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Research Article

Influence of Preharvest Application of Salicylic Acid and Potassium Silicate on Postharvest Quality of Mango Fruits (*Mangifera indica* L.) cv. Alphonso

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Abstract

An field experiment was carried out to assess the effect of salicylic acid and potassium silicate on fruit quality and shelf life in mango (*Mangifera indica* L.) cv. Alphonso. The experiment consisted of nine treatments viz. T_1 (control), T_2 (potassium nitrate @ 1%), T_3 (salicylic acid @ 100 ppm), T_4 (salicylic acid @ 200 ppm), T_5 (potassium silicate @ 0.1%), T_6 (potassium silicate @ 0.2%), T_7 (salicylic acid @ 100 ppm + potassium silicate @ 0.1%), T_8 (salicylic acid @ 0.2% + potassium silicate @ 200 ppm), T_9 (paclobutrazol @ 3 ml m^{-1}).Seven years old mango orchard was selected for experiment and planted with spacing 7.5 m in square system. Results revealed that foliar application of salicylic acid @ 200 ppm + potassium silicate @ 0.2% (T_8) found to improve fruit quality attributes like TSS (19.70oBrix), Ascorbic acid content (57.35 mg/100 g), reducing sugars (4.20%). This treatment also enhance shelf life of fruits (15.10 days), marketable fruits percentage (88.94%), firmness (4.97 kg/cm^2) and reduce physiological loss in weight during storage period.

Keywords: Salicylic Acid; Physiological Loss in Weight; Shelf Life; Firmness; TSS

Introduction

Mango (*Mangifera indica* L.) is one of the most important fruit crops of the tropics and subtropics that belong to family *Anacardiaceae*, native to Indo-Burma region. It has been grown since long and leading fruit crop of India and is known as "King of fruits" due to its sweetness, richness of taste, huge variability, large production volume and a variety of end usage. Besides, having delicious taste, captivating flavour with multifarious colours, it is an excellent source of dietary nutrients and Vitamin A. It is grown in almost all parts of the world and India is considered as the largest mango producing country of the world, cultivated in an area of 2.25 million hectares with a production of 21.82 million metric tonnes [1]. The area and production of mango in Andhra Pradesh with 0.33 million hectares and 3.16 million metric tonnes [1].

Mango is a climacteric fruit, generally harvested at mature green stage, and ripens up during the marketing process (transport, storage etc.). However, due to the application of conventional technology for the transfer of the produce and an irregular storage period more than 30% is wasted. Short production season, short storage period and development of post-harvest diseases leading to decay are the major constraints of the mango trade. It is a crop which always requires attention and care during its postharvest handling and marketing, especially for reduction of postharvest superficial blemishes. Maintenance of proper quality fruits (TSS, Sugars, Firmness etc.,) during storage period also an important aspect now a days along with enhace shelf life of mango fruits.

Salicylic acid belongs to phytohormone which classified as a phenylpropanoid compound and stimulated by biotic and abiotic stresses to induce defense responses. Moreover, it is also classified as an ethylene inhibitor [2]. Exogenous Salicylic acid application has been used to maintain postharvest quality, extend shelf-life, control diseases and physiological disorders during storage [3]. Salicylic acid acts as a concentration-dependent plant resistance enhancer. It alters the fruit physiology by increasing secondary metabolites in plant tissues which in turn increases the resistance level of plant organs against the external as well as internal factors. These alterations might be due to decrease in activity of enzymes like lipoxygenase and allene oxide synthase etc., inhibition of ethylene biosynthesis, delaying down the onset of ethylene climacteric, and delay the ripening process in fruits. Silicon has been reported as a beneficial nutrient, protecting plants against various diseases. It confers resistance to certain diseases are associated with the physical block created by the deposition of this element under the cuticle and on the epidermal cell wall or with the enhancement of defense mechanisms such as production of phenolic compounds, hence, increase lignification and promote cell wall strengthening to control many diseases in plant [4]. Foliar application of potassium nitrate leads to improves fruit quality in mango fruits [5,6]. Paclobutrazol act have antigibberellic property and it enhances early panicle emergence and also enable the trees to produce shorter and compact panicle, with more number of hermaphrodite flowers which results in maximum of fruit set. Shinde., *et al.* [7] and Subbaiah., *et al.* [8] reported that paclobutrazol application in mango improves its fruit quality.

