

Original Research Article

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Physiological Changes and Shelf-Life Extension of Papaya (*Carica papaya* L.) cv. Red Lady as Influenced by Pre-Harvest Spray of Plant Elicitors

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ABSTRACT

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To study the effect of pre-harvest spray of plant elicitors at flowering on fruit characters and post-harvest behaviour of papaya, was planned at Horticultural Research station, Anantharajupeta, Railway Kodur, Andhra Pradesh during 2015-16 and 2016-17 with the application of salicylic acid (50 ppm, 100 ppm, 150 ppm), jasmonic acid (50 µM, 100 µM, 150 µM) once at 50 Days After Anthesis and twice at 50 Days After Anthesis and 75 Days After Anthesis and control (no spray). The data revealed that T₉ (SA @ 150 ppm at 50 and 75 DAA) recorded highest fruit weight (1.03 kg), fruit length (17.89 cm), fruit girth (41.34 cm), fruit volume (1.38 liters), cavity length (12.64 cm), cavity width (7.37 cm), weight of the pulp (0.87 kg) and flesh thickness (2.95 cm). T₈ (SA @ 100 ppm at 50 and 75 DAA) and T₇ (SA @ 50 ppm at 50 and 75 DAA) were observed to be on par with T₉ in majority of the cases with respect to these fruit physical characters. The corresponding lowest values in this regard were recorded with T₁₃ (control). The positive influence of T₉ and T₈ was also observed on increased shelf life of papaya fruits (10.5 and 10.17 days respectively). However, the fruits obtained from untreated plants (T₁₃) recorded minimum shelf life (6.17 days). The quality attribute such as T.S.S. showed an increasing trend up to 9 days after storage and decreased further.

Introduction

Papaya (*Carica papaya* L.) belongs to the genus *Carica*, of the family Caricaceae. Among the 48 species of this family, it is the most cultivated species and commonly called

as papaw or paw paw (Australia), mamao (Brazil) and tree melon (China). It is cultivated in the world in an area of 0.44 million ha with production of 12.67 million MT. In India it is grown in an area of 1,36,100 ha and annual production of 6.10

million MT with a productivity of 44.9 t ha⁻¹. Papaya in India is the highest producer occupying 44.4 per cent of world's papaya production. We are exporting of about 12,773 MT of papaya to different countries specially United Arab Emirates, Saudi Arabia, Netherland, Bahrain, Qatar, Omen, Nepal, US and Germany (Indiastat, 2016-17). So, there is need of extending the shelf life period of papaya as it is transported to very distant markets. Jasmonic acid (JA) and Salicylic acid (SA) are two endogenous signalling molecules used in regulation of plant resistance to pathogens and herbivores (Farousk and Osman, 2011). Further, it was reported that SA and JA plays an important role in maintaining the shelf life and improving post-harvest quality of the fruit. Hence, SA and JA were used as preharvest spray to extend the shelflife of papaya. The pattern of fruit development in papaya follows a double sigmoid type of growth curve with definite lag phase. Physiologically papaya is a climacteric fruit with typical respiratory peak and ethylene production patterns during ripening. Among several post-harvest quality problems in papaya, pulp lumpiness (uneven ripening), decay and excessive pulp firmness at the edible stage are some crucial parameters to be taken care of. It is also true that the extremely delicate nature of papaya fruits causes more weight loss and heavy spoilage during transport before it reaches to the consumer.

Salicylic acid is reported to be directly toxic to fungi as it significantly inhibits fungal growth and spore germination of the pathogen *in vitro*. It can delay ripening of fruits, probably through inhibition of ethylene biosynthesis or action.

Besides methyl jasmonate also extends shelf life and reduce microbial contamination of fresh-cut celery and peppers (Buta and Moline, 1998).

Materials and Methods

The experiment was carried out at Horticultural Research Station, Anantharajupeta, Kadapa district, Andhra Pradesh during the period from November, 2015 to October, 2016 and November, 2016 to October, 2017. The experiment was laid out in a randomized block design with thirteen treatments and three replications. The treatments tested were application of salicylic acid @ 50 ppm (T₁), 100 ppm (T₂), 150 ppm (T₃) at 50DAA, jasmonic acid @ 50 µ M (T₄), 100 µ M (T₅), 150 µ M (T₆) at 50DAA, salicylic acid @ 50 ppm (T₇), 100 ppm (T₈), 150 ppm (T₉) at 50 DAA and 75 DAA, jasmonic acid @ 50 µ M (T₁₀), 100 µ M (T₁₁), 150 µ M (T₁₂) at 50 DAA and 75 DAA and control (T₁₃).

