OCCURRENCE AND PREVALENCE OF MANGO DECLINE IN THE PUNJAB PROVINCE OF PAKISTAN

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ABSTRACT

Mango (*Mangifera indica*) is a popular fruit in Pakistan and ranks second to citrus. Pakistani mangoes have a large export potential in overseas markets that has yet to be realized. In Pakistan, important fruit trees such as citrus, mango, guava, etc. are facing a decline. Among these fruits, mango decline has been addressed strongly as they are important foreign exchange earnings and export items. In the case of mango, the decline has different forms, generally known as progressive, slow decline, or dieback; quick dieback, and sudden death. This type of condition is most common in poorly managed orchards that do not follow correct nutrition, plant protection, or irrigation techniques. Such a drop can be easily addressed if orchards are cultivated using the greatest possible production methods. The updated studies on the occurrence of mango decline are necessary to become a reference for further research and management strategies. Therefore, the present study was designed for disease estimation in the mango-growing areas of the Punjab province of Pakistan. According to the results, maximum mean disease severity of 2.70 was observed in district Bahawalpur followed by Khanewal (2.30), Multan (2.11), and Muzaffar Garh (2.00). The minimum disease severity (1.90) was recorded in Rahim Yar Khan district. Similarly, the maximum mean disease incidence (100%) was found in Khanewal followed by Bahawalpur (99.30%), Muzaffar Garh (96.00%), and Multan (96.00%) while the minimum disease incidence (90.00%) was observed in Rahim Yar Khan. The disease index which gives the actual picture of the disease was found to be the maximum in Bahawalpur (53.30%) followed by Khanewal (46.50%), Rahim Yar Khan (39.10%), and Muzaffar Garh (37.30%) while the minimum disease index of 36.89 was found in Multan district. This information will serve as the baseline information for research and management strategies in mango decline.

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INTRODUCTION

Mango (*Mangifera indica*) is a popular fruit in Pakistan and ranks second only to citrus. It is gaining attraction in the international market due to its flavor and shape. The United Kingdom, France, and Germany, which consume 15% of the EU's mango imports, are the biggest overseas markets. Since 2002, EU countries have boosted their imports of Pakistani mango by 50%, totaling 199,000 tons worth 228 million euros in 2006. The reason for this growth is that mangoes are not grown in Europe.

India, Mexico, Brazil, and Peru are the top mango exporters. Pakistani mangoes have a large export potential in overseas markets that have yet to be realized. In 2012, Pakistani mango exports were Rs. 3.27 million (Anonymous, 2013). Mango trees are produced on 0.175 million hectares with a productivity of 1.720 million tons (Anonymous, 2016). Mango orchards range in size from less than 2 hectares to 200 hectares (Khan, 2010). In Pakistan, important fruit trees such as citrus, mango, guava etc. are facing decline. Among these fruits, mango decline has been addressed strongly as they are important foreign exchange earnings and export items.

In case of mango, decline has different forms, generally known as progressive, slow decline or die back; quick die back and sudden death (Fateh et al., 2006; Iqbal et al., 2004b; Iqbal et al., 2004a; Iqbal et al., 2005a; Iqbal et al., 2007a; Iqbal et al., 2005b; Irshad et al., 2012; Mukhtar et al., 2007; Saeed et al., 2019). Mango trees are suffering from twig and branch dieback which is causing them to deteriorate. It begins at the top of the canopy and moves down to the lower braches. This suppresses the usual flush of trees, as well as cause leaf discoloration. The canopy appears bare due to poor flushes, and the quantity of dead twigs is often high. This type of condition is most common in poorly managed orchards that do not follow correct nutrition, plant protection, or irrigation techniques. Such a drop can be easily addressed if orchards are cultivated using the greatest possible production methods (Fateh et al., 2016; Fateh et al., 2009).

