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RESEARCHARTICLE

Pre-harvest spray of salicylic acid to improve the quality and shelf life of ber fruit *(Ziziphus mauritiana)*

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ABSTRACT

Ber (*Ziziphus mauritiana*) is popular fruit among the poor community of Indo-Pak subcontinent. Vitamin A, B, C and essential minerals are major constituents of ber pulp. Pre-harvest drop and poor fruit quality are major problems of this fruit. Pre-harvest spray of salicylic acid (SA) directly or indirectly affects the oxidative metabolism and preserves the nutritional value of fruit during storage, following higher capacity to hold up oxidative injury. It also decreases the disease and pathogen attack. Therefore, an experiment was designed to find out the effect of foliar spray of SA on Ber. Two foliar sprays of Salicylic acid with different concentrations (1, 2 and 3 mM) were applied 30 and 15 days before harvesting. Plants sprayed with 1mM SA recorded higher fruit yield. Minimum fruit drop of 37.48% was noted in fruits of T1 (1 mM salicylic acid). Fruit length, diameter, color and weight were significantly higher in plants treated with 1mM SA as compared to non-treated ones. The highest TSS (9.57 °Brix), acidity (0.16%) Vitamin C (57.66 mg/100g) and total phenolics (263.93 mg GAE/100g), while, minimum seed weight of 0.78 g was observed in fruits of T3 (3 mM SA). Furthermore, the total sugars, reducing sugars and non-reducing sugars were significantly more in the treated fruits in comparison to untreated fruits. Hence, it is concluded that salicylic acid (1 mM) is effective to improve the quality of ber fruits (*Ziziphus mauritiana*).

Keywords: Ber, salicylic acid, pre-harvest spray, fruit quality, postharvest, shelf life.

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INTRODUCTION

Ber (*Ziziphus mauritiana*) belongs to the family Rhamnaceae has 45 generas and 550 species, that is widely distributed in the tropical and subtropical regions of the wold (Mukhtar et al., 2004). It is a drought tolerant tree, originated in central Asia (Mortan, 1987) and commonly known as “poor man apple”. Its fruit is palatable and delicious with high contents of essential minerals, iron and calcium, Vit A, B and C and generally consumed fresh as well as in dry form (Pareek, 2002, Mukhtar et al., 2004). On the other hand, flavonoids, alkaloids, tannins, sterols, saponin and fatty acids have been secluded and chemically recognized from different species of the genus Ziziphus (Croueour et al. 2002; Abdel-Zaher et al. 2005; Bhargava et al. 2005; Zhao et al. 2006). In Pakistan ber is cultivated over an area of 5266 ha with production is about 25309 tons. Sindh is the largest Ber producing province in Pakistan (Anon., 2013-14). Ber is never grown commercially by farmers because of its

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excessive pre harvest fruit drop, poor fruit quality and extremely short shelf life that reduce the income of farmers. Moreover, there are many factors that reduce fruit quality and the most important are improper nutrient management and biotic and abiotic stress.

Salicylic acid (SA) placed in group of phenolic compounds which is present in plants and now believed as plant hormone (Raskin, 1992a). It also regulates the various physiological processes and growth of the plant (Raskin, 1992a and 1992b). SA activates the defense-related genes in plant (Loake and Grant, 2007) biosynthesis of nutritional components and prevents degradation of carotenoids (lycopene, α-carotene). SA also enhance the physical properties of fruits such as weight (Elwan and El-Hamahmy 2009), size (Marzouk and Kassem 2011) and firmness ((Srivastava and Dwivedi 2000; Zhang et al. 2003; Shafiee et al. 2010). They regulates stomatal conductivity (Hayat *et al.*, 2010), plant growth (Khan *et al.*, 2003), photosynthesis (Fariduddin *et al.*, 2003), disease resistance (Janda *et al.*, 2007), seed germination (Babalar *et al.*, 2007; Loïc et al., 2006), improving productivity and quality (Elwan and El- Hamahmy, 2009), protein synthesis (Hao et al., 2012), nutrient uptake and vegetative growth (Shakirova and Sakhabutdinova, 2003), chlorophyll synthesis and photosynthesis (Zhao et al., 1995) and protect plant from abiotic stress and salinity (Hayat et al., 2008).

