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Pre-Harvest Treatments Influencing Post Harvest Life of Mango

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Introduction

Mango *(Mangifera indica* L.) belonging to the family Anacardiaceae is one of the oldest and most important crops of the world, mainly grown in the tropical and subtropical region. It is known as the King of fruits and more than 1000 varieties exist today.

India is the largest producer of Mango in the world followed by China, Thailand, Mexico and Indonesia. From an area of about 2262.8 thousand ha of land, the production of Mango in India was around 19686.9 MT with
a productivity of 8.7 MT/ha (Indian database 2016-17). Uttar Pradesh is the leading producing state in India followed by Andhra Pradesh and Karnataka. In Uttar Pradesh, it occupies an area of 264.93 thousand ha with an annual production of 4540.23 thousand MT with a productivity of 17.1 MT/ha (Indian database 2016-17).In the North-eastern part of India, it is grown on a limited scale mostly in Assam, Tripura and in some parts of Nagaland, Mizoram and Arunachal Pradesh. In Nagaland, it is cultivated in an area of 0.64 thousand ha with an annual production of 4.19 thousand MT and with a productivity of 6.5 MT/ha (Indian database 2016-17).

Mango is a highly nutritive fruit and it is a rich source of vitamin A. Immature and green mature fruit are suitable for pickling and chutney preparation because of theirs acidic nature and Ripe fruits are used in the preparation of juices, squash, jam, nectar, custard powder, baby food,mango leather etc. The unripe mango fruits is reported to have 90% moisture,0.7% protein ,0.1% fat,8.8% carbohydrates,0.01% calcium, 0.02% phosphorus, 4.5 mg/100 g iron, carotene (as vitamin A- 150 i.u), 30 µg/100 g riboflavin, 3 mg/100g ascorbic acid(Anon,1962). The ripe fruit is reported to have 83.46-86.70% moisture,0.82 g protein, 0.38 g fat, 14.98 g carbohydrate, 11 mg calcium, 14 mg phosphorus, 0.16 mg iron ,0.135-1.872 vitamin A (mg/

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100g β-carotene), 0.038/ 100 g riboflavin and 36.4 mg/100 g ascorbic acid, 12.0-23.0 TSS (B), 0.12-0.38% acidity (Anon,2010).

A wide range of pre-harvest factors can affect the quality and post-harvest life of the harvested product. These include biological factors (pathological, entomological, animal); physiological factors (physiological disorders, nutritional imbalances, maturity); environmental/cultural factors (e.g. climate, weather, soils, water relations, light intensity); mechanical damage; extraneous matter (growing medium, vegetable matter, chemical residues); and genetic variation and aberrations. Creating and or maintaining production conditions that minimize undesirable product appearance is essential.

The pre-harvest factors like light, temperature, carbon and water availabilities affect fruit growth during its development by changing the accumulation of water and dry matter, including biochemical and mineral compounds and fruit behaviour during its storage, which can be controlled by various cultural practices such as tree pruning, fruit thinning and irrigation management (Lechaudel*et al.*, 2007)

Pre-harvest treatments in mango

The pre-harvest treatments may reduce the fungal inoculums on the surface of the fruit, residues of fungicides on the fruit surface may protect the wounds that are created at harvest and handling and may control latent infections (Xiao et al., 2011).

A. Application of plant growth regulators

Pre-harvest sprays of plant growth regulators have been proved to be effective in enhancing the shelf life of fruits besides improving the flowering and quality of mango. The use of Plant Bio Regulators such as auxins, gibberellins, cytokinins, abscisic acid and paclobutrazol as pre-harvest sprays can increase the shelf life of the fruit and also improve its growth parameters.

Naleo (2008) reported that the treatment paclobutrazol @ 5 ml and NAA@100ppm were found to be effective as a pre-harvest spray for enhancing the flower characters yield and its attributes as well as physio-chemical characteristics of fruits. The longest shelf life (15.33 days) was shown by PVZ treatment closely followed by NAA (15 days).

