SURVEY AND PATHOLOGICAL INVESTIGATION ON LOSSES OF MANGO DUE TO POST-HARVEST DISEASES

A Thesis

By

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A Thesis (Course No. PLP-6104) Submitted to the Agrotechnology Discipline in Partial Fulfillment of the Requirements for the Degree of

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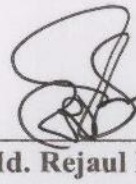

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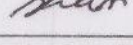

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CHAPTER I

INTRODUCTION

Mango (*Mangifera indica*) is the most popular fruits of Bangladesh which is cultivated under 44366 hectares of land and the annual production is 1165804 MT. It is ranked as first in production among all the fruits in our country (BBS, 2018).

Mango fruit is very popular due to its wide range of adaptability, high nutritive value, richer in variety, delicious taste and excellent flavor. The fruit contains nearly 81% moisture, 0.4% fat, 0.6% proteins, 0.8% of fibers and nearly 17% of carbohydrates. The fruit is also rich in important minerals like potassium, magnesium, sodium, phosphorus and sulphur (Anonymous, 2013).

It is an excellent source of dietary fibre, provitamin A and vitamin C. It is a fruit with versatile properties and has naturally found application for processing into several products (Litz, 2003).

The yield of mango in Bangladesh is 1.16 Million Tons (BBS, 2018) which is lower than neighboring countries such as India (18.77 Million T.), China (4.77 Million T.) etc. (Alemu, 2014). Among various causes (injuries such as insects, mechanical force, chemicals, heat or freezing, non-disease disorders, diseases etc.) of low yield of mango in our country, post-harvest losses are one of the most important causes. Unfortunately, a considerable proportion of the harvested produce never reaches the consumers mainly because of postharvest losses. The estimated postharvest losses of fruits and vegetables lie in the range of 20-40% (Wills et al., 2004). Srivastava (2002) estimated around 10% post-harvest losses in food grains and 25-40 % in fruits and vegetables, which was responsible for waste in terms of food as well as money.

The reasons of post-harvest losses in mango includes diseases caused by fungi, bacteria, insects, injuries, mechanical forces, chemicals, heat or freezing, non-disease

disorders and so on. Moreover, improper harvesting schedule, handling and inefficient marketing lead to poor quality of mangoes (Litz, 2003).

Turan (2008) reported that, improper harvesting practices result in loss due to the spoilage of produce before reaching the market along with the loss in quality of the produce such as deterioration in appearance, taste and nutritional value. Moreover post-harvest diseases caused by various microbes have had considerable influence nutritive value, harvesting, transshipment and storage of fruits. The post-harvest losses due to diseases, is the most serious problem of mango cultivation because annual post-harvest losses are 23.6-43.5% in Bangladesh (Kamrul, 2010).

Post-harvest diseases cause serious problems during storage and transportation of mango fruits. Both anthracnose disease caused by *Colletotrichum gloeosporioides* and stem-end rot caused by *Lasiodiplodia theobromae* are usually considered to be the most severe post-harvest diseases of mango worldwide (Ploetz, 1994).

Post-harvest losses due to fungal diseases is of prime importance which reduces the quality and quantity of marketable fruits leads to heavy losses to sellers as well as consumers. But data on post-harvest losses due to diseases are scare. Considering these facts, the present investigation was carried out with survey, isolation of the organism responsible for post-harvest spoilage, assessing their pathogenicity and disease incidence and severity.

1.1 Statement of the Problem

Among all other agricultural practices, only post-harvest losses of mango have been taken as present research topic. In order to minimize fruit sellers' losses in mango marketing the researcher undertook the investigation entitled **"Survey and Pathological Investigation on Losses of Mango Due to Post-Harvest Diseases"** in three markets of Khulna region in order to have an understanding of the extent of losses of mango as perceived by the fruit sellers. Research information is required which could be helpful to the policy maker, regarding supply of inputs, technological knowledge and problem being encountered on mango production. The purpose of the study was to assess the losses of Mango as perceived by the fruit sellers regarding marketing to explore the relationship of the selected characteristics of the fruit sellers with the losses of mango as perceived by them. In order to make the study manageable, the following research questions were taken into consideration.

- Are there any losses in mango marketing as perceived by the fruit sellers?
- What is the extent and causes of losses in mango marketing as perceived by the fruit sellers?
- Is there any relationship between the fruit sellers' selected characteristics and losses of mango as perceived by them?

1.2 Objectives of the Study

In these circumstances the present research was conducted with the following objectives:

- To assess the knowledge of mango sellers
- To identify the major problem faced by mango sellers
- To determine losses of mango as perceived by the sellers

- To explore the relationship between the selected characteristics of the fruit sellers (mango) with the losses in mango as perceived by them
- To determine disease incidence and percent disease index during storage condition
- To assess the losses of mango in stored condition due to important post-harvest diseases

1.3 Scope and Significance of the Study

- Disease assessment is useful for research and also essential for management of losses of mango.
- To reduce the economic losses of mango loss assessment and disease survey program is essential.
- Mango losses can be protected by measuring diseases and thus they are part of any disease survey program.

1.4 Hypothesis of the Study

A hypothesis is a proposition or a set of proposition set forth as an explanation for the concurrence of some specific group of phenomena either asserted merely as a provisional conjecture to guide some investigation or accepted as highly probably in the light of established fact (Kothari, 1994). Hypothesis may be divided into two categories- a) Research hypothesis (Ha) and b) Null hypothesis (Ho). A null hypothesis states that there is no relationship between the concerned variables. The following null hypothesis was undertaken for the present study:

Ho: "There is no relationship between the selected characteristics of the fruit seller with the losses of mango as perceived by the mango sellers".

The related characteristics are age, level of education, family type, family size, experience in mango selling, seasonal imbalance facing of mango sellers, difficulties facing of mango sellers, knowledge on mango selling, problems faced by the mango fruit seller and losses of mango as perceived by the sellers.

1.5 Assumptions of the Study

An assumption has been defined as the supposition that an apparent fact or principle is true in the light of the available evidence (Goode and Hatt, 1952). That means the assumption is taken as a fact or belief to be true. The researcher had the following assumptions in mind while undertaking this study:

- The respondents, included in the sample have to be capable of satisfying proper responses to the questions included in the interview schedule.
- Views and opinions furnished by the respondents should be the representative views and opinions of the whole population of the study.
- The responses furnished by the respondents must be reliable. The researcher have to be well adjusted to the social environment of the study area. So, the respondents gave their opinions without any hesitation.
- All the data concerning the independent and dependent variables are normally and independently distributed with their respective means and standard deviation.
- The findings of the study will have general applications to other parts of the country with similar personal, socio-economic and cultural conditions.

CHAPTER II

REVIEW OF LITERATURE

Post-harvest diseases of fruits are most severe causes of loss of production. Mango is susceptible to a number of diseases at all stages of its development from the seeding to the fruits. Post-harvest diseases result not only in substantial losses and reduction in mango production but also reduce quality of the fruits.

Bally et al. (2009) and Chala et al. (2014) found post-harvest disease development elsewhere is reported to be one of the major constraints to the quality and shelf life of mango fruit limiting its domestic and export marketing.

2.1 Pathogen Associated with Post-Harvest Diseases

Madan and Ullasa (1991) conducted a survey was in markets and processing units in Karntaka, India by to determine the extent and causes of postharvest losses of mango. They found that modern postharvest technology to reduce losses had not been used by the growers and other players in the mango supply chain. Postharvest losses of up to 49% were estimated at the processing end of the marketing system. The major cause of losses was identified as postharvest diseases including stem end rot and anthracnose.

Rathod (2010) observed that mango fruits were commonly infected by fungal disease like anthracnose, *Alternaria* rot, *A. niger* rot, Blue mould rot, *Botryodiplodia* rot, *Rhizopus* rot and Phomopsis rot during the survey of different fruit markets of Marathawada regions of Maharashtra.

Arauz (2000) stated anthracnose is the major postharvest disease of mango, caused by *Colletotrichum gloeosporioides* and can result in serious decay of fruit during marketing and after sale.

