Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2320-7051.2478

ISSN: 2320 – 7051

Int. J. Pure App. Biosci. **5 (1):** 48-56 (2017)

Review Article

International Journal of Pure & Applied Bioscience

OPEN ACCESS

Anthracnose of Mango Incited by *Colletotrichum gloeosporioides* : A Comprehensive Review

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Received: 19.01.2017 | Revised: 26.01.2017 | Accepted: 28.01.2017

ABSTRACT

Mango (Mangifera indica L.) is one of the world's most important and esteemed fruits of the tropical and subtropical countries. By the virtue of its wide range, delicious taste, superb flavour, very high nutritive and medicinal value as well as great religio-historical significance, it is called the "King of the fruits". Mango is affected by a number of diseases at all stages of the development right from nursery to post harvest including storage and transit. Its production is drastically affected by Colletotrichum gloeosporioides, is one of the most damaging pathogen cause mango anthracnose. This paper reviews the research and development of Anthracnose of mango during the precedent in relation to pathogen taxonomy, distribution, biology, disease cycle and management.

Key words: *Anthracnose, Colletotrichum gloeosporioides, pathogen*

INTRODUCTION

Mangoes (*Mangifera indica* L.) are universally considered as one of the choicest fruits in tropical and subtropical countries[41,61] and are cultivated extensively as a commercial fruit crop in India, China, Indonesia, Thailand and Mexico. By the virtue of its wide range, delicious taste, superb flavour, very high nutritive and medicinal value as well as great religio-historical significance, it is called the "King of the fruits"[24]. India is the world's largest producer of mango followed by China and Thailand[33]. Mango is grown in at least 87 countries but no where it is so greatly value in India where 40 per cent of total fruits grown in India is only mango[41]. Mango is one of the world's most important and esteemed fruit crops, are exposed to various pathogen, which infect and disturb the normal physiological functions during growth and development. Among the diseases that hindered the productivity of mango, Anthracnose caused by *C. gloeosporioides* (Penz. & Sacc.), is most destructive disease worldwide.

Distribution and Host Range

C. 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[46,52,63].

Cite this article: Kumari, P., Rakesh and Singh, R., Anthracnose of Mango Incited by *Colletotrichum gloeosporioides*: A Comprehensive Review, *Int. J. Pure App. Biosci.* **5(1):** 48-56 (2017). doi: http://dx.doi.org/10.18782/2320-7051.2478

The pathogen poses a threat to many economically important crops such as mango, almond, avocado, apple, Arabica coffee, guava, dragon fruit, cassava, sorghum and strawberry[3,16,36,39]. Amongst them mango anthracnose is very important from Indian prospective[63].

History of Pathogen *Colletotrichum gloeosporioides*

C. gloeosporioides is one of the frequently reported plant pathogens among genus *Colletotrichum* in India. It is known to infect a variety of host with characteristic symptoms. The generic name *Colletotrichum* was introduced by Corda[13] for *C. lineola*, a species associated with a member of the family *Apiaceae*, in the Czech Republic. The pathogenic *C. gloeosporioides* was reported in Penzig for first time[44]. The naming is based on *Vermicularia gloeosporioides*, the type specimen of which was collected from *Citrus* in Italy[34]. In India, it was first reported by Butler[11] on coffee. McRae[37] reported it as the causal pathogen of mango anthracnose. *Glomerella cingulata* is the sexual stage (teleomorph) while the asexual stage (anamorph) is called *C. gloeosporioides*[60]. The most accepted taxonomic detail of *C. gloeosporioides* is provided herewith; the pathogen belongs to kingdom Fungi, phylum Ascomycota, class Sordariomycetes, order Phyllachorales, family Phyllachoraceae[22].

