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EFFECT OF FRUIT BAGGING TIME ON FRUIT QUALITY AND PEST DYNAMICS OF GUAVA (PSIDIUM GUAJAVA L.)

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ABSTRACT

Background: The present study entitled "Effect of fruit bagging time on fruit quality and pest dynamics of guava (Psidium guajava L.)" evaluated the impact of zinc sulphate spray, bagging time, and bagging material on fruit quality attributes and pest dynamics of guava (Psidium guajava L.). The field experiment was conducted in a randomized block design with 15 treatments and 3 replications, comprising two zinc levels $ZnSO_4$ at 0.25% (Z1) and 0.50% (Z2), two bagging times 10 days after fruit set (T1) and 20 days after fruit set (T2), three bagging materials brown perforated paper bag (B1), white perforated polythene bag (B2), and blue perforated polythene bag (B3), two non-bagged zinc controls, and one untreated control. On pooled observations, treatment T_{11} (Z2 + T2 + B2) recorded superior overall performance, showing maximum maturity (90.83%), fruit weight (194.81g), fruit volume (202.43 cm^3), TSS (12.65 °Brix), which were statistically at par with T12 (Z2 +T2+ B3). However, T_{11} recorded significantly higher pulp weight (189.99 g) and ascorbic acid (182.88 mg/100 g pulp) than all other treatments, alongside the lowest fruit drop (9.15%) and number of seeds per fruit (226.21). For pest suppression, however, T_5 (Z2 + T1 + B2) proved superior, registering the lowest pest infestation (0.95%). The untreated control consistently showed inferior performance. These findings indicate that 0.50% $ZnSO_4$ combined with bagging at 20 days after fruit set, particularly using white perforated polythene bags, markedly enhances fruit quality and suppresses pest pressure in guava. The integrated use of zinc nutrition and timely fruit bagging can therefore serve as an effective pre-harvest management strategy for high-quality guava production.

KEYWORDS: Guava, zinc sulphate, pre-harvest bagging, fruit quality, fruit fly, Brown, White, Blue, perforated polythene bag.

INTRODUCTION

Guava (Psidium guajava L.) occupies a prominent position among tropical and subtropical fruit crops, owing to its high nutritional value, adaptability, and commercial importance. The fruit is an excellent source of vitamin C, dietary fiber, phenolic compounds, and antioxidants, making it highly valued for both fresh consumption and processing. Fruit bagging has emerged as an effective approach for controlling fruit fly infestation and improving overall fruit quality in guava (1). India is the world's leading producer of guava, where the crop is widely cultivated because of its hardiness, regular bearing habit, and suitability to diverse agro-climatic conditions (2). Uttar Pradesh, Bihar, Rajasthan, Madhya Pradesh and Maharashtra are the major guava growing states in the country. However, Allahabad of Uttar Pradesh has the reputation of growing best quality guava fruits in the world (3).

Despite its economic significance, guava fruit quality is often affected by seasonal fluctuations and severe infestation of insect pests and diseases, particularly during the rainy season. Such conditions result in poor fruit appearance, reduced sweetness, lower total soluble solids, and considerable yield losses. Therefore, the adoption of effective pre-harvest technologies for improving fruit quality and minimizing pest damage has become increasingly important. Generally, fruit yield is more in rainy season crop as compared to winter season (4,5) but fruits of rainy season crop are insipid in taste and poor in quality (6). And more infestation of pests like fruit flies in comparison to winter season (7). On the contrary, in winter season fruits are of superior quality and fetches high monetary returns (8).

Fruit bagging is pre-harvest practice that modifies the fruit microenvironment and provides physical protection against insect pests mechanical injury, pesticide residues, and adverse weather conditions. By altering light intensity, temperature, and humidity around developing fruits, bagging can significantly influence fruit growth, colour development, sugar accumulation, and overall fruit quality (9). Moreover, bagging has been reported to reduce fruit fly infestation and disease incidence while enhancing marketable fruit yield in guava and other fruit crops (10).