Malik et al. (2016) concluded that mango can suffer from serious losses by pre and post-harvest diseases. Mango post-harvest diseases include anthracnose (*C. gloeosporiodies*), stem end rot (*Botrydiplodia theobromae*), Aspergillus rot (*Aspergillus niger* L. Var. *Tieghem*) and *Alterneria* rot and the incidence was found in range of 40.00-90.00 per cent, 16.00-86.60 per cent, 3.33-53.30 per cent and 16.76 per cent respectively. None the less, there are some sporadic reports, in relation to postharvest losses, especially on a few fruit commodities.

2.2 Assessment of Losses of Mango Post-Harvest Diseases

Alemu (2014) found susceptibility of mango to a number of diseases at all stages of its development from the seeding to the fruits. Post-harvest diseases result not only in substantial losses and reduction in mango production but also reduce quality of the fruits

Wills et al. (2004) reported post-harvest diseases of fruits as the most severe causes of loss of production. The estimated postharvest losses of fruits and vegetables lie in the range of 20-40%.

Amiruzzaman (1990) estimated 25-50% postharvest loss in banana. Quroshi and Meah (1991) reported the losses in mango 0-16.3%.

Murthy et al. (2009) reported that post-harvest losses up to 31% due to fungal diseases at retail level in Bangalore.

Laorden et al. (2011) found average post-harvest losses of 28.30%for jackfruit across the marketing levels in Philippine.

Haq (2006) opined that post-harvest losses of jackfruit can be as much as 30-34 %.

Yuen and Teng (1990) estimated 15%–25%post-harvest losses in tropical fruits production.

Reza and Kader (1995) found in Bangladesh, about 25 to 30% loses of mango production due to anthracnose and stem end rot in Bangladesh.

Hassan et al. (2010) reported that damage occurred to mango fruits by post-harvest diseases were 48.00 to 56.00 per cent in Dhaka and Rajshahi markets of Bangladesh. Amiruzzaman (1990) found 25-30%post-harvest losses of fresh fruits and vegetables in Bangladesh comparing to developed countries (5-25%) (Kader, 1992).

Prabakar et al. (2005) observed that the post-harvest fungal spoilage was higher in retail market than other stages of marketing. The total loss in mango by different pathogens at retail market was 31.20 to 51.70 per cent. Of these, anthracnose accounted for 17.10 to 31.80 per cent, stem end rot 10.80 to 13.10 per cent, mixed infection 3.70 to 8.00 per cent and *Aspergillus* and *Rhizopus* rot together accounted for 0.60 to 0.90 per cent loss. The total loss was recorded as 2.30 to 3.60 per cent in which anthracnose contributed to 0.30 to 1.00 per cent, stem end rot 0.90 to 1.50 per cent, mixed infection 0.30 to 0.50 per cent and *A. niger* and *R. arrhizus* together accounted for 0.70 to 0.80% loss.

2.3 Assessment of Disease Incidence and Disease Severity of Mango

Malik et al. (2016) observed percent disease incidence of four different post-harvest diseases were observed in mango at different locations of Pakistan in which Multan has highest incidence of anthracnose (90.00%), stem end rot (86.60%), alternaria rot (76.60%), aspergillus rot (53.30%) while Khaniwal has the least incidence of anthracnose (40.00%), stem end rot (16.00%), alternaria rot (16.00%) and aspergillus rot (3.33%) as compared to Multan and Muzaffargarh with 100% prevalence of four

post-harvest disease i.e. anthracnose, stem end rot, aspergillus rot, alternaria rot at all locations.

Meer et al. (2013) also observed at Multan the disease severity range of anthracnose, stem end rot, Alternaria rot and Aspergillus rot was 1-5 severity scale while at Shujabad the Alternaria rot was also in 1-5 severity scale. Per cent disease index of anthracnose (12.6%) was high at Faisalabad followed by Rawalpindi, Multan and Shujabad. Stem end rot (6.00%) per cent disease index was high at Rawalpindi and low at Shujabad. Per cent disease index of Alternaria rot (5.33%) was high at Multan and absent at Rawalpindi. Aspergillus rot (3.33%) was high at Rawalpindi and absent at Faisalabad.

CHAPTER III

MATERIALS AND METHODS

Methods and procedures used in conducting research need very careful consideration. Methodology should be such that enables the researcher to collect valid information and to analyze the same properly to arrive at correct decisions. A sequential description of the methodologies followed in conducting this research work has been presented in this chapter.

3.1 Survey on Determination of Losses Due To Post Harvest Diseases

3.1.1 Locale of the Study

The study was conducted in purposively selected markets namely Baro bazar, Gollamary, Dakbangla under Khulna City. A Map of Khulna District Showing the Study Area Khulna City is presented in Figure 3.1.

3.1.2 Population and Sample of the Study

A total of 200 fruit seller (mango) were listed which constituted the population of this study. For proportionate representation 50 mango seller were selected as the sample of the study by taking random sampling method.

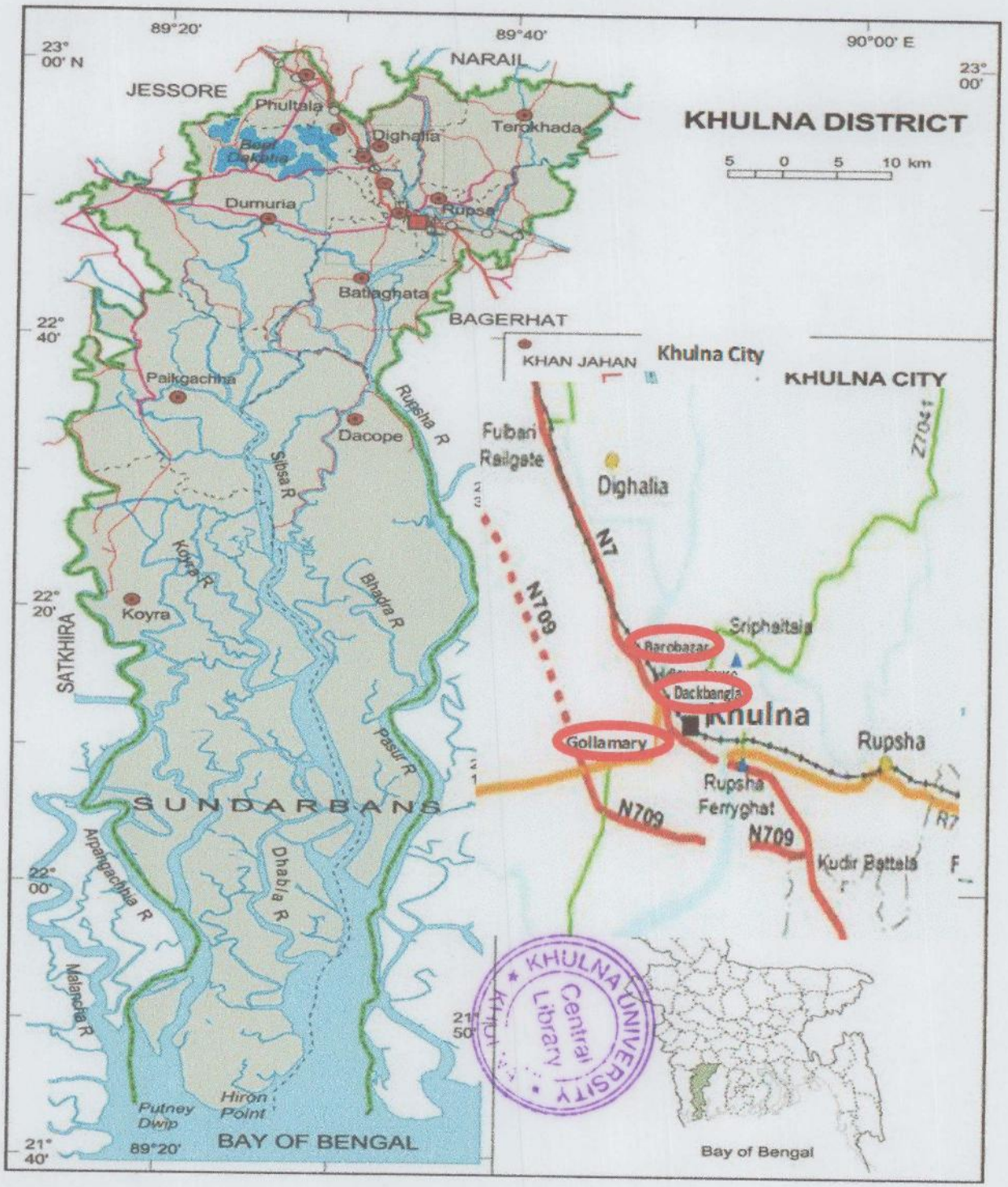


Figure 3.1 A Map of Khulna District Showing the Study Area Baro bazar, Gollamary, Dakbangla in Khulna City

3.1.3 Selection and Measurement of variables

In order to collect relevant information from the respondents, a previously structured interview schedule was prepared in English considering the objectives of the study. The interview schedule was pre-tested in actual market situations before using the same for final data collection. This survey provided an opportunity to examine the effectiveness of the schedule which revealed some unforeseen defects associated with it. Necessary correction, modification and adjustment were made in the interview schedule on the basis of results of pre-test. The interview schedule was then printed in its final form. An interview schedule in English version has been presented in Appendix- A.

