Original Research Article

Nutri-hormonal manipulation for yield and quality improvement in guava (*Psidium guajava* L.)

ABSTRACT

Aims: To study the effect of nutrients and plant growth regulators through foliar spray on yield and quality characteristics of guava var. Arka Kiran.
Study design: Randomized Block Design (RBD)
Place and Duration of Study: The experimental trial was conducted at a Farmer's field in Theethipalayam village of Coimbatore district, Tamil Nadu during 2022
Methodology: The current study included six treatments and three replications. Three-year-old guava trees with uniform size, growth, and bearing habit were chosen for imposing treatments. Observations on fruit yield and the physical and quality characteristics of guava were recorded.
Results: Fruit diameter (6.30 cm), Fruit weight (168.17 g), fruit volume (146.46 ml), fruit yield (16.53 kg/tree) and the number of fruits per tree (98.35) was recorded maximum in plants which were treated with nutri-hormonal spray-I. The best-quality fruits in terms of increased TSS (12.08), ascorbic acid (185.35 mg/g), reducing (3.15%), non-reducing (4.19%), and total sugars (7.34%) and reduced acidity (0.40%) were also recorded in the same combination.
Conclusion: The foliar application of nutrients and PGRs spray-I can be advocated to improve the yield and quality attributes of guava.

Keywords: Guava, nutrients, growth regulators, yield, quality

1. INTRODUCTION

Guava (*Psidium guajava* L.) is a member of Myrtaceace family. It is an evergreen tree that is highly productive and widely cultivated in the tropical and subtropical areas of the world. In view of its nutritional content, guava is referred to as the "Apple of Tropics". Every 100 g of fruit contains 68 kcal of energy, 14.32 g of carbohydrates and 5.4 g of dietary fiber (Kafle *et al*., 2018) [1]. Besides guava is a good source of vitamin C (228 mg / 100g), phosphorus (40 mg/100 g), calcium (18 mg/100 g), potassium (417 mg/ 100g) and iron (0.26 mg/100 g) as reported by USDA. In India, guava is the fifth most widely grown fruit crop after banana, mango, citrus and papaya. The growing traction towards guava among agriculturalists is because of its hardy and prolific bearing nature, adaptability to a wide range of soils and agro climatic regions, relatively high profit margin and nutritional values (Jat *et al*., 2018) [2]. The area under guava cultivation is 0.353 million hectares, with a total production of 5.52 million metric tonnes. In Tamil Nadu guava is cultivated in an area of 0.014 million hectares with a production of 0.363 million metric tonnes. (Anon, 2022a) [3]

Guava responds effectively to fertilizer in terms of increased fruit production and quality (Ram *et al.*, 2003) [4]. Water and nutrients are more important than other aspects to increase the production and productivity of guava. A persistent micronutrient shortage has been observed in guava which impairs fruit development and lowers fruit quality. For proper development and yield, guava trees require certain nutrients and plant hormones. Macronutrients like nitrogen, phosphorus, and potassium aid in plant growth and development. Despite their need in relatively smaller quantities, micronutrients like Fe, Zn, Mn, Cu, and B also have equal significance (Yadav and Solanki, 2015) [5]. These nutrients help in cell wall development, respiration, leaf chlorophyll formation, enzyme functioning, synthesis of hormones and favor uptake of macronutrients (Das, 2001) [6]. In addition, application of plant growth hormones increases flowering, reduces fruit drop, and enhances fruit quality of guava (Lal and Das, 2017) [7].

Fertilization can be divided into two types based on the method of application and plant absorption: Root and foliar fertilization (Niu *et al*., 2021) [8]. The most common way to apply fertilizer is through soil incorporation (Fageria *et al*., 2009) [9]; however, this approach is influenced by a number of variables, such as soil pH, temperature and microbiota (Li *et al*., 2009) [10], leading to nutrient fixation and overfertilization. Foliar fertilization is a rational method of supplying nutrients, since they are applied directly to the leaves and above-ground parts in limited quantities at critical growth stages (Fernandez *et al.*, 2013) [11]. Foliar sprays have become more common as a result of the commercialization of water-soluble fertilizers, mechanized spray delivery systems, and overhead irrigation (Fageria *et al*., 2009) [9]. The effectiveness of applied nutrients and hormones is increased by formulating foliar sprays with a suitable combination of nutrients and adjuvants that facilitate proper wetting, spreading, and permeation of chemicals (Fernandez *et al.*, 2013) [11].

