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Effect of GA_3 and NAA on fruit quality and storage characteristics of fruit in sapota cv. Kalipatti

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Abstract
The investigation was conducted at Department of Horticulture, College of Agriculture, Dapoli (M.S.) during 2017-19 to study the effect of GA_3 and NAA on fruit quality and storage in sapota cv. Kalipatti. The application of GA_3 150 ppm resulted in significantly maximum fruit length (6.16 cm),fruit diameter (5.81 cm),fruit weight (146.17 g),volume of fruit(138.77 cm^3),specific gravity of fruit (1.05), pulp weight (138.00 g),pulp/seed ratio (99.28). The significantly maximum fruit TSS (25.10 ^{0}B),TSS/acidity ratio (192.60),reducing sugars (11.58%),non-reducing sugars(5.65%),total sugars (17.23%) and minimum titratable acidity of fruit(0.13%) were in fruits of GA_3 150 ppm treatment. The GA_3 150 ppm treatment resulted in significantly minimum PLW% on 2nd, 4th, 6th, 8th, and 10th day of storage of fruits (i.e. 3.11%, 6.29%, 9.98%, 11.55% and 28.43% respectively), shrivelling and/or spoilage percentage on 4th, 6th, 8th, and 10th day of storage of fruits (i.e. 0%, 5.33%, 9.33% and 18.67% respectively) and maximum shelf life (8.67 days).

Keywords: Sapota, NAA, GA3, fruit, storage

Introduction
Sapota [*Manilkara achras* (Mill.) Forsberg. Syn *Acharas sapota* L.] is a major tropical fruit, popularly known as *'chiku'* in India. It is an evergreen tree usually growing up to 10 m height. Being a hardy crop, it can be grown on wide range of soil and climatic conditions (Dutton, 1976). In India, sapota cultivation was taken up for the first time in Maharashtra in 1898 in a village named Gholwad (Cheema *et al*., 1954) [4]. The major sapota growing states are Maharashtra, Gujarat, Tamil Nadu, Andra Pradesh, Karnataka, West Bengal, Uttar Pradesh, Punjab and Haryana. Among the sapota cultivars, Kalipatti is a leading cultivar and has commercial value.
Sapota fruit is a fleshy berry, variable in shape, size and weight (75 to 150 g).The fruit when fully ripen is delicious and eaten as dessert fruit. The pulp is sweet and melting. The fruit skin can also be eaten since it is richer than the pulp in nutritive value. The sapota fruits are a good source of sugar which ranges between 12 to 14 per cent.
Sapota produces a large number of flowers throughout the year in different flushes. But flowers and fruits tends to drop in different stages of development right from its setting to maturity. However, incompatibility, low fertility and low fruit set drastically reduce the yield. To overcome this problem, the exogenous application of plant growth regulators is one of the remedy. In recent years, considerable attention has been given to increase fruit set, yield and qualitative characters of many fruit crops with the help of plant growth regulators. The auxins and gibberellins are mostly used to improve fruit set. Besides fruit set, the influence of auxins and gibberellins on fruit quality and shelf life desires to assess. With this view, the present investigation was carried out to study the effect of GA_3 and NAA on fruit quality and storage in sapota cv. Kalipatti.

Material and Methods
The present investigation was conducted at Department of Horticulture, College of Agriculture, Dapoli (M.S.) during 2017-19. The uniformly grown 27 years old sapota trees (cv. Kalipatti) were selected for experiment. The experiment was conducted in randomized

block design with three replications and seven treatments (T_1 - – Control, T_2 – GA_3 50 ppm, T_3 – GA_3 100 ppm, T_4 – GA_3 150 ppm, T_5 – NAA 100 ppm, T_6 – NAA 150 ppm and T_6 – NAA 200 ppm). The GA_3 and NAA application (Sprays) were given in 1st week of Jan and 1st week of Feb 2018. The recommended cultural practices viz; manures and fertilizer application, irrigation, plant protection were timely adopted. The fruits were harvested from individual experimental tree at appropriate maturity stage. The observations on physical properties of sapota fruits (Length, breadth, weight, volume of fruit, seed, pulp content) were measured. The chemical properties of fruits were analyzed (TSS, acidity and sugars) following standard procedures. The storage study of the fruits was taken. The data obtained was analyzed statistically as per the method suggested by Panse and Sukhatme (1985) [8].

