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Impact of Nutrient Application and Bagging on Development and Quality of Guava (*Psidium guajava* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Guava is a tropical fruit known for its unique flavor and nutritional benefits. Guava is also recognized for its potential health benefits, including improved digestion and immune system support. The benefits of using calcium nitrate and potassium sulphate spraying in guava includes improved fruit size, enhanced nutrient uptake, increased fruit firmness, and better overall plant health. Calcium nitrate promotes cellular development and strengthens cell walls, while potassium sulphate along with bagging aids in fruit development and improves water uptake. These sprays can result in larger, firmer, and healthier guava fruits, contributing to better market value and consumer satisfaction. Therefore, the present investigation was carried out at the Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh during the *Rainy*-2022-23 with a view to determine the effect of different nutrient applications and bagging on guava variety Allahabad Safeda for its growth quality and to work out the economics of various treatments. Under this experiment, overall,

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10 treatment was prepared by spraying of different nutrients on plants and bagging of fruits with different polythene bags. From the above experimental finding it may be concluded that the treatment T_7 (Ca $(NO_3)_2$ @ 2% + Bagging (Red colour Polythene) was found to be best in terms of physical parameters like fruit weight (147.27 g), fruit polar length (8.91 cm), fruit equatorial length (9.46 cm), fruit diameter (8.14 cm), fruit volume (697.02 cm^3) among different treatment combinations of guava while T_6 (Ca $(NO_3)_2$ @ 2% + Bagging (Yellow colour Polythene) and T_9 (K_2SO_4 @ 2% + Bagging (Yellow colour Polythene) was found to be best in terms of quality parameters like TSS (10.12 °Brix), acidity (1.27%), ascorbic acid content (153.17 mg/100 g), reducing sugar (5.24%), total sugar (9.51%).

Keywords: Guava; Ca $(NO_3)_2$; K_2SO_4; bagging.

