*Plant Archives* Volume 2, No. 2, 2020 pp. 4417-4422 e-ISSN:2581-6063 (online), ISSN:0972-5210

# MINIMIZATION OF PHYSIOLOGICAL LOSSES AND ENHANCEMENT OF SHELF LIFE OF BER (*ZIZIPHUS MAURTIANA* LAMK) FRUITS CV BANARASI KARAKA THROUGH SALICYLIC ACID AND PROPYL GALLATE

**Deepti Shrivastva*, Akhilesh K. Pal, S.P. Singh and Kalyan Barman**

Department of Horticulture, Institute of Agriculture Science, Banaras Hindu University, Varanasi (U.P.), India.

## Abstract

Ber (*Ziziphus maurtiana* Lamk), commonly known as Indian jujube, is an underutilized fruit and native to India and adoption to varied climatic conditions. Fruits are small, round to oblong in shape with thin and glossy skin. The ber fruits passes antioxidant, antiflammatory and antibacterial properties but its quality deteriorates rapidly after harvest. Therefore, increasing the shelf life of harvested fruits investable in order to ensure their availability for long period. Considering this experiment was conducted to study the effect of pre-harvest spray of Salicylic Acid @200, 400, 600 ppm and Propyl Gallate @150, 300 and 450 ppm on, along with control (water spray only) storage quality of Banarasi Karaka fruits. Fruits of uniform in size were harvested at physiological maturity (December, January and February) and after washing and drying under shade on blotting paper were packed in CFB and using paper cutting on Cushing material and kept at room temperature ($24^0$C) and Stored fruit were evaluated on zero day and thereafter at 2days interval over a period of 8 days for different parameters. The highest palatability rating minimum decay loss, physiological loss in weight and minimum loss in chlorophyll was recorded with SA (600 ppm) which was followed Propyl Galalte (450 ppm). However, in these parameter increased with irrespective of treatments advancement of storage period.

## Introduction

Ber (*Zizyphus mauritiana* Lamk.) which is also known as Chinese apple, Indian plum, Masau and Chinese date and belong to the family Rhamnaceae and very often called King of Arid fruits. It is considered to have originated in India but found growing widely in China, Africa, Afghanistan, Malaysia, Australia, and Fiji. The commercial cultivation of ber in India is confined to Punjab, Haryana, Rajasthtan, Gujarat, Madhya Pradesh, Maharashtra and Andhra Pradesh (Pareek and Vashishtha, 1983). In India, the total area under ber fruit covered has been 50 thousand hectare. Producing 6.3 MT fruits annually (NHB, 2017). The *Ziziphus* species are distributed throughout the tropical, subtropical and temperate regions of both the hemisphere (Rendle, 1972). It is hardy in nature, able to grow on poor soil and suitable for low cost of production. There are 125 varieties of ber grown in different parts of India (Abhang *et al.,* 2015) as an underutilized fruit crop and providing good nutrition and fuel to poor farmer's. It is one of the world's most nutritious fruit crops which contains Vitamin A, minerals, like calcium, Phosphorus and iron (Ermosele *et al.,* 1991, Al-Niami *et al.,* 1992, Pareek, 2002). Roots, bark leaves and Fruits have medicinal properties and also contain various types of bioactive substances such as triterpene acid volatile oil, glycosides, saponins and flavonoids that have wide pharmacological effects on humans (Zhao *et al.,* 2008). It is eaten as raw and processed into candy, murabba, pickled and beverage. It is easily digestible because has a laxative effect, the pulp is sweet and rich in flavor. Ber fruits are within the reach of the poor people, hence rightly known as 'Poor man's apple' (Bal and Uppal, 1992). Limited availability, economic constraints, lack of knowledge and information, and lack of demand for nutritious foods are critical factors that limit poor people's access to such foods. Ber can thrive

***Author for correspondence :** E-mail: deeptibhu16@gmail.com

well under adverse conditions, *viz*., salinity, drought and waterlogging. However, high post-harvest losses are the major constraint in developing the ber fruit industry in the country. In theory, the agriculture sector could help address this problem by helping at-risk groups to generate more income and by making nutritious foods more available, affordable, acceptable, and to increase the postharvest life of fruits.