Bagging of fruits; a physical protection technique is considered suitable to control the damage of pests like fruit fly which are difficult to manage with other practices and is universally adopted to control fruit fly damage in many fruit crops (11).

This practice is an eco-friendly technology as there will be no pesticide residue in fruit and environment. Bagging of fruits can also reduce the incidence of disease, mechanical damage, sun burning of the fruits, and bird damage (12) and increases the cosmetic value of fruits by improving the peel colour (13). However, the selection of bagging material and time of fruit bagging is of utmost importance for better results (14,15). Despite this substantial production, significant quantitative and qualitative losses occur due to fruit fly infestation, anthracnose, bird damage, and adverse weather conditions, especially during the rainy season. Previous studies have demonstrated that pre-harvest fruit bagging can significantly reduce fruit fly damage and improve marketable fruit yield in guava (10). More recently, (9) reported that appropriately timed bagging improves fruit size, sweetness, colour development, and nutritional quality across several fruit crops by creating a favorable microenvironment around developing fruits. Similarly, (16) observed that bagging enhanced fruit quality and antioxidant metabolism while reducing external defects and postharvest losses.

The effectiveness of fruit bagging largely depends on the stage of fruit development at which bagging is performed and the type of bagging material used. The present study was undertaken to evaluate the impact of different bagging times and bagging materials on fruit quality attributes and pest dynamics in guava (Psidium guajava L.).

MATERIALS AND METHODS

Experimental site and plant material

The present investigation entitled "Effect of fruit bagging time on fruit quality and pest dynamics of guava (Psidium guajava L.)" was carried at Horticultural Research Centre and Post-harvest Technology Laboratory, College of Horticulture, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India. During two consecutive rainy seasons (Ambe Bahar) 2023-2024 and 2024-2025. Three-year-old guava trees cv. SHWETA planted in a Meadow orchard system were used for the study.

Experimental design and treatment details

The experiment was laid out in a Randomized Block Design (RBD) comprising 15 treatments with 3 replications. The treatment combinations consisted of two concentrations of zinc sulphate ($ZnSO_4$), two fruit bagging times and three bagging materials. Zinc sulphate was applied twice as a foliar spray at two concentrations, namely 0.25% (Z1) and 0.50% (Z2) 1st before flowering and the 2nd one was sprayed just after the fruit set. Fruit bagging was carried out at two stages of fruit development: 10 days after fruit set (T1) and 20 days after fruit set (T2). Three different bagging materials were used, viz., brown perforated paper bag (B1), white perforated polythene bag (B2) and blue perforated polythene bag (B3). The treatment combinations were as follows: T_0 (control), T_1 (Z1 + T1 + B1), T_2 (Z1 + T1 + B2), T_3 (Z1 + T1 + B3), T_4 (Z2 + T1 + B1), T_5 (Z2 + T1 + B2), T_6 (Z2 + T1 + B3), T_7 (Z1 + T2 + B1), T_8 (Z1 + T2 + B2), T_9 (Z1 + T2 + B3), T_{10} (Z2 + T2 + B1), T_{11} (Z2 + T2 + B2), T_{12} (Z2 + T2 + B3), T_{13} (Z1 without bagging) and T_{14} (Z2 without bagging).

Fruit bagging

Fruit bagging was performed according to the assigned treatments at either 10 or 20 days after fruit set, 20 uniform, pest-free fruitlets per plant (60 tagged fruits per treatment per replication) were selected. Bagging was executed at designated stages (T1 or T2). The bags were perforated to facilitate adequate ventilation and gaseous exchange and were securely fastened around the fruit stalk to prevent insect entry while allowing normal fruit growth. The bags remained on the fruits until harvest.