The integrated supply of nutrients and hormones in correct proportions is one of the key factors that influence tree growth. It minimizes the reliance on plant protection chemicals and eliminates physiological disorders thereby increasing the marketable yield (Yadav *et al*., 2019) [12]. In this context, the present study was undertaken to investigate the influence of nutri-hormonal spray on yield and quality in guava (*Psidium guajava* L.).

2. MATERIAL AND METHODS

2.1 Geographical location

The experiment was conducted at a farmer's field in Theethipalayam village of Coimbatore district which is geographically located in the western agro-climatic zone of Tamil Nadu.

2.2 Experiment details

Crop	:	Guava
Variety	:	Arka Kiran
Design	:	Randomized Block Design (RBD)
Number of treatments	:	Six (6)
Number of replications	:	Four (4)
Plant spacing	:	2.2 x 1.8m
Age of the tree	:	Three (3) years old
Experiment period	:	2022 – 2023
Number of sprays	:	Three (3)
Stage of application	:	1. Bud emergence stage 2. Fruit set stage 3. Fruit development stage (30 days after 2nd spray)

2.2.1 Treatments details

Six treatments were used in the experiment. The treatment combinations include foliar application nutrients and growth regulators in various concentrations.

Table 1: Treatment details

T_1	Absolute control
T_2	Recommended Dose of Fertilizer

T_3	RDF + Micronutrients
T_4	RDF + Nutrients and PGRs spray I
T_5	RDF + Nutrients and PGRs spray II
T_6	RDF + Nutrients and PGRs spray III

T_1 - Absolute control: No fertilizers and foliar spray

T_2 - Recommended Dose of Fertilizer: 900:600:600 g of nitrogen, phosphorus and potassium per tree (Anon.,2023) [13]. All -19 (19:19:19), single super phosphate and murate of potash were used to supply the recommended dose of NPK at weekly intervals through fertigation.

T_3 - Micronutrients: 0.3% Borax + 0.5% $ZnSO_4$ + 0.5% $MgSO_4$ + 0.5% $MnSO_4$ + 0.25% $CuSO_4$ and $FeSO_4$ (Anon., 2022b) [14].

T_4, T_5, T_6 - Nutrients and PGRs spray: A mixture of macro and micronutrients with plant growth regulators that promotes the growth, yield and quality of guava was premeasured and quantified at three different concentrations.

2.2.2 Cultural operations

Trees with uniform size, growth and bearing habit exposed to similar weather conditions were chosen randomly from the orchard. Soil and cultural operations including irrigation, manuring, fertilization and plant protection measures were administered uniformly to all the trees at scheduled intervals.

2.3 Observations recorded

2.3.1 Fruit yield parameters

2.3.1.1 Fruit weight (g)

Fruits were randomly collected from each treatment, weighed in an electronic balance and their average fruit weight was calculated and expressed in grams.

2.3.1.2 Fruit diameter (cm)

The diameter of the fruits was measured at its broadest portion using a tape measure, and their mean value was expressed in centimeters.

2.3.1.3 Fruit volume (ml)

The volume of the fruit was measured through water displacement method and expressed in milliliters.

2.3.1.4 Seed weight (g)

The weight of seeds extracted from 100 g of fully ripe fruit was measured and expressed in grams per 100 g of fruit.

2.3.1.5 Fruit yield (kg/tree)

The weight of fruits harvested at mature green stage (color change from dark to light green) were summed up and the final yield was expressed in kilo grams per tree.

2.1.3.1.6 Number of fruits per tree

The number of harvested fruits was counted for each treatment and replication. It was added up, and the average number of fruits per tree was calculated.

