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Effect of pre-harvest treatments of paclobutrazol and calcium chloride on physical quality traits of mango cv. Amrapali

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Abstract
The present investigation was carried out during 2017-2018 in mango to find out the effect of pre-harvest treatments of paclobutrazol and calcium chloride on physical quality traits of mango cv. Amrapali. The experiment was laid out in a completely randomized design (CRD) with twelve treatments and three repetitions. The analysis of data revealed the significant effect of paclobutrazol and calcium chloride on all the parameters under study.Paclobutrazol at 200 mg/l with $CaCl_2$ at 1.5 per cent significantly increased fruit weight (244.52 g), fruit length (11.02 cm), fruit breadth (7.01 cm), fruit volume (206.81cm^3), pulp to peel + stone ratio (3.34), yield (44.20 kg/tree) and fruit firmness (3.62 kg/cm^2) of mango cv. Amrapali fruits. While, 100 mg/l paclobutrazol with 1.5 per cent $CaCl_2$ application significantly increased shelf life (6.83 days). The same treatment significantly reduced PLW of fruit for 2nd, 4th and 6th day of storage (1.20%, 1.50% and 2.47%, respectively) and spoilage per cent (22.03%) of mango cv. Amrapali fruits.

Keywords: Paclobutrazol, $CaCl_2$, Mango cv. Amrapali

1. Introduction
fruits because of its nutritive value, strong aroma, delicious taste, strong peel coloration and contain high amount of vitamin C, beta-caroteniods and trace amount of minerals. The genus *Mangifera* originated in South-East Asia and the natural spread is limited to Indo-Malayan region stretching from India to the Philippines and New Guinea. It is recorded that as many as 69 valid species of *Mangifera* are distributed throughout the world and 11,595 cultivars are available. India is proud of having the largest available germplasm wealth of mango with about 1,000 cultivars. (Bose, 1999) [1]. India is the largest producer and exporter of mango in the world. In India, highest area under fruit crops is covered by mango. There are number of cultivars and hybrids of mango under cultivation.

Amrapali (Dashehari × Neelum) is a well known, dwarf, late maturing and regular bearer, which possesses quality par excellence with oblong fruit shape. Due to its dwarf nature, the cultivar is recommended for high density planting and kitchen gardens. (Ray, 1999) [2]. Fruits are green to apricot yellow, small to medium sized, sweet in taste having fibreless flesh. In spite of above good characters, problems of fruit drops and undersized fruits have been observed. Pre-harvest application of growth regulators and nutrients can modify the place and direction of physical and biochemical changes in developing fruit and has potential to transform its quality at harvest.

Paclobutrazol, a triazole derivative, has been effectively used to induce and manipulate flowering, fruiting and tree vigour in several perennial fruit crops. However its use in mango is quite common. It can be applied to mango trees as a foliar spray or as soil drench. (Tongumpai *et al*., 1991) [3]. It is an antagonist of gibberellin and hence is referred as 'antigibberellin'. (Hedden, 1983) [4]. It is very active in low rates and taken up into the xylem through the leaves, stems or root and translocate to growing sub apical meristems. (Hamid and Williams 1997, Wang *et al*. 1986) [5, 6]. It results in retardation of vegetative growth and diversion of assimilates to reproductive organs there by enhances the bud break and improves the fruit yield and quality. Paclobutrazol application probably lengthens both flowering and fruit filling up periods in mango and provide adequate assimilates by hastening photosynthetic activities for fruit development. (Burondkar and Gunjate, 1993) [7]. It has been effectively used for flower regulation, yield and quality improvement in various perennial fruit crops. (Nartvaranant*et al*. 2000, Koukourikou-Petridou 1996, Adato 1990) [8, 9, 10].

