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Review Article

Review on Post-Harvest Diseases and Management of Mango Fruits

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ABSTRACT

Botanical name of mango is *Mangifera indica L.* and is the most important species of the genus *Mangifera*. The main objective of this study was to find out the most important pre-harvest treatment and management of mango fruit to get the maximum fruit yield with better quality and shelf life of mango. Shelf life is one of the important quality characters for fruit production especially for climacteric fruits which might be affected by various factors. Post-harvest management means the handling of an agricultural product after harvest to prolong storage life, freshness and an attractive appearance. Postharvest diseases of mango include anthracnose caused by *Colletotrichum gloeosporioides*, stem-end rot by *Lasiodiploidia theobromae*, Diplodia stem-end rot by *Diplodia natalensis*, black mould rot by *Aspergillus niger*, brown spot by *Pestalotiopsis mangiferae* and black spot rot by *Phomopsis mangiferae*. This study aimed at reviewing the management of post-harvest disorders like field burning of crop residues, soil tillage, fertilization, irrigation, weeding, and other horticultural practices used to control or reduce losses from plant disease. Chemical fungicides are the primary means for management of the post-harvest diseases of fruits and vegetables. Benomyl was found more effective against quiescent infections of anthracnose of mango in hot water than cold water.

Keywords: Mango; Anthracnose; Pathogen; Post-harvest diseases; Management

INTRODUCTION

Mango is native to India and is one of the most important fruit crops world-wide. Its botanical name is *Mangifera indica L.* and is the most important species of the genus *Mangifera*, which produces the most delicious fruit called the mango. The genus *Mangifera* contains about 49 species, of which 8 are of doubtful status and 41 are valid species. Morphologically the genus could be separated under two sections based on the character of the flower disc: the first, with 34 species, has flowers with well-developed swollen disc, and the second, with 7 species, has obsolete or pedicellate disc [1].

The history of Mango began thousands of years ago on the Indian sub-continent. The Mango is the national fruit of India, Pakistan, Philippines and Bangladesh. In ancient India, the ruling class used names of Mango varieties to bestow titles on eminent people, like the honour given to the famous courtesan of Vaishali, Amrapali. The Mango tree was also associated with the god of love "Manmatha" and its blossoms were considered to be the god's arrows by the Hindu Nanda kings. It was during the Nanda rule that Alexander arrived in India and fought the famous battle with King Porus. When it was time for him to return to Greece, he took with him several varieties of the delicious fruit [2].

Many parts of the plant, namely, trunk, branch, twig, leaf, petiole, flower and fruit have many pharmacological properties like Anticancer, Antidiabetic, Anti-inflammatory, Hepatoprotective, Anti-hemorrhagic, Anti-tetanus, Analgesic and Antipyretic, Kidney damage, Anti-ulcer, Antibacterial, Antifungal, Antiviral, Antimalarial etc. [3].

The main objective of the experimental study was to find out the most important pre-harvest treatment to get the maximum fruit yield with better quality and shelf life of mango. Shelf life is one of the important quality characters for fruit production especially for climacteric fruits which might be affected by various factors. Shelf life of mango fruits as influenced by different plant nutrient availability, climatic factors, harvesting, handling and post-harvest management, packaging materials and temperature in storage room [4]. Mango is an important component of the diet in many countries in the subtropics and tropics. In regions of the world that have experienced low living standards and serious nutritional deficiency, their attractiveness and flavor have also enhanced the quality of life [5]. However, mango production is consternated by a number of diseases at all stages of its development, right from the seedling in the nursery to the fruits in storage or transit. Field diseases result in the crop loss while postharvest diseases are directly

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linked with the losses in export and domestic market [6].