2.3.2 Fruit quality parameters

2.3.2.1 Total Soluble Solids (˚brix)

Total soluble solids of guava fruits was determined using a refractometer and expressed in ˚brix.

2.3.2.2 Acidity (%) and Ascorbic acid (mg/100g)

The acidity and ascorbic acid content of the fruits was estimated by titration method described by Ranganna (1977) [15] and expressed in percentage and mg/100g of fresh fruit, respectively.

2.3.2.3 Total sugars (%)

Total sugars was calculated based on the method proposed by Somogyi (1952) [16] and expressed as percentage.

2.3.2.4 Reducing sugars (%)

Reducing sugars was calculated based on the method proposed by Hedge and Hofreiter (1962) [17] and expressed as percentage.

2.3.2.5 Non reducing sugars (%)

Non-reducing sugar was calculated as the difference between total sugar and reducing sugar and expressed as percentage.

2.3.2.6 Pectin (%)

Pectin content was estimated based on the method proposed by Ranganna (1977) [15] and expressed as percentage.

2.4 Statistical analysis

The experiment was laid under Randomized Block Design and one way ANOVA was performed to compare the means and Least Significant Difference (LSD) was used to determine the significant treatments. Significance of the data was determined at $p < 0.05$. All the statistical analysis was performed using R software (R version 4.3.1 (2023-06-16 Universal C Runtime)).

3. RESULTS AND DISCUSSION

Table 2. Effect of nutri-hormonal spray on fruit yield parameters of guava (*Psidium guajava* L.)

	Treatments	Fruit diameter (cm)	Fruit volume (ml)	Fruit weight (g)	Seed weight (g)	Fruit yield (kg/tree)	No.of fruits/tree
T_1	Absolute control	5.45^{c}	107.53^{e}	132.30^{e}	3.57^{e}	11.16^{e}	84.40^{c}
T_2	Recommended Dose of Fertilizer	5.43^{c}	113.96^{d}	140.24^{d}	3.87_{bc}	12.29^{d}	87.68^{c}
T_3	RDF + Micronutrients	5.78^{bc}	128.64^{b}	153.61^{bc}	4.05^{a}	14.38^{b}	93.57^{b}
T_4	RDF + Nutrients and PGRs spray I	6.30^{a}	146.46^{a}	168.17^{a}	3.94^{ab}	16.53^{a}	98.35^{a}
T_5	RDF + Nutrients and PGRs spray II	6.03^{ab}	130.55^{b}	157.20^{b}	3.74^{cd}	14.80^{b}	94.18^{b}
T_6	RDF + Nutrients and PGRs spray III	5.88^{abc}	125.68^{c}	150.07^{c}	3.69^{de}	13.81^{c}	91.99^{b}
	SEd	**0.232**	**1.031**	**2.103**	**0.066**	**0.242**	**1.750**
	CD	**0.496**	**2.199**	**4.481**	**0.142**	**0.517**	**3.730**

Table 3. Effect of nutri-hormonal spray on fruit quality parameters of guava (*Psidium guajava* L.)

	Treatments	TSS (˚brix)	Titrable acidity (%)	Ascorbic acid (mg/g)	Reducing sugars (%)	Non reducing sugars (%)	Total sugars (%)	Pectin (%)
T_1	Absolute control	9.72^{d}	0.53^{a}	168.04^{c}	2.90_{c}	2.80^{c}	5.70^{d}	1.06^{c}
T_2	Recommended Dose of Fertilizer	10.37^{c}	0.49^{ab}	170.13^{c}	3.42^{b}	2.84^{c}	6.26^{c}	1.07^{bc}
T_3	RDF + Micronutrients	11.55^{b}	0.47^{ab}	176.36^{b}	4.06^{a}	3.26^{a}	7.32^{a}	1.09^{abc}
T_4	RDF + Nutrients and PGRs spray I	12.08^{a}	0.40^{c}	185.35^{a}	4.19^{a}	3.15^{ab}	7.35^{a}	1.12^{a}
T_5	RDF + Nutrients and PGRs spray II	11.38^{b}	0.44^{bc}	187.43^{a}	3.54^{b}	2.98^{bc}	6.52^{bc}	1.08^{bc}
T_6	RDF + Nutrients and PGRs spray III	11.53^{b}	0.47^{ab}	173.72^{bc}	3.46^{b}	3.21^{ab}	6.68^{b}	1.10^{ab}
	SEd	**0.198**	**0.031**	**2.686**	**0.145**	**0.126**	**0.150**	**0.018**
	CD	**0.423**	**0.066**	**5.726**	**0.309**	**0.268**	**0.320**	**0.038**