1. INTRODUCTION

Guava is a widely cultivated tropical fruit found in various tropical and subtropical regions. The common guava, scientifically known as *Psidium guajava* (L.) (lemon guava, apple guava), is a small tree belonging to the myrtle family (Myrtaceae). It is native to Mexico, Central America, the Caribbean, and northern South America (Morton, 1987). Guava has a chromosome number of 2n=22 [1]. Global guava production in 2019 reached 55 million tonnes, with India accounting for 45% of the total output. Guava fruits typically range from 4 to 12 centimetres (1+1⁄2 to 4+1⁄2 inches) in length and have a round or oval shape depending on the species. They emit a distinct and characteristic fragrance, similar to lemon rind but milder. The outer skin can be either rough with a bitter taste or soft and sweet. According to the National Institute of Nutrition [2], guava's nutritional composition includes protein (2.55 g), crude fibre (5.44 g), carbohydrates (14.32 g), calories (68 Kcal), calcium (18 mg/100 g), phosphorus (40 mg/100 g), iron (0.26 mg), vitamin B3 (1.083 mg/100 g), vitamin C (228.30 mg/100 g), and magnesium (22 mg/100 g). Guava is also a rich source of vitamin A, which plays a crucial role in maintaining healthy skin and eyes. Guava leaves contain carotenoids and polyphenols such as (+)-Gallo catechin and leucocyanidin [3]. The presence of these phytochemicals contributes to the coloration of the fruit's skin and flesh. Guavas with a red-orange hue generally have higher levels of polyphenols and carotenoids compared to yellow-green ones. In India, guava is grown on an estimated 315 thousand hectares of land, with a production volume of 45.16 million metric tons. Uttar Pradesh ranks first in guava production, followed by Madhya Pradesh and Bihar. In Uttar Pradesh alone, guava is cultivated across 29 thousand hectares, yielding a production of 9.83 million metric tons. The district of Allahabad is renowned for producing the finest guavas in the country and even globally [2]. A balanced and sufficient supply of nutrients, particularly calcium nitrate and potassium nitrate, is crucial for the optimal growth, health, and productivity of fruit crops. Calcium nitrate provides calcium and nitrogen, essential for plant development, fruit firmness, and photosynthesis. Inadequate calcium can lead to fruit disorders in various crops. Proper calcium supply ensures healthy fruit development, cell wall integrity, and the distribution of essential nutrients. Potassium nitrate supplies potassium and nitrogen, important for water regulation and stress tolerance in plants. Adequate potassium levels enhance fruit development and quality. Nitrogen promotes vegetative growth and fruit set. Studies have shown the positive effects of bagging fruits with polythene, such as improved appearance, protection, and yield, reducing the need for pesticides. Bagging has been effective in enhancing fruit quality in various crops like apples, peaches, pears, and grapes. Pre-harvest spraying of calcium on fruits improves quality, decay resistance, and calcium uptake. Bagging fruits before harvest reduces stresses, improves appearance, and minimizes pest infestation, diseases, and disorders. These techniques contribute to improving fruit production, quality, and reducing chemical usage in agriculture. Zhang et al., [4] demonstrated that calcium is essential for maintaining cell wall integrity and strength. Adequate calcium supply ensures proper cell division and elongation, leading to healthy fruit development. Calcium also influences the transport and distribution of other essential nutrients within the plant, contributing to overall fruit quality. Wang et al., [5] investigated the effect of calcium on guava fruit quality and found that calcium applications increased fruit firmness, enhanced vitamin C content, and improved sensory attributes. Calcium also contributes to the regulation of enzymatic activities involved in fruit ripening processes, such as pectin degradation and flavor development. Potassium nitrate provides both potassium and nitrogen, and potassium is important for regulating water movement in plants, helping them withstand environmental stresses. Adequate potassium supports fruit development and improves fruit quality, including size, color, and flavor. Nitrogen in potassium nitrate promotes vegetative growth and fruit set. Fruit crops require proper nutrition to produce high-quality, nutritious fruits [6]. Souri et al., [7] examined the impact of potassium nitrate on apple trees (*Malus domestica*) and found significant improvements in various growth parameters. Several studies have investigated the role of bagging with polythene in fruit crop production, highlighting its positive effects on fruit appearance, protection, and yield. Additionally, bagging can help to reduce the need for pesticides and increase the value of the fruit [8]. Several studies have shown the positive effects of bagging on fruit quality in various fruit crops, such as apples, peaches, pears, and grapes. For example, a study on bagging in apples showed that bagged fruits had higher fruit color, lower insect damage, and lower disease incidence compared to non-bagged fruits. Similarly, bagging in peaches has been shown to improve fruit size, color, and flavor [9].

2. MATERIALS AND METHODS

The present investigation was done to understand the plant growth, fruit yield and quality of guava using different combinations of treatment with bagging and Calcium Nitrate and Potassium Sulphate. The details of the materials used, and the methods adopted in the investigation, which was carried out at Horticultural Research Farm (CRF), Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj during the *Rainy* season of 2022. The design used in study was randomized block design (RBD) each treatment was replicated thrice. The data were statistically analysed (by the method suggested by Fisher and Yates [10]. The treatments comprised of T_1 (Control), T_2 (Ca $(NO_3)_2$ @ 2%), T_3 (K_2SO_4 @ 2%), T_4 (Ca $(NO_3)_2$ @ 2% + K_2SO_4 @ 2%), T_5 (Ca $(NO_3)_2$ @ 2% + Bagging (Green colour Polythene), T_6 (Ca $(NO_3)_2$ @ 2% + Bagging (Yellow colour Polythene), T_7 (Ca $(NO_3)_2$ @ 2% + Bagging (Red colour Polythene), T_8 (K_2SO_4 @ 2% + Bagging (Green colour Polythene), T_9 (K_2SO_4 @ 2% + Bagging (Yellow colour Polythene) and T_{10} (K_2SO_4 @ 2% + Bagging (Red colour Polythene). Bagging was done prior to fruit harvest at time of formation of fruit. While spraying was done 2 days prior to bagging. Observations were recorded at different stages of growth periods for characters like fruit weight, fruit volume, lengths of fruit, fruit specific gravity etc. Chemical parameters like reducing sugars, acidity, TSS etc were also calculated. Fruit weight was calculated after harvest using electronic balance. TSS was measured using refractometer, acidity was measured by volumetric analysis of fruit juice. The fruit's specific gravity is then calculated by dividing its weight in air by its weight loss when immersed in water. Some fruit with a higher specific gravity is generally denser and more mature, indicating better quality. The formula for specific gravity of fruit is: Specific gravity = Weight in air / (Weight in air - Weight in water). Vitamin C or Ascorbic acid content in the pulp was estimated by using 2, 6 dichlorophenol indophenol dye as reported by Ranganna [11].

