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Practices for Integrated Control of Mango (*Mangifera indica* L.) Diseases to Protect in Preharvest as Well as Postharvest Phases

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Abstract

The present overview shows some of the most important diseases of mango and their control measures to eliminate the intensity of pest's damage. Mango *Mangifera indica* L., is one of the most famous tropical fruits, as a member of the family Anacardiaceae. Mango trees are affected by a number of pests of which the disease are a major and serious threat during the flowering and fruit setting seasons as well as after fruit harvesting period. Mango trees less than ten years old may produce flower and fruit regularly every year. Thereafter, most mango trees tend toward alternate or biennial bearing, which is due to several pests that are responsible to reduce mango yield. In Pakistan, Mango plants experience more than a few diseases at all stages of their existence in nature. All the parts of the plant, namely, trunk, branch, twig, leaf, petiole, flower and fruit are attacked by a number of pathogens including fungi, bacteria and algae. These cause several kinds of rot, die back, anthracnose, scab, necrosis, blotch, spots, mildew, etc., to the host. A few of these diseases like anthracnose and powdery mildew are of great economic importance as these cause heavy losses in mango production. Now a day, integrated pest management is the most effective weapon based on several important principles such as agricultural practices and chemical pesticides for diseases and pests management. It is better to consider the entire orchard's system (production, harvest, postharvest and marketing) when developing pest management strategies. Growers are encouraged to be on the lookout for any new or unusual pest occurrences and to discuss these and any other concerns with the staff of the department of horticulture industry.

Keywords

Mango, Disease, Pest, Pathogens, Manage, Orchard

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1. Introduction

Mango (*Mangifera indica* L.), is amongst the primarily top important fruits encompassing appetizing flavor, outstanding taste, striking appearance and necessitates somewhat little preservation expenses owing to its strong temperament. It is a sweetened, succulent, sweet-smelling, valuable and nourishing fruit. Mango produce is consumed in its adolescent and fully-developed growth stages within a lot of states worldwide. While still in green form, it may be utilized for making of pickles, ketchup, and can be dried-up to preserve. Whilst in ripe form, it may well be treated into fruit drink, pulp, squash, puree, nectar and jam. Several hybrids of mango have been developed for gardening that may be vulnerable to various pests resulting in shedding of flower and fruit. The mango diseases are significant pests within the most parts of the tropical countries in the world and have been documented for upsetting the worth and quality of produce, particularly at the time when circumstances are optimal for pests development (Sarwar et al., 2013; 2014 a; 2015; Shah et al., 2014).

The mango business is the mainly famous segment of horticulture and its development has been fast and

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remarkable. On the other hand, in spite of the inspiring growth of this sector, a number of issues are need to be addressed principally the productivity of mango trees in the region. Presently, mango suffers from several diseases at all stages of its life. All the parts of the plant, namely, trunk, branch, twig, leaf, petiole, flower and fruit are attacked by a number of pathogens including fungi, bacteria and algae. They cause several kinds of rot, dieback, anthracnose, malformation, scab, necrosis, blotch, spots, mildew, and so on (Ploetz, 2003). Therefore, the current article gives an idea concerning the various most essential diseases of mango and their control measures as discussed underneath.

2. Pre-harvest Diseases of Mango

The mango fruit faces so many pre harvest diseases caused by various pathogens in the field at ambient conditions of temperature and humidity.

2.1. Powdery Mildew (*Oidium mangiferae* Berthet)

This disease is one of the principally serious diseases of mango affecting almost all the varieties. It occurs throughout the mango growing areas of the country. Powdery mildew is reported to cause approximately 20 per cent crop loss in few areas. Sometimes, as high as of 70-80 per cent crop loss has been recorded on individual plant. The characteristic symptom of the disease is the white superficial powdery fungal growth on leaves, stalks of panicles, flowers and young fruits. The affected flowers and fruits drop pre-maturely reducing the plant weight considerably or might even prevent the fruit setting. Rains or mists accompanied by cooler nights during flowering are congenial for the disease spread. The fungus parasitizes young tissues of all parts of the inflorescence, leaves and fruits. For the control of this disease, following sprays of fungicides at 15 days interval is recommended for effective control: Wettable sulphur 0.2 per cent (2 g Sulfex/ liter water) or Topass, Topsin-M or Bayton Foliar by dissolving in water (Nofal and Haggag, 2006).