Pre-harvest spray of SA directly or indirectly changes the oxidative metabolism and preserves the nutritional value of fruit during storage, following higher capacity to hold up oxidative injury. Previously it has been shown that SA before harvesting decreases the disease and pathogen attack in cherry and pear (Yao and Tian 2005; Jiankang et al., 2006). In melon fruits before harvest treatment of SA restrict the contamination of postharvest fungal diseases (Huang et al., 2000). Foliar spray of SA before harvesting of citrus improves resistance against chilling injury, biotic and abiotic stress. (Dat et al., 1998; Kang et al., 2003; Chan and Tian, 2006). Srivastava and Dwivedi (2000) found that SA treatment decreases the increase in pulp to peel ratio leading to delay in banana fruit ripening. The result demonstrated that the invertase activity is associated with decline in non-reducing sugar content. The level of non-reducing sugars is decreased and reducing sugars is increased during senescence and ripening. In tomatoes pre-treatment of SA provide defense against salinity because by applying SA maximized the activity of enzymes and increased the sugar and proline (Tari et al., 2004). The anthracnose disease considerably decreased when sprayed with SA @100 mg L^{-1} on mango inflorescence. There was no inhibitory effect of salicylic acid on colony growth and spore germination. It is concluded that salicylic acid has induced the resistance against the *Colletotrichum gleosporoides* in mango fruits (Jianliang et al., 2003). SA prolongs the flowering duration; enhance the fruit setting percentage and fruit yield in strawberry (Tawseef Rehman Baba et al., 2017).

Researchers reported that SA can increase the physical properties of fruits such weight (Elwan and El-Hamahmy 2009), size (Marzouk and Kassem 2011) and firmness (Srivastava and Dwivedi 2000; Zhang et al. 2003; Shafiee et al. 2010). Additionally SA was found to speed up the maturity of both non climacteric and climacteric fruits like tomato (Mady 2009; Yıldırım and Dursun 2009) and strawberry (Karlidag et al., 2009). Keeping in mind the importance of SA current study was planned to improve the quality and shelf life of ber fruit by pre-harvest exogenous spray of different concentrations of salicylic acid.

MATERIAL AND METHODS

This investigation was carried out during 2015 and 2016 seasons to study the pre-harvest spray of salicylic acid on physical and chemical properties of ber fruit cultivar Gola, at the Experimental Fruit Orchard Square No. 32 Institute of Horticultural Sciences, University of Agriculture, Faisalabad. There were total twelve numbers of plants and the height of these plants was managed by adopting the canopy management at 4 feet. Then these plants were sprayed with different concentration of salicylic acid 2 times after 15 days interval. Then fruits were harvested from the plants of each replication in a treatment. Fruits

were washed with tap water and fruit analysis were carried out and compared with controlled treatment. The experiment was conducted under RCBD arrangement with three replications. Pre-harvest treatments are as follows;

T_0: control (sprayed with water)
T_1: 1 mM SA
T_3: 2 mM SA
T_4: 3 mM SA

The fruits was harvested and sorted according to size and color for the data recording. Fruit yield/plant in Kg was calculated by multiplying total number of fruits by average fruit weight. Physical parameters like fruit weight and seed weight was recorded by digital weighing balance. Fruit length and diameter was measured by vernier caliper and means was calculated. Fruit color was calibrated by the color chat of ber fruits. Shelf life was calculated by keeping the fruits at room temperature (25±3 °C) and counting the number of days they remain fresh and in edible state.

Total soluble solids (TSS) of extracted juice were measured by a digital refractometer (ATAGO. RS-5000, Atago. Japan) and results were expressed in ^{o}Brix. For titratable acidity 10 ml of extracted was diluted with 50ml of distil water in 100 ml flask. Then extracted juice were titrated against 0.1 N sodium hydroxide (NaOH) using 2-3 drops of phenolphthalein as an indicator. Titratable acidity was determined as a percentage of citric acid by this formula:

$$TA\ (\%) = [(V \times N \times meq)/Y] \times 100$$

Where V= volume of sodium hydroxide used ml,
N =sodium hydroxide normality,
meq = 0.064,
Y = volume of bulk fruit juice ml.

TSS/TA ratio was calculated by dividing the TSS value with their respective TA and expresses as TSS/TA ratio (Nasir et al., 2016). Vitamin C content of fruits was measured by using titrimetric method with the titration of filterate against 2,6-dichlorophenol indophenol and vitamin C results were expressed in mg/100 g (Pila et al., 2010). Sugars in juice were determined by following the Lane and Eynon (1923) method described by Hortwits (1960). Total phenolic content was measured by the procedure outlined by Nasir et al. (2016) and expressed as mg GAE/100 g.

