The Pharma Innovation Journal 2022; 11(7): 3669-3673

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(7): 3669-3673

www.thepharmajournal.com
Received: 06-04-2022
Accepted: 10-06-2022

Rajashekar
Department of Horticulture, School of Agriculture, Lovely Professional University, Phagwara, Punjab, India

Archi Gupta
Department of Horticulture School of Agriculture, Lovely Professional University, Phagwara, Punjab, India

AK Baswal
College of Agriculture, Sumerpur (Pali), Agriculture University, Jodhpur, Rajasthan, India

Puneeth
Department of Horticulture, School of Agriculture, Lovely Professional University, Phagwara, Punjab, India

Corresponding Author:
Rajashekar
Department of Horticulture, School of Agriculture, Lovely Professional University, Phagwara, Punjab, India

Effect of pre-harvest application of salicylic acid on fruits, vegetables & ornamental crops

Rajashekar, Archi Gupta, AK Baswal and Puneeth

Abstract
Salicylic acid (SA), an endogenous plant growth regulator, has been shown to induce a variety of metabolic and physiological reactions in plants, impacting their growth and development. The cytoplasmic cell of the plant is the primary manufacturing location for SA. Salicin, a compound found in *Salix* spp., is present in the plant in the form of free phenolic acids or in combination with other amino acids. SA, being a naturally occurring and nontoxic phenolic molecule, has a great deal of potential for reducing pre-harvest losses in horticultural crops. SA must be used at the right concentration, for the right amount of time, and for the right type of crop to be commercialized. This review article talks about how to use SA to keep the quality of certain horticultural crops good before they are ready to be harvested. An additional goal of this review is to provide growers with more information about the various factors that influence how they respond to SA.

Keywords: Salicylic acid, phenolic acids, amino acids, pre-harvest losses

Introduction
Salicylic acid, also known as Ortho-hydroxy benzoic acid, is found throughout the plant kingdom and has a long history dating back to 1874, when it was the world's most popular medication manufactured in Germany. In 1938, Rafacle Piria gave the name salicylic acid, which was taken from the Latin word "*Salix*," which means willow tree. In 34 plants, SA has been identified being a member of various groups (Raskin *et al*., 1992) [36]. The salicylic acid was first discovered in *Salix* spp. Containing about 9.5 to 11 of salicilin compound (Hasson and Abduljabbar, 2019) [15]. Because of its various regulatory activities in plant metabolism (Popova *et al*., 1997) [35], salicylic acid is regarded a powerful plant hormone (Raskin *et al*., 1992) [36]. Salicylic acid is a phenolic endogenous plant growth regulator with an aromatic ring containing a hydroxyl group or a functional derivative. SA is a crystalline powder with a melting point of 157–159°C and a pH of 2.4 in its free form (Raskin *et al*. 1992) [36]. Salicylic acid has been discovered to have an important part in plant growth, development, interactions with other species, and reactions to environmental challenges (Raskin, 1992a, b; Yalpani *et al*., 1994; Senaratna *et al*., 2000) [36, 51, 40]. It also has a function in seed germination, fruit yield, glycolysis, blooming in thermogenic plants (Klessig and Malamy, 1994) [16], ion absorption and transport (Harper and Balke, 1981) [14], photosynthetic rate, stomatal conductance, and transpiration (Klessig and Malamy, 1994) [16]. (Khan *et al*., 2003) [24].
Transpiration and stomatal conductance (Khan *et al*., 2003) [24]. In response to numerous pathogenic assaults, salicylic acid is thought to be a key signaling molecule involved in local and endemic disease resistance in plants (Enyedi *et al*., 1992) [11]. SA may alter plant responses to a wide range of oxidative stressors in addition to providing disease resistance (Shirasu *et al*., 1997) [41].
The signal molecule salicylic acid is an endogenous plant growth chemical that plays an important role in plant growth, development, and stress responses. These signal molecules are involved in signal transduction systems that cause specific enzymes to catalyze biosynthetic reactions to produce defense compounds such as polyphenols, alkaloids, or pathogenesis-related (PR) proteins (Hahlbrock and Scheel, 1989; Creelman and Mullet, 1995; Tamari *et al*., 1995; Van Loon, 1995) [13, 6, 46, 48]. Delaney *et al*., 1994; Kozlowski *et al*., 1999) [8, 28] have shown that this can induce defensive responses and protect plants from pathogen assault.When given exogenously, salicylic acid has been demonstrated to migrate systemically across plants, resulting in the activation of a set of defensive genes triggered by pathogen infection, resulting in disease resistance (Epple *et al*., 1997; Kozlowski *et al*., 1999) [10, 28].

