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Effect of foliar sprays of different chemicals and plant growth regulators on quality attributes of papaya (*Carica papaya* L.) cv. Arka Surya

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Abstract
This study was carried out two successive years of 2021 and 2022 at YSRHU- College of Horticulture, Anantharajupeta to study the effect of foliar application of different chemicals and plant growth regulator on quality attributes and shelf life of papaya cv. Arka surya. Various chemicals such as oxalic acid, humic acid and K_2HPO_4, and plant growth regulators *i.e.*, brassinosteriods, putrescine, N-Acetyl Thiazolidine 4-Carboxylic acid and salicylic acid were applied by foliar means at 45, 90, 135, and 180 DAP. The papaya fruits treated with putrescine @ 150 ppm had exhibited the highest pulp thickness (3.09 cm), fruit firmness (2.84 kg cm^{-2}), pulp weight (818.50 g), pulp to peel ratio (22.64), number of seeds per fruit (659.28), fresh weight (79.28 g), dry weight of seeds per fruit (12.42 g), ascorbic acid content (144.62 mg100 g^{-1}), total soluble solids (13.61 ^{0}Brix), TSS/Acid ratio (80.98), total sugars (10.10%), reducing sugars (7.23%), non-reducing sugar (2.85%), lycopene (5.34 mg 100g^{-1}), carotenoids content (2.46 mg 100 g-1), lowest titrable acidity (0.19%) and maximum shelf life (7.70 Days) in comparison to control.

Keywords: Papaya, plant growth regulators, chemicals, fruit quality

Introduction
Papaya (*Carica papaya* L.) is indeed an important fruit crop that belongs to the family caricaceae. It is widely grown in tropical and subtropical regions around the world. Known for its numerous health benefits, papaya is often referred to as a wonder fruit. It goes by various vernacular names such as papaw or paw paw in Australia, mamao in Brazil, and tree melon in China. Over time, papaya has transitioned from being a plant commonly found in home gardens to becoming a commercially cultivated crop. This shift can be attributed to several factors, including the availability of papaya fruits throughout the year, ease of cultivation, and relatively fast returns on investment (Drew *et al*., 1998) [8]. In India, papaya was introduced during the early 16th century from the Philippines via Malaysia. It is predominantly cultivated in several states, including Andhra Pradesh, Karnataka, Gujarat, Orissa, West Bengal, Assam, Kerala, Madhya Pradesh, and Maharashtra. These regions provide suitable agro-climatic conditions for papaya cultivation, contributing to its widespread presence in those areas.
The use of plant growth regulators has assumed an integral part of modern fruit production to improve the production and quality of fruits, and it has resulted in outstanding achievements in many fruit crops with regard to improvements in yield and quality (Jain and Dashora, 2011) [10]. Because of its diverse positive effects, it is possible to use certain growth regulating chemicals at particular stages of fruit growth and development to exhibit maximum effects. Occasionally, they are needed to be supplemented exogenously for additional stimulus for plants such as papaya, which require quick responses for increased growth, fruit set and yield (Singh and Singh, 2009) [34]. This experiment was conducted with aim to improve the yield and quality of the papaya cv. Arka Surya by spraying different chemicals and plant growth regulators.

Materials and Methods
The experiment was carried out at YSRHU - College of Horticulture, Anantharajupeta during the year 2021 - 2022, which is situated at an altitude of 162 meters (531 feet) above mean sea level and at 13.99º North latitude and 79.30º East longitude. The experiment was laid out in a randomized block design with fourteen treatments and three replications.

The treatments tested were application of oxalic acid @ 5 mM (T_1), 10 mM (T_2), humic acid @ 0.5% (T_3), 1% (T_4), K_2HPO_4 @ 0.5% (T_5), 1% (T_6), brassinosteriods @ 2 ppm (T_7), 4 ppm (T_8), putrescine @ 150 ppm (T_9), 250 ppm (T_{10}), N-Acetyl Thiazolidine 4-Carboxylic acid @ 500 ppm (T_{11}), 1000 ppm (T_{12}), salicylic acid @ 150 ppm (T_{13}) and control (T_{14}) at 45, 90, 135 and 180 DAT. Fully ripe fruits were peeled and pulp was crushed for juice extraction. The juice was used for determining the soluble solids by using "Atago digital refractometer" with 0-32 range. The values were expressed as degree brix. The percentage of total sugars was estimated by A.O.A.C. (1980) method. Caroteneoids was determined by the method described by Srivastava and Kumar (2009) [35]. Ascorbic acid content of papaya pulp samples was determined by 2, 6-dichlorophenol indophenol visual titration method described by Ranganna (1986) [29].

