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Improved fruit quality in papaya cv. Red Lady though foliar sprays of silicon and seaweed extract

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Abstract
An experiment was carried out during 2017-18 at Instructional Farm, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari to investigate the effect of silicon and seaweed extract on fruit quality attributes of papaya cv. Red Lady.The experiment comprising of eleven treatments and three replications was evaluated in a Randomized Block Design. Treatments involved foliar spray of potassium silicate (0.2 and 0.4%), ortho silicic acid (0.2 and 0.4%) and seaweed extract (2 and 4%) either alone or in combination and unsprayed control. Results indicated a significant impact of treatments on all parameters included in the study. Foliar spray of Ortho silicic acid @ 0.2% + Seaweed extract @ 2% recorded the maximum TSS, total sugars, reducing sugars, ascorbic acid and β-carotene content. Whereas, pulp thickness was found maximum by the application of Seaweed extract @ 4%.

Keywords: Papaya, fruit quality, ortho silicic acid, seaweed extract, TSS, total sugars

Introduction
Popular in India for its sweet taste, rich colour and health benefits, papaya (*Carica papaya* L.) is now commercially grown almost throughout the country and all the year round. In historic times, papaya was considered as an exotic fruit because of its buttery taste and appearance. It belongs to family *Caricaceae*, is a native of Tropical America and was introduced to India in the 16th century from Malacca [13]. Major papaya growing states of India are Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh and Tamil Nadu [3]. Of which, Gujarat is the second largest producer contributing about 21% to the total national production. Papaya grown in Gujarat has a huge demand in metropolitan cities like Ahmedabad, Surat, Vadodara, Mumbai and Delhi.

Papaya is an evergreen, herbaceous, rapidly growing, short lived perennial tree with upright growing pattern. Papaya fruit is deliciously sweet with musky undertones and a distinctive pleasant aroma. Immature fruits of papaya are rich source of papain, chymopapain and proteolytic enzymes, which are helpful in digestion of protein and are used for tenderizing meat, preparation of chewing gum, pre shrinking of wool, degumming natural silk and in cosmetics [19]. Red Lady (F_1 Hybrid) is a gynodioecious cultivar, which is famous among farmers due to its orange red colored pulp, high yielding potential, exceptional quality and long shelf life.

Silicon is the second most abundant element after oxygen in our soils and comprises approximately 28% of the earth's crust [7, 8]. It plays an important role in increasing the uptake and transport of nutrients like N, P, K, Ca and Mg, thus increasing the concentration of these nutrients in leaves and fruits thereby resulting in higher yield of superior quality fruits with prolonged storability. Seaweed extract being organic and biodegradable in nature is considered as an important source of nutrition for sustainable agriculture [6]. It has many positive effects on treated plants such as improved crop yield, increased nutrient uptake, resistant to frost and stress conditions, increased postharvest shelf life, increased seed germination and reduced incidence of fungal and insect attack [14]. Therefore, keeping in view the potential benefits of silicon and seaweed extract, it was felt necessary to assess the response of silicon and seaweed extract on quality attributes of papaya cv. Red Lady under South Gujarat conditions.

Materials and Methods
A field experiment to assess the effect of silicon and seaweed extract on quality parameters of papaya cv. Red Lady was carried out during 2017-2018 at Instructional Farm, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat, India.

Treatments were imposed on seven weeks old papaya seedlings of cv. Red Lady Taiwan, planted at a distance of 2 m x 2 m after 3, 4, 5 and 6 months of planting. The experiment comprising of eleven treatments was evaluated in a Randomized Block Design (RBD) and replicated thrice. Treatment details were as under:

T_1: Control
T_2: Potassium silicate 0.2%
T_3: Potassium silicate 0.4%
T_4: Ortho silicic acid 0.2%
T_5: Ortho silicic acid 0.4%
T_6: Seaweed extract 2%
T_7: Seaweed extract 4%
T_8: Potassium silicate 0.2% + Seaweed extract 2%
T_9: Potassium silicate 0.4% + Seaweed extract 4%
T_{10}: Ortho silicic acid 0.2% + Seaweed extract 2%
T_{11}: Ortho silicic acid 0.4% + Seaweed extract 4%

The recommended dose of fertilizer 200:200:250 g NPK/plant/year was applied at 2, 4, 6 and 8 months after planting. Five fruits per treatment from each replication were randomly drawn for analysis of quality parameters. Total Soluble Solids of papaya pulp was measured using a digital refractometer (0-32 ^{0}Brix) at room temperature. The titrimetric method proposed by Lane and Eynon as described by [18] was adopted for estimation of total sugars (%) and reducing sugars (%). The value of non reducing sugars (%) was reached by subtracting the value of reducing sugars from total sugars. Ascorbic acid (mg/100 g) was estimated in accordance to the titrimetric method described by [18]. Fruits were cut into two halves and pulp thickness (cm) was estimated from the mid region. Spectrophotometric method as detailed by [17] was adopted for estimation of beta carotene in which Optical Density (OD) of the solution was measured at 452 nm wavelength in a UV visible spectrophotometer.

Results and Discussion

Silicon and seaweed extract treatments, when applied alone or in combination had a significant influence on all quality attributes of papaya cv. Red Lady Taiwan included in the present investigation, which finds reflection in Table I and II.

A perusal of data presented in Table I indicated that maximum TSS (13.17 and 13.08 ^{0}Brix)was recorded in treatment T_{10} which was at par with treatment T_3 (12.67 and 12.42 ^{0}Brix) and treatment T_9 (12.58 and 12.33 ^{0}Brix) during 2017 and 2018, respectively. Further, the maximum values for total sugar content (10.39 and 10.30%) was noted in treatment T_{10} during both the years, which was at par with T_3 (10.34%), T_9 (10.30%), T_6 (10.06%) during 2017 and with T_3 (10.22%), T_9 (10.22%), T_6 (10.00%) and T_7 (9.98%) during 2018. The reducing sugar content was maximum (8.99 and 8.86%) when plants were subjected to treatment T_{10} and it was at par with treatment T_9 (8.74 and 8.59%) during both the years, respectively. Significantly, the lowest per cent of non reducing sugar (1.33 and 1.37%) was recorded in treatment T_{10} which was on same bar with treatment T_3 (1.40 and 1.44%), T_6(1.46 and 1.52%) and T_9(1.48 and 1.55%) during first and second year of study, respectively.

Silicon promotes the synthesis of sugars in fruits and thus may have helped in increasing TSS [12]. Similar observations were made by [5] in Bangalore Blue grapes with silicon. It may also be related with enzymes which are present in seaweed extract that enhanced the synthesis of different proteins, acids and sugars [11]. Akin results with seaweed extract were reported in crops like date palm [4, 15, 16] and mango [2]. This progressive increase in total and reducing sugars could be related to an increase in Total Soluble Solids content of fruits. Enhanced level of leaf chlorophyll in papaya ultimately resulted in increased rate of photosynthesis and accumulation of carbohydrate reserves. The non-reducing sugar percent and total sugars depend on factors like respiration rate and the conversion of carbohydrates into sugars [10].

Significantly, the maximum ascorbic acid content of fruit (53.33 and 50.50 mg/100g) was recorded in treatment T_{10}, which was statistically at par with T_3 (49.17 mg/100g) during first year and with T_3 (48.50 mg/100g) and T_9 (47.17 mg/100g) during second year of the study. The highestβ – Carotene content (3.72 and 3.66 µg/g) was observed in treatment T_{10} during 2017 and 2018, respectively.Pulp thickness (3.71 and 3.64 cm) was maximum in treatment T_{10} during both the years, which was at par with T_9 (3.54 cm), T_8 (3.52 cm) and T_4 (3.48 cm) during 2017 and with T_9 (3.45 cm) during 2018 (Table II).

The increase in ascorbic acid contents may be ascribed to the combined effect of amino acids and enzymes present in seaweed extract. This may have enhanced the synthesis of different proteins, acids and sugars [11]. Similar results were obtained by [15] in date palm, [1] in mango, [11] in grapes and [2] in mango with seaweed extract. Further, the promotive impact of silicon on plant pigments and the biosynthesis of carbohydrates may have contributed to improved fruit quality [9].

Table 1: Effect of silicon and seaweed extract on TSS, total sugars, reducing sugars and non reducing sugar of papaya fruits cv. Red Lady

Treatments	TSS (^{0}Brix)		Total Sugars (%)		Reducing Sugars (%)		Non Reducing Sugars (%)	
	2017	2018	2017	2018	2017	2018	2017	2018
T_1	11.25	10.92	9.13	9.08	7.04	6.94	1.98	2.04
T_2	11.92	11.58	9.59	9.52	7.77	7.56	1.73	1.86
T_3	12.67	12.42	10.34	10.22	8.86	8.71	1.40	1.44
T_4	12.00	11.75	9.90	9.82	8.09	7.99	1.71	1.74
T_5	11.42	11.08	9.22	9.15	7.14	7.04	1.97	2.00
T_6	12.50	12.25	10.06	10.00	8.52	8.41	1.46	1.52
T_7	12.17	12.00	10.03	9.98	8.34	8.20	1.61	1.69
T_8	11.83	11.33	9.55	9.48	7.62	7.45	1.83	1.93
T_9	12.58	12.33	10.30	10.22	8.74	8.59	1.48	1.55
T_{10}	13.17	13.08	10.39	10.30	8.99	8.86	1.33	1.37
T_{11}	12.08	11.83	10.00	9.92	8.23	8.13	1.68	1.71
S.Em ±	0.20	0.26	0.12	0.11	0.11	0.10	0.08	0.10
CD	0.60	0.78	0.34	0.33	0.33	0.28	0.24	0.29
CV%	2.88	3.86	2.05	2.01	2.42	2.08	8.54	9.87

Table 2: Effect of silicon and seaweed extract on ascorbic acid, β – carotene and pulp thickness of papaya fruits cv. Red Lady

Treatments	Ascorbic acid (mg/100g)		β – Carotene (µg/g)		Pulp thickness (cm)	
	2017	2018	2017	2018	2017	2018
T_1	40.83	40.00	1.84	1.62	2.89	2.95
T_2	45.83	44.33	2.53	2.23	2.92	2.98
T_3	49.17	48.50	3.44	3.39	2.95	3.02
T_4	46.17	44.50	2.72	2.47	3.48	3.18
T_5	43.33	41.83	2.28	2.01	3.11	3.06
T_6	47.50	46.00	3.24	2.94	3.17	3.08
T_7	47.00	45.83	3.17	2.85	3.71	3.64
T_8	44.17	42.67	2.07	1.83	3.52	3.32
T_9	48.33	47.17	3.43	3.04	3.54	3.45
T_{10}	53.33	50.50	3.72	3.66	3.22	3.12
T_{11}	46.67	45.33	2.88	2.61	3.43	3.17
S.Em ±	1.56	1.39	0.07	0.07	0.08	0.06
CD	4.61	4.10	0.21	0.21	0.23	0.19
CV%	5.81	5.33	4.29	4.71	4.22	3.47

Conclusion

The current investigation, highlights the positive effect of ortho silicic acid @ 0.2% + seaweed extract @ 2% when applied as foliar spray at 3, 4, 5 and 6 months after transplanting on fruit quality of papaya cv. Red Lady under South Gujarat conditions.

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