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Improving productivity in Mango (*Mangifera indica* L.) cv. Kesar through foliar sprays of silicon and salicylic acid

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Abstract
An experiment was conducted at RHRS farm, Navsari Agricultural University, Navsari during the year 2016-17 to assess the effect of different silicon sources and salicyclic acid on fruiting in mango cv. Kesar. The experiment was evaluated in a Randomized Block Design with ten treatments and replicated thrice. Treatments involved foliar sprays of potassium silicate (1, 2 and 3 ml/l), silicic acid (2, 3 and 4 ml/l), salicylic acid (1500, 2000 and 2500 ppm) and unsprayed control. Results revealed a significant impact of treatments on all parameters included in the study. Application of silisic acid and salicylic acid recorded significantly higher number of fruits per tree, fruit weight and fruit yield in mango cv. Kesar. Trees sprayed with salicylic acid at 2000 ppm had the maximum fruit retention (89.83%), fruit weight (290.17g), fruit length (12.10 cm) and breadth (8.60 cm). However, number of fruits per panicle (1.77), number of fruits per tree (419) and fruit yield per tree (120.64 kg/tree) were highest under salicylic acid at 2500 ppm. In the current investigation, salicyclic acid at 2000 ppm proved most effective for improving fruit retention, increasing fruit yield and inducing better sized fruits.

Keywords: Fruit retention, Fruit weigth, Fruit yield, Silisic acid, Salicylic acid

Introduction
Mango is considered to be the choicest of all indigenous fruits grown in Hindustan. Due to high palatability, excellent flavor, taste and admirable medicinal and nutritive value, it is said to be the "king of tropical fruits". Geographical, climactic and genetic studies of mango indicate that it has originated in Indo-Burma region (Candolle, 1904) [1]. India is the largest consumer and producer of mango in the world followed by Brazil, Pakistan, Mexico, Indonesia, Thailand, Philippines and China. India contributes about 45.1% to the total mango production at the global level. Mango covers an area of 2516 thousand ha with a production of 18431.3 thousand MT at the national level. The major mango growing states of India are Uttar Pradesh, Andhra Pradesh, Karnataka and Telangana. In Gujarat, the total area under mango cultivation is 142.69 thousand ha with a production of about 1125.61 thousand MT and a productivity of 7.9 MT/ha (Anon., 2014) [2].

Most of the commercial varieties in mango suffer from erratic fruit drop and sometimes only 0.1% of set fruit reach maturity, which often is a consequence of biotic and abiotic stress. Salicylic acid (C_6H_4 (OH) COOH) basically known as 'natural plant defender' is a phenolic phytohormone found in plants and plays an important role in plant growth and development, photosynthesis, transpiration, ion uptake and transport. At low concentration, it induces formation of female flowers, improves production and enhances plant resistance against diseases thereby increasing shelf life of the produce. Srivastava and Dwivedi (2000) [3], Zgang *et al.* (2003) [4], Shaaban *et al.* (2011) [5] and Ahmed *et al.* (2013) [6] have confirmed the beneficial effects of using salicylic acid on growth and fruiting of different fruit crops.

Silicon (Si) is the eighth most common element in nature and the second most common element found in soil after oxygen. One of the main functions of Si is improving the plants growth and yield especially under stress conditions. In the past few years, efforts have been made towards promoting yield and quality in different mango cultivars by using silicon sources. Silicon can help in improving plant growth by correcting their deficiencies especially in highly weathered soil of tropical regions. It promotes growth, enhances pollination and imparts disease resistance. Kanto (2012) [7], Qin and Tian (2004) [8] and Gad El-Kareem *et al.* (2014) [9] emphasized the importance of using silicon sources in fruit crops.

Realizing the importance of salicylic acid and silica in various physiological processes, it was deemed necessary to study their effect on fruiting in mango cultivar 'Kesar'.

Materials and Methods

The present study was conducted during 2016-17 at the Regional Horticultural Research Station, Navsari Agricultural University, Navsari, Gujarat in a mango orchard of cultivar 'Kesar' planted at a distance of 10m x 10m. The experiment was laid out in Randomized Block Design (RBD) with three replications and ten treatments namely Control, Potassium silicate @ 1ml/L, Potassium silicate @ 2ml/L, Potassium silicate @ 3ml/L, Silicic acid @ 2ml/L, Silicic acid @ 3ml/L, Silicic acid @ 4ml/L, Salicylic acid (1500 ppm), Salicylic acid (2000 ppm) and Salicylic acid (2500 ppm). These treatments were imposed through foliar sprays at pea and marble stage of fruit development on twenty year's old grafted trees of uniform shape and size.