Statistical analysis

The experiment was carried out under Randomized Complete Block Design (RCBD). The data recorded were analyzed using Analysis of variance techniques with the help of computer run statistical program 8.1 and the Least Significant Difference (LSD) test ($P \leq 0.05$) was used to compare the differences among treatment means (Steel et al., 1997).

RESULTS

Yield and physical fruit quality

The data on fruit yield, fruit drop, weight, length, diameter, seed weight and shelf life were presented in table 1. The results indicated that salicylic acid caused a significant ($p \leq 0.05$) improvement in yield and physical fruit quality of Ber (Table 1). The fruit yield/plant was increased to its maximum level 200.33 kg/plant after foliar spray of 1mM Salicylic acid followed by 3 mM SA (Table 1).

Table 1: Effect of pre harvest spray of salicylic acid on yield, physical fruit quality and shelf life of ber cv. Gola

Treatments	Fruit yield (kg/plant)	Fruit drop (%)	Color chart	Fruit weight (g)	Fruit length (cm)	fruit diameter (cm)	Seed weight (g)	Shelf life (No. of days)
Control	123d	67.46a	3.67d	12.97d	2.35b	1.27b	1.16a	3.00b
1mM SA	200.33a	37.48c	7.67a	25.76a	2.84a	1.75a	1.15a	4.00b
2mM SA	146.67c	51.48b	6.33b	21.72b	2.60ab	1.64a	0.95b	4.33ab
3mM SA	168.67b	44.84bc	5.33c	18.76c	1.82c	0.93c	0.78c	5.67a
LSD (*P* ≥0.05)	**3.16**	**7.95**	**0.8810**	**6.45**	**9.29**	**5.19**	**2.98**	**16.17**

NS represents not significant. Means within a column followed by the same letter are not significant at $P \leq 0.05$.

Fruit drop was significantly reduced after foliar application of SA (Table 1). 1mM SA significantly decreases the fruit drop up to 37.48%. After that 3mM SA decreases the fruit drop upto 44.84%. Similarly, fruits treated with 1mM SA shows maximum scales rating for fruit color which is 7.67 followed by 2mM SA having 6.33 rating.

Fruits treated with 1mM SA showed maximum fruit weight of 25.76 g and minimum was observed in control, where the fruit weight was 12.97 g. Furthermore, 1mM SA significantly increased the fruit length and diameter (2.84cm and 1.75cm, respectively) of Ber fruits which eventually increased the size of the fruit (Table 1). Minimum seed weight of 0.93g was observed in fruits treated with 3mM SA, on the other hand 1mM SA shows average seed weight of 1.15g.

Shelf life

Shelf life of fruits was significantly improved after pre-harvest application of SA on Ber (Table 1). The shelf life of Ber fruits ranged from 2-6 days at room temperature (Table 1). The highest shelf life was observed in 3mM SA (6 days) and the lowest was in control (3 days), while the shelf life of rest of the concentrations was almost 4 days (Table 1) .

Bio-chemical fruit quality

Significant influence on total soluble solids content of fruits was observed among the concentrations (Table 2). The fruits treated with 1mM SA were found to be superior (9.67%) among other concentrations followed by the 2mM SA (8.56%). A significant decrease in acidity was observed in 1mM SA conc. (0.16%) followed by the 3mM SA (0.18%) and highest titratable acidity was observed in fruits of controlled treatment (0.25%) (Table 2). Maximum TSS/acid ratio was observed in fruits of treated with 1 mM SA, while lower TSS/acid ratio of 31.77 was noted in the fruits of control treatment (Table 2).

Salicylic acid significantly increases the vitamin C of Ber fruits. Highest vitamin C was observed in fruits treated with 1mM SA that's 57.66 mg/100g followed by 2mM SA (55.84 mg/100g) and lowest contents was observed in 52.84 mg/100g (Table 2). Significantly higher amount of total sugars was observed in 1mM SA treatment (10.75%). Controlled treatment shows minimum amount of total sugars among other treatments (7.66%). 1mM SA significantly increases reducing and non reducing sugars (6.52% , 4.23% respectively) followed by the fruits treated with 2mM SA (5.75%, 3.27%) and minimum values were

observed in control treatment. Total phenolic compounds were significantly higher in 1mM SA (263.93 mg GAE/100mg), while lowest TPCs were found in control treatment (Table 2).