The word salicylic acid derived from Latin word Salix meaning willow tree which is distributed in whole plant kingdom (Raskin *et al.,* 1990). Salicylic acid is also an endogenous plant growth regulator with phenolic nature, which participates in the regulation of several physiological processes in plants, such as stomata closure, ion uptake, inhibition of ethylene biosynthesis and transpiration (Khan *et al.,* 2003). It is used as a food additive in handling harvested fruits to delay ripening processes of some fruits as well as enhancing the tolerance of fruits against pathogens, particularly at the early maturity stage (Cao *et al.,* 2006). Furthermore, salicylic acid was reported to reduce fruit weight loss and softening (Shafiee *et al.,* 2010). SA is an endogenous signal mediating local and systemic plant defense responses against pathogens. It has also been found that SA plays a role during the plant response to abiotic stresses such as drought, chilling, heavy metal toxicity, heat, and osmotic stress. SA is assigned diverse regulatory roles in the metabolism of plants (Popova *et al.,* 1997). It contributes to maintaining cellular redox homeostasis through the regulation of antioxidant enzymes activity (Durner and Klessig, 1995, 1996; Slaymaker *et al.,* 2002) and induction of the alternative respiratory pathway (Moore *et al.,* 2002), and to regulate gene expression by inducing an RNA-dependent RNA polymerase which is important for posttranscriptional gene silencing (Xie *et al.,* 2001). It serves as a regulator of biogenesis of chloroplasts (Uzunova and Popova, 2000) and activity of photosynthesis Fariduddin *et al*.(2003), gravitropism (Medvedev and Markova, 1991), inhibition of fruit ripening (Srivastava and Dwivedi, 2000) and of other processes.

Propyl Gallate is the n-propyl ester of gallic acid (3, 4, 5- trihydroxybenzoic acid). It is stable and neutral or slightly acidic in nature but is unstable when heated or in mild state it behave as alkaline (Bentz *et al*. 1952) and is soluble in ethanol. It discolors in the presence of iron or when it is exposed to air or light for long periods of time (Elder, 1985). Propyl Gallate is a phenolic compound and a free-radical scavenger which is used to prevent the free-radical peroxidation of lipids and that free radicals can be generated by ionizing radiation, chemical reaction, oxidation, or enzymatic reactions (Gutteridge and Fu, 1981). It is a generally recognized as safe (GRAS) antioxidant to protect fats, oils, and fatcontaining food from rancidity that results from the formation of peroxides and have antibacterial activity. Hence, it is used for inhibition of germination of seed, prevention of food and preservative and enhancement of postharvest life of fruits. The fruit growers are much more benefited, if postharvest life can be extended without deterioration in the quality of fruits. The peak season of harvesting of ber in North India is mid-March to mid –April. However, from beginning of April to end of April there is paucity of local fruit in the market and extension in shelf life of ber fruits will make their availability in the market and will fetch good income to growers with this background the present investigation was carried out for a period of two consecutive years

## Materials and Method

The proposed study was conducted in the garden of Horticulturist Unit, BHU Varanasi during twenty-one plant of Banarasi Karaka ber was selected and tagged. Standard cultural practices and proper plant protection measures were followed by out during the crop period. Three pre-harvest sprays (December, January and February) of Salicylic Acid @ (200, 400 and 400 ppm) and Propyl Gallate @ (150, 300 and 450 ppm) were applied on all the selected plants. Fruits were harvested at full maturity and stored for 8 days at 25C. There were seven treatments each with three replications under CRD. Each replication contained two kilogram fruits. The fruit were analyzed at two days interval over a period of 8 days for physiological characters in storage.

Data were analyzed under CRD at 0.05% level of probability under two -way ANOVA by Using OPSTAT software (CCS, HAU, HIsar) Haryana, to determine the fruit weight loss, decay loss and chlorophyll loss of fruit.

**Physiological loss in weight %**

The cumulative physiological loss in weight of fruits was calculated in per cent at two days interval on initial weight using the formula as given below

PLW % = Initial weight – final weight/Initial weight × 100

The decay loss of fruit was worked out on the basis of weight. Decay loss happened due to over ripening and pathogenic infection of fruits. The decayed fruits were weighed on the day of each interval. Weight of decayed fruits included the total weight of fruits decayed up to the date of observation. Chlorophyll content was following the method as suggested by Thimaah (1999) using 80% acetone. The peel weight of 5gram was taken of crushed and centrifuged for 15min at 5000rpm. The supernatant was filtered and kept in spectrophotometer at observance of 663 and 645nm.

## Results and Discussion

The analyzed data presented in table 1, showed statistically significant treatments on storage period. However, the interaction of treatment x days was non-significant. The minimum (0.41 and 0.46 mg/100g) loss of chlorophyll was found with Salicylic acid treated fruit (600 ppm)) followed by Propyl Gallate with (450 ppm). The maximum loss was found in control in two years. Similarly, adverse effect of salt stress on chlorophyll content in strawberry (Kaya *et al.,* 2002) and fruit treated with 0.25 mMSA showed that there was not increase in chlorophyll content but 0.50 and 1.00 mM SA spectacularly increased the chlorophyll content Salicylic acid under salt stress inhibited the chlorophyll content in leaves of many crops (Parida & Das, 2005). The inhibition of chlorophyll might be owing to revention of ethylene production and accumulation (Fariduddin *et al.,* 2003., Kaya *et al.,* 2007) In waterlogged condition treated tomato with salicylic acid exhibited the chlorophyll content but in normal condition SA increased the chlorophyll content due to its anti-oxidative nature which is protecting chloroplasts and preventing chlorophyll degradation from the toxic reactive oxygen radicals (Bowler *et al.,* 1992; Aono *et al.,* 1993. Salicylic acid increased chlorophyll content in barley El-Tayeb (2005), Gunes *et al*. (2007) in maize and Yildirim *et al*. (2008) in cucumber. Enhancing effect of SA on photosynthetic capacity can be attributed to its stimulatory effects on Rubisco activity and pigment contents. Sinha *et al* (1993) revealed that chlorophyll and carotenoid contents of maize leaves increased with SA treatments in lead stress condition. The metabolic aspect of plants supplied with SA or its derivate shifted to a varied degree depending on the plant type and the mode of application of SA. The application of SA (20 mg/ml) to the foliage of *Brassica napus*, improved the chlorophyll content. Foliar application and dipping treatments of salicylic acid increased the pigment content in wheat (Hayat *et al.,* 2005) or in rapeseed (Ghai *et al.,* 2002). In sunflower 0.001-10 M SA increased chlorophyll while 1mM SA decreased both chlorophyll and carotenoids content in cotyledon (Cag *et al.,* 2009).Decay loss (%).

**Decay loss (%)**

The data was present in table 2 indicated that fruit treated with Salicylic Acid (600 ppm) showed the minimum (5.06 and 5.38 %) and (4.02 and 4.32 %) decay incidence whereas the fruits under control exhibited the maximum (6.80 and 7.09 %) and (6.48 and 6.82 %) decay loss. Salicylic Acid and Propyl Gallate have known for their antioxidant properties that help to maintain the membrane structure, as well as provide protection from oxidative damage (Yao and Tian, 2019; Apelbaum *et al.,* 2004). SA is known to induce the accumulation of hydrogen peroxide ($H_2O_2$) levels in plant tissues which acts as a signal activating the SAR (Klessig & Malamy, 1994; Tian, *et al.,* 2007). It also increases ROS associated with OB which may contribute to resistance via several mechanisms, including directly killing the invading pathogen (Dempsey *et al.,* 1999). Some researches indicate that 2mmolL SA showed direct fungal toxicity on *Monilinia fructicola* and significantly inhibited the mycelial growth and spore germination of the pathogen *in vitro* (Yao & Tian, 2005). Endogenous application of salicylic acid exhibits resistance to diseases (Raskin, 1992). Several findings indicated that exogenous