2.2. Anthracnose (*Colletotrichum cingulata* Ston, Spaull and Schrenk)

The anthracnose disease is of extensive occurrence. The disease causes serious losses to young shoots, flowers and fruits under favorable climatic conditions of high humidity, frequent rains and a temperature of 24-32^{o}C. It also affects fruits during storage. The disease produces leaf spot, blossom blight, wither tip, twig blight and fruit rot symptoms. Tender shoots and foliage are easily affected which ultimately cause 'die back' of young branches. Older twigs may also be infected through wounds which in severe cases may be fatal. Depending upon the prevailing weather conditions, blossom blight may vary in severity from slight to a heavy infection of the panicles. Black spots develop on panicles as well as on fruits. Severe infection destroys the entire inflorescence resulting in no setting of fruits. Young infected fruits develop black spots, shrivel and drop off. Fruits infected at mature stage carry the fungus into storage and cause considerable loss during storage, transit and marketing. The fungus perpetuates on twigs and leaves of mango or other hosts. Since the fungus has long saprophytic survival ability on dead twigs, the diseased twigs should be pruned and burnt along with fallen leaves for reducing the inoculums potential. For the management of this disease, trees may be sprayed twice with Cupravit or Cobox at 15 days interval during flowering to control blossom infection. Spraying of copper fungicides (0.3%) is recommended for the control of foliar infection (McMillan, 1984; McMillan and Mitchell, 1991).

2.3. Die Back (*Botryodiplodia theobromae* Pat)

Die back is one of the serious diseases of mango. The disease on the tree may be noticed at any time of the year, but it is most conspicuous during October- November. The disease is characterized by drying of twigs and branches followed by complete defoliation, which gives to the tree an appearance of scorching by fire. The onset of die back becomes evident by discolouration and darkening of the bark. The dark area advances and young green twigs start withering first at the base and then extending outwards along the veins of leaf edges. The affected leaf turns brown and its margins roll upwards. At this stage, the twig or branch dies, shrivels and falls. This may be accompanied by exudation of gum. In old branches, brown streaking of vascular tissue is seen on splitting it longitudinally. The areas of cambium and phloem show brown discolouration and yellow gum like substance is found in some of the cells. This pest can be controlled by: (i) Pruning the diseased twigs and spray with Copper Oxychloride (0.3%) on infected trees. Pruning should be done in such a way that the twigs are removed 2-3 inches below the affected portion. (ii) In small plants, pruning of twigs is followed by pasting of Copper Oxychloride (Hassan et al., 2002).

2.4. Phoma Blight [*Phoma glomerata* (Cords) Woll Hochapf]

Phoma blight is a new disease, but now it is gaining economic importance. The symptoms of the disease are noticeable only on old leaves. Initially, the lesions are angular, minute, irregular, yellow to light brown, and scattered over leaf lamina. As the lesions enlarge their colour changes from brown to cinnamon and they become almost irregular. Fully

developed spots are characterized by dark margins and dull grey necrotic centers. In case of severe infection such spots coalesce forming patches measuring 3.5-13 cm in size, resulting in complete withering and defoliation of infected leaves. The disease may possibly be kept under control by spray of Copper Oxychloride (0.3%) just after the appearance of the disease and subsequent sprays at 20 day intervals (Haggag, 2010).

2.5. Bacterial Canker (*Xanthomonas campestris*)

Canker disease of mango, is caused by a bacterium in some mango growing areas. The disease causes fruit drop (10-70%), yield loss (10-85%) and storage rot (5-100%). Many commercial cultivars of mango including Langra, Dashehari and Totapuri are susceptible to this disease. The disease is found on leaves, petioles, twigs, branches and fruits, initially producing water-soaked lesions and later turning into typical cankers. The disease first appears as minute water-soaked irregular lesions on any part of leaf or leaf lamina. The lesions are light yellow in color, but with age, enlarge and turn dark brown to black. They become angular, cankerous and raised, and are surrounded by chlorotic halos. Several lesions coalesce to form irregular necrotic cankerous patches. In severe infections the leaves turn yellow and drop off. Cankerous lesions appear on petioles, twigs and young fruits. The water soaked lesions also develop on fruits which later turn dark brown to black. They often burst open, releasing highly contagious gummy ooze containing bacterial cells. The fresh lesions on branches and twigs are water soaked which later become raised and dark brown in color with longitudinal cracks, but without any ooze. Seedling certification, inspection and orchard sanitation are effective to control this disease. Three sprays of Streptocycline (100 ppm) or Agrimycin-100 (100 ppm) after first visual symptom at 10-days intervals are successful. Monthly sprays of Copper Oxychloride (3000 ppm) are also found effective. As precautions, the key to success for full control is to start application of fungicides before the infection has established (Hassan et al., 2002).

2.6. Red Rust (*Cephaleuros virescens* Kunze)

Red rust disease is caused by an alga and has been observed in some mango growing areas. The algal attack causes reduction in photosynthetic activity and defoliation of leaves thereby lowering vitality of the host plant. The disease can easily be recognized by the rusty red spots mainly on leaves and sometimes on petioles and bark of young twigs and is epiphytic in nature. The spots are greenish grey in colour and velvety in texture. Later, they turn reddish brown. The circular and slightly elevated spots sometimes coalesce to form larger and irregular spots. The disease is more common in closely planted orchards. Fruiting bodies of the alga are formed in humid atmosphere. The zoospores formed by the sporangia initiate fresh infections. Stem entry is achieved by way of cracks. The affected areas crack and scale off. In severe infection the bark becomes thickened, twigs get enlarged, but remain stunted and the foliage becomes sparse and finally dries up. Two to three sprays of Copper Oxychloride (0.3%) are effective in controlling the disease (Coates et al., 2009).

2.7. Sooty Mould (*Meliola mangiferae*)

Sooty mould disease is widespread in the orchards where mealy bug, scale insect and hopper are not controlled efficiently. The disease in the field is known by the presence of a black velvety coating, i.e., sooty mould on the leaf surface. In severe cases the trees turn completely black due to the presence of mould over the entire surface of twigs and leaves. The severity of infection depends on the honey dew secretion by the above said insects. Honey dew secretions from insects sticks to the leaf surface and provide necessary medium for fungal growth. The fungus is essentially saprophytic and non-pathogenic because it does not derive nutrients from the host tissues. Although no direct damage is caused by the fungus, the photosynthetic activity of the leaf is adversely affected due to blockage of stomata. This disease can be controlled by: Pruning of affected branches and their prompt destruction prevent the spread of the disease. Spraying of 2 per cent starch is found effective. It could also be controlled by spray of Antracol 80 WP (Hassan et al., 2002; Haggag, 2010).

2.8. Scab (*Elsinoe mangiferae*)

Scab is a pathogen of young leaves and its colonization is favored in cool, wet conditions. Signs of scab on leaves are small spots on the underside of leaves which turn from dark-brown to gray. Leaves may become distorted and twisted if the infestation is heavy. Gray lesions on twigs may also be apparent. Fruit develops irregular, with gray lesions which enlarge as it matures. The lesion centers become corky, cracked, and often exhibit the velvety growth of the fungus in moist weather. Copper has long been used as a fungicide and can be applied in multiple forms (copper hydroxide or copper sulfate) (Conde et al., 1997).

2.9. Mango Malformation (*Fusarium mangiferae*)

The most important and damaging symptom on mangoes is the development of malformed or abnormal inflorescences. This is caused by hormonal imbalance associated with the Fusarium infection leading to the development of sterile

florets on short internodes and there is no fruit production. Vegetative symptoms include distorted shoots with shortened internodes and often with a witches broom appearance that are most common in younger trees. Cultural practices e.g., pruning malformed flowers, avoiding damage to tree roots by ploughing and flood irrigation would definitely contribute to prevent the spread of pathogens throughout the orchards (Kvas et al., 2008).

3. Post-harvest Diseases of Mango

The mango fruit is subjected to many post harvest diseases caused by anthracnose (*Colletotrichum gloeosporioides*) and stem end rot (*L. theobromae*) during storage under ambient conditions or even at low temperature. Aspergillus rot is another post-harvest disease of mango. For their control, pre-harvest sprays of fungicides might control the diseases caused by latent infection of these fungi. Post-harvest dip treatment of fruits with fungicides could also control the diseases during storage. Some treatments suggested are: (i) Three sprays of carbendazim (0.1%) and orthiophante-methyl (0.1%) at 15 days interval should be done in such a way that the last spray falls 15 days prior to harvest. (ii) Post-harvest dip treatment of fruits in carbendazim (0.1%) in hot water at 52$\pm$1^{o}C for 15 minutes. Careful handling during and after harvest, removal of infected mangos during grading can help in minimizing losses from post-harvest decays. Washing the fruits immediately after harvest is essential, as the sap which leaks from the stem burns the skin of the fruit making black lesions which leads to rotting (Chrys et al., 2006).