Table 2: Effect of Pre Harvest spray of Salicylic acid on Bio-Chemical fruit quality of Ber Cv. Gola

Treatments	TSS (°Brix)	Total Acidity (%)	TSS/ TA ratio	Vitamin C (mg/100 g)	Total sugars (%)	Reducing sugars (%)	Non-Reducing sugars (%)	Total phenolics (mg GAE/100g)
Control	7.73c	0.25a	31.49c	52.84c	7.66d	4.79d	2.87d	198.08d
1mM SA	9.67a	0.16d	60.70a	57.66a	10.75a	6.52a	4.23a	263.93a
2mM SA	8.56b	0.20b	42.13b	55.84ab	9.02b	5.75b	3.27b	221.52c
3mM SA	8.00bc	0.18c	45.52b	54.78bc	8.61c	4.96c	3.65c	248.60b
LSD (P≥0.05)	**3.86**	**4.01**	**4.75**	**1.89**	**1.06**	**0.55**	**1.62**	**2.09**

NS represents not significant. Means within a column followed by the same letter are not significant at $P \leq 0.05$.

DISCUSSION

The yield is major and most important parameter for the crops which determine its commercial value. In general, yield potential of ber depends upon cultivar or varieties and crop management practices but in some cases it also depends upon physiological process of the plants (Singh and Sharma, 2020). Many growth regulators have been used to balance these processes but in this study salicylic acid was used to enhance the physiological process of the plants. Generally, in ber fruit drop occurs due to imbalance of auxin in the plants. If auxin level reduces and the concentration of abscisic acid increases that results in the formation of the abscission layer and dropping of the fruits. Exogenous applications of plant growth regulator can effectively control the fruit drop in ber (Kumar et al., 2018). SA acts as the endogenous growth regulator. Exogenous application of SA may influence a range of physiological process such as ion uptake and transport, ethylene biosyntheses and also act as ABA inhibitor and regulates the enzymatic activities in the plants hence increasing the plant tolerance (Khan et al., 2003, Karimi et al., 2012, Kassem et al., 2012, and El-Shazly et al., 2013). Preharvest treatment of salicylic acid prevents the degradation of carotenoids (lycopene, α-carotene) which ultimately enhance the color of fruit. SA application maintains the fruit weight because it effectively reduces the transpiration and respiration rate through controlling the degradation of cell wall and reducing ethylene biosynthesis (Srivastava and Dwivedi, 2000). SA treatment slows down the process of ethylene biosynthesis and effectively reduces the transpiration and respiration rate through controlling degradation of cell wall, eventually increasing shelf life of the fruits. Increase in TSS may be due to breakdown of relatively complex polymers into simpler substances by hydrolytic enzymes (Garg and Ram, 1974). The reason for decreased TA is due to breakup of fermentation of acids into sugars during respiration process (Ball, 1997). Thakur et al. (2002) noticed that reduction in acidity may be due to the utilization of acids in respiratory processes. Similar observations were reported by the Ilhami Koksal (1988) in pomegranate and by Thakur et al. (2002) in kinnow fruits. Sugar acid ratio is very important regarding suitable taste of fruits. Lower sugar acid ratio usually leads to poor taste and overall quality of the studied fruits. So, those treatments should be used which can retain higher sugar acid ratio for true or characteristics taste and quality of fruits (De Reuck et al., 2009). Fruit quality status can be determined from the level of SSC: TA ratio. These higher levels of SSC: TA ratio may be attributed to

decrease concentration of titratable acidity in SA treated fruits. The prospective reasons for higher vitamin C were that applied treatments had delayed the fruit senescence and oxidation of different organic acids. The treatment salicylic acid application has the capability to conserve higher ascorbic acid contents (Cohen et al., 1990; Ling et al., 2008; Marti et al., 2009). The results of our study are in agreement with King et al., (1995), Mir and Beaudry (2002), those reported that untreated fruits showed losses in sugar contents (total sugars , reducing sugars and non reducing sugars) which may implicate negatively by altering the expression gene associated with quality. Total and reducing sugar contents increased in Alphonso mango fruit, this increase of sugar content was due to conversion of starch into simpler sugar (Babu, 1994). The possible reasons for higher reducing sugars in treated samples were that treatments had delayed the conversion of carbohydrates into simple sugars and retarded fruit senescence (Gul et al., 1990). The possible reasons for higher non-reducing sugars in treated samples were that treatments had delayed the conversion of complex carbohydrates into simple sugars and delayed fruit senescence onset (Ahmad et al., 1986). In our study increase in phenolics are in line with Yao and Tian (2005) who demonstrated that SA stimulates phenylalanine ammonia lyase activity with consequent production of the main phenolic compounds and the synthesis of new polyphenolic substances in sweet cherry fruit by Huang et al., (2008) reported that SA treated 'Cara cara' navel oranges showed increased total phenolic content.

