International Journal of Advanced Research and Review

www.ijarr.in

PLANT GROWTH REGULATORS AND SHELF LIFE EXTENSION OF FRUITS: CURRENT SCENARIO

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ABSTRACT
Different scientists and researchers work on various to investigate the effect of different plant growth regulators in the different climatic conditions of the world. This paper highlights the main findings of some relevant research work. The results and experimental work on the use of various plant growth regulators for the extension of post-harvest life various fruits are briefly compiled.

INTRODUCTION
Fruits are the demanding source of food in regard of nutrition and health. The demand for fruits is very much high in the market because of their unique taste and flavor. Fruits have a great potential but the post-harvest losses during transportation and storage for long term use is very high. This loss could be minimized by extending the shelf life of fruits. Several technologies are evolved to extend the shelf life of fruits and application of plant growth regulators most importantly gibberellins (GA_3) was proven be effective in extending shelf-life in different cultivars of fruits belonging to different climatic conditions. Application of GA3 increases the shelf life of fruits and besides thisit also delays the softening of pulp of fruits.

Considering above facts the present review is briefly compiled on collecting the main findings of various research scientists who worked on the use of plant growth regulators as a pre and post-harvest agent for the extension of shelf life of fruits.

MAIN FINDINGS OF VARIOUS RESEARCH WORK ON THE INFLUENCE OF PLANT GROWTH REGULATORS ON VARIOUS FRUITS OF DIFFERENT CLIMATES
Rokaya*et al*. (2016) performed an experiment on Mandarin by using different concentrations of gibberellic acid i.e. 10, 20 and 30 ppm in Nepal. The following parameters were studied i.e. fruit weight (g), rind color (1-5 index), decay loss (%), PLW (%) (Peel Puncture Resistance**)**, TSS/acid ratio, juice recovery (%), ascorbic acid ($mg100ml^{-1}$) and fruit firmness ($kgcm^{-2}$). The results revealed that GA_3 application significantly improved fruit weight, fruit firmness, juice recovery and better TSS/acid ratio. GA_3 at 30 ppm was not much superior in both the storage conditions i.e. cellar and ambient for peel puncture resistance besides control. Since, 30 ppm of

GA_3 controlled the decay loss equally at ambient temperature and cellar storage conditions instead of control at ambient and cellar.

Singh *et al.* (2016) performed an experiment on guava by using different levels of GA_3 and zinc sulphate on yield and other vegetative characteristics. The results indicated that highest fruit weight, volume, size, pulp: stone ratio was recorded in fruits treated with foliar application of GA_3 at 150 ppm.

Archana and Sivachandiran (2015) inspected the influence of GA_3 at different concentrations on shelf life of Banana c.v."Kathali". GA_3 at 250, 350, 500 and 750 ppm were applied through dipping method. Results showed that GA_3 concentrations significantly affected the quality attributes of banana during postharvest storage as compared to control. GA_3 at 500 and 750 ppm significantly increased the postharvest life of banana against the control.

Arti*et al.* (2015) investigated the response of different plant growth regulators on Kinnow in subtropical environmental conditions of Jammu and Kashmir, India. Results indicated that 20 ppm 2, 4-D significantly controlled fruit drop and increased yield. 75 ppm GA_3 increased the fruit weight, fruit length, fruit diameter, fruit volume and juice percentage.

Rizwan*et al.* (2014) studied the influence of gibberellic acid on fruit drop and fruit set in sweet orange by using different concentrations of gibberellic acid i.e. 10, 20 and 30 ppm and were applied as a foliar application on three different cultivars of sweet orange at full bloom stage in Tarnab, Peshawar, Pakistan. Results showed that percent fruit drop, percent June drop and yield tree-^{1} extensively decreased by 30 ppm gibberellic acid. However, fruit set branch-1, pre harvest fruit drop and fruit weight was improved by 10 ppm of gibberellic acid application.

Khan *et al.* (2014) accomplished an experiment on sweet orange (Blood Red) by using GA_3, 2, 4-D and combination at different bloom stages. The results showed that both GA_3 and 2, 4-D at 20 mg L^{-1} had significantly reduced the flower and fruit drop as well as increased the fruit set. In combination of GA_3 and 2, 4-D had also significantly reduced the fruit drop as compared to control.

Tuan and Ruey(2013) conducted a research on the impact of PGRs (GA_3& 2, 4-D) on apple. These growth regulators were applied at small bud and petal fall stage. Results showed that 10 ppm of GA_3 significantly affected the number of flowers. However, fruit set, fruit size and fruit drop distinctly enhanced by the application of 30 and 10 ppm of GA_3 as compared to control. The GA_3 at 30 ppm also controlled the fruit drop and improved total soluble solids and titratable acidity. Since, it was observed that 2, 4-D at 10 ppm also significantly affected the fruit growth and other physiological aspects of fruit against the control.