Materials and Methods

The experiment was carried out at farmer's field, it was situated 2 km away from College of Horticulture, Anantharajupeta, YSR Kadapa (D), Dr. Y.S.R Horticultural University, Andhra Pradesh. The field is situated at an altitude of 162 meters (531 feet) above mean sea level and at 14.02o North latitude and 79.33o East longitude which falls under tropical zone with a normal rainfall of 966.1 mm. The soil of the orchard selected is a red sandy loam with a pH of 7.1 and electrical conductivity of 0.24 dsm^{-1}. Soil contains 0.38%, 7.5 kg ha^{-1}, and 395 kg ha^{-1} of organic carbon, available phosphorus and potassium contents, respectively. The experimental material consisted of 7 years old, well grown, uniform statured trees of mango cultivar 'Alphonso' (syn Khader). The trees were spaced at 7.5 m and planted in square system. In all, 27 uniform trees of 'Alphonso' were selected for experimentation. All cultural practices like fertilizer application, spraying of pesticides, fungicides and irrigation were uniformly practiced in experimental trees.

The experiment was laid out in Randomized Block Design with three replications and nine treatments namely, Control (T_1), Potassium nitrate (KNO_3) @ 1% (T_2), (Salicylic acid (SA) @ 100 ppm (T_3), Salicylic acid (SA) @ 200 ppm (T_4), Potassium silicate (PS) @ 0.1% (T_5), Potassium silicate (PS) @ 0.2% (T_6), Salicylic acid (SA) @ 100 ppm + Potassium silicate (PS) @ 0.1% (T_7), Salicylic acid (SA) @ 200 ppm + Potassium silicate (PS) @ 0.2% (T8), Paclobutrazol (PBZ) @ 3 ml m-1 (T_9). Paclobutrazol was applied as soil application at September first week and remaining all chemicals were applied as foliar spray, first at flower bud initiation stage (December first week), second at two weeks after fruit set (February second week).

From each plant five fruits were taken for estimate quality attributes. Total soluble solids (TSS) of fully ripened fruits was estimated with the help of digital pocket refractometer. Titrimetric method described by Ranganna [9] was adopted for the estimation of ascorbic acid, Titrable acidity [9], Total sugar content [10], Reducing sugars [9]. The firmness of the fruit was tested by means of a pocket penetrometer (FR-5120 Digital Fruit Firmness Tester). Physiological loss in weight of fruits was determined by weighing the fruits immediately after harvesting and was recorded as the initial fruit weight. There after they were weighed periodically at 3 days interval up to days of storage at ambient temperature which served as the final weight. The number of visibly sound and healthy fruits were counted and expressed as percentage over the total number of fruits during storage. Each fruit was thoroughly scrutinized for any visible symptoms of spoilage and shelf-life was considered when 30 per cent of the fruits shown over ripening or spoilage symptoms.The data obtained from experiment were subjected to statistical analysis as per the method of Panse and Sukhatme [11]. The treatments means were compared by means of critical difference of 5 per cent level of probability.

Results and Discussion

Trees sprayed with salicylic acid @ 200 ppm + potassium silicate @ 0.2% (T_8) displayed the highest TSS (19.70 oBrix), but statistically comparable to that resulting from all other chemical treatments except T_9 (paclobutrazol @ 3 ml m^{-1}). Control trees (T_1) displayed the lowest TSS (18.07 0Brix) content.The lowest acidity (0.23%) was recorded in fruits harvested from trees treated with salicylic acid @ 200 ppm + potassium silicate @ 0.2% (T_8) which was statistically comparable to that resulting from salicylic acid 100 ppm + potassium silicate @ 0.1% (T_7) (0.29%), 1% potassium nitrate (T_2) (0.30%), 200 ppm salicylic acid (T4) (0.31%) and 0.2% potassium silicate (T6) (0.32%) treatment. Highest acidity (0.47%) was observed in untreated control trees (T_1). Above results were confirmed by Ahmed., *et al.* [12] and Reddy., *et al.* [13] in mango by using salicylic acid, Mohamed., *et al.* [14] and Wassel., et al. [15] in mango by using potassium silicate.

Plants treated with combined application of salicylic acid @ 200 ppm + potassium silicate @ 0.2% (T8) displayed highest ascorbic acid content (57.35 mg/100 g) in the fruit of mango cv. Alphonso. The lowest ascorbic content (42.92 mg/100 g) was observed in control (T_1) trees. Similar results also found in mango by Ahmed., *et al.* [16], Ahmed., *et al.* [12] by salicylic acid application, Mohamed., *et al.* [14] and Wassel., *et al.* [15] by potassium silicate application. The highest percentage of reducing sugars (4.20%) was recorded in T_8 (salicylic acid @ 200 ppm + potassium silicate @ 0.2%) which was statistically at par with T_7 (salicylic acid @ 100 ppm + potassium silicate @ 0.1%) (4.10%), T_4 (salicylic acid @ 200 ppm) (4.03%) and T_3 (salicylic acid @ 100 ppm) (3.92%). Except for T_8, T_7, T_4, T_3 treatments, reducing sugars percentage recorded in the remaining chemical treatments were comparable to that of control. Meanwhile, lowest percent reducing sugars (3.18%) was observed in the control (T_1).

