

EFFECT OF NOVEL PLANT GROWTH REGULATORS AND FRUIT BAGGING ON YIELD AND SHELF LIFE OF GUAVA (*Psidium guajava* L.)

ABSTRACT

The present investigation was carried out to identify the effect of novel Plant Growth Regulators and fruit bagging techniques on the yield and shelf life of guava cv Gwalior-27. Yield and shelf life parameters such as yield tree⁻¹, yield hectare⁻¹, yield hectare⁻¹, physiological loss in weight, and rotting were analyzed. Brassinosteroids (BRs) have emerged as pleiotropic phytohormone owing to their wide function in crop growth and metabolism. Homobrassinolide (HBR) being an analogue of BRs is known to improve the growth, yield and quality parameters in many crop plants. Salicylic acid is accepted as safe and natural chemical compound for pre and post-harvest application on fruits to delay ripening, softening and reduction in lipid peroxidation and chilling injury in fruits. The experiment was laid in Factorial Randomized Block Design with 20 treatment combinations. It was observed that treatment combination P₃B₃ (Brassinosteroid (1.5 ppm) + White polyethylene bag) produced the maximum yield, while the maximum shelf life of guava fruits was attained in treatment combination P₅B₃ (Salicylic acid 600ppm + White polyethylene bag).

KEY WORDS: fruit bagging, guava, novel PGRs, shelf life, yield

INTRODUCTION

Guava (*Psidium guajava* L.) is very popular fruit. Its available throughout the year except during the summer season. Guava commonly referred to as the "apple of the tropics" or "poor man's apple," is one of the most widely grown fruits in tropical and subtropical climates. India produced 5.59 million metric tons of guava across 359,000 hectares of land in 2023. It is indigenous to Tropical America, which stretches from Mexico to Peru, and is a member of the Myrtaceae family with chromosome number 2n= 22 (Radha and Mathew, 2007). It is a perishable and has a short postharvest shelf life at environment temperature due to climacteric ripening with changes in physicochemical properties. Early in the 17th century, the Portuguese brought the plant to the Indian subcontinent. However, at the moment, the main nations that produce guavas are Mexico, Indonesia, Brazil, Bangladesh, China, Thailand, India, and Pakistan. But given its accessibility, abundance of nutrients, and affordability for the average person, the fruit appears to be indigenous to India (Dinesh and Vasugi, 2010). India is the major producer of guava fruit in the world and it shares about 45 % of total production of guava. A selection of

Guava variety Gwalior 27 comes from the Allahabadi Safeda Seedlings. The fruits are medium to medium-sized, with thick flesh, few seeds, cream white color, acid sweetness, and good quality.

In guava plants, the induction of flowers is significantly facilitated by plant growth regulators. The ovary enlarges and fruit development is initiated by the process of pollination and fertilization, which also causes the ovary to produce growth regulators. Brassinosteroids (BRs) have emerged as pleiotropic phytohormone owing to their wide function in crop growth and metabolism. Homobrassinolide (HBR) being an analogue of BRs is known to improve the growth, yield and quality parameters in many crop plants. Brassinosteroids are a new group of polyhydroxy steroids that have been recognized as a class of phytohormones. Brassinosteroids play prominent roles in many developmental processes including the increase of cell elongation, pollen tube growth, flowering, fruit set senescence, abscission and maturation (Swamy and Rao, 2008). Brassinosteroids (BRs) are a group of polyhydroxylated steroidal phytohormones that are required for the development, growth, and productivity of plants.

Moreover, Pre-harvest bagging significantly protects the fruit from biotic and abiotic stresses such as incidence of pests, birds damage, risk of microbial pathogens and disease incidence in fruit, physical and mechanical damage (Teixeira *et al.*, 2011) (Jia *et al.*, 2005; Sharma *et al.*, 2014) (Hofman *et al.*, 1997). On tree fruit bagging influences quality of guava harvested at different maturity stages during summer. Fruit fly infestation adversely affects guava crop especially during summer and resulted in significant economic losses. Therefore, the current experiment focuses on the improvement of yield and shelf life of guava fruits by application of novel PGRs and fruit bagging techniques.

MATERIAL AND METHODS

1. Experimental Site

The current research was performed in the field of Horticulture Research Orchard, Department of Horticulture, College of Agriculture, RVSKVV, Gwalior (M.P.). The research was conducted during 2022-23 and 2023-24. Gwalior lies at 26° 13' N latitude and 78° 14' E longitudes at an altitude of 211.5 m above mean sea level in Gird region. It experiences subtropical climate with summer temperature exceeding 45 °C in May-June, while the winters are too cold with chilling temperature as low as 2°C in December and January. The annual rainfall ranges between 650 to

751 mm, most of which received from end of June to end of September. Drought is the common feature due to the scanty and uneven distribution of rainfall. The soil of experimental area was sandy loam having good drainage.

