International Journal of Botany Studies
www.botanyjournals.com
ISSN: 2455-541X
Received: 20-08-2021, Accepted: 05-09-2021, Published: 21-09-2021
Volume 6, Issue 5, 2021, Page No. 742-746

A review on the management practices of *Colletotrichum gloeosporioides* (Penz.) Penz. & Sacc. Causes anthracnose disease of mango

Priya Lokare[1], Sumia Fatima[1], P E Jagdale[2]
[1] Pesticides and Plant Protection Research Laboratory, Dr. Rafiq Zakaria College for Women, Aurangabad, Maharashtra, India
[2] Loknete Ramdas Patil Dhumal Arts, Science and Commerce College, Rahuri Ahmednagar, Maharashtra, India

Abstract
Mango *(Mangifera indica L.)*, the King of the fruits, is the eighth-most cultivated fruit globally, producing more than 43 million tons in India, Bangladesh, Nepal, and many other tropical nations. It is a crucial component of nutrition in many developing nations since it offers vitamins and minerals and the demand is rising day by day. Mango is the leading producer in Bangladesh, with a typical yield of 82 kg per acre in annual output. Compared to other mango-producing nations worldwide, this number is insignificant because of various insect assaults and illnesses. This study examined the various pre-harvest and post-harvest treatment techniques employed to limit the efficacy of anthracnose diseases. One of the most severe mango diseases in many developing countries is Colletotrichum gloeosporioides induced by anthracnotic illness. Anthracnose and stem end red which can spread with rainfall, have reported about 25 to 30 percent loss of overall mango yield. Various methods to control this mango-fruit anthracnosis illness, including chemical therapy, have been employed before and after harvest.

Keywords: *Colletotrichum gloeosporioides*, mango, pesticides

Introduction
Mango (*Mangifera indica* L) is a significant crop of the Anacardiaceous family, supposedly from a vast region, including Myanmar, Bangladesh, and India. It ranks seventh in terms of output throughout the world as King of all fruits. In Bangladesh, India, Nepal, and many other tropical nations, annual mango manufacturing are above 43 million tons (Galsurker, Diskin, Maurer, Feygenberg, & Alkan, 2018; Uddin, Shefat, Afroz, & Moon, 2018) [35]. In particular, in developing nations, worldwide demand for fresh fruit increases daily since it is a vital component of nutrition and provides vitamins and minerals. Mango is the second-largest in manufacturing in Bangladesh and first in the yearly fruit cultivation ranking, equaling 93480 ha of land with an average annual output of 11616850 tons per acre (Sarkar, Ashik-E-Rabbani, Saha, & Alam, 2020) [28]. The returns are insignificant compared to other mango-producing countries worldwide (Madalageri, Bharati, Orsat, Raghavan, & Kage, 2015) [23], such as Pakistan, India, and others. Pesticide assault and nematode, fungal, viral, insect or bacterial illnesses, etc., are the causes for the reduced yield. In Bangladesh, at least eighteen significant and minor mango illnesses were documented. Mango anthracnosis disease is one of the world's leading mango fruit pre-harvest and post-harvest diseases and *Colletotrichum gloeosporioides* in Bangladesh (Arriel *et al*., 2016; Bhanudas, 2020; Uddin *et al*., 2018) [4, 6, 35]. The disease may also emerge in the storage of ripe fruits as Anthracnose affects blossoms, young fruits, leaves, and branches. Symptoms of the disease show as leveled, black sunken lesions in an irregular form that progressively expand and develop, marking leaves, black flowers, dye fruit, and redness. The entire output of Anthracnose and stem rot has fallen by around 25 to 30% (Nasreen, Kamal, Siddiky, Rannu, & Islam, 2014). This illness is spread via rainfall. Thus, it is essential to have a good understanding of this illness to guarantee its successful production, as appropriate treatment of this disease may improve the return of the fruits to farmers. Several chemicals, spray, and dip treatments manage anthracnose diseases, some more successful and others less efficient. In order to examine mango disease, the anti-harvest management, and the efficiency of various control methods before and after harvesting Anthracnose, this study was conducted (Ochiki, 2015; Reglinski, Dann, & Deverall, 2014).