3. RESULTS AND DISCUSSION

3.1 Physical Parameters

Data from the Tables 1 and 2 depicts the physical parameters observed for guava.

3.1.1 Fruit weight, fruit lengths, fruit diameter and fruit volume

The fruit weight significantly varied among different treatment combinations. The maximum fruit weight (147.27 g) was observed with treatment T_7 (Ca $(NO_3)_2$ @ 2% + Bagging (Red colour Polythene) followed by T_6 (Ca $(NO_3)_2$ @ 2% + Bagging (Yellow colour Polythene) with 146.16 g. Minimum fruit weight (132.04 g) was observed in T_1 (Control).

The fruit polar length significantly varied among different treatment combinations. The fruit diameter significantly varied among different treatment combinations. The maximum fruit diameter (8.14 cm) was observed with treatment T_7 (Ca $(NO_3)_2$ @ 2% + Bagging (Red colour Polythene) followed by T_6 (Ca $(NO_3)_2$ @ 2% + Bagging (Yellow colour Polythene) with 7.96 cm. Minimum fruit diameter (6.43 cm) was observed in T_1 (Control).

The fruit volume significantly varied among different treatment combinations. The maximum fruit volume (697.02 cm^3) was observed with treatment T_7 (Ca $(NO_3)_2$ @ 2% + Bagging (Red colour Polythene) followed by T_6 (Ca $(NO_3)_2$ @ 2% + Bagging (Yellow colour Polythene) with

666.82 cm^3. Minimum fruit volume (292.47 cm^3) was observed in T_1 (Control).

The increased weight, length, diameter, and volume of guava fruits can be attributed to the synergistic effect of two factors: the application of calcium nitrate and the use of polythene bags for bagging. Calcium nitrate spraying facilitates improved nutrient uptake and cellular development in the fruits, resulting in increased weight. By bagging the fruits with polythene bags, a microenvironment is created that reduces moisture loss, enabling the fruits to retain more water and consequently gain weight. Similar findings were reported by Mishra et al., [12]; Rahman et al., [13]; Saroj et al., [14]; Carpenter et al., [15]; Kanpure et al., [16]; Poojan et al., [17] and Vani et al., [18] in guava.

3.1.2 Specific gravity of fruit, fruit firmness, spotted fruit percentage and percentage of insect damaged fruit

The fruit specific gravity significantly varied among different treatment combinations. The maximum fruit specific gravity (0.96) was observed with treatment T_6 (Ca $(NO_3)_2$ @ 2% + Bagging (Yellow colour Polythene) followed by T_9 (K_2SO_4 @ 2% + Bagging (Yellow colour Polythene) with 0.96. Minimum fruit specific gravity (0.73) was observed in T_1 (Control). The fruit firmness significantly varied among different treatment combinations. The maximum fruit firmness (10.53 kg/cm^2) was observed with treatment T_9 (K_2SO_4 @ 2% + Bagging (Yellow colour Polythene) followed by T_6 (Ca $(NO_3)_2$ @ 2% + Bagging (Yellow colour Polythene) with 10.20 kg/cm^2. Minimum fruit firmness (8.24 kg/cm^2) was observed in T_1 (Control).