3.1.3.1 Selection of variables

A variable is any characteristics which can assume varying or different values in successive individual cases (Ezekiel and Fox, 1959). In a descriptive research, the selection and measurement of the variables are the important task. Based on relevant available literature, discussion with teachers, experts and research fellows in the relevant field and considering the time and resources available to the researcher, variables were selected. The researcher selected ten characteristics of the mango seller as the variables. The selected characteristics are:

(i) Age

(ii) Level of education

(iii) Family type

(iv) Family size

(v) Experience in mango selling

(vi) Seasonal imbalance facing of mango sellers

(vii) Difficulties facing of mango sellers

(viii) Knowledge on mango sellers

(ix) Problem faced by mango sellers

(x) Losses of mango as perceived by the sellers

On the other hand, losses of mango were the main focus of the study.

3.1.3.2 Measurement of Variables

In order to conduct the study in accordance with the objectives, it was necessary to measure the variables. The procedure for measuring the variables has been described below.

3.1.3.2.1 Age

Age of the respondents was measured in terms of year. The age of a respondent was measured by counting the period of time from his birth to the time of interview. However, based on available information of respondents, ''one'' score was assigned for each and every complete year of respondents. Based on age, the respondents were classified into different categories as shown in Table 3.1.

Table 3.1 Categories of the respondents according to their age

Categories	Age of fruit sellers (Years)
Young	≤ 35
Medium	36-55
Old	>55

3.1.3.2.2 Level of Education

Level of Education of a respondent was measured in terms of years of successful schooling completed by an individual in educational institute. A score of one (1) was assigned for each year of schooling completed. For example, if a respondent completed study of class five his education score was assigned as 5. The educational status of a respondent who could illiterate was assigned a score 0 if a respondent could not read and write. Based on level of education score, the respondents were grouped into different categories as presented in Table 3.2.

Table 3.2 Categories of respondents according to their level of education

Categories	Score (Year of schooling)
No education/Illiterate	0
Primary level	1-5
Secondary level	6-10
Higher secondary level or above	>10

3.1.3.2.3 Family Type

The family type of a respondent was measured by the total number of his family members including himself, his wife, children and other dependents who were eating and staying together accordingly as Nuclear, Joint, Extended family.

3.1.3.2.4 Family Size

The family size of a respondent was measured by the total number of his family members including himself, his wife, children and other dependents who were eating

and staying together. Based on family size, the respondents were classified into different categories as shown in Table 3.3.

Table 3.3 Categories of respondents according to family size

Categories	No of family members
Small sized family	1-4
Medium sized family	5-7
Large sized family	>7

3.1.3.2.5 Experience in mango selling

Experience in mango cultivation of a respondent was measured on the basis of his duration of mango cultivation in terms of years. The experience of a respondent was measured by counting the period of time of mango cultivation. A score of one (1) was assigned for each year of mango cultivation. It was measured in complete years as reported by a respondent. Based on experience in mango selling, the respondents were classified into different categories as shown in Table 3.4.

Table 3.4 Categories of respondents according to experience in mango selling

Categories	Experience in mango selling(years)
Low	<5
Medium	5 -10
High	>10

3.1.3.2.6 Seasonal imbalance faced by mango sellers

The occurrence and prevalence of mango diseases vary from season to season depending on the presence of the pathogen, environmental conditions and varieties of mangoes. These were calculated by-

$$\text{Seasonal imbalance faced by mango sellers } (\%) = \frac{\text{Total number of seasonal imbalance faced by mango sellers or not}}{\text{Total number of mango sellers}} \times 100$$

(Ahad, 2010)

3.1.3.2.7 Difficulties faced by mango sellers

These were calculated by-

$$\text{Difficulties faced by mango sellers } (\%) = \frac{\text{Total number of difficulties faced by mango sellers or not}}{\text{Total number of mango sellers}} \times 100$$

(Ahad, 2010)

3.1.3.2.8 Knowledge on Mango cultivation

Knowledge refers to the ability of a respondent to recall or recognize items of information related to anything. A scale consisting of 08 questions was used to determine the knowledge score of the respondents on mango sellers. Each respondent was asked 08 questions. A score of two (2) was assigned for each complete and correct answer and 0 (zero) for incorrect or no answer for each question. Partial score (1) was assigned for partially correct answer for each question. Thus, the total assigned score of all the questions was 16. The total score obtained by answering all the questions by a respondent was the knowledge score of the respondents. Thus, the score could range from 0 to 16 where '0' indicating 'very low knowledge' and '16' indicating 'very high knowledge' on mango marketing.

Table 3.5 Categories of the respondents based on knowledge about fruit selling (mango)

Categories	Score
Low knowledge	≤5
Medium knowledge	6-10
High knowledge	>10

3.1.3.2.9 Problems faced by the mango fruit seller

Problem faced in mango selling of respondent fruit seller was measured on the basis of the nature of problem that they faced in mango marketing activities. Ten items of problems were asked to the respondents with the following four alternative responses with the following assigned scores:

Table 3.6 Categories of the nature of problem

Nature of problem	Scores assigned
No problem	0
Little problem	1
Medium problem	2
High problem	3

Score of problem faced in mango selling of a respondent was computed by adding all the scores obtained by those responses from all the ten problem items. Thus, the problem faced in mango selling of the mango seller could range from 0 to 30 where '0' indicated no problem and 30 indicated highest problem in mango selling.

3.1.3.2.9.1 Measurement of Problem Faced Index (PFI) to Assess the Losses of Mango

Ten problems were selected for the study after through consultation with supervisor and relevant experts. The respondents were asked to respond on four alternative responses as 'high problem', 'medium problem', 'little problem' and 'no problem' for each of ten selected problems. Scores were assigned to those alternative responses as 3, 2, 1, and 0, respectively. Score for particular problem was measured by Problem Faced Index (PFI) as follows:

$PFI = (P_h \times 3) + (P_m \times 2) + (P_l \times 1) + (P_n \times 0)$

Where,

PFI = Problem Faced Index

P_h = Number of respondents faced high problem

P_m = Number of respondents faced medium problem

P_l = Number of respondents faced little problem

P_n = Number of respondents faced no problem

Thus, PFI for a particular problem could range from '0' to '300', while '0' indicating no problem '300' indicating highest problem faced. PFI for all the problems were determined (Ahad, 2010).

Finally a rank order was made on the basis of PFI.

3.1.3.2.10 Measurement of Losses of Mango as Perceived by the Fruit Seller

Five different loss items of marketing phase were considered for measuring mango losses at market level in this study. Losses of mango were measured by asking perception on these five different items of mango loss to the each respondent individually. It was recorded based on the perception of the fruit seller and expressed in percentage. Percentage of losses of mango was perceived in terms of total marketing of mango. Finally losses of mango was measured by adding the

percentage of losses of all items (Islam, 1995). The losses were estimated and expressed in percentage using the following formula:

$$\%\ Loss = \frac{y}{Y} \times 100$$

Where,

Y = weight of total amount of observed mangoes and

y = weight of diseased mangoes

3.2 The lab experiment was carried out at the Plant Protection Laboratory, Agrotechnology Discipline, Khulna University, Khulna.