Trees treated with soil application of paclobutrazol 3 ml m^{-1} (T_9) recorded maximum total sugars (13.44%) which are statistically at par with T_8 (salicylic acid 200 @ ppm + potassium silicate @ 0.2%) (13.20%), T_7 (salicylic acid @ 100 ppm + potassium silicate @ 0.1%) (12.70%), T_2 (potassium nitrate @ 1%) (12.52%), T6 (potassium silicate @ 0.2%) (12.27%) and T_4 (salicylic acid @ 200 ppm) (12.25%). While, treatment T_1 (Control) recorded minimum total sugars (10.07%). Furthermore, all the chemical treatments are statistically superior over control with regard to total sugars content in the fruits. Above results were accordance with Ahmed., *et al.* [16], Nugullie., *et al.* [17] in mango by spray as salicylic acid, Wassel., *et al.* [15] and Mohamed., *et al.* [18] in mango by potassium silicate spray.

The promotive effect of salicylic acid on improving the biosynthesis and translocation of plant pigments and sugars [19] could have resulted in the enhancement of fruit quality. Thus, the accumulation of reducing sugar might be due to increased translocation

Treatments	TSS (°Brix)	Acidity (%)	Ascorbic acid (mg/100g)	Reducing sugars (%)	Total sugars (%)
T_1: Control	18.07	0.47	42.92	3.18	10.07
T_2: Potassium nitrate @ 1%	19.10	0.30	44.77	3.38	12.52
T_3: Salicylic acid @ 100 ppm	19.33	0.33	44.40	3.92	11.57
T_4: Salicylic acid @ 200 ppm	19.53	0.31	46.48	4.03	12.25
T_5: Potassium silicate @ 0.1%	19.27	0.34	48.47	3.46	11.63
T_6: Potassium silicate @ 0.2%	19.30	0.32	49.58	3.53	12.27
T_7: Salicylic acid @ 100 ppm + Potassium silicate @ 0.1%	19.57	0.29	54.02	4.10	12.70
T_8: Salicylic acid @ 200 ppm + Potassium silicate @ 0.2%	19.70	0.23	57.35	4.20	13.20
T_9: Paclobutrazol @ 3 ml m^{-1}	18.80	0.28	54.76	3.63	13.44
SEM ±	0.22	0.03	1.24	0.16	0.45
C.D. at 5%	0.66	0.09	3.71	0.48	1.34

Table 1: Influence of preharvest application of salicylic acid and potassium silicate on fruit quality attributes in mango (*Mangifera indica* L.) cv. Alphonso.

of more photosynthetic assimilates to the fruits and breakdown of starch during ripening.The beneficial effects of silicon on protecting the plants from unfavourable effects of the environment during maturity might have improved fruit quality [20]. Silicon and potassium may have stimulated the synthesis of more sugars in the fruit which helped in increasing total soluble solids. The decrease in acidity might be due to an increase in total soluble solids. Increase in sugar content by paclobutrazol application is presumed to be the result of favourable mobilization of photo assimilates to the developing sink created by maturing fruits. Similar increasing sugar content in mango fruits also obtained by Sarker and Rahim [21], Subbaiah., *et al.* [8].

On the 3rd day of storage, there is no significant difference in the physiological loss in weight (PLW) in treated trees including control. On the 6th day of storage, PLW recorded in all treatments showed a significant difference over control. The PLW on the 6th day of storage was minimum in fruits harvested from trees treated with salicylic acid @ 200 ppm + potassium silicate @ 0.2% (T_8) (7.33%) which was statistically at par with salicylic acid @ 100 ppm + potassium silicate @ 0.2% (T_7) (7.57%). The same trend continued on the 9th day of storage, where in salicylic acid 200 @ ppm + potassium silicate @ 0.2% (T_8) registered the lowest physiological loss in weight (10.69%), while the highest physiological loss in weight (13.19%) observed in control (T_1) it was comparable with the application of Paclobutrazol (T_9) (13.05%). On 12th day of storage, fruits from trees treated with salicylic acid @ 200 ppm + potassium silicate @ 0.2% (T_8) recorded the lowest physiological loss in weight (13.68%), which was statistically on par with the application of salicylic acid @ 100 ppm + potassium silicate @ 0.1% (T_7) (13.94%) and T_6 (potassium silicate @ 0.2%) (13.96%). On 15th day of storage, trees treated with salicylic acid @ 200 ppm + potassium silicate @ 0.2% (T8) showed the lowest physiological loss in weight (17.21%) in fruits which was statistically comparable with T_7 (salicylic acid @ 100 ppm + potassium silicate @ 0.1%) (17.24%), T_6 (potassium silicate @ 0.2%) (17.28%), T_5 (potassium silicate @ 0.1%) (17.32%) and T_2 (potassium nitrate @ 1%)

