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PREVALENCE OF POSTHARVEST ROTS OF MANGO IN DIFFERENT FARMS OF SINDH, PAKISTAN

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Abstract

A serious threat to the mango industry is postharvest decay. Postharvest losses of fresh mango fruits are reported to be more than half of its production in some of the developing countries. Pakistan is one of the main mango growing countries of the world. Highly perishable nature and its susceptibility to post harvest diseases, is the major hindrance in exporting to distant foreign markets. Latent infections by plant pathogenic fungi in the field are the main reason of postharvest disease development during transit and storage. A study was carried out for three consecutive years (2013-2015) to provide an overview of postharvest diseases and pathogens in different orchards of the Sindh. In isolation from the twigs collected from trees *Lasiodiplodia theobromae* was the most predominant fungus with significant highest frequency of 30.77, 25.00 and 7.5%, followed by *Alternaria alternata* with the frequency of 20.00, 9.1 and 14.5% while, *Colletotrichum gloeosporioides* frequencies were 4.82, 6.2 and 3.9% during 2013, 2014 and 2015, respectively. Incidences and severity of the diseases greatly varied from farm to farm. No significant difference were observed between the incidence of postharvest rots and fruits collected from either side of the trees. Irrespective of fruits position on the tree, stem end rot (SER) remains the predominant postharvest rots on the mangoes of selected orchards. The overall incidences of SER were 10.83, 14.64 and 3.21% in 2013, 2014 and 2015, respectively. The incidences of anthracnose and Alternaria rot were very low. It's evident from the data that with the passage of time a considerable reduction was occurred in the development of postharvest rots on the mangoes of selected orchards due to the adoption of good farm management practices. *L. theobromae* was predominantly isolated from the mango fruits having typical symptoms of the stem end rot disease. It is concluded that attention should be given to develop effective strategy to control mango postharvest diseases and more focus should be given to stem end rot. Moreover, it also appears that pre-harvest practices including farm sanitation plays a vital role in keeping the development of postharvest diseases at low level.

Introduction

Pakistan is the fourth largest mango producer and exporter in the world. Its production is mainly clustered in Punjab followed by Sindh province with the production of 1503.2 and 381.3 thousands tones, respectively. While, total Pakistan's production was 1885.9 thousand tones during 2010-11 (Anon., 2012). However, its yield per hectare is considered low as compared to other mango producing countries of the world. This might be due to non adaptation of improved techniques by the small mango growers (Saifullah *et al*., 2007), resulting the massive loss of fruit quantity and quality. While, some enthusiastic grower such as "Sindh Mango Growers & Exporters" (SMGE) are well in adopting the innovative technologies.

In 2013, Pakistan have exported 103478 tones of mangoes fruits of value 4706 million rupees (Memon, 2014). The main factor that limiting the domestic and international trade is the postharvest susceptibility of mangoes to diseases, improper storage conditions and non-availability of proper supply chains (Litz, 2003). Pre and postharvest diseases are considered to cause significant losses to fruits (Jacob, 2002). High water and nutrients contents of ripening fruits make them ideal substrate for infection process by the pathogens and for further development and perpetuation of pathogenic microorganisms (Sanzani *et al.,* 2009). Infection to mangoes from pathogens takes place before or during harvesting, remains latent and progress during storage and shows up during ripening. The harvested fruits are more prone to postharvest diseases during storage because of physiological changes and senescence, which favors the quiescent infection to develop rapidly (Prusky, 1996; Eckert *et al.*, 1996).

A serious threat to the mango industry is postharvest decay. Postharvest losses of fresh mango fruits are reported to be 25-40% in India and 69% in Pakistan. Microbial decay accounts for 17.0-26.9% of the total postharvest losses in Asian countries (Prabakar *et al.,* 2005). Postharvest losses may be due to various factors, including physiological changes, physical damage, chemical injury or residues and pathological decay (Swart, 1999). Postharvest diseases of mango deteriorate the fruit quality and make them unfit for consumption (Barkai-Golan, 2001; Narayanasam, 2006; Bally *et al.,* 2009). In most cases, blemished fruit remain unmarketable, so it causes heavy economic loss in international trade (Diedhiou *et al.,* 2007).

