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Some Minor Diseases of Mango Trees that Affect in Quality Mango Production for Supply Chain of Mango

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ABSTRACT

Mango is one of the most important tropical and subtropical fruits are subjected to a number of diseases at all stages of its growth and development. At present there is no precise up to date information available to assess the different diseases of mango tree. Efficient and accurate assessment of disease intensity is a major concern for quality mango production for quality supply chain. To find out the problems of quality mango production and quality supply chain data were collected through focus group discussion and visiting the mango orchards. This paper will provide the assessment of important and minor mango diseases. Accurate measurement of plant disease is an important in any study relating disease severity to disease losses and subsequent management tactics for quality mango production ultimately quality supply chain of mango. So this paper will be an indispensable guideline for the farmers, pathologists and other related persons who are directly and indirectly engaged in mango cultivation for producing quality mango and supply chain.

Keywords: Cultivation, Fruits, Minor disease, Quality mango, Supply chain

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1. INTRODUCTION

Mango (*Mangifera indica* L.) is the most important fruit of the tropical world (Akhtar & Alam, 2002). Mango tree grows to 35-40 m (115-131 feet). It is an ancient where it was grown 4,000 years ago. In the soil, the main root extends to a depth of 6 m (20 ft) with a number of many widespread nutritious roots (Dutta, 1997). The leaves are evergreen, with a length of about fifteen and thirty-five centimeters, and the width can be about sixteen centimeters (Elqassas & Abu-Naser, 2018).

Mangoes are regarded as a delicious and most important fruits in tropical and subtropical regions of the world (Naqvi et al., 2014; Prusky et al., 2009). At present, mango trees are cultivated in about 87 countries of the world reported by Goyal, et al. (2008). This type of fruit has many diseases which threaten its production (Elqassas & Abu-Naser, 2018).

It may suffer from some minor diseases, including canker, die back, malformation and gummosis. Information about these minor threatening diseases is scanty at Chapainawabganj district in Bangladesh. It is the need for work to be done to gather more information about the disease to facilitate the development of control measures against these diseases. For effective control measures to be formulated against a disease, knowledge of its etiology and epidemiology is very essential. Different diseases are affecting in quality mango production ultimately quality mango supply chain. Through supply chains, producers in developing countries and emerging economies can access

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market information and knowledge to hone their value added activities. Mangoes are perishable goods.

For a perishable item, effective logistic capabilities of supply chain can reduce 50% of the losses (Orjuela-Castro et al., 2017). Keeping all these points in mind it was decided to collect the information for the pathogenecity of some minor and important diseases of mango.

This research work was carried out to determine the nature and spread of the minor diseases at Chapainawabganj in Bangladesh and determine the causal agent responsible for the disease that affect in supply chain of mango.

2. MATERIALS AND METHODS

There are two focus groups namely, farmers (FG-1) and agriculturists (FG-2) as well as four sub focus groups namely, mango growers (SFG-1), businessmen (SFG-2), agriculture specialists (SFG-3) and mango supply chain specialists (SFG-4) were formed for collecting data.

First focus group was formed with farmers who are engaged with mango production; second focus group was formed with agriculturists and the four sub focus groups were formed with the peoples who are directly or indirectly engaged in supply chain of mango in five upazilas of Chapainawabganj district to find out the causes of disease, symptoms and control measure of four specific diseases of mango that affect on quality supply chain of mango.

Table 1 Four minor diseases of mango trees

Name of Disease	Name of the pathogen
Canker disease	*Xanthomonas campestris pv. Mangiferae indicae*
Die back	*Botryodiploidia (Lasiodiplodia) theobromae*
Malformation	*Fusarium* spp.
Gummosis	*Botryodiplodia theobromae*

The respondents of focus group that formed with farmers were 75. In this focus group there are 15 respondents (farmers) were selected randomly from each upazila of Chapainawabganj district. The respondents of focus group that formed with agriculturists were 25. In this focus group there are 5 respondents (agriculturists) were selected randomly from each upazila of Chapainawabganj district. In each sub focus group SFG-1, SFG-2, SFG-3 and SFG-4 there are 5 mango growers, 5 businessmen, 5 agriculture specialists and 5 supply chain specialists were randomly selected from each upazila of Chapainawabganj district respectively.