CONCLUSION

Pre-harvest fruit drop and inferior fruit quality of Ber is a serious issue faced by growers. This study revealed the effectiveness of pre-harvest spray of salicylic acid on the quality of ber fruit Cv. Gola. Among various doses of SA sprayed; 1mM SA spray effectively reduced the fruit drop, increased the yield and improved fruit quality of ber as compared to other treatments.

REFERENCES

Abdel-Zaher, A., F. Alferez and L. Zacarias. 2005. Postharvest pitting in navel oranges at non chilling temperature: Influence of relative humidity. Acta Horticulturea. 533: 307-308.

Agamy R.A., E.H. Elsayed and H.T. Tarek. 2013. Acquired resistant motivated by salicylic acid applications on salt stressed tomato (*Lycopersicon esculentum* Mill.). American-Eurasian. Journal of Agriculture and Environmental Science, 13: 50-57.

Arfan, M., H.R. Athar and M. Ashraf. 2007. Does exogenous application of salicylic acid through the rooting medium modulate growth and photosynthetic capacity in two differently adapted spring wheat cultivars under salt stress. Journal of Plant. Physiology, 164: 685-694.

Babalar, M., M. Asghari, A. Talaei and A. Khosroshahi. 2007. Effect of pre- and postharvest Salicylic acid treatment on ethylene production, fungal decay and overall quality of Selva strawberry fruit. Food Chemistry, 105:449-453.

Bhargava, R.L., L.K. Dhashora and S. Mukherjee. 2005. Effect of neem leaf extract and Benzyl adenine on postharvest shelf life of orange (*Citrus reticulate*). Journal of Advance Research,1:32-37.

Bhupinder, S., and K. Usha. 2003. Salicylic acid induced physiological and biochemical changes in wheat seedlings under water stress. Plant Growth Regulator, 39: 137-141.

Croueour, L.M., F. Sheu and H.R. Lin. 2002. A simple and reliable method to detect gamma irradiated lentil. seeds by germination efficiency and seedling growth test. Radiation Physics and Chemistry, 64: 131-136.

Dat. J., S. Vandenabeele, E. Vra nova, M. Vanmontagu, D. Inze and F. Vanbreusegem. 1998. Dual action of the active oxygen species during plant stress responses.- Cell and Molecular Life Science, 57: 779-795.

Dogar, J.C., G. Singh and N.T. Singh. 2001. Evaluating forest and fruit trees for rehabilitation of semiarid alkali-sodic soils in India. Arid Land Research and Management. 15: 115-33.

EL-Shazly, S.M., A.M. Eisa, A.M.H. Moatamed, and H.R.M. Kotb. 2013. Effect of Some Agro-Chemicals Pre-harvest Foliar Application on Yield and Fruit Quality of "Swelling" Peach Trees. Alexandria Journal of Agricultural and Research, 58(3): 219-229.

El-Tayeb, M.A. 2005. Response of barley grains to the interactive effect of salinity and salicylic acid. Plant Growth Regulation, 45: 215-224.

Elwan M.W.M. and M.A.M. El-Hamahmy. 2009. Improved productivity and quality associated with salicylic acid application in greenhouse pepper. Scientia Horticuturae, 122:521–526

Fariduddin Q., S. Hayat and A. Ahmad. 2003. Salicylic acid influences net photosynthetic rate, carboxylation efficiency, nitrate reductase activity and seed yield in Brassica juncea. Photosynthetica, 41: 281-284.

Gupta, O.P., S. Siddiqui and O.P. Pareek. 1992. Postharvest handling of ber (*Ziziphus mauritiana* Lamk.). Agricultural Reviews, 13:199.

Gutierrez-Coronado, M.A., C. Trejo-Lopez and A. Largue-Saavedra. 1998. Effects of salicylic acid on growth of roots and shoots in soybean. Plant Physiology and Biochemistry, 36: 653-665.

Hayat, Q., S. Hayat, M. Irfan and A. Ahmad. 2010. Effect of exogenous salicylic acid under changing environment: A review. Environmental and Experimental Botany, 68:14-25.

Janda, T., E. Horvath, G. Szalai and E. Paldi. 2007. Role of salicylic acid in the induction of abiotic stress tolerance. Pp. 91-150. *In*: Hayat, S. and A. Ahmad (ed.). Salicylic acid: a plant hormone. Springer, The Netherlands.

