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An Overview On Major Diseases, Damage Pattern, And Management Of Mango (*Mangifera Indica* L.) Fruit And Tree

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Abstract

Mango is one of the most important tropical fruits grown throughout the world particularly in Asia with high economic and nutritional value. However, several diseases and pests cause significant damages to different parts of mango trees and mango fruits, resulting in severe economic losses to farmers and the agricultural sector. Some of the major mango diseases are anthracnose, powdery mildew, die back, and mango malformation. These diseases affect various parts of mango tree, including leaves, flowers, fruits, stems, and roots. The causative organisms of mango diseases include fungi, bacteria, and viruses. Of these, the majority is caused by fungi. Some of the common fungal diseases of mango include anthracnose, powdery mildew, stem-end rot, and sooty mould. Therefore, it is a pressing need to accurately identify the causative organisms for determination of the best management strategy for an effective control. To manage mango diseases, farmers and researchers use several approaches, including cultural practices, chemical control, biological control, and genetic resistance. In this article, the major mango diseases, damage patterns, and management strategies for sustainable mango production has been critically reviewed and presented.

Keywords: Mango, Diseases, Fungal, Control, Dose, Damage.

1 Introduction

Mango fruit is native to Indo-Burma region and is an important crop in tropical and subtropical countries of the world. It is ranked fifth among the most significant fruit crops globally (Matheyambath et al; 2016). The worldwide production of mango is estimated to be approximately 35.0 million tonnes (FAO, 2009). Globally, India is one of the leading producers of mango, where it is grown over an area of 1.23 million hectares, producing 10.99 million tonnes, accounting for 57.18% of the total world production (Negi,2000). Despite

being a large producer of mango, India ranks sixth globally in terms of productivity. This low production is due to various diseases and climatic conditions affecting the fruit crop. Among the significant factors that affect sustainable mango fruit production worldwide are pests and diseases (Misra,2011). Some of the major mango diseases include anthracnose, powdery mildew, die back, and mango malformation (Misra et al;2012). Mango commercialization has significantly altered the pest and disease community structure in this crop, characterized by the expansion of new areas, changing crop management, replacement of varieties, and increased chemical interventions. Climate change has also led to the emergence of new pests and diseases, while globalization and trade liberalization have created opportunities for mango commercialization but also resulted in faster dispersion of pests and diseases among different mango growing areas. Therefore, some pests and diseases which were earlier considered as minor have become serious problems now a days. It is mandatory to keep the losses well below the Economic Threshold Level, if not at all possible to control the diseases completely. Therefore, it is essential to understand mango's primary diseases and their management practices to mitigate their impact effectively.

2 Powdery Mildew

In India, the powdery mildew is widespread, and it poses a significant threat to the production of mango (Kulkarni, 1924). The severity of this disease is largely dependent on the prevailing climatic conditions. Other countries such as Iran, Pakistan, and Mexico have also reported major losses to mango crops due to this disease. However, by taking proactive measures, we can reduce the impact of this disease and ensure that the mango harvest is healthy and sustainable.

2.1 Damages: The fungal disease usually occurs during the time of flowering. Its primary symptom is the appearance of a superficial, powdery, white fungal growth on the leaves, inflorescences, stalks of the inflorescences, and young fruits. Before fertilization, the mildew affects mango flowers, leading to falling off unfertilized flowers. The mildew covers young fruits entirely, and as they grow, the epidermis of the infected area cracks, forming corky tissue that often falls prematurely during the pea-size stage. This disease is mainly responsible for the loss of young fruits in India, and the dropping of unfertilized and infected flowers and immature fruits which results in significant losses (Wagle, 1928). The underside of new leaves is mostly affected, but in advanced cases, both sides of the leaf are affected. The central rib area of the leaves where the symptoms are limited, causing them to curl and distort (Prakash & Srivastava, 1987).

2.2 Causative organism: In 1928, Wagle discovered that *Erysiphe cichoracearum* is responsible for causing powdery mildew. Later research revealed that the mildew fungus has globular haustoria and its conidial germination type ought to be identified as *Erysiphe polygoni*, according to Uppal's report in 1937 (Misra et al;2012).