In quick dieback, trees start losing their shape quickly. Such type of dieback indicates a deficit or toxicity of certain elements. Leaves turn yellow and fall off; moisture does not reach the higher branches, and the tops of the trees appear to be dead. As a result of the dryness, opportunistic fungi can infiltrate the plants, causing them to generate gum of varied colors. Appropriate feeding, timely irrigation, and foliar sprays of systemic fungicides all aid in the management of mango tree dieback (Fateh et al., 2017; Kazmi et al., 2007). Sudden death decline is a real threat for the mango growers. The name "sudden death" given to this disease is tree death visible in shortest time may be in few days or a month. Once the decline causing pathogens infect trees, the internal break down of the tissues is initiated. However, the symptoms remain masked. As the climate becomes more conducive to the pathogen, rapid growth and tree vitality declines, healthy-looking trees develop severe symptoms and die suddenly. Leaf drying, drooping, and leathery appearance are some of the signs. Cracks form in the collar region of the stem, the bark splits, and the trees leak dark brown gum. The collar area occasionally leaks a thick dark brown substance. When the bark is removed from the stems of diseased trees, mouse grey stripes develop, indicating that infections have thoroughly penetrated the trees and that recovery is improbable (Fateh et al., 2006). In Pakistan, the etiology of mango sudden death was described for the first time in 2005. When compared to the Punjab province, the disease was more prevalent in mango-growing districts of Sindh. *Botryodiplodia theobromae*, *Phytophthora* sp., and Fusarium sp. were among the infecting mycoflora. Meanwhile, in 2006, a novel fungus known as *Ceratocystis fimbriata* was discovered in Oman, attacking mango in conjunction *with Lasiodiplodia theobromae*. Later, a new species, *Ceratocystis omanensis*, was discovered (Al-Adawi et al., 2006). In Pakistan, the fungus *C. fimbriata* for the first time was reported in Sindh from declining mango trees. It's identification was confirmed by morphological characteristics of perithecia (brown to black with globose base, necks almost 800-900 μm long with ostiolar hyphae), ascospores (elliptical 4-8 × 2-5 μm, hat shaped) conidiophores (hyaline, septate up to 150 μm long and conidia that were cylindrical, sometimes in chains and truncated at the ends (Fateh et al., 2006; Khaskheli et al., 2011).

Mango decline in Pakistan was reported from the Punjab province in one of the orchards at Muzaffar Garh in 1995. The symptoms like leaf drooping bark splitting, gummosis stem canker and stem bleeding appeared. This type of decline was called quick decline. Twig dieback and the branches dieback are also observed but that might be due to many reasons (Fateh et al., 2006; Naqvi, 2004). In Pakistan, as well as in few other nations where the disease has become a problem, researchers have looked into the relationship between pathogenic fungus and the role of the bark beetle in mango decline. Leaf drying, discoloration, gum leaking, canker growth under the bark, and vascular blockage were the most common symptoms. When the bark beetle *Hypocryphalus mangiferae* bores into the stem, the symptoms become more severe. Some Pakistani mango types, such as Malda, Langra, and Anwar Ratol showed some tolerance to decline. *L. theobromae*, *C. fimbriata*, and *Phomopsis* sp. were among the mycoflora found on

decline-affected trees and the bark beetle (*H. mangiferae*) (Masood et al., 2010; Masood et al., 2011). About 60% mango production was lost in Oman in the fifth year after the introduction of mango sudden decline (Al-Adawi et al., 2013; Al-Adawi et al., 2003) causing mortality of over 200,000 mango trees, and replacement of 13% of the trees in order to stop dispersal (Montoya and Wingfield, 2006) which continued in Oman till now in spite of all measures taken by the Ministry of Agriculture and Fisheries (Al-Adawi et al., 2003). The losses in Pakistan varied between 20 and 60% of the production depending on which part of the country reported. Keeping in mind the severe losses caused by mango decline also known as mango sudden death by the growers an updated study was planned for its occurrence. The updated studies on the mango decline occurrence are necessary to become reference for further research and management strategies. Therefore, the present study was designed for disease estimation in the Punjab mango growing areas.