Tadur*et al.*(2017) reported that fruits trees sprayed with 75 ppm GA3 at 20 DBH (T3) and 1.50% $CaCl_2$ at 20 DBH(T6) took more days for ripening (16.3 and 16.0 days) while

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it was found to be least in control (8.3 days). Fruits sprayed with GA3 @75ppm at 20 DBH showed shelf life up to 21.0 days followed by 1.50% $CaCl_2$ at 20 DBH (20.8days) as against 11.3 days of control trees. Spray of 75 ppm GA3 at 20 DBH and spray of 1.50% $CaCl_2$ at 20DBH significantly improved the physio-chemical parameters and organoleptic evaluation of mango fruits compared to control

Tsomu and Patel (2019) concluded that three spray applications of NAA 20 mg/l + Borax 0. 2 % at full bloom, pea and marble stages effectively increased the fruit yield (79.97 kg/tree) and various biochemical parameters such as highest TSS, reducing and non reducing sugar, total sugar and ascorbic acid whereas the highest shelf life (13.83 days) of fruits during storage was recorded with NAA 20 mg/l + ZnSO4 0.5 % on mango cv. Mallika.

B. Application Of Nutrients

Bhatt *et al.* (2008) studied on pre-harvest application of nutrients on yield, quality and shelf life of mango cv. Dashehari by giving pre-harvest foliar spray of nutrients at 'marvel stage' of mango fruits. The treatments include $CaCl_2$ @ 1.2 %, Borax @ 0.5 %, K_2SO_4 @ 0.5% , $Ca(NO3)_2$ @ 1.0 %, $ZnSO_4$ @ 0.5%, $ZnCl_2$ @ 0.3 % and control. The results obtained indicated the minimum physiological loss in weight (30.22%) followed by (30.33%) in 1.0% Ca $(NO_3)_2$ and $CaCl_2$ @ 1.2% receptively on 12th day of storage.

Bhatt *et al.* (2012) studied the foliar application of potassium, calcium, zinc and boron to enhancethe yield, quality and shelf life of mango. The minimum physiological loss in weight was reported in 1.0% Ca $(NO_3)_2$ followed by $CaCl_2$ (1.2%) up to the end of the 12th day of storage. Other quality parameters like fruit TSS, sugar and ascorbic acid content were best maintained by borax, calcium and potassium treatment.

Bhowmick*et al.* (2012) studied the response of pre-harvest foliar application of zinc and boron on mango cv. Amrapalli under the new alluvial zone of West Bengal. The chemicals, zinc sulphate (0.5, 1.0 & 1.5%) and borax (0.25, 0.5 & 0.75%) were sprayed at pea and marble stages of fruit growth and development. And maximum fruit retention at marble stage (40.95%), at harvest stage (7.66%), a maximum number of fruits per plant (170), maximum yield per tree (36.00 kg) and maximum reducing sugar (5.10%) were obtained with borax 0.5%. Whereas, average maximum fruit length (10.33 cm), breadth (6.33 cm), was recorded with borax 0.25% and maximum pulp content (73.57%), reduced peel

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content (11.49%) and minimum stone percentage (14.95%) were obtained from the treatment with borax 0.75%.

Singh *et al.* (2012) studied the effect of pre-harvest chemical treatments and mulching on 10 years old Dashehari mango. They sprayed $CaCl_2$at 2.0, 4.0, 6.0 % and Ca $(NO_3)_2$ 4.0 % in combination with polythene mulching and control (water spray without mulching) at 30 days before the anticipated harvest date. Maximum fruit marketability (90.01%) and minimum physiological loss in weight (23.99%) was recorded in 2.0% $CaCl_2$ in combination with mulching on10th day of storage.

Yongkongtula (2013) concluded that the spray applications of 100 ppm NAA atthe pre-bloom stage were found out to be best for flowering characters in mango plant and 40 ppm NAA along with bagging of mango fruit was found to be superior in setting maximum no. of fruits and enhancing the yield of mango. T3 (200 ppm) along with B^1(bagging) was found to be best for improving the physical characters of mango.

Jakhar and Pathak (2014) observed that the spray of 2% $CaCl_2$ and 1% K_2SO_4 combined with bagging was found superior to increase the quality of fruits in respect of fruit weight, TSS, ascorbic acid, sugars, β-carotene content and TSS: acid ratio and decrease the total acidity with minimum black-spotted fruits per cent and highest organoleptic quality among all treatments in both the seasons.

