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Use of Plant Growth Regulators for Improving Quality and Shelf Life of Mandarin Oranges—A Review

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Abstract

Orange (*Citrus reticulata* Blanco.) is an important citrus fruit widely cultivated in the states of Maharashtra, Madhya Pradesh, Karnataka and Rajasthan besides many other states. However, confronted by poor quality fruits, farmers hardly receive proper price in the market. Furthermore, the fruits being living entity even after harvest, they invariably undergo deterioration. Plant growth regulators (PGRs) have shown promise in improving quality and shelf life of mandarins. The present paper is an attempt to focus on the use of growth regulators in improving quality and shelf life of mandarins. From the review of literature it appears that auxins particularly NAA, 2, 4-D, ethrel and gibberellins find uses in improving quality and shelf life of mandarin fruits.

Key words : Auxins, Mandarin, Plant growth regulators, Quality, Shelf life.

Citrus fruits are quite popular throughout the world for their nutritive value, taste, processing potential and relatively margin of price over many fruits. Out of the total citrus production of the world oranges contribute almost 65% followed by mandarin 19%, lemons and limes 11% and grapefruits 5%. Country wide oranges cover an area of 1.83 lakh hectares and production is of the order of 12.36 lakh tonnes accounting for 3.8 and 2.5% share under total acreage and production, respectively (1). In India mandarin is extensively cultivated in states of Maharashtra, Rajasthan, Madhya Pradesh, Karnataka, Nagaland, Mizoram, Tamil Nadu, West Bengal and Meghalaya. Among these states, Maharashtra holds the key position in orange cultivation and 60—70% country's orange production is met in by the state alone (2). Mandarin is commercially grown for its juicy fruits, which are either used as fresh or after being converted into various value added products viz. juice, squash, cordial, concentrate, ready to serve beverage, canned segments, jam, jelly and marmalade. The fruits are delicious, refreshing and recognized as the principle source of vitamin C and folic acid from time immemorial. But the quality of fruits scarcely matches international standards resulting in poor marketing especially in global trade. Furthermore, in India post-harvest fruit losses are enormous due to poor orchard management, improper method of harvesting, unscientific handling, packaging and transport of fruits to the distant markets. The post harvest losses of citrus fruits are 5—10% in most developed countries and 25—30% in developing countries (3). Therefore, an attempt was made to review the work done on the use of plant growth regulators in improving quality and shelf life of mandarin fruits.

Improvement in Quality

Increase in Size. Small sized fruits are one of the major constraints in mandarin production. Such fruits neither look appealing nor fetch lucrative price in the market. Among various growth regulators, auxins especially synthetic phenoxy compounds viz. 2, 4-dichlorophenoxy acetic acid (2, 4-D), 2, 4-dichlorophenoxy propionic acid (2, 4-DP), 2, 4, 5-trichlorophenoxy acetic acid (2, 4, 5-T) and naphthalene acetic acid (NAA) have been found to increase size and diameter of the fruits. Application of auxins usually delays maturity and lengthens the growing period, which may reflect in the increase of fruit size (4). In an experiment on mature trees of Satsuma mandarin (*Citrus unshiu*), spray of NAA at the concentration of 400 mg/liter markedly increased the size and

Table 1. Effect of post-harvest treatments including growth regulators on the shelf life of mandarin oranges.

Variety of orange	Treatment	Storage temp (C)	Storage (days)	References
Nagpur	6% wax + 2, 4-D (100 ppm)	25 ± 6	24	19
Coorg	3% wax + 2, 4-D (100 ppm) + PE	20 – 26	21	20
Sathgudi	Vitamin K_3 (menadine)	28 – 30	16	21
Mosambi	8% wax + 2, 4-D (100 ppm) + PE	Room temp	40	22
Mosambi	9% wax + 2, 4-D (500 ppm) + carbendazim (0.1%) + non-perforated PE	Ambient	63	23

appearance of the fruit NAA is used as a thinning agent (5). Application of NAA causes early fruit drop by increasing the production of abscission–inducing ethylene and thereby increase the size of the remaining fruits. Therefore, mandarin trees expected to have excessively large number of fruits per tree should be treated with NAA. Addition of non-ionic surfactant viz. Silwet (0.05% vol/vol) in NAA sprays was found to increase the production of large sized mandarin fruits cv Murcott (6). It has been reported that the use of Crop set (a natural bio-stimulant that contains a plant extract) is useful in increasing the fruit size of mandarin fruits (7).