2. Experimental layout

The experiment was laid in Factorial Randomized Block Design with 20 treatment combinations of novel Plant Growth Regulators and fruit bagging techniques with control. The treatment combination is presented in Table no. 1.

Table no. 1. Treatment combination

S.No.	Notation	Treatment combination
1	P ₁ B ₁	Control
2	P ₁ B ₂	News paper
3	P ₁ B ₃	White polyethene bag
4	P ₁ B ₄	Brown paper bag
5	P ₂ B ₁	Brassinosteroid (0.75 ppm)
6	P ₂ B ₂	Brassinosteroid (0.75 ppm) + News paper
7	P ₂ B ₃	Brassinosteroid (0.75 ppm) + White polyethylene bag
8	P ₂ B ₄	Brassinosteroid (0.75 ppm) + Brown paper bag
9	P ₃ B ₁	Brassinosteroid (1.5 ppm)
10	P ₃ B ₂	Brassinosteroid (1.5 ppm) + News paper
11	P ₃ B ₃	Brassinosteroid (1.5 ppm) + White polyethylene bag
12	P ₃ B ₄	Brassinosteroid (1.5 ppm) + Brown paper bag
13	P ₄ B ₁	Salicylic acid (400 ppm)
14	P ₄ B ₂	Salicylic acid (400 ppm) + News paper
15	P ₄ B ₃	Salicylic acid (400 ppm) + White polyethylene bag

16	P ₄ B ₄	Salicylic acid (400 ppm) + Brown paper bag
17	P ₅ B ₁	Salicylic acid (600 ppm)
18	P ₅ B ₂	Salicylic acid (600 ppm) + News paper
19	P ₅ B ₃	Salicylic acid (600 ppm) + White polyethylene bag
20	P ₅ B ₄	Salicylic acid (600 ppm) + Brown paper bag

3. Experimental Procedure

3.1 Number of fruits plant⁻¹

The total number of fruits harvested from each plant was counted and average fruits per plant were also computed.

3.2 Yield tree⁻¹ (kg)

The fruit of each plant were weighed separately by digital weighing balance and recorded at each picking.

3.3 Yield hectare⁻¹ (q)

The yield per hectare were calculated in quintal per hectare by calculating total number of plants per hectare and multiplied with average yield per plant.

3.4 Physiological loss in weight (%)

Fruits from each treatment were taken to record the physiological loss in weight. The weight of the fruits was recorded using electronic weighing balance (model: Essae, DS-852, Teraoaka Ltd.) before storage. Thereafter, the weights were recorded at two days interval during storage and the cumulative PLW was calculated with the following formula.

$$PLW (\%) = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

3.5 Rotting (%) The number of days the mature guava fruits were in edible condition was taken as the shelf life or keeping quality of fruits