**Table 1:** Effect of salicylic acid and propyl gallate on chlorophyll content of ber fruits.

| Treatment X | Chlorophyll (mg/100g) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2017 | | | | | | 2018 | | | | | |
| | Days after storage | | | | | | Days after storage | | | | | |
| | 0 | 2nd | 4th | 6th | 8th | Mean | 0 | 2nd | 4th | 6th | 8th | Mean |
| Control | 0.52 | 0.22 | 0.15 | 0.10 | 0.08 | 0.21 | 0.58 | 0.28 | 0.16 | 0.12 | 0.11 | 0.25 |
| (SA,200 ppm) | 0.61 | 0.34 | 0.22 | 0.15 | 0.11 | 0.28 | 0.69 | 0.40 | 0.22 | 0.16 | 0.13 | 0.32 |
| (SA, 400 ppm) | 0.68 | 0.39 | 0.25 | 0.19 | 0.14 | 0.33 | 0.77 | 0.48 | 0.31 | 0.22 | 0.15 | 0.38 |
| (SA, 600 ppm) | 0.76 | 0.45 | 0.36 | 0.28 | 0.21 | 0.41 | 0.81 | 0.58 | 0.40 | 0.31 | 0.24 | 0.46 |
| (PG,150 ppm) | 0.57 | 0.30 | 0.20 | 0.13 | 0.10 | 0.26 | 0.64 | 0.32 | 0.18 | 0.19 | 0.11 | 0.28 |
| (PG, 300 ppm) | 0.65 | 0.37 | 0.23 | 0.20 | 0.11 | 0.32 | 0.73 | 0.40 | 0.28 | 0.16 | 0.13 | 0.34 |
| T7 (PG,450,ppm) | 0.72 | 0.40 | 0.30 | 0.22 | 0.17 | 0.36 | 0.79 | 0.44 | 0.38 | 0.28 | 0.20 | 0.41 |
| Mean | 0.64 | 0.35 | 0.25 | 0.18 | 0.13 | | 0.71 | 0.41 | 0.27 | 0.20 | 0.15 | |
| CD Value | Days | | | | 0.056 | | | Days | | | | 0.039 |
| | Treatment | | | | 0.047 | | | Treatment | | | | 0.033 |
| | Treatment X Days | | | | N/A | | | Treatment X Days | | | | N/A |

**Table 2:** Effect of salicylic acid and propyl gallte on decay loss of ber fruits.

| Treatment X | Decay Loss (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2017 | | | | | 2018 | | | | |
| | Days after storage | | | | | Days after storage | | | | |
| | 2nd | 4th | 6th | 8th | Mean | 2nd | 4th | 6th | 8th | Mean |
| Control | 3.70 | 6.30 | 7.62 | 8.32 | 6.48 | 3.95 | 6.93 | 8.38 | 9.12 | 7.09 |
| (SA,200 ppm) | 2.70 | 5.67 | 6.88 | 7.35 | 5.65 | 3.52 | 6.55 | 7.68 | 8.60 | 6.58 |
| (SA, 400 ppm) | 2.32 | 4.68 | 6.52 | 7.10 | 5.15 | 3.10 | 5.80 | 6.80 | 8.15 | 5.96 |
| (SA, 600 ppm) | 2.16 | 3.89 | 4.84 | 5.21 | 4.02 | 2.74 | 5.10 | 6.15 | 7.55 | 5.38 |
| (PG,150 ppm) | 3.10 | 6.20 | 7.25 | 8.10 | 6.16 | 3.78 | 6.81 | 7.88 | 8.74 | 6.80 |
| (PG, 300 ppm) | 3.50 | 5.14 | 6.48 | 7.25 | 5.59 | 3.38 | 6.35 | 7.30 | 8.40 | 6.35 |
| (PG,450,ppm) | 2.30 | 4.12 | 5.25 | 6.32 | 4.49 | 2.92 | 5.35 | 6.54 | 7.75 | 5.64 |
| MEAN | 2.82 | 5.14 | 6.40 | 7.09 | | 3.31 | 6.12 | 7.24 | 8.33 | |
| CD Value | Days | | | 0.441 | | Days | | | | 0.373 |
| | Treatment | | | 0.333 | | Treatment | | | | 0.282 |
| | Treatment X Days | | | N/A | | Treatment X Days | | | | N/A |

**Table 3:** Effect of salicylic acid and propyl gallate on PLW of ber fruits.

| Treatment X | Physiological loos in weight (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2017 | | | | | 2018 | | | | |
| | Days after storage | | | | | Days after storage | | | | |
| | 2nd | 4th | 6th | 8th | Mean | 2nd | 4th | 6th | 8th | Mean |
| Control | 3.28 | 6.28 | 8.92 | 10.10 | 7.14 | 4.10 | 7.65 | 9.20 | 10.35 | 7.82 |
| SA,200 ppm | 2.50 | 5.90 | 8.32 | 9.60 | 6.58 | 3.34 | 6.75 | 8.80 | 9.75 | 7.16 |
| SA, 400 ppm | 2.60 | 5.52 | 7.82 | 8.52 | 6.11 | 2.93 | 6.10 | 8.30 | 9.32 | 6.66 |
| SA, 600 ppm | 2.28 | 4.92 | 6.80 | 7.35 | 5.33 | 2.47 | 5.20 | 7.45 | 8.12 | 5.81 |
| PG,150 ppm | 3.12 | 6.10 | 8.52 | 9.80 | 6.88 | 3.50 | 7.29 | 9.11 | 9.87 | 7.44 |
| PG, 300 ppm | 2.72 | 5.65 | 8.15 | 9.20 | 6.43 | 3.19 | 6.42 | 8.65 | 9.15 | 6.85 |
| PG,450,ppm | 2.42 | 5.20 | 7.25 | 8.55 | 5.85 | 2.74 | 5.74 | 7.75 | 8.42 | 6.16 |
| MEAN | 2.70 | 5.38 | 7.97 | 9.01 | | 3.18 | 6.45 | 8.46 | 9.28 | |
| CD Value | Days | | | 0.469 | | Days | | | | 0.347 |
| | Treatment | | | 0.354 | | Treatment | | | | 0.262 |
| | Treatment X Days | | | N/A | | Treatment X Days | | | | N/A |

application of SA have induced the expression of many defense genes (Loake and Grant, 2007; Wang *et al.,* 2006). Further, it has been reported that Postharvest treatment of table grapes with SA before coating with chitosan significantly enhanced the efficacy of coating and decreased fruit total decay (Asghari *et al.,* 2009). The excessive water accumulation in fruits treated with SA has a damaging impact on fruits. However, increased AA activity under SA might be used for mitigation of excessive water content. Similar findings have been reported in Kiwifruits where fungal decay reduced remarkably under vapour treatment through minimization in activities of CAT and APX (Aghdam *et al.,* 2011). Zeng *et al.*, (2006) reported that SA treated fruits exhibited increased activity of GlU than control during 4 days. However, the level of water and the rate of $O_2$ generation were noted to be higher than there in control within 8 days of storage. Similar finding in salicylic acid treated apple and pear fruits have been reported by Yu and Zheng (2006) ; Yu *et al*. (2007).

### Physiological loss in weight (%)

The physiological loss in weight of stored ber fruit increased during storage period irrespective of treatments applied. Salicylic acid (SA) treated fruits showed the lowest fresh weight loss (5.33 and 5.81 %) and (5.04 and5.69 %) when applied as pre-harvest and postharvest treatments during 2016-17 and 2017-2018 as compared to other treatments. The highest weight loss (7.14 and 7.82 %) and (6.90 and 7.67 5) was recorded under control. The fruits treated with propyl gallate (PG) also maintained the lower weight loss than those the control.

The lower weight loss in fruits treated with propyl gallate and salicylic acid may be due to reduction in respiration rate of fruits (Asgharia and Aghdam, 2005). The weight loss occurs due to biological activities respiration and transpiration consisting of metabolism. Because salicylic acid an electron donor which prevents normal respiration and it decreases respiration rate and fruit weight loss by stomata closing (Manthe *et al.,* 199; Zheng and Zhang, 2004). Further, Shafiee *et al*. (2010) reported that, fruits of strawberry dipped in salicylic acid solution had less weight loss than control. SA acid activated the defense mechanism and cell wall strengthening enzyme in association with PAL (phenylalanine ammonia lyase) activity in pear. Addition of SA induced expression of enzymes that were important to PAL pathway by the PAL gene. Wolucka *et al*. (2005) reported that fruits which received SA in their nutrient solution showed less smaller weight loss than there devoid of fruits without SA in their nutrient solution. The weight loss is mainly in combined reflection of metabolic activity, respiration and transpiration.

## Conclusion

Salicylic acid and Proopyl Gallate reduced losses of cv Banarasi Karaka ber fruits. Their use as pre and postharvest treatments could be a promising tool for enhancing nutritional quality of fruits and extending storage life which could be beneficial for long distance transport and fetching remunerative price to growers, specially during the period when there exists a glut situation in the local markets.

## References


Abhang, A.R., G.Y. Rohokale, S.A. Pathare and P.G. Rohokale (2015). Changes in the mineral contentduring development and maturity in ber (*Ziziphus maurtiana*, Lamk) fruits cv Mehrun khedi, Mehrun and M.P.K.V. *International Journal of Current Research*, **7(2):**12425-12429.

Aghdam, M.S., A. Motallebiazar, Y. Mostofi, J.E. Moghabdam and M. Ghasemnezhad (2011). Methyl salicylate affects the quality of Hayward kiwifruit during storage at low temperature. *Journal of Agricultural Science*, **3:** 149-156.

Al-Niami, J.H., R. Saggar and M.F. Abbas (1992). The Physiology of ripening of jujube fruit (*Zizyphus spinachristi* (L) wild). *Scietia Horticultuare*., **51:** 303-308.

Aono, M.A., H. Kubo, K. Saji, Tanaka and N. Kondo (1993). Enhanced tolerance to photo-oxidative stress of transgenic (*Nicotiana lahaci*) with high chloroplastic glutathione reductase activity. *Plant Cell Physiology*, **34:**129-135.

Asghari, M. and M.S. Aghdam (2010). Impact of salicylic acid on postharvest physiology of horticultural crops. *Trends Food Science and Technology*, **2:** 502-509.

Babalar (2010). Jasmonate alters polyamine metabolism and induces Addition of salicylic acid to nutrient solution systemic protection against powdery mildew combined with postharvest treatments (hot water, infection in barley seedlings. *Journal of Experimental Botany*, **53:** 747-756.

Bal, J.S. and D.K. Uppal (1992). Ber varieties. Associated Publishing Company, New Delhi, 1-4.

Bentz, R.W., T.J. O'Grady and S.B. Wright (1952). Antioxidants and food preservation. *Food Technology,* **6(8):** 302-30.

Bowwler, C., M.V. Montogunand and D. Inze (1992). Superoxide dismutase and stress tolerance.*Annual Review of Plant Physiology and Plant Molecular Bilology*, **48:** 223-250.

Cag, S., G. Cevahir-oz, M. Sarsag and N. Goren Sanglam (2009). Effect of salicylic acid on pigments, protein, content and peroxidase activity in excised sunflower cotyledon. *Pakistan Journal of Botany*, **41:** 2297-2303.