Major postharvest diseases that deteriorate the fruit quality include anthracnose, stem end rot and soft rots (Cappellini *et al.,* 1988; Jeffries *et al*., 1990; Crane & Campbell, 1991). Anthracnose and stem end rot are two most common diseases, caused by several fungi (Johnsons & Coates, 1993). Fungal pathogens play a major role in postharvest rotting of mangoes. Fungal pathogens involved in mango rotting after harvest includes *Colletotrichum gloeosporioides* responsible for mango anthracnose, *Alternaria alternata* and *Alternaria tenuissima* that cause *Alternaria* rots, *Botryodiplodia theobromae* and *Dothiorella* species responsible for stem end rot, *Phoma mangiferae* and *Pestalotiopsis mangiferae* causing gray leaf spots (Dodd *et al*., 1997; Kuos, 1999; Arauz, 2000; Okigbo & Osuinde, 2003; Ko *et al*., 2007). Mangoes therefore, experience different levels of stress in diversified environment, which together with varying levels of pathogen inoculum pressure, can trigger symptom development and result in disease expression (Finennemore, 2000).

Efforts must be channelized to improve and maintain the marketing standard for competitiveness and successful consignment of mangoes to overseas markets (Simmons *et al.,* 1997; Amin *et al.,* 2008). Proper identification of the disease and involved pathogen is the prerequisite for appropriate disease management. Often symptoms of postharvest disease can appear to be similar despite being caused by different pathogens. In such cases, isolation from disease lesions is needed to identify the causal agent. The morphological criterion for identification is generally not enough to differentiate between these species (Jacobs & Rehner, 1998; Denman *et al.,* 2000).

Disease assessments have various objectives; can be used to quantify disease development, differences in various treatments and different management practices. Therefore, the present study is planned on postharvest diseases assessment of different mango orchards to providing avenue for better management of mango to meet the demands of the country and to export overseas.

Materials and Methods

Selection of farms: A total of seven farms were included in this study. These farms are located in different regions of Sindh *viz*., Kotri, Sakrand, Tando Allahyar, Tando Ghulam Ali and Tando Mohammad Khan. Five representative trees were selected (with double diagonal pattern or "x" pattern of equal distance) from each farm.

Isolation of pathogens from orchards: Twigs were collected from each selected tree, placed in the paper bag that were properly labeled and brought to the laboratory. For isolation of pathogens, these twigs were cut into the small pieces (1 cm) with the help of sterilized scissors. These pieces were surface sterilized with 5% commercial bleach (Sodium hypochlorite) for 2-3 minutes and placed on sterilized Petri dishes containing PDA medium amended with Streptomycin sulphate @ 1ml L^{-1} and Penicillin @ 1000,000 units L^{-1} to avoid bacterial contamination. Five twigs pieces were placed in each Petri dish, after closing the lid these were incubated in incubator at 25°C for 5-7 days. Later on, the appearing fungal colonies were purified by transferring to new Petri plates. The isolated fungi were identified on the basis of morphological characteristics.

Effect of fruit position on postharvest diseases: From each tree, 24 good fruits were collected (four from east top, four from east middle and four from east low position of the tree. Similarly, twelve fruits were collected from west side of the tree with same pattern. It means total of 120 fruits were harvested from each farm. Each fruit were marked with farm number, tree number and position on the tree. They were immediately brought to the lab in air-conditioned vehicle without delay and without leaving in the sun.

Initially fruits were harvested by hands with long stem intact with fruit and de-stem from the flush node in the lab and immediately inverted on wire rack for 1 hour so the sap can drain away. After de-sapping, fruits were kept in an air conditioned room in cardboard boxes with the flush node upward position at temperature 18-20°C with relative humidity of 80%. Observations on following parameter of disease assessment were recorded at alternate days during ripening:

- Disease symptoms (disease type i.e. anthracnose, stem end rot, side rot etc).
- Disease incidence (no. of affected fruit).
- Disease severity (by use rating scale Corkidi *et al*., 2006).

$$\text{Disease incidence (of specific disease)} = \frac{\text{No. of fruits affected with that specific disease}}{\text{Total numbers of fruits assessed}} \times 100$$

Pathogens isolation from affected fruits: For characterization and identification of causal agents isolation was carried out from predominant rot type, representative lesion and from the twigs on PDA medium at 25°C. Identification of fungal culture was done on colony appearance and on morphological basis. Purified cultures of each fungus was maintained and preserved for future studies.