Karemera*et al.* (2014) studied the effect of pre-harvest calcium chloride on postharvest behaviour of mango fruits (*Mangifera indica* L.) cv. Alphonso. The results revealed that 1.50% $CaCl_2$ significantly increased the number of days taken for ripening of fruits, the shelf life of fruits, physicochemical parameters and organoleptic evaluation of mango fruits compared to control. Higher fruit length (12.49cm), breadth (7.73cm), thickness (6.97cm), fruit weight (347.89g) and pulp weight of fruit (215.56g) were recorded when trees were sprayed with $CaCl_2$ @ 1.50% at 30days before harvest.

Karemera and Habimana (2014) reported that the shelf life of mango cv. Totapuri was extended to 25.89 days when sprayed with 1.50% $CaCl_2$at 30 days before harvest.

Rio (2015) reported that the treatment T_1 (NPK:1000:400:800) showed maximum TSS(19.76^0Brix),total sugars(11.66%), reducing sugars(2.75%), non-reducing sugars(8.91%), TSS: Acid ratio (164.66) and ascorbic acid content(44.72 mg/100g) followed by T_5 (NPK 50%+ FYM 50%) with TSS of 18.43^0 Brix, total sugar of 9.93%, reducing sugar of 2.57%,

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non reducing sugar of 7.00%, TSS: acid ratio of 141.76 and ascorbic acid content of 38.48 mg/100 g.

Singh *et al.*(2017) studied the influence of pre-harvest treatments on shelf life and fruit quality of Dashehari mango and it was revealed that fruits double sprayed with 1% $CaNO_3$ started ripening at 7^{th} day of storage and reached deterioration at 13^{th} day while untreated fruits started ripening at 5^{th} day and reached deterioration stage at 9^{th} day). Maximum fruit firmness (3.47 $kgcm^2$), shelf life (6.0 days) and organoleptic score (8.9) were recorded under double sprayed 1% $CaCl_2$ treatment followed by double sprayed treatment compared to a minimum in control. Minimum loss in weight was recorded with double sprayed 1% CaNO3 (3.50 %) followed by $CaCl_2$ (3.43 %) while maximum in control (9.40 %) at control ripening stage.

Pavithra (2018) concluded that treatment with Agricol (2.5g) and DOT (2.5g) was found to be good in all aspects of Mango compared with Chemibor-P as Agricol 2.5 g was found to give more yield of fruits with good size fruits and enhanced the quality of fruits including a bioactive compound in mango fruits. Highest TSS (21.75 and 22.04 ^{0}Brix), low acidity (0.17 % and 0.17%), maximum TSS acid ratio (66.91 and 65.50), total sugar (18.86% and 18.61%), reducing sugar (7.33% and 7.43%) in the north east and south-west of canopy were found to be maximum with Agricol treatment (2.5) closely followed by Agricol (5g).

C. Special Horticultural Practices:-

1. Mulching

Mulches have a substantial impact on enhancing the sustainable yield and quality of fruit. It improves the physical and chemical qualities of the soil and the availability of the nutrient pool and biological qualities by increasing beneficial soil microbes (Dutta and Kundu, 2012).

Singh *et al.* (2012) studied the effect of black polythene mulching and pre-harvest chemical treatments on Dashehari mango and it was revealed that the treatment of 1.0 % borax with polythene mulching was found more effective for increasing the fruit weight (161.66 g) and yield (37.20 kg/tree). This treatment was also found effective for increasing the TSS (16.22 &19.51°Brix), total sugars (8.98 & 15.94%) and for decreasing the acidity (0.32 & 0.16%) at the time of harvest and end of the storage period, respectively. Onthe 10th day of storage, the maximum fruit marketability (90.01%) and minimum physiological loss in

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weight (23.99%) were observed with the treatment of 2.0% $CaCl_2$ in combination with mulching. They reported $CaCl_2$ at 2.0% is effective for improving the fruit marketability and decreasing the physiological loss in weight (PLW); whereas, the borax at 1.0% with mulching proved effective for improving the fruit quality of Dashehari mango.