OBSERVATIONS RECORDED

Fruit maturity and retention

Fruit maturity percentage was calculated based on the proportion of mature fruits harvested from the total number of tagged fruits. Fruit drop percentage was determined by recording the number of fruits dropped during the experimental period relative to the initial number of tagged fruits.

Physical characteristics of fruits

At harvest, representative fruits from each treatment were collected for the assessment of physical parameters. Fruit weight (g) was measured using a digital electronic balance. Fruit volume (cm^3) was determined by the water displacement method. Pulp weight (g), seed weight (g), and the number of seeds per fruit were recorded after manual separation of pulp and seeds.

Biochemical analysis

Total soluble solids (TSS) were measured using a digital hand refractometer and expressed as °Brix. Ascorbic acid content was determined by titration using 2,6-dichlorophenol indophenol dye method and expressed as mg/100 g pulp.

Pest infestation

Pest infestation (%) was recorded at harvest based on the number of fruits showing visible insect damage in relation to the total number of fruits examined.

Statistical analysis

The experimental data were subjected to analysis of variance (ANOVA) appropriate for a Randomized Block Design as described by (17). The significance of treatment effects was tested at the 5% probability level. Whenever the treatment effects were found significant, the means were compared using the Critical Difference (CD) test at $P \leq 0.05$. Statistical analysis was performed using standard statistical procedures, and the results were interpreted accordingly.

Table.1: Effect of fruit bagging time on fruit quality and pest dynamics of rainy season guava (*Psidium guajava* L.) cv. SHWETA pooled data 2023-24 and 2024-25.

Parameter	Maturity (%)	Fruit drop (%)	Fruit weight (g)	Fruit volume (cm3)	Pulp weight (g)	TSS (°Brix)	Ascorbic acid (mg/100 g)	Seeds per fruit	Pest infestation (%)
Control	72.15	27.84	100.47	101.26	94.46	6.73	144.45	322.99	27.51
Z1+T1+B1	82.82	17.17	159.88	168.05	154.49	9.99	152.91	297.71	1.08
Z1+T1+B2	82.15	17.85	162.94	175.29	157.59	9.61	158.59	287.87	1.07
Z1+T1+B3	82.02	17.97	157.18	168.93	151.51	9.88	156.1	292.06	1.15
Z2+T1+B1	84	16.01	169.03	175.3	170.82	9.53	151.37	277.85	1.08
Z2+T1+B2	85.6	14.35	177.82	182.88	178.05	10.2	158.49	267.55	0.95
Z2+T1+B3	84.8	15.2	175.68	178.85	171.05	10.7	154.62	272.76	1.04
Z1+T2+B1	87.55	12.4	177.28	184.21	167.99	10.9	161.21	262.52	1.65
Z1+T2+B2	87.53	12.45	183.62	188.65	178.53	10.9	167.05	257.69	1.54
Z1+T2+B3	86.75	13.25	185.83	181.70	171.64	10.88	164.86	263.65	1.57
Z2+T2+B1	88.32	11.6	179.58	192.21	182.64	11.53	172.95	237.70	1.46
Z2+T2+B2	90.83	9.15	194.81	202.43	189.99	12.65	182.88	226.21	1.61
Z2+T2+B3	89.20	10.77	190.49	196.03	187.56	12.2	176.34	232.56	1.72
Z1(No Bagging)	78.65	21.35	150.08	160.85	144.11	8.13	152.61	302.61	22.59
Z2(No Bagging)	81.05	18.95	132.70	149.58	126.86	9.23	154.30	292.78	21.93
S. Ed. (±)	**3.46**	**0.49**	**3.67**	**3.35**	**3.48**	**0.64**	**0.83**	**4.21**	**0.27**
C. D. (5%)	**10.01**	**1.39**	**9.01**	**10.05**	**9.94**	**1.93**	**2.49**	**12.02**	**0.81**