RESULTS AND DISCUSSIONS

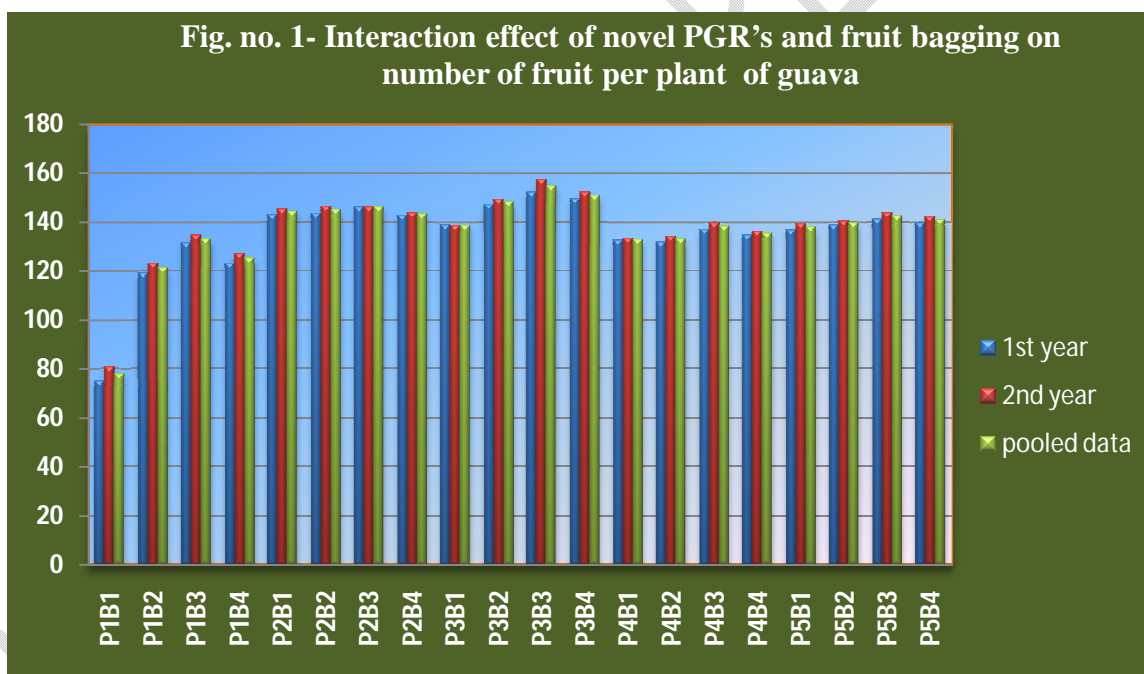
4.1 Number of fruits plant⁻¹

Through the analysis of the data presented in table 2 and figure.1 it was found that the interaction effect of the two factors i.e. novel PGRs and fruit bagging exerted statistically significant effect on the number of fruits per plant. Maximum number of fruits per plant in the first second and pooled data was recorded in treatment P₃B₃ (Brassinosteroid (1.5 ppm) + White polyethylene bag) with 152.07, 157.30 and 154.68, whereas minimum number of fruits per plant in the first, second and pooled data was observed in P₁B₁ (control) with 75.11, 80.80 and 77.95 respectively. The findings are in accordance with Cao *et al.* (2005) who reported that at the organism level, brassinosteroids promote overall growth, reproductive development, shorten the period of vegetative growth, increase crop yield and improve the quality of fruits in Arabidopsis. The results are also in agreement with Sharma *et al.* (2020) observed the effects of five different types of bags on the rainy-season crop of 'Allahabad Safeda' guava. All bags significantly advanced fruit maturity and improved fruit weight, texture, visual appeal, quality, and functional attributes over unbagged (control) fruits.

Table no. 2 Interaction effect of novel PGR's and fruit bagging on Number of fruits per plant of guava during 1st year, 2nd year and pooled data

	Number of fruits per plant				
	Novel PGR's				
	1 st year				
Fruit bagging	P ₁	P ₂	P ₃	P ₄	P ₅
B ₁	75.11	142.90	138.71	132.45	136.59
B ₂	119.29	143.62	147.12	131.85	138.81
B ₃	131.52	146.21	152.07	136.91	141.17
B ₄	123.20	142.66	149.41	134.53	139.57
	2 nd year				
B ₁	80.80	145.46	138.57	133.21	139.24

B₂	123.13	146.35	149.29	134.14	140.28
B₃	134.50	146.04	157.30	139.50	143.82
B₄	127.10	143.83	152.10	136.26	142.11
	Pooled data				
B₁	77.95	144.18	138.64	132.83	137.92
B₂	121.21	144.99	148.20	133.00	139.55
B₃	133.01	146.12	154.68	138.21	142.50
B₄	125.15	143.24	150.76	135.39	140.84
	1st year		2nd year		Pooled
SE(M)	5.86		6.43		6.14
CD (5%)	16.78		18.41		17.58



4.2 Yield tree⁻¹ (kg)

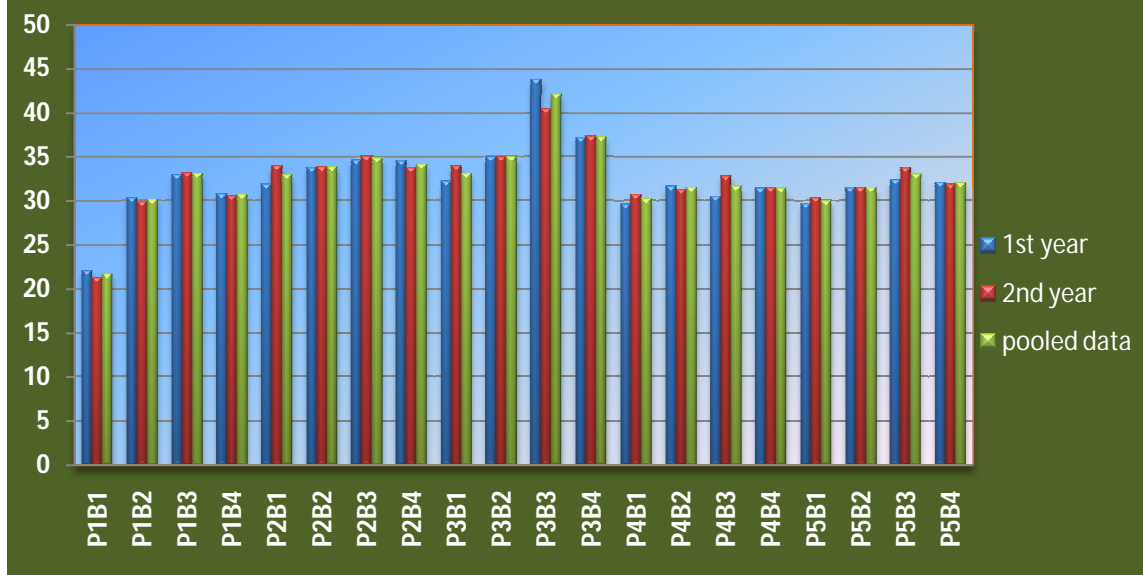
Through the evaluation of the data presented in table 3 and figure 2 it was found that the highest yield per tree in the first, second and pooled data was obtained in treatment P₃B₃ (Brassinosteroid (1.5 ppm) + White polyethylene bag) with 43.79, 40.45 and 42.12 (kg), whereas minimum yield per tree in the first, second and pooled data was recorded in P₁B₁ (control) with 22.05, 21.27 and