Fruits were harvested from tagged treatmental plants which were sprayed with different concentration of salicylic acid and jasmonic acid at 50 and 75 DAA. This experiment was carried out with full mature green papaya fruits collected from each treatment separately. The fruits were separated into healthy marketable fruits, disease fruits and unmarketable fruits. Experimental material was selected randomly from the lot of healthy marketable fruits. But, Fruit characters studied by taking averages of the randomly selected plants. Fruits were harvested at colour break stage when green colour changed to light green with slight yellowish tinge at blossom end. Observations on the physico-chemical characteristics were recorded for every 3 days after harvesting of fruits. These fruits were kept for storage at ambient temperatures.

Results and Discussion

The fruit characters such as Fruit weight (kg), Fruit length (cm), Fruit girth (cm) and Fruit volume (Litre) were presented in Table 1.

Fruit weight (kg)

In pooled mean data the maximum fruit weight (1.03 kg) was noticed in T₉ (SA @ 150 ppm at 50 and 75 DAA) and it was on a par with T₈ (1.00 kg).

Fruit length (cm)

During second year and pooled mean data, the maximum fruit length was observed in T₉ (SA @ 150 ppm at 50 and 75 DAA) (17.67 and 17.89 cm respectively), which was statistically on a par with T₈ (17.33 and 17.60 cm respectively).

Fruit girth (cm)

Highest fruit girth (41.34 cm) was recorded in T₈ (SA @ 100 ppm at 50 and 75 DAA) than all other treatments except T₉ (41.23 cm), T₇ (39.48 cm) and T₁₀ (39.17 cm) which were at par with T₈ in pooled data.

Fruit volume (L)

The data from both the years and its pooled mean revealed that, application of T₉ (SA @ 150 ppm at 50 and 75 DAA) recorded maximum fruit volume (1.45, 1.31 and 1.38 litre respectively), which was comparable with that of T₈ (1.31, 1.26 and 1.28 litre respectively) and T₇ (1.34, 1.22 and 1.28 litre respectively).

Cavity length (cm)

Highest cavity length (12.64 cm) in T₉ (SA @ 150 ppm at 50 and 75 DAA) which was at par with T₈ (12.43 cm) was observed in pooled data (Table 2).

Cavity width (cm)

Regarding pooled data, highest cavity width was observed in T₈ (SA @ 100 ppm at 50 and

75 DAA) (7.37 cm) and it was on par with T₉ (7.31 cm), T₇ (7.17 cm) and T₁₀ (7.14 cm) (Table 2).

Cavity index (%)

In pooled mean data, pre harvest spray of salicylic acid @ 150 ppm at 50 and 75 DAA) (T₉), T₈ and T₇ recorded minimum percentage of cavity index (19.11, 19.30 and 19.61% respectively) in papaya fruit and found at a par (Table 2).

Weight of pulp (kg)

Maximum pulp weight (0.87 kg) was observed in T₉ (SA @ 150 ppm at 50 and 75 DAA), and it was statistically at a par with T₈ (0.85 kg) and T₇ (0.84 kg) in pooled data (Table 3).

Flesh thickness (cm) (pulp thickness)

In second year of study, T₉ (2.76 cm), T₈ (2.67 cm) and T₇ (2.64 cm) recorded significantly maximum pulp thickness and all are comparable with each other. Moreover, in pooled mean also almost the same trend was observed (Table 3).

In the present study foliar application of salicylic acid at increased concentrations at 50 and 75 DAA showed a positive effect in increasing fruit weight, fruit length, fruit volume, fruit girth, cavity length, cavity width and reduction in cavity index.

The increased fruit weight in present study by application of salicylic acid might be due to Salicylic acid enhances the biosynthesis of natural hormones, carbohydrates and stimulates cell division, enhances tolerance of plants to all stresses namely diseases, salt and water stresses and also protects plant cells from oxidation by production of free radicals (Raskin, 1992).