At the pea stage, eight panicles were randomly selected from each direction on every tree and labeled. At the marble stage, numbers of fruits on each labeled panicle were counted. The number of fruits retained on these labeled panicles were once again recorded at harvesting. Fruit drop per panicle was calculated by subtracting the number of fruits at harvest from the number of fruits at marble stage. Fruits retained per panicle at harvesting were estimated using the following formula

$$\text{Fruit retention (\%)} = \frac{\text{No. of fruits at marble stage} - \text{No. of fruits dropped}}{\text{No. of fruits at marble stage}} \text{ x } 100$$

Five fruits from each treatment were drawn randomly to calculate fruit weight (g), fruit length (cm) and fruit breadth (cm). The length and breadth of randomly selected fruits were measured with the help of digital vernier caliper. The number of fruits was computed from each treated tree at the time of harvest. The total produce per tree was weighed (kg/tree) and noted treatment wise for experimental trees. Data was statistically analyzed as per the method suggested by Panse and Sukhatme (1967) [10] for Randomized Block Design (RBD). Treatment means were compared by means of critical differences at 5 per cent level of probability.

Results and Discussion

Statistically analyzed results are described and explained under the following subheads.

Effect on fruit retention

There was a significant influence of silicon and salicylic acid on fruit retention in mango cv. 'Kesar'. In the present investigation, the highest fruit retention (89.83%) was recorded by the application of salicylic acid at 2000 ppm which was at par with salicylic acid at 2500 ppm, potassium silicate@ 3 ml/L, salicylic acid @ 1500 ppm, potassium silicate @ 1 ml/L and silicic acid @ 4 ml/L (Table-1). Nunez-Elisea and Davenport (1986) [11] demonstrated that ethylene production by fruit pericarp was involved in premature fruitlet abscission and that maximum abscission of fruitlets occurred during the first 30 days after fertilization. This offered the opportunity to explore the possibility of enhancing fruit retention by interfering in ethylene production/action with the application of salicylic acid. Like $Co2^{+}$, salicylic acid also inhibits the putative ethylene forming enzyme (EFE) that converts 1- aminocyclopropane -1 –carboxylic acid (ACC) to ethylene (Leslie and Romani, 1986 and 1988) [12, 13]. Therefore, it is highly probable that aqueous spraying of salicylic acid, at the pea and marble stage of fruit development may have interfered with the biosynthesis/action of ethylene, which in turn reduced fruitlet abscission and enhanced fruit retention. Another probable reason for increased fruit retention might be due to better photosynthetic activity (Singh and Usha, 2003) [14] leading to proper supply of carbohydrates to the fruits. Similar finding were also observed by Singh *et al.* (2001) [15], Ngullie *et al.* (2014) [16] and Ahmed *et al.* (2015a) [17] in mango and Ashraf *et al.* (2013) [18] in kinnow, which are in support and agreement with the present study.

Potassium silicate at 4ml/L and 1ml/L and silicic acid at 4ml/L was found best next to salicylic acid with regards of fruit retention. This might be attributed to the essential role of silicon in counteracting the adverse effects of water stress and disorders on growth and fruiting as well as enhancing the tolerance of trees to drought, water transport and root development (Epstein, 1999 and Matichenkov *et al.*, 2000) [19, 20]. This result is in harmony with those obtained by Ahmed *et al.* (2013) [6] and Abd El-Rahman (2015) [21] in mango and Ahmed *et al.* (2015b) [22] in pomegranate.

Effect on fruit yield and its attributes

It is evident from the data presented in Table-2 that fruit weight, number of fruits per tree and yield of mango cv. Kesar were significantly influenced by the application of silicon and salicylic acid. Trees sprayed with salicylic acid at 2000 ppm had the maximum fruit weight (290.17 g), fruit length (12.10 cm) and breadth (8.60 cm). Whereas, foliar spray of salicylic acid at 2500 ppm resulted in the maximum number of fruits per panicle (1.77), number of fruits per tree (419.00) and total yield (120.64 kg/tree). The increase in yield parameters due to salicylic acid observed in the present investigation can be attributed to increased photosynthetic activity in leaves and translocation of more photoassimilates to fruits. Salicylic acid is responsible for increasing yield by increasing fruit set percentage, increase in fruit weight and number of fruits per tree. It also stimulates cell division and the tolerance of plants to all stresses namely diseases, water and salt stresses and protects plant cells from oxidation by free radicals which can explain the above results (Raskin, 1992; Lee *et al.*, 1995 and Shah, 2003) [23,24,25]. These findings are in agreement with the findings of Singh *et al.* (2001) [15], Ngullie *et al.* (2014) [16] and Ahmed *et al.* (2015a) [17] in mango and Ashraf *et al.* (2013) [18] in kinnow.

Potassium silicate @ 2ml/L and silicic acid at all levels (2, 3 and 4 ml/L) registered significantly higher number of fruits per tree, fruit weight and fruit yield per tree. Higher yield under silicon sources can be attributed to increased photosynthetic activity of plant, water metabolism, chlorophyll content, more formation of carbohydrates membrane, lipid peroxidation, and protective enzymes under drought condition and more uptakes of essential nutrients (Yasuto and Eiichi, 1983) [26]. Moreover, silicon might have helped in cell division, more nutrient and water uptake and therefore resulted in the enhancement of fruit physical attributes. The results are in accordance with Abd El-Rahman (2015) [21] and Ahmed *et al.* (2013) [6] in mango and Ahmed *et al.* (2015b) [22] in pomegranate.

Table 1: Effect of silicon and salicylic acid on fruit retention (%) in mango cv. Kesar

Treatments	Fruit retention (%)
T_1: Control	49.02
T_2: Potassium silicate @ 1 ml/l	74.31
T_3: Potassium silicate @ 2 ml/l	71.23
T_4: Potassium silicate @ 3 ml/l	79.34
T_5: Silicic acid @ 2 ml/l	69.49
T_6: Silicic acid @ 3 ml/l	71.45
T_7: Silicic acid @ 4 ml/l	72.41
T_8: Salicylic acid (1500 ppm)	77.88
T_9: Salicylic acid (2000 ppm)	89.83
T_{10}: Salicylic acid (2500 ppm)	83.15
S. Em. ±	6.08
CD at 5%	18.06
CV %	14.26

Table 2: Effect of silicon and salicylic acid on yield attributes in mango cv. Kesar

Treatments	No. of fruits per panicle	No. of fruits per tree	Avg. fruit weight (g)	Fruit length (cm)	Fruit breadth (cm)	Yield (kg/tree)
T_1: Control	0.85	306.67	232.63	9.10	6.24	71.58
T_2: Potassium silicate @ 1 ml/l	1.23	267.17	289.57	11.30	7.47	77.51
T_3: Potassium silicate @ 2 ml/l	1.27	387.50	273.55	11.13	7.13	105.20
T_4: Potassium silicate @ 3 ml/l	1.30	283.00	286.45	11.13	7.23	81.37
T_5: Silicic acid @ 2 ml/l	1.30	374.00	283.60	10.93	7.23	106.50
T_6: Silicic acid @ 3 ml/l	1.30	357.00	285.82	11.07	7.53	101.39
T_7: Silicic acid @ 4 ml/l	1.53	350.50	274.23	10.53	7.37	97.44
T_8: Salicylic acid (1500 ppm)	1.48	383.00	286.53	11.17	7.30	109.77
T_9: Salicylic acid (2000 ppm)	1.65	395.33	290.17	12.10	8.60	115.13
T_{10}: Salicylic acid (2500 ppm)	1.77	419.00	287.73	11.40	7.87	120.64
S. Em. ±	0.07	24.22	10.92	0.41	0.34	8.27
CD at 5%	0.20	71.96	32.46	1.23	1.00	24.56
CV %	8.66	11.91	6.78	6.54	7.91	14.51

Conclusion

Foliar sprays of silicic acid and salicylic acid had a pronounced effect on most of the parameters included in the investigation. Application of salicylic acid at 2000 ppm emerged as the best treatment in all aspects, as it recorded the highest fruit retention (89.83%), fruit weight (290.17 g), fruit length (12.10 cm) and fruit girth (8.60 cm). It was statistically at par with salicylic acid @2500 ppm for number of fruits per tree (395.33) and fruit yield per tree (115.13). Based on this study, it can be summarized that salicylic acid at 2000 ppm was beneficial for improving fruit yield and physical parameters of fruit quality in mango cv. Kesar when sprayed at the pea and marble stage of fruit development under South Gujarat conditions.

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