3.2.1Collection of diseased sample from selected markets

Mangoes were collected in the local markets including Barobazar, Dackbangla and Gollamary. In order to assess post-harvest diseases mango fruits were collected from these study areas. Three common varieties (Himsagar, Langra and Amrapali) of mangoes were used in the experiment.

3.2.2 Data collection for laboratory analysis

For collecting data, the mangoes were spread over the floor and the diseased mangoes (anthracnose, stem end rot etc.) of each variety was sorted out and weight was taken. Data were collected separately on 2nd day, 6th day and 12th days.

Mangoes were completely sterilized and kept at room temperature 25˚C for 12 days.

3.2.3 Assessment of mango losses due to post-harvest diseases

Separate performa was designed to note down the disease severity by using disease severity scale of 1-5 (Corikidi et al. 2006) for post-harvest diseases on the basis of visual observation. These performa was evaluated to calculate the loss, prevalence, percent disease index and incidence of each disease.

3.2.3.1 Assessment of loss of mango post-harvest diseases

The diseased mangoes from these samples were weighed and these amounts was divided by the total amount of observed mangoes and multiplied by 100 so as to find out the parentage of loss due to diseases (Islam, 1995). The figure obtained was the amount of diseased mangoes of the samples.

The losses was estimated and expressed in percentage using the following formula:

$$\%\ Loss = \frac{y}{Y} \times 100$$

Where, Y = weight of total amount of observed mangoes and y = weight of diseased mangoes

3.2.3.2 Disease incidence

Disease incidence was assessed by counting the number of apparently diseased mangoes per site with respect to overall mangoes (Tucho et al. 2014).

$$\%\ \text{Disease Incidence} = \frac{\text{No. of diseased mangoes}}{\text{Total no. of mangoes}} \times 100$$

3.2.3.3 Percent disease index (PDI)

Percentage disease index was measured by using following formula (Prabakar et al. 2005).

$$\text{Percent disease index} = \frac{\text{Sum of all individual ratings}}{\text{Total number of mangoes observed} \times \text{maximum grade}} \times 100$$

Table 3.7 Severity scale

Scale	% severity
1	0–1%
2	2-5%
3	6–10%
4	11–49%
5	50–100%

Percentage disease index data will be collected by using the scales (Corikidi et al. 2006).

3.3 Isolation and identification of fungi associated with mango post-harvest diseases

Before the isolation process media bottles, distilled water, Petri plates and surgical blades were sterilized in the autoclave at 121°C for 20 minutes and then dried at 90°C in hot air oven. From each area sample causal fungus were isolated. Infected diseased samples along with healthy tissues were washed with tap water and then cut into small pieces. These small pieces were surface sterilized and washed with sterilized distilled water. Then these pieces were put on the whatman filter paper for drying and evenly spaced in petri dishes (90 mm diameter) containing PDA (potato dextrose agar) media. Then these were incubated at room temperature (25±1°C) for seven to ten days. After fungal isolations fungal identification were done by compound microscope.

3.4 Pathogenicity test

The pathogens were isolated, identified and cultures were used to confirm their pathogenicity test in their respective hosts. Fresh disease free mangoes were brought in to the laboratory and surface sterilized with 0.1% $HgCl_2$. They were sterilized by

placing in spirit lamp flame, dipping in alcohol and shaking off the excess alcohol by flaming (Granger and Horne 1924). The inoculated samples and their respective controls were kept under sterile humid conditions at room temperature under bell jars. The artificially inoculated samples were examined daily and the extent of damage was recorded. The pathogens were reisolated and disease symptoms were clearly evident, the culture and symptoms signs were compared with original.

3.5 Experimental design and Statistical analysis

The laboratory experiment was conducted in completely randomized design (CRD). The data was analyzed statistically by using STAR (Statistical Tool for Agricultural Research, version-2, IRRI, Los Banos, Philippines), Nebula developed by International Rice Research Institute (IRRI).

Descriptive statistical methods like number and percentage distribution, range, mean, standard deviation etc. were used in describing the variables of the survey study. For clarity and understanding, tables were also used in presenting the data, for exploring the relationships between the extent of losses of mango as perceived by the fruit seller and their selected characteristics; Pearson's Product Moment Coefficient of Correlation (r) and Chi Square test were used.

The analysis of data was performed by using SPSS (Statistical Package for the Social Sciences, version 17) computer program. Throughout the study, at least 5% (0.05) level of probability was used as a basis of rejecting any null hypothesis.

CHAPTER IV

RESULTS AND DISCUSSION

4. Survey on determination of losses due to post harvest diseases

Data were collected from the respondents and were carefully accomplished, coded, computed, tabulated and analyzed in accordance with the objectives of the study. After completion of those processes this chapter was written carefully. The findings of the study and logical interpretations of the results have been presented in this chapter.

4.1 Selected characteristics of the respondents

Ten characteristics of the fruit seller (mango) were selected. The selected characteristics included age, level of education, family type, family size, experience in mango selling, seasonal imbalance facing of mango sellers, difficulties facing of mango sellers, knowledge on mango cultivation, problems faced by the mango fruit seller and losses of mango as perceived by the sellers. These characteristics of fruit seller are described in this section.

4.1.1 Age

The age of the respondents ranged from 15 to 72 years, with a mean with 44.86 years and the standard deviation was 15.51. The distribution of the fruit seller (mango) according to their age is shown in Table 4.1.

Data presented in Table 4.1 indicated that majority (44%) of the respondents fall in the middle aged category compared to (26%) young aged and (30%) old aged. It was also found that middle aged respondents are more interested in participation in fruit selling (mango) activities.

Table 4.1 Distribution of fruit seller according to their age

Categories	Scores (Years)	Respondents(N=50)		Mean	SD	Min	Max
		Number	Percentage				
Young aged	≤ 35	13	26	44.86	15.51	15.0	72.0
Middle aged	36-55	22	44				
Old aged	>55	15	30				
Total		50	100				

4.1.2 Level of Education

The level of education score of the fruit seller (mango) ranged from 0-16, with a mean of 5.34 and standard deviation 5.03. Based on their education scores, the fruit seller (mango) were classified into categories namely illiterate (0), primary education (1-5), secondary education (6-10), higher secondary (>10) or above. The distribution of the fruit seller (mango) according to their level of education is shown in Table 4.2. Data presented in Table 4.2 show that majority (36%) of the fruit seller (mango) belonged to the secondary education category compared to 28%, 26% and 10% of the fruit seller (mango) belonged to illiterate, primary level and higher secondary level or above education, respectively. The findings also indicate that most of (36%) the respondents had secondary level of education.

Table 4.2 Distribution of fruit seller according to their education

Categories	Score (Years of schooling)	Respondents (N=50)		Mean	SD	Min	Max
		Number	Percentage				
Illiterate	0	14	28.0	5.34	5.03	0	16
Primary	1-5	13	26.0				
Secondary	6-10	18	36.0				
Higher secondary or above	>10	5	10.0				
Total		50	100				

4.1.3 Family Type

Based on their family type, the respondents 'families were classified into three categories namely nuclear, joint family and extended family. The distribution of the respondents according to their family size is shown in Table 4.3.

Data presented in Table 4.3 show that majority (86%) of the fruit seller (mango) belonged to the nuclear family and 14% of the fruit seller (respondents) belonged to joint family whereas nobody was belonged to extended family. The findings also reveal that a large proportion of (100%) the fruit seller belonged nuclear to joint family involved in marketing activities.

Table 4.3 Distribution of the fruit seller according to their family type

Category	Respondents(N=50)	
	Number	Percentage
Nuclear Family	43	86.0
Joint family	7	14.0
Extended family	0	00.0
Total	50	100.0

4.1.4 Family Size

Family size of the fruit seller (mango) ranged from 2-11, with a mean of 4.72 and standard deviation 2.00. The distribution of the respondents according to their family size is shown in Table 4.4.