Yield Losses

Loss estimated due to Anthracnose disease was reported 60 per cent or higher during the heavy rainy season[5]. Anthracnose was recognized as the most important field and post harvest disease of mango worldwide[46]. It is major constraint on the expansion of export trade of mango[28]. Crop losses caused by *C. gloeosporioides* generally occur as a direct reduction in quantity or quality of the harvested produce[33]. The disease incidence from different countries has been reported to be 32 per cent in South Africa[57], 64.6 per cent in Costa Rica during 1990[6] and could reach almost 100 per cent in fruit produced under wet or very humid condition[7]. Mahfud[35] reported that the disease caused severe yield losses up to 50.28 per cent was in Gondunglegi, Indonesia. In India, Himachal Pradesh, during 1990-92, post-harvest decay due to anthracnose was 29.6 per cent[62]. Prakash *et al*[50]., also observed up to 20-30 per cent mango fruits were rotten due to *C. gloeosporioides* from Hyderabad. This pathogen causes flower set reduction and yield losses in mango and can also damage foliage and under crowded and moist conditions cause serious problems in nurseries and young orchards[4,31].

Disease Symptom

The characteristic symptoms are numerous oval or irregular vinaceous brown or deep brownish spots of various sizes scattered all over the leaf surface under damp conditions. The fungus grows rapidly forming elongated mass brown or mummy brown necrotic areas measuring 20-25 mm in diameter (Fig. 1) which when old become ruptured and blighted[59]. Symptomology of *C. gloeosporioides* infection varies very little between different hosts and is characterized by dark, depressed lesions on ripe fruit often accompanied by pink slimy spore masses which develop as acervuli mature[27]. Lesions often coalesce to form large necrotic areas frequently along the leaf margins severely affected leaves usually curl. Lesions develop primarily on young tissue and conidia are formed and can be observed in lesions of all ages. Under favourable conditions conidia are strewn and invade young twigs causing twig die back in some cases[47]. Relative humidity >95 per cent for at least 12 hours is essential for infection and development of *C. gloeosporioides* on mango fruit. Infection progresses faster in wounded tissues and in ripe fruits[49].

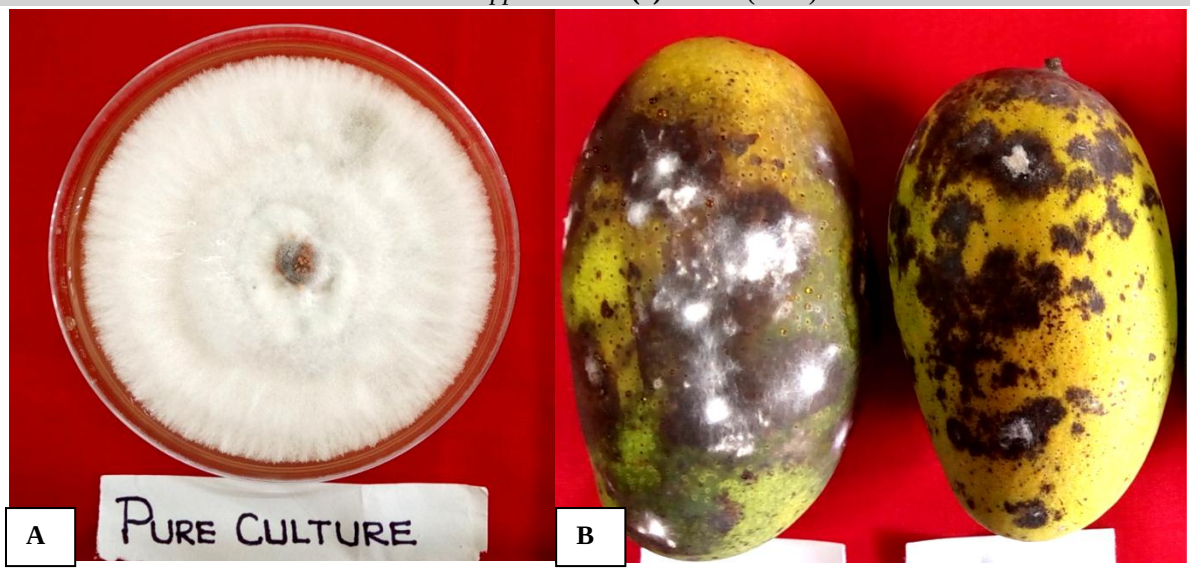

Fig. 1: A. Pure culture of *C. gloeosporioides*, B. Symptoms of anthracnose on mango fruits