Karimi, H.R., S. Sarmadi-Far, and B. Panahi. 2012. The effect of Salicylic acid and Zinc on Inflorescence and Characteristic of Pistachio Nut cv. Owhadi. Journal of Nuts, 3: 31-36.

Karlidag, H., E. Yildirim, M. Turan. 2009. Exogenous applications of salicylic acid effect quality and yield of strawberry grown under antifrost heated greenhouse conditions. Journal of Plant Nutrition and Soil Science. 172: 270–276. doi: 10.1002/jpln.200800058.

Kassem, H.A., R.S. Al-Obeed and M.A. Ahmed. 2012. Effect of bio-regulators preharvest application on date palm fruit productivity, ripening and quality. African Journal of Agricultural Research, 7(49):6565-6572.

Khan, W., B. Prithiviraj and D. Smith. 2003. Photosynthetic responses of corn and soybean to foliar application of salicylates. Journal of Plant Physiology, 160: 485-492.

Khodary, S.E.A. 2004. Effect of salicylic acid on the growth, photosynthesis and carbohydrate metabolism in salt stressed maize plants. International Journal of Agriculture and Biology, 6:5-8.

Kumar, S., D. Kumar and Premnaresh. 2018. Effect of plant growth regulators on initial fruit set, fruit set retention and fruit drop of Indian ber (*Zizyphus mauritiana* lamk.). Life Sciences Leaflets, 101:25-31.

Loake, G. and M. Grant. 2007. Salicylic acid in plant defenses the players and protagonists. Plant Biology, 10: 466-472.

Mady, M.A. 2009. Effect of foliar application with salicylic acid and vitamin E on growth and productivity of tomato (*Lycopersicon esculentum* Mill.) plant. Journal of Agriculture and Science Mansoura University, 34:6735–6746.

Marzouk, H.A. and H.A. Kassem, 2011. Improving yield, quality and shelf life of Thompson seedless grapevine by preharvest foliar applications. Scientia Horticulturae, 130:425–430.

Mukhtar, H.M., S.H. Ansari, M. Ali and T. Naved. 2004. New compounds from Zizyphus vulgaris. Pharmaceutical Biology, 42(7):508-11

Pareek, O.P. 2002. Ber (*Ziziphus mauritania*) Available by International Centre for Underutilised Crops. Available:http://www.civil.soton.ac.uk/icuc/cd_icuc_ber_tamarind/c ontent/ber/ber_book_html via the INTERNET. Accesed 2004 Apr 6.

Raskin, I. 1992a. Salicylate, a new plant hormone. Plant Physiology, 99: 799–803

Raskin, I. 1992b. Role of salicylic acid in plants. Annual review of plant physiology and plant molecular biology, 43: 439–463.

Renhua, H.R.X., Y. Lu, L. Hu and Y. Xu. 2008. Effect of pre-harvest salicylic acid spray treatment on post-harvest antioxidant in the pulp and peel of 'Cara cara' navel orange (*Citrus sinenisis* L. Osbeck). Journal of science food and agriculture, 88(2): 229-236.

Senaratna, T., D. Touchell, E. Bunn and K. Dixon. 2000. Acetyl salicylic acid (aspirin) and salicylic acid induce multiple stress tolerance in bean and tomato plants. Plant Growth Regulator. 30: 157-161.

Shafiee, M., T. S. Taghave and M. Babalar. 2010. Application of SA to nutrient solution combined with postharvest treatments (hot water, SA and Ca dipping) improved postharvest fruit quality of strawberry. Scientia Horticulturae, 124:40–45

Singh, and Sharma. 2020. Advancement and efficacy of plant growth regulators in Ber (*Ziziphus mauritiana* Lamk) - A review. Journal of Applied and Natural Science, 12(3): 372 - 379.

Srivastava, M.K. and U.N. Dwivedi. 2000. Delay ripening of banana fruit by salicylic acid. Plant Science, 158: 87-96.

Yıldırım, E. and A. Dursun. 2009. Effect of foliar salicylic acid applications on plant growth and yield of tomato under greenhouse conditions. Acta Horticultarae, 807:395–400.

Zhao, H., S.D. Dube and Chauhan, V.S. 2006. Effect of salicylic acid on growth, development and some biochemical aspects of soybean (*Glycine max* L.). International Journal of Plant Physiology, 4: 327-330.