2022a) GA_3 (60 ppm)+$ZnSO_4$ (1.0%) in mango; and Tripathi and Vivekanand (2022b) zinc sulphate at 0.6% in Aonla with maximized TSS content.

The lowest titratable acidity (0.43%) was observed with the foliar application of zinc sulphate at 1% (T_4), followed by zinc sulphate at 0.75% (T_3) and calcium nitrate at 1.5% (T_{10}) during the present investigation (Table 2). The role of zinc in decreasing the titratable acidity of fruits might be due either to the conversion of sugar and its derivatives by a relation involving the reverse glycolytic pathway or growth, which might be held responsible for reducing titratable acidity. Similar results were also obtained by Baloda et al. (2023) applied $ZnSO_4$ @ 125 g plant^{-1} and Meena et al. (2023) Borax 0.2%+Zinc Sulphate 0.2% in Guava; Khan et al. (2022) $ZnSO_4$ at 0.8%, Kumar et al. (2018a) GA_3 (40 ppm)+$ZnSO_4$ (1.0%), and Verma et al. (2025) application of NAA 20 ppm+$ZnSO_4$ 0.4% in mango found reduced titratable acidity.

3.3.2. Reducing, non-reducing and total sugars (%)

The maximum total sugars (88.02%), reducing sugars (3.84%), and non-reducing sugars (4.18%) were recorded with the foliar application of zinc sulphate at 1% (T_4), which was significantly superior to the other treatments (Table 2). However, the minimum total sugars (7.21%), reducing sugars (3.45%), and non-reducing sugars (3.76%) were recorded in plants produced from plants kept under control. The increase in reducing sugar, non-reducing sugar and total sugars might be due to an increased rate of photosynthesis and a perceptible increase in sugar contents through the foliar feeding of zinc sulphate might be due to the active synthesis of tryptophan in the presence of zinc, an increase in the rate of chlorophyll synthesis which ultimately accelerated the photosynthetic activity which accumulated more sugars in fruits. These findings were in agreement with those of Babu and Tripathi (2022) application of 1.0% zinc application; and Meena et al. (2023) Borax 0.2%+zinc sulphate 0.2% in guava; Kumar et al. (2018a) GA_3 (40 ppm)+$ZnSO_4$ (1.0%) in mango; and Tripathi and Vivekanand (2022b) zinc sulphate at 0.6% application in

Aonla, and Rawat and Tripathi (2024a) NAA @ 50 ppm and zinc sulphate @ 0.4% in litchi can significantly increases sugars content.

4. CONCLUSION

The dose of zinc sulphate at 1.0% (T_4) can significantly maximized the flowering, fruiting, yield, and quality parameters of the investigation in the guava cv. L-49. Thus, in light of the above achievement, a 1.0% zinc sulphate application might be recommended safely to guava growers for profitable crop production in the central Uttar Pradesh region.

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