Calcium chlorideis an important calcium salt that has many household and industrial applications. Pre-harvest spray of $CaCl_2$ reduces the weight loss, delays the ripening of fruits,

increases the shelf life, physico-chemical parameters and organoleptic quality of mango fruits. (Karemera and Habimana, 2014) [11]. It also increases the calcium content, thus improving nutritional value of the fruit. Calcium is a key plant nutrient that has a significant role in cell functions, reduces softening and senescence of fruits. (Barker and Pibeam, 2007, Jones and Lunt, 1967) [12, 13]. Pre harvest spray of calcium increases the productivity of mango due to reduction of abscission and it enhances the fruit quality by increasing the fruit firmness and by maintaining the turgidity of middle lamella cells. (Kumar *et al*., 2006, Wahdan *et al*., 2011) [14, 15]. Calcium spray during fruit development provides a safe mode of supplementing endogenous calcium to fresh fruits. (Gerasopoulos *et al*. 1996; Tzoutzoukou and Bouranis 1997; Raese and Drake 2000) [16, 17, 18]. The aim of this work was to determine the effect of pre-harvest foliar spray of paclobutrazol and calcium chloride on physical quality traits of Amrapali mango.

2. Materials and Methods

The present investigation was conducted during 2017-18 at Regional Horticultural Research Station, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat. The experimental site was situated at 20º 57' North latitude, 72º 54'East longitude and has altitude of 10 meters above the mean sea level. The climate of this area was characterized by three well defined seasons *viz*., monsoon, mild winter and summer. The experiment was laid out in a completely randomized design (CRD) with twelve treatments and three repetitions. Paclobutrazol and $CaCl_2$ were sprayed at 75 days after full bloom and 15 days before harvest, respectively on 10 years old mango orchard planted 2.5 m × 2.5 m spacing. The solution of paclobutrazol of desired concentration was prepared by dissolving required quantities of its commercial formulations (Cultar having 24.2 *a.i*. paclobutrazol) in water. The solution of calcium chloride was prepared by accurately weighing the calcium chloride on a digital balance and then dissolving it in required quantity of water. The spray applications were performed during the morning hours. The various treatments followed for the investigation were as follows: T_1= Control, T_2 = 1.0% $CaCl_2$, T_3 = 1.5% $CaCl_2$, T_4 = 100 mg/l PBZ, T_5 = 200 mg/l PBZ, T_6 = 300 mg/l PBZ, T_7 = 100 mg/l PBZ + 1.0% $CaCl_2$, T_8 = 100 mg/l PBZ + 1.5% $CaCl_2$, T_9 = 200 mg/l PBZ + 1.0% $CaCl_2$, T_{10} = 200 mg/l PBZ + 1.5% $CaCl_2$, T_{11} = 300 mg/l PBZ + 1.0% $CaCl_2$ and T_{12} = 300 mg/l PBZ + 1.5% $CaCl_2$.

3. Results and Discussion

The data on physical quality parameters were taken from five randomly selected fruits from each treatment just after harvesting.

Fruit weight and yield per tree were measured by using digital weighing machine. Fruit length and breadth were recorded by using digital verniercalliper. A measuring cylinder of 5l capacity was employed for measuring fruit volume in which water was added up to 3 l mark. Individual fruits were dipped in water, this led to a rise in the volume of water from the 3l mark which was noted as the volume of fruits. Fruit firmness was measured with the help of penetrometer.

Pulp to peel + stone ratio was calculated as pulp weight divided by peel weight + stone weight. Physiological loss of weight of fruit (%) recorded at 2nd, 4th and 6th day of storage. Spoilage percent were counted on each sampling date from successive storage intervalsand shelf life of fruits was recorded under ambient conditions.