21.66 respectively. The findings are in accordance with Rajan *et al.* (2017) who found that post-shooting spray of banana bunches with brassinosteroid at the rate of 2.0 mg L^{-1} resulted in a yield of 114.46 t ha^{-1} in cultivar Grand Naine as against 84.24 t ha^{-1} in control. The improvement in yield was attributed to the effect of brassinosteroids on cell elongation by increasing the cell permeability to water and osmotic solutes of the cells.

Table no. 3 Interaction effect of novel PGR's and fruit bagging on Yield per tree of guava during 1st year, 2nd year and pooled data

	Yield per trees				
	Novel PGR's				
	1 st year				
Fruit bagging	P ₁	P ₂	P ₃	P ₄	P ₅
B ₁	22.05	31.85	32.22	29.63	29.68
B ₂	25.36	33.75	34.97	31.62	31.52
B ₃	28.96	34.59	43.79	30.51	32.33
B ₄	26.80	34.54	37.13	31.39	32.05
	2 nd year				
B ₁	21.27	33.98	33.96	30.73	30.32
B ₂	26.91	33.83	34.95	31.30	31.50
B ₃	30.15	35.08	40.45	32.83	33.73
B ₄	27.52	33.73	37.31	31.51	31.88
	Pooled data				
B ₁	21.66	32.92	33.09	30.18	30.00
B ₂	26.13	33.79	34.96	31.46	31.51
B ₃	29.06	34.84	42.12	31.67	33.03
B ₄	27.66	34.14	37.22	31.45	31.97
	1 st year		2 nd year		Pooled
SE(M)	1.349		1.609		1.351
CD (5%)	3.862		4.606		3.867

Fig. no. 2- Interaction effect of novel PGR's and fruit bagging on yield per tree of guava



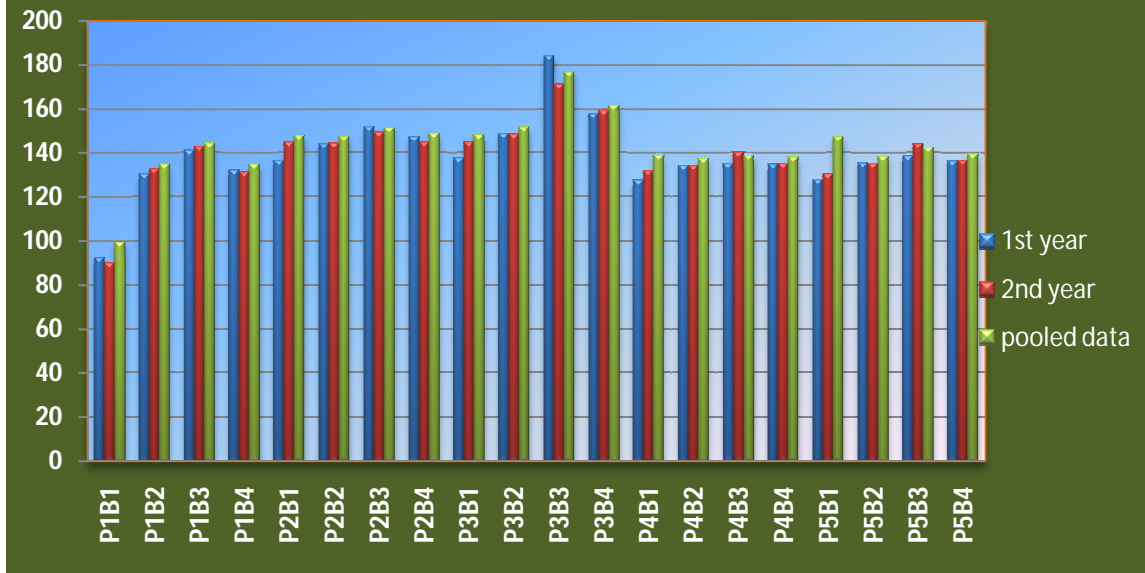
4.3 Yield hectare⁻¹ (q)