MATERIALS AND METHODS

The study was carried out in 5 districts of Punjab viz. Khanewal, Multan, Muzaffar Garh, Rahim Yar Khan and Bahawalpur. In total 50 locations were visited, in each location 3 mango orchards were surveyed and in each orchard 5 out of 35 trees were observed. A total of 150

mango orchards were surveyed and 750 mango trees were observed (Table 1). The incidence of decline in mango was calculated by the formula (Rehman et al., 2011).

$$\text{Disease Incidence (\%)} = \frac{\text{No. of declined plants}}{\text{Total No. of plants observed}} \times 100$$

Disease Severity was recorded using 0-5 visual rating scale (Kazmi et al., 2005). Where:

0 = Healthy Plants; 1 = 1-10% decline; 2 = 11-20%; 3 = 21-30%, 4 = 31-50% 5 = More than 50%.

Disease Index in each orchard was determined by the formula (Kazmi et al., 2005) given below;

$$\text{Disease Index (\%)} = \frac{0(n1) + 1(n2) + 2(n3) + 3(n4) + 4(n5) + 5(n6)}{N}$$
$$\times \frac{100}{5}$$

Where n1 = No. of trees in 0 rating, n2 =No. of trees in 1 rating, n3 = No. of trees in 2 rating, n4 = No. of trees in 3 rating, n5 = No. of trees in 4 rating, n6 = No. of trees in 5 rating, N = Total Number of Trees.

RESULTS

According to results shown in Table 2, the maximum mean disease severity of 2.70 was observed in district Bahawalpur followed by Khanewal (2.30), Multan (2.11), Muzaffar Garh (2.00). The minimum disease severity (1.90) was recorded in Rahim Yar Khan District.

Table 1: Areas surveyed for mango decline assessment in various districts of Punjab.

S. No.	District	Tehsils	Localities
1	Khanewal	Kabirwala	Qadirpur Rawan, 5 Kassi, Solgi, Matti Tal, Abbas Pur, 8 Kassi, Maula Pur, Bilawal Pur, Basti Toheed Nagar and Hassan Pur
2	Multan	Multan	Qasim Bela, Nandla, Chah Nizam Wala, and Basti Band Bosan.
		Shujabad	Basti Khokhran, Shahpur Ubbha, Abbas Pura
		Jalalpur Pirwala	Ghazipur, Basti Malkani, ManikWali
3	MuzaffarGarh	Muzaffar Garh	Makhan Bela, Rohillanwali, Shah Jamali
		Kot Addu	Ali Wala, Musay Wala, Shuhrat Wala, Basti Drigh
		Alipur	Muradpur Pull, Basti Nukray, Basti Jat Lashari
4	Rahim Yar Khan	Rahim Yar Khan	Taranda Muhammad Panah, Wahi Shah Muhammad, Mianwali Qureshian
		Sadiqabad	Ahmad Pur Lumma
		Khan Pur	Chak 2P, Chak 3 P, Bagh o Bahar,
		Liaqat Pur	Chak 22 A, Chak 23 A, Islam Nagar
5	Bahawalpur	Bahawalpur	Khanqah Sharif, Chak 13 BC, Chak 23 BC, Nowshera, Munshi Wala

Similarly, the maximum mean disease incidence (100%) was found in Khanewal followed by Bahawalpur (99.30%), Muzaffar Garh (96.00%), Multan (96.00%) and the minimum disease incidence (90.00%) was observed in Rahim Yar Khan. Disease index which gave the actual picture of the disease was found to be the maximum in Bahawalpur (53.30%) followed by Khanewal (46.50%), Rahim Yar Khan (39.10%), and Muzaffar Garh (37.30%) while the minimum disease index of 36.89 was found in Multan district (Table 2).