Data presented in Table 4.4 show that majority (58%) of the fruit seller (mango) belonged to the small family whereas 32% and 10% of the fruit seller (respondents) belonged to medium size family and large size family respectively. Average five members are including per family. The findings also reveal that a large proportion of (90%) the fruit seller (mango) belonged small to medium sized family involved in marketing activities.

Table 4.4 Distribution of the fruit seller (mango) according to their family size

Category	Scores (Number)	Respondents(N=50)		Mean	SD	Min	Max
		Number	Percentage				
Small size family	1-4	29	58.0	4.72	2.00	2	11
Medium size family	5-7	16	32.0				
Large size family	>7	5	10.0				
Total		50	100.0				

4.1.5 Experience in mango selling

The data admit that fruit selling (mango) experience score of the fruit seller ranged from 1.00-40.00 years with a mean of 13.38 and standard deviation of 10.60. The distribution of the fruit seller (mango) according to fruit selling experience their score is presented in Table 4.5.

Data presented in table 4.6 reveal that majority (48%) were highly experienced while 30% and 22% were medium and low experiences, respectively.

Table 4.5 Distribution of the mango sellers according to their marketing experience

Categories	Scores (Years)	Respondents(N=50)		Mean	SD	Min	Max
		Number	Percentage				
Low	< 5	11	22.0				
Medium	5-10	15	30.0				
High	> 10	24	48.0	13.38	10.60	1	40
Total		50	100				

4.1.6 Seasonal imbalance facing of mango sellers

Data presented in Table 4.6 show that majority 56% of the fruit seller (mango) faced seasonal imbalance (temperature, cloudy weather, heavy rain, diseases of mango etc.) whereas 44% of the fruit seller (respondents) did not face any seasonal imbalance.

Table 4.6 Distribution of the mango sellers according to facing seasonal imbalance

Category	Respondents(N=50)	
	Number	Percentage
Face seasonal imbalance	28	56.0
Does not face any seasonal imbalance	22	44.0
Total	50	100.0

4.1.7 Difficulties faced by mango sellers

Data presented in Table 4.7 show that majority (78%) of the fruit seller (mango) faced difficulties due to diseases whereas 16% of the fruit seller (respondents) faced storage difficulties, 4% of the fruit seller (mango) faced quality and 2% of the fruit seller (mango) faced price determination.

Table 4.7 Distribution of the fruit sellers (mango) according to facing difficulties

Category	Respondents(N=50)	
	Number	Percentage
Price determination	1	2.0
Spoilage due to diseases	39	78.0
Storage of mangoes	8	16.0
Quality of fruits (mangoes)	2	4.0
Total	50	100.0

4.1.8 Knowledge

Knowledge of the respondents ranged from 2 to 11 with a mean of 5.4 and standard deviation of 1.69. The distribution of the fruit seller (respondents) according to their knowledge is shown in Table 4.10.

Data reveal that 58% had low knowledge about mango because all most could not know how diseases were affected or not so their knowledge power about mango was very low whereas 40% of the fruit seller (respondents) had medium knowledge and 2% were high knowledge.

Table 4.8 Distribution of the fruit sellers (mango) according to Knowledge

Categories	Scores	Respondents (N=60)		Mean	SD	Min	Max
		Number	Percentage				
Low knowledge	≤5	29	58.0	5.4	1.69	2	11
Medium knowledge	6-10	20	40.0				
High knowledge	> 10	1	2.0				
Total		50	100				

4.1.9 Problem faced by mango sellers

The data admit that problem faced score of the fruit seller ranged from 5.00- 14.00 with a mean of 8.90 and standard deviation of 2.3. The distribution of the fruit seller (mango) according to problem faced their score is presented in Table 4.8.

Data presented in Table 4.8 show that majority (72%) of the mango seller confronted the low problem whereas 28% of the fruit seller (respondents) faced medium problem.

Table 4.9 Distribution of the mango sellers according to problem faced by mango sellers

Categories	Scores	Respondents (N=60)		Mean	SD	Min	Max
		Number	Percentage				
Low problem	≤10	36	72.0	8.90	2.3	5	14
Medium problem	11-20	14	28.0				
High problem	> 20	0	0.0				
Total		50	100				

4.1.9.1 Problem Faced Index (PFI) in Assessment of Losses of Mango

The observed problem faced index of the problems in assessment of losses of mango ranged from 0 to 137 against the possible range of 0 to 300. The formula for determining PFI has been shown in chapter 3. The selected ten problems faced by the respondents which were arranged in rank order according to their problem faced index (PFI) are shown in Table 4.9.1.

On the basis of PFI, it was observed that fruit infected with stem end rot ranked first followed by fruit infected with anthracnose, others (cracking in marketing, excessive rain, storage etc.) causes, lower market price, high prices of inputs, deformed fruits, disease controlling problem, rotten mangoes due to aspergillus rot, deformed fruits, and rotten mangoes due to bacterial black spot.

Table 4.9.1 Rank order of 10 selected problems faced by the fruit seller (mango) in marketing

Sl. No.	Problems	Nature of Problem faced				PFI	Rank Order
		High problem (3)	Medium problem (2)	Little problem (1)	No problem (0)		
1	Fruit infected with Anthracnose	29	21	0	0	129	2
2	Fruit infected with stem end rot	37	13	0	0	137	1
3	Rotten mangoes due to bacterial black spot	0	0	0	0	0	10
4	Rotten mangoes due to *Aspergillus* rot	0	0	7	43	7	9
5	Quick rot before marketing	0	8	3	39	19	7
6	Disease controlling problem	0	3	11	36	17	8
7	Deformed fruits	0	1	20	29	22	6
8	High prices of inputs	0	3	21	26	27	5
9	Lower market price	0	3	29	18	35	4
10	Others(cracking in marketing, excessive rain, storage etc.) causes	2	16	15	17	53	3

PFI = Problem Faced Index N = 50

4.1.10 Losses of mango as perceived by the fruit sellers

Fruit loss at the market level of mango has been presented in Table 4.10.Total observed fruit (mango) of selected 50 fruit sellers (respondents) were 11960 in number. But due to several causes, mangoes have significantly lost 1743 in number from market level. It was revealed that the losses of mango were highest due to stem end rot disease 7.38%. Besides 6.24% due to anthracnose disease, 0.23% due to aspergillus rot and 0.87% due to other causes (storage, excessive rain, transport, high temperature, cracks etc.).

Table 4.10 Distribution of the fruit seller according to losses of mango

Fruit Type	Total Observed Fruit (in number)	Damage Category	Respondents (N=60) Average loss (Percentage)	Damages (in number)	Rank Order
Mango	11960	Due to Anthracnose	6.24	746	2
		Due to Stem End Rot	7.38	883	1
		Due to Aspergillus rot	0.23	27	4
		Due to bacterial black spot	00	00	5
		Others	0.73	87	3
		Total	14.58	1743	

Finally it was observed that the total loss of mango at the market level was 14.58%. Postharvest loss in banana was 25-50% (Amiruzzaman, 1990), and the losses in mango were reported as 0-16.3% by Quroshi and Meah (1991) and 27.2% by Azad, (2000).