The examination of the data presented in table 4 and figure 3 revealed that the maximum yield per hectare in the first, second and pooled data was found in treatment P₃B₃ (Brassinosteroid (1.5 ppm) + White polyethylene bag) with 184.17, 171.04 and 176.60 (q), while the minimum yield per hectare in the first, second and pooled data was recorded in P₁B₁ (control) with 92.23, 89.99 and 99.32 (q) respectively. The findings are in agreement with Gomes *et al.* 2006 who reported that the application of brassinosteroid analog (BR-3) during a period of reproductive development has increased the yield by 65% in passion fruit over control. It stimulated better accumulation of photosynthates resulting into increased fruit number. Similarly, the increased yield was also observed in Navel orange and sweet cherry due to BRs application by Sugiyama and Kuraishi 1989; Roghabadi and Pakkish 2014. Asreyet *al.* (2011) concluded that under subtropical climatic condition, there is frequent fluctuation in atmospheric humidity and steep variation in day night temperature. This phenomenon makes the pomegranate suture (rind) more prone to cracking. Bagging films act as physical barriers and regulate water loss as well as temperature fluctuation and thus prevents fruit cracking.

Table no. 4 Interaction effect of novel PGR's and fruit bagging on Yield per hectare of guava during 1st year, 2nd year and pooled data

	Yield per hectare				
	Novel PGR's				
	1 st year				
Fruit bagging	P ₁	P ₂	P ₃	P ₄	P ₅
B ₁	92.23	136.44	137.57	127.56	127.72
B ₂	130.45	144.00	148.57	134.15	135.37
B ₃	134.98	151.74	184.17	135.07	138.35
B ₄	132.22	147.20	157.55	134.58	136.03
	2 nd year				
B ₁	89.99	144.92	144.84	131.93	130.24
B ₂	132.65	144.30	148.37	134.21	135.03
B ₃	136.96	149.35	171.04	140.34	143.93
B ₄	131.15	144.77	159.18	135.07	136.53
	Pooled data				
B ₁	99.32	147.67	148.20	138.73	147.28
B ₂	134.55	147.15	151.52	137.19	138.07
B ₃	135.55	151.36	176.60	138.70	142.14
B ₄	134.67	148.57	161.35	137.83	139.31
	1 st year		2 nd year		Pooled
SE(M)	5.257		6.269		5.211
CD (5%)	15.049		17.947		14.918

Fig. no.3- Interaction effect of novel PGR's and fruit bagging on yield per hectare (q) of guava



4.4 Physiological loss in weight (%)

The interaction effect of the two factors i.e. novel PGRs and fruit bagging on the physiological loss in weight of guava fruits presented in table 5 and figure.4 demonstrates that minimum physiological loss in weight of guava fruits was recorded in the combination P₅B₃ (Salicylic acid 600ppm + White polyethylene bag) i.e. (2.98, 4.52 and 5.86) (3.07, 4.59 and 5.85) (3.08, 4.56 and 5.86) respectively throughout 3rd day, 6th day and 9th day of storage in ambient condition in both the year as well as in pooled data. While the maximum physiological loss in weight of guava fruits was recorded in the combination P₁B₁ (control) i.e. (4.23, 6.11 and 7.62) (4.70, 6.13 and 8.12) (4.46, 6.12 and 7.87) respectively throughout 3rd day, 6th day and 9th day of storage in ambient condition in 1st year, 2nd year and in pooled data. The results are in accordance with Arafat (2019) who reported that salicylic acid (SA) different concentrations assessed on mycelial linear growth inhibition (MLGI %) of (*P. capitalensis*) in vitro. Exogenous postharvest treatment of guava fruit with SA tested at five concentrations, three times of immersion and kept for three period time of shelf life. DS per cent evaluated after three period times. Total soluble solids (TSS) and weight loss (WL) evaluated after three period times. The findings are in agreement with Son and Kim, (2010) who examined the effects of bagging periods on berry cracking during development in grape cv. Kyoho and concluded that the berry weight was highest in late period

of bagging treated at 7 to 9 weeks after full bloom as compared to the lowest in unbagged fruits. Bagging also critically reduced the fruit cracking rate as compared with the unbagged treatments.