DISEASES AND DISORDERS

A range of leaf, fruit, and soil diseases can affect mango, many of which can be adequately controlled with good management and use of fungicides and bactericides. The diseases are powdery mildew, anthracnose, blossom blight, die back, malformation, sooty mould, shoulder browning, phoma blight, red rust, sclerotium rot, root rot and damping off, bacterial canker, lichen, gummosis, wilt, etc. Some of these diseases cause heavy loss, and have become limiting factor in mango cultivation. In India, powdery mildew, die back, malformation, anthracnose, etc. cause great economic loss to the orchardists. Other fruit diseases are Alternaria rot (*Alternaria alternata*), Powdery mildew (*Oidium mangiferae Berthet*), Stem end rot (*Lasiodiplodia theobromae*, *Dothiorella dominicana* or *Phomopsis mangiferae*), and Mango malformation (*Fusarium* sp.) As it is not possible to control all diseases completely but it should be kept under such a level that it does not cause major economic loss. For this purpose, it is required that integrated disease management practices should be adopted for their control [7].

POST-HARVEST DISEASES

Sriram and Poornachanddra discussed about the post-harvest management means the handling of an agricultural product after harvest to prolong storage life, freshness and an attractive appearance [8]. Post-harvest management operations are quite diversified, consisting of collection, curing, pretreatment, grading, packaging, pre-cooling, low temperature storage, pallet loading, transporting, and depending upon various crops. Postharvest diseases of mango include anthracnose caused by *Colletotrichum gloeosporioides*, stem-end rot by *Lasiodiploidia theobromae*, Diplodia stem-end rot by *Diplodia natalensis*, black mould rot by *Aspergillus niger*, brown spot by *Pestalotiopsis mangiferae* and black spot rot by *Phomopsis mangiferae* [8].

There are various reasons for post-harvest losses of horticultural produce like mechanical injury, injuries due to thermal shock, disease and pest attack, microbial attack and physio-biochemical reasons.

ANTHRACNOSE

Colletotrichum gloeosporioides causing Anthracnose disease in mango is worldwide in distribution and is pathogenic to more than 470 different host plant at various development stages of plants. Anthracnose is a serious fungal disease of flowers, fruit, and leaves. Anthracnose of mango disease is caused by two species where *Colletotrichum gloeosporioides* is mainly responsible and *Colletotrichum acutatum* plays very less role in few locations [9].

The pathogen possess a threat to many economically important crops such as mango, almond, apple, Arabica coffee, guava, dragon fruit, sorghum and strawberry. Amongst them mango anthracnose is very important from Indian prospective. Postharvest anthracnose is the major reason for losses of mangos during storage and transport [10].

SYMPTOMS AND HISTORY OF PATHOGEN *COLLETOTRICHUM GLOEOSPORIOIDES*

C. gloeosporioides is one of the frequently reported plant pathogens among genus *Colletotrichum* in India. The naming is based on *Vermicularia gloeosporioides*, the type specimen of which was collected from Citrus in Italy. In India, it was first reported by Butler on coffee. The germination in *C. gloeosporioides* follows two routes: pathogenic and saprophytic. Pathogenic germination takes place on plants or on a hydrophobic surface and is characterized by fast mitosis followed by development of a single germ tube [10].

At flowering and early fruit development, anthracnose causes the flowers and young fruit to develop black lesions and be aborted from the inflorescence. At flowering stage wet conditions promote anthracnose development. When the fruit softens during the ripening process, the natural defense mechanisms break down, and latent infections of anthracnose develop into black lesions that rot the whole fruit in days [11]. Anthracnose attacks flowers, young fruits, leaves and twigs, even this disease can also appear in the storage of mature fruits. Disease symptoms appear as slightly, black, sunken irregular shape lesions, which gradually enlarge and developed, leaf spotting, blossom blight, fruit staining and rot as heavy infections cause rapid rotting [12].

CONTROL OR MANAGEMENT

Control of post-harvest diseases in Mango can be achieved by a combination of pre-harvest and post-harvest pesticide application, orchard hygiene and post-harvest temperature management. Control of diseases occurring on leaves, stems and flowers (pre-harvest) are important in reducing post-harvest losses.