4. Discussion

The results obtained from the present investigation on different physical quality attributes of mango fruits are summarized below: Fruit weight was influenced significantly by different pre-harvest treatments and found maximum (244.52 g) in T_{10}. It might be attributable to the activity of paclobutrazol to induce resistance in plants against environmental stresses while, calcium acts as a messenger to these environmental stimuli that trigger defense mechanism induced by paclobutrazol. PBZ has ability to hasten the photosynthetic activity leading to assimilation of more photosynthates. (Kim *et al*., 1990) [19]. This activity might have contributed significant increase in fruit weight in the present study. The finding obtained in the present investigation can be compared to those obtained by Khader (1990) [20], Kurian and Iyer (1993) [21], Benjawan *et al*. (2006) [22], Reddy and Kurian (2008) [23] in mango. Significantly maximum fruit length (11.02 cm) and fruit breadth (7.01 cm) of mango cv. Amrapali was obtained in T_{10}. It might be due to synergetic effect of PBZ and $CaCl_2$with each other. PBZ hasten the photosynthesis activity which ultimately cause production of more food inside the plant. This result was in the close vicinity with the findings of Benjawan *et al*. (2006) [22], Reddy and Kurian (2008) [23] in mango. It is observed from the result that $T_{10}$was observed significantly higher fruit volume (206.81 cm^3) of mango cv. Amrapali. It might be attributable to the activity of paclobutrazol to induce resistance in plants against environmental stresses while, calcium acts as a messenger to these environmental stimuli that trigger defense mechanism induced by paclobutrazol. (Kim *et al*., 1990) [19].

The similar result was also obtained by Kurian and Iyer (1993) [21], Benjawan *et al*. (2006) [22] in mango. It is clear from the results that T_{10} was recorded significantly higher pulp to peel + stone ratio (3.34) of mango cv. Amrapali. Such an increase may be due to synergetic effect between paclobutrazol and $CaCl_2$ spray. As paclobutrazol helps to accelerate photosynthetic activity and Ca brings important changes in carbohydrates and activates many enzymes. The result of present study is in conformation with the findings of Karemera *et al*. (2013) [24] in mangoand Singh (2000) [25] in ber. Physiological loss of weight of mango cv. Amrapali showed significant differences among the different pre-harvest treatments. Significantly minimum physiological loss of weight for 2nd, 4th and 6th day of storage (1.20%, 1.50% and 2.47%, respectively). was recorded in T_8. However, treatments containing $CaCl_2$ had lower physiological weight loss as compared to paclobutrazol treatments. $CaCl_2$ applications have been known to play an important role in cell membrane functionality and integrity maintenance, which may be the reason for the occurrence of lower weight loss in calcium treated fruits. Similar results were obtained by Vishwakarma *et al*. (2017) [26] in mango. Significantly maximum yield (44.20 kg/tree) of mango cv. Amrapali was obtained in T_{10}(200 mg/l paclobutrazol+ 1.5% $CaCl_2$). It might be due to synergetic effect of both of them with each other.

Paclobutrazol induce resistance in plants against environmental stresses while, calcium acts as a messenger to these environmental stimuli that trigger defense mechanism induced by paclobutrazol. Paclobutrazol has ability to hasten the photosynthetic activity leading to assimilation of more photosynthates. (Kim *et al*., 1990) [19]. Similar findings were reported by Benjawan *et al*. (2006) [22] in mango; Kazemi (2014) [27] in strawberry. Pre-harvest application of $CaCl_2$ was

also reported to increase fruit yield per tree. It might be due to the effect of $CaCl_2$ to influence formation and changes of carbohydrates and carbohydrate enzymes. Similar findings were obtained by Ajender *et al*. (2019) [28] in apple. It is observed from the result that Paclobutrazol at 200 mg/l and 1.5 per cent $CaCl_2$ recorded significantly higher fruit firmness (3.62 kg/cm^2) of mango cv. Amrapali. It might be due to calcium interacts with pectic acid in the cell wall to form calcium pectate, thereby having a direct influence on fruit firmness. Fruit firmness was higher when trees were sprayed with 1.5 per cent $CaCl_2$ than those of which were sprayed with 1.0 per cent $CaCl_2$, because pectin degradation is higher with high calcium content in fruit. Similar results were observed by Singh *et al*. (2017) [29] in mango, Bhalerao *et al*. (2009) [30] in sapota.