Methods
Information was collected from several scientific research papers, reports, publications, peer reviews, yearly reports, magazines, relevant books, procedures, and other resources and published in various national and international journals. Another primary source of information was electronic media. The websites of several independent and private research institutes have also received information. The collected material has been methodically and chronologically assembled from secondary sources.

Colletotrichum gloeosporioides Etiology
Colletotrichum Blight Causes: Mangrove anthracnose is pathogenic to about 470 different plants at different phases in their growth, including mango, almond, apple, avocado, guava, Arabica coffee, mango cassava, dragon fruit, sorghum, and strawberry (P. Kumari, Singh, & Punia, 2017) [21]. Among these, mango anthracnose is of great commercial importance. Two species are responsible for anthracnosis of mango disease (Sarker, Islam, Hossain, & Rangpur, 2016) [29], although, in rare places, *Colletotrichum gloeosporioides* is significantly less critical. Another

Colletotrichum gloeosporioides var. minor is not identified any further. The leading cause of mango anthracnosis's spread and development are high humidity and moisture conditions (Hassan Kamil, 2018) [13].

Mango anthracnosis symptoms include many oval or irregular brown or brownish spots of different dimensions dispersed across the leaf under wet circumstances. The anthracnosis of mango after harvest is formed during maturation and transit to remote markets due to latent infection. The symptom was dark around the epicarp on which salmon-free masses of spores formed, sometimes sunken or irregular. When the fruit matures, they might stretch over the entire surface, together with the weakening and rotting of the fruit. In humid circumstances, minute pinky reproductive corpses of the fungus, staining, russets, and tear streaming are covered over the blackened areas (Uddin *et al*., 2018) [35]. *Colletotrichum gloeosporioides* conidia generate and develop primary fungal inoculum sources for mummified inflorescences, panicles, branch ends, twigs, floral bracts, mummified fruit, and leaves. Their output is most freely humidified and lowest at a relative humidity of 95%. Conidia are propagated by rain and require free moisture for infection (Islam, Alam, Ahmed, & Islam, 2019; Jenny, Kader, & Bhuiyan, 2020; SULTANA, 2019) [16, 17, 34]. They become melanized as an oppressor age. The aspersorium can be strengthened and helped penetrate the cuticle by infection bindings produced by the aspersoria. Small fruit disease, if infected early in its development, can cause brown spot minutes and abort. After the fruit is more than 4 to 5 cm in diameter, an aspersorium develops, infections are stopped. Quiescent infections resume the formation of preexisting fungal inhibitor concentrations in fruit which decrease throughout maturation. Lesions can be produced anywhere on more significant fruit, but linear strawberries radiate from the tip to the Mango fruit apex are prevalent (Ajay Kumar, 2014; HOSSAIN, 2017) [2, 14]. In fruits, infections are secondary and only spread into the flesh when much of the fruit surface is damaged. Even the development of superficial diseases leads to severe damage and fruit repulsion. Black spots are developed on preserved fruits that combine to create substantial irregular botches or cover the entire fruit. There are significant deep fractures in the places. Under humid circumstances, minute rose reproductive corpses of the fungus are coated in blackened patches. Stitching, rushing, and tearing the fruit's skin alone are attributed to the same fungus (Nandhavathy *et al*., 2021) [24].

***Colletotrichum gloeosporioides* produced product loss.**

Anthracnose disease estimated loss has been recorded in the severe rainy season to 60% or more (Alemu, 2014; Giblin *et al*., 2018; Udhayakumar & Muthukumar, 2019) [3, 11, 36]. Crop losses are typically caused by the direct reduction in harvested product quantity or quality. In South Africa, the incidence of the illness from diverse nations has been reported to be 32%; in Costa Rica, 64.6% can be nearly 100% wet or very humid. In Gondunglegi of Indonesia (Litz & Hormaza, 2020) [22], 50.28 percent of anthracnose output was recorded, while the Himachal Pradesh of India's 29.6 percent loss after harvest (Diallo, 2016) [9] was documented in 1990-92. *Colletotrichum gloeosporioides* in Hyderabad observed 20 to 30 percent rotting of mango fruit. *Colletotrichum gloeosporioides* can also lead to decreased bloom levels, loss of yield and leaf deterioration, and severe difficulties in bird and orchard conditions (González-Fernández & Hormaza, 2020) [21, 22] in crowded and wet circumstances. Anthracnosis was 37-57% and 16-31% in 2010, respectively incidence and severity. The incidence of Anthracnose was between 33% and 65%, but the severity was between 17% and 35%. During market surveys, the incidence and gravity of the illness were 77 and 46 percent, respectively (Kamle, Pandey, Kumar, & Muthu Kumar, 2013; Yeboah, 2014) [18, 38].