Results

Pathogens prevalence in different orchards: During the present studies an attempt has been made to develop disease forecast model for possible mango postharvest rots to appear. In this regard 6-8 days before the real time of harvesting, twigs or fruit stem (without fruit) of last season as well as of new one were collected from each surveyed farm. Prevalence of each pathogen varied year to year. However, *L. theobromae* remains the highly isolated pathogen. In 2013, L. *theobromae* was the most frequently prevalent fungus in all studied orchards with over all frequency of 30.8%. The other important pathogens were *Alternaria alternata* (20%) and *Colletotrichum gloeosporioides* (4.8%). Some less important fungi were also isolated from twigs with varying frequencies such as *Aspergillus niger* (12.6%), *A. flavus* (1.8%) and *Rhizopus oryzae* (0.8%).

Same trend was recorded during mango season 2014, *L. theobromae* followed by *A. alternata* and *C. gloeosporioides* was the most frequently prevalent important fungi in all the studied orchards. In 2015, a remarkable reduction in *L. theobromae* population was noted in comparison to last two years. The overall frequency of *L. theobromae* was only 7.5%. *A. alternata* appears as the most predominant fungus with significant highest frequency of 14.5% followed by *A. niger* (11%) and *C. gloeosporioides* (3.9%) (Fig. 1).

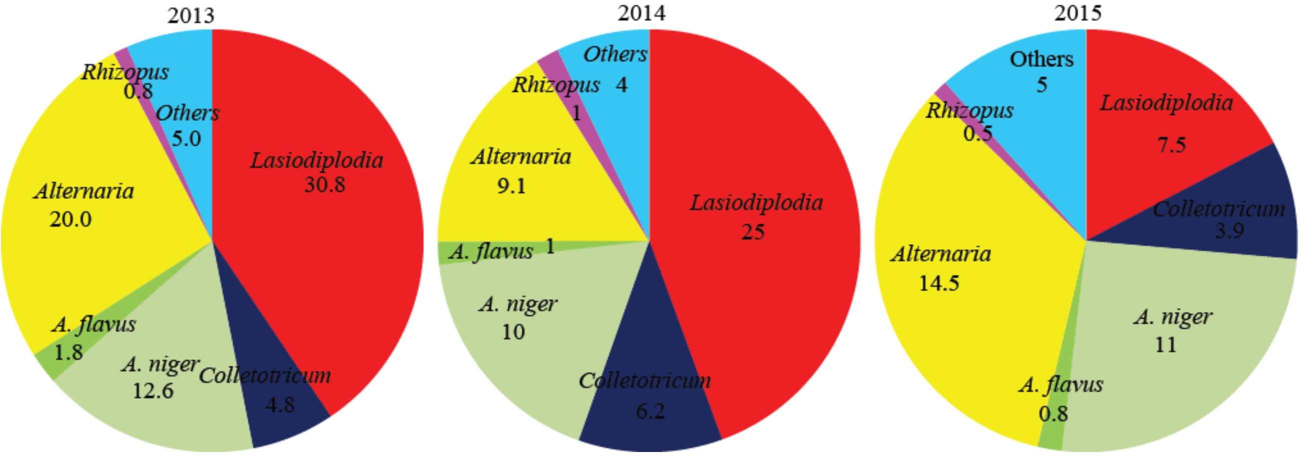

Fig. 1. Frequency (%) of different fungi isolated from twigs of mango trees of seven different orchards of Sindh in 2013, 2014 and 2015 mango season.

Effect of fruit position on mango postharvest diseases: During the study period (2013-15), no persistent trend was observed between fruit positions and incidence of postharvest diseases (Fig. 2). The major types of postharvest rots recorded were stem end rot (SER), anthracnose rot, side rot and Alternaria rot (Fig. 3).

Disease incidence: Irrespective of fruits position, SER remains the predominant postharvest rots on the mangoes of selected orchards. The overall incidences of SER were 10.83, 14.64 and 3.21% in 2013, 2014 and 2015, respectively. The side rot was the 2nd dominant postharvest disease with overall incidences of 6.25, 9.40 and 1.07% in 2013, 2014 and 2015, respectively. The incidences of anthracnose and Alternaria rot were very low ranging from 0.83-3.81% (anthracnose rot) and 0.0-1.9% (Alternaria rot) during the study period. It was also evident that with passage of time a considerable reduction was occurred in the development of postharvest rots on the mangoes of selected orchards (Fig. 4).

