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Response of nutrients and different bagging materials on fruit growth and quality of guava (*Psidium guajava* L) during rainy season

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Abstract
Guava is one of the important fruit being grown by the farmers as remunerative crop. The rainy season guava bears more number of fruits than winter season crop. The major problem of rainy season crop may be attributed with poor fruit size & quality because of high humidity, more infestations with insect pests and diseases resulting into shrivelled fruit size, less sweetness and poor storage life. There is ample scope to improve the fruit colour, size and high quality during rainy season crops to meet the consumer demand in order to fetch the high premium price. Pre-harvest spray of different concentrations of nutrients and fruit bagging are being used as intervention to improve the fruit colour, size and quality. Generally, the pre-harvest application of nutrient plays an important role in promoting fruit growth & development along with fruit quality of guava as it acts readily compared to conventional methods of fertilizer application. Nutrients applied through foliar applications are absorbed quickly through leaves of stomata and easily available to plants for their growth. The present investigation was carried out during 2022-23 in factorial randomized block design with two factors *viz;* varieties and nutrients to improve the fruit growth, quality and fruit yield of guava varieties during rainy season. Guava cultivars *viz.* Allahabad Safeda & Lalit are considered to be factor and foliar spray of five concentrations each of 1%, 1.5%, 2%, 0.5% & 0.75 calcium nitrate and potassium nitrate 1%, 3%, 0.5%, 1.75% & 2.25% along with different bagging materials blue, yellow, black, and silver polythene and aluminium foil, brown paper bag and news paper bag which makes a total of 26 treatments. Based on experimental results, it was concluded that the treatment T_3V_1Yellow (Polythene) + $Ca(No_3)_2$ @ 2% was found to be the best in terms of fruit growth & development. The average number of fruit/tree (161.07), fruit weight (151.13 g), polar fruit diameter (6.83 cm), radial fruit diameter (7.13 cm), seed weight (10.19), pulp weight (140.94 g), pulp: seed ratio (13.83), pulp % (93.26) with an average yield (97.37 kg/ha) along with minimum deformity & spoilage (10.20%) of fruits during rainy season.

Keywords: Guava, calcium nitrate, potassium nitrate, bagging, fruit growth, quality

1. Introduction

Guava (*Psidium guajava* L.) is also known to be "Apple of the tropics". Globally, this is being commonly cultivated for fresh fruit along with processing purposes. Guava belongs to the family 'Myrtaceae' and the genus *Psidium* comprises about 150 species of small shrubs and trees (Singh *et al.*, 2000b) [19]. Although, about 20 species have edible fruits of which the most commonly cultivated is the common guava (*Psidium guajava* L). The most commonly grown varieties of guava are Allahabad Safeda, Lucknow-49, Lalit, Surkha, Pant Prabhat, Red Guava etc. (Singh *et al.*, 2023) [17]. In India it is being grown as very remunerative fruit crop for fresh fruit and processing purposes. For jelly, jam, toffee, juice, RTS, canned dices, nectar, squash, ice cream, wine and syrup. Fruits are very rich source of minerals, vitamins and other nutraceuticals contents. Guava has significant economic and productive potential with high nutritional value and therapeutic characteristics coupled with low calorie rich in dietary fibre (Serrano *et al.*, 2004) [15]. The guava fruit is an excellent source of vitamin C (235 mg/100 g fruit) and pectin (1.15%). The fruit has an appreciable amount of minerals such as phosphorus (23 to 37mg/100 g), calcium (14 to 30 mg/ 100 g), iron (0.6 to 1.4 mg/100 g) as well as vitamins like niacin, thiamine, riboflavin and vitamin A (Lester *et al.* 2007) [6]. Guava flowers twice in the agro-climate region of north India (Rathore *et al*., 1974) [13].

The rainy season crop bears flowers in April-May and winter season crop bears flower in September-October (Singh, B.P *et al*., 2006) [18]. Generally the rainy season crops produce more fruit than winter season but the fruit size, and quality are not too good to receive the consumer attention as the rainy season fruits are not sweet (Singh *et al*., 2000a & Maji *et al*., 2015) [20, 7]. Similarly there is more pressure of biotic stresses especially fruit fly because of high humidity and more weed growth on the orchard floor (Rawal *et al*., 1988) [14]. There is ample scope to improve the fruit size and high quality fruit during rainy season crops to meet the consumer demand along with high premium price (Bin *et al*. 2006) [1]. In order to address the above mentioned issues, the pre-harvest spray of nutrients and individual fruit bagging study were initiated to improve the high quality fruits to fetch the premium price in the market resulting in to grower's livelihood (Ping *et al*. 2003, Kim *et al*,. 2003 & Singh *et al*, 2019) [12, 4, 22].