Results and Discussion

Physical characteristics

The data pertaining to effect of GA_3 and NAA on physical characteristics of fruit are presented in Table 1. The treatments of different doses of GA_3 and NAA significantly influenced the physical parameters of sapota fruit. However, the number and weight of seed did not differ significantly.

Table 1: Effect of growth regulators on physical characteristics of fruit in sapota cv. Kalipatti

Treatments	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)	Fruit volume (cc)	Specific gravity	No. of seeds/ fruit	Seeds weight (g))	Pulp weight (g)	Pulp/ Seed ratio
T_1 (Control)	5.22	5.09	89.20	92.27	0.97	1.70	1.40	81.87	57.29
T_2 (GA_3 50 ppm)	5.52	5.24	116.47	117.76	0.99	1.63	1.39	108.74	78.00
T_3 (GA_3 100 ppm)	5.83	5.46	132.13	128.72	1.03	1.63	1.39	124.43	89.31
T_4 (GA_3 150 ppm)	6.16	5.81	146.17	138.77	1.05	1.60	1.39	138.00	99.28
T_5 (NAA 100 ppm)	5.74	5.31	121.00	119.81	1.01	1.67	1.40	113.20	81.05
T_6 (NAA 150 ppm)	5.82	5.40	126.30	123.02	1.03	1.63	1.39	118.67	85.37
T_7 (NAA 200 ppm)	6.03	5.72	137.97	132.67	1.04	1.67	1.39	130.63	93.98
Range	5.22 – 6.16	5.09 – 5.81	89.20 – 146.17	92.27 – 38.77	0.97 – 1.05	1.60 – 1.70	1.39 – 1.40	81.87 – 138.00	57.29 – 99.28
Mean	5.76	5.43	124.18	121.86	1.02	1.60	1.39	116.51	83.47
SEm ±	0.01	0.01	0.35	0.62	0.004	0.03	0.004	0.46	0.43
CD @ 5%	0.03	0.03	1.09	1.92	0.01	NS	NS	1.43	1.31

Fruit length

The significantly maximum fruit length (6.16 cm) was recorded in T_4 (GA_3 150 ppm) which was followed by T_7 (6.03 cm), T_3 (5.83 cm) which at par with T_6 (5.82 cm). The minimum fruit length (5.22 cm) was in T_1 (Control).

Fruit diameter

The highest fruit diameter (5.81 cm) was recorded in T_4 and it was followed by T_7 (5.72 cm), T_3 (5.46 cm), T_6 (5.40 cm), T_5 (5.31 cm), T_2 (5.24 cm). The minimum fruit diameter (5.09 cm) was measured in T_1.

Fruit weight

The significantly highest fruit weight (146.17 g) was recorded in T_4 which was followed by T_7 (137.97 g), T_3 (132.13), T_6 (126.30 g), T_5 (121.00 g), T_2 (116.47 g). The lowest fruit weight was recorded in T_1 (89.20 g).

Fruit volume

The highest fruit volume (138.77 cc) was in T_4 and it was followed by T_7 (132.67 cc), T_3 (128.72 cc), T_6 (123.02 cc), T_5 (119.81 cc), T_2 (117.76 cc). The minimum fruit volume (92.27 cc) was recorded in T_1.

Specific gravity

The highest specific gravity (1.05) in sapota was recorded in T_4 which was it was at par with T_7 (1.04) and T_3 and T_6 (1.03) which are same and then it was followed by T_5 (1.01), T_2 (0.99). The lower specific gravity (0.97) was estimated in T_1. The significant variation in fruit weight and volume eventually caused variation in specific gravity of sapota fruits.

Number of seeds per fruit

There was non-significant effect of growth regulators on number of seeds per fruit and average number of seeds per fruit was1.60

Weight of seeds

There was non-significant difference among the treatments for the weight of seeds and the average weight of seeds 1.39 g was recorded.