Pre-harvest impact of salicylic acid

Effect of SA on plant growth

Photosynthesis, ion transport, and other physiological and biochemical processes are all influenced by phenolic chemicals. Absorption, permeability of membranes, enzyme activity, blooming, and heat Plant production, growth, and development. One, in particular, is a natural. Salicylic acid is a chemical that may act as a plant growth regulator. The use of salicylic acid (SA) and acetyl salicylic acid (ASA)To corn elaves, use gentisic acid (GTA) or other analogues of ASA. Plants such as corn and soybean increased their leaf area and dry mass output, however, the height and root length of the plants were unaffected (Khan *et al*., 2003) [24]. (Farid uddin *et al*. 2003) [12] found that a concentration of 10-5 M resulted in the greatest increase in dry matter buildup among the various SA concentrations examined. Supplemented to the leaves of standing *Brassica juncea* plants but, Concentrations higher than that were shown to be inhibiting. Wheat is also a good source of protein. Seedlings produced from grains soaked in 10-5M of SA had a higher level of SA content. Compared to the previous year, there were more leaves and a greater fresh and dry mass control, soaked in water (Hayat *et al*., 2005) [19]. Similarly, (Pancheva *et al*., 1996) [35] treated 2-day old barley seedlings with SA, which resulted in dramatically increased growth but delayed leaf emergence. The mature blades were thin and shorter, and the blades grew slowly over a longer period of time. Some ornamental plant stem cuttings treated with SA showed a quick rate of root differentiation (Singh *et al*., 1993) [2]. In contrast to the foregoing, (Pancheva *et al*., 1996) [35] found that salicylic acid inhibited the development of leaves and roots of barley seedlings, and that increasing the concentration of SA increased it even more. Salicylic acid is responsible for Gene stimulation in enzymes like Manganese superoxide dismutase (Ali and Inas 2020).

Impact of SA on flowering of horticultural crops

Flowering has a direct relationship with plant production and productivity (Hayat *et al*., 2010) [19]. Some plants are induced to blossom by SA (Vlot *et al*., 2009) [49]. Stress-induced blooming in inadequate diet is suppressed by amino-oxyacetic acid, a phenylalanine ammonia lyase inhibitor, and reversed by salicylic acid, according to researchers. However, SA does not stimulate flowering in nonstress circumstances, implying that SA is required but not sufficient to cause flowering (Wada and Takeno, 2010) [50]. Furthermore, when cucumbers and tomatoes were sprinkled with lower quantities of SA, fruit output rose dramatically (Javaheri *et al*., 2012) [20]. SA application to soybean leaves improved blooming and pod development (Kumar *et al*., 1999) [31]. The flower inducing factor is known as SA in certain research, which is compatible with reports of the usage of SA in the induction of organic tobacco blooming (Muthulakshmi and Lingakumar, 2017) [31]. The actual mechanism of the SA inducer feature, however, has not yet been discovered. As a result, it is possible to assume that SA can operate as a regulator, influencing plant development and production (Hayat *et al*., 2010) [19] (Khatiby and Shadmehri, 2019) [25].