2. Materials and Methods

The present investigation entitled "Response of nutrients and different bagging material on fruit growth and quality of guava during rainy season were carried out at the experimental farm of Department of Horticulture, SHUATS Naini, Prayagraj during 2022-23. Ten years old plants of guava cv. Allahabad Safeda and Lalit were selected as factor A whereas different concentrations of calcium and potassium nitrate along with different bagging materials were selected as factor B (Table 1). The average thickness of the bagging materials range from 50 micron of newspaper to 125 micron of polythene. Combining both the factors a total of 26 treatments with 02 plants of in each replication were taken for observations using factorial randomized block design, (Panse and Shukhatme 1985) [11]. Following observations viz; number of fruits/tree, fruit weight (g), fruit polar diameter (cm), fruit radial diameter (cm), seed weight (g), pulp weight (g), pulp: seed ratio, pulp (%), fruit yield (kg/tree) and (q/ha) along with spoilage (%) were recorded.

3. Results and Discussion

3.1 Effect of pre-harvest spray of nutrients & fruit bagging on physical fruit parameters

Pre-harvest spray of nutrients followed by fruit bagging significantly influences the physical fruit characters of guava cv. Allahabad Safeda and Lalit in rainy season. Spraying of calcium nitrate and potassium nitrate positively affected the fruit size, weight, polar and radial diameter of fruits along with colour and firmness (Table 1). Maximum fruit weight (151.13 g) was recorded with pre harvest spraying of 2% calcium nitrate followed fruit bagging with yellow polythene (T_3) followed T_2 (1.5% calcium nitrate coupled with blue polythene) fruit bagging (148.80 g). Similarly, the maximum fruit polar diameter (6.83 cm) and radial fruit diameter (7.13 cm) were recorded in treatment T_3 followed by T_2 than control in cv Allahabad Safeda. In general fruit weight, polar and radial fruit diameter was recorded more in *cvs* Allahabad Safeda than Lalit may be attributed because of genetic constitution of cultivars, (Sharma *et al*., 2021) [16]. The various treatment of nutrients led by fruit bagging increases the fruit appealing performance coupled with better fruit firmness by reducing the post-harvest physiological loss in weight aligning with the findings of various workers, (Kawit et. al., 2002) [3]. Calcium aids in cell division, elongation and membrane integrity resulting into increase in fruit size. Warmer temperatures in yellow bagged fruits likely led to early harvesting. Bagging of fruit impacts light interception and affecting further fruit growth by improving fruit size and quality as reported by (Meena *et al*. 2016) [8]. Yellow and blue polythene were found to be best as when compared to the other treatment which might be aids in the physical parameter of fruit because of the fact that these colours polythene falls between the visible light range and somewhat close to range of Photosystem II and I (PS II & PS I). The range of PS II is 700 nm and PS I is 680 nm and at this range plant produce maximum food**.**

3.2 Seed and pulp characters

Data pertaining to seed and pulp characters are being depicted in Table 2. It is very clear and obvious that pre-harvest spraying of nutrients followed by fruit bagging treatments greatly influenced the seed weight (g/fruit) of guava fruit in both the cultivars. In general significantly less seed weight per fruit were recorded in majority of treatments either pre-harvest spraying alone or coupled with fruit bagging treatment compared to control. Moreover, the treatment 2% spraying of calcium nitrate coupled with yellow polythene fruit bags recorded the lowest seed weight in cvs Allahabad Safeda (10.19 g) and Lalit (10.54 g) than including control (13.39 g) and 14.26 g respectively. Similarly maximum pulp weight and pulp percentage were recorded in 2% pre-harvest spraying of calcium nitrate coupled with yellow polythene bagging in cvs. Allahabad Safeda (140.94 g) and Lalit (119.51 g). No significant differences were recorded between cultivars (Singh *et al*., 2020) [21].