Pulp weight

The significantly maximum pulp weight in sapota was recorded in T_4 (138.00 g) which was followed by T_7 (130.63 g), T_3 (124.43 g), T_6 (118.67 g), T_5 (113.20 g), T_2 (108.74 g).The minimum pulp weight (81.87 g) was in T_1.

Pulp/seed ratio

The significantly highest pulp/seed ratio (99.28) was recorded in T_4 which followed by T_7 (93.98), T_3 (89.31), T_6 (85.37), T_5 (81.05) and T_2 (78.00), whereas, the lowest ratio (57.29) was in T_1.

Increase in physical characteristics of fruit like fruit length, fruit diameter, fruit weight, pulp weight, fruit volume, specific gravity and pulp to seed ratio of fruit by GA_3 application was probably due to rapid cell division, cell expansion and increased in the volume of intercellular spaces mesocarp cells and accumulation of water and nutrients in these intercellular spaces. Further these fruit characters were also increased by foliar application of NAA which cause excessive cell division in mesocarp and plasticity of cells.

The above findings are in close conformity with the results obtained by Patil *et al.* (2011), Bhujbal *et al.* (2013), Garhwal (2015), Desai (2016) and Khawle (2016) [9, 2, 6, 5, 7].

Chemical characteristics

The data pertaining to effect of different doses of GA_3 and NAA on chemical properties of fruit in sapota cv. Kalipatti are presented in Table 2.

Total soluble solids (TSS)

The significantly maximum TSS (25.10^{0}B) was recorded in T_4 which was followed by T_7 (24.03 ^{0}B). The treatments T_6 (23.40 ^{0}B), T_3 (23.03 ^{0}B), T_2 (22.87 ^{0}B), T_5 (22.80 ^{0}B) was at par with each other. The minimum TSS was observed in T_1 (20.77 ^{0}B).

Titratable acidity

The significantly minimum titrable acidity (0.13%) was recorded in T_4which was lowest to all other treatments and it was followed by T_7 (0.14%), T_6 and T_3 (0.15%) were recorded same value, then it was followed by T_2 which was equal to T_5 (0.16%).The maximum acidity (0.17%) was recorded in T_1.

TSS/acidity ratio

The significantly highest TSS/acidity ratio (192.60) was observed in T_4 (GA3 150 ppm) and it was followed by T_7 (171.65), and T_3 (153.60) which was at par with T_6 (153.28). Then it was followed by T_5 (140.74) which was at par with T_2 (139.45).The minimum TSS/acidity ratio (121.68) was in T_1 (Control).

Reducing sugars

The significantly maximum reducing sugars (11.58%) was recorded in T_4 which was followed by T_7 (11.03%), T_3 (10.76%), T_6 (10.65%), T_5 (10.49%) and T_2 (10.23%). The minimum reducing sugars was estimated in T_1 (9.89%).

Non reducing sugars

The significantly highest non-reducing sugars (5.65%) in sapota fruits was in T_4 and it was followed by T_7 (5.39%) and T_6 (5.26%) was at par with T_5 (5.23%), then it was followed by T_3(5.15%), T_2 (5.00%).The minimum non-reducing sugars (4.70%) was recorded in T_1 (Table 14 and Fig. 29).

Table 14: Effect of growth regulators on chemical characteristics of fruit in sapota cv. Kalipatti

Treatments	TSS (^{0}B)	Titrable acidity (%)	TSS/acidity ratio	Reducing sugars (%)	Non -reducing sugars (%)	Total sugars (%)
T_1 (Control)	20.77	0.17	121.68	9.89	4.70	14.60
T_2 (GA_3 50 ppm)	22.87	0.16	139.45	10.23	5.00	15.23
T_3 (GA_3 100 ppm)	23.03	0.15	153.60	10.76	5.15	15.91
T_4 (GA_3 150 ppm)	25.10	0.13	192.60	11.58	5.65	17.23
T_5 (NAA 100 ppm)	22.80	0.16	140.74	10.49	5.23	15.72
T_6 (NAA 150 ppm)	23.40	0.15	153.28	10.65	5.26	15.91
T_7 (NAA 200 ppm)	24.03	0.14	171.65	11.03	5.39	16.42
Range	20.77 – 25.10	0.13 – 0.17	121.68 – 192.60	9.89 – 11.58	4.70 – 5.65	14.60 – 17.23
Mean	23.14	0.15	153.28	10.66	5.20	15.86
SEm ±	0.18	0.002	0.96	0.03	0.02	0.03
CD @ 5%	0.55	0.005	2.95	0.08	0.06	0.09

Total sugars

The treatment T_4 recorded significantly maximum total sugars (17.23%) and it was followed by T_7 (16.42%) and T_6 was recorded same with T_3 (15.91%), then it was followed by T_5 (15.72%), T_2 (15.23%).The minimum total sugars registered in T_1 (14.60%).