Table no. 5 Interaction effect of novel PGR's and fruit bagging on physiological loss in weight of guava during 1st year, 2nd year and polled data

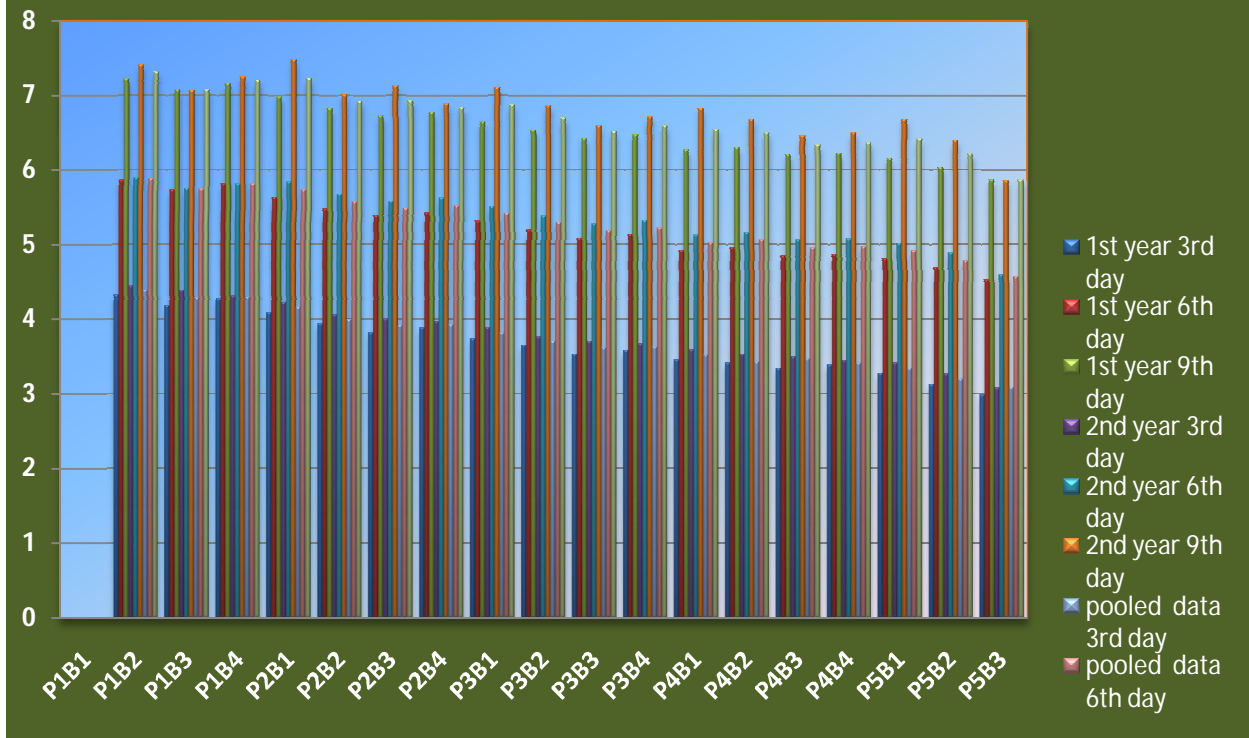
UNDER PEER REVIEW

	Physiological loss in weight (%)														
	3 rd day					6 th day					9 th day				
	Novel PGR's														
Fruit bagging	P ₁	P ₂	P ₃	P ₄	P ₅	P ₁	P ₂	P ₃	P ₄	P ₅	P ₁	P ₂	P ₃	P ₄	P ₅
B₁	4.23	4.08	3.73	3.45	3.27	6.11	5.63	5.31	4.92	4.80	7.62	6.97	6.64	6.26	6.15
B₂	4.32	3.93	3.65	3.41	3.12	5.86	5.47	5.19	4.96	4.68	7.21	6.82	6.53	6.30	6.03
B₃	4.18	3.81	3.53	3.34	2.98	5.73	5.39	5.08	4.85	4.52	7.07	6.72	6.42	6.20	5.86
B₄	4.26	3.88	3.58	3.38	3.06	5.81	5.42	5.13	4.86	4.60	7.15	6.77	6.47	6.22	5.95
	2 nd year														
B₁	4.70	4.22	3.89	3.59	3.41	6.13	5.83	5.51	5.12	5.01	8.12	7.47	7.10	6.82	6.67
B₂	4.44	4.05	3.76	3.53	3.26	5.89	5.67	5.38	5.16	4.88	7.40	7.00	6.85	6.67	6.39
B₃	4.38	4.00	3.70	3.49	3.07	5.75	5.58	5.28	5.06	4.59	7.06	7.12	6.59	6.45	5.85
B₄	4.31	3.96	3.66	3.44	3.19	5.81	5.62	5.32	5.07	4.80	7.24	6.88	6.71	6.49	6.20
	Pooled data														
B₁	4.46	4.15	3.81	3.52	3.34	6.12	5.73	5.41	5.02	4.91	7.87	7.22	6.87	6.54	6.41
B₂	4.38	3.99	3.70	3.42	3.19	5.88	5.57	5.29	5.06	4.78	7.31	6.91	6.69	6.49	6.21
B₃	4.28	3.91	3.61	3.47	3.08	5.74	5.48	5.18	4.95	4.56	7.07	6.92	6.51	6.33	5.86

B₄	4.29	3.92	3.62	3.41	3.10	5.81	5.52	5.22	4.97	4.70	7.20	6.83	6.59	6.36	6.08
	1st year		2nd year		Pooled	1st year		2nd year		Pooled	1st year		2nd year		Pooled
SE(M) ±	0.033		0.031		0.056	0.030		0.035		0.063	0.028		0.058		0.110
CD (5%)	0.094		0.087		0.161	0.086		0.101		0.181	0.080		0.165		0.315

UNDER PEER REVIEW

Fig. no. 4- Interaction effect of novel PGR's and fruit bagging on physiological loss in weight (%)



4.5 Rotting (%)

The interaction effect of the two factors i.e. novel PGRs and fruit bagging on the total sugar shown in table 6 and figure 5 reveals that the minimum rotting was found in the combination P₅B₃ (Salicylic acid 600ppm + White polyethylene bag) i.e. (0, 15.27 and 25.23) (0, 30.13 and 24.66%) (0, 15.02 and 24.95%) in the first, second and pooled data respectively. While the maximum total rotting was found in the combination P₁B₁ (control) i.e. (0, 32.42 and 44.52%) (0, 32.48 and 44.34%) (0, 32.45 and 44.43%) in the first year, second year and pooled data respectively. The findings are in accordance with Baliga *et al.*(2011) who reported that the loss in moisture causes a rapid rise in the concentration of sugars, leading to the maturation of the fruit. Salicylic acid can improve physical properties of fruits such as size in Thompson seedless grapevine. Pre-harvest spray of salicylic acid on Thompson Seedless grape increased cluster weight, length, and berry shape index compared to the control. Abbasi *et al.* (2018) noticed that bagging techniques can protect fruits from pests and eliminates the use of pesticides, thus

improves the quality of fruit, by different materials viz. newspaper bags, perforated polyethylene bags, muslin cloth bags and netted cloth bags used for on-tree bagging of guava fruit to improve fruit quality.

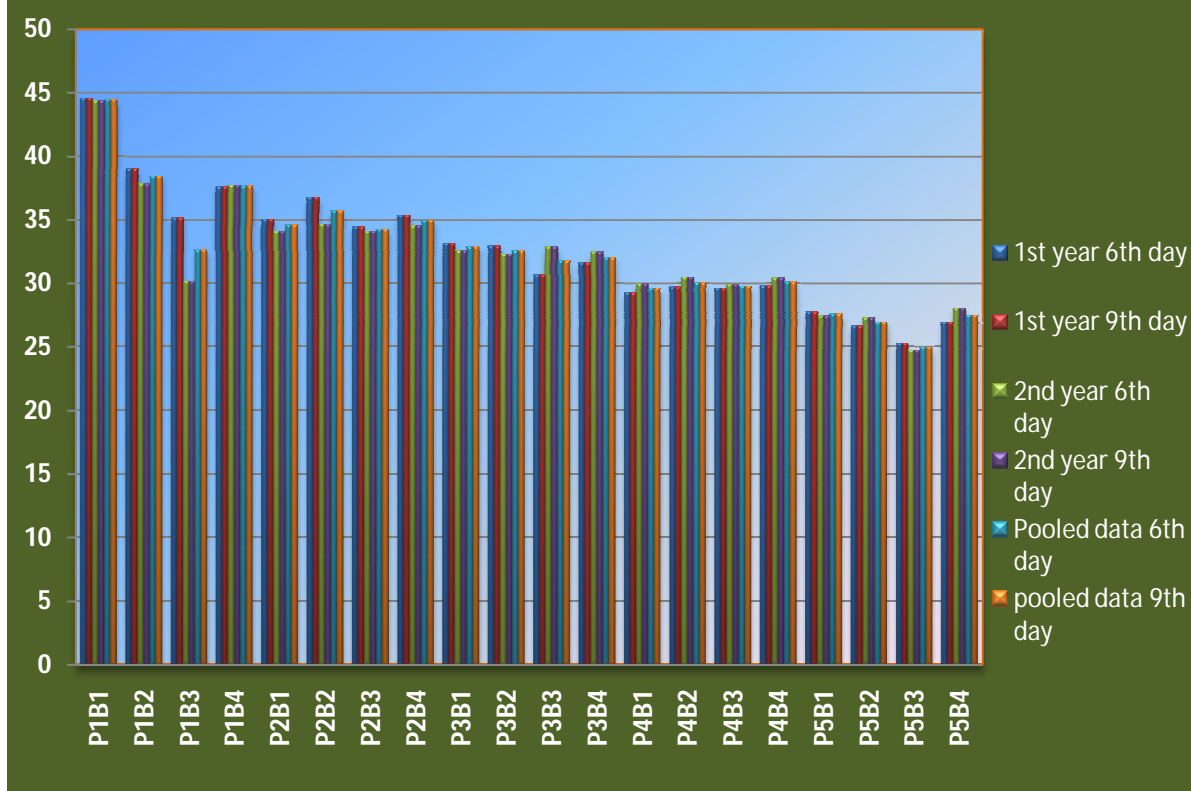
Table no. 6 Interaction effect of novel PGR's and fruit bagging on rotting percentage of guava during 1st year, 2nd year and pooled data