Similar observation on pulp percentage and pulp: seed ratio was also influenced by the application of different treatments resulting in enhanced fruit size, pulp quality with higher pulp yield as reported by (Singh *et al*., 2021) [23]. The treatment spraying of 2% calcium nitrate along with bagging of fruits with yellow polythene bag resulted maximum pulp (93.26%) at par with treatment T_2V_1 (1.5% calcium nitrate + bagging with blue polythene) with (92.97%) pulp in cv Allahabad Safeda than control (88.17%). Highest pulp: seed ratio is being recorded (13.83) in treatment T_3V_1 followed by T_2V_1 (13.22) in cv Allahabad Safeda.

3.3 Yield contributing traits

Various observations on different yield contributing traits viz; number of fruit per tree, yield (Kg/trees) and total fruit yield (q/ha) were recorded (Table 3.) It is very clear and obvious that the maximum number of fruit/tree was obtained from the cv. Allahabad Safeda when it was interacted with the spraying of 2% calcium nitrate coupled with yellow polythene bagging (161.07) followed by spraying of 1.5% spraying of calcium nitrate coupled with blue polythene bagging (153.07) than control (121.93). In general, cv. Lalit recorded less number of fruit than cv. Allahabad Safeda amongst all the treatments applied than control (69.66). Cultivar Allahabad Safeda attained maximum number of fruit which might be due to the fact that the climate required to Allahabad Safeda is very favourable for its proper development which was stimulated by the interaction of T_3V_1 which has lead to rapid meiosis and cell elongation led to increase the number and size of the fruit as suggested by (Mishra *et. al*,. 2017 & Srivastava *et al*. 2023) [9, 24] in guava. Similarly, the application of different concentrations nutrient and bagging treatments significantly enhance the yield (Kg/tree). The data indicated that the significantly highest yield was recorded by the pre-harvest spray of 2% calcium nitrate coupled with bagging of yellow polythene (24.34 Kg/plant) followed by 1.5% spraying of calcium nitrate coupled with bagging of blue polythene (22.78 Kg/plant) than control (13.80 Kg/plant) in cv. Allahabad Safeda. Significant difference in yield were also recorded in all the treatments in both the cvs Allahabad Safeda and Lalit than control although very less yield were recorded in cv Lalit. Present findings are in line of (Edirimanna *et al.* 2015) [2] in guava. Similar findings were also recorded with total fruit yield per hectare in treatment T_3XV_1 (97.37q/ha) followed by T_2V_1 (91.11q/ha) than control (55.22q/ha). These findings align with results from (Omar *et al.* 2014) [10] in date palm.

Table 1: Effect of pre-harvest spray of nutrients and different bagging materials on physical fruit characters of guava cv. Allahabad Safeda and Lalit in rainy season during 2022-23.

Treatments and its code	Fruit Weight (g)			Polar Fruit diameter (cm)			Radial Fruit diameter (cm)		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
Control (T_0)	113.21	76.97	95.09	4.65	3.60	4.13	4.77	3.70	4.24
1.0% Ca $(No_3)_2$ + White (Polythene) (T_1)	146.73	124.34	135.53	5.82	5.33	5.58	6.04	5.56	5.80
1.50% Ca $(No_3)_2$ + Blue (Polythene) (T_2)	148.80	126.06	137.43	6.78	5.52	6.15	7.02	5.80	6.41
2.0% Ca $(No_3)_2$ + Yellow (Polythene) (T_3)	151.13	130.05	140.59	6.83	5.78	6.30	7.13	6.08	6.60
1.0% KNO_3 + Black (Polythene) (T_4)	140.99	118.33	129.66	5.58	5.22	5.40	5.80	5.40	5.60
3.0% KNO_3 + Silver polythene (T_5)	144.09	121.56	132.83	5.73	5.27	5.50	5.94	5.47	5.71
0.50% Ca $(No_3)_2$ + 0.50% KNO_3 + Aluminum Foil (T_6)	138.10	110.35	124.22	5.44	5.13	5.29	5.66	5.29	5.48
0.75% Ca $(No_3)_2$ + 1.75% KNO_3 + Brown paper bag (T_7)	134.88	109.44	122.16	5.18	4.82	5.00	5.45	4.96	5.21
1% Ca $(No_3)_2$ + 2.25% KNO_3 + Newspaper bag (T_8)	136.59	112.45	124.52	5.26	4.93	5.09	5.47	5.06	5.27
1.0% Calcium nitrate (T_9)	132.88	105.24	119.06	5.20	4.76	4.98	5.37	4.91	5.14
1.50% Calcium nitrate (T_{10})	131.38	102.67	117.02	5.09	4.61	4.85	5.31	4.74	5.03
1.0% Potassium nitrate (T_{11})	127.64	101.77	114.71	4.85	4.50	4.68	5.07	4.64	4.86
3.0% Potassium nitrate (T_{12})	123.06	98.43	110.75	4.44	4.26	4.35	4.58	4.37	4.48
Mean	136.11	110.59	-	5.45	4.90	-	5.66	5.08	-
LSD at %									
Treatment	2.443	1.213	0.858	0.120	0.060	0.042	0.172	0.085	0.060
Cultivars	0.958	0.476	0.336	0.047	0.023	0.017	0.067	0.033	0.024
Treatment X Cultivars	3.455	1.715	1.213	0.170	0.084	0.060	0.243	0.121	0.085

