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Tanvi A Patel
Department of Fruit Science, Agricultural University, ASPEE College of Horticulture and Forestry, Navsari, Gujarat, India

Urvashi K Boricha
Department of Fruit Science, Agricultural University, ASPEE College of Horticulture and Forestry, Navsari, Gujarat, India

Arpita M Patel
Department of Fruit Science, Agricultural University, ASPEE College of Horticulture and Forestry, Navsari, Gujarat, India

Corresponding Author:
Tanvi A Patel
Department of Fruit Science, Agricultural University, ASPEE College of Horticulture and Forestry, Navsari, Gujarat, India

Impact of pre harvest management on biochemical behaviour in mango cv. Amrapali

Tanvi A Patel, Urvashi K Boricha and Arpita M Patel

Abstract
The study titled "Impact of pre-harvest management on biochemical behaviour in mango cv. Amrapali" was performed in the 2018-19. The experimental design employed was a completely randomized design (CRD) comprising ten treatments and three replications. Upon analyzing the facts, it was noticed when using a combination of 3000 ppm salicylic acid and 1.0% $CaCl_2$ had a significant impact on various parameters. This treatment resulted in an increase in fruit firmness, total soluble solids, the levels of total sugars, reducing sugars, ascorbic acid content, total carotenoids, phenolic compounds and pectin content in the sample were found to be 3.55 kg/cm², 20.10°B, 16.04%, 6.43%, 34.46 mg/100 g, 0.97 mg/100 g, 86.23 mg/100 g, 0.45% respectively. Furthermore, the same treatment led to a significant decrease in titrable acidity 0.20% in the mango cv. Amrapali fruits.

Keywords: Calcium chloride, Mango, Salicylic acid

Introduction
Amrapali, a mango cultivar resulting from the cross between Dashehari and Neelum, is characterized by its dwarf stature, late maturation, and consistent fruit-bearing capabilities. The fruits of this cultivar are known for their oblong shape, superior taste, fibreless pulp, and high percentage of pulp content. The compact size of the tree makes it suitable for HDP and Culinary garden, as suggested by Ray (1999) [20].

However, despite these favourable characteristics, issues such as premature fruit dropping and variations in fruit size have been observed. In order to overcome these challenges, the application of growth regulators and nutrients before harvest can play a significant role in influencing the physical and biochemical transformations taking place in the developing fruit. Such interventions have the potential to enhance the quality of the fruit at the time of harvest.

Salicylic acid can hinder the biosynthesis of ethylene in plants by obstructing the conversion of 1-amino-cyclopropane l-carboxylic acid into ethylene, as described by Leslie and Romani (1986) [14]. Moreover, salicylic acid has an impact on the physical properties of fruits and can strengthening the activity of antioxidant enzymes.

Calcium is an essential macronutrient element which holds significant importance in various physiological and biosynthetic processes in plants. The application of $CaCl_2$ through pre-harvest sprays has been shown to have several beneficial effects on mango fruits. These include reducing weight loss, delaying fruit ripening, increasing shelf life, and improving the physical parameters of the fruits, as documented by Karemera and Habimana (2014) [10].

Material and Methods
During 2018-19, the investigation took place at the Regional Horticultural Research Station, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari. Geographically, Navsari is located at 20°57' North latitude and 72°54' East longitude, with an altitude of 11.89 m above mean sea level. Based on its agro-climatic situation, the location is classified as South Gujarat Heavy Rainfall Zone-I. The research adopted a completely randomized design (CRD) comprising ten treatments and three repetitions. To prepare the salicylic acid solution of the desired concentration, the required quantities were dissolved in ethanol/alcohol and then mixed with water. Similarly, the calcium chloride solution was prepared by precisely weighing it on an electronic measuring balance and dissolving it in the necessary amount of water. The application of salicylic acid through foliar spray was performed at 5 weeks after full bloom, while calcium chloride was sprayed 15 days before harvesting on a 12-year-old mango orchard planted with a spacing of 2.5 m × 2.5 m. The spraying procedures were conducted in the early morning hours.