Table.1 Effect of pre-harvest spray of salicylic acid and Jasmonic acid on fruit characters in papaya

| Treatments | Fruit characters | | | | | | | | | | | |
|--|-------------------|--------------------|----------------|-------------------|--------------------|----------------|-------------------|--------------------|----------------|----------------------|--------------------|----------------|
| | Fruit weight (kg) | | | Fruit length (cm) | | | Fruit girth (cm) | | | Fruit volume (Litre) | | |
| | I year 2015-16 | II year 2016-17 | Pooled data | I year 2015-16 | II year 2016-17 | Pooled data | I year 2015-16 | II year 2016-17 | Pooled data | I year 2015-16 | II year 2016-17 | Pooled data |
| T₁ : Salicylic acid @ 50 ppm at 50 DAA | 0.83 | 0.87 | 0.85 | 16.33 | 16.73 | 16.53 | 36.51 | 37.48 | 36.99 | 1.10 | 1.13 | 1.12 |
| T₂ : Salicylic acid @ 100 ppm at 50 DAA | 0.84 | 0.89 | 0.86 | 17.48 | 16.63 | 17.06 | 36.85 | 37.71 | 37.28 | 1.13 | 1.14 | 1.13 |
| T₃ : Salicylic acid @ 150 ppm at 50 DAA | 0.97 | 0.91 | 0.94 | 17.57 | 16.90 | 17.23 | 39.74 | 38.09 | 38.91 | 1.28 | 1.19 | 1.23 |
| T₄ : Jasmonic acid @ 50 µ M at 50 DAA | 0.83 | 0.84 | 0.84 | 17.47 | 16.52 | 16.99 | 37.27 | 35.19 | 36.23 | 1.08 | 1.15 | 1.12 |
| T₅ : Jasmonic acid @ 100 µ M at 50 DAA | 0.90 | 0.86 | 0.88 | 16.80 | 16.81 | 16.81 | 37.76 | 37.53 | 37.65 | 1.18 | 1.13 | 1.15 |
| T₆ : Jasmonic acid @ 150 µ M at 50 DAA | 0.81 | 0.85 | 0.83 | 15.96 | 16.69 | 16.33 | 34.13 | 36.59 | 35.36 | 0.99 | 1.06 | 1.02 |
| T₇ : Salicylic acid @ 50 ppm at 50 DAA and 75 DAA | 0.99 | 0.96 | 0.97 | 17.65 | 17.19 | 17.42 | 39.36 | 39.61 | 39.48 | 1.34 | 1.22 | 1.28 |
| T₈ : Salicylic acid @ 100 ppm at 50 DAA and 75 DAA | 1.01 | 0.98 | 1.00 | 17.88 | 17.33 | 17.60 | 42.25 | 40.43 | 41.34 | 1.31 | 1.26 | 1.28 |
| T₉ : Salicylic acid @ 150 ppm at 50 DAA and 75 DAA | 1.05 | 1.01 | 1.03 | 18.10 | 17.67 | 17.89 | 41.35 | 41.11 | 41.23 | 1.45 | 1.31 | 1.38 |
| T₁₀ : Jasmonic acid @ 50 µ M at 50 DAA and 75 DAA | 0.91 | 0.90 | 0.90 | 17.64 | 16.94 | 17.29 | 39.23 | 39.12 | 39.17 | 1.20 | 1.15 | 1.17 |
| T₁₁ : Jasmonic acid @ 100 µ M at 50 DAA and 75 DAA | 0.92 | 0.87 | 0.90 | 17.35 | 17.00 | 17.17 | 37.83 | 38.01 | 37.92 | 1.10 | 1.10 | 1.10 |
| T₁₂ : Jasmonic acid @ 150 µ M at 50 DAA and 75 DAA | 0.89 | 0.88 | 0.88 | 16.62 | 16.85 | 16.74 | 38.72 | 37.56 | 38.14 | 1.15 | 1.13 | 1.14 |
| T₁₃ : Control | 0.78 | 0.81 | 0.80 | 15.78 | 16.11 | 15.95 | 33.96 | 34.59 | 34.27 | 0.87 | 0.97 | 0.92 |
| S.Em. ± | 0.02 | 0.02 | 0.01 | 0.16 | 0.16 | 0.11 | 1.37 | 1.07 | 0.92 | 0.08 | 0.04 | 0.04 |
| C.D. at 5% | 0.06 | 0.05 | 0.03 | 0.48 | 0.47 | 0.31 | 4.01 | 3.12 | 2.68 | 0.22 | 0.12 | 0.12 |