The results from Table 2 and 3 indicate that foliar application of nutrients and growth regulators produced a significant difference. Increased yield and quality of guava fruits owing to the foliar application of micronutrients individually or in combination with growth regulators has been reported by various researchers viz., Dutta and Banik (2005) [18], Suman *et al*. (2016) [19], Lenka *et al*. (2019) [20] and Kumar *et al*. (2022) [21] which validates the findings of this experiment.

3.1. Yield parameters

3.1.1. Fruit diameter (cm)

Highest fruit diameter was measured under T_4 (6.30 cm) and the lowest fruit diameter was measured under T_2 and T_1 (5.45 and 5.43 cm, respectively) which were statistically on par with each other. The increase in diameter of treated fruits could be attributed to improved water mobilization facilitated by micronutrient-mediated cell wall permeability as reported by Wali et al. (2005) [22]. Adequate supply of water and mineral nutrients improves the interior physiology of the fruit, promoting its growth and development. (Dutta and Banik, 2005) [16].

3.1.2. Fruit volume (ml)

T_4 recorded maximum fruit volume (146.46 ml) which was significantly superior over control (107.53 ml) and rest of the treatments. Exogenously applied nutrients and hormones accelerates translocation of photoassimilates from leaves to the developing fruits of the plant thereby increasing the fruit volume (Singh *et al*., 2001) [23]. Growth regulators have a regulatory effect on the activity and strength of sinks (Kuiper, 1993) [24]. They aid in photosynthate partitioning and promote nutrient flow through phloem to the sink (fruits) (Zhang *et al*., 2007) [25]. Besides they stimulate the activity of enzymes involved in sugar metabolism resulting in larger fruits. (Brenner, 1995) [26].

3.1.3. Fruit weight (g)

Maximum fruit weight of about 168.17 g was recorded in T_4, and a significantly minimum fruit weight of about 132.30 g was recorded in T_1. T_4 was followed by T_5 (157.20 g), T_3 (153.61 g) and T_6 (150.07 g), all of which were on par. The increase in fruit weight in T_4 might be due to the indirect effect of micronutrients via tryptophan-dependent auxin synthesis (Marschner, 1995 [27]; Pedler *et al*., 2000 [28]). Auxin accelerates the process of cell division and cell elongation in fruit tissues resulting in larger fruits having more intercellular spaces (Osman *et al*., 2000) [29]. Similar results were obtained by Rawat *et al*. (2010) [30] and Jat *et al*. (2017) [31], Yadav *et al*. (2017) [32] and Meena *et al*. (2020) [33].

3.1.4. Fruit yield (kg/tree)

The fruit yield/tree of guava ranged from 11.16 kg to 16.53 kg. The highest fruit yield was recorded in T_4 (16.53 kg) followed by T_5 (14.80 kg) and T_3 (14.38 kg) while the lowest fruit yield was recorded in T_1 (11.16 kg). Higher fruit yield caused by foliar application of micronutrients and growth regulators may be associated with expansive vegetative growth at first, which results in the synthesis of more metabolites for later-developing fruits. (Darshan *et al*.,) [34]. These findings were in agreement with Janaki *et al*. (2022) [35].

3.1.5. Number of fruits

T_4 (98.35) yielded the highest number of fruits followed by T_5 (94.18), T_3 (93.57) and T_6 (91.99) which were at par with each other and significantly superior over T_1 (84.40) and T_2 (87.68). The increment in number of fruits might be due to the increase in photosynthetic pigment contents which improves the photochemical efficiency of guava leaves. This leads to an increased production of metabolites in the plant system, which accelerates fruit growth and the uptake of other nutrients through the leaves (Rokaya *et al*., 2019) [36]. The results are similar to those reported by Jat and Kacha, 2014 [37].

3.1.6. Seed weight (g)

Foliar spray had no significant effect on seed weight in the present experiment. All treatments were on par with each other.

3.2. Quality parameters

3.2.1. Total Soluble Solids (˚Brix)

The TSS significantly increased with foliar application of nutrients and growth regulators. T_4 (12.08˚Brix) recorded the highest level of TSS and T_1 (9.72˚Brix) recorded the lowest level of TSS while the other treatments showed the intermittent values. Maximum total soluble solids caused by nutrient administration is due to the breakdown of complex polysaccharides into simple sugars and its translocation from other parts of the plant to fruit pulp (Rawat *et al*., 2010) [30]. According to Kumar and Bhusan (1980) [38], plants with more photosynthetic activity produce more sugars which increases the TSS of the fruits. These results closely align with the findings of El-Sisy (2011) [39] and Rajkumar *et al.* (2014) [40].

3.2.2. Titrable acidity (%)

The titrable acidity of guava ranges from 0.39% to 0.52%. The lowest percent of acidity was found in T_4 (0.40 %) followed by T_5 (0.44%), which was at par with treatments T_2 (0.49%), T_3 (0.47%) and T_6 (0.47%). The highest percent of acidity was found in T_1 (0.53%). The decrease in acidity percentage is related to the involvement of mineral compounds in the conversion of starch to sugar via reverse glycolytic pathways (Singh *et al*., 2003) [41]. Increased membrane permeability, according to Kjewer (1971) [42], permits acids to be stored in respiring cells, where they are used as a substrate for respiration. With the increase in volume of treated fruits, there might also have been a dilution impact that contributed to a decline in organic acids as advocated by Rawat *et al*., 2010 [30].

3.2.3. Vitamin C (mg/g)

T_5 recorded the highest vitamin C content (187.43 mg/g) which was at par with T_4 (185.35 mg/g) whereas the lowest vitamin C content was recorded in T_1 (168.04 mg/g). The plant growth regulators catalyze ascorbic acid synthesis from sugars and inhibit the activity of oxidative enzymes, enhancing the ascorbic acid content of guava fruits. (Yadav *et al*., 2011) [43].

3.2.4. Sugars (%)

The treatments showed significant increase in sugar content of fruits. Among the treatments, T_4 recorded highest percent of total sugars and reducing sugars (7.35% and 4.19% respectively) which was on par with T_3 (7.32% and 4.06% respectively). Maximum percentage of non-reducing sugars was recorded in T_3 (3.26%) which was statistically on par with T_6 (3.21%) and T_4 (3.15%). The lowest percent of total, reducing and non-reducing sugars was recorded in T_1 (5.70%, 2.90% and 2.80% respectively). Mineral ions in the fruits of treated trees either get associated with the cellular membrane or react with sucrose, forming complexes that facilitate the passage of sugars through the membrane thereby increasing the sugar content of the fruits (Gauch and Dugger, 1953) [44]. The current findings are in agreement with the results proposed by Baranwal *et al.* (2017) [45].

3.2.5. Pectin (%)

Although there was no significant difference between treatments, T_4 (1.12%) registered higher percentage of pectin content. The synthesis of pectic compounds is due to increased translocation of photoassimilates (Whiting, 1970) [46].

4. CONCLUSION

The present investigation clearly reflects that application of nutri-hormonal spray- I (T_4) at bud emergence, fruit set and fruit development stage was found to be beneficial in increasing the productivity by enhancing the number of fruits per tree, yield per tree and fruit quality.

ABBREVIATIONS

PGRs – Plant Growth Regulators
TSS- Total Soluble Solids
% - Percentage

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