Kulkarni *et al.* (2013) studied the effect of mulching and chemical treatments on the shelf life of mango cv. Keshar, where mulching was done in the first week of October and chemicals viz. $CaCl_2$ (2.0, 4.0 and 6.0 %), Ca $(NO_3)_2$ (4.0 %), K_2SO_4 (1.0%) and borax (1.0 %) were sprayed one month prior to harvesting. Significant differences in the physiological loss in weight PLW up to 8 days of storage were recorded. Minimum PLW (25.85 %, 24.21%) throughout the storage period was recorded in (mulching + 4.0 % Ca $(NO_3)_2$, mulching +2.0% $CaCl_2$) and the maximum (30.92 %) was recorded in control. The application of calcium salts showed a beneficial effect on the postharvest life of fruits.

Bhusan*et al.* (2015) reported that the treatment of $CaCl_2$along with mulching proved very effective for maintaining higher marketability standards of mango fruits. A significantly higher percentage of marketable fruit (95.51%, 94.63%, 93.63%, 90.58%) on the 6th, 8th, 10th and 12th day of storage was recorded with fruits treated with black LDPE mulching + $CaCl_2$ @ 2.0%. Whereas lower marketable fruit percentage was observed in control on the 12^{th} day of storage. Therefore the use of $CaCl_2$ @ 2.0% along with mulching seems to be more economical for improving fruit marketability that is shelf-life.

Das and Dutta (2018) reported that fruits treated with black polythene mulch showed less evolution of CO_2 compared to other mulching mulches used, black polythene mulch proved to be most effective in improving the fruit physicochemical parameters of fruit and biological attributes of soil and also helps in increasing the shelf-life of fruit during storage having good marketable quality.

2. Planting Density

Dutta *et al.* (2019) reported that increased in plant growth, fruit yield and fruit quality parameters per unit area were found out to be maximum in planting density of1600 plants per hectare (2.5x2.5 m) as compared to the planting densities with 1333 (3x2.5 m) and 2666 (2.5x1.5 m) plants in Amrapali mango in sub-humid climate. Plant vegetative, reproductive variables and fruit quality parameters were evaluated at second to fourth years after transplantation in the field.

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High-density planting is a highly efficient and advanced production system of fruit cultivation. High yield and good fruit quality can be achieved with a high-density orchard in mango when the orchard has good light distribution throughout the tree canopy and there is a balance between vegetative growth and cropping. Plants spaced at 2.5 x 2.5 m spacing with plastic mulch increased the yield per hectare (Sagar *et al.* 2019).

3. INTERCROPPING

Various cropping sequences had a significant effect on the biochemical characters of mango fruit the maximum TSS content (18.33^0 Brix),Ascorbic acid content(66.13 mg/100g) of mango was recorded in T2-mango + pea + brinjal, whereas total sugar(13.34%) was recorded maximum in T7- mango + cauliflower + elephant foot yam (Longkumar 2006).

Singh *et al.* (2013) reported that maximum fruit length (8.20 cm) and breadth(7.21 cm) were recorded in Mango + Cowpea, peel weight (35.67 g) was highest in Mango + Soybeans whereas the higher stone weight (35.79 g) was in sole crop (Mango only).The pulp weight and pulp: stone ratio (193.53 g and 5.80) were observed in Mango + French bean respectively. The quality parameters such as TSS, reducing sugar, vitamin c, acidity and shelf-life showed non-significant variation among the different treatments.

4. Pruning And Training

Pruning resulted in significantly higher fruit weight, fruit firmness, total carotenoids, antioxidant capacity and total phenolic content. Early maturity of fruits was observed from unpruned trees with faster color change, higher total soluble solids and lower titratable acidity. The fruits harvested from pruned trees showed slower ripening, and lower respiration, ethylene evolution rate and enzyme activity as compared with fruits from unpruned trees (Asrey*et al.*, 2013).

5. Thinning

When fruits were thinned to one and two fruits per panicle, fruit number, weight and yield per tree at harvest were all increased. When 50% of the panicles were thinned there was an increase in the fruit retention potential of the trees as well as in the size and quality of the fruit produced (Yeshitela*et al.*, 2004).