DAA: Days after anthesis

Table.2 Effect of salicylic acid and jasmonic acid on cavity parameters of papaya

| Treatments | Cavity length (cm) | | | Cavity width (cm) | | | Cavity index (%) | | |
|--|--------------------|--------------------|----------------|-------------------|--------------------|----------------|-------------------|--------------------|----------------|
| | I year 2015-16 | II year 2016-17 | Pooled data | I year 2015-16 | II year 2016-17 | Pooled data | I year 2015-16 | II year 2016-17 | Pooled data |
| T₁ : Salicylic acid @ 50 ppm B.I. | 11.50 | 11.78 | 11.64 | 6.76 | 6.73 | 6.75 | 26.44 | 25.38 | 25.91 |
| T₂ : Salicylic acid @ 100 ppm B.I. | 11.90 | 11.89 | 11.90 | 6.19 | 6.65 | 6.42 | 25.71 | 24.88 | 25.30 |
| T₃ : Salicylic acid @ 150 ppm B.I. | 11.95 | 11.66 | 11.80 | 6.88 | 7.00 | 6.94 | 20.76 | 22.94 | 21.85 |
| T₄ : Jasmonic acid @ 50 µM B.I. | 11.95 | 12.00 | 11.98 | 6.85 | 6.89 | 6.87 | 27.39 | 24.52 | 25.96 |
| T₅ : Jasmonic acid @ 100 µM B.I. | 11.73 | 12.09 | 11.91 | 6.27 | 6.26 | 6.27 | 23.01 | 24.37 | 23.69 |
| T₆ : Jasmonic acid @ 150 µM B.I. | 11.25 | 11.58 | 11.41 | 6.41 | 6.77 | 6.59 | 26.51 | 26.53 | 26.52 |
| T₇ : Salicylic acid @ 50 ppm A.I. | 11.90 | 11.92 | 11.91 | 7.43 | 6.90 | 7.17 | 18.83 | 20.39 | 19.61 |
| T₈ : Salicylic acid @ 100 ppm A.I. | 12.65 | 12.21 | 12.43 | 7.52 | 7.22 | 7.37 | 19.23 | 19.37 | 19.30 |
| T₉ : Salicylic acid @ 150 ppm A.I. | 12.80 | 12.49 | 12.64 | 7.48 | 7.15 | 7.31 | 18.69 | 19.53 | 19.11 |
| T₁₀ : Jasmonic acid @ 50 µM A.I. | 12.39 | 12.03 | 12.21 | 7.16 | 7.12 | 7.14 | 22.51 | 24.54 | 23.53 |
| T₁₁ : Jasmonic acid @ 100 µM A.I. | 11.96 | 11.97 | 11.97 | 6.54 | 6.39 | 6.47 | 25.95 | 26.49 | 26.22 |
| T₁₂ : Jasmonic acid @ 150 µM A.I. | 11.82 | 12.11 | 11.96 | 6.53 | 6.31 | 6.42 | 24.71 | 25.94 | 25.33 |
| T₁₃ : Control | 11.05 | 11.28 | 11.17 | 5.92 | 6.62 | 6.27 | 29.53 | 27.39 | 28.46 |
| S.Em. ± | 0.14 | 0.11 | 0.10 | 0.16 | 0.09 | 0.09 | 0.63 | 0.66 | 0.43 |
| C.D. at 5% | 0.41 | 0.32 | 0.28 | 0.45 | 0.27 | 0.27 | 1.85 | 1.93 | 1.26 |