Biology and Disease Cycle of *Colletotrichum gloeosporioides*

C. gloeosporioides (Penz. & Sacc.) belonging to the family Phyllachoraceae of the division Ascomycota, is an asexual facultative parasite. The fungus comprises *C. gloeosporioides* as anamorph imperfect or asexual state while, *Glomerella cingulata* as sexual (perfect) teleomorph state[60]. *G. cingulata* occurres on a broad range of host species produce acervuli within the host tissue during asexual (mitotic) phase of their life cycle. The teleomorph state is known for their ability to cause serious disease[12]. The fungus prefers warm humid environment for spreading the anthracnose disease uniformly and effectively[18,48]. The fungus is primarily invade into injured or weakened tissues of plants, produces various specialized structures during infection process. These specialized structures *viz.*, conidia, acervulli, setae and appressoria are formed during the interaction between host and pathogen. *C. gloeosporioides* colonises injures, plant tissues and forms number of acervuli and conidia. Conidia can be spread over relatively short distances by rain splash or overhead irrigation and infect other health plant tissues. The penetration into host tissues generally relies on formation of specialized infection structures known as appressoria. These appressoria allows the fungus to penetrate the host cuticle and epidermal cell wall directly by narrow penetration peg that emerges the base of appressorium. Acervli are the asexual bodies produced during the infection process in the tissue of infected host as small, flask shaped structure with a small cushion at the bottom, of which short crowded conidophores are formed and can be observed on the surface of diseased plants. The conidia escape through an opening at the top of acervuli. Setae are usually long brownish coloured emerged from acervuli[22,32,45,53]. The whole infection process, including the formation of conidia, acervuli, setae and appressoria, and infection results into tissue necrosis. Dead wood and plant debris are also primary sources of inoculum. The sunken, water soaked spots, rapidly expand on infected plant tissue become soft on full expansion and show a range of colours from red-brown to tan to black, generally described anthracnose disease. But a great variation in the symptoms produced by *C. gloeosporioides* is recorded from host to host. The symptoms may be sunken, water soaked, round to oval, regular to irregular and brownish red to black spots. Similarly, the fungal characteristic on culture media also varies among hosts. Generally, the fungus produces circular, wooly or cottony mycelia growth on culture media with characteristic colour *i.e.* pale brown or grayish white[25,69]. The mycelium of growing culture is hyaline, septate and branched. The

conidiomata are acervular, separate, composed of hyaline to dark brown septate hyphae. The setae are long, brown and septate. The conidiogenous cells are enteroblastic, phialidic, hyaline, conidia are hyaline, one celled, straight, cylindrical and obtuse at apices. Variation in the dimension of conidiogenous cells is also observed in different studies. The fungus produces hyaline, one celled, ovoid to oblong, slightly curved or dumbbell shaped conidia, 10-15 µm (average) up to 20 µm in length and 5-7 µm in width. There is a great variation in size and shape of conidia of *C. gloeosporioides* depending upon the host from which the pathogen is isolated and its area of origin. Normally the conidia may be oblong with obtuse ends[20].

The germination in *C. gloeosporioides* follows two routes: pathogenic and saprophytic[8]. 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. This process is initiated immediately and results in the formation of appressoria. Saprophytic germination occurs in rich medium. It takes a much longer period of time and is characterized by development of two germ tube. *C. gloeosporioides* requires 25-28˚ C temperature, pH 5.8-6.5 for better growth. This pathogen is inactive in dry season and switches to active stages when encountered favourable environmental conditions[14,48,63].

Survival/ Viability of *Colletotrichum Gloeosporioides*

Survival studies on anthracnose fungi (*C. gloeosporioides*) of strawberries, beans and lentil proved the ability of this fungus to survive for longer period in soil[10,15,67,70]. Eradication of infected materials through burial after harvest could reduce inoculum build-up in the field before the planting season[26,38]. Boland *et al*[9]., observed that *C. gloeosporioides* survived for two dry seasons as conidia on infected stem pieces of *S. scabra* placed on the soil surface. On the other hand, Urena-Padilla *et al*[68]., reported that *C. gloeosporioides* was still detected on infected strawberry crowns after burial for 100 days. However, several studies showed that the effect of residue burial on survival of the pathogen may vary greatly, depending upon the plant organ and soil conditions.