So, the total numbers of respondents of these four sub groups were 100. Therefore, the total numbers of respondents in this study were 200. A list of possible questions on four minor diseases for the participants were developed before conducting the survey to ensure some structure and direction in the discussions.

Each focus group (FGD) session ran for two hours and different aspects like causes of disease, symptoms and control measures of the four minor diseases of mango were covered. On the other hand, each sub focus group discussion also ran for two hours and different aspects of quality supply chain of mango were covered. In all sub focus groups, a thoroughly discussion was made with the peoples who are directly or indirectly engaged in supply chain of mango in five upazilas of Chapainawabganj district.

For keenly observation, four specific diseases symptoms were collected through physically visiting to the mango farms and markets. Possible solutions were prepared through discussing with the respective specialists

3. RESULTS AND DISCUSSION

3.1. The Present Scenario of Minor Disease of Mango at Chapainawabganj

There are many plant pathogenic organisms such as bacteria, virus and fungus which causes different types of diseases in mango tree. Among the pathogenic organisms, fungus is one of them. Physical visit was conducted to different mango orchards for observing various symptoms emerge as minor diseases in mango trees that caused by different fungus. Through focus group discussion different minor diseases of mango fruits were found. The list of different fungal diseases is placed in the Table 1.

3.2. Feedback about Four Minor Diseases of Mango Trees

In respect of canker disease 40% respondents opined that they can identify the diseases, 05% opined that they can identify the causes of disease, 70% opined that they knew the diseases before, 05% opined that they have knowledge on possible remedies, 80% stated that they have received prescription from the specialists and 06% opined that they can apply remedies by own decision.

In case of die back disease 50% respondents opined that they can identify the diseases, 10% opined they can identify the causes of disease, 90% stated that they knew the diseases before, 09% opined that they have knowledge on possible remedies, 98% stated that they have received prescription from the specialists and 08% opined that they can apply remedies by own decision. In case of malformation disease 80% respondents stated that they can identify the diseases, 12% opined they can identify the causes of disease, 95% stated that they knew the diseases before, 12% opined that they have knowledge on possible remedies, 85% stated that they have received prescription from the specialists and 10% opined that they can apply remedies by own decision.

In case of gummosis disease 90% respondents opined that they can identify the diseases, 15% stated that they can identify the causes of disease, 99% stated that they knew the diseases before, 10% opined that they have knowledge on possible remedies, 70% stated that they have received prescription from the specialists and 12% opined that they can apply remedies by their own decision (Table 2).

For collecting feedback from the agricultural specialists about four minor diseases of mango trees, a focus group discussion was made with 25 agricultural specialists of five upazilas of Chapainawabganj district. In respect of canker

disease 75% respondents opined that they can identify diseases timely, 100% respondents said that they knew the diseases before, 100% respondents stated that they know the causes diseases, 90% respondents opined that they have knowledge on possible remedies, 75% respondents opined that the remedy of this disease is possible and 100% respondents opined that they can give the treatment of the disease. In respect of die back disease 80% respondents opined that they can identify diseases timely, 100%

Table 2 Feedback of the farmers about four minor diseases of mango trees (n=75)

Name of Disease	Can Identify the diseases (%)	Can identify the causes of disease (%)	Knew these diseases before (%)	Having the knowledge on possible remedies (%)	Prescription received from specialists (%)	Remedies can apply by own decision (%)
Canker disease	40	05	70	05	80	06
Die back	50	10	90	09	98	08
Malformation	80	12	95	12	85	10
Gummosis	90	15	99	10	70	12

Table 3 Feedback of the agriculturists about four minor diseases of mango trees (n=25)

Name of Disease	Can identify diseases timely (%)	Knew the diseases before (%)	Know the causes of disease (%)	Have knowledge on possible remedies (%)	Opine remedy is possible (%)	Can give treatment of the disease (%)
Canker disease	75	100	100	90	75	100
Die back	80	100	100	95	70	100
Malformation	85	100	100	92	85	100
Gummosis	85	100	100	93	80	100

Table 4 Some specific diseases that affect on mango trees and hampers effective quality supply chain of Mango (Based on FGD)

