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Effect of salicylic acid and potassium silicate on shelf life of mango (*Mangifera indica* L.) cv. Alphonso

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Abstract
An experiment was conducted at farmer's field, near College of Horticulture, Anantharajupeta, Andhra Pradesh during the year 2017-2018 under Dr. Y.S.R Horticultural University, to assess the effect of potassium silicate and salicylic acid on fruit 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 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: Mango, 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 belongs 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 2.26 million hectares with a production of 19.68 million metric tonnes (Anon., 2017) [1]. The area and production are highest in Andhra Pradesh with 0.33 million hectares and 3.16 million metric tonnes, respectively contributing 16 percent to the country's total production (Anon., 2017) [1].

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 (Gerailoo and Ghasemnezhad, 2011) [7]. Exogenous Salicylic acid application has been used to maintain postharvest quality, extend shelf-life, control diseases and allevative physiological disorders during storage (Asghari and Aghdam, 2010) [2]. 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 (Lopes *et al*., 2014) [10]. Foliar application of potassium nitrate leads to improves fruit quality in mango fruits (Yadav *et al*., 2017 and Patoliya *et al*., 2017) [20, 13]. Shinde *et al* (2015) [16] and Subbaiah *et al*. (2017) [18] reported that paclobutrazol application in mango improves its fruit quality. So, based on the above research background apply salicylic acid, potassium silicate, potassium nitrate and paclobutrazol on mango plants for improving shelf life of fruits.

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 14.02° North latitude and 79.33° 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 @ 1% (T_2), Salicylic acid @ 100 ppm (T_3), Salicylic acid @ 200 ppm (T_4), Potassium silicate @ 0.1% (T_5), Potassium silicate @ 0.2% (T_6), Salicylic acid @ 100 ppm + Potassium silicate @ 0.1% (T_7), Salicylic acid @ 200 ppm + Potassium silicate @ 0.2% (T_8), Paclobutrazol @ 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).

In each treatment five fruits were taken for quality attributes. 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 were subjected to statistical analysis as per the method of Panse and Sukhatme, 1985 [12]. The treatments means were compared by means of critical difference of 5 per cent level of probability.

Results and Discussion

Results in Table.1 indicated that 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%).

Table 1: Effect of salicylic acid and potassium silicate on Physiological loss in weight (%) of mango (*Mangifera indica* L.) cv. Alphonso

Treatments	Physiological loss in weight (%) Days after harvest				
	3rd	6th	9th	12th	15th
T_1 : Control	3.01	8.41	13.19	16.88	18.73
T_2 : Potassium nitrate @ 1%	2.90	7.82	11.34	15.34	17.37
T_3 : Salicylic acid @ 100 ppm	2.93	7.78	11.26	14.96	18.18
T_4 : Salicylic acid @ 200 ppm	2.91	7.64	11.44	14.85	18.13
T_5 : Potassium silicate @ 0.1%	2.92	8.01	12.12	14.81	17.32
T_6 : Potassium silicate @ 0.2%	2.87	7.90	11.66	13.96	17.28
T_7 : Salicylic acid @ 100 ppm + Potassium silicate @ 0.1%	2.85	7.57	11.97	13.94	17.24
T_8 : Salicylic acid @ 200 ppm + Potassium silicate @ 0.2%	2.82	7.33	10.69	13.68	17.21
T_9 : Paclobutrazol @ 3 ml m^{-1}	2.94	8.17	13.05	15.88	18.00
S.Em. ±	0.05	0.08	0.10	0.29	0.15
C.D. at 5%	NS	0.25	0.30	0.86	0.44

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% (T_8) 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%) (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 trees.

The perusal of data in Table. 2 indicated that highest fruit firmness (4.97 kg/cm^2) was recorded with the spray of 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 treatment 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). There was a significant improvement among the treatments regarding percent marketable fruits as compared to control. Maximum percentage of marketable

fruits (88.94%) was observed in treatment T_8 (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 (Srivastava and Dwivedi, 2000) [17]. Salicylic acid also interferes with biosynthesis and/or action of ethylene (Raskin, 1992) [14]. Similar effects of salicylic acid on maintenance of higher fruit firmness was also been reported by Reddy *et al.* (2016) [15] in mango, Barakat *et al*. (2015) [4], Barzinji *et al*. (2017) [5] in pear and Deljou *et al.* (2017) [6] in apple. In the same context of the obtained data in the present study, Babak and Majid (2011) [3] 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*. (2017) [11] 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*. (2017) [11], Vidya *et al*. (2014) [19] in mango and Lalithya *et al.* (2013) [9] in sapota and Hanumanthaiah *et al*. (2015) [8] in banana.

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

Treatments	Firmness (kg/cm^2)	Shelf life (days)	Marketable fruits (%)
T_1 : Control	3.11	12.84	62.50
T_2 : Potassium nitrate @ 1%	3.61	14.10	77.79
T_3 : Salicylic acid @ 100 ppm	3.62	13.48	76.33
T_4 : Salicylic acid @ 200 ppm	3.74	13.57	85.55
T_5 : Potassium silicate @ 0.1%	3.98	13.84	79.40
T_6 : Potassium silicate @ 0.2%	4.11	14.06	82.23
T_7 : Salicylic acid @ 100 ppm + Potassium silicate @ 0.1%	4.60	14.25	85.25
T_8 : Salicylic acid @ 200 ppm + Potassium silicate @ 0.2%	4.97	15.10	88.94
T_9 : Paclobutrazol @ 3 ml m^{-1}	3.58	13.38	66.48
S.Em. ±	0.14	0.27	0.56
C.D. at 5%	0.43	0.80	1.69

Conclusion

Based on the present investigation it can be concluded that minimum physiological loss in weight at 12th and day (13.68%) and 15th day (17.21%) was observed in the fruits harvested from the trees treated with salicylic acid @ 200 ppm + potassium silicate @ 0.2% (T_8). Further, the highest shelf life of fruits (15.10 days) and marketable fruits percentage (88.94) during storage were recorded in treatment T_8 (salicylic acid @ 200 ppm + potassium silicate @ 0.2%).

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