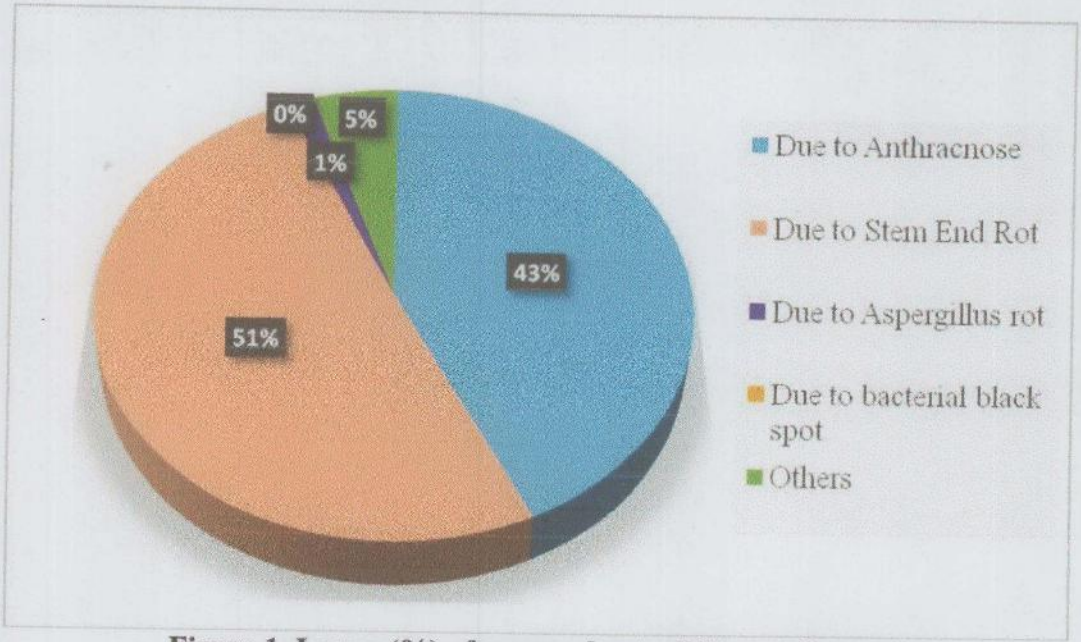


Figure 1. Losses (%) of mango due to different diseases

4.2 Relationship between the characteristics of the fruit sellers (mango) with the losses in mango as perceived by them

Coefficient of correlation was computed in order to explore the relationship between the selected characteristics of the fruit sellers (mango) with the losses in mango as perceived by them. The selected characteristics of the fruit sellers (mango) constituted independent variables and the losses in mango constituted the dependent variable of the study. In this section relationships between six selected characteristics (independent variables) of the fruit sellers (mango) and dependent variable i.e. Losses of mango as perceived by the fruit sellers have been described.

Person's Product Moment Co-efficient of Correlation (r) and Chi Square test (X^2) were used. Five percent and one percent level of probability were used. The results of the coefficient of correlation indicating the relationships between the selected characteristics of the respondents and their participation fruit selling (mango) activities are shown in Table 4.11.

Table 4.11 Relationship between the selected characteristics of the fruit sellers (mango) with the losses in mango as perceived by them

Characteristics (Independent variable)	Dependent variable	Correlation coefficient	Remarks
1. Age	Losses of mango as perceived by the fruit sellers	-0.116 ^{NS}	PPCC
2. Level of Education		-0.080 ^{NS}	PPCC
3. Family Type		0.618 ^{NS}	χ^2
4. Family Size		0.054 ^{NS}	PPCC
5. Experience		-0.087 ^{NS}	PPCC
6. Seasonal imbalance facing of mango sellers		0.219 ^{NS}	χ^2
7. Difficulties facing of mango sellers		0.551 ^{NS}	χ^2
8. Knowledge		0.171**	PPCC
9. Problem		0.099**	PPCC

NS= Non-significant **, Correlation is significant at the 0.01 level (2-tailed)

PPCC= Person's Product Moment Co-efficient of Correlation, χ^2= Chi Square test

4.2.1 Relationship between ages of the fruit sellers (mango) with the losses in mango as perceived by them

The computed value of coefficient of correlation r (-0.116) showed a negative and non-significant relationship between age of the fruit sellers (mango) with the losses in mango as perceived by them. On the basis of the findings, the null hypothesis could be accepted i.e. research hypothesis was rejected. It can be concluded that, "there is no relationship between ages of the fruit sellers (mango) with the losses in mango as perceived by them".

4.2.2 Relationship between levels of education of the fruit sellers (mango) with the losses in mango as perceived by them

The computed value of coefficient of correlation r (-0.080) showed a negative and non-significant relationship between level of education of the fruit sellers (mango) with the losses in mango as perceived by them. On the basis of the findings, the null hypothesis could be accepted i.e. research hypothesis was rejected. It can be concluded that, "there is no relationship between levels of education of the fruit sellers (mango) with the losses in mango as perceived by them".

4.2.3 Relationship between family types of the fruit sellers (mango) with the losses in mango as perceived by them

The computed value of coefficient of correlation (0.618) showed a negative and non-significant relationship between family types of the fruit sellers (mango) with the losses in mango as perceived by them. On the basis of the findings, the null hypothesis could be accepted i.e. research hypothesis was rejected. It can be concluded that, "there is no relationship between family types of the fruit sellers (mango) with the losses in mango as perceived by them".

4.2.4 Relationship between family sizes of the fruit sellers (mango) with the losses in mango as perceived by them

The computed value of coefficient of correlation r (0.054) showed a positive and non-significant relationship between family sizes of the fruit sellers (mango) with the losses in mango as perceived by them. On the basis of the findings, the null hypothesis could be accepted i.e. research hypothesis was rejected. It can be concluded that, "there is no relationship between family sizes of the fruit sellers (mango) with the losses in mango as perceived by them".

4.2.5 Relationship between experiences of the fruit sellers (mango) with the losses in mango as perceived by them

The computed value of coefficient of correlation r (-0.087) showed a negative and non-significant relationship between experiences of the fruit sellers (mango) with the losses in mango as perceived by them. On the basis of the findings, the null hypothesis could be accepted i.e. research hypothesis was rejected. It can be concluded that, "there is no relationship between experiences of the fruit sellers (mango) with the losses in mango as perceived by them".

4.2.6 Relationship between seasonal imbalances facing of mango sellers with the losses in mango as perceived by them

The computed value of coefficient of correlation (0.551) showed a positive and non-significant relationship between seasonal imbalances facing of mango sellers with the losses in mango as perceived by them. On the basis of the findings, the null hypothesis could be accepted i.e. research hypothesis was rejected. It can be concluded that, "there is no relationship between seasonal imbalances facing of mango sellers with the losses in mango as perceived by them".

4.2.7 Relationship between difficulties facing of mango sellers with the losses in mango as perceived by them

The computed value of coefficient of correlation (0.171) showed a positive and non-significant relationship between difficulties facing of mango sellers with the losses in mango as perceived by them. On the basis of the findings, the null hypothesis could be accepted i.e. research hypothesis was rejected. It can be concluded that, "there is no relationship between difficulties facing of mango sellers with the losses in mango as perceived by them".

4.2.8 Relationship between knowledge of the fruit sellers (mango) with the losses in mango as perceived by them

The computed value of coefficient of correlation r (0.171^{**}) showed a positive and significant relationship between knowledge of the fruit sellers (mango) with the losses in mango as perceived by them. On the basis of the findings, the null hypothesis could be rejected i.e. research hypothesis was accepted. It can be concluded that, "there is a positive relationship between knowledge of the fruit sellers (mango) with the losses in mango as perceived by them".

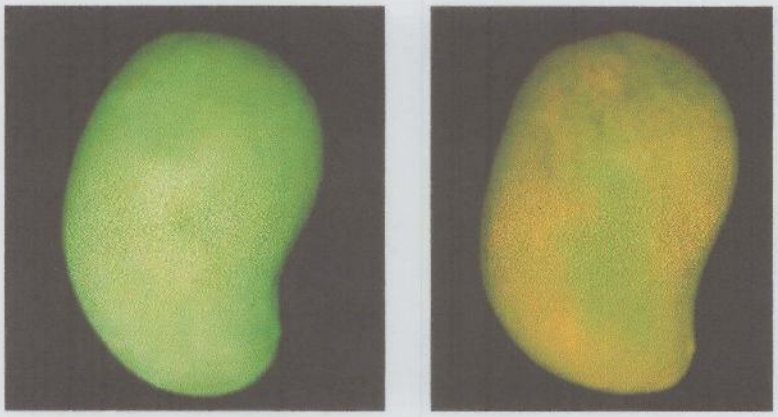
4.2.9 Relationship between problems faced by the fruit sellers (mango) with the losses in mango as perceived by them

The computed value of coefficient of correlation r (0.099^{**}) showed a positive and significant relationship between problems faced by the fruit sellers (mango) with the losses in mango as perceived by them. On the basis of the findings, the null hypothesis could be rejected i.e. research hypothesis was accepted. It can be concluded that, "there is a positive relationship between problems faced by the fruit sellers (mango) with the losses in mango as perceived by them".