Methods to Disease Management

Resilient cultivars to manage plant diseases are an excellent, most straightforward, and cheapest technique. The incidence of banana, mango, lychee, and longan was decreased via thermal therapy. Anthracnose is one of the most significant mango fruit diseases affecting fruit quality before and after harvest. It is also effective year-round across the canopy for flowers, leaves, and inoculum. In arid places, Anthracnose is common but well managed and non-important. In order to generate good yield and quality fruits, management of these diseases is necessary. Disease management needs a knowledge of the ever-present hazard and the climate that increases the development of infections and diseases. The management of diseases is based on optimum control (Siddiqui & Ali, 2014) [31].

Management of pre-harvest

Early investigations have shown that non-systemic fungicides zineb, maneb, and captan have reasonable control during blooming and subsequent monthly throughout fruit maturing. Breeding in the fungicide layer on trees in Florida uses up to 25 sprays per year. Copper fungicides have shown improved outcomes. Benomyl with surfactant provides reasonable control of protective fungicides by anthracnose superior. For anthracnose management in South Africa, copper oxychloride or coffee mixes or copper oxychloride and zineb applied in wet and dry circumstances every 14 days and 28 days after that were suggested. Mancozeb was administered between the appearance of panicles and fruit every 14 days. Furthermore, every three weeks' copper oxychloride has also been used. These fungicides were replaced monthly until the fruit was harvested. In rainy seasons, the therapy was successful if the fruit set was avoided without the administration of fungicide. A study contrasted a single dosage of copper oxychloride with a bi-monthly application of a lower-concentration combination following flowering. The fruit set was considerably enhanced by copper oxychloride but not the other. Therefore, the time of spraying is important to avoid the spread of diseases (Bautista-Rosales, Calderon-Santoyo, Servín-Villegas, Ochoa-Álvarez, & Ragazzo-Sánchez, 2013; Wolde, 2016) [5, 37]. The anthracnose phase in Blossom Blight designed a spray program to manage Anthracnose in the Philippines, which reduces the quantity of fruit set dramatically. Today, five sprays are administered between floral induction and fruit set, with the sixth treatment between fruit and harvest. It has been found that Benomyl, Captafol, and Mancozeb all have sufficient control of the flowers, increasing the fruit set by 55% to 80% per inflorescence in comparison with the untreated control. The alteration of copper sprays on business orchards in the Philippines and its economic effects were also utilized. Chlorothalonil. The abuse of comparable spray programs has been documented in a study with an

anticipated outcome. This fungicide might survive post-harvest therapies for Benomyl-tolerant strains of *C. gloeosporioides*. Similar concerns with pre-harvest Benomyl usage of Malaysian mango hedges have been reported in recent years. A considerable, *in-vitro* activity against *Colletotrichum* sp. has been demonstrated to be associated with an alternate curative fungicide prochloraz. Another study has revealed that prochloraz sprayed substantially better than mancozeb and copper control over flower blight. A later field test for prochloraz found that instead of conventional protective spray programs, up to eight spray sites can be spared throughout the flowering (Bordoh, Ali, Dickinson, Siddiqui, & Romanazzi, 2020; Sharma & Kulshrestha, 2015) [7, 30].

Management after harvest

The mango is caught in mature green and kept 2-3 weeks before maturity at 10-120C. The challenge of management of Anthracnose after harvest is shifted from the producer to exporter since it is sold to purchasers still on trees. Stocking fungus in mango fruits causes anthracnose rot and loss of fruit quality. Various treatments were used to limit the development of Anthracnose after harvest, with various success levels (Silva-Jara, López-Cruz, Ragazzo-Sánchez, & Calderón-Santoyo, 2020) [32].