Results and Discussion

Fruit quality parameters

The fruits harvested from putrescine @ 150 ppm (T_9) and oxalic acid @ 10 mM (T_2) treated trees had the highest pulp thickness (3.09 cm) (Table - 1), which was statistically on par with K_2HPO_4 @ 1% (T_6) (2.95 cm) and humic acid @ 1% (T_4) (2.91 cm) treated trees. Fruits harvested from control (T_{14}) trees had the lowest pulp thickness (2.02 cm).The highest fruit firmness (2.84 kg cm^{-2}) was observed (Table - 1) in treatment consist of putrescine @ 150 ppm (T_9) which was significantly superior to the other treatments. However, minimum fruit firmness was observed in control (1.19 kg cm^{-2}). In the present study the highest fruit firmness observed with putrescine treatment might be due to its application causes changes in cell wall stability by preventing the activity of softening enzymes polygalacturonase and pectin methyl esterase, as well as cross-linking pectic substances in the cell wall, resulting in rigidification and thereby increases fruit firmness (Perez-Vicente *et al*. 2002) [28]. This might be the reason of decrease in fruit softening by putrescine application as reported by Valero *et al*. (1998) [36] in lemon and Khan *et al*. (2007) [16] in plum.

Significant difference was observed with respect to the pulp weight of the fruit among different treatments (Table - 2). As compared to control, the pulp weight was significantly high in all chemical and plant growth regulator treatments. The maximum pulp weight (818.50 g) was produced by foliar application of putrescine at a concentration of 150 ppm (T_9) and was significantly superior to all other treatments. The minimum pulp weight (398.94 g) was observed in control. The highest photosynthetic rate with putrescine treatment might have resulted in efficient mobility of photosynthates from source to sink, *i.e.,* higher photosynthates translocation rate to the fruits resulted in larger sized fruits, which might have lead to more pulp accumulation. The pooled mean (Table - 2) revealed that application of chemicals and plant growth regulators had significant effect on peel weight of the fruit. The treatment K_2HPO_4 at 1% (T_6) bestowed with highest peel weight (58.93 g) and it was significantly superior to all other treatments. However, the control had the lowest peel weigh (24.08 g).

Significant differences were noticed among the treatments on pulp to peel ratio in fruits (Table- 3). Application of putrescine @ 150 ppm (T_9) recorded maximum pulp to peel ratio (22.64) which was found to be significantly superior over all the treatments. Whereas, minimum pulp to peel ratio (8.52) was observed in treatment T_{12} (N-Acetyl Thiazolidine 4-Carboxylic acid @ 1000). The maximum pulp with putrescine treatment resulted in high pulp to peel ratio. Foliar application of putrescine @ 150 ppm (T_9) had the highest number of seeds per fruit (659.28), which was found to be significantly superior over all other treatments (Table - 3). The control, on the other hand, had the lowest number of seeds per fruit (232.81).

Treatment (T_9) putrescine @ 150 ppm had the maximum fresh weight of seeds per fruit (79.28 g), which was found to be significantly superior to all other treatments (Table- 4). However, the minimum fresh weight of seeds per fruit (36.56 g) was observed in the control. The present findings of maximum fresh weight of seeds per fruits with putrescine @ 150 ppm treatment are in accordance with the findings of Ali *et al.* (2014) in peach. Application of putrescine @ 150 ppm (T_9) showed the highest dry weight of seeds per fruit (12.42 g) and was significantly superior to other treatments, while, the lowest dry weight of seeds per fruit (6.31 g) was observed in control. Application of putrescine caused heavier seeds with maximum fresh weight which in turn leads to high dry weight of seeds.

The influence of foliar sprays of various chemicals and plant growth regulators on ascorbic acid content in fruits as expressed in table. 5 clearly indicated that different treatments significantly affect the ascorbic acid content in fruits. Treatment consist of putrescine @ 150 ppm (T_9) had the highest ascorbic acid content (144.62 mg100 g^{-1}) in fruits and found to be significantly superior to all other treatments, however, the lowest ascorbic acid content (66.48 mg100 g^{-1}) was noticed in plant without any application of chemicals and plant growth regulators. Increased ascorbic acid content in fruit treated with a putrescine might be due to suppression of ascorbate oxidase activity as a result of increased levels of endogenous polyamines in fruit pulp. The present findings are in accordance with the findings of Malik and Singh (2006) [21]; Venu and Ramdevputra, (2018) [37] in mango, Ali *et al.* (2014) in peach, Yahia *et al*. (2001) [38] in capsicum.

Foliar application of putrescine @ 150 ppm (T_9) (Table - 5) had the highest total soluble solids (13.61 ^{0} Brix), followed by application of humic acid @ 1% (T_4) and K_2HPO_4 @ 1% (T_6) had the TSS of 13.58 ^{o}Brix. The control, however, contained the lowest total soluble solids (11.37 ^{0} Brix). The maximum TSS in the fruits was observed with the foliar spray of putrescine, which might be due to high sugar content in the fruit due to high photosynthates production and transfer to the fruits. Further application of putrescine might have helped to improved the fruit growth and nutrient uptake, which accelerated metabolic processes and sugar transport to actively growing regions and developing fruits (El-Migeed *et al*., 2013) [9]. These results are in agreement with the findings of Naser *et al*. (2016) [27] and El-Migeed *et al*. (2013) [9] in date palm and Ataweia *et al*. (2012) [4] in Washington navel orange who reported that increased fruit TSS with the application of putrescine.