UNDER PEER REVIEW

	Rotting %														
	3 rd day					6 th day					9 th day				
	Novel PGR's														
Fruit bagging	P ₁	P ₂	P ₃	P ₄	P ₅	P ₁	P ₂	P ₃	P ₄	P ₅	P ₁	P ₂	P ₃	P ₄	P ₅
B ₁	-	-	-	-	-	32.42	23.7 6	22.1 1	18.7 1	17.70	44.52	35.00	33.1 1	29.22	27.70
B ₂	-	-	-	-	-	25.04	23.9 7	20.5 5	19.1 7	16.60	38.97	36.73	32.8 9	29.67	26.60
B ₃	-	-	-	-	-	23.11	23.3 2	19.6 4	19.2 8	15.27	35.11	34.40	30.6 4	29.58	25.23
B ₄	-	-	-	-	-	26.32	23.7 9	21.4 6	12.3 5	17.80	37.58	35.29	31.5 8	29.77	26.93
	2 nd year														
B ₁	-	-	-	-	-	32.48	22.5 7	21.5 7	19.4 3	17.40	44.34 7	34.067	32.5 67	29.933	27.400
B ₂	-	-	-	-	-	26.31	23.1 3	21.2 3	19.9 3	17.27	37.80 0	34.633	32.2 33	30.433	27.267
B ₃	-	-	-	-	-	18.10	23.8 0	21.6 3	19.3 7	14.77	30.13 3	34.067	32.8 33	29.867	24.667

B₄	-	-	-	-	-	26.00	23.0 3	21.6 7	19.9 0	18.00	37.66 7	34.533	32.4 27	30.400	28.000	
	Pooled data															
B₁	-	-	-	-	-	32.45	23.1 7	21.8 4	19.0 7	17.55	44.43	34.54	32.8 4	29.58	27.55	
B₂	-	-	-	-	-	25.67	23.5 5	20.8 9	19.5 5	14.98	38.39	35.68	32.5 6	30.05	26.93	
B₃	-	-	-	-	-	25.20	23.5 6	20.8 9	19.3 2	15.02	32.62	34.23	31.7 4	29.72	24.95	
B₄	-	-	-	-	-	26.16	23.4 1	21.5 6	19.4 4	17.90	37.62	34.91	32.0 0	30.09	27.47	
	1st year		2nd year		Pooled	1st year		2nd year		Pooled	1st year		2nd year		Pooled	
SE(M) ±						1.576		1.274		2.029	0.990		1.590		0.876	
CD (5%)						4.513		3.648		5.808	0.279		4.552		2.509	

Fig. no.5- Interaction effect of novel PGR's and fruit bagging on rotting (%) of guava



CONCLUSION

The evaluation of the effect of novel Plant Growth Regulators and fruit bagging on the yield and shelf life parameters of guava revealed that treatment combination P₃B₃ (Brassinosteroid (1.5 ppm) + White polyethylene bag) exerted most significant effect on the yield of guava, whereas treatment combination P₅B₃ (Salicylic acid 600ppm + White polyethylene bag) was found most significant in the enhancement of shelf life of guava fruits. Therefore, it can be concluded that Brassinosteroids can be applied to enhance the yield of guava along with suitable fruit bagging technique. Salicylic acid combined with fruit bagging plays an important role in reducing the physiological loss in weight and rotting of fruits. Further studies should be performed to analyze the impact of different novel PGRs and fruit bagging materials on yield and shelf life of different fruits.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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