The main ways to control fruit and vegetable diseases after harvest are chemical fungicides. The possible environmental and human health effects of fungicides are nonetheless mainly restricted. Environmentally friendly management has become one of the most promising alternatives to chemicals. Dip therapy has been explored for several fungicides. Benomyl has been proven to be more efficacious than cold water against mild mango anthracnose infections. This was because of the thicker mango cuticles, compared with the thinner cuticles of banana or papaya, that act as a barrier to the fungicide entrance. Prochloraz has recently been demonstrated to be efficacious in hot or cold dips against the Anthracnose but less effective than hot Benomyl dips. For some mango types such as thiophanate-methyl and hot imazalil, other fungicides were effectively employed as well. Post-harvest fruit dips against mango anthracnosis are thought to be somewhat effective (Admasu, Sahile, & Kibret, 2014; Deressa, Lemessa, & Wakjira, 2015) [1, 8].

Hot water dips have been recognized for many years for their usefulness for mango anthracnose management treatments after harvest. Mango hot-water therapy is an ancient, successful approach that numerous employees have recommended. Alone hot water dips can significantly decrease the growth of Anthracnose, although fruit can indicate damage to heat under certain storage conditions. The 55 and 60°C hot water treatment against mango anthracnose was shown to be effective after harvest. A study has found substantial fruit anthracnose reduction in hot water treatment. A study observed that 5, 15, and 30-minute hot water dips are beneficial for the management of mango after harvest.

Studies employing Gamma irradiation to reduce mangrove anthracnosis have found that hot fungicide dip integration is needed to enhance irradiation disease management. Suitable post-harvest therapy for specific mango cultivars and potentially even for the same cultivar in various contexts has to be chosen. In suppressing the development of post-harvest anthracnosis, sodium hypochlorite and film-wrapping were not found to be succeeding (González-Fernández & Hormaza, 2020; M. Kumari & Jha, 2020) [12, 22].

Eco-friendly, effective, and alternative approaches for any disease management technique are biological controls. In conjunction with fungicides and herbal extract, Singh examined the impact of heat treatment to prevent mango fruit storage caused by the *Colletotrichum gloeosporioides*. Propiconazole dip therapy was most effective against Anthracnose, at 500 ppm, and *Cannabis sativa* extract. The heating treatment at 45°C improved the healing capabilities and the conservation of mango at room temperature for pesticide and extract. The effectiveness of a fungicide called azoxystrobin in vitro as well as in vivo was investigated. Azoxystrobin reduced *C. gloeosporioides* mycelial growth in in-vitro experiments. In field tests, the growth of panicle and leaf anthracnose was substantially inhibited by azoxystrobin. Azoxystrobin treated mango trees produced more fruit than control and did not indicate phytotoxicity. Different studies have assessed the multiple isolates from Anthracnose inhibited the sporous germination and development of *Colletotrichum gloeosporioides* by the cell suspensions and culture filtration of isolates. The isolates in *B. diminuta, S. maltophilia,* and *Enterobacteriaceae* were bacterial, while *C. membranifaciens* and a novel species were yeast isolates. In the management of mango anthracnosis, the following post-harvest treatments may be employed (Khanzada *et al*., 2018; Sulochana, Jayachandra, Anil Kumar, & Dayanand, 2013) [19, 33].

1 percent NaOCl scrubbing
Dip of warm water (50-55oC for 3 - 10 minutes)
Hot Brazilian dip (500 - 1000 ppm)
Prochlora dip hot/cold (400 - l000 ppm)
Hot picturesque (1000 ppm)
Hot water + 20 k FLOWER
Hot water + 75 k Radiation Hot water
Hot benlatc/iprodionc + 75 k RAD + waxing (1000 ppm)

Conclusion

Anthracnose mango is one of the world's leading mango fruit pre-and post-harvest diseases, which attack blossoms, immature fruits, leaves, and twigs, causing massive losses in mango cultivation pre-and post-harvest. The loss in the overall production of anthracnose and end red in Bangladesh is around 25-30% (Huang, Tian, Huang, & Huang, 2020; Udhayakumar & Muthukumar, 2019) [15, 36]. In anthracnose disease management, several sprays and dip treatments of chemicals are employed, some more successful and others less effective. The timely use of fungicide spray is beneficial in controlling anthracnosis, increasing environmental and health risks. Another approach to preventing infection due to *Colletotrichum gloeosporioides* is to use Eucalyptus and Neem leaf extract. To guarantee a successful outcome of this condition, a thorough understanding is essential to manage it properly. Other approaches in the management of diseases such as developing resistant types, the use of plant and natural products, and bio-control and alterations in agricultural practices are thus now being emphasized since they are economic, environmentally sound, and safe.

References

1. Admasu W, Sahile S, Kibret M. Assessment of potential antagonists for anthracnose (Colletotrichum gloeosporioides) disease of mango (Mangifera indica

L.) in North-Western Ethiopia (Pawe). Archives of Phytopathology and Plant Protection,2014:47(18):2176-2186.
2. Ajay Kumar G. Colletotrichum gloeosporioides: biology, pathogenicity, and management in India. J Plant Physiol Pathol,2014:2:2.
3. Alemu K. Dynamics and management of major post-harvest fungal diseases of mango fruits, 2014, 4.
4. Arriel DAA, da Silva Guimarães LM, de Resende MDV, Neto FPL, Silva DFSHS, de Siqueira DL. *et al*. Genetic control of resistance on Mangifera indica to Ceratocystis wilt. Scientia Horticulturae,2016:211:312-318.
5. Bautista-Rosales PU, Calderon-Santoyo M, Servín-Villegas R, Ochoa-Álvarez NA, Ragazzo-Sánchez JA. Action mechanisms of the yeast Meyerozyma caribbica for the control of the phytopathogen Colletotrichum gloeosporioides in mangoes. Biological Control,2013:65(3):293-301.
6. Bhanudas SS. Studies on Biological Control of Post Harvest Diseases of Mango Grape and Banana Fruits in Marathwada Region Maharashtra, 2020.
7. Bordoh PK, Ali A, Dickinson M, Siddiqui Y, Romanazzi G. A review on the management of post-harvest Anthracnose in dragon fruits caused by Colletotrichum spp. Crop Protection,2020:130:105067.
8. Deressa T, Lemessa F, Wakjira M. Antifungal activity of some invasive alien plant leaf extracts against mango (Mangifera indica) anthracnose caused by Colletotrichum gloeosporioides. International Journal of Pest Management,2015:61(2):99-105.
9. Diallo Y. Control of Anthracnose (caused by Colletotrichum gloeosporioides sl) on mango in Senegal by fungicides and biofungicides. Virginia Tech, 2016.
10. Galsurker O, Diskin S, Maurer D, Feygenberg O, Alkan N. Fruit stem-end rot. Horticulturae,2018:4(4):50.
11. Giblin F, Tan Y, Mitchell R, Coates L, Irwin J, Shivas R. Colletotrichum species associated with pre-and post-harvest diseases of avocado and mango in eastern Australia. Australasian Plant Pathology,2018:47(3):269-276.
12. González-Fernández J, Hormaza J, Plagas. y enfermedades del mango (Mangifera indica L.), 2020.
13. Hassan Kamil FA. Identification of Pathogens Associated With Mango Dieback Disease on Mango in the United Arab Emirates, 2018.
14. HOSSAIN MM. MANAGEMENT OF POST-HARVEST ANTHRACNOSE DISEASE OF, 2017.
15. Huang H, Tian C, Huang Y, Huang H. Biological control of poplar anthracnose caused by Colletotrichum gloeosporioides (Penz.) Penz. & Sacc. Egyptian Journal of Biological Pest Control,2020:30(1):1-9.
16. Islam T, Alam S, Ahmed M, Islam M. MANGO DISEASES DIAGNOSIS COMPETENCY OF FARMERS USING COLOUR DISEASES IMAGES. Measurement, 2019.
17. Jenny F, Kader MA, Bhuiyan MAB. First report of jackfruit decline caused by Phytophthora spp. in Bangladesh. Fundamental and Applied Agriculture,2020:5(3):315-318-315-318.
18. Kamle M, Pandey B, Kumar P, Muthu Kumar M. A species-specific PCR based assay for rapid detection of mango anthracnose pathogen Colletotrichum gloeosporioides Penz. and Sacc. J Plant Pathol Microbiol, 2013, 4(6).
19. Khanzada MA, Ansari A, Rajput MA, Maitlo S, Rajput AQ, Ujjan AA. Effect of different abiotic factors on the growth and sporulation of Colletotrichum gloeosporioides causing Anthracnose of mango. Plant Protection,2018:2(1):23-30.
20. Kumari M, Jha P. Etiology, Symptomatology and Management of Black Spot of Aloe vera (Aloe barbadensis Miller) through Botanicals and Biocontrol Agents–A Brief Review. Current Journal of Applied Science and Technology, 2020, 11-20.