Findings and Discussion

TSS: Several studies have reported similar results in various fruits. For example, Eman *et al*. (2013) [6], Singh *et al*. (2001) [23], Singh *et al*. (2017) [24], Patel *et al*. (2015) [18], Karemera *et al*. (2014) [10] and Bhatt *et al*. (2012) [3] observed comparable findings in mango. Saied (2011) [22] found similar results in banana, Rajkumar *et al*. (2006) [19] in papaya, Lo'ay (2017) [11] and Obeed (2011) [17] in grape and Kassem *et al*. (2011) [11] in ber. These studies indicate that the utilization of Salicylic acid at a concentration of 3000 ppm along with 1% $CaCl_2$ can lead to a significant increase in TSS (20.10°B) in fruits, possibly through the enzymatic breakdown of starch and the conversion of organic matter into soluble solids, suggested that the applied measures exhibit a favourable influence on the maturation of fruits and the buildup of sugars. (Reddy *et al*., 2016; Karemera *et al*., 2014) [10, 21].

Fruit firmness: The study revealed that the application of Salicylic acid at 3000 ppm and 1% $CaCl_2$ significantly increased the fruit firmness (3.55 kg/cm^2) in mango cv. Amrapali. This effect may be ascribed to the suppression and delay of ethylene production and decrease the fruit softening enzymes during ripening, resulting from the treatment with Salicylic acid (Reddy *et al*., 2016) [21]. Calcium, on the other hand, interacts with pectic acid in the cell wall, resulting in the creation of calcium pectate, an element that directly impacts fruit firmness. The utilization of 1% $CaCl_2$ spray to trees obtained in higher fruit firmness compared to the application of 0.5% $CaCl_2$ spray, as higher calcium content in the fruit can accelerate pectin degradation. Comparable studies found by Eman *et al*. (2013) [6], Singh *et al*. (2017) [24], Wahdan *et al*. (2011) [28] in mango; Tsomu and Patel (2014) [26], Bhalerao *et al*. (2009) [2] in sapota; Chawla *et al*. (2018) [14], Mishra *et al*. (2017) [15] in guava; Rajkumar *et al*. (2006) [19] in papaya; Cronje *et al*. (2009) [5] in litchi; Lo'ay (2017) [11] and Obeed (2011) [17] in grape.

Titrable acidity: The data pertaining to 3000 ppm Salicylic acid and 1% $CaCl_2$ resulted in a significantly lower titrable acidity (0.20%) in mango cv. Amrapali. This reduction may be due to synergistic impact of Salicylic acid and $CaCl_2$. The treatment with Salicylic acid may have contributed to retardation of ripening and senescence processes, leading to a decrease in acid oxidation in the mango fruits (Reddy *et al*., 2016) [21]. Calcium, on the other hand, influences the alteration of acids into sugars through the action of the enzyme invertase, which could lead to a reduction in titrable acidity. These findings align with similar studies conducted by Karemera *et al*. (2014) [10], Singh *et al*. (2017) [24] in mango; Lo'ay (2017) [11] in grape, and Kazemi (2014) [12] in strawberry.