Highest acidity (0.81%) (Table - 6) was recorded in control, whereas, the lowest titrable acidity (0.19%) was observed in fruit harvested from plant applied with putrescine @ 150 ppm. The maximum TSS/Acid ratio (80.98) (Table - 6) was observed in treatment consist of (T_9) putrescine @ 150 ppm which was statistically significantly superior over all the other treatments. The control, on the other hand, had the minimum TSS/Acid ratio (16.29%).

The influence of foliar sprays of various chemicals and plant growth regulators on total sugars and reducing sugars as depicted in Table - 7. From pooled mean it was observed that different treatments had significant influence on the total sugar contents in fruits. Application of putrescine @ 150 ppm (T_9) had the highest total sugar content (10.10%) in fruits and was shown to be significantly superior over all other treatments, whereas the lowest total sugar level (5.48%) was reported in control. Highest percentage of reducing sugars (7.23%) in fruits was observed in plants treated with putrescine @ 150 ppm (T_9) and was significantly superior to all other treatments. It was followed by application of humic acid @ 1% (T_4) (6.39%). However, the control exhibited the lowest percentage of reducing sugars (5.35%).

Foliar application of putrescine @ 150 ppm (T_9) (Table - 8) had the highest non-reducing sugar concentration (2.85%), which was stastically superior to all other treatments. However, the least amount of non-reducing sugar (0.12%) in papaya fruit was found in the control. Increased percentage of soluble sugars in fruits include increasing the amount of chlorophyll content, leaf area and number of leaves, increase the photosynthetic capacity and protecting macromolecules such as proteins and cell membranes (Savvas and Ntatsi, 2015) [31]. Amino acids stimulate carbohydrate content due to their critical role in the biosynthesis of chlorophyll molecules, which affect chlorophyll content (Nahed *et al*., 2009) [26]. Based on the effect of polyamines on leaf area, leaf number, and photosynthetic pigments, it can be concluded that polyamines improve photosynthetic capacity and thus increase soluble sugar content with putrescine treatment. The present research finding are in harmony with the findings of Costa and Bagni (1983) [7] in apple, Mitra and Sanyal (1990) [25] in litchi, Baniassadi *et al*. (2015) in *calendula officinalis* and Kandil *et al*. (2015) [12] in *salvia splendens*.

The data presented in Table 8 showed that there was a significant difference with respect to the lycopene content among different treatments. The highest lycopene content (5.34 mg 100 g^{-1}) was noticed in T_9 (Putrescine @ 150 ppm) and T_6 (K_2HPO_4 @ 1%) which was on par with application of oxalic acid @ 10 mM (T_2) (5.24 mg 100g^{-1}). The lowest lycopene content (3.78 mg 100 g $^{-1}$) was noticed in control. Table 9 showed the pooled mean for carotenoid content of the fruits as influenced by different treatments. When compared to the control, all treatments increased carotenoid content of the fruits significantly. The fruits harvested from putrescine @ 150 ppm (T_9) treated trees had the highest carotenoids content (2.46 mg100 g^{-1}) (Table - 9) in the fruits, which was statistically on par with T_6 (K_2HPO4 @ 1%) (2.45 mg100 g^{-1}) treated trees. Fruits harvested from control (T_{14}) trees had the lowest carotenoids content (2.21 mg100 g^{-1}). Beneficial influence of putrescine on fruit chemical characteristics could be attributed to its fruit quality enhancement due to the bio regulatory effect on enzymatic activity and translocation processes from leaves to fruits, linking or converting to other plant metabolites (Serafini-Fracassini and Del Duca, 2008) [32].

The data clearly showed that foliar sprays of various chemical and plant growth regulators have a significant impact on fruit's shelf life (Table - 9). The maximum shelf life (7.70 days) of fruit was observed in treatment T_9 (Putrescine @ 150 ppm). It was found to be significantly superior to all the other treatments, whereas the minimum shelf life (5.77 days) of fruit was observed in control. According to Ke and Romani (1988) [14], a group of natural compounds known as polyamines is assumed to delay ripening and increase fruit shelf life by inhibiting the formation of enzymes necessary for the synthesis of ethylene. Applying putrescine at 150 ppm may prolong shelf life by delaying senescent changes like ethylene production, browning, peroxide level, and cell leakage (Jiang and Chen, 1995) [11], preventing fungal infection (Mirdehghan *et al*., 2013a) [23], and delaying fruit softening due to the inhibition of polygalacturonase activities, which is likely accomplished by binding to pectic substances (Kramer *et al*., 1989).Similar findings were also observed by Malik *et al*., (2006) [21] in mango, Khan and Singh (2008) [17] in plum, Mirdehghan *et al*., (2013a) [23] in pistachio nut and Mirdehghan *et al*., (2013b) [24] in grape, Bal (2012) [5] in sweet cherry, Khosroshahi *et al*. (2007) [18] in strawberry and Khan *et al*. (2008) [17] in plum.