2.3 Management: Various techniques exist for managing powdery mildew in mangoes. Sandolin (0.3%) and three other sulphur preparations such as thiovit, lime sulphur, and spersul, were found to be effective by (Bose,1953). Naik (1949) reported the effectiveness of Bordeaux mixture. Gupta & Yadav (1984) recommended the use of fungicides like Karathane and Wettasul. Rawal and Ullasa (1985), on the other hand, suggested copper oxychloride, triademifon, and tridemorph. According to Jadeja et al. (1985), Sulfex-O and Sulfex-A (2000 ppm) were effective, while Joshi and Chauhan (1985) recommended Tridemorph and Karathane. Dang et al. (1997) reported that flusilazole, tridemorph, dinocap, and sulphur were highly effective in controlling powdery mildew of mango. Sharma et al. (2011) assessed six fungicides and revealed that flusilazole @ (0.015%) was the most effective for managing powdery mildew.

3 Anthracnose

Anthracnose is a disease that causes unsightly blemishes on mango fruits. It was first reported in Puerto Rico in 1903 and has since been confirmed in multiple regions of the world (Misra et al;2012). All mango-growing

states in India suffer from this widespread and destructive disease. The disease has several forms in mango, such as blossom blight, peduncle blight, leaf spot, twig blight, wither tip, fruit russeting or staining, and fruit rot. It results in significant losses in both field and storage.

3.1 Damages: The leaves of the plant are marked by numerous vinaceous brown or deep brownish spots, which are oval or irregular in shape and can be of varying sizes. These spots can appear at the tip of the leaf or any other part of the margin, or they may develop in the centre of the leaf. When the weather is damp, these spots grow quickly, resulting in elongated brown or brown necrotic areas that later rupture and become blighted. The disease also causes black necrotic areas to form on the twigs, with the tip of very young branches being the first to be affected. The twigs continue to dry from the tip downwards. The disease has two stages of attack, during flowering, causing blossom blight, and during fruit ripening, causing typical anthracnose. Initially, the disease causes the production of blackish-brown specks on the peduncle and flowers. Small black spots then appear in the open flower panicle, which gradually enlarges and often merge, causing the death of flowers either directly or indirectly by drying up flower stalks.

The disease can affect the fruit during any stage of development. Black spots appear on older fruits, making them unsightly and reducing their keeping quality. Under moist conditions, the blackened areas become covered with minute pinkish pustules or reproductive bodies, producing numerous minute spores, each capable of causing fresh infection (Prakash & Srivastava, 1987). On the ripening fruit, the disease manifests as sunken, blackish-brown blotches upon which salmon buff masses of spores develop.

3.2 Causative organism: The causal agent of the disease is *Colletotrichum gloeosporioides*, which has been considered as a conidial stage of *Glomerella cingulata*. *Gloeosporium mangiferae* P. Henn causes the twig blight phase of the disease, as reported by Hayes (1953) from UP.

3.3 Management: It is recommended to remove any infected twigs from the tree and dispose of them by burning, as the fungus can survive on dead twigs for a long time. To prevent the disease, Sattar & Mallik (1939) suggested spraying of young plants in the nursery with Bordeaux mixture (3:3:50). Gadre (1982) achieved good results by using fungicides such as Bordeaux mixture, Captan, copper oxychloride, and Difolatan. An effective approach involves spraying copper oxychloride with Zineb after heavy rain followed by wettable sulphur (0.2%) before flowering, carbendazim (0.3%) at pea stage, and Zineb (0.2%) before the maturation of stone, and carbendazim (0.1%) at 15-day intervals.

4 Die back

The drying or dieback of plants from the top down is a widespread issue in states where mangoes are grown throughout the country. In 1939 and 1945**,** Das Gupta and Zachariah first reported the disease in UP. Every year, the disease is spreading and causing harm to new orchards and mango groves in tropical and subtropical regions.

4.1 Damages: The disease causes the top part of older trees to have twigs dying back, followed by complete defoliation, giving the tree the appearance of being scorched by fire. The bark becomes discoloured and darkened at a certain distance from the tip, with dark patches mostly visible on young green twigs, which are less noticeable in older branches. The bark discolouration occurs in multiple areas. As the dark lesions grow, the young twigs at the base start to wither, affecting the leaf midribs and extending outwards along the veins. The upper leaves lose their healthy green colour and turn brown, accompanied by the upward rolling of the leaf margin. In the advanced stage of the disease, the leaves shrivel and fall off in a month or more, leaving the shrivelled twigs completely bare.