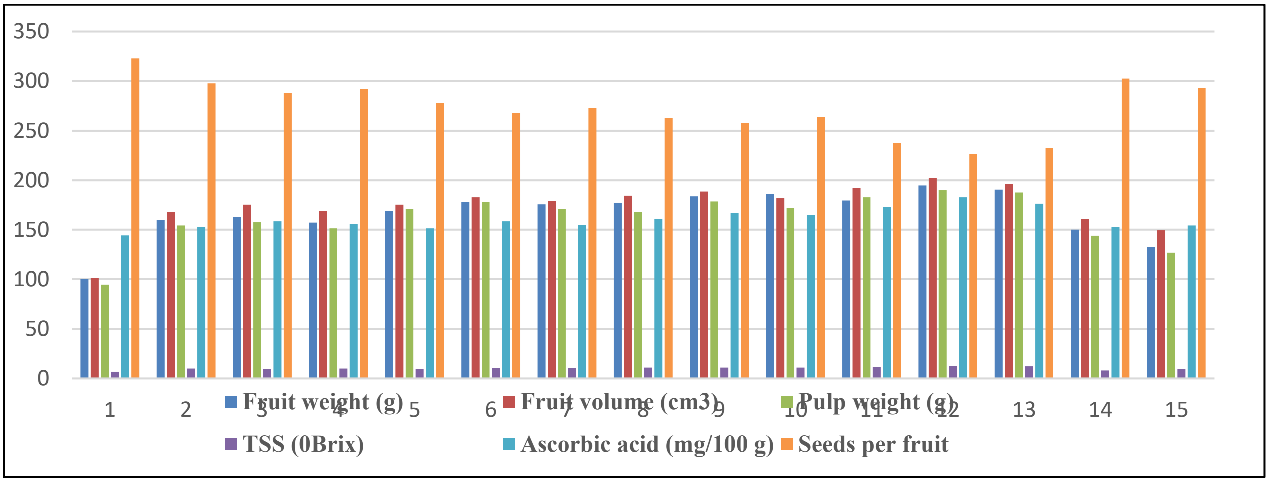

Fig.1: Effect on physical and bio-chemical fruit traits of guava (*Psidium guajava* L.) cv. SHWETA.

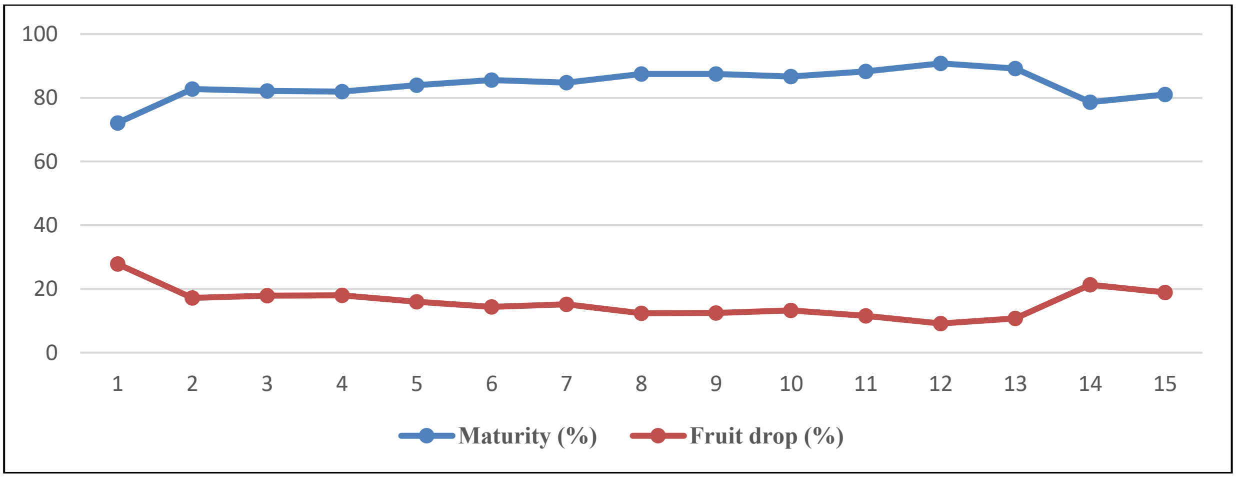

Fig.2: Effect on maturity and fruit drop of guava (*Psidium guajava* L.) cv. SHWETA.

RESULT

Pooled data (2023–24 and 2024–25) on the physical, biochemical, and phytosanitary parameters of guava as influenced by zinc sulphate spray, bagging time, and bagging material are presented in **Table 1, Fig. 1 & Fig.2.**

Effect on maturity and fruit drop

The treatments significantly influenced fruit maturity and fruit drop (Table 1). The highest pooled maturity percentage was observed in T11 (90.83%), followed by T12 (89.20%) and T10 (88.32%), while the untreated control T0 showed the lowest maturity (72.15%). The improvement in maturity under T11 suggests that higher zinc concentration combined with later bagging and White perforated polythene created favorable physiological conditions for fruit development. Fruit drop exhibited an inverse trend. The lowest pooled fruit drop was recorded in T11 (9.15%), followed closely by T12 (10.77%) and T10 (11.60%), whereas the untreated control showed the highest fruit drop (27.84%) Fig. 2. This indicates that zinc nutrition and bagging substantially improved fruit retention.

Effect on physical fruit traits

Marked treatment differences were recorded for physical fruit attributes (Table 1, Fig. 1). The highest pooled fruit weight was obtained under T11 (194.81g), which was statistically at par with T12 (190.49 g) followed by T9 (185.83 g), whereas lowest fruit weight (100.47 g) was observed in control. Fruit size and fruit volume followed a similar pattern reaching a maximum of (202.43 cm3) in T11, compared with (101.26 cm3) in the control. Pulp weight was likewise highest in T11 (189.99g). These findings clearly show that integrated zinc spray and bagging promoted fruit enlargement and pulp development.

Effect on seed traits

Seed characteristics were significantly affected by the treatments (Table 1). The lowest number of seeds per fruit was observed in T11 (226.21) compared with (322.99) in the control (Fig.1). Reduced seed load in treated fruits coincided with higher pulp development and consumer-preferred fruit quality.

Effect on biochemical fruit quality

The biochemical quality of guava improved substantially with zinc spray and bagging combinations (Table 1). The highest pooled TSS was recorded in T11 (12.65 °Brix), whereas the control had only (6.73 °Brix). Ascorbic acid content showed a strong positive response. Treatment T11 recorded the highest pooled ascorbic acid (182.88 mg/100 g pulp), followed by T12 (176.34 mg/100 g) and T10 (172.95 mg/100 g), whereas the control showed the lowest value (144.45 mg/100 g) (Fig. 1).

Effect on pest infestation

Substantial reductions in pest were achieved through treatment combinations (Table 1). The lowest pooled pest infestation at harvest was recorded under T5 (0.95%), followed by T6 (1.04%) and T2 (1.07%), whereas the control had a very high infestation level (27.51%) Fig. 1. These results strongly support the protective role of fruit bagging, especially when combined with improved zinc nutrition.

DISCUSSION

Effect on Maturity and Fruit Drop

Fruit bagging significantly influenced fruit maturity and fruit drop in guava. Fruits bagged at 20 days after fruit set exhibited higher maturity percentage and lower fruit drop compared with early bagging and non-bagged fruits. The reduction in fruit drop could be associated with protection from insect injury and environmental factors that often induce premature fruit abscission. Similar findings were reported by (10), who observed enhanced fruit retention and reduced fruit drop in bagged guava fruits due to decreased biotic stress and improved fruit development. (9) also reported that fruit bagging improves fruit retention by maintaining a stable microclimate around developing fruits.