Impact of SA on Disease Resistance of Horticultural Crops

The SA signal is created, controlled, and transduced, resulting in HR cell death and the production of defense genes. One of the most pressing topics in SA biology today is how this chemical is originally recognized and how resistance signaling is triggered as a result of this occurrence. Despite the fact that four SA-binding proteins have been identified, none of them is the SA receptor. The many feedback loops that regulate (typically enhance) the SA signal have impeded efforts to clarify early signaling processes following SA induction. The resolution of early identification and signaling events before they are obfuscated by signal potentiation will be a major problem. Although it is generally understood that SA buildup in systemic tissue of locally infected plants is essential to elicit SAR, several components of the SAR signal and how they interact with SA to promote systemic resistance remain unclear or poorly understood (Vlot AC *et al.* 2008) [49]. A local basal defensive (PTI) response (Maleck *et al*. 2001), which is a slower, less intense version of ETI, is transcriptionally mimicked by SAR Determining which signal (s) are transportable and least necessary to trigger the systemic SA- potentiating loop that generates SAR will be a problem (Tao Y *et al.* 2003).

Impact of SA on biotic and abiotic stress

Stress induces oxidative damage to plant macromolecules such as proteins, lipids, and nucleic acids (Seedlings *et al*., 2003), as well as enzyme inactivation, gene expression modifications, and interference in numerous metabolic pathways (Chaparzadeh and Hosseinzad-Behboud, 2015) [7]. ROS generate free radicals such as H_2O_2, which disrupt metabolic events. H_2O_2 can be reduced with salicylic acid. SA is engaged in activating particular responses to numerous biotic and abiotic challenges (Kareem *et al*., 2017) [26] as well as several physiological processes of plants, such as blooming, root ion absorption regulation, and stomatal closure (Shahmoradi and Naderi, 2018) [42]. This molecule is a plant regulator that protects plants from oxidative damage. Certain doses of SA can block antioxidant enzymes that catabolize H_2O_2 and hence diminish H_2O_2 buildup; in fact, H_2O_2 can play an important role in the production of defensive responses in plants. This method, however, cannot be generalised. SA is a pro-oxidant and phytotoxin, and the high level of H_2O_2 induced by the high concentration of SA results in lipid structure degradation and the like. Thus, modest quantities of salicylic acid can benefit oxidative stress protection (Anjum *et al*., 2008; Krantev *et al*., 2008) [1, 32].

Effect of salicylic acid on storage and quality of horticultural crops

Marketability retention, decrease in ethylene production & fungal decay in strawberry (Babalar *et al*. 2007) [4]. Inhibition of PAL activity, retention of vitamin C content reduction of CI & EL in pomegranate (Sayyari, Babalar, Kalantari, Serrano, and Valero 2009) [39]. Inhibition of ACS, ACO & LOX activity, suppression of ethylene & superoxide free radical production, increase in total SA content. The fruit dipping in salicylic acid it more effective to maintain the quality of Murcoot mandarin fruit during the storage, and reducing the weight loss and decay, fruit firmness maintained. Tss acid ratio and Vitamin C at acceptable levels that extend the fruit marketability chances and storability. As Salicylic Acid is effective way maintaining the Quality of papaya fruit during 28 days of cold storage by reducing the fruit decay percentage, and its firmness, acidity, sugars, TSS. It enhanced the activity of Antioxidative enzymes (SOD, POD, CAT) (Saeed Ahmad *et al*., 2020) [17]. Fruits treated with 2.0 mmol

L-1 salicylic acid had significant effect on quality parameters of peach fruits cv. 'Flordaking' during five weeks of storage period. retained maximum firmness, higher levels of SSC, increased contents of ascorbic acid and total phenolics and reduced REC (Nadeem Akhtar abbasi *et al*., 2012) [47].