No. of FGs	Name of the Focus Group	Associated Problems	Possible Solutions
FG-1	Farmers (n=75)	Disease attack during vegetative stage	1. Infested branches, shoots and inflorescence should be removed from the tree. 2. Specific fungicides should be applied to control the diseases.
FG-2	Agriculturists (n=25)	Disease attack during vegetative and reproductive stage	1. Timely pruning, regular inspection of the mango gardens, sanitation and seedling certification are preventive measures against these diseases. 2. Crop residues should be destroyed after harvesting the mango fruits. 3. Specific fungicides should be used to control disease. 4. Infested branches, shoots and inflorescence should be removed from the tree. 5. Dead tree material should be removed immediately from the garden.

respondents said that they knew the diseases before, 100% respondents stated that they know the causes diseases, 95% respondents opined that they have knowledge on possible remedies, 70% respondents opined that the remedy of this disease is possible and 100% respondents opined that they can give the treatment of the disease.

In respect of malformation disease 85% respondents opined that they can identify diseases timely, 100% respondents said that they knew the diseases before, 100% respondents stated that they know the causes diseases, 92% respondents opined that they have knowledge on possible remedies, 85% respondents opined that the remedy of this disease is possible and 100% respondents opined that they can give the treatment of the disease. In respect of gummosis disease 85% respondents opined that they can identify diseases timely, 100% respondents said that they knew the diseases before, 100% respondents stated that they know the causes diseases, 93% respondents opined that they have knowledge on possible remedies, 80% respondents opined that the remedy of this disease is possible and 100% respondents opined that they can give the treatment of the disease (Table 3).

3.3. Associated Problems and Possible Solutions from Focus Groups

There are a lot of problems associated in quality mango production for supply chain of mango. Two focus groups were formed with the farmers (FG-1) and agriculturists (FG-2) to find out the problems created by some minor diseases of mango and their possible solutions at Chapainawabganj district (Table 4).

3.4. Description of Different Diseases that Hampers in Quality Mango Production as well as Quality Supply Chain

More importantly, mango is an economically important crop that is both locally consumed and internationally exported. This growing global market might be seen as an interesting economic opportunity for countries that produce mango. Disease is the main factor that affect quality mango production ultimately quality mango supply chain.

The total amount of mango production is decreased by different diseases that ultimately hampers in supply of mango in supply chain. Mangoes are good substrates for pathogen growth and survival when stored in a variety of temperatures. This fruit could be considered as potential vehicles for food borne diseases. Mangoes are commonly eaten in a raw state, and the possible presence of pathogens on their surface or inside the fruits can be problematic during the manipulation process or even in the case of internalization, which would allow the growth/survival of food borne pathogens in these foods and pose a problem for the consumers. Pathogen internalization into this fruits is a process that should be controlled with attention to the quality and temperature of the water applied in washing these fruits. Studies have shown that the application of preventive measures, such as washing hands, good personal hygiene, appropriate use of sanitary facilities, treated manure (fertilizers), quality of the irrigation water, avoiding flooding events, cleaning and sanitizing of equipment, can reduce microbial contamination on fresh produce. According to Park et al. (2013) microbial contamination of produce is influenced by farm management and environmental factors. The implementation of strategies such as Good Agricultural Practices GAPs, Good Manufacturing Practices GMPs and Hazard Analysis Critical (HACCP) can eliminate or significantly reduce microbial contamination on fresh mangoes (Park et al., 2013). Different diseases of mango, causal organisms, disease symptoms and control measures of the disease that hampers in quality mango production as well as quality supply chain are discussed in this part in different heads and sub heads.