In District Khanewal, disease severity (3) was recorded in Matti Tal, Bilawal Pur and Basti Toheed Nagar followed by disease severity (2) in Qadirpur Rawan, 5 Kassi, Solgi, Abbas Pur, 8 Kassi, Maula Pur and Hassan Pur. Mean disease incidence observed was 100% in all orchards observed in all locations. However, the maximum disease index of 65% was observed in Basti Toheed Nagar followed by 57% in Bilawal Pur, 51% in Matti Tal, 49% in Maula Pur, 47% in 8 Kassi, 41% in Solgi, 40% in Abbas Pur, 39% in Qadirpur Rawan and 5 Kassi and the minimum of 37% in Hassan Pur (Table 3).

Table 2: Mean mango decline incidence, severity and disease index in different districts of Punjab province.

Sr. No.	District	Mean Disease Severity (0-5)	Mean Disease Incidence (%)	Disease Index (%)
1	Khanewal	2.30	100	46.50
2	Multan	2.11	92.67	36.89
3	MuzaffarGarh	2.00	96.00	37.30
4	Rahim Yar Khan	1.90	90.00	39.10
5	Bahawalpur	2.70	99.30	53.30

Table 3: Mean mango decline incidence, severity and disease index in different locations of district Khanewal.

Sr. No.	Tehsil	Location	Mean Disease Severity (0-5)	Mean Disease Incidence (%)	Disease Index (%)
1	Kabirwala	QadirpurRawan	2	100	39
		5 Kassi	2	100	39
		Solgi	2	100	41
		Matti Tal	3	100	51
		Abbas Pur	2	100	40
		8 Kassi	2	100	47
		Maula Pur	2	100	49
		Bilawal Pur	3	100	57
		BastiToheed Nagar and	3	100	65
		Hassan Pur	2	100	37

Survey condcuted in 3 tehsils of Multan showed mean disease severity ranging from 1-3. Maximum mean disease severity (3) was observed in Chah Nizam Wala (Tehsil & district Multan) and Ghazi Pur (Tehsil Jalalpur Pirwala, district Multan) followed by disease severity (2) in Nandla, Basti Band Bosan (Tehsil Multan); Basti Khokhran, Shahpur Ubbha, Abbas Pura (Tehsil Shujabad) and Manik Wali (Tehsil Jalal Pur Pirwala). The minimum mean disease severity (1) was observed in Qasim Bela of Multan. Mean disease incidence was 100% in all the orchards except Qasim Bela and Nandla in tehsil Multan where it was 67%. Disease index was the maximum (52%) in Chah Nizam

Wala (Multan) and Ghazipur (Jalalpur Pirwala) followed by 40% in Shahpur Ubbha and Abbas Pura (Shujabad), 39% in Manik Wali (Jalalpur Pirwala), 33% Bast Band Bosan (Multan), 32% Basti Khokhran (Shujabad), 31% Nandla (Multan) and the minimum of 13% in Qasim Bela of tehsil Multan (Table 4).

In Muzaffar Garh district, 3 tehsils were covered i.e. Muzaffar Garh, Kot Addu and Ali Pur. Mean disease severity ranged from 1-3. The maximum mean disease severity of 3 was recorded in Basti Drigh of Muzaffar Garh tehsil and Basti Nukray of Alipur tehsil followed by disease severity of 2 in Makhan Bela, Rohillanwali, Shah

Jamali (Tehsil Muzaffar Garh), Shuhrat Wala (Kot Addu), Muradpur Pull and Basti Jat Lashri (Ali Pur). The minimum mean disease severity of 1 was observed in Ali Wala and Musay Wala of tehsil Kot Addu, District Muzaffar Garh. Mean disease incidence 100% was observed in Rohillanwali, Shah Jamal (Muzaffar Garh); Ali Wala and Shuhrat Wala, Basti Drigh (Kot Addu) and Murad Pur Pull, Basti Nukray and Basti Jatt Lashri of

tehsil Ali Pur. The maximum disease index (52%) was recorded in Basti Drigh of Kot Addu tehsil and Basti Nukray of Ali Pur tehsil followed by 44% in Makhan Bela and Shah Jamali (Muzaffar Garh); 41% Basti Jat Lashari (Ali Pur), 40% Shuhrat Wala (Kot Addu); 31% Muradpur Pull (Ali Pur); 29% Ali Wala (Kot Addu), 27 % Rohillanwali (Muzaffar Garh) and the minimum 13% Musay walla (Kot Addu) (Table 5).