Treatments	Physiological Loss in Weight (%) Days after harvest					Firmness (kg/cm²)	Shelf life (days)	Marketable fruits (%)
	3rd	6th	9th	12th	15th			
T_1: Control	3.01	8.41	13.19	16.88	18.73	3.11	12.84	62.50
T_2: Potassium nitrate @ 1%	2.90	7.82	11.34	15.34	17.37	3.61	14.10	77.79
T_3: Salicylic acid @ 100 ppm	2.93	7.78	11.26	14.96	18.18	3.62	13.48	76.33
T_4: Salicylic acid @ 200 ppm	2.91	7.64	11.44	14.85	18.13	3.74	13.57	85.55
T_5: Potassium silicate @ 0.1%	2.92	8.01	12.12	14.81	17.32	3.98	13.84	79.40
T_6: Potassium silicate @ 0.2%	2.87	7.90	11.66	13.96	17.28	4.11	14.06	82.23
T_7: Salicylic acid @ 100 ppm + Potassium silicate @ 0.1%	2.85	7.57	11.97	13.94	17.24	4.60	14.25	85.25
T_8: Salicylic acid @ 200 ppm + Potassium silicate @ 0.2%	2.82	7.33	10.69	13.68	17.21	4.97	15.10	88.94
T_9: Paclobutrazol @ 3 ml m^{-1}	2.94	8.17	13.05	15.88	18.00	3.58	13.38	66.48
SEM ±	0.05	0.08	0.10	0.29	0.15	0.14	0.27	0.56
C.D. at 5%	NS	0.25	0.30	0.86	0.44	0.43	0.80	1.69

Table 2: Influence of preharvest application of salicylic acid and potassium silicate on shelf life of mango (*Mangifera indica* L.) cv. Alphonso.

(17.37%). At all the stages of storage, fruits from untreated trees registered a significantly higher physiological loss in weight (3.01, 8.41, 13.19, 16.88 and 18.73% on 3rd, 6th, 9th, 12th, and 15th day of storage, respectively) as compared to sprayed fruits.

Highest fruit firmness (4.97 kg/cm^2) was recorded in fruits which were sprayed with salicylic acid @ 200 ppm + potassium silicate @ 0.2% (T_8), which was statistically significant than all remaining treatments. Fruits harvested from untreated trees exhibited the lowest firmness (3.11 kg/cm^2). The maximum shelf life (15.10) was recorded in fruits which were sprayed with salicylic acid @ 200 ppm + potassium silicate @ 0.2% (T_8), which was significantly superior over other treatments including control. Moreover, the minimum shelf life (12.84 days) of fruits was noticed in control (T_1).

The perusal of data indicated that there was a significant improvement among the treatments regarding percent marketable fruits as compared to control. Maximum percentage of marketable fruits (88.94%) was recorded in fruits which were sprayed with salicylic acid @ 200 ppm + potassium silicate @ 0.2%. However, minimum marketable fruits percentage (62.50%) was observed in control (T_1).

The results showed that foliar application of salicylic acid and potassium silicate alone or in combination had a significant effect on maintaining higher firmness in mango fruits. Increase in fruit firmness with salicylic acid might be due to decrease in the activity of cell wall degrading enzymes like cellulose, polygalacturonase, and xylanase [22]. Salicylic acid also interferes with biosynthesis and/or action of ethylene [19]. Similar effects of salicylic acid on maintenance of higher fruit firmness was also been reported by Reddy., *et al.* [13] in mango and Deljou., *et al*. [23] in apple. Prasad and Sharma [24] concluded that salicylic acid was most effective to decrease in postharvest decay occurred without any adverse effect on soluble solids concentrates and total carotenoids. In the same context of the obtained data in the present study, Babak and Majid [25] reported that silicon lowers ethylene production and forms complexes with organic compounds in the cell wall of epidermal cells, therefore imparting resistance against degrading enzymes. Mohamed., *et al*. [14] also reported improvement of fruit firmness with silicon in mango. Potassium silicate also improves the shelf life of fruits because this may have minimized the physiological loss in weight and ultimately increased shelf life. A similar increase in shelf life and decrease in physiological loss in weight of fruits with silicon application were reported by Mohamed., *et al.* [14] and Vidya., *et al.* [26] in mango.

Conclusion

Foliar application of salicylic acid and potassium silicate alone or in combination with both higher and lower concentration significantly improve quality parameters and shelf life in mango cv. Alphonso compared to control. Foliar application of salicylic acid @ 200 ppm + potassium silicate @ 0.2% (T_8) found to improve fruit quality attributes along with enhancing shelf life of fruits during storage period.

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