Lolaei*et al.* (2013) investigated the effect of GA_3 on pre- and postharvest performance of strawberry. GA_3 at 150 ppm increased the number of leaves and fruits. All the GA_3 concentrations i.e. 50, 100 and 150 ppm improved fruit weight and delayed fruit ripening. The number of stolen was significantly increased by 100 and 150 ppm as compared to control treatment.

Islam *et al.* (2013) examined the response of various concentrations of GA_3 on two cultivars of mango (Langra and Khirshapat) in Bangladesh. Results revealed that GA_3 at 400 ppm significantly affect the quality parameters of Khirshapat and extended shelf life and delayed skin color changes than Langra at all the storage interval.

Khalid *et al.* (2012) observed the impact of foliar application of Benzyl adenine and kinetine (20 mg L^{-1}), applied at flowering and fruit set stage in district Sargodha, Pakistan. However, at fruit set, BA, kinetine and GA_3 (10, 20 & 30 mg L^{-1}) respectively were applied on kinnow mandarin trees. Results indicated that all the plant growth regulators had considerable effect on juice content, ascorbic acid, TSS, titratable acidity and reducing sugars.

Nawaz *et al.* (2008) conducted a research on Kinnow mandarin by using different concentrations of GA_3, 2, 4-D and NAA to control fruit drop and enhanced quality parameters of the kinnow mandarin fruit in Faisalabad Pakistan. The growth regulators were applied in the last week of November. Results showed that all the growth regulators resulted in low fruit drop and higher fruits per plant as well as enhanced the quality attributes.

Saleem*et al.* (2008) performed an experiment on blood red sweet orange by using GA_3 and 2, 4-D as spring application at full bloom stage in Faisalabad, Pakistan. They studied the physiological and morphological attributes of the fruit. Results indicated that fruit weight, fruit diameter, peel thickness and peel quantity were greatly reduced by the plant growth regulators as compared to control. However, all the sugar contents i.e. reducing, non-reducing and total sugars, pulp percentage, juice percentage, seed quality and quantity, organoleptic properties i.e. taste, peel color, pulp color and appearance was drastically enhanced by gibberellic acid as compared to untreated fruits.

Kucuker*et al*. (2015) studied the post-harvest life of plum fruit. They applied different concentrations of AVG before harvesting. The Applications of delayed maturity, firmness, weight loss and color during storage. The minimum weight loss was at 200 mgL^{-1} AVG application in paralleled tountreated. While the lowerfirmness of the fruit was noted in untreated and more firmness was found in 200 Mgl^{-1} AVG dose.

Attri et al. (2015) inspected the influence of SA on the postharvest life of plum. The fruits subjected to SA caused reduction in weight loss as compared to untreated fruit. While the more weight loss was witnessed in the fruits dipped in distilled water as compared to 14.97% in salicylic acid after 20 days.

Luo*et al*. (2011) executed a trial to find out the impact of SA on chilling injury, respiration rate, ethylene production and disease incidence on 'Qingnai' plum fruit. They concluded that salicylic acid positively affect the respiration and ethylene synthesis. The consequences indicated that for controlling chilling injury in Qingnai plum during cold storage.

Kassem*et al.* (2011) of growth regulator conducted an experiment in order to examine the influence of foliar sprays on jujuba trees. After the fruit set of salicylic acid (SA), gibberellic acid (GA), and naphthalene acetic acid) on were applied and the fruit evaluated for the chemical quality .The analyses of the data showed that all the treatment delayed initial harvest compared

to the untreated control. By contrast all the treatment have significant effect on fruit retention, maturity index, flesh and seed weight and moisture content of the fruit.

Khan and Singh (2010) conducted in experiment to examine the effect of pre-harvest use of putrescine (PUT) for regulating fruit ripening as well as quality in Japanese plum. Trees were sprayed one week earlier thin commercial harvest. They concluded that application of 2.0 mm PUT before their harvest delay the fruit ripening by reducing the rate of respiration ethylene production and fruit softening.

Kaur *et al.* (2008) describe the behavior of growth regulators i.e. GA_3 and NAA which were sprayed twice during the fruiting season in order to check the fruit drop percentage in plum cv. Satluj Purple. Maximum fruit retention and minimum fruit drop was observed for those plant which were sprayed by GA_3 followed by NAA. Other parameters like sugar, TSS and acidity was superior or in fruits which are treated with GA_3 as compared to NAA and control.

Monika and Harminder. (2007) studied the effect of pre-harvest foliar spray of NAA, ethrel and GA_3 on fruit drop in plum cv. Satluj Purple. Among all the treatment Ethrel was effective to decrease the pre-harvest fruit drop followed by NAA. Other parameters i.e. fruit weight, TSS and yield were significantly higher in those fruit which are sprayed by ether. Carbohydrate content in shoot and leaves were found higher for those sprayed by NAA.

CONCLUSION

The review summarizes the main findings as plant growth regulators especially gibberellic acid (GA_3) have a very positive role in the extension of shelf life of various fruits of different climates. GA_3 appeared to be best pre as well as post-harvest agent for the shelf life extension of fruits.

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