The enhanced fruit specific gravity in guava can be attributed to the effects of calcium nitrate and potassium sulphate spraying, along with the practice of bagging the fruits with polythene bags. Calcium nitrate and potassium sulphate promote better nutrient absorption and cellular development in the fruits, resulting in denser fruit tissues. Bagging the fruits with polythene bags creates a microclimate that minimizes moisture loss, allowing the fruits to retain more water content. The improved nutrient uptake and increased water retention contributes to enhanced fruit specific gravity in guava. Similar findings were reported by Mishra et al., [12]; Rahman et al., [13]; Saroj et al., [14]; Carpenter et al., [15]; Kanpure et al., [16]; Poojan et al., [17] and Vani et al., [18] in guava.

The percentage of spotted fruit significantly varied among different treatment combinations. The minimum spotted fruit (6.36 %) was observed with treatment T_7 (Ca $(NO_3)_2$ @ 2% + Bagging (Red colour Polythene) followed by T_6 (Ca $(NO_3)_2$ @ 2% + Bagging (Yellow colour Polythene) with 8.91%. Maximum spotted fruit (60.24 %) was observed in T_1 (Control). The percentage of insect damaged fruit significantly varied among different treatment combinations. The minimum insect damaged fruit (3.57%) was observed with treatment T_7 (Ca $(NO_3)_2$ @ 2% + Bagging (Red colour Polythene) followed by T_6 (Ca $(NO_3)_2$ @ 2% + Bagging (Yellow colour Polythene) with 3.58%. Maximum insect damaged fruit (29.57%) was observed in T_1 (Control).

The decrease in the occurrence of spotted and insect-infested guava fruits is credited to the combined use of calcium nitrate spraying and polythene bagging. Calcium nitrate strengthens the plant's inherent defence mechanisms, making it less appealing to insects and reducing their infestation. Meanwhile, bagging the fruits with polythene bags acts as a physical barrier, preventing insects from reaching and harming the fruits. By employing both calcium nitrate spraying and bagging, a protective shield is established around the guava fruits, resulting in a lower risk of insect infestation, and promoting the production of healthier, insect-free fruits. Similar findings were reported by Mishra et al., [12]; Rahman et al., [13]; Saroj et al., [14]; Carpenter et al., [15]; Kanpure et al., [16]; Poojan et al., [17] and Vani et al., [18] in guava.

3.2 Chemical Parameters

Data from the Table 2 depicts the phenological characters observed for guava.

3.2.1 TSS, acidity and ascorbic acid content

The TSS significantly varied among different treatment combinations. The maximum TSS (10.12 °Brix) was observed with treatment T_6 (Ca $(NO_3)_2$ @ 2% + Bagging (Yellow colour Polythene) followed by T_9 (K_2SO_4 @ 2% + Bagging (Yellow colour Polythene) with 9.80 °Brix. Minimum TSS (8.21 °Brix) was observed in T_1 (Control). Similar findings were reported by Mishra et al., [12]; Rahman et al., [13]; Saroj et al., [14]; Carpenter et al., [15]; Kanpure et al., [16]; Poojan et al., [17] and Vani et al., [18] in guava.

Table 1. Performance of different nutrient application and bagging on various physical parameters of guava