It is observed that the exogenous applications of GA_3 and NAA increased the chemical characters of fruits like TSS and reducing, non-reducing, and total sugars with increasing concentrations which might be due to more accumulation of metabolites and quick conversion of starch into simple sugars during the fruit development. The reduction in titratable acidity probably due to increased cell sizeand intercellular spaces coupled with accumulation of water, sugar and other soluble solids in greater amount as a result of translocation of metabolites towards the fruit which decreased the acidity by increased sugar content of fruit. The above findings are in report of Ray *et al.* (1991), Chavan *et al.* (2009) Bhujabal *et al.* (2013), Garhwal (2015) and Khawle (2016) [3, 2, 6, 7].

Storage parameters

The perusal data on effect of different doses of GA_3 and NAA on storage parameters of sapota cv. Kalipatti was presented in Table 3.

Shriveling and spoilage

The data shown in Table 15 and Fig. 30 revealed that different growth regulators significantly affected the shriveling and/or spoilage percentage of sapota fruits

At second day of storage there was no shriveling and/or spoilage of fruits was observed. At fourth day of storage shriveling and/or spoilage (5.33%) was observed in treatment T1 (Control) which is significantly maximum to all other treatments and it is followed by T_5 (1.33%). However, the shriveling and/or spoilage of sapota fruits were not absolutely observed in rest of the treatments.

At sixth day of storage significantly minimum shriveling and/or spoilage of fruits was noticed in T_4 (5.33%) which was at par with T_3 and T_7 (9.33%) which were recorded same value and then it was followed by T_6 (10.67%) which was at par with T_2 (12.00%) and T_5 (13.33%).The maximum shriveling and/or spoilage (22.33%) was in fruits of control (T_1).

At eighth day of storage, significantly minimum shriveling and/or spoilage (9.33%) was observed in T_4(GA_3 150 ppm)which was at par with T_3 (12.00) and T_7 (13.33%), then it was followed by T_6 (17.33%) which was at par with T_2 (20.00%), T_5 (21.33%).The maximum shriveling and/or spoilage was noticed in T_1 (34.67%).

At tenth day of storage, significantly minimum shriveling and/or spoilage (18.67%) was observed in T_4 and it was followed by T_3 (22.67%) and then T_7 and T_6 (36.00%) which were recorded same value and was at par withT_2 (37.33%), then it was followed by T_5 (45.33%). The maximum shriveling and/or spoilage (54.67%) recorded in T_1.

Physiological loss in weight (PLW%)

The perusal data presented in Table 15 and Fig. 31 revealed that different growth regulators treatments significantly influenced the PLW percentage of sapota fruits.

At second day of storage, significantly lowest PLW (3.11%) was observed in T_4. It was followed by T_3 (3.31%) and T_2 (3.48%) which was at par with T_7 (3.52%), then it was followed by T_6 (3.76%), T_5 (4.52%).The maximum PLW (5.07%) was recorded in T_1.

At fourth day of storage, similar trend was yet again seen. The minimum PLW (6.29%) of fruits was in T_4 and it was followed by T_3(6.91%), T_2 (7.11%), T_7 (7.32%) and T_6 (7.49%) which were at par with each other and it was followed by T_5 (8.69%).The highest PLW was in T_1 (9.94%).

At sixth day of storage, significantly lowest PLW% of sapota fruits was observed in T_4 (9.98%) and it was followed by T_3 (10.27%) and then T_2 (10.57%) which was at par with T_7 (10.60%), then it was followed by T_6(10.82%), T_5 (12.07%).The highest PLW (14.07%) was recorded in T_1.