3.4.1. Canker Disease of Mango

Canker disease of mango caused by *Xanthomonas campestris pv. Mangiferae indicae*. It is a serious problem in most of the mango growing regions of Bangladesh and other parts of the world. This disease causes fruit drop (10-70%), yield loss (10-85%) and storage rot (5-100%). Many commercial cultivars of mango including Langra,

Arnrapali and Mallika were susceptible to this disease. This disease is more severe on fruits in the month of May but in winter season, generally November to March it remains dormant. This disease varies from cultivar to cultivar but its severity is more in poly embryonic cultivars (Prakash et al., 1994). Meteorological observations indicate that frequent rainfall is not essential for building up of inoculums (Prakash et al., 1994). The disease is noticed on leaves, leaf stalks, stems, twigs, branches and fruits, initially producing water soaked lesions, later turning into typical canker. On leaves, water soaked irregular satellite to angular raised lesions measuring 1-4 mm in diameter are formed (Fig.1). These lesions are light yellow in color, initially with yellow halo but with age enlarge or coalesce to form irregular necrotic cankerous patches with dark brown color. On fruits, water-soaked, dark brown to black colored lesions are observed which gradually developed into cankerous, raised or flat spots (Fig. 1). These spots grow bigger usually up to 1 to 5 mm in diameter, which covers almost the whole fruit. These spots often, burst extruding gummy substances containing highly contagious bacterial cells (Elqassas & Abu-Naser, 2018).

3.4.1.1. Symptoms

- Cankerous lesions are generally found on leaves, leaf petioles, stems, twigs, branches and fruits. Initially this disease produce water soaked lesions
- This disease first appears as minute water soaked irregular lesions on any part of leaf or leaf lamina, later turning into typical canker.
- On leaves, water soaked irregular satellite to angular raised lesions measuring 1-4 mm in diameter are formed.
- Several lesions coalesce together to form irregular necrotic cankerous patches. In severe infections the leaves turn yellow and drop off.
- On fruits, water soaked and sometimes dark brown to black colored lesions are observed which gradually developed into cankerous, raised or flat spots. The water soaked lesions also develop on fruits which later turn dark brown to black.
- These lesions are light yellow in color, initially with yellow halo but with age enlarge or coalesce to form irregular necrotic cankerous patches with dark brown color.
- These sots grow bigger usually 1 to 5 mm in diameter that covers almost the whole fruit.
- These spots often burst open and release highly contagious gummy ooze containing bacterial cells.

Fig. 1 Symptoms of Canker disease of mango on leave and fruits.

3.4.1.2. Control

Canker disease of mango can be controlled in different ways as follows:

- Timely pruning, regular inspection of the mango gardens, sanitation and seedling certification are preventive measures against this disease.
- Clean planting materials should be used. Mango stones (root stock) should be taken from the healthy fruits for raising sapling.
- Spraying with Streptocycline (0.01%) or Agrimycin-100 (0.01%) three times at 10 days intervals after first visual symptom. Monthly sprays of Carbendazim (Bavistin 0.1%) or Copper Oxychloride (0.3%) are also effective in controlling the disease.
- Spraying with copper based fungicides has been found effective in controlling bacteria canker.
- Dipping the fruits in 200 ppm solutions of Plantamyxin is also effective.
- The best way of controlling the disease is to prevent it from being introduced to the new areas by imposing strict quarantine measures (Prakash et al., 1994).

3.4.2. Mango dieback

Mango dieback or decline disease is a serious disease of mango trees. The causal organism of this disease is *Botryodiploidia theobromae*. The disease is most conspicuous during October-November. It is characterized by drying back of twigs from top downwards, particularly in older trees followed by drying of leaves which gives an appearance of fire scorch. The causal agents of dieback disease remained uncertain for many years due to different fungi are associated with it (Ploetz, 2003).

Consequently, mango dieback is considered to be an important problem confronting the mango industry, supply chain and marketing system (Haggag et al., 2010). Different fungal pathogens, such as *Neofusicoccum ribis*, *Botryosphaeria dothidea*, *Diplodia* spp., *Pseudofusicoccum* sp., and *Ceratocystis* spp. may infect mango trees individually, or in combinations, to cause mango dieback in different parts of the world (Sakalidis et al., 2011).

3.4.2.1. Symptoms of dieback disease

Symptoms of dieback disease on mango trees are commonly associated with drying and withering of twigs from top to downwards, followed by discoloration, drying and eventual dropping of leaves (Khanzada et al., 2004). The internal browning in wood tissue is observed when it is slit open along with the long axis. Generally cracks appear on branches and gum exudes before they die out.

When the graft union of nursery plant is affected, it usually dies (Elqassas & Abu-Naser, 2018). Typical symptoms of mango decline include terminal and marginal necrosis of the leaves, which ultimately lead to the death of the leaf blade. The die-back gradually progresses to large branches with eventual reduction in the number of secondary roots. The bark of the affected tree is discolored and darkened at a certain distance from the tip usually in young green twigs (Akhtar & Alam, 2002).

The disease may lead to browning of leaves and upward rolling of thin margins resulting in fall of leaves, ultimately in the drying and death of twigs. In the affected plants, twigs die from the tips back into the old wood, giving a scorched appearance to the limb. The 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. Leaves scorch and fall, leaving a dead branch. In severe conditions, branches start drying one after another in a sequence resulting in death of the whole tree (Khanzada et al., 2004).

At the initial stage of the dieback disease barks of the tree become discoloration and turn darker. In the advanced stages, the disease symptoms were also characterized by the curling and drying of leaves, leading to complete defoliation of the tree and discoloration of vascular regions of the stems and branches. The main symptoms are stunted growth, withering of new branches, necrosis at the margins of leaves, dryness of inflorescences, and the death of one or more branches ultimately the whole plant (Fig. 2).

Fig. 2 Symptoms of Die back disease of mango tree.

3.4.2.2. Control of dieback disease

We should monitor the garden regularly to identify possible infections of this disease at the early stages for taking necessary steps. We have to keep the mango trees healthy and water them regularly. We should not plant in the areas where prone to freezing stress or nutrient deficiency. We have to avoid damage and lesions to trees, which are the predominant entry sites for the fungus.

Dead tree material should be removed immediately from the garden. We can also prevent this disease by applying balance fertilizer in the garden. Infected tree parts should be removed and destroyed immediately after infection. Some of the surrounding healthy branches should cut back to ensure aeration, sunlight and a complete eradication of the pathogen. Just after pruning, Copper Oxychloride should be applied at a concentration of 0.3% on the wounds.

Bordeaux mixture has to be applied twice a year to reduce the infection rate on the mature trees. Bark beetles or caterpillar borers can control by applying Bifenthrin on the trees. Sprays containing the fungicide Thiophanate-methyl have proven very effective against *B. rhodina*.

Pruning of the diseased twigs 2-3 inches below the affected portion and spraying Sulcox 50%WP (Copper Oxychloride) @ 0.3% on infected trees controls the disease (Ullah et al., 2021).

3.4.3. Malformation disease of mango

Malformation disease of mango is caused by *Fusarium* spp. fungus species. It is a main problem and serious constraint to mango production in different mango growing countries of tropical and subtropical in the world (Crane & Campbell, 1990). This disease is widespread in flowers and vegetative shoots of mango tree.

It has a crippling effect on mango production (Hiffny et al., 1978) bringing a heavy economic losses of the farmers. Malformation disease causes heavy damage to trees as the inflorescence fails to produce fruits. The extent of damage varies from 50 to 60 % in some cases and in severe cases the loss may be 100 per cent (Summanwar, 1967). In spite of several decades of incessant research since its recognition in 1891, the etiology of this disease has not yet been established and no effective control measure is known (Bains & Pant, 2003).

3.4.3.1. Disease symptoms

Mango malformation disease has been broadly classified into two categories, such as; vegetative and floral malformation (Kumar & Beniwal, 1987). The two classes of malformation are assumed to be symptoms of the same disease since hypertrophy of tissues is involved in both cases, and vegetative malformation appears at times on trees bearing malformed inflorescence (Kumar & Beniwal, 1987; Schlosser, 1971; Tripathi, 1954). Further proof was obtained by grafting diseased scion onto the healthy rootstocks. The diseased scion that would have produced a malformed inflorescence in flowering year produced symptoms typical of vegetative malformation (Kumar & Beniwal, 1987).

3.4.3.1.1. Vegetative malformation

The vegetative malformation is more pronounced on young seedlings (Elqassas & Abu-Naser, 2018; Nirvan, 1953). The seedlings produce small shoot-lets bearing small scaly leaves with a bunch like appearance on the shoot apices. The affected seedlings develop vegetative growths which are abnormal growth, swollen and have very short internodes (Ullah et al., 2021; Elqassas & Abu-Naser, 2018).

The apical dominance is lost in these seedlings and numerous vegetative buds sprout producing hypertrophied growth which constitutes the vegetative malformation. The multi branching of the shoot apex with scaly leaves is known as “Bunchy Top”, also referred to as ‘Witch’s Broom” (Kanwar & Nijjar, 1979; Bhatnagar & Beniwal, 1977). The seedlings which become malformed early remain stunted and die young while those getting infected later resume normal growth above the malformed areas (Kumar & Beniwal, 1992; Singh et al., 1961).

3.4.3.1.2. Floral malformation

The floral malformation is the malformation of panicles of mango trees. The flower buds are generally transformed into vegetative buds and a large number of small leaves and stems which are characterized by appreciably reduced internodes and give an appearance of witch’s broom (Ullah et al., 2021; Elqassas & Abu-Naser, 2018). The flower buds seldom open and remain dull green without fruits (Elqassas & Abu-Naser, 2018). The primary, secondary and tertiary rachises are become short, thickened and much enlarged or hypertrophied.

These kinds of panicles are greener and heavier with increased crowded branching. These types of panicles have numerous flowers that remain unopened and are male and rarely bisexual (Hiffny et al., 1978). The ovary of the malformed bisexual flowers is exceptionally enlarged and non-functional with poor pollen viability (Shawky et al., 1980). Both healthy and malformed flowers appear on the same panicle or on the same shoot (Fig. 3 and Fig. 4). The severity of malformation disease may vary on the same shoot from light to medium or heavy malformation of panicles (Varma et al., 1969).

The heavily malformed panicles are become compact and overcrowded due to larger flowers. They continue to grow and remain as black masses of dry tissue during summer but some of them continue to grow till the next season. They bear flowers after fruit set has taken place in normal panicles (Shawky et al., 1980) and contain brownish fluid (Ram & Yadav, 1999; Prasad et al., 1965).

Fig. 3 Symptoms of vegetative malformation on the leaves of mango tree.

Fig. 4 Symptoms of vegetative malformation on the flower of mango tree.

3.4.3.2. Protection and non-chemical control

- Pest free nursery stock should be established to avoid introducing mango malformation disease.

- Shoots carrying malformed panicles should be removed along with 15-20 cm healthy portion from March 15 to May 15 to reduce the intensity of malformation of inflorescence during the subsequent years.
- By cleaning of the pruning equipment reduces the spread of pests and disease.
- Mango trees should be fertilized with recommended doses of NPK in split applications on bi-monthly and quarterly basis. Trees should also be sprayed with trace element solution of zinc, boron and copper before bloom and after fruit harvesting to minimize the incidence of malformation. Urea sprayed after fruit harvest in early July proved to reduce the incidence of malformation of inflorescence.
- Nurseries should be established away from the orchards affected by mango malformation disease.
- In the mango orchards smoky fires should be applied for several days during a vegetative flush to incite good flowering and reduce malformation (Ullah et al., 2021).

3.4.3.3. Chemical control

- Malformed panicles should be treated with 600 ppm $AgNO_3$ that helps plants to bear normal panicles with fruits borne on them.
- This disease can be reduced by spraying with 100-200 ppm NAA (Planofix) during October, followed by the spraying with Carbendazim @ 0.1% and with Thiophanate Methyl @ 0.1%.
- Mango trees should be sprayed with Plant growth regulators GA @ 30 ppm/NAA @ 150 ppm/Paclabutrazol @ 1000 ppm at pre-bloom and post harvest stage to control the incidence followed by spraying of Carbendazim @ 0.2% (Ullah et al., 2021).

3.4.4. Gummosis disease of mango

Gummosis disease of mango caused by *Botryodiplodia theobromae* is a serious problem on many popular varieties of mango particularly during monsoon and post-monsoon periods (Suresh et al., 2017). The disease takes its name from the large amounts of gum that are exuded from the bark of trees. Gummosis disease is a nonspecific condition where sap leaks from a wound in the tree. It usually occurs when the tree has a perennial or bacterial canker, or is attacked by the peach tree borer.

3.4.4.1. Symptoms of gummosis disease

Symptoms of gummosis disease on mango trees appears as milky gum exuded out from the stem and main branches that later turned into brownish color (Fig. 5). The disease is characterized by the presence of profuse oozing of gum on the surface of the affected wood and bark of the trunk and also on the larger branches but more common on the cracked branches. Under severe infection in susceptible varieties, droplets of gum trickle down on stem and bark turns dark brown with longitudinal cracks and the tree dries up because of cracking, rotting and girdling of the stem (Elqassas & Abu-Naser, 2018; Khanzada et al., 2004; Narasimhudu & Reddy, 1992). In severe infections, the necrosis expands to the internal tissues and girdles the whole branch, eventually kill it. Blossoms, leaves, and fruits are usually not infected.

3.4.4.2. Control of gummosis disease

- Drainage should be provided by amending the soil or transplanting is essential for its recovery.
- The gummosis treatment involves removing the diseased bark.
- An integrated approach with prevention measures should be considered together with biological treatments if available.
- The darkened area of bark should be removed from the tree and a strip of the healthy bark should be added until the wound is surrounded by a margin of healthy bark.
- Systemic fungicides can prevent against some types of gummosis.
- Treatment with Kresoxim-methyl is also effective when applied with an air-blast sprayer.

Fig. 5 Symptoms of gummosis disease of mango tree.

3.5. Effects of Four Minor Diseases of Mango on the Quality Supply Chain

There are four sub focus groups namely mango growers (SFG-1), businessmen (SFG-2), agriculture specialists (SFG-3) and mango supply chain specialists (SFG-4) were formed with the peoples who are directly or indirectly engaged in production and supply chain of mango in five upazilas of Chapainawabganj district to find out the problems associated with quality supply chain of mango. Number of respondents in each sub focus group was 25 and the total numbers of respondents in four sub focus groups were 100.

Among the 25 respondents of sub focus group title mango growers (SFG-1) 70% agreed with disease attack, 60% agreed with fertilizer, 50% agreed with insecticide and 40% agreed with hormone while the 25 respondents of sub focus group title businessmen (SFG-2) 70% agreed with disease attack, 60% agreed with grading, 65% agreed with packaging materials and 60% agreed with temporary shop that hampers in mango supply chain.

On the other hand the 25 respondents of sub focus group title agriculture specialists (SFG-3) 90% agreed with pest and disease attack, 80% agreed with short of cold storage and 60% agreed with grading while the 25 respondents of sub focus group title mango supply chain specialists (SFG-4) 80% agreed with grading, 70% agreed with packaging materials, 80% agreed with shortage of cold storage, 60% agreed with transportation and 50% agreed with temporary shop respectively that hampers in mango supply chain (Table 5).

Table 5 Feedback from the peoples who are directly and indirectly engaged in quality supply chain of Mango (n=100)

No. of FGs	Name of the Focus Group	Associated problems in mango production that hampers in supply chain	Agreed (%)
SFG-1	Mango growers (n=25)	Disease attack	70
		Fertilizer	60
		Insecticide	50
		Hormone	40
SFG-2	Businessmen (n=25)	Disease attack	70
		Grading	60
		Packaging materials	65
		Temporary shop	60
SFG-3	Agriculture specialists (n=25)	Pest and disease	90
		Short of cold storage	80
		Grading	60
SFG-4	Mango supply chain specialists (n=25)	Grading	80
		Packaging materials	70
		Short of cold storage	80
		Transportation	60
		Temporary shop	50

4. CONCLUSION

Mango is one of the many fruits, popularly and universally acceptable and enjoyed throughout the world. The mango industry in Bangladesh has expanded considerably over recent years, not only in size but also in terms of geographical location. This has made the mango fruit become more popular with the local population wherever it is grown. Soil and climate of Chapainawabganj district is suitable for mango production but different disease of mango tree is serious problem that affecting the quality mango production as well as quality mango supply chain. Most of the mangoes produced is consumed within the same production area, or sold in urban markets. The two main market destinations for fresh mangoes are the local and export markets. Suitable and high quality planting material e.g. cultivar is a prerequisite for improving the quality of mango fruits as well as supply chain of mango. Research on this issue is urgently needed and should focus first on evaluation and characterization of available rootstock and scion varieties to select the most suitable ones for efficient dissemination to farmers in Barind track of Chapainawabganj district for producing quality mango for quality supply chain.

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