Blossom infection by anthracnose can be controlled effectively by to sprays of carbendazim (0.1 percent) at 15 days interval, while the foliar infection can be controlled by spray of 0.3 percent Copper oxychloride. For the control of post-harvest fruit infection, pre-harvest sprays of 0.1 percent thiophanate Methyl or Carbendazim followed by post-harvest hot water treatment at 52 ± 1 DC for 30 min. have been found effective. The duration of hot water treatment can be reduced to 15 min by adding carbendazim (0.05 per cent) [13].

Chemical fungicides are the primary means for management of the post-harvest diseases of fruits and vegetables. Benomyl was found more effective against quiescent infections of anthracnose of mango in hot water than cold water. The effectiveness of hot water dips as post-harvest treatments for the control of mango anthracnose has been known for many years. Dip treatment with propiconazole at 500 ppm and *Cannabis sativa* extract were most effective against anthracnose [9].

Induction of resistance by using physical, biological, and chemical elicitors is becoming popular alternatives to chemical fungicides for controlling post-harvest diseases of mango. Field burning of crop residues, soil tillage, fertilization, irrigation, weeding and other horticultural practices used to control or reduce losses from plant disease can be beneficial to the environment and thereby maintain sound ecological balance [14].

The major benefit of essential oils is their bioactivity in vapour phase which act as fumigants to protect stored products. These essential oils are found to be effective against many phytopathogens and to protect post-harvest diseases [15]. The quality of mango fruit could be improved by application of some harmless substances in the form of plant extracts such as botanicals. These botanicals are sustainable, cost-effective and effective against many post-harvest pathogens [16]. Botanicals *viz.*, Indian lilac (*Azadirachta indica*), Eucalyptus (*Eucalyptus camaldulensis*), Garlic (*Allium sativum*), Ginger (*Zingiber officinale*) and Rubber bush (*Allotropic procera*) at

5%, 7% and 8% concentrations were used with spraying to control post-harvest diseases of mango [16]. Essential oils *viz*., Basel oil (*Ocimumba silicum*), Orange oil (*Citrus sinensis*), Lemon oil (*Citrus medica*) and Mustard oil (*Brassica juncea L.*) at 150 ppm (µg/mL) are used to reduce post-harvest losses of mango by *C. gloeosporioides* [17]. Thymol-based essential oil showed a strong fungi toxic activity against *C. gloeosporioides*. Moreover, coating of individual mango with coconut oil, mustard oil, desi ghee and natural wax are used to protect the fruit from many postharvest pathogens. The oils are smeared on the surface of the fruit with cotton swab. After coating, fruits should be air dried and stored at room temperature in pierced brown bags for 7 days [18].

STEM END ROT

Stem-end rot is the most common postharvest disease of mango (*Mangifera indica L.*), resulting in sporadic losses of up to 20% [19]. *Botryosphaeria dothidea* growing endophytically in pedicels spreads into fruit a few weeks before they reach harvest maturity and forms quiescent infections [19,20]. Alternatively, the fungus may infect fruit through wounds during harvest and subsequent handling [19,20]. On ripening, the fungus resumes growth and further invades the fruit.

In recent years, there has been a rising demand for ripe and ready-to-eat fruit. However, as the fruit ripens, it becomes susceptible to various postharvest diseases [21]. Stem-End Rot (SER) disease occurs in various fruit and particularly in tropical and subtropical fruit, including mango, avocado, citrus, mangosteen, carambola and others. In mangoes, for example, SER is considered to be the second most severe disease worldwide, after anthracnose, caused by *Colletotrichum gloeosporioides* [22]. While in dry areas, SER is the major postharvest pathogen. For example, in Israel, SER caused 30%-40% loss of harvested mango fruit during 2014 [23]. SER-causing pathogens penetrate to the stem through natural openings and wounds, mainly during inflorescence and flowering stages. Those fungal pathogens live endophytically, mainly in the phloem but also in the xylem, and exist asymptomatically in the stem tissue until fruit ripening [19]. Unripe fruits are resistant to SER. This resistance is compromised when fruit ripening initiates during fruit storage [24]. During ripening, fruits undergo dramatic biochemical and physiological changes including ethylene emission in climacteric fruit and other phytohormone changes, accumulation of soluble sugar, cell wall loosening, a decrease in phytoanticipin and phytoalexin levels, a decline in inducible plant defense mechanisms, and changes in ambient host pH [25].

Infection of mango tree and fruit by *Botryospareia* spp. can result in many different disease symptoms. The development of control for economically important pre and postharvest disease caused by these fungi should include a focus on pathogen epidemiology. The fungi exist endophytically in the mango tree, spread systematically through the vascular system and symptom pre and postharvest if pathogen invasion and colonization is not inhibited chemically or biologically [26].

SYMPTOMS AND HISTORY OF PATHOGEN

Stem-end rot diseases can be caused by the fungal pathogens *Lasiodiplodia theobromae*, Homopsis *mangifera* or *Dithiorella dominicana* and *Colletotrichum gloeosporioides*. Stem-end rot is one of the most severe postharvest diseases of mango worldwide, cause's significant postharvest losses of fruit [27]. Losses can increase during prolonged storage of fruit. The disease becomes more severe in an orchard as trees become older [28].

The development of watery decay in ripe mangoes begins to appear around the stem-end which would rapidly expand through the pulp tissues, softening the entire upper half of the fruit, depending on the cultivar. The colonization extends ahead of symptoms along vascular tissue while colonization progresses into the fruit flesh and the seed coat. The symptoms produced during infection also vary with the pathogen. Fast moving dark lesions are produced by *L. theobromae* and *Botryosphaeraceaeous* fungi. Steel grey mycelium can develop over the surface on fruit affected by *Neofusicoccum* spp. Pycnidia may develop around the stem end particularly with infections caused by *N. parvum* (formerly *D. dominicana*) and [29]. Symptom development is slower with *Phomopsis mangiferae* or *Cytosphaera mangiferae* and a dark lesion of more uniform radius develops at the stem end. Superficial mycelium does not usually develop [29]. The occurrence of SER caused by *P. mangiferae* can be more frequent in fruit from dry areas [30].

CONTROL OR MANAGEMENTS

In recent years, the emphasis has been on the development and improvement of postharvest practices such as irradiation, warm water treatment and controlled atmosphere and low temperature storage [28,31]. The alternate use of increased CO_2 level has proven to be useful in controlling postharvest pathogens during long term, low-temperature storage. Dipping of fruits in hot water (55°C) amended with fungicides such as prochloraz, can adequately control most of the superficial infection and prevent transmission of inoculum. Biological control measure is at an early stage of commercialization. A warm water dip *B. lichiforms*, followed by reduced concentrations of prochloraz was found to effectively control various mango diseases, including fruit rots [28,32].

Partial-pressure infiltration generally enhanced *in vivo* activity of the otherwise ineffective fungicides Sportak and Scala for control of stem-end rot in mangoes. However, Sportak and Scala were ineffective against stem-end rot when applied as a dip, and in fact promoted this disease. Fruit in these dip treatments were evidently more susceptible to stem-end rot due to eradication of competing anthracnose disease. Sportak is an effective fungicide against anthracnose. Johnson determined that fruit affected by anthracnose have low levels of stem-end rot despite an extensive presence of the pathogen in their pedicels [19]. Benlate was more effective than Sportak and Scala in reducing stem-end rot disease incidence and maintaining fruit firmness [33].

DISCUSSION AND CONCLUSION

This study has been carried out to investigate the anthracnose disease of mango fruits, pre-harvest and post-harvest management of anthracnose and the efficiencies of different control measures. Future strategies for controlling SER disease of mango should aim to interrupt the infection process in time to suppress SER pathogens and ultimately reduce disease incidence after ripening. The economic costs of such postharvest losses are higher than the field losses. The successful management of such diseases depends on understanding the biology of the pathosystem, the conditions that promote disease development and the economics, efficacy and market acceptability of the various control measures.

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