Up to 15% increase in size has been observed over control by application of 50 ppm of 2, 4-dichlorophenoxypropionic acid (2, 4-DP) on Satsuma mandarins (8). Similarly, consecutive sprays of 300 ppm NAA on fruitlets of Michael mandarin of 10 mm diameter followed by 50 ppm 2, 4-dichlorophenoxypropionic acid (2, 4-DP) on fruitlets of 14 mm diameter have also shown to increase the fruit size and resulted in higher income to the farmers (9). Apart from auxins, application of gibberellins (GA_3) during winter at the rate of 50—100 mg/liter has also proved to be beneficial in increasing the percentage of large sized fruits in Satsuma mandarins (10).

Degreening. Development of characteristic yellow color is an important quality attribute in mandarins which determines their marketability and price. During maturation of citrus fruits, there is loss of chlorophyll and gain of carotenoids. But in most cases, loss of chlorophyll is incomplete since it largely depends on climate. It occurs when fruits are exposed to a minimum temperature below 4 C. Alternatively, fruits could easily be degreened by exogenous application of growth regulators, especially ethylene liberating chemicals such as ethrel (ethephon ; 2-chloroethyl phosphonic acid). Ethylene gas activates the chloropyllase enzyme which causes degradation in the chlorophyll content of the rind (4). Several workers have used aqueous solution of ethrel as a pre-harvest spray for degreening the citrus fruits. The effective concentration of ethrel depends upon the cultivars and prevailing climatic conditions. It has been observed that pre-harvest spray of 250 ppm ethaphon in combination with 1% of calcium acetate and 500 ppm of carbendazim on Nagpur mandarin advanced the color development by 20 days with less fruit abscission, less decay and better flavor and over all acceptability (11). Pre-harvest application of ethrel to the ripening fruits gives homogenous coloration and degreening fruits at one time, facilitates uniform and single picking. Ethrel also loosens the fruit, making hand picking easy. Post harvest degreening of mandarin fruits can be done in degreening chambers. In an experiment it was found that when mature (yellowish green) Nagpur mandarin fruits were exposed to 5 ± 2 ppm ethylene concentration under trickle system at 27—29 C and 90—95% RH in a degreening chamber (170 × 170 × 227 cm internal dimension) it took 48 hours to develop yellow to yellowish- orange color and disappearance of green color (12). Degreening of mandarin fruits can also be achieved by dipping of fruits in 100—200 ppm ethrel solution, however, dipping of fruits at higher concentration than this caused appearance of black spots and deterioration in the quality of fruits (13). In Satsuma mandarin, degreening with ethylene had no effect on TSS and acidity content (14).

Post-Harvest Handling

Like other fruits mandarin is also seasonal and perishable in nature. During the harvesting season, there is a glut in the market leading to low rates and post-harvest losses. These losses can either be due to pathological breakdown or due to respiration, transpiration, mechanical injuries encountered by poor harvesting and handling techniques, chilling injury and physiological disorder such as rind breakdown, fruit softening (15). In India, the prevalence of high inoculums of pathogens in the orchard due to poor plant protection measures besides non-adoption of scientific harvesting, handling, storage and transport lead to heavy post-harvest losses and hence farmers could not get reasonable price for their produce (16). Under such conditions, the post-harvest losses of oranges are estimated to 8.3—30.7% (17). Whereas, during off season, prices go high due to shortage of supply. Therefore proper storage of citrus fruits for extended period is essential for phased selling. Researches have shown that by low temperature management immediately after harvest and during storage causes reduction in metabolic activities viz. respiration, ethylene synthesis, thermal decomposition and microbial decomposition and extension in storage life of fruits could be achieved (18). Off late, growth regulators have been put to use for short term storage of fruits at room temperature with appreciable success. The use of certain growth regulators in many cases not only keeps the fruits in good physiological condition for a few weeks but also reduces decay losses (Table 1).

Minimum PLW (6.3%) has been reported in Kinnow fruits treated with 200 ppm of 2, 4-D and wrapped in HDPE film after 90 days of storage at ambient temperature (13—25 C) (24). Similarly, orange fruits treated with 2, 4-D+topsin and wrapped in polyethylene film remained green and glossy with good eating quality for longer duration (25). It was observed that pre-harvest application of GA_3 along with Silwet L-77 (0.05%) prolonged the shelf life of mandarin hybrids with higher retention of green color, greater peel puncture resistance and reduced post harvest pitting (26). Post-harvest dip of mandarin fruits in GA_3 reduced the physiological loss in weight (PLW) and promoted the shelf life of fruits at 12.5—30 C storage temperature (27). Similarly, application of 200 ppm of GA_3 in combination with 9% wax emulsion was reported to prolong the shelf life of Kinnow mandarin fruits up to 28 days with lower physiological loss in weight (17.9%), less spoilage (13.9%) and highest organoleptic score (7.5 / 10.0) (28).

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