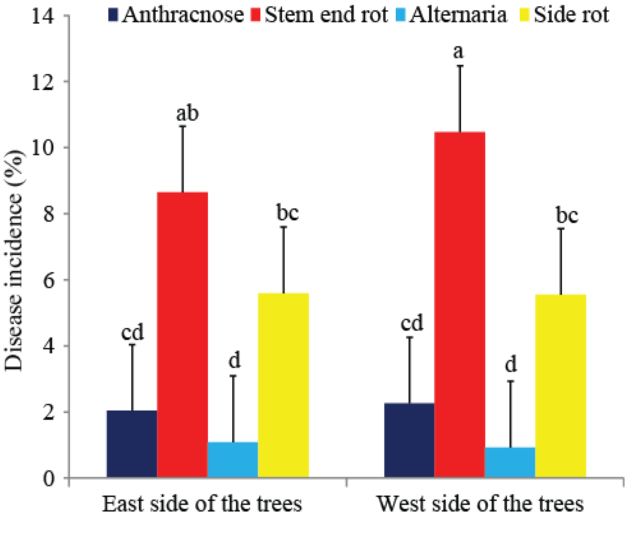

Fig. 2. Effect of fruit positions on the occurrence of mango post harvest diseases. Each bar represents cumulative disease incidence percent calculated for the assessment of 1200 fruits during 2013, 2014 and 2015 mango seasons. Data was taken after 20 days of storage at 20°C with relative humidity of 80%.

Disease severity: The disease severity score of stem end rot was higher in all farms as compared to other postharvest rots except in farm 4 where side rot was higher in score. At farm 2 disease severity score of stem end rot was 103 followed by farm 3, farm 6 and farm 7 with disease severity score 62, 49 and 45, respectively. While, lowest stem end rot severity score (17) was in farm 1 and farm 5. Side rot was higher in farm 4 while 52, 27, 16, 7 and 7 was found in the mangoes harvested from farm 2, farm 3, farm 6, farm 1 and farm 5, respectively. Whereas, less severity score of side rot (4) was found in farm 7. Anthracnose rot was not found in the mangoes harvested from farm 1 and 5. In farm 3, the severity score of anthracnose was higher as compared to other farm. Alternaria rot was found in only two farms with the severity score of 19 and 11 (Fig. 5).

Pathogens associated from affected fruits: In 2013, isolation from the affected fruits collected from different farms revealed the maximum association of *L. theobromae* with the diseased fruits. It was isolated in high frequencies with the affected fruits of all farms. In aggregate, during 2013 the frequency of *L. theobromae, C. gloeosporioides* and *A. alternata* was 75, 6, and 2%, respectively.

In 2014, *L. theobromae* remained as the predominant fungus with frequency of 52%, followed by *C. gloeosporioides* (12%) and *A. alternata* (5%). In 2015, the overall recovery of *L. theobromae* reduced to 47% isolated from the affected mango fruits of all the selected orchards, while the frequency of *C. gloeosporioides* and *A. alternata* was 15 and 3%, respectively. The other fungi such as *Aspergillus* spp., *R. oryzae* and some un-identified were also isolated from the affected fruits in varying frequencies, which grouped as 'others'. The recovery of these other fungi was 17, 31 and 35% in 2013, 2014 and 2015, respectively.

The aggregate data clearly indicates that *L. theobromae* was the most predominant fungus with frequency of 75, 52 and 47%, associated with fruits of studied mango orchards during 2013, 2014 and 2015, respectively (Fig. 6).

Fig. 3. Major types of post harvest rots associated with mango harvested from different orchards of Sindh.