Table 2: Effect of pre-harvest spray of nutrients and different bagging materials on Seed and pulp characters of guava cv Allahabad Safeda and Lalit in rainy season during 2022-23.

Treatment details	Seed weight (g)			Pulp weight (g)			Pulp: seed ratio			Pulp (%)		
	Allahabad Safeda	Lalit	Mean	Allahabad Safeda	Lalit	Mean	Allahabad Safeda	Lalit	Mean	Allahabad Safeda	Lalit	Mean
Control (T_0)	13.39	14.26	13.83	99.81	62.71	81.26	7.45	4.39	5.92	88.17	81.29	84.73
1.0% Calcium nitrate + White Polythene (T_1)	10.69	11.26	10.97	136.04	113.08	124.56	12.73	10.04	11.39	92.72	90.94	91.83
1.50% Calcium nitrate + Blue Polythene (T_2)	10.46	11.33	10.90	138.33	114.73	126.53	13.22	10.12	11.67	92.97	91.01	91.99
2.0% Calcium nitrate + Yellow Polythene (T_3)	10.19	10.54	10.37	140.94	119.51	130.22	13.83	11.34	12.58	93.26	91.89	92.57
1.0% Potassium nitrate + Black Polythene (T_4)	11.23	11.15	11.19	129.76	107.17	118.47	11.56	9.61	10.58	92.04	90.57	91.31
3.0% Potassium nitrate + Silver polythene (T_5)	11.07	11.20	11.13	133.02	110.37	121.69	12.02	9.86	10.94	92.32	90.79	91.55
0.50% $Ca(No_3)_2$ + 0.50% KNO_3 +Aluminium Foil (T_6)	11.32	12.25	11.79	126.78	98.10	112.44	11.20	8.01	9.60	91.81	88.90	90.35
0.75% $Ca(No_3)_2$ + 1.75% KNO_3 + Brown paper bag (T_7)	10.86	11.42	11.14	124.02	98.02	111.02	11.45	8.58	10.02	91.95	89.57	90.76
1% $Ca(No_3)_2$ + 2.25% KNO_3 + Newspaper bag (T_8)	11.43	11.69	11.56	125.17	100.76	112.96	10.95	8.63	9.79	91.63	89.60	90.62
Calcium nitrate 1.0% (T_9)	11.55	12.40	11.98	121.32	92.84	107.08	10.50	7.48	8.99	91.31	88.21	89.76
Calcium nitrate 1.50% (T_{10})	11.47	12.47	11.97	119.91	90.20	105.06	10.46	7.23	8.85	91.27	87.85	89.56
Potassium nitrate 1.0% (T_{11})	11.80	12.52	12.16	115.84	89.25	102.54	9.82	7.13	8.47	90.75	87.70	89.23
Potassium nitrate 3.0% (T_{12})	11.80	12.57	12.18	111.26	85.86	98.56	9.43	6.83	8.13	90.41	87.23	88.82
Mean	11.33	11.93		124.78	98.66		11.13	8.41		91.58	88.89	
LSD at 5%												
Treatment	0.228	0.113	0.080	2.429	1.206	0.853	0.286	0.142	0.1	0.519	0.258	0.182
Cultivars	0.089	0.044	0.031	0.953	0.473	0.334	0.112	0.056	0.039	0.204	0.101	0.071
Treatment X Cultivars	0.322	0.160	0.113	3.435	1.705	1.206	0.404	0.201	0.142	0.734	0.364	0.258

Table 3: Effect of pre-harvest spray of nutrients and different bagging materials on number of fruits, fruit yield and spoilage percentage of guava cv Allahabad Safeda and Lalit in rainy season during 2022-23.