At eighth day of storage, the minimum PLW was again observed in T_4 (11.55%) and it was followed by T_3 (12.18%), T_2 (12.95%), T_7 (13.51%), T_6 (14.27%), T_5 (15.03%).The maximum PLW% was recorded in T_1 (25.45%).

At tenth day of storage, significantly minimum PLW (28.43%) was observed in T_4 which was at par with T_3 (29.19%) and then it was followed by T_2 (31.24%) which was at par with T_7 (31.31%) and T_6 (32.85%), then it was followed byT_5 (34.33%). The maximum PLW% was observed in T_1 (40.71%).

Table 15: Effect of growth regulators on storage characteristics (room temperature 27^0C) of sapota cv. Kalipatti

Treatments	Shriveling and spoilage (%)					PLW (%)					Shelf life (days)
	Day 2	Day 4	Day 6	Day 8	Day 10	Day 2	Day 4	Day 6	Day 8	Day 10	
T_1 (Control)	0	5.33	22.33	34.67	54.67	5.07	9.94	14.07	25.45	40.71	4.00
T_2 (GA_3 50 ppm)	0	0.00	12.00	20.00	37.33	3.48	7.11	10.57	12.95	31.24	6.67
T_3 (GA_3 100 ppm)	0	0.00	9.33	12.00	26.67	3.31	6.91	10.27	12.18	29.19	7.33
T_4 (GA_3 150 ppm)	0	0.00	5.33	9.33	18.67	3.11	6.29	9.98	11.55	28.43	8.67
T_5 (NAA 100 ppm)	0	1.33	13.33	21.33	45.33	4.52	8.69	12.07	15.03	34.33	5.33
T_6 (NAA 150 ppm)	0	0.00	10.67	17.33	36.00	3.76	7.49	10.82	14.27	32.85	7.00
T_7 (NAA 200 ppm)	0	0.00	9.33	13.33	36.00	3.52	7.32	10.60	13.51	31.31	7.33
Range	0	0.00 - 5.33	5.33 - 22.33	9.33 - 34.67	18.67 - 54.67	3.11 - 5.07	6.29 - 9.94	9.98 - 14.07	11.55 - 25.45	28.43 - 40.71	4.00 - 8.67
Mean	0	0.95	11.76	18.29	36.38	3.82	7.68	11.20	14.99	32.58	6.62
SEm ±	0	0.57	1.35	1.37	1.24	0.05	0.07	0.05	0.28	0.59	0.22
CD @ 5%	0	1.77	4.15	4.22	3.84	0	0.22	0.17	0.39	1.58	0.68

Shelf life

The data presented in Table 15 and Fig. 32 revealed that different doses of growth regulators significantly influenced the shelf life of sapota fruits.

The significantly highest shelf life of sapota fruits (8.67 days) was recorded in T_4. It was followed by T_3 and T_7 (7.33 days) which were recorded same value and was at par with T_6 (7.00 days) and T_2 (6.67 days) and then it was followed by T_5 (5.33 days). The minimum shelf life (4.00 days) was recorded in control (T_1).

Interpretation of the data also revealed that storage attributes like decreased shriveling and spoilage and PLW percentage and increased shelf life of sapota fruits with increasing levels of GA_3 and NAA might be due to growth regulators minimized physiological loss in weight, spoilage loss, shriveling to the possible extent through the catalytic influence of plant growth regulators on biosynthesis of ascorbic acid from sugar and inhibition of oxidative enzymes. In another way, GA_3 enhances shelf life due to its action as anti-ethylene and ultimately delay ripening process. These above findings are in agreement with the results of Bhanja and Lenka (1994), Garhwal (2015) [1, 6] in sapota.

It is inferred from the present investigation that withGA_3 at 150 ppm (T_4) have increased yield and yield attributing characters like number of fruits per plant, yield per plant and per hectare and also improved physical characters of fruit like fruit and pulp weight, fruit volume, specific gravity and pulp to seed ratio, and same treatment also improved quality characters of fruits viz. total soluble solids, sugar content (reducing, non-reducing and total sugar), TSS/ acid ratio, and reduction in fruit acidity and also reduced PLW per cent and shrivelling and spoilage of fruits and thus it increased the shelf life of fruits.

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