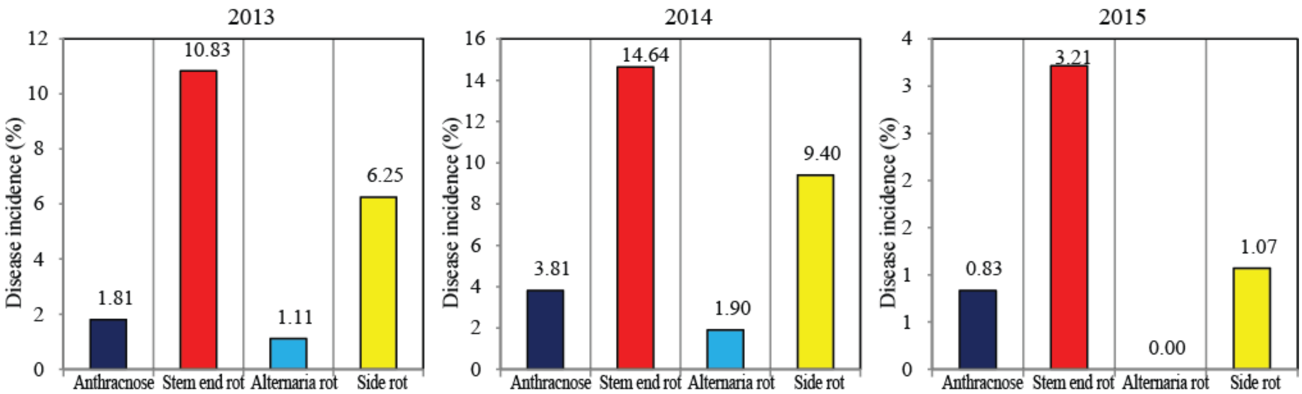

Fig. 4. Collective disease incidence of post harvest rots on fruits of seven different farms of Sindh in 2013, 2014 and 2015 mango season. Each bar represents disease incidence percent calculated for 840 fruits. Data was taken after 20 days of storage at 20°C with relative humidity of 80%.

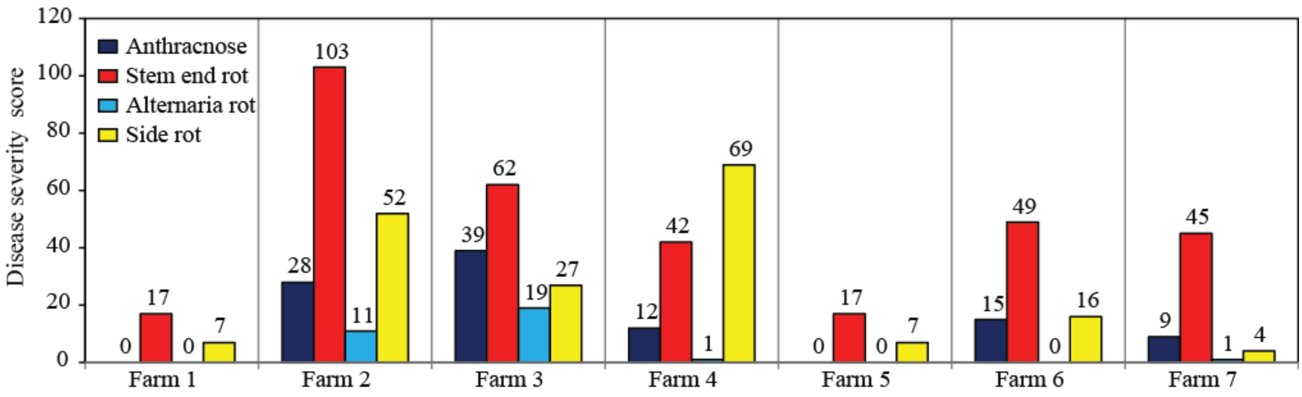

Fig. 5. Disease severity score of different post harvest rots on fruits of seven different farms of Sindh. Each bar represent cumulative disease severity score of 120 fruits calculated after using disease rating scale of Corkidi *et al*. (2006).