Table 4: Mean mango decline incidence, severity and disease index in different locations of district Multan.

Sr. No.	Tehsil	Location	Mean Disease Severity (0-5)	Mean Disease Incidence (%)	Disease Index (%)
1	Multan	Qasim Bela	1	67	13
		Nandla	2	67	31
		Chah NizamWala	3	100	52
		Basti Band Bosan	2	100	33
2	Shujabad	Basti Khokhran	2	100	32
		Shahpur Ubbha	2	100	40
		Abbas Pura	2	100	40
3	Jalalpur Pirwala	Ghazipur	3	100	52
		ManikWali	2	100	39

Table 5: Mean mango decline incidence, severity and disease index in different locations of district Muzaffar Garh.

Sr. No.	Tehsil	Location	Mean Disease Severity (0-5)	Mean Disease Incidence (%)	Disease Index (%)
1	Muzaffar Garh	Makhan Bela	2	93	44
		Rohillanwali	2	100	27
		Shah Jamal	2	100	44
2	KotAddu	Ali Wala	1	100	29
		Musay Wala	1	67	13
		Shuhrat Wala	2	100	40
		Basti Drigh	3	100	52
3	Alipur	Muradpur Pull	2	100	31
		Basti Nukray	3	100	52
		BastiJatLashari	2	100	41

In district Rahim Yar Khan, 4 tehsils i.e. Rahim Yar Khan, Sadiqabad, Khan Pur and Liqat Pur were surveyed. The maximum mean disease severity (3) was observed in Wahi Shah Muhammad of tehsil Rahim Yar Khan only followed by disease severity (2) in all locations. Disease incidence was 100% in all the surveyed locations. However, the maximum disease index (52%) was found in Wahi Shah Muhammad (Rahim Yar Khan) followed by

49% in Chak 23 A (Liaqat Pur); 48% Chak 2P (Khan Pur). and Islam Nagar (Liaqat Pur); the minimum 37 % in Taranda Muhammad Panah and Mianwali Qureshian of tehsil Rahim Yar Khan (Table 6).
Tehsil Bahawalur and Ahmedpur East were surveyed in the district of Bahawalpur. Mean disease severity ranged from 2-4 based on 0-5 rating scale. The maximum mean disease severity of 4 was recorded in Chak 23 BC of

tehsil Bahawalpur followed by 3 in Khanqah Sharif, Chak 13 BC, Munshi Wala (Bahawalpur). and Mehrab Wala and Basti Johnan (Ahmed Pur East). The minimum mean disease intensity of 2 was recorded in Nowshera (Bahawalpur) and Channi Goth, Muhabbat Pur and Basti Khokhran of tehsil Ahmedpur East. Mean disease

incidence was 100% in all the locations except in Khanqah Sharif (Bahawalpur) which was 93%. The maximum disease index of 76% was observed in Chak 23 BC (Bahawalpur) followed by 61% in Basti Johnan and it was the minimum in Channi Goth as shown in Table 7.

Table 6: Mean mango decline incidence, severity and disease index in different locations of district Rahim Yar Khan.

Sr. No.	Tehsil	Location	Mean Disease Severity (0-5)	Mean Disease Incidence (%)	Disease Index (%)
1	Rahim Yar Khan	Taranda Muhammad Panah	2	100	32
		Wahi Shah Muhammad	3	100	52
		Mianwali Qureshian	2	100	32
2	Sadiqabad	Ahmad Pur Lumma	2	100	41
3	Khan Pur	Chak 2P	2	100	48
		Chak 3 P	2	100	44
4	Liaqat Pur	Chak 22 A	2	100	45
		Chak 23 A	2	100	49
		Islam Nagar	2	100	48

Table 7: Mean mango decline incidence, severity and disease index in different locations of district Bahawalpur.

Sr. No.	Tehsil	Location	Mean Disease Severity (0-5)	Mean Disease Incidence (%)	Disease Index (%)
1	Bahawalpur	Khanqah Sharif	3	93	53
		Chak 13 BC	3	100	52
		Chak 23 BC	4	100	76
		Nowshera	2	100	49
		Munshi Wala	3	100	57
2	Ahmed Pur East	Channi Goth	2	100	32
		Mehrab Wala	3	100	60
		Muhabbat Pur	2	100	48
		Basti Khokhran,	2	100	45
		BastiJohnan	3	100	61

DISCUSSION

Mango decline is a problem of all traditional mango growing areas of Pakistan. The survey to record the occurrence of mango decline was done in Khanewal, Multan, Muzaffar Garh, Rahim Yar Khan and Bahawalpur distrcits which are famous for mango production. The maximum disease index of 53.30% was recorded in district Bahawalpur. During survey, the large overlapping trees were observed in this district. Most of the areas surveyed had more than 100 years old plantations (Fateh et al., 2006). The growers were not even aware of the disease and they thought that

senescens had resulted in such symptoms of the trees. Secondly, mango orchards were not given the first importance rather the intercropped crops were considered important to the growers. The large farms are owned by the absent landlords who stay abroad and leave orchard management on their managers (munshies). These munshies strongly believe in traditional mango cultivation and show harshness towards the adoption of innovative technologies (Khushk and Smith, 1996).

The farmers have lost their interest in mango orchards and taking more interest in the housing colonies. The

orchards were neglected and animal grazing and lopping of trees were common. Most of the trees have been uprooted. The existing trees had many wounds. The age of the trees ranged from 26-50 years. The old age itself a problem for the trees as they are more vulnerable to be attacked by the diseases (Kazmi et al., 2005; Malik et al., 2005). However, mango tree decline was not limited to only old age trees but equally found on young trees as well. The trees were large in size, overlapping with each other giving a complete shade in the orchard and not allowing any penetration of sunlight. The pruning of the trees was like sin for the growers (Jiskani, 2002).

Flood irrigation was adopted in the orchards which could easily spread the disease from infected trees to healthy ones. The water was directly touching the stems of the trees and leaf drop was much more common. The chemical fungicides which were not supposed to be for mango were sprayed intentionally on the trees i.e. the chemicals left over after spraying on cotton and other crops (Iqbal et al., 2007b).

Along the Multan-Khanewal and Multan-Shujabad Road, many orchards were pruned and few orchards also showed the lime pasting around tree trunk that showed that these orchards are not as neglected as the orchards along Band Bosan Road. Another reason may be that orchards along Shujabad road were in the area of Mango Research Station, Shujabad and had links with the experts. Therefore, the growers were taking interest in the management of their orchards and decline occurrence in these orchards was little bit less (Fateh et al., 2006).

CONCLUSION

It can be concluded from the present study that the disease prevalence in terms of disease severity, incidence and index is not related geographically, however, the results are directly linked with the extent of orchard management practices. This study showed that good orchard management is the best way to manage the disease in the mango orchards. It has also been concluded that the farmers who are taking more interest in the orchard management are contributing to the management of mango decline and the absentee farmers are putting everything on the shoulders of contractors and are aggravating the decline situation. Furthermore, timely and proper management (cultural, chemical and biological control methods) supported healthy mango orchards and reduced prevalence of mango decline.

AUTHORS' CONTRIBUTION

FSF and TM designed and formulated the study, prepared layout of surveys, FSF and AM conducted surveys and recorded the data, FSF, SU and MRK compiled and organized the data, TM supervised the work, all the authors helped in manuscript write up and formatting and FSF and TM proofread the manuscript.

CONFLICT OF INTEREST

The authors declare no conflict of interests.

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