Treatment symbol	Treatment Details	Fruit weight (g)	Fruit Polar Length (cm)	Fruit Equatorial Length (cm)	Fruit diameter (cm)	Fruit Volume (cm^3)	Fruit specific gravity	Fruit firmness (Kg/cm^2)	Spotted fruit (%)	Insect damaged fruit (%)
T_1	Control	132.04	6.39	6.96	6.43	292.47	0.73	8.24	60.24	29.57
T_2	Ca $(NO_3)_2$ @ 2%	136.61	7.33	7.90	6.98	412.30	0.76	8.48	22.91	24.27
T_3	K_2SO_4 @ 2%	135.93	7.59	8.12	7.24	454.49	0.74	8.45	16.90	16.44
T_4	Ca $(NO_3)_2$ @ 2% + K_2SO_4 @ 2%	136.84	8.01	8.58	7.51	524.81	0.77	8.75	14.91	13.57
T_5	Ca $(NO_3)_2$ @ 2% + Bagging (Green colour Polythene)	140.91	7.49	8.06	6.89	424.27	0.85	9.48	17.57	14.26
T_6	Ca $(NO_3)_2$ @ 2% + Bagging (Yellow colour Polythene)	146.16	8.80	9.37	7.96	666.82	0.96	10.20	8.91	3.58
T_7	Ca $(NO_3)_2$ @ 2% + Bagging (Red colour Polythene)	147.27	8.91	9.46	8.14	697.02	0.92	9.97	6.36	3.57
T_8	K_2SO_4 @ 2% + Bagging (Green colour Polythene)	134.13	7.72	8.29	7.11	463.44	0.80	9.49	19.57	7.57
T_9	K_2SO_4 @ 2% + Bagging (Yellow colour Polythene)	145.06	8.60	9.17	7.87	630.21	0.96	9.78	7.57	4.24
T_{10}	K_2SO_4 @ 2% + Bagging (Red colour Polythene)	143.72	8.56	9.13	7.77	617.35	0.93	10.53	10.24	5.57
F-Test		**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**
S.E.(m) (±)		**0.04**	**0.01**	**0.01**	**0.14**	**2.15**	**0.05**	**0.26**	**0.04**	**0.07**
C.D. (5%)		**0.11**	**0.05**	**0.04**	**0.41**	**6.45**	**0.16**	**0.76**	**0.12**	**0.20**
C.V.		**0.04**	**0.03**	**0.29**	**6.43**	**7.20**	**11.10**	**4.72**	**0.38**	**0.93**

Table 2. Performance of different nutrient application and bagging on various Chemical parameters of guava

Treatment symbol	Treatment Details	TSS (°Brix)	Acidity (%)	Ascorbic acid content (mg/100 g)	Reducing sugar (%)	Non-Reducing sugar (%)	Total sugar (%)	Invert sugar (%)
T_1	Control	8.21	1.14	113.70	4.18	3.26	7.44	1.72
T_2	Ca $(NO_3)_2$ @ 2%	8.70	1.16	120.50	4.72	3.50	8.22	1.97
T_3	K_2SO_4 @ 2%	9.96	1.15	122.71	4.77	3.55	8.79	2.02
T_4	Ca $(NO_3)_2$ @ 2% + K_2SO_4 @ 2%	9.70	1.13	129.41	4.69	3.74	8.47	1.95
T_5	Ca $(NO_3)_2$ @ 2% + Bagging (Green colour Polythene)	9.63	1.18	126.07	4.61	3.44	8.10	1.86
T_6	Ca $(NO_3)_2$ @ 2% + Bagging (Yellow colour Polythene)	10.12	1.27	153.17	5.24	4.55	9.51	2.19
T_7	Ca $(NO_3)_2$ @ 2% + Bagging (Red colour Polythene)	9.76	1.23	151.59	5.08	4.41	9.16	2.11
T_8	K_2SO_4 @ 2% + Bagging (Green colour Polythene)	9.26	1.15	140.71	5.90	3.63	8.75	2.01
T_9	K_2SO_4 @ 2% + Bagging (Yellow colour Polythene)	9.80	1.24	146.41	5.06	4.52	9.15	2.10
T_{10}	K_2SO_4 @ 2% + Bagging (Red colour Polythene)	9.62	1.20	145.53	5.00	4.13	9.05	2.08
F-Test		**S**	**S**	**S**	**S**	**S**	**S**	**S**
S.E.(m) (±)		**0.01**	**0.04**	**0.29**	**0.06**	**0.06**	**0.03**	**0.02**
C.D. (5%)		**0.02**	**0.01**	**0.87**	**0.02**	**0.02**	**0.08**	**0.06**
C.V.		**0.11**	**0.05**	**0.37**	**0.07**	**0.07**	**0.06**	**0.18**

The percentage of acidity significantly varied among different treatment combinations. The maximum acidity (1.27 %) was observed with treatment T_6 (Ca $(NO_3)_2$ @ 2% + Bagging (Yellow colour Polythene) followed by T_7 (Ca $(NO_3)_2$ @ 2% + Bagging (Red colour Polythene) with 1.23 %. Minimum acidity (1.13 %) was observed in T_4 (Ca $(NO_3)_2$ @ 2% + K_2SO_4 @ 2%).

The percentage of ascorbic acid content significantly varied among different treatment combinations. The maximum ascorbic acid content (153.17 mg/100 g) was observed with treatment T_6 (Ca $(NO_3)_2$ @ 2 mg/100 g + Bagging (Yellow colour Polythene) followed by T_7 (Ca $(NO_3)_2$ @ 2 mg/100 g + Bagging (Red colour Polythene) with 151.59 mg/100 g. Minimum ascorbic acid content (113.70 mg/100 g) was observed in T_1 (Control). Similar findings were reported by Mishra et al., [12]; Rahman et al., [13]; Saroj et al., [14]; Carpenter et al., [15]; Kanpure et al., [16]; Poojan et al., [17] and Vani et al., [18] in guava.

3.2.2 Reducing and non-reducing sugar, total sugar and invert sugar

The percentage of reducing sugar significantly varied among different treatment combinations. The maximum reducing sugar (5.24%) was observed with treatment T_6 (Ca $(NO_3)_2$ @ 2% + Bagging (Yellow colour Polythene) followed by T_7 (Ca $(NO_3)_2$ @ 2% + Bagging (Red colour Polythene) with 5.08%. Minimum reducing sugar (4.18%) was observed in T_1 (Control).

The percentage of non-reducing sugar significantly varied among different treatment combinations. The maximum non-reducing sugar (4.55%) was observed with treatment T_6 (Ca $(NO_3)_2$ @ 2% + Bagging (Yellow colour Polythene) followed by T_9 (K_2SO_4 @ 2% + Bagging (Yellow colour Polythene) with 4.52%. Minimum non-reducing sugar (3.26%) was observed in T_1 (Control).

The percentage of total sugar significantly varied among different treatment combinations. The maximum total sugar (9.51%) was observed with treatment T_6 (Ca $(NO_3)_2$ @ 2% + Bagging (Yellow colour Polythene) followed by T_7 (Ca $(NO_3)_2$ @ 2% + Bagging (Yellow colour Polythene) with 9.16%. Minimum total sugar (7.44%) was observed in T_1 (Control). The percentage of invert sugar significantly varied among different treatment combinations. The maximum invert sugar (2.19%) was observed with treatment T_6 (Ca $(NO_3)_2$ @ 2% + Bagging (Yellow colour Polythene) followed by T_7 (Ca $(NO_3)_2$ @ 2% + Bagging (Yellow colour Polythene) with 2.11%. Minimum invert sugar (1.72%) was observed in T_1 (Control). Similar findings were reported by Mishra et al., [12]; Rahman et al., [13]; Saroj et al., [14]; Carpenter et al., [15]; Kanpure et al., [16]; Poojan et al., [17] and Vani et al., [18] in guava.

4. CONCLUSION

From the above experimental finding it may be concluded that the treatment T_7 (Ca $(NO_3)_2$ @ 2% + Bagging (Red colour Polythene) and T_{10} (K_2SO_4 @ 2% + Bagging (Red colour Polythene) was found to be best in the terms of physical parameters like fruit weight, fruit length etc among different treatment combinations of guava while T_6 (Ca $(NO_3)_2$ @ 2% + Bagging (Yellow colour Polythene)) and T_9 (K_2SO_4 @ 2% + Bagging (Yellow colour Polythene) was found to be best in terms of quality parameters like TSS, acidity etc.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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