6. Irrigation

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Wei *et al.*(2017) concluded that the mango fruit production and quality at the fruit growth stage were significantly affected under different irrigation water treatments amounts (T1:79%-82%, T2:75%-78%, T3:71%-74%, T4: 65%-70%, T5:63%-66%) Amount of applied irrigation water for different varied from 2.93m^3 to 1.08 m^3 showed variation in soil water content not only had effects on fruit size but also fruit yield. The highest fruit yield and irrigation water use efficiency were obtained from the T4 treatment. Irrigation water amount also affected fruit quality parameters like fruit total soluble solids, soluble sugar, starch, titratable acid and vitamin C content.

7. Fruit Bagging

The pre-harvest bagging had a significant effect on all qualitative parameters, spongy tissue occurrence and mealybug incidence at a ripe stage in mango cv. Alphonso (Haldankar*et al.*, 2015)

Islam *et al.*(2017) concluded that brown paper bags showed the best performance for fruit retention, days required for harvesting, fruit length, total soluble solids, pulp weight, pulp stone ratio and β-carotene content of fruit. White paper bag contributed the best performance for citric acid content, reducing sugar and total sugar content whereas muslin cloth bag increases fruit diameter and stone weight. Bagging showed a significant effect on mealybug infestation. Bagged fruits were found to have a good shelf life which is an important criterion for exportable mango.

Mohapatra (2016) reported that fruit bagged with Newspaper bag at the ripe stage of mango cv. Ratna showed the highest TSS content (22.40 ^{0}Brix) and lowest (8.50^0 Brix) in a brown paper bag with polythene bagged fruit. The highest total sugar content(3.92%) in scurting bagged fruit and lowest (3.52%) in a brown paper bag with polythene bagged fruits, highest acidity in control (2.19%) and lowest in scurting bagged fruits (1.83%) were recorded. Maximum β- carotene content was recorded in brown paper bagged fruit at harvest (329.65 µg/100g) and ripe stage in butter paper bagged fruit (12489.60 µg/100g).

8. Maturity Indices

Amarakoon*et al.* (1999) suggested that the rising of the shoulder with maturity is better to indicate on of maturity than peel colour development in mango cv. Karuthacolombon, Velleicolombon and Willard. They further recommended that the mean

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value of TSS recorded from Karuthacolombon and Velleicolombon harvested 13 weeks after flowering was 18° Brix while titrable acidity was 0.3%. The fruits harvested before optimum stages of maturity contained significantly lower TSS, higher titrable acidity and poorer sensory properties than matured fruits.

Khdachikar*et al.* (2001) reported the optimum stage of maturity for the harvest of mango variety Neelum as 110 days after the fruit set. They further suggested that the specific gravity of fruits increased with fruit development and reached a peak of 1.14 at 70 days after the fruit set. Acidity and ascorbic acid content in developing fruits increased up to 90 and 70 days after fruit set respectively and then decreased to 1.5% and 70.5 mg/ 100g respectively at 110 days after fruit set. The level of total soluble solids, total sugar and total carotenoids increased gradually with maturity up to 120 days after the fruit set. Result did not show any significant changes in Physico-chemical characteristics between 110 and 120 days after the fruit set.

Conclusion

The quality, as well as storability of mango fruits, depends much on pre-harvest treatments. Like other many fruits, mango is also perishable and after harvest spoils rapidly. Post-harvest losses in mango are estimated in the range of 25 to 40 per cent which may result due to pre-harvest factors. For the quality assurance in mango, pre-harvest practices are necessary to minimize the losses. In this regard use of plant growth regulators and chemicals that affect the ripening process directly or indirectly has been found very promising. Maximum researches were done in plant growth regulators and chemicals application. PGRs and chemicals give the best results in terms of quality and shelf-life improvement. Scarcity in the application of plant growth regulators and chemicals during the developmental stages results in poor storability due to the increased rate of respiration and irregular biochemical function of fruit cells. Foliar spray with GA_3 and $Cacl_2$ at the marble stage were found out to give the best results in improvement of shelf-life, Physico-chemical parameters and organoleptic evaluation of the fruit.$CaCl_2$ along with black polythene mulching are best in decreasing physiological loss in weight thus, gives higher marketability standards. For good fruit colouration and smoothness of the fruit surface, pre-harvest bagging is found to be the best treatment.

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