The data indicated (Table - 10) that organoleptic scoring of papaya fruits was significantly influenced by treatments. The pooled mean revealed that the maximum organoleptic scoring for pulp colour (9.00), taste (9.00) and overall acceptability (9.00) were observed in treatments consist of foliar application of putrescine @ 150 ppm (T_9) followed by K_2HPO4 @ 1% (T_6) and oxalic acid @ 10 mM while, the lowest sensory score was observed in control. Better sensory score exhibited with putrescine @ 150 ppm treated fruits might be due to reduced production of ethylene, maintaining fruit firmness, reduction weight loss, and delayed in the changing in fruit color which extended the storage life of fruits (Serrano *et al*., 2003) [33]. The present finding are in accordance with the findings of Sallem *et al*. (2008) in sweet oranges. The higher carotenoids synthesis in fruits with increased maturity is likely the cause of the better pulp colour. A higher taste score can be attributed to trees treated with polyamine accumulating photosynthates more effectively, which led to higher yields and better quality in terms of TSS, total sugars, and reducing sugars (Kassem *et al*. 2011). The aroma and taste of fruits are already well associated with TSS and sugars. It's possible that fruits with higher TSS and sugar levels have higher levels of aroma-containing molecules, which contribute to the better taste of fruits from putrescine-treated trees. Putrescine treatments had higher overall acceptability than controls, which could be attributed to better fruit firmness retention over time as well as higher scores for other organoleptic characteristics. These results are in agreement with those obtained by Malik and Singh (2006) [21] in mango, Marzouk and Kassem (2011) [13] in grape and Ali *et al*. (2010) in apricot.

Conclusion

On the basis of findings of present study it was concluded that foliar application of T_9 (Putrescine @ 150 ppm) was found effective for increasing fruit firmness, total soluble solids, ascorbic acid, carotenoids, lycopene, total sugar, reducing sugar, non-reducing sugar, shelf life, organoleptic score and minimum acidity of papaya cv. Arka Surya.

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Table 1: Pulp thickness and fruit firmness as influenced by foliar spray of different chemicals and plant growth regulators in papaya cv. Arka Surya

Treatments		Pulp thickness (cm)			Fruit firmness (kg cm^{-2})		
		2021	2022	Pooled	2021	2022	Pooled
T_1	Oxalic acid @ 5 mM	2.48	2.46	2.47	1.28	1.25	1.27
T_2	Oxalic acid @ 10 mM	3.11	3.07	3.09	1.33	1.41	1.37
T_3	Humic acid @ 0.5%	2.56	2.78	2.67	1.31	1.39	1.35
T_4	Humic acid @ 1%	2.86	2.97	2.91	2.09	2.04	2.07
T_5	K_2HPO_4 @ 0.5%	2.80	2.86	2.83	1.45	1.39	1.42
T_6	K_2HPO_4 @ 1%	2.92	2.98	2.95	1.30	1.35	1.33
T_7	Brassinosteriods @ 2 ppm	2.51	2.67	2.59	2.48	2.37	2.43
T_8	Brassinosteriods @ 4 ppm	2.35	2.56	2.46	2.39	2.21	2.30
T_9	Putrescine @ 150 ppm	3.08	3.09	3.09	2.94	2.73	2.84
T_{10}	Putrescine @ 250 ppm	2.00	2.15	2.08	2.17	2.11	2.14
T_{11}	N-Acetyl Thiazolidine 4-Carboxylic acid @ 500 ppm	2.12	2.29	2.21	1.31	1.63	1.47
T_{12}	N-Acetyl Thiazolidine 4-Carboxylic acid @ 1000 ppm	2.43	2.52	2.47	1.84	2.09	1.97
T_{13}	Salicylic acid @ 150 ppm	2.09	2.26	2.17	1.51	1.95	1.73
T_{14}	Control	1.91	2.12	2.02	1.18	1.20	1.19
CD at 5%		0.13	0.28	0.18	0.06	0.10	0.04
S.Em (±)		0.04	0.09	0.06	0.02	0.03	0.01

Table 2: Pulp and peel weight as influenced by foliar spray of different chemicals and plant growth regulators in papaya cv. Arka Surya