Cao, S.F., Z.C. Hu, Y.H. Zheng and B.H. Lu (2010). Synergistic effect of heat treatment and salicylic acid on alleviating internal browning in cold-stored peach fruit. *Postharvest Biology and Technol*ogy, **58:** 93-97.

Desender, S., D. Andrivon and F. Val (2007). Activation of defense reactions in Solanaceae: where is the specificity. *Cell Microbiology*, **9:** 21-30.

Durner, J. and D.F. Klessig (1995). Inhibition of ascorbate peroxidase by salicylic acid and 2,6 dichloroisonicotinic acid, two inducers of plant defense responses. *Proceedings of the National Academy of Sciences,* USA, **92:**11312-11316.

Durner, J. and D.F. Klessig (1996). Salicylic acid is a modulator of tobacco and mammalian catalases. *Journal of Biological Chemistry*, **271:** 28492-28501.

Elder, R.L. (1985). Final report on the safety assessment of Propyl Gallate. *Journal of American Collage of Toxicology*, **4(3):** 23-64.

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

Ermosele, I.C., C.O. Ermosele and D.M. Kuzhkuzha (1991). Evaluation of mineral elements and ascorbic acid contents in fruits of some wild plants. *Plant Foods for Human Nutrition*, **41:** 151-154.

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.

Fariduddin, Q., 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.

Ghai, N., R.C. Setia and N. Setia (2002). Effect of paclobutrazole and salicylic acid on chlorophyll content, hill activity and yield component in *Brassica napus* L. (cv GSL-1). *Phytopharmologhy*, **52:** 83-87.

Greenberg, J.T., F.P. Silverman and H. Liang (2000). Uncoupling salicylic acid-dependent cell death and defense-related responses from disease resistance in the Arabidopsis mutant acd5. *Genetics*, **156:** 341-350.

Gunes, A., A. Inal, M. Alpaslan, F. Eraslan, E.G. Bagci and N. Cicek (2007). Salicylic acid induced changes on some physiological parameters symptomatic for oxidative stress and mineral nutrition in maize (*Zea mays* L.) grown under salinity. *Journal of Plant Physiology*, **164:** 728-736.

Gutteridge, J.M. and K.C. Fu (1981). Enhancement of bleomycin-iron free radical damage to DNA by antioxidants and their inhibition of lipid peroxidation. *FEBS Lett.*, **123:** 71-74.

Hayat, S., Q. Fariduddin, B. Ali and A. Ahmad (2005). Effect of salicylic acid on growth and enzyme activities of wheat seedlings. *Acta Agronomica Hungarica*, **53:** 433–437.

Kaya, C., H. Kirnak, D. Higgs and K. Saltati (2002). Supplementary calcium enhances plant growth and fruit yield in strawberry cultivars grown at high (NaCl) salinity. *Scientia Horticulturae*, **26:** 807-820.

Klessig, D. F. and Malamy, J. 1994 The salicylic acid signal in plants, *Plant Molecular Biology*. 26: 1439-1458.

Manthe, B., M. Schulz and H. Schnabl (1992). Effects of salicylic acid on growth and stomatal movements of *Vicia faba* L.: evidence for salicylic acid metabolization. *Journal of Chemical Ecologhy*, **18:** 1525-1539.

Moore, A.L., M.S. Albury, P.G. Chrichton and C. Affourtit (2002). Function of the Alternative Oxidase: Is it still a scavenger? *Trends Plant Science,* **7:** 478–471.

Pareek, O.P. (2002). Ber-*Ziziphus mauritania*. Available by International Centre for Underutilized Crops(Online). Available:http://www.civil.soton.ac.uk/icuc/cd-icuc-bertamarind/content/ber/ber-book-html via the Internet. Accessed 2004 Apr.6

Parida, A.K. and A.B. Das (2005). Salt tolerance and salinity effects on plants: a review. *Ecotoxicology and Environmental Safety*, **60:** 324-349.

Raskin, I. (1992). Salicylate, a new plant hormone. *Plant Physiol.*, **99:** 799-803.

Rendle, A.B. (1959). The classification of flowering plants. Cambridge University Press, Cambridge, UK.

Shafiee, M., T.S. Taghavi and M. Babalar (2010). Addition of salicylic acid to nutrient solution combined with postharvest treatments (hot water, salicylic acid, and calcium dipping) improved postharvest fruit quality of strawberry. *Scientia Horticulturae*, **124:** 40- 45.

Sinha, S.K., H.S. Srivastava and R.D. Tripathi (1993). Influence of some growth regulators and cations on inhibition of chlorophyll biosynthesis by lead in Maize. *Bulletin of Environmental Contamination and Toxicology*, **51:** 241.

Slaymaker, D.H., D.A. Navarre, D. Clark, O. del Pozo, G.B. Martin and D.F. Klessig (2002). The tobacco salicylic acid-binding protein 3 (SABP3) is the chloroplast carbonic anhydrase, which exhibits antioxidant capacity and plays a role in the hypersensitive response. *Proceedings of the National Academy of Sciences*, USA, **99:** 11640-11645.

Srivastava, M.K. and U.N. Dwivedi (2000). Delayed ripening of banana fruit by salicylic acid. *Plant Science*, **158:** 87–96.

Uzunova, A.N. and L.P. Popova (2000). Effect of salicylic acid on leaf anatomy and chloroplast ultrastructure of barley plants. *Photosynthetica*, **38:** 243-250.

Vashishtha, B.B. (1997). Ziziphus for drylands - a perennial crop solving perennial problems. *Agroforestry Today*, 10-12.

Wang, D., N. Amornsiripanitch and X.A. Dong (2006). Genomic approach to identify regulatory nodesinthe transcriptional network of systemic acquired resistance in plants. *PLoS Pathogens,* **2:** 123.

Wang, L., S. Chena, W. Kong, S. Li and D. Archbold (2006). Salicylic acid pretreatment alleviates chilling injury and affects the antioxidant system and heat shock proteins of peaches during cold storage. *Postharvest Biology and Technology*, **41:** 244–251.

Wolucka, B.A., A. Goossens and D. Inzé (2005). Methyl jasmonate stimulates the de novo biosynthesis of vitamin C in plant cell suspensions, *Journal of Experimental Botany,* **56:** 2527-2538.

Xie, Z., B. Fan, C. Chen and Z. Chen (2001). An important role of an inducible RNA-dependent RNA polymerase in plant antiviral defense. *Proceedings of the National Academy of Sciences*, USA, **98:** 6516-6521.

Yao, H. and S.H. Tian (2005). Effects of pre and postharvest application of salicylic acid or methyl jasmonate on inducing disease resistance of sweet cherry fruit in storage. *Postharvest Biology and Technology*, **35:**253-262.

Yildirim, E., M. Turan and I. Guvenc (2008). Effect of foliar salicylic acid applications on growth, chlorophyll and mineral content of cucumber (*Cucumis sativus* L.) grown under salt stress. *Journal of Plant Nutrition,* **31:** 593-612.

Yu, T., J. Chen, R. Chen, B. Hung, D. Liu and X. Zheng (2007). Bocontrol of blue and gray mold disease of pear fruit by integration of antagonistic yeast with salicylic acid. *International journal of Food Microbiloghy,* **116:**339-345.

Yu, T. and X.D. Zheng (2006). Salicylic acid enhances biocontrol efficacy of the antagonist *Crytococcous laurentii* in apple fruit. *Journal of Plant Growth Regulators*, **25:** 166-174.

Yu, Z., C. Fu, Y. Han, Y. Li and D. Zhao (2006). Salicylic acid enhances jaceosidin and syringin production in cell cultures of *Saussurea medusa*. *Biotechnology Letters*, **28:** 1027-1031.

Zheng, Y. and Q. Zhang (2004). Effects of polyamines and salicylic acid postharvest storage of 'Ponkan' mandarin. *Acta. Horticulture*, **632:** 317-320.