4.2 Causative organism: The cause of the disease is found to be *Botryodiplodia theobromae* Pat. but the perfect stage of the fungus is not reported (Prakash & Srivastava, 1987).

4.3 Management: Precautionary measures can be implemented to manage the disease in grafted trees. These measures entail selecting a scion from healthy trees, sterilizing the budding knife, maintaining a relatively arid environment for the grafted tree, and gradually exposing it to full sunlight. According to Srivastava & Tandon's report from 1971, Captan has been discovered to be effective in vitro against the fungus. Additionally, as Prakash & Raoof have reported in 1985 and 1989, cutting off the diseased twigs approximately 7-8 cm below the infection site and then spraying Bordeaux mixture (5:5:50) or copper oxychloride (0.3%) has been found to be effective in managing the disease.

5 Sooty mould

Sooty mould, also known as sooty blotch, is a common fungal disease that appears in areas where honeydew or sugary secretions are present. These secretions are usually produced by insects such as mango hoppers, scales, coccids, and mealy bugs (Kulkarni & Kulkarni, 1978).

5.1 Damages: The disease can be easily identified by the presence of a black and velvety thin membranous covering on the leaf lamina. This covering can either entirely cover the lamina or appear as flakes on the leaf. In severe cases, the mold can spread to the entire surface of twigs and leaves, causing the tree to turn black. The affected leaves tend to curl and shrivel under dry conditions. The fungus that causes this disease multiplies on sugary secretions called "honey dew," which are produced by insects. The fungus spreads on the plant surface, making it look unsightly due to the masses of black spores on the leaf surface. The severity of the disease incidence depends on the sugary secretion by the insects. If the disease attacks during flowering time, it can result in reduced fruit set and sometimes cause fruit fall. Late mango varieties are also affected by this disease, and it is noticeable on the fruits (Prakash, 1988).

5.2 Causative organism: Sooty mould can be caused by various species of fungi, including *Meliola mangiferae* Earle, *Capnodium mangiferae* Cke. & Brown, *Capnodium ramosum* Cke., and *Tricospermum acerinum* (Syd.) Speg (Misra et al;2012). The fungus feeds on the sugary secretion produced by insects known as "honeydew" and is not considered pathogenic since it does not invade the host tissue to obtain nutrients. Although it does not directly harm the plant, it can disrupt its normal functioning.

5.3 Management: Insecticides can be used to eliminate honey dew secreting insects, which also eliminates the mould that grows on the leaves due to their secretion. According to Singh & Singh (1972), spraying Elosal (900 g/450 litres) every 10-15 days is an effective method. Prakash (1988) recommended spraying a mixture of wettasul, metacid, and gum acacia (0.2+0.1+3.0%) every 15 days to control sooty mould. Additionally, applying soluble starch to remove the dry flakes of sooty mould, along with spraying insecticides, proved to be a highly effective method of controlling its growth.

6 Phoma blight

According to a report by Prakash & Singh in 1977, the disease was found to be widespread in Lucknow. Additionally, they reported in 1987 that the disease is prevalent in West Bengal, Bihar, Maharashtra, Karnataka, Madhya Pradesh, Rajasthan, Gujarat, Uttar Pradesh, and Goa.

6.1 Damages: The disease shows symptoms only on old leaves. At first, the spots on the leaves are small, uneven, and yellow to light brown in color. They are scattered across the surface of the leaf. As these spots grow bigger, they turn from brown to cinnamon and become irregular in shape. When fully developed, the spots are surrounded by a dark margin and have dull grey necrotic centers. In severe cases, the spots merge to form patches that are 3.5-13 cm in size, causing the infected twigs to wither and the leaves to fall off.

6.1 Causative organism: The disease is caused by fungus *Phoma glomerata* (Corda) Woll. and Hochapf (Misra et al;2012).

6.2 Management: Two fungicides, benomyl at 0.2% concentration and copper oxychloride at 0.3%, were found to be the most effective in controlling phoma blight in studies conducted in 1978 and 1979. In 1986, a survey of 110 cultivars revealed that 51 had low incidence of phoma blight, 43 had medium incidence, and 16 had high incidence. A similar survey in 1987 of 279 cultivars showed that 30 had medium incidence and 12 had high incidence of phoma blight.

7 Malformation

The mango industry is under threat due to mango malformation, also known as bunchy top, which is a serious problem in mango-growing regions worldwide. The disease has become so widespread in recent years that it could cause the extinction of the mango industry, particularly in the northern parts of India. The first recorded instance of mango malformation was in 1891 by Maries from Darbhanga, Bihar. Over 50% of mango trees in northern India are affected by the disease (Misra et al;2012).

7.1 Damages: The symptoms of plant disease can be categorized into three types: bunchy top of seedlings, vegetative malformation, and floral malformation. Young plants in the nursery beds, show the bunchy top phase of the disease, where a bunch or several bunches appear at the top or a little lower down the main shoot of the young plant. These bunches are formed of numerous thickened small shootlets that cluster together. On these shootlets, many small rudimentary leaves are borne, and they are much thicker than the main axis from which they arise. The growth of the plant is halted, which gives it the appearance of 'Bunchy top'. Vegetative malformation is more pronounced in seedling trees than in grafted plants, where the affected seedlings develop excessive vegetative branches that are swollen and have very short internodes.

7.2 Causative organism: Mango malformation was found to be caused by *Fusarium oxysporum*, which was isolated from all parts of the plant. The fungus was found to be systemically present in the parenchymatous cells of the pith region of malformed tissues (Bhatnagar & Beniwal, 1977). More than one species of *Fusarium* may be responsible for the disease.

7.3 Management: Varma et al.1971 tested 34 fungicides, 17 insecticides, and 4 growth regulators to determine their fungicidal and fungistatic properties. Among the tested chemicals, Benlate, Brestan, Busan, Captan, Dithane M-45, Panogen, and Thiram were found to be the most effective.

8 Red rust

Different workers have reported the disease in India on various occasions. This disease can lead to a decrease in photosynthetic activity and defoliation, ultimately resulting in reduced plant vitality. The disease has been documented by Chowdhury in 1975 and by Prakash & Raoof in 1985.

8.1 Damages: The algal disease can be easily recognized by the rusty red growths that appear on the surface of leaves, veins, petioles, and young twigs. Initially, these growths have a greenish-gray and velvety texture, but they eventually turn reddish-brown. Depending on their merging pattern, the spots can either be circular or have an irregular shape, with a diameter of 2 mm that can reach up to 1 cm.

8.2 Causative organism: The source of the disease is the alga *Cephaleuros virescens* Kunze, also known as *C. parasiticus* Karst or *C. mycoidea* Karst. During the rainy season, infection rates have been found to increase, possibly due to rainwater spreading the alga (Thrimurty et al., 1981).

8.3 Management: In 1979, Prakash and Singh recommended the use of Bordeaux mixture (2:2:250) along with copper oxychloride to manage this type of algal infection. Other effective remedies for algal infection include spraying with fungicides such as Difolatan, Bordeaux mixture (Gupta et al., 1980), and copper fungicides (Thrimurty et al., 1981).

9 Conclusion

Mangoes around the world are vulnerable to various diseases, including powdery mildew, anthracnose, die back, sooty mold, malformation, phoma blight, and red rust. Different countries have identified other diseases affecting the fruit, foliar, floral, and soil, which could pose a threat to the global commercial trade of mangoes. To combat the adverse impact of pests and diseases on mango production worldwide, it is crucial to synchronize efforts at all levels of mango management and utilize a combination of different approaches. To prevent the introduction of new pests and diseases, stringent quarantine and regulatory measures should be implemented at the entry points of countries where mango is produced. At the farmers level, mango growers should receive proper and adequate training in adopting good agricultural practices that include integrated pest and disease management, reduction in the use of chemicals, and implementation of a sound monitoring and surveillance system. To find effective responses and proper management approaches to current pests and diseases and be prepared for any new threats, coordinated research, development, and innovation efforts should be undertaken internationally. Although chemical management is prevalent, non-chemical measures such as the selection of disease-resistant mango varieties are more desirable. Ideally, an effective management plan for mango pests and diseases will involve a holistic combination of management approaches.

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