Table 1: Effect of different pre-harvest treatments on fruit weight, length, breadth, volume, pulp to peel + stone ratio, firmness, spoilage per cent, shelf life and yieldof mango cv. Amrapali

Treatments	Fruit weight	Fruit length	Fruit breadth	Fruit volume	Pulp to peel + stone ratio	Fruit firmness (kg/cm^2)	Spoilage (%)	Shelf life	Yield (kg/ tree)
T1: Control	139.35	8.40	5.26	126.66	2.57	1.52	37.68	4.92	27.76
T2: 1.0% $CaCl_2$	156.41	9.16	5.42	137.40	2.81	2.30	27.19	5.58	29.03
T3: 1.5% $CaCl_2$	160.04	9.48	5.49	144.61	2.75	2.69	26.74	5.83	31.57
T4: 100 mg/l PBZ	197.98	9.86	5.81	171.48	2.95	1.68	31.44	5.17	33.41
T5: 200 mg/l PBZ	220.11	10.00	5.95	189.90	2.91	1.62	30.54	5.42	38.86
T6: 300 mg/l PBZ	214.27	10.05	5.86	192.33	2.94	1.54	30.59	5.33	36.75
T7: 100 mg/l PBZ + 1.0% $CaCl_2$	219.53	10.04	6.11	196.38	2.96	2.63	23.22	5.42	38.29
T8: 100 mg/l PBZ + 1.5% $CaCl_2$	221.15	10.08	6.29	197.51	2.97	2.93	22.03	6.83	38.06
T9: 200 mg/l PBZ + 1.0% $CaCl_2$	234.92	10.50	6.51	202.66	3.07	2.77	26.58	5.92	40.26
T10: 200 mg/l PBZ + 1.5% $CaCl_2$	244.52	11.02	7.01	206.81	3.34	3.62	22.75	6.58	44.20
T11: 300 mg/l PBZ + 1.0% $CaCl_2$	220.45	10.06	6.37	197.05	2.98	3.23	27.49	6.08	38.33
T12: 300 mg/l PBZ + 1.5% $CaCl_2$	221.14	10.01	6.44	197.63	3.00	3.45	24.22	6.33	38.47
SEm±	7.91	0.31	0.17	2.04	0.10	0.11	0.77	0.09	1.77
CD at 5%	23.09	0.93	0.50	5.82	0.30	0.34	2.27	0.27	5.18
CV %	6.71	5.59	4.97	1.96	6.24	8.17	4.89	2.79	8.49

Table 2: Effect of different pre-harvest treatments on physiological loss of weight of mango cv. Amrapali

Treatments	Physiological loss of weight of fruit (%)		
	2nd day of storage	4th day of storage	6thday of storage
T1: Control	1.79	2.19	3.20
T2: 1.0% $CaCl_2$	1.47	1.68	2.65
T3: 1.5% $CaCl_2$	1.46	1.67	2.63
T4: 100 mg/l PBZ	1.52	1.80	2.78
T5: 200 mg/l PBZ	1.41	1.73	2.77
T6: 300 mg/l PBZ	1.48	1.77	2.78
T7: 100 mg/l PBZ + 1.0% $CaCl_2$	1.39	1.71	2.74
T8: 100 mg/l PBZ + 1.5% $CaCl_2$	1.20	1.50	2.47
T9: 200 mg/l PBZ + 1.0% $CaCl_2$	1.36	1.68	2.67
T10: 200 mg/l PBZ + 1.5% $CaCl_2$	1.24	1.60	2.64
T11: 300 mg/l PBZ + 1.0% $CaCl_2$	1.34	1.71	2.72
T12: 300 mg/l PBZ + 1.5% $CaCl_2$	1.31	1.70	2.68
SEm±	0.04	0.04	0.06
CD at 5%	0.10	0.11	0.17
CV %	4.43	4.07	3.90

5. Conclusion

On the basis of results obtained in the present investigation it is concluded that foliar application of paclobutrazol (75 days after full bloom) at 200 mg/l and $CaCl_2$ (15 days before harvest) at 1.5 per cent resulted in maximum fruit weight, fruit length, fruit breadth, fruit volume, pulp to peel + stone ratio, fruit firmness, yield and organoleptic scores of mango cv. Amrapali. Whereas, paclobutrazol at 100 mg/l and $CaCl_2$ at 1.5 per cent resulted in maximum shelf life. The same treatment minimized PLW of fruit and spoilage per cent of mango cv. Amrapali.

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