Treatment details	Number of fruits/tree			Fruit yield (kg/tree)			Fruit yield (q/ha)			Spoilage (%)		
	Allahabad Safeda	Lalit	Mean	Allahabad Safeda	Lalit	Mean	Allahabad Safeda	Lalit	Mean	Allahabad Safeda	Lalit	Mean
Control (T_0)	121.93	69.66	95.79	13.80	5.41	9.61	55.22	21.64	38.43	29.25	52.09	40.67
1.0% Calcium nitrate + White Polythene (T_1)	151.49	116.48	133.99	22.23	14.48	18.36	88.91	57.93	73.42	11.11	18.30	14.70
1.50% Calcium nitrate + Blue Polythene (T_2)	153.07	120.52	136.80	22.78	15.19	18.98	91.11	60.76	75.94	10.99	17.68	14.34
2.0% Calcium nitrate + Yellow Polythene (T_3)	161.07	123.39	142.23	24.34	16.05	20.19	97.37	64.19	80.78	10.20	16.62	13.41
1.0% Potassium nitrate + Black Polythene (T_4)	147.87	110.42	129.14	20.85	13.07	16.96	83.39	52.26	67.83	11.38	19.29	15.33
3.0% Potassium nitrate + Silver polythene (T_5)	150.06	112.57	131.32	21.62	13.68	17.65	86.49	54.74	70.61	10.95	18.22	14.58
0.50% $Ca(No_3)_2$ + 0.50% KNO_3 +Aluminium Foil (T_6)	146.43	109.57	128.00	20.22	12.09	16.16	80.89	48.36	64.63	11.49	19.44	15.46
0.75% $Ca(No_3)_2$ + 1.75% KNO_3 + Brown paper bag (T_7)	141.47	103.55	122.51	19.08	11.33	15.21	76.32	45.33	60.83	11.61	19.80	15.70
1% $Ca(No_3)_2$ + 2.25% KNO_3 + Newspaper bag (T_8)	143.17	104.50	123.84	19.56	11.75	15.65	78.22	47.01	62.62	11.75	20.38	16.07
Calcium nitrate 1.0% (T_9)	140.06	100.98	120.52	18.61	10.63	14.62	74.45	42.51	58.48	11.73	20.33	16.03
Calcium nitrate 1.50% (T_{10})	136.41	96.36	116.38	17.92	9.89	13.91	71.68	39.57	55.63	12.34	22.12	17.23
Potassium nitrate 1.0% (T_{11})	132.75	89.47	111.11	16.94	9.11	13.03	67.78	36.42	52.10	12.38	22.93	17.66
Potassium nitrate 3.0% (T_{12})	129.77	82.98	106.38	15.97	8.17	12.07	63.88	32.67	48.28	12.97	25.69	19.33
Mean	142.73	103.11		19.53	11.60		78.13	46.42		12.93	22.53	
LSD at 5%												
Treatment	2.550	1.266	0.895	0.383	0.19	0.135	1.532	0.760	0.538	1.828	0.907	0.642
Cultivars	1.000	0.497	0.351	0.15	0.075	0.053	0.601	0.298	0.211	0.717	0.356	0.252
Treatment X Cultivars	3.607	1.790	1.266	-	0.269	0.19	-	1.075	0.760	2.585	1.283	0.907

3.4 Spoilage

Pre-harvest application of 2% calcium nitrate along with bagging with yellow polythene bags significantly reduce the spoilage (10.20%) which is very closed to treatment 1.5% calcium nitrate + bagging with blue polythene (10.99%) compared to control (29.25%) in cv Allahabad Safeda. The cv Lalit recorded significantly more spoilage than cv Allahabad Safeda although significant pronounced effect of nutrients and fruit bagging treatments on spoilage were recorded being highest spoilage (52.09%) in control fruits. This clearly indicates that calcium nitrate and yellow polythene bagging help to improve fruit shelf life and reduce postharvest losses (Kumar *et al*., 2020) [5].

4. Conclusion

Based on the findings of the present investigation it can be concluded that different nutrients and bagging material had significant influence on fruit growth, yield and fruit quality with minimum fruit spoilage percentages. Based on the finding the pre-harvest spraying of 2% calcium nitrate coupled with fruit bagging with yellow polythene bags could be recommended for rainy season guava production to improve the overall fruit quality and marketability. The conclusions drawn from the present investigation are based on two seasons in a particular location, which may have wide implications. The experiment needs to be repeated over years and locations under different agro-climatic regions before drawing any definite conclusion.

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