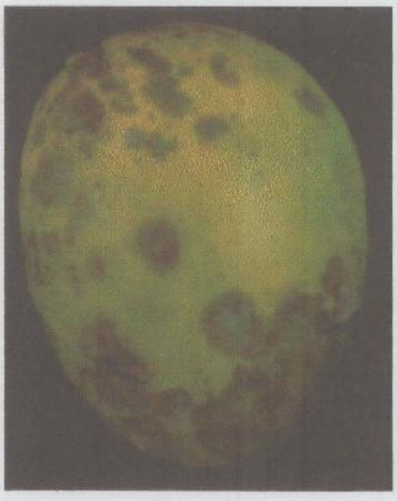
4.3 Pathogenicity test

4.3.1Confirmation and characterization of an incitants of major post-harvest fungal diseases

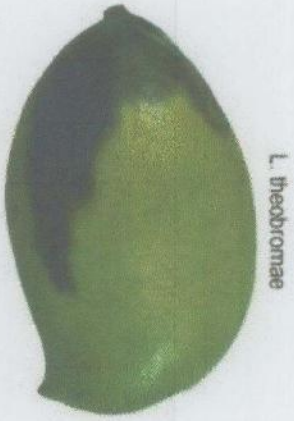
Accurate taxonomic identification is necessary for plant breeding purposes and disease management (Freeman et al., 1998).



Picture 4. Healthy mango



Picture 5. An infected mango showing anthracnose symptoms



Picture 6. An infected mango showing stem end rot symptoms

4.4Assessment of mango losses due to post-harvest diseases

4.4.1 Assessment of disease incidence, percent disease index and loss of mango post-harvest diseases at second day of mango storage condition

At the second day of storage condition, disease incidence of three varieties varied significantly ($p<0.01$). The highest disease incidence (20%) was recorded from stem end rot of Langra. While the lowest (3.33%) was in the anthracnose of Himsagar followed by stem end rot (5.67%) of Amrapali.

Percent disease index of three varieties also showed significant variation ($p<0.05$). The maximum (7.55%) percent disease index was recorded from anthracnose of Langra. While the lowest (1.77%) was in the anthracnose of Himsagar followed by stem end rot (2.77%) of Amrapali.

Losses of three varieties due to diseases varied significantly ($p<0.01$). The highest loss of mango (14.5%) was revealed from stem end rot of Langra. Whereas, the lowest (4.39%) was in the anthracnose of Himsagar which was statistically similar to stem end rot (5.07%) of Amrapali.

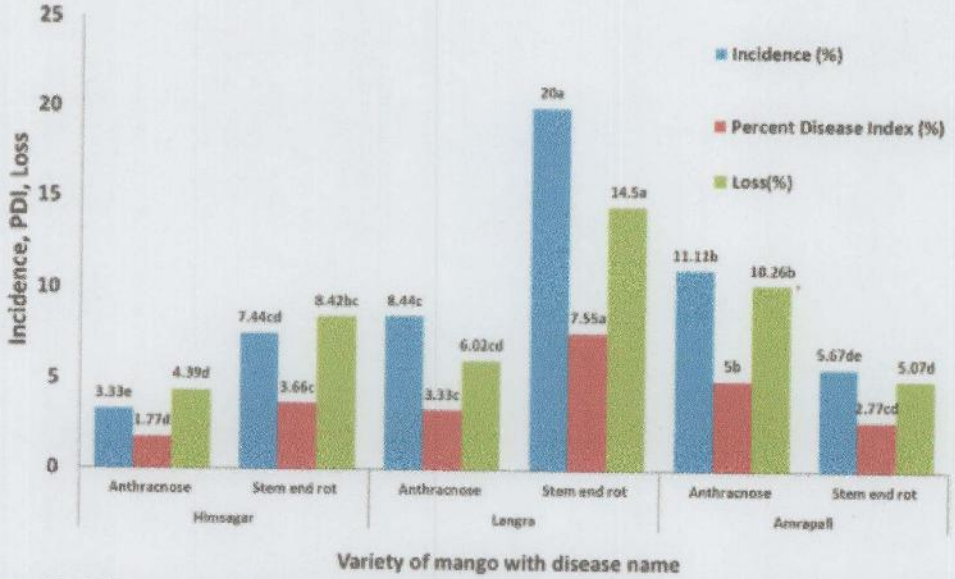


Figure 2. Disease incidence, percent disease index and loss of three varieties of mango at 2nd day

4.4.2 Assessment of disease incidence, percent disease index and loss of mango post-harvest diseases at sixth day of mango storage condition

At the sixth day of storage condition, disease incidence of three varieties varied significantly ($p<0.01$). The highest disease incidence (54.56%) was recorded from stem end rot of Himsagar. On the other hand, the lowest was in the stem end rot of Amrapali showed the lowest (16%).

Percent disease index showed more or less statistically similar result. The maximum percent disease index (50.89%) was recorded from stem end rot of Himsagar and the minimum (35.33%) was in the anthracnose of Himsagar.

Loss of mango due to anthracnose and stem end rot revealed significant variation ($p<0.01$). The highest loss of mango (63.52%) was recorded from stem end rot of Himsagar. While, the lowest (17.59%) was in the stem end rot of Amrapali.

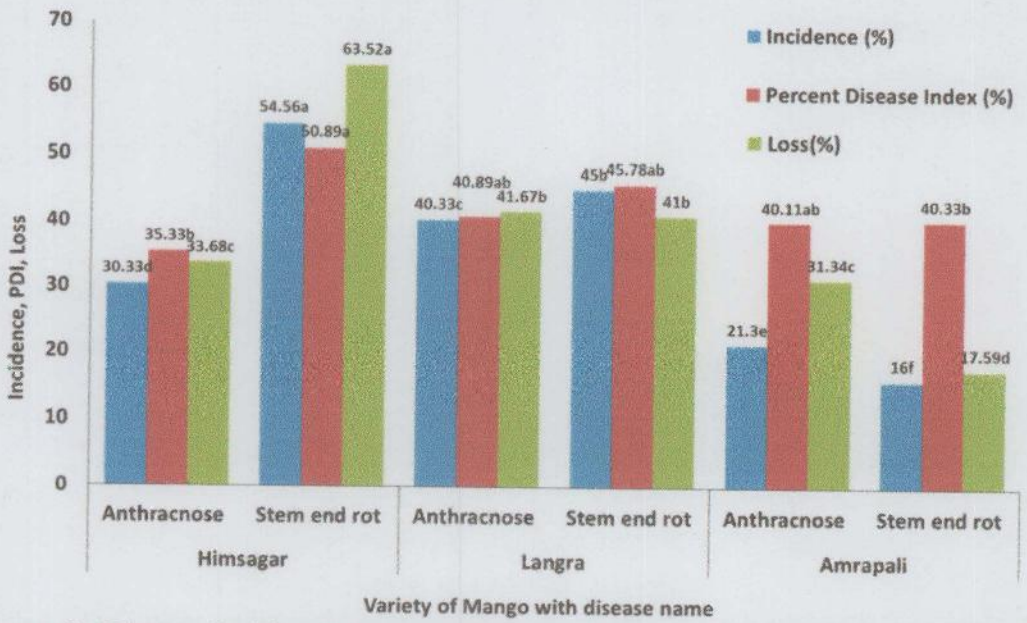


Figure 3. Disease incidence, percent disease index and loss of three varieties of mango at 6th day

4.4.3 Assessment of disease incidence, percent disease index and loss of mango post-harvest diseases at twelfth day of mango storage condition

The disease incidence showed significant variation ($p<0.01\%$). The highest (76.78%) disease incidence was observed from stem end rot of Himsagar. However, the lowest (37.67%) was in the anthracnose of Amrapali.

The maximum (74.56%) percent disease index was recorded from stem end rot of Himsagar and minimum (50.77%) was in the anthracnose of Amrapali which was statistically similar to others.

The highest (88.33%) loss of mango was found at stem end rot of Himsagar. On the other hand, stem end rot of Amrapali revealed the minimum (44.04%) loss.