4. Integrated Management for Mango Diseases

The widespread and rapid establishments of the pests in orchards or gardens require immediate changes in integrated pest management (IPM) program as promising prospect (Sarwar, 2006 a; 2006 b; 2011; Sarwar et al., 2014 b; 2014 c). The best way to ensure success of mango disease management program is to use integrated disease control measures. A successful disease control program could involve the usage of specific practices, but the long term reduction of disease losses usually requires the application of several control measures. Three foliar applications of bio-agents or natural compounds alone or in combination to mango trees can markedly decrease infection with malformation, anthracnose, powdery mildew, dieback diseases, mites, insects in leaves and blossom clusters to increase fruit set as well as yield (Joubert et al., 2000; Haggag et al., 2014). Generally, integrated management is regarded as the use of environmentally safe practices to reduce the disease incidence and development or use of multiple control tactics integrated into a pest control plan (Renkang and Keith, 2005; Sarwar, 2004; Sarwar, 2013).

5. Pre-harvest

It is better to begin mango sowing with cultivars which are offering natural resistance to the pests expected within a specific region. Always plant only good quality and clean seed from a healthy stock. Generally, use appropriate cultural practices during fruit production to assist the produce to avoid and resist pest attack (proper planting density, fertilization, irrigation, pH modification, weeding, pruning, thinning, proper ventilation or air movement through the canopy). Monitoring of orchards to determine actual pest levels before implementing pest controls is vital. It is superior to use a combination of appropriate pest control methods (biological control, chemical pesticides, protectants, sanitation practices). Always, take efforts to keep fields and orchards free of debris and discarded produce, and eradicate diseased produce.

6. Harvest

In general, avoid damage during harvest by handling produce gently and harvest at the proper maturity of produce to have the maximum resistance against pests. As a general rule, use sharp and clean tools for fruit harvest and trimming processes.

7. Curing

In most cases, cure root, foliage, twig and trunk of plant, and heal harvest wounds in order to increase resistance to the pests.

8. Packinghouse

Try to sort or remove any damaged, decayed, and over-matured or under-ripped produce. In addition, wash or clean produce to remove soil and debris, and to reduce the amount of innoculum on surfaces. Trim the senescent leaves from produce and remove dried flower parts from fruits. Use appropriate postharvest treatments to manage pest problems (chemicals, heat, hot water, pesticides).

9. Packing

Generally, avoid over-use of liners that constrict air flow in the package and contribute to condensation (free moisture), and poor cooling efficiency. Always use ventilated plastic bags as liners for produces that are highly susceptible to water loss.

10. Storage

Usually, avoid damage to sensitive fruit and avoid mixing lots of produce in storage. Typically, keep produce at its lowest safe temperature for maximum pest management, also avoid chilling injury by keeping sensitive commodities at appropriate moderate temperature.

11. Conclusion

Approximately, in all the mango producing localities, the growers start spraying of chemicals on plants injudiciously. The farmers are not cautioned to utilize those chemicals which can create pest resurgence in the later phase of the plant growth. So, it is sensible to incorporate compatible fungicide along with the pesticide for effective pests management. The management strategies by keeping orchards clean, pruning of overcrowding and over lapping branches during August to September, collecting and destroying of affected inflorescence or sticky inflorescence are very helpful to keep low the considerable pests damage to mango plants. Many of the practices described so far are valuable because they help to reduce diseases problem during pre-harvest, post-harvest handling, storage and marketing of mango. The first line of defense against diseases is good management during orchard production. Mango monitoring to determine actual pest levels and a combination of appropriate genetic, biological, cultural, physical and chemical controls is usually enough to prevent serious pests damage. The second defence is careful mango harvesting and preparation for market in the field, since most diseases can not gain a good start without easy entry through cuts, bruises or injuries. Next step is sorting out damaged, over-ripped or decaying produce that can limit contamination of the remaining healthy produce. Finally, even when the greatest care is taken, sometimes produce must be treated to control insects or decay causing organisms. Further, to address mango diseases and other issues, researchers in partnership with industry, should disseminate their research results to orchard growers which may then help them to improve yield and quality of mango.

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