21. Kumari P, Singh R, Punia R. Survival of Colletotrichum gloeosporioides causing Anthracnose of mango at different depths and durations in soil. Journal of Pharmacognosy and Phytochemistry,2017:6(5):194-2198.
22. Litz RE, Hormaza JI. 2.2 Mangifera indica Mango. Biotechnology of Fruit and Nut Crops, 2020, 27.
23. Madalageri D, Bharati P, Orsat V, Raghavan V, Kage U. Antioxidant activity in pulp and peel of three mango varieties. Journal of Horticultural Sciences,2015:10(2):199-209.
24. Nandhavathy G, Dharini V, Babu PA, Nambiar RB, Selvam SP, Sadiku ER *et al*. Determination of antifungal activities of essential oils incorporated-pomegranate peel fibers reinforced-polyvinyl alcohol biocomposite film against mango post-harvest pathogens. Materials Today: Proceedings,2021:38:923-927.
25. Nasreen S, Kamal A, Siddiky M, Rannu R, Islam M. Effect of nitrogen, phosphorus, potassium and sulphur on the yield of mango. Bangladesh Journal of Agricultural Research,2014:39(4):631-640.
26. Ochiki S. Effect of aloe (Aloe vera) leaf extract coating on quality and shelf life of mango (Mangifera indica l.) fruits at two controlled temperature levels. Egerton University, 2015.
27. Reglinski T, Dann E, Deverall B. 12 Implementation of Induced Resistance for Crop Protection. Induced Resistance for Plant Defense: A Sustainable Approach to Crop Protection, 2014, 249.
28. Sarkar S, Ashik-E-Rabbani M, Saha CK, Alam MM. Assessment of Custom HiringService Provision for Rice Transplanter in the Southern Delta of Bangladesh using RuralInvest Tool. Paper presented at the 2020 ASABE Annual International Virtual Meeting, 2020.
29. Sarker SR, Islam MR, Hossain I, Rangpur B. Prevalence and eco-friendly management of some important nursery diseases of mango in Bangladesh. Journal of Agricultural Science (Toronto),2016:8(1):205-220.
30. Sharma M, Kulshrestha S. Colletotrichum gloeosporioides: an anthracnose causing pathogen of fruits and vegetables. Biosciences Biotechnology Research Asia,2015:12(2):1233-1246.
31. Siddiqui Y, Ali A. Colletotrichum gloeosporioides (Anthracnose) Postharvest Decay Elsevier, 2014, 337-371.
32. Silva-Jara J, López-Cruz R, Ragazzo-Sánchez J, Calderón-Santoyo M. Antagonistic microorganisms efficiency to suppress damage caused by Colletotrichum gloeosporioides in papaya crop:

Perspectives and challenges. Revista Mexicana de Ingeniería Química,2020:19(2):839-849.
33. Sulochana M, Jayachandra S, Anil Kumar S, Dayanand A. Antifungal attributes of siderophore produced by the. Pseudomonas aeruginosa, 2013.
34. Sultana N. STANDARDIZATION OF HOT WATER TREATMENT IN CONTROLLING MAJOR SEED BORNE PATHOGENS OF VEGETABLES. DEPARTMENT OF PLANT PATHOLOGY, SHER-E-BANGLA AGRICULTURAL UNIVERSITY, DHAKA-1207, 2019.
35. Uddin MN, Shefat S, Afroz M, Moon N. Management of anthracnose disease of mango caused by Colletotrichum gloeosporioides: A review. Acta Scientific Agriculture,2018:2(10):169-177.
36. Udhayakumar R, Muthukumar A. Biological Management of Mango Anthracnose Caused by Colletotrichum gloeosporioides. Current Research and Innovations in Plant Pathology, 2019, 135.
37. Wolde KF. Identification and characterization of Colletotrichum species associated with mango and citrus diseases in the Ashanti region of Ghana, 2016.
38. Yeboah A. Screening of Eggplant Genotypes for resistance to Anthracnose, 2014.