Table 1: Effect of Salicylic acid concentration, time and temperature on pre harvest quality of selected horticultural crops

Papaya (*Carica papaya*)	3 mM	20-25 ℃	7 days	Delay ripening increase shelf life for 14 days	Mandal *et al.*, 2017
Peach (*Prunus persica*)	2 mM	20 ℃	15 days	Higher fruit firmness and less TA loss at the end of shelf life	Erogul *et al.*, 2020
Sweet Orange (*Citrus sinensis*)	8 mM & 9 mM	5 ℃	10 days	Minimize the fruit rot, chilling injury and to maintain the quality of fruit.	Ahmad *et al.*, 2009
Tomato (*Solanum lycopersicum*)	4 mM	10 ℃	21 days	Effective treatment in reducing losses of fruit quality	Baninaiem *et al.*, (2016) [5]
				(TA, Ascorbic acid)	
Strawberry (*Fragaria X ananassa* Duch.)	4 mM	20-25 ℃	30 days	The treatment has resulted in enhancing the growth parameters like height of the plant, area of leaf and fruit yield	Kumar *et al*., 2019 [31]
Cut Rose (*Rosa hybrid* L.)	1.5 mM	13-20 ℃	12days	Increase in the vase life of the cut roses was observed after treating with SA	Kazemi *et al.*, 2017.

Response of salicylic acid on important horticultural crops

Apple

Pre harvest application of SA exhibited effectively able to maintain visual appearance and firmness of the fruit during storage and no effect in fruit colour, TSS, loss of fresh weight, total anthocyanin content of the wax apple fruit during short-term storage (Suriyan supapvanich *et al*. 2016) [46]. SA exhibited cell swelling which usually leads to maintain firmness of harvested fruits (Zhang *et al*., 2003) [52].

Mango

Pre harvest application of SA exhibited delaying the fruit ripening and senescence passes through suppression of respiration rate and ethylene production rate and retention of firmness, colour, TSS and titratable acidity. (Manish Srivastav *et al.*, 2016) [38]. Reduced ethylene generation and limited activities of fruit softening enzymes such as poly galacturonase (Lazan *et al*., 2012) [33], galactosidases (Ali *et al*., 2002), pectin esterase, and -1,4-glucanase (Ali *et al*., 2001) during ripening could explain the reduced fruit softening and preservation of pulp texture in SA treated mango fruits.

Ber

Pre harvest application of SA exhibited reduced the fruit drop, increase yield, and improve fruit quality (Nasir *et al.*, 2021) [27]. SA treatment preserves fruit weight by successfully lowering transpiration and respiration rates by limiting cell wall disintegration and reducing ethylene production (Srivastava and Dwivedi, 2000) [43].

Papaya

Pre harvest application of SA exhibited delay ripening increase shelf life for 14 days. According to Zhang *et al*., SA can efficiently retain fruit firmness by lowering the rate of ethylene generation and inhibiting cell wall disintegrating enzymes. Application of SA exhibited lowest physiological loss in weight of fruits (Devarakonda *et al*., 2020) [9].

Peach

Fruits treated with SA exhibit improved attributes such as fruit weight, fruit flesh hardness, total antioxidant content, total phenol content, and titratable acidity level at harvest and after storage, as well as a longer shelf life than fruits treated with other treatments. The total soluble solids were not affected by the treatments at harvest, after storage, or during the shelf life of the product. When compared to the control, SA treatments reduced the loss of fruit flesh firmness and the loss of acidity after shelf life in comparison to the control.

Sweet orange

Pre harvest application of SA exhibited Minimize the fruit rot, chilling injury and to maintain the quality of fruit. It was discovered that fruit that had not been treated with SA were closer to ageing or rotting than those that had been treated with higher doses of SA. (Zhang *et al*., 2003) [52].

Strawberry

The pre-harvest application of SA demonstrated to be the most effective treatment in terms of improving plant development parameters such as plant height, total leaf area, fruit set percentage, number of runners, and fruit yield (Kumar *et al*., 2019) [31]. The increase in total leaf area may be attributed to the anti-senescence impact of salicylic acid on plant organs, which may cause vegetative growth to be delayed, resulting in increased leaf area in strawberry plants (Jamali *et al*. 2011) [21].

Tomato

Pre harvest application of SA exhibited the usage of salicylic acid can help to prevent tissue softening in fruits by lowering cell wall hydrolase activity and maintaining cell membrane consistency (Supapvanich, 2015) [45]. Effective treatment in reducing losses of fruit quality (TA, Ascorbic acid) (Baninaiem *et al.*, 2016) [5].

Cut rose

SA treatment significantly suppressed the increase of CAT and POD activities. SA treatment inhibited lipid peroxidation and MDA production (V. Abdossi *et al.* 2017) [25]. Increase in the vase life of the cut roses was observed after treating with SA (Kazemi *et al.*, 2017) [22].

Conclusion

In horticultural crops, SA has had a substantial influence in ways that are outside the scope of this analysis, which was forced to focus on a restricted number of SA characteristics. There are several opportunities for combining SA with current technology to supply customers with high-quality horticultural output while also reducing pre-harvest losses, particularly for perishable fruits, vegetables, and ornamentals. SA also gives researchers a way to look at the biochemical and physiological reactions of horticultural products to ethylene. In order to allow safe usage of the technology, further study is needed to understand the diverse reactions inside different horticulture crops.

Reference

1. Anjum NA, Umar S, Ahmad A, Iqbal M, Khan NA. Sulphur protects mustard (*Brassica campestris* L.) from cadmium toxicity by improving leaf ascorbate and glutathione. Plant Growth Regulation. 2008;54(3):271-279.
2. Ahmad S, Singh Z, Khan AS, Iqbal Z. pre-harvest application of salicylic acid maintain the rind textural properties and reduce fruit rot and chilling injury of sweet orange during cold storage. Pakistan Journal of Agricultural Sciences. 2013, 50(4).
3. Ali ZM, Chin LH, Lazan H. A comparative study on wall degrading enzymes, pectin modifications and softening during ripening of selected tropical fruits. Plant Science, 2004;167(2):317-327.
4. Babalar M, Asghari M, Talaei A, Khosroshahi A. Effect of pre-and postharvest salicylic acid treatment on ethylene production, fungal decay and overall quality of Selva strawberry fruit. Food chemistry. 2007;105(2):449-453.
5. Baninaiem E, Mirzaaliandastjerdi AM, Rastegar S, Abbaszade KH. Effect of pre-and postharvest salicylic acid treatment on quality characteristics of tomato during cold storage. Advances in Horticultural Science. 2016;30(3):183-192.
6. Creelman RA, Mullet JE. Jasmonic acid distribution and action in plants: regulation during development and response to biotic and abiotic stress. Proceedings of the National Academy of Sciences. 1995;92(10):4114-4119.
7. Chaparzadeh N, Hosseinzad-Behboud E. Evidence for enhancement of salinity induced oxidative damages by salicylic acid in radish (*Raphanus sativus* L.). Journal of Plant Physiology and Breeding. 2015;5(1):23-33.
8. Delaney TP, Uknes S, Vernooij B, Friedrich L, Weymann K, Negrotto D. A central role of salicylic acid in plant disease resistance. Science. 1994;266(5188):1247-1250.
9. Devarakonda S, Madhumathi C, Umamahesh V, Mukunda L, Lakshmi M, Bhaskar VV. Influence of pre-harvest spray of salicylic acid and Jasmonic acid on fruit quality and postharvest behaviour of papaya (*Carica papaya* L.) cv. red lady. Journal of Pharmacognosy and Phytochemistry. 2020;9(3):622-626.
10. Epple P, Apel K, Bohlmann H. Overexpression of an endogenous thionin enhances resistance of Arabidopsis against *Fusarium oxysporum*. The Plant Cell. 1997;9(4):509- 520.
11. Enyedi AJ, Yalpani N, Silverman P, Raskin I. Signal molecules in systemic plant resistance to pathogens and pests. Cell. 1992;70(6):879-886.
12. Fariduddin Q, Hayat S, Ahmad A. Salicylic acid influences net photosynthetic rate, carboxylation efficiency, nitrate reductase activity, and seed yield in *Brassica juncea*. Photosynthetica. 2003;41(2):281-284.
13. Hahlbrock K, Scheel D. Physiology and molecular biology of phenylpropanoid metabolism. Annual review of plant biology. 1989;40(1):347-369.
14. Harper JR, Balke NE. Characterization of the inhibition of K+ absorption in oat roots by salicylic acid. Plant physiology. 1981;68(6):1349-1353.
15. Hasson AS, Abduljabbar IA. Review on the role of salicylic acid in plants. Book chapter, 2019.
16. Klessig DF, Malamy J. The salicylic acid signal in plants. Plant molecular, 1994.
17. Haider SA, Ahmad S, Khan AS, Anjum MA, Nasir M, Naz S. Effects of salicylic acid on postharvest fruit quality of “Kinnow” mandarin under cold storage. Scientia Horticulturae. 2020;259:108843.
18. Biology. In: Sustainable crop production. 26(5):1439-1458, 1-7. DOI: 10.5772/intechopen.83521.
19. Hayat Q, Hayat S, Irfan M, Ahmad A. Effect of exogenous salicylic acid under changing environment: A review. Environmental and experimental botany. 2010;68(1):14-25.
20. Javaheri M, Mashayekhi K, Dadkhah A, Tavallaee FZ. Effects of salicylic acid on yield and quality characters of tomato fruit (*Lycopersicum esculentum* Mill.). International Journal of Agriculture and Crop Sciences (IJACS). 2012;4(16):1184-1187.
21. Jamali B, Eshghi S, Tafazoli E. Vegetative and reproductive growth of strawberry plants cv. ‘Pajaro’ affected by salicylic acid and nickel. Journal of Agricultural science and Technology. 2011;13(6):895-904.
22. Kazemi M, Hadavi E, Hekmati J. Role of Salicylic Acid in Decreases of Membrane Senescence in Cut. American Journal of Plant Physiology. 2011;6(2):106-112.
23. Kazemi M, Abdossi V, Kalateh Jari S, Ladan Moghadam, AR. Effect of pre- and postharvest salicylic acid treatment on physio-chemical attributes in relation to the vase life of cut rose flowers. The Journal of Horticultural Science and Biotechnology. 2018;93(1):81-90.
24. Khan W, Prithiviraj B, Smith DL. Photosynthetic responses of corn and soybean to foliar application of salicylates. Journal of plant physiology. 2003;160(5):485-492.
25. Khatiby A, Shadmehri AA. Effect of foliar application with salicylic acid on some morphological traits of sesame under water deficit stress conditions. In First National Congress of Agronomy, Plant Protection & Biotechnology, 2019.
26. Kareem F, Rihan H, Fuller M. The effect of exogenous applications of salicylic acid and molybdenum on the tolerance of drought in wheat, 2017.
27. Kanwal MAJ, Ahmad S, Nasir M, Jaskani MJ, Aziz M. Pre-harvest spray of salicylic acid to improve the quality and shelf life of ber fruit (*Ziziphus mauritiana*). Journal of Postharvest Technology. 2021;9(1):64-71.
28. Kozlowski G, Buchala A, Métraux JP. Methyl jasmonate protects Norway spruce [*Picea abies* (L.) Karst.] Seedlings against *Pythium ultimum* Trow. Physiological and Molecular Plant Pathology. 1999;55(1):53-58.
29. Koc E, ÜSTÜN AS, Celik N. Effect of exogenously applied salicylic acid on cadmium chloride-induced oxidative stress and nitrogen metabolism in tomato (*Lycopersicon esculentum* L.). Turkish Journal of Biology. 2013;37(3):361-369.
30. Kumar P, Dube SD, Chauhan VS. Effect of salicylic acid on growth, development and some biochemical aspects of

soybean (*Glycine max* L. Merrill). Indian Journal of Plant Physiology. 1999;4(4):327-330.
31. Kumar S, Kaur G. Effect of pre harvest application of salicylic acid on plant growth parameters and yield of strawberry cv. Chandler. Journal of Pharmacognosy and Phytochemistry. 2019;SP4:85-87.
32. Krantev A, Yordanova R, Janda T, Szalai G, Popova L. Treatment with salicylic acid decreases the effect of cadmium on photosynthesis in maize plants. Journal of plant physiology. 2008;165(9):920-931.
33. Lazan H, Ali ZM, Lee K, Voon J, Chaplin G. The potential role of polygalacturonase in pectin degradation and softening of mango fruit. Asean Food J. 1986;2(3-4):93-98.
34. Muthulakshmi S, Lingakumar K. Role of salicylic acid (SA) in plants: A review. Int. J Appl. Res. 2017;3(3):33-37.
35. Popova L, Pancheva T, Uzunova A. Salicylic acid: properties, biosynthesis and physiological role. Bulg. J. Plant Physiol. 1997;33(1-2):85-93.
36. Raskin I. Salicylate, a new plant hormone. Plant physiology. 1992;99(3):799.
37. Raskin I. Role of salicylic acid in plants. Annual review of plant biology. 1992;43(1):439-463.
38. Reddy SVR, Sharma RR, Srivastava M, Kaur C. Effect of pre-harvest application of Salicylic acid on the postharvest behavior of 'Amrapali' mango fruits during storage, 2016.
39. Sayyari M, Babalar M, Kalantari S, Serrano M, Valero D. Effect of salicylic acid treatment on reducing chilling injury in stored pomegranates. Postharvest biology and technology. 2009;53(3):152-154.
40. Senaratna T, Touchell D, Bunn E, Dixon K. Acetyl salicylic acid (Aspirin) and salicylic acid induce multiple stress tolerance in bean and tomato plants. Plant Growth Regulation. 2000;30(2):157-161.
41. Shirasu K, Nakajima H, Rajasekhar VK, Dixon RA, Lamb C. Salicylic acid potentiates an agonist-dependent gain control that amplifies pathogen signals in the activation of defense mechanisms. The Plant Cell. 1997;9(2):261-270.
42. Shahmoradi H, Naderi D. Improving effects of salicylic acid on morphological, physiological and biochemical responses of salt-imposed winter jasmine. International Journal of Horticultural Science and Technology. 2018;5(2):219-230.
43. Srivastava MK, Dwivedi UN. Delayed ripening of banana fruit by salicylic acid. Plant science. 2000;158(1-2):87-96.
44. Supapvanich S, Pimsaga J, Srisujan P. Physicochemical changes in fresh-cut wax apple (*Syzygium samarangenese* [Blume] Merrill & LM Perry) during storage. Food Chemistry. 2011;127(3):912-917.
45. Supapvanich S. Effects of salicylic acid incorporated with lukewarm water dips on the quality and bioactive compounds of rambutan fruit (*Nephelium lappaceum* L.). CMU J. Nat. Sci. 2015;14(1):23-27.
46. Tamari G, Borochov A, Atzorn R, Weiss D. Methyl jasmonate induces pigmentation and flavonoid gene expression in petunia corollas: a possible role in wound response. Physiologia Plantarum. 1995;94(1):45-50.
47. Tareen MJ, Abbasi NA, Hafiz IA. Effect of salicylic acid treatments on storage life of peach fruits cv. 'Flordaking'. Pakistan Journal of Botany. 2012;44(1):119-124.
48. Van Loon LC. Pathogenesis-related proteins. Plant Molecular Biology. 1985;4(2):111-116.
49. Vlot AC, Dempsey DMA, Klessig DF. Salicylic acid, a multifaceted hormone to combat disease. Annual review of phytopathology. 2009;47:177-206.
50. Wada KC, Takeno K. Stress-induced flowering. Plant signaling & behavior. 2010;5(8):944-947.
51. Yalpani N, Enyedi AJ, León J, Raskin I. Ultraviolet light and ozone stimulate accumulation of salicylic acid, pathogenesis-related proteins and virus resistance in tobacco. Planta. 1994;193(3):372-376.
52. Zhang Y, Chen K, Zhang S, Ferguson I. The role of salicylic acid in postharvest ripening of kiwifruit. Postharvest Biology and Technology. 2003;28(1):67-74.