Sankar and Kumari[58] reported that the *C. gloeosporioides* survived up to 90 days when infected plant parts buried in soil. At 120 days of burial no propagules could be recovered. Under laboratory conditions *C. gloeosporioides* survived up to 150 days. The survival of C. *gloeosporioides* generally reduced with increased soil depth and duration of burial of infected plant materials. The maximum reduction of fungal survival was observed below 20 per cent at 150 days of burial below 20 cm depth[19,21]. The number of C. *gloeosporioides* conidia diminished sharply after the first month of burial. The number of conidia was higher in residues placed on the soil surface due to large amount of readily available substrate. Later, survival of C. *gloeosporioides* was mainly limited by the competition with microorganisms decomposing residues[54]. Recently, Takushi[65], observed that *C. gloeosporioides* was able to survive for long periods on diseased withered leaves, with survival period increasing with decreasing temperature.

Different Inoculation Methods for Diseases Development

Hasabins[23] proved that *C. gloeosporioides* was pathogenic on mango fruits. The fungus produced typical anthracnose lesions within 72 hours in unwounded and within 48 hours in wounded fruits. Patel[42] reported that tooth brush injury method found more efficient in development of anthracnose symptoms followed by pinprick method.

Management of Disease

Patel[42] reported that among systemic fungicides carbendazim (0.1%), thiophanate methyl (0.1%), propiconazole (0.1%) and hexaconaazole (0.05%) were strongly fungitoxic whereas in non-systemic group, MBMC proved superior followed by thiram (0.2%) against *C. gloeosporioides in vitro.* Patil *et al*[43]. (2007) reported that among the twelve fungicides tested; Bordeaux mixture (1%), tricyclazole (0.1%), difenconazole

(0.05%) and propiconazole (0.1%) completely inhibited the growth of *C. gloeosporioides* causing anthracnose of guava. Prashanth *et al*[51]., observed that non-systemic fungicide mancozeb had inhibited mycelia growth (64.0%) of *C. gloeosporioides* at 0.1 per cent concentration, while systemic fungicides difenconazole and propiconazole inhibited mycelia growth up to 90.7 per cent at 0.1 per cent concentration. Singh *et al*[64]., reported that fungicides *viz.*, Bavistin (carbendazim), Contaf (hexaconazole) and Score (difenconazole) had completely inhibited the growth of pathogen at 100µg/ml concentrations tested *in vitro*, while copper oxychloride was least effective as it did not cause substantial reduction in growth of pathogen. The systemic fungicide carbendazim had completely (100%) inhibited mycelia growth of *C. gloeosporioides* at all the concentrations *in vitro* conditions[62,66]. Among systemic fungicides, carbendazim was found the most effective, while non-systemic fungicide, mancozeb showed the best inhibition of *C. gloeosporioides*, causing anthracnose of mango[29].

The benzimidazoles, primarily benomyl and carbendazim provided excellent anthracnose control under field conditions[1]. Singh *et al*[64]., observed that carbendazim was most effective promising providing 71.41 per cent disease control under field conditions followed by hexaconazole and difenconazole in which the disease control 66.62 per cent and 57.14 per cent, respectively. Minimum per cent disease index (18.8) was recorded in difenconazole at 0.1 per cent concentration followed by carbendazim (0.1%) with PDI 32.7[51].

Pandey *et al*[40]., reported highest growth inhibition in all isolates of *C. gloeosporioides* by leaf extract of *Moras alba* and *Azadirachta indica.* Neem leaf extract was found effective in mycelial growth inhibition (35.21 %) at 5 per cent concentration[29]. Neem, garlic, eucalyptus and akk extract were used for the management of *C. gloeosporioides* causal agent of mango anthracnose under *in vitro* and field conditions. Eucalyptus has showed the highest mycelia growth inhibition at all concentrations among all the selected plant extracts[2,17,30,51,55,56].

CONCLUSION

Anthracnose disease of mango incited by *Colletotrichum gloeosporioides* is serious threat of concern among farmers not only in India but around the world as it causes huge pre and post harvest losses to mango crop. The only method to control anthracnose is by timely application of fungicides spray, which also raises environmental and health hazard. Another way is to use of Eucalyptus and neem leaf extract against the infection caused by *Colletotrichum gloeosporioides*. Hence, at the present time more emphasis is made on other methods of disease management like growing resistant varieties, use of plant and natural products, bio-control agents and alteration in agronomic practices because they are more economical, eco-friendly and safe

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