Treatments		Pulp weight (g)			Peel weight (g)		
		2021	2022	Pooled	2021	2022	Pooled
T_1	Oxalic acid @ 5 mM	510.13	505.80	507.97	31.76	29.58	30.67
T_2	Oxalic acid @ 10 mM	691.73	690.07	690.90	38.71	37.15	37.93
T_3	Humic acid @ 0.5%	463.17	461.43	462.30	42.44	41.20	41.82
T_4	Humic acid @ 1%	638.37	647.80	643.08	50.07	47.45	48.76
T_5	K_2HPO_4 @ 0.5%	550.17	536.77	543.47	37.07	37.12	37.09
T_6	K_2HPO_4 @ 1%	761.43	761.54	761.49	61.03	56.83	58.93
T_7	Brassinosteriods @ 2 ppm	551.74	552.82	552.28	37.08	36.21	36.65
T_8	Brassinosteriods @ 4 ppm	462.77	464.04	463.40	39.81	35.85	37.83
T_9	Putrescine @ 150 ppm	819.80	817.19	818.50	37.30	35.11	36.20
T_{10}	Putrescine @ 250 ppm	407.14	413.93	410.54	40.73	44.12	42.43
T_{11}	N-Acetyl Thiazolidine 4-Carboxylic acid @ 500 ppm	589.07	584.12	586.60	41.42	42.23	41.83
T_{12}	N-Acetyl Thiazolidine 4-Carboxylic acid @ 1000 ppm	423.47	420.17	421.82	51.08	48.17	49.63
T_{13}	Salicylic acid @ 150 ppm	435.83	432.47	434.15	27.47	28.12	27.80
T_{14}	Control	398.80	399.09	398.94	21.42	26.74	24.08
CD at 5%		7.48	8.16	6.43	4.08	1.97	2.61
S.Em (±)		2.56	2.79	2.20	1.39	0.67	0.89

Table 3: Pulp to peel ratio and number of seeds per fruit as influenced by foliar spray of different chemicals and plant growth regulators in papaya cv. Arka Surya

Treatments		Pulp to peel ratio			Number of seeds per fruit		
		2021	2022	Pooled	2021	2022	Pooled
T_1	Oxalic acid @ 5 mM	16.07	17.13	16.60	442.47	421.40	431.93
T_2	Oxalic acid @ 10 mM	17.88	18.58	18.23	415.07	407.43	411.25
T_3	Humic acid @ 0.5%	10.92	11.20	11.06	193.43	200.13	196.78
T_4	Humic acid @ 1%	12.76	13.66	13.21	504.03	512.77	508.40
T_5	K_2HPO_4 @ 0.5%	14.87	14.46	14.67	409.21	415.70	412.45
T_6	K_2HPO_4 @ 1%	12.49	13.41	12.95	557.93	530.07	544.00
T_7	Brassinosteriods @ 2 ppm	14.89	15.27	15.08	309.10	291.07	300.08
T_8	Brassinosteriods @ 4 ppm	11.64	12.96	12.30	420.40	410.44	415.42
T_9	Putrescine @ 150 ppm	21.99	23.29	22.64	665.90	652.67	659.28
T_{10}	Putrescine @ 250 ppm	10.15	9.39	9.77	435.43	409.53	422.48
T_{11}	N-Acetyl Thiazolidine 4-Carboxylic acid @ 500 ppm	14.23	13.85	14.04	408.43	414.47	411.45
T_{12}	N-Acetyl Thiazolidine 4-Carboxylic acid @ 1000 ppm	8.31	8.73	8.52	358.77	352.18	355.47
T_{13}	Salicylic acid @ 150 ppm	15.93	15.39	15.66	301.57	278.23	289.90
T_{14}	Control	18.76	14.96	16.86	226.15	239.47	232.81
CD at 5%		1.47	0.80	0.97	9.37	23.69	12.89
S.Em (±)		0.50	0.27	0.33	3.20	8.10	4.41

Table 4: Fresh weight and dry weight of seeds per fruit as influenced by foliar spray of different chemicals and plant growth regulators in papaya cv. Arka Surya

Treatments		Fresh weight of seeds per fruit (g)			Dry weight of seeds per fruit (g)		
		2021	2022	Pooled	2021	2022	Pooled
T_1	Oxalic acid @ 5 mM	46.46	45.74	46.10	8.18	8.00	8.09
T_2	Oxalic acid @ 10 mM	53.53	52.45	52.99	8.43	8.18	8.31
T_3	Humic acid @ 0.5%	40.93	43.24	42.09	9.50	9.32	9.41
T_4	Humic acid @ 1%	59.07	67.74	63.41	9.17	9.36	9.26
T_5	K_2HPO_4 @ 0.5%	49.40	60.07	54.73	9.20	9.26	9.23
T_6	K_2HPO_4 @ 1%	61.19	67.83	64.51	10.00	10.12	10.06
T_7	Brassinosteriods @ 2 ppm	41.40	41.40	41.40	8.20	8.88	8.54
T_8	Brassinosteriods @ 4 ppm	54.40	53.74	54.07	9.55	9.49	9.52
T_9	Putrescine @ 150 ppm	80.73	77.83	79.28	12.37	12.48	12.42
T_{10}	Putrescine @ 250 ppm	56.13	51.88	54.01	8.27	8.29	8.28
T_{11}	N-Acetyl Thiazolidine 4-Carboxylic acid @ 500 ppm	51.40	43.73	47.57	9.17	9.16	9.16
T_{12}	N-Acetyl Thiazolidine 4-Carboxylic acid @ 1000 ppm	47.47	43.40	45.43	8.10	8.58	8.34
T_{13}	Salicylic acid @ 150 ppm	40.47	37.83	39.15	7.28	7.25	7.27
T_{14}	Control	38.09	35.03	36.56	6.13	6.48	6.31
CD at 5%		3.54	1.43	2.19	0.65	0.41	0.48
S.Em (±)		1.21	0.49	0.75	0.22	0.14	0.16