Effect on Physical Fruit Traits

Fruit bagging significantly improved physical fruit characteristics including fruit weight, and pulp weight. The highest values recorded under bagging at 20 days after fruit set indicate that delayed bagging allowed normal initial fruit establishment while subsequently providing a protected environment for fruit enlargement. The favorable humidity and temperature conditions inside perforated bags likely enhanced cell division, cell expansion, and assimilate accumulation. Moreover, bagging minimized surface damage caused by insects and environmental factors, resulting in better fruit growth and marketable quality. Similar results were reported by (18), who observed that pre-harvest nutrient spraying combined with bagging using different coloured polythene significantly improved the physico-chemical quality of rainy-season guava cv. L-49.

Effect on Seed Traits

Bagging treatments significantly affected seed characteristics, including seed weight and number of seeds per fruit. This response may be related to alterations in fruit developmental processes caused by changes in light penetration and temperature around developing fruits. Enhanced pulp development under bagging may also contribute to a relatively lower seed proportion. Similar observations have been reported in guava and other fruit crops where fruit bagging altered internal fruit development and seed characteristics through micro environmental modification (9). The reduction in seed content is considered a desirable trait because it enhances consumer acceptability and edible fruit portion.

Effect on Biochemical Fruit Quality

Bagging significantly enhanced biochemical quality parameters of guava fruits. Fruits bagged at 20 days after fruit set recorded higher total soluble solids (TSS) and ascorbic acid content. The increase in TSS may be attributed to enhanced photosynthate accumulation and reduced respiratory losses under the modified fruit microenvironment. Higher ascorbic acid content may be associated with improved antioxidant metabolism and reduced oxidative degradation under protected conditions. These findings agree with reports by (16,19), who observed enhanced nutritional quality and improved biochemical composition in bagged fruits due to favorable changes in fruit physiology and metabolism. These findings agree with (20,21), who reported that foliar application of zinc significantly improved fruit weight, size, and biochemical quality of guava and with (22), who observed that fruit bagging enhanced physical and biochemical quality attributes in guava cv. Lalit.

Effect on Pest infestation

Fruit bagging markedly reduced pest infestation at harvest. The protective barrier created by the bags effectively prevented fruit fly oviposition, insect feeding, and direct exposure of fruits to pathogen inoculum. The lower incidence of pests in bagged fruits highlights the effectiveness of bagging as alternative to chemical protection measures. The superiority of perforated polythene bags may be attributed to their ability to exclude pests while maintaining sufficient ventilation, thereby reducing fruit fly damage and other pre-harvest fruit disorders, as similarly reported in guava and several horticultural crops following fruit bagging (10). Recent studies have emphasized that fruit bagging is an effective integrated pest management strategy that enhances fruit quality while reducing pesticide dependence and residue contamination (9,16).

CONCLUSION

The present investigation demonstrated that fruit bagging is an effective pre-harvest management practice for improving fruit quality and reducing pest infestation in guava. Among the treatments evaluated, T11 ($ZnSO_4$ 0.50% + bagging at 20 days after fruit set + white perforated polythene bag) recorded the highest value of maturity (90.83%), fruit weight (194.81g), fruit volume (202.43 cm3), pulp weight (189.99 g), TSS (12.65 °Brix) and ascorbic acid (182.88 mg/100 g pulp) among all the treatments. However, based on the critical difference values, T11 was statistically at par with T12 for maturity, fruit weight, fruit volume and TSS, and T11 was significantly superior to all other treatments for pulp weight and ascorbic acid content. Overall, the findings suggest that foliar application of $ZnSO_4$ at 0.50% combined with fruit bagging at 20 days after fruit set using white perforated polythene bags can be recommended as an efficient strategy for producing high-quality guava fruits with reduced pest incidence, particularly rainy season Guava. Adoption of this integrated approach may contribute to improved fruit quality, safer production systems, enhanced marketability, and greater profitability for guava growers.

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