B.I. :Before inoculation; A.I. : After inoculation; DAI : Days after inoculation

Table.3 Effect of pre-harvest spray of salicylic acid and jasmonic acid on weight of pulp (kg) and flesh thickness (cm) in papaya

| Treatments | Weight of pulp (kg) | | | Flesh thickness (cm) | | |
|--|---------------------|--------------------|----------------|----------------------|--------------------|----------------|
| | I year 2015-16 | II year 2016-17 | Pooled data | I year 2015-16 | II year 2016-17 | Pooled data |
| T₁ : Salicylic acid @ 50 ppm at 50 DAA | 0.72 | 0.76 | 0.74 | 2.10 | 2.26 | 2.18 |
| T₂ : Salicylic acid @ 100 ppm at 50 DAA | 0.71 | 0.75 | 0.73 | 1.97 | 2.51 | 2.24 |
| T₃ : Salicylic acid @ 150 ppm at 50 DAA | 0.82 | 0.76 | 0.79 | 2.28 | 2.56 | 2.42 |
| T₄ : Jasmonic acid @ 50 µ M at 50 DAA | 0.69 | 0.69 | 0.69 | 2.33 | 2.36 | 2.34 |
| T₅ : Jasmonic acid @ 100 µ M at 50 DAA | 0.76 | 0.72 | 0.74 | 2.54 | 2.50 | 2.52 |
| T₆ : Jasmonic acid @ 150 µ M at 50 DAA | 0.69 | 0.71 | 0.70 | 2.08 | 2.34 | 2.21 |
| T₇ : Salicylic acid @ 50 ppm at 50 DAA and 75 DAA | 0.86 | 0.83 | 0.84 | 2.73 | 2.64 | 2.69 |
| T₈ : Salicylic acid @ 100 ppm at 50 DAA and 75 DAA | 0.86 | 0.84 | 0.85 | 2.72 | 2.67 | 2.69 |
| T₉ : Salicylic acid @ 150 ppm at 50 DAA and 75 DAA | 0.89 | 0.84 | 0.87 | 3.15 | 2.76 | 2.95 |
| T₁₀: Jasmonic acid @ 50 µ M at 50 DAA and 75 DAA | 0.79 | 0.79 | 0.79 | 2.66 | 2.52 | 2.59 |
| T₁₁: Jasmonic acid @ 100 µ M at 50 DAA and 75 DAA | 0.77 | 0.73 | 0.75 | 1.92 | 2.33 | 2.13 |
| T₁₂: Jasmonic acid @ 150 µ M at 50 DAA and 75 DAA | 0.76 | 0.72 | 0.74 | 2.11 | 2.36 | 2.23 |
| T₁₃: Control | 0.64 | 0.67 | 0.66 | 1.83 | 2.21 | 2.02 |
| S.Em. ± | 0.02 | 0.02 | 0.01 | 0.19 | 0.05 | 0.09 |
| C.D. at 5% | 0.06 | 0.06 | 0.04 | 0.54 | 0.15 | 0.27 |

DAA: Days after anthesis

Table.4 Effect of pre-harvest spray of salicylic acid and jasmonic acid on shelf life (Days) in papaya

| Treatments | I year 2015-16 | II year 2016-17 | Pooled data |
|--|-------------------|--------------------|----------------|
| T₁ : Salicylic acid @ 50 ppm at 50 DAA | 8.33 | 8.00 | 8.17 |
| T₂ : Salicylic acid @ 100 ppm at 50 DAA | 8.00 | 8.00 | 8.00 |
| T₃ : Salicylic acid @ 150 ppm at 50 DAA | 8.67 | 8.67 | 8.67 |
| T₄ : Jasmonic acid @ 50 µ M at 50 DAA | 7.00 | 7.33 | 7.17 |
| T₅ : Jasmonic acid @ 100 µ M at 50 DAA | 7.33 | 7.67 | 7.50 |
| T₆ : Jasmonic acid @ 150 µ M at 50 DAA | 7.67 | 7.67 | 7.67 |
| T₇ : Salicylic acid @ 50 ppm at 50 DAA and 75 DAA | 9.00 | 9.33 | 9.17 |
| T₈ : Salicylic acid @ 100 ppm at 50 DAA and 75 DAA | 10.00 | 10.33 | 10.17 |
| T₉ : Salicylic acid @ 150 ppm at 50 DAA and 75 DAA | 10.33 | 10.67 | 10.50 |
| T₁₀: Jasmonic acid @ 50 µ M at 50 DAA and 75 DAA | 8.33 | 8.33 | 8.33 |
| T₁₁: Jasmonic acid @ 100 µ M at 50 DAA and 75 DAA | 8.67 | 9.00 | 8.83 |
| T₁₂: Jasmonic acid @ 150 µ M at 50 DAA and 75 DAA | 9.33 | 9.33 | 9.33 |
| T₁₃: Control | 6.00 | 6.33 | 6.17 |
| S.Em. ± | 0.27 | 0.35 | 0.24 |
| C.D. at 5% | 0.79 | 1.01 | 0.70 |

DAA: Days after anthesis

Table.5 Effect of pre-harvest spray of salicylic acid and jasmonic acid on total soluble solids (⁰ Brix) in papaya

| Treatments | Days after harvest | | | | | | | | | | | |
|--|--------------------|-----------------|-------------|-----------------|-----------------|-------------|-----------------|-----------------|-------------|------------------|-----------------|-------------|
| | 3 rd | | | 6 th | | | 9 th | | | 12 th | | |
| | I year 2015-16 | II year 2016-17 | Pooled data | I year 2015-16 | II year 2016-17 | Pooled data | I year 2015-16 | II year 2016-17 | Pooled data | I year 2015-16 | II year 2016-17 | Pooled data |
| T₁ : Salicylic acid @ 50 ppm at 50 DAA | 8.80 | 8.40 | 8.60 | 9.60 | 9.40 | 9.50 | 11.70 | 11.50 | 11.60 | 9.80 | 9.60 | 9.70 |
| T₂ : Salicylic acid @ 100 ppm at 50 DAA | 8.50 | 8.20 | 8.35 | 9.60 | 9.30 | 9.45 | 11.90 | 11.60 | 11.75 | 10.40 | 10.10 | 10.25 |
| T₃ : Salicylic acid @ 150 ppm at 50 DAA | 8.30 | 7.90 | 8.10 | 9.80 | 9.40 | 9.60 | 11.40 | 11.00 | 11.20 | 9.90 | 9.70 | 9.80 |
| T₄ : Jasmonic acid @ 50 μ M at 50 DAA | 8.30 | 8.10 | 8.20 | 9.67 | 9.93 | 9.80 | 11.93 | 11.77 | 11.85 | 10.17 | 10.33 | 10.25 |
| T₅ : Jasmonic acid @ 100 μ M at 50 DAA | 8.20 | 8.10 | 8.15 | 9.50 | 9.30 | 9.40 | 11.40 | 11.00 | 11.20 | 10.00 | 9.60 | 9.80 |
| T₆ : Jasmonic acid @ 150 μ M at 50 DAA | 8.10 | 7.90 | 8.00 | 9.80 | 9.50 | 9.65 | 11.90 | 11.70 | 11.80 | 10.30 | 10.10 | 10.20 |
| T₇ : Salicylic acid @ 50 ppm at 50 DAA and 75 DAA | 8.80 | 8.50 | 8.65 | 10.80 | 10.40 | 10.60 | 12.40 | 12.10 | 12.25 | 10.70 | 10.30 | 10.50 |
| T₈ : Salicylic acid @ 100 ppm at 50 DAA and 75 DAA | 9.00 | 8.80 | 8.90 | 10.70 | 10.40 | 10.55 | 12.50 | 12.10 | 12.30 | 10.80 | 10.63 | 10.72 |
| T₉ : Salicylic acid @ 150 ppm at 50 DAA and 75 DAA | 9.00 | 8.70 | 8.85 | 11.00 | 10.60 | 10.80 | 12.70 | 12.50 | 12.60 | 11.00 | 11.00 | 11.00 |
| T₁₀ : Jasmonic acid @ 50 μ M at 50 DAA and 75 DAA | 8.50 | 8.10 | 8.30 | 10.50 | 10.30 | 10.40 | 12.00 | 11.80 | 11.90 | 10.30 | 10.10 | 10.20 |
| T₁₁ : Jasmonic acid @ 100 μ M at 50 DAA and 75 DAA | 8.40 | 8.20 | 8.30 | 10.10 | 10.00 | 10.05 | 11.80 | 11.50 | 11.65 | 10.20 | 10.10 | 10.15 |
| T₁₂ : Jasmonic acid @ 150 μ M at 50 DAA and 75 DAA | 8.30 | 8.10 | 8.20 | 10.30 | 10.10 | 10.20 | 12.00 | 11.60 | 11.80 | 10.30 | 10.10 | 10.20 |
| T₁₃ : Control | 10.30 | 10.00 | 10.15 | 11.60 | 11.20 | 11.40 | 10.80 | 10.47 | 10.63 | 9.27 | 9.30 | 9.28 |
| S.Em. ± | 0.15 | 0.17 | 0.13 | 0.1792 | 0.20 | 0.14 | 0.20 | 0.17 | 0.14 | 0.15 | 0.17 | 0.11 |
| C.D. at 5% | 0.43 | 0.48 | 0.37 | 0.5231 | 0.59 | 0.41 | 0.57 | 0.50 | 0.42 | 0.44 | 0.51 | 0.32 |

DAA: Days after anthesis

Salicylic acid also increases potassium content (Farouk *et al.*, 2008) in plant which is useful for maintenance of water flow through stomata, and SA might have increased the number of chloroplasts per cell, number of cells per leaf and consequently more leaf area (Possingham, 1980) which leads to enhanced the efficacy of photosynthetic apparatus with a more potential for resistance against the diseases (Amaresh and Bhatt, 1998). These accumulation of photosynthetic assimilates might have enabled the shoot to meet the nutrient requirement of fruits throughout their development.

A similar increase in the fruit physical parameters by application of salicylic acid was also noticed by Faissal *et al.*, (2014) in keitte mango, Ahmed *et al.*, (2015) in sukkary mango and Gioushy (2016) in Washington navel orange.

Shelf life (days)

The shelf life recorded in both years and in its pooled mean revealed that highest shelf life of papaya fruits (10.33, 10.67 and 10.50) was recorded in treatment T₉ (SA @ 150 ppm at 50 and 75 DAA) which was at a par with T₈ (SA @ 100 ppm at 50 and 75 DAA) (10.00, 10.33 and 10.17). However, control (T₁₃) recorded minimum shelf life (6.00, 6.33 and 6.17) (Table 4).

The increase in shelf life due to salicylic acid application might be attributed to its role in suppression in respiration and reduction in transpiration rates of papaya fruits by closing the stomata of treated fruits, which otherwise could lead to increased weight loss. Moreover, application of salicylic acid enhanced firmness of fruits (Srivastava and Dwivedi, 2000) by suppressing the activity of cell wall degrading enzyme like pectinmethyl esterase, cellulase, polygalactronase, xylanase, and β -1-3 glucanase (Ali *et al.*, 2004).

Production of ethylene was delayed by interference of Salicylic acid (Raskin, 1992) thereby increased the shelf life. Such delay in ethylene production might be associated with the decreased 1-Aminocyclopropane-1-Carboxylic Acid (ACC) synthase and or ACC oxidase activity as reported in Banana (Srivastava and Dwivedi, 2000).

Total soluble solids (°Brix)

A gradual increase in T.S.S (°Brix) during the storage period was observed in all the treatments upto 9th day of storage it was decreased later on. However, in control (T₁₃) higher TSS was recorded at 6 days after storage and showed a declining trend later on. This could be due to the faster ripening process in control which was regulated by the application of salicylic acid and jasmonic acid. On 12th day of storage highest TSS was (11.00 °Brix) was observed in the treatment T₉ which was at a par with T₈ (10.72 °Brix). At 9th day after storage even the jasmonic acid applied at different concentrations improved the total soluble solids of the fruits compared to control (Table 5).

The increase of TSS by salicylic acid might be due to regulation of plant growth by enhancing the “Rubisco” activity and also enhanced the sugar translocation from leaves to the developing fruit by improving the α -amylase activity by salicylic acid (Sharma *et al.*, 1986). The hydrolysis of sucrose by invertase regulates by the levels of some plant hormones like IAA, salicylic acid and jasmonic acid (Leclere *et al.*, 2003).

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