Table 5: Ascorbic acid and total soluble solids as influenced by foliar spray of different chemicals and plant growth regulators in papaya cv. Arka Surya

Treatments		Ascorbic acid (mg/100 g of pulp)			Total soluble solids (^{0} Brix)		
		2021	2022	Pooled	2021	2022	Pooled
T_1	Oxalic acid @ 5 mM	93.90	95.93	94.92	12.64	12.94	12.79
T_2	Oxalic acid @ 10 mM	115.43	117.30	116.37	13.73	13.25	13.49
T_3	Humic acid @ 0.5%	90.55	92.55	91.55	12.49	12.27	12.38
T_4	Humic acid @ 1%	105.43	105.10	105.27	13.27	13.90	13.58
T_5	K_2HPO_4 @ 0.5%	100.79	101.43	101.11	12.97	13.14	13.06
T_6	K_2HPO_4 @ 1%	138.13	146.77	142.45	13.74	13.41	13.58
T_7	Brassinosteriods @ 2 ppm	120.77	114.77	117.77	13.38	12.32	12.85
T_8	Brassinosteriods @ 4 ppm	84.73	84.77	84.75	13.11	12.81	12.96
T_9	Putrescine @ 150 ppm	145.93	143.31	144.62	14.55	12.67	13.61
T_{10}	Putrescine @ 250 ppm	79.87	81.93	80.90	12.27	14.13	13.20
T_{11}	N-Acetyl Thiazolidine 4-Carboxylic acid @ 500 ppm	110.10	106.83	108.47	12.60	12.47	12.54
T_{12}	N-Acetyl Thiazolidine 4-Carboxylic acid @ 1000 ppm	69.23	69.90	69.57	12.11	13.30	12.70
T_{13}	Salicylic acid @ 150 ppm	81.51	80.20	80.85	10.71	13.24	11.97
T_{14}	Control	66.48	66.48	66.48	11.83	10.90	11.37
CD at 5%		5.38	4.95	4.22	0.80	0.89	0.52
S.Em (±)		1.84	1.69	1.44	0.27	0.30	0.17

Table 6: Titrable acidity and TSS/Acid ratio as influenced by foliar spray of different chemicals and plant growth regulators in papaya cv. Arka Surya

Treatments		Titrable acidity (%)			TSS/Acid ratio		
		2021	2022	Pooled	2021	2022	Pooled
T_1	Oxalic acid @ 5 mM	0.36 (1.16)	0.36 (1.16)	0.36 (1.16)	35.98	36.97	36.48
T_2	Oxalic acid @ 10 mM	0.21 (1.10)	0.27 (1.12)	0.24 (1.11)	65.89	49.20	57.55
T_3	Humic acid @ 0.5%	0.34 (1.15)	0.40 (1.18)	0.37 (1.17)	39.38	31.33	35.35
T_4	Humic acid @ 1%	0.30 (1.13)	0.27 (1.12)	0.29 (1.13)	45.25	51.34	48.30
T_5	K_2HPO_4 @ 0.5%	0.32 (1.14)	0.32 (1.14)	0.32 (1.14)	40.53	41.06	40.80
T_6	K_2HPO_4 @ 1%	0.21 (1.10)	0.25 (1.11)	0.23 (1.11)	66.00	66.21	66.11
T_7	Brassinosteriods @ 2 ppm	0.30 (1.13)	0.30 (1.13)	0.30 (1.14)	45.48	42.01	43.75
T_8	Brassinosteriods @ 4 ppm	0.42 (1.19)	0.40 (1.18)	0.41 (1.18)	31.37	32.81	32.09
T_9	Putrescine @ 150 ppm	0.14 (1.06)	0.23 (1.10)	0.19 (1.09)	106.18	55.78	80.98
T_{10}	Putrescine @ 250 ppm	0.53 (1.23)	0.43 (1.19)	0.48 (1.21)	23.59	36.25	29.92
T_{11}	N-Acetyl Thiazolidine 4-Carboxylic acid @ 500 ppm	0.36 (1.16)	0.36 (1.16)	0.36 (1.16)	35.77	35.51	35.64
T_{12}	N-Acetyl Thiazolidine 4-Carboxylic acid @ 1000 ppm	0.57 (1.25)	0.59 (1.26)	0.58 (1.25)	21.24	22.49	21.86
T_{13}	Salicylic acid @ 150 ppm	0.55 (1.24)	0.53 (1.23)	0.54 (1.24)	20.05	25.61	22.83
T_{14}	Control	0.93 (1.38)	0.68 (1.29)	0.81 (1.34)	13.61	18.96	16.29
CD at 5%		0.05	0.08	0.05	16.54	22.84	13.64
S.Em (±)		0.01	0.02	0.02	5.66	7.81	4.66

Table 7: Total sugars and reducing sugars as influenced by foliar spray of different chemicals and plant growth regulators in papaya cv. Arka Surya

Treatments		Total sugars (%)			Reducing sugars (%)		
		2021	2022	Pooled	2021	2022	Pooled
T_1	Oxalic acid @ 5 mM	8.00 (3.00)	7.40 (2.89)	7.70 (2.94)	6.17 (2.67)	6.13 (2.67)	6.13 (2.67)
T_2	Oxalic acid @ 10 mM	6.15 (2.67)	6.23 (2.68)	6.19 (2.68)	5.92 (2.63)	6.05 (2.65)	6.05 (2.64)
T_3	Humic acid @ 0.5%	7.50 (2.91)	6.89 (2.81)	7.20 (2.86)	6.12 (2.66)	6.13 (2.67)	6.13 (2.67)
T_4	Humic acid @ 1%	8.12 (3.02)	8.16 (3.02)	8.14 (3.02)	6.48 (2.73)	6.39 (2.71)	6.39 (2.72)
T_5	K_2HPO_4 @ 0.5%	5.79 (2.60)	5.84 (2.61)	5.82 (2.61)	5.58 (2.56)	5.63 (2.57)	5.63 (2.57)
T_6	K_2HPO_4 @ 1%	6.27 (2.69)	6.40 (2.71)	6.33 (2.70)	6.10 (2.66)	6.23 (2.68)	6.23 (2.67)
T_7	Brassinosteriods @ 2 ppm	8.25 (3.04)	8.39 (3.06)	8.32 (3.05)	6.38 (2.71)	6.26 (2.69)	6.26 (2.70)
T_8	Brassinosteriods @ 4 ppm	7.49 (2.91)	7.78 (2.96)	7.63 (2.93)	5.96 (2.63)	5.96 (2.63)	5.96 (2.63)
T_9	Putrescine @ 150 ppm	10.27 (3.35)	9.92 (3.30)	10.10 (3.33)	7.27 (2.87)	7.23 (2.86)	7.23 (2.87)
T_{10}	Putrescine @ 250 ppm	7.36 (2.89)	7.35 (2.88)	7.35 (2.89)	5.94 (2.63)	5.89 (2.62)	5.89 (2.63)
T_{11}	N-Acetyl Thiazolidine 4-Carboxylicacid @ 500 ppm	7.93 (2.99)	7.77 (2.96)	7.85 (2.97)	6.11 (2.66)	6.03 (2.65)	6.03 (2.66)
T_{12}	N-Acetyl Thiazolidine 4-Carboxylic acid @ 1000 ppm	6.83 (2.79)	6.51 (2.74)	6.67 (2.76)	5.94 (2.63)	5.91 (2.57)	5.91 (2.63)
T_{13}	Salicylic acid @ 150 ppm	5.97 (2.64)	5.80 (2.60)	5.89 (2.62)	5.79 (2.60)	5.62 (2.51)	5.62 (2.58)
T_{14}	Control	5.47 (2.54)	5.49 (2.5)	5.48 (2.54)	5.38 (2.52)	5.35 (2.51)	5.35 (2.52)
CD at 5%		0.07	0.14	0.09	0.03	0.06	0.04
S.Em (±)		0.02	0.04	0.03	0.01	0.02	0.01

Table 8: Non reducing sugars and lycopene content as influenced by foliar spray of different chemicals and plant growth regulators in papaya cv. Arka Surya

Treatments		Non-reducing sugars (%)			Lycopene content (mg/100 g of pulp)		
		2021	2022	Pooled	2021	2022	Pooled
T_1	Oxalic acid @ 5 mM	1.83 (1.68)	1.27 (1.49)	1.55 (1.59)	4.33	4.21	4.27
T_2	Oxalic acid @ 10 mM	0.23 (1.10)	0.18 (1.08)	0.20 (1.09)	5.26	5.22	5.24
T_3	Humic acid @ 0.5%	1.38 (1.54)	0.76 (1.30)	1.07 (1.43)	4.28	4.18	4.23
T_4	Humic acid @ 1%	1.64 (1.62)	1.77 (1.66)	1.71 (1.64)	5.19	5.17	5.18
T_5	K_2HPO_4 @ 0.5%	0.21 (1.10)	0.21 (1.10)	0.21 (1.10)	4.93	4.96	4.94
T_6	K_2HPO_4 @ 1%	0.17 (1.08)	0.17 (1.08)	0.17 (1.08)	5.28	5.39	5.34
T_7	Brassinosteriods @ 2 ppm	1.87 (1.69)	2.12 (1.76)	2.00 (1.72)	5.20	5.13	5.17
T_8	Brassinosteriods @ 4 ppm	1.53 (1.58)	1.82 (1.67)	1.67 (1.63)	4.25	4.25	4.25
T_9	Putrescine @ 150 ppm	3.01 (1.99)	2.69 (1.92)	2.85 (1.96)	5.37	5.30	5.34
T_{10}	Putrescine @ 250 ppm	1.42 (1.55)	1.46 (1.56)	1.44 (1.56)	4.22	4.22	4.22
T_{11}	N-Acetyl Thiazolidine 4-Carboxylic acid @ 500 ppm	1.82 (1.68)	1.73 (1.64)	1.78 (1.66)	4.18	4.23	4.21
T_{12}	N-Acetyl Thiazolidine 4-Carboxylic acid @ 1000 ppm	0.89 (1.37)	0.60 (1.25)	0.75 (1.31)	4.21	4.21	4.21
T_{13}	Salicylic acid @ 150 ppm	0.19 (1.08)	0.18 (1.08)	0.19 (1.08)	4.00	3.97	3.99
T_{14}	Control	0.09 (1.08)	0.14 (1.06)	0.12 (1.05)	3.77	3.80	3.78
CD at 5%		0.13	0.22	0.14	0.17	0.17	0.14
S.Em (±)		0.04	0.07	0.05	0.05	0.08	0.04

Table 9: Carotenoids and shelf life of fruits as influenced by foliar spray of different chemicals and plant growth regulators in papaya cv. Arka Surya

Treatments		Carotenoids (mg/100 g of pulp)			Shelf life (days)		
		2021	2022	Pooled	2021	2022	Pooled
T_1	Oxalic acid @ 5 mM	2.22	2.39	2.31	6.47	6.40	6.43
T_2	Oxalic acid @ 10 mM	2.31	2.50	2.41	6.73	6.67	6.70
T_3	Humic acid @ 0.5%	2.15	2.32	2.24	6.47	6.40	6.43
T_4	Humic acid @ 1%	2.32	2.38	2.35	7.00	6.87	6.93
T_5	K_2HPO_4 @ 0.5%	2.29	2.45	2.37	6.67	6.60	6.63
T_6	K_2HPO_4 @ 1%	2.42	2.47	2.45	6.80	6.87	6.83
T_7	Brassinosteriods @ 2 ppm	2.32	2.40	2.36	6.47	6.47	6.47
T_8	Brassinosteriods @ 4 ppm	2.22	2.33	2.27	6.27	6.13	6.20
T_9	Putrescine @ 150 ppm	2.40	2.52	2.46	7.80	7.60	7.70
T_{10}	Putrescine @ 250 ppm	2.25	2.29	2.27	6.20	6.13	6.17
T_{11}	N-Acetyl Thiazolidine 4-Carboxylic acid @ 500 ppm	2.24	2.34	2.29	6.27	6.13	6.20
T_{12}	N-Acetyl Thiazolidine 4-Carboxylic acid @ 1000 ppm	2.22	2.33	2.28	6.13	6.00	6.07
T_{13}	Salicylic acid @ 150 ppm	2.15	2.34	2.25	5.93	5.87	5.90
T_{14}	Control	2.12	2.30	2.21	5.73	5.80	5.77
CD at 5%		0.08	0.07	0.06	0.36	0.35	0.20
S.Em (±)		0.02	0.02	0.02	0.12	0.12	0.07

Table 10: Sensory evaluation of fruits as influenced by foliar spray of different chemicals and plant growth regulator in papaya cv. Arka Surya

Treatments	Pulp colour			Taste			Overall acceptability		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
T_1	8.60	8.07	8.33	8.27	8.13	8.20	8.13	8.27	8.20
T_2	8.87	8.93	8.90	8.67	8.67	8.67	9.00	8.67	8.83
T_3	8.07	7.40	7.73	8.00	7.67	7.83	7.67	8.13	7.90
T_4	8.73	8.93	8.83	8.67	8.67	8.67	9.00	8.67	8.83
T_5	8.40	8.13	8.27	8.27	8.13	8.20	8.47	8.20	8.33
T_6	8.87	8.93	8.90	8.67	8.67	8.67	9.00	8.67	8.83
T_7	8.00	8.47	8.23	8.60	8.60	8.60	8.27	8.47	8.37
T_8	7.67	7.40	7.53	8.00	7.53	7.77	7.53	8.00	7.77
T_9	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
T_{10}	7.60	7.33	7.47	7.93	7.53	7.73	7.53	7.87	7.70
T_{11}	8.13	8.07	8.10	8.27	7.80	8.03	8.13	8.13	8.13
T_{12}	7.40	7.27	7.33	7.67	7.27	7.47	7.27	7.60	7.43
T_{13}	7.47	7.27	7.37	7.80	7.40	7.60	7.40	7.73	7.57
T_{14}	7.07	6.93	7.00	7.67	7.27	7.47	7.27	7.27	7.27
CD at 5%	0.71	0.65	0.58	0.63	0.59	0.44	0.44	0.64	0.43
S.Em ($\pm$)	0.24	0.22	0.20	0.21	0.20	0.15	0.15	0.22	0.15

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