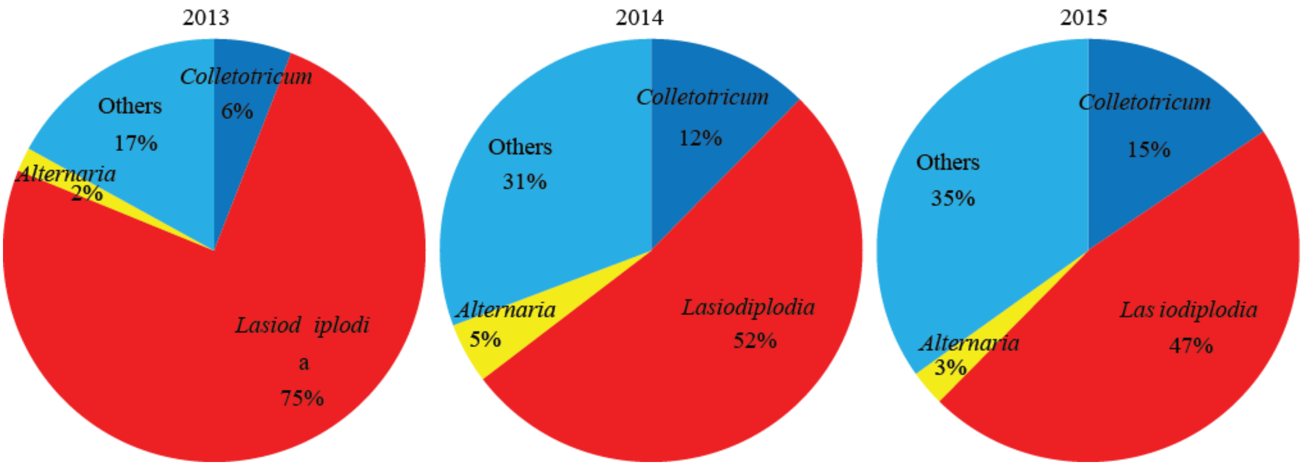

Fig. 6. Over all prevalence of different fungi isolated from post harvest mango rot of seven different orchards of Sindh in 2013, 2014 and 2015 mango season.

Discussion

Mango fruit quality, marketability and shelf life adversely affected by postharvest disease development (Amin *et al.,* 2011). During the assessment of various mango orchards it is appeared that stem end rot followed by side rot, anthracnose rot and Alternaria rot are the most prevalent postharvest diseases on cv. Sindhri. Stem end rot appeared as the most prevalent disease with high severity score followed by side rot, anthracnose rot and Alternaria rot. Other workers are also reported the same diseases (Jeffries *et al*., 1990; Amin *et al.,* 2011; Meer *et al*., 2013). Anthracnose rot and stem end rot were also the major mango postharvest diseases in other mango growing regions of the world (Ko & Liu, 2009; Rong *et al.,* 2000; Kajamuhan *et al.,* 2000). Fischer *et al.* (2009) evaluated the occurrence of postharvest diseases on 15 mango varieties and found that anthracnose remain the main disease in the fifteen varieties of mangos, followed by stem end rot.

Generally, no persistent trend observed between orchards and fruit positions and incidence of postharvest diseases. There were no significant difference between the fruits collected from either side of the trees contradictory to Johnson *et al*. (2012) observed more prevalence of stem end rot on fruit of east side of trees, while more incidence of anthracnose on fruit harvested from lower west side of trees (in Southern hemisphere).

Commonly fruits are used to assess the pathogen associated with postharvest diseases. Here we wanted to reduce the expense by assessment of pathogen from fruits and a step to develop a monitoring system for the assessment of postharvest disease available even before fruits mature. Mangoes acquire infection either from endophytic colonization of fungus at stem end before harvest or by soil contamination at harvest. The main pathogen found to be associated with twigs as well as with fruit is *L. theobromae* causal agent of SER-the major postharvest disease of mango. The cv. Sindhri is most popular and potential variety of Sindh and found to highly susceptible to the stem end rot disease (Syed *et al*., 2014). This disease is caused by a complex of fungal pathogens, of which various *Botryosphaeria* spp. are dominant (Darvas, 1991; Johnson *et al.,* 1991; Sangchote, 1991). *Botryodiplodia theobromae* (Pat.) Griffon & Maubl., is geographically widespread specie of Botryosphaeriaceae to tropics and subtropics regions of the world (Punithalingam, 1980; Johnson *et al*., 1992). It was responsible for 26.7% of decay diseases in Himachal Pradesh, India, in 1990-92 (Sharma *et al*., 1994). *A. alternata, Phomopsis mangiferae* and *Botryodiplodia* spp. were the main pathogens associated with SER of mango under the agro-ecological conditions of Punjab province of Pakistan (Amin *et al*., 2011). Fatima *et al.* (2009) isolated and identified a number of fungi *viz*., *Alternaria alternata*, *A. citri*, *Aspergillus niger*, *A. flavus, Aspergillus* sp., *Cladosporium cladosporioides*, *Drechslera australeinsis*, *Fusarium solani*, *Fusarium* sp., *Geotrichum candidum, Penicillium* spp., *Phytophthora capsici* and *Rhizopus stolonifer* involved in postharvest deterioration of fresh fruits. Sharma *et al.* (1994) also reported that 17 pathogens associated with postharvest diseases in Himachal Pradesh, India, in 1990-92.

Incidences of postharvest diseases from the collected mangoes varied farm to farm and the incidences within the study duration of 2013-2015 gradually decreased with the passage of time. With the intervention of R&D projects, pre-harvested practices have been improved, that minimized the primary pathogens inoculums, resulted in reduced incidences of postharvest diseases (Collins & Iqbal, 2011).

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