Total sugars and reducing sugar: The various pre harvest treatment showed that Salicylic acid at 3000 ppm and 1% $CaCl_2$ obtained the higher levels of total sugars (16.04%) and reducing sugars (6.43%) in mango cv. Amrapali. The spray of Salicylic acid plays a role in regulating carbohydrate metabolism occurs in both source and sink tissues of plants. It impacts the hydrolysis of sucrose by invertase and influences the concentrations of plant hormones such as Salicylic acid. This suggested a correlation between Salicylic acid and invertase activity. The enhanced translocation of photosynthetic assimilates to the fruits and the degradation of starch during ripening might play a role in the buildup of reducing sugars (Ngullie *et al*., 2014) [16]. Calcium chloride also contributes to the elevation of total and reducing sugars through its facilitation of the conversion of organic matter in fruits into soluble solids under the influence of calcium-dependent enzymatic activities. Similar observations have been reported by Eman *et al*. (2013) [6], Singh *et al*. (2001) [23], Singh *et al*. (2017) [24], Karemera *et al*. (2014) [10], Junmatong *et al*. (2015) [9] in mango; Saied (2011) [22], Srivastava and Dwivedi (2000) [25] in banana; Rajkumar *et al*. (2006) [19] in papaya; Gioushy (2016) [8] in Washington Novel Orange, and Kassem *et al*. (2011) [11] in bar.

Ascorbic acid

The mango cv. Amrapali treated with 3000 ppm Salicylic acid and 1% $CaCl_2$ exhibited the highest ascorbic acid levels (34.46 mg/100 g). The combined application of Salicylic acid and $CaCl_2$ appears to have a synergetic impact on increasing ascorbic acid content in mango. Salicylic acid is recognized for its substantial involvement in enhancing antioxidant levels. The application of Calcium chloride also demonstrated a significant influence on maintaining the ascorbic acid content in the fruits, potentially by slowing down the rapid oxidation of ascorbic acid. Similar findings were described by Junmatong *et al*. (2015) [9], Patel *et al*. (2015) [18], Bhatt *et al*. (2012) [3] in mango; Kassem *et al*. (2011) [11] in ber, and Chawla *et al*. (2018) [14] in guava.

Total carotenoid

The application of 3000 ppm Salicylic acid and 1% $CaCl_2$ resulted in a significantly higher total carotenoids content in the fruits (0.97 mg/100 g). Salicylic acid is believed to stimulate the synthesis of carotenoids and xanthophylls, which could explain the observed increase (Lo'ay, 2017) [11]. Similar findings have been conveyed by Barman and Asrey (2014) [1] and Patel *et al*. (2015) [18] in mango, as well as Rajkumar *et al*. (2006) [19] in papaya. The effect of $CaCl_2$ may be attributed to the promotion of pigment or secondary metabolite synthesis, which is responsible for the higher vitamin A content (Patel *et al*., 2015) [18].

Pectin

Pectin content of mango cv. Amrapali was reported significantly higher (0.45%) in treatment with 3000 ppm Salicylic acid and 1% $CaCl_2$. This rise may be ascribed to Salicylic acid's capacity to delay pectin degradation by inhibiting cell wall degrading enzymes, as proposed by Ezzat *et al.* (2017). In the case of $CaCl_2$-treated fruits, the lower respiration rates, proteolysis, and tissue breakdown observed during storage might contribute to the maintenance of higher pectin content.

Phenol

The mango cv. Amrapali exhibited a significantly higher phenol content (86.23 mg/100 g) when treated with 3000 ppm Salicylic acid and 1% $CaCl_2$. The elevated levels of phenolic compounds in the Salicylic acid-treated fruit may be linked to the reduced activity of polyphenol oxidase (PPO) and the enhanced activity of phenylalanine ammonia-lyase (PAL) enzymes, as suggested by Barman and Asrey (2014) [1]. Similar findings have been mentioned by Junmatong *et al*. (2015) [9] in mango, Vatanparast *et al*. (2013) [27] in pomegranate, and Lo'ay (2017) [11] in grape.

Table 1: Impact of pre-harvest management on TSS, fruit firmness and titrable acidity in mango cv. Amrapali

Treatments	TSS (°B)	Fruit firmness (kg/cm^2)	Titrable acidity (%)
T_1: Absolute control	18.73	2.07	0.29
T_2: 1000 ppm Salicylic acid	18.75	2.11	0.28
T_3: 2000 ppm Salicylic acid	19.02	2.12	0.26
T_4: 3000 ppm Salicylic acid	18.93	3.35	0.28
T_5: 1000 ppm Salicylic acid + 0.5% $CaCl_2$	19.27	2.96	0.26
T_6: 1000 ppm Salicylic acid + 1.0% $CaCl_2$	19.40	3.44	0.25
T_7: 2000 ppm Salicylic acid + 0.5% $CaCl_2$	19.87	2.57	0.24
T_8: 2000 ppm Salicylic acid + 1.0% $CaCl_2$	19.97	3.46	0.22
T_9: 3000 ppm Salicylic acid + 0.5% $CaCl_2$	19.89	3.47	0.23
T_{10}: 3000 ppm Salicylic acid + 1.0% $CaCl_2$	20.10	3.55	0.20
SEm±	0.29	0.11	0.007
CD at 5%	0.85	0.32	0.02
CV%	2.58	6.36	4.97

Table 2: Impact of pre-harvest management on total sugars, reducing sugar and ascorbic acid in mango cv. Amrapali

Treatments	Total sugars (%)	Reducing sugar (%)	Ascorbic acid (mg/100 g)
T_1: Absolute control	13.27	4.45	26.55
T_2: 1000 ppm Salicylic acid	13.88	4.72	29.14
T_3: 2000 ppm Salicylic acid	14.06	4.86	29.68
T_4: 3000 ppm Salicylic acid	13.98	4.78	29.42
T_5: 1000 ppm Salicylic acid + 0.5% $CaCl_2$	14.52	5.28	30.54
T_6: 1000 ppm Salicylic acid + 1.0% $CaCl_2$	14.59	5.34	31.86
T_7: 2000 ppm Salicylic acid + 0.5% $CaCl_2$	14.79	5.52	32.71
T_8: 2000 ppm Salicylic acid + 1.0% $CaCl_2$	15.59	5.99	34.13
T_9: 3000 ppm Salicylic acid + 0.5% $CaCl_2$	14.92	5.64	34.09
T_{10}: 3000 ppm Salicylic acid + 1.0% $CaCl_2$	16.04	6.43	34.46
SEm±	0.21	0.12	0.62
CD at 5%	0.61	0.36	1.82
CV%	2.46	3.94	3.42

Table 3: Impact of pre-harvest management on total carotenoids, pectin content and phenol content in mango cv. Amrapali

Treatments	Total carotenoids (mg/100 g)	Pectin content (%)	Phenol (mg/100g)
T_1: Absolute control	0.78	0.41	76.59
T_2: 1000 ppm Salicylic acid	0.82	0.42	77.92
T_3: 2000 ppm Salicylic acid	0.88	0.42	81.73
T_4: 3000 ppm Salicylic acid	0.84	0.42	79.02
T_5: 1000 ppm Salicylic acid + 0.5% $CaCl_2$	0.92	0.43	82.43
T_6: 1000 ppm Salicylic acid + 1.0% $CaCl_2$	0.92	0.43	83.36
T_7: 2000 ppm Salicylic acid + 0.5% $CaCl_2$	0.93	0.43	83.73
T_8: 2000 ppm Salicylic acid + 1.0% $CaCl_2$	0.96	0.44	85.46
T_9: 3000 ppm Salicylic acid + 0.5% $CaCl_2$	0.95	0.43	84.63
T_{10}: 3000 ppm Salicylic acid + 1.0% $CaCl_2$	0.97	0.45	86.23
SEm±	0.007	0.006	1.18
CD at 5%	0.02	0.018	3.50
CV%	1.41	2.41	2.50

Conclusion

The present experiment concludes that applying 3000 ppm Salicylic acid via foliar application five weeks after full bloom, along with 1.0% $CaCl_2$ treatment 15 days prior to harvest resulted in maximum fruit firmness, TSS, total sugars, reducing sugars, the levels of total carotenoids, ascorbic acid content, pectin, and phenol were assessed in mango cv. Amrapali. Additionally, this treatment also minimized titrable acidity.

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