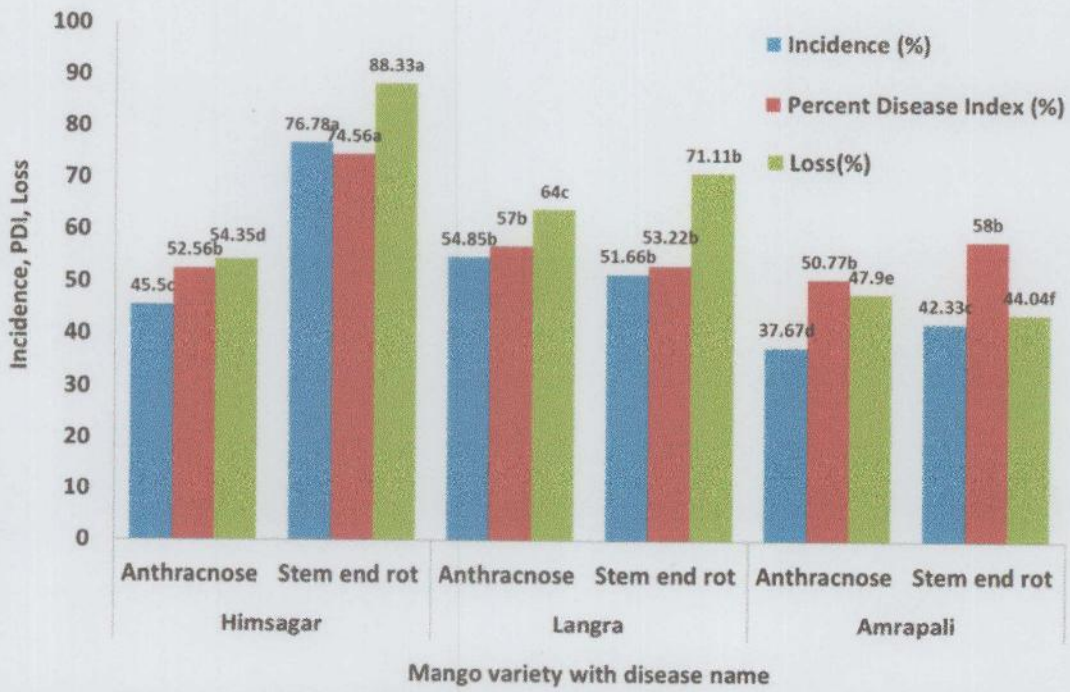


Figure 4. Disease incidence, percent disease index and loss of three varieties of mango at 12thday

Malik et al. (2016), mango can suffer from serious losses by post-harvest diseases. Mango post-harvest diseases include anthracnose (*C. gloeosporiodies*), stem end rot (*Botrydiplodia theobromae*), Aspergillus rot (*Aspergillus niger* L. Var. *Tieghem*) and *Alterneria* rot and the incidence was found in range of 40.00-90.00%, 16.00-86.60%, 3.33-53.30% and 16.76%, respectively.

CHAPTER V

SUMMARY

A survey and a laboratory experiment were conducted to assess the losses of mango due to post-harvest diseases. For conducting survey three markets namely Baro bazar, Gollamary, Dacbangla and 50 respondents (fruit sellers) were selected.

From the result of survey, it was found that majority of the mango sellers were middled aged(44%) followed byyoung aged (26%) and old aged (30%).The majority (36%) of the fruit seller (mango)belonged to the secondary education category. While, most (86%) of the fruit seller (mango) belonged to the nuclear family and a large proportion (90%) of the fruit seller (mango) belonged small to medium sized family involved in marketing activities. The maximum (48%) fruit seller (mango) were high experienced. The majority (56%) of the fruit seller (mango) faced seasonal imbalance (temperature, cloudy weather, heavy rain, diseases of mango etc.) whereas most (78%) of the fruit seller (mango) faced difficulties due to diseases.58% had low knowledge about mango because all most could not know how diseases were affected or not so their knowledge power about fruit selling is knowledge very low. Majority (72%) of the fruit seller faced low problem. According to the respondents, the losses of mango were highest due to Stem End Rot disease 7.38% and 6.24% due to Anthracnose disease, 0.23% due to *Aspergillus* rot and 0.87% due to other causes (storage, excessive rain, transport, high temperature, cracks etc.).

In the laboratory, during storage condition, the highest (88.33%) loss of mango was reported from stem end rot of Himsagar, while lowest (44.04%) was in the stem end rot of Amrapali. Moreover, the highest (76.78%) diseases incidence and percent disease index (74.56%) was observed from stem end rot of Himsagar. Two fungal diseases (Anthracnose, Stem End Rot) were identified as the causes of fruit losses.

CONCLUSION

- Among the respondents, most of the (58%) mango sellers had low knowledge about mango diseases.
- On the basis of Problem Faced Index, it was observed that mango infected with stem end rot disease ranked as first.
- According to them, the losses of mango were the highest (7.38%) due to Stem End Rot disease while 6.24% due to Anthracnose disease, 0.23% due to *Aspergillus* rot and 0.87% due to other causes (transport, high temperature, cracks, storage, excessive rain etc.).
- In case of co-efficient correlation, there was a positive relationship between the knowledge and problems faced by the mango sellers with the losses in mango as perceived by them.
- In the laboratory condition during storage, the highest diseases incidence (76.78%), percent disease index (74.56%) and maximum loss (88.33%) was also was observed from Stem End Rot of Himsagar.

5.1 Recommendations for further study

A small and limited research work cannot provide unique and universal information. Further studies should be undertaken on related matters. On the basis of scope and limitations of the present study and observation made by the researcher, the following recommendations are made for further study:

- ❖ The present study was carried out in only Khulna City of Bangladesh. Similar studies should be conducted to other parts of the country to get a clear picture of the whole country which will be helpful for effective policy formulation.

- ❖ The present study was undertaken to explore relationships of ten selected characteristics of the fruit seller (mango) with their extent of losses of mango as perceived by them. Therefore, it could be recommended that further studies should be designed considering other agricultural and non-agricultural activities and including other characteristics of the fruit seller (mango) that might affect the losses of mango.

- ❖ In the present study age, level of education, family types, family sizes, experiences, faced seasonal imbalance, faced by difficulties by the fruit sellers (mango) had no significant relationship with the losses of mango. In this connection, further verification is necessary.

- ❖ The laboratory experiment was conducted to evaluate the losses of three varieties of mango in three markets. More varieties and markets should be included.

- ❖ Similar experiment should be repeated to next season to estimate the post-harvest losses accurately.

CHAPTER VII

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7. What are the difficulties while selling? a) Price determination b) Spoilage due to disease c) Storage d) Quality

8.**Knowledge on Mango sellers**

Please answer the following questions regarding mango.

Sl. No.	Questions	Assigned Score	Obtained Score
1	Name some varieties of mangoes	2	
2	Do you know the storage temperature of mangoes?	2	
3	Do you know any seasonal imbalance	2	
4	Knowledge about identification of pest/diseases	2	
5	Do you know which varieties gets mostly affected by pest/diseases	2	
6	Mention seasons when pest/diseases increases	2	
7	Mention three diseases of mangoes	2	
8	Mention ways of controlling disease	2	

9. Problem Faced by the Mango Seller

Please mention the extent of problems related to jackfruit cultivation and marketing.

Sl. No.	Problems	Nature of Problem faced			
		High problem (3)	Medium problem (2)	Little problem (1)	No problem (0)
1	Fruit infected with Anthracnose				
2	Fruit infected with Stem end rot				
3	Rotten mangoes due to bacterial black spot				
4	Rotten mangoes due to *Aspergillus* rot				
5	Quick rot before marketing				
6	Disease controlling problem				
7	Deformed fruits				
8	High prices of inputs				
9	Lower market price				
10	Others(cracking in marketing, excessive rain, storage etc.) causes				
Total					

10. Losses of Mangoes as Perceived by the sellers

Please mention your perception on losses of mango in Percentage.

Items	Total Quantity	Quantity loss	% Loss of Mango in Terms of Total Marketing	Rank
1.Due to Anthracnose				
2.Due to Stem end rot				
3.Due to *Aspergillus* rot				
4.Due to bacterial black spot				
5.Others				
Total				

Signature of data collector

Signature of sellers

Date: