STATUS OF POST HARVEST DISEASES OF PAPAYA AND JUJUBE IN DHAKA CITY

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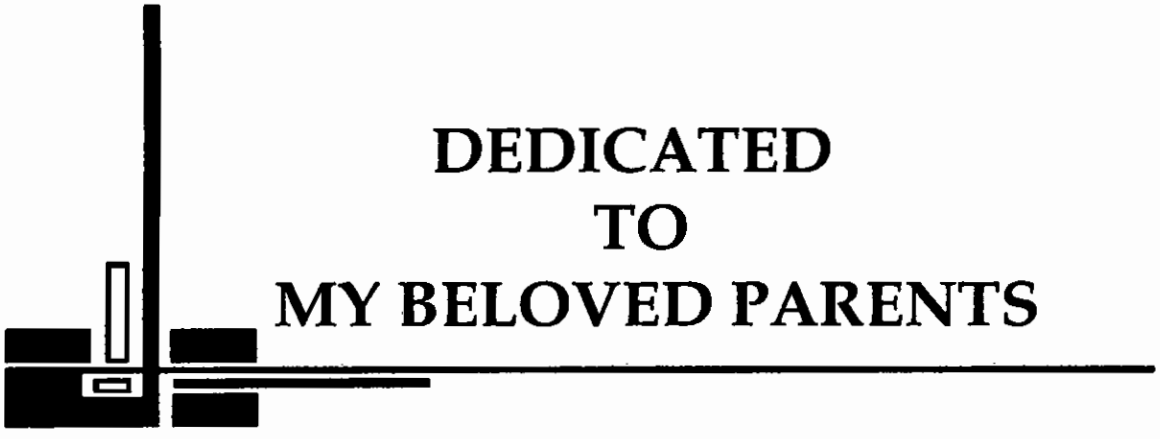

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CERTIFICATE

This is to certify that the thesis entitled "**Status of Post Harvest Diseases of Papaya and Jujube in Dhaka city**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **PLANT PATHOLOGY**, embodies the result of a piece of bonafide research work carried out by **Md. Golam Mostofa**, Registration number: **04-01252** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, received during the course of this investigation has duly been acknowledged.

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The Author

STATUS OF POST HARVEST DISEASES OF PAPAYA AND JUJUBE IN DHAKA CITY

ABSTRACT

The present experiment was conducted during the period from November, 2009 to March, 2010 to find out the status of post harvest diseases of papaya and jujube fruits in Dhaka city. Consequently three experiments were conducted for identification of post harvest diseases, causal organism and isolation of causal organism from diseased of papaya and jujube. The survey was conducted in the wholesale markets of Dhaka in the area of Kawran Bazar, Zatrabari and Mazar Road Mirpur-1. Papaya and jujube were collected from different division in Dhaka wholesale market. In case of papaya the highest percentage of papaya fruits (32.33%) was collected from Dhaka division. For jujube the highest percentage (37.22%) was collected from Dhaka division. In case of papaya, in an average the highest incidence (28.13%) was recorded in the month of March, 2010 whereas the lowest incidence (15.29%) was recorded in the month of November, 2009 and the highest severity (28.37%) was recorded in the month of March, 2010 whereas the lowest severity (15.87%) was recorded in the month of November, 2009. In case of jujube, the highest incidence (47.18%) was recorded in the month of March, 2010 whereas the lowest incidence (21.83%) was recorded in the month of January, 2010 and the highest severity (53.46%) was recorded in the month of March, 2010 while the lowest severity (16.35%) in the month of January, 2010. In case of tissue infection in papaya it was found that 100% fruits were infected by *C. gloeosporioides*, *Rhizopus*, *Fusarium*, *Stemphylium* and *Aspergillus* pathogen. In case of tissue infection by using block the highest infected tissue (30%) was recorded for *C. gloeosporioides* and the lowest for *Aspergillus* (5%) For tissue infection using scrap the highest infected tissue (35%) was recorded for *C. gloeosporioides*, while the lowest for *Aspergillus* (6%). In case of control condition it was found that 33% fruit were infected by *C. gloeosporioides*, *Rhizopus*, *Fusarium*, *Stemphylium* and no infection was recorded for *Aspergillus* pathogen. In control condition the highest (15%) infected tissue was recorded for *Anthracnose*, whereas no infection for *Aspergillus*. And in case of jujube the highest infected fruit was recorded for *Phomopsis* (90%), whereas the lowest was recorded for *Stemphylium* (30%). In case of tissue infection using block, the highest infected fruit was recorded for *Alternaria* (32%), while the lowest was recorded for *Rhizopus* (10%). In case of tissue infection using scrap, the highest infected fruit was found for *Alternaria* (37%), while the lowest was recorded for *Rhizopus* (15%). In case of control condition no infected fruit and no infected tissues were observed for *Phomopsis*, *Stemphylium*, *Rhizopus*, *Anthracnose* and *Alternaria* pathogen.

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CHAPTER I

INTRODUCTION

Bangladesh is a developing country lies in the tropical and sub-tropical climatic region and is imbued with good natural resources of fertile sedimentary soils, pleasant climate and industrious people- criteria for sustainable agricultural development. These are particularly true for the production of valuable and nutritious tropical and sub-tropical fruits of diverse origin (BBS, 2008). The country abounds with a large variety of tropical and sub-tropical fruits. The most widely cultivated fruits are mango, jackfruit, jujube, papaya, guava, black berry, pineapple, banana, litchi, lemon, custard apple, wood apple, elephant apple, golden apple, Indian berry, tamarind, melon, watermelon, cashew nut, pomegranate, plum, rose apple, Indian olive, Indian jujube etc.

In fruit production, planted area and production in 2007-08 were 232,000 ha and 2.247 m ton, respectively. The horticultural crops, especially fruits, are playing a vital role in crop diversification and nutrition, economy and environment. Considerable successes have been achieved in the recent years in variety development and technology generation of fruits albeit their application is inadequate. Improved varieties of fruit like papaya, jujube, mango, banana, orange, star apple, wild date palm, guava, litchi, jackfruit, berry etc. are available in Bangladesh, which can contribute in the poverty ridden economy and nutrition sector significantly (Rahim, 2009).

However, postharvest losses in fruits and vegetables are estimated at 20–25%. For highly perishable fruits and vegetables, these losses may go as high as 40% (Rahman *et al.*, 2003). The shelf-life of most tropical and subtropical fruit crops is limited by their high susceptibility to postharvest diseases caused by fungi - examples are the diseases anthracnose and stem-end rot - with losses of 20% common (Coates, 1997). The problem of postharvest losses is compounded by the lack of proper processing, preservation and storage systems. Post harvest decay is the major factor limiting the extension of storage and shelf life of fruits in Bangladesh. The citrus fruit, papaya, guava, jujube, mango, jackfruit are attacked by a number of pathogens from bloom to harvesting stage and subsequently by post-harvest pathogens that affect the production of the crop and considerably deteriorate the fruit quality (Naqvi, 2004; Hossain and Meah, 1992).

The pre-harvest pathogens like *Colletotrichum gloeosporioides*, *Botryodiplodia theobromae*, *Alternaria*, *Phomopsis*, *Fusarium*, *Aspergillus*, *Monilinia fructicola* etc. attack the fruit from fruit set till harvest and cause considerable damage to its production and quality (Ploetz *et al.*, 1994). Viable technologies have to be developed to reduce these losses through pre-harvest management of diseases, improved handling, transport, storage, packing and marketing. Quantification and identification of postharvest diseases should be conducted in different phases of postharvest handling to find out the most critical phases of fruits affected by diseases. Accurate diagnosis of diseases and pathogens involved are imperative so specific corrective measures can be formulated (Qin *et al.*, 2004). Among the different fruits of Bangladesh papaya (*Carica papaya*) and jujube

(*Zizyphus jujuba*) are the most common fruits in context of price availability and nutrient status (Pinkerton *et al.*, 1998; MacHardy *et al.*, 2001 and Mondal and Timmer, 2002). A significant amount of losses was recorded post harvest diseases of papaya and jujube in the fruits imported from different parts of the country in the wholesale market of Dhaka (Hopkins *et al.*, 2000).

Papaya should be transported with the required size and stage of ripeness (as defined in the market specifications) with sufficient yellow peel and orange or red pulp colouration, free from bruises, blemishes, insect and spray damage and uniform in size and ripeness within each carton. Papaya fruits are sensitive to poor quality outturns and high post-harvest losses if harvesting, treatments and handling techniques are inadequate or inappropriate. From harvest, a shelf-life of four to six days under tropical conditions and up to three weeks at low temperature days under tropical conditions and up to three weeks at low temperature storage can be achieved with the correct harvest maturities, disease control measures, handling techniques and storage conditions. For the maximum marketing period of papaya, the fruit should be stored at 10 to 12^{0}C. Temperatures below this range will cause chilling injury and rapid deterioration in fruit quality. To develop ripening in papaya, fruits should be stored at 18 to 25^{0}C and treated with ethylene gas at 100 ppm (0.01%) for 24 hours. Unripe papaya is sensitive to ethylene and will commence ripening if stored with ethylene-producing commodities. Similarly, ripe papaya produces ethylene and will cause deterioration in ethylene-sensitive crops (Medlicott, 2005).

Papaya is particularly susceptible to post-harvest losses as a result of high susceptibility to bruising and disease infection. Careful handling must be employed during harvesting, handling and shipping, and the relevant disease control measures employed. Damage to the skin immediately after harvest, as a result of the harvesting implement, dropping into crates, over-filling of crates and excess movement of fruit during in-field transport, will result in latex staining, punctures, scars and bruises (Mondal and Timmer, 2002). During ripening, bruised areas will develop into dark soft regions which become affected by secondary microbial infection. Similar effects can occur as a result of poor handling during washing, grading and packing. Damage can be reduced by taking protective measures throughout the handling procedures. Staff should be trained with harvesting techniques, foam should be included in the base of field crates and crates should contain only one layer of fruit. Stems are to be removed in the field to prevent puncturing or scratching of adjacent fruit. Vehicles used to transport the fruit from the field to packing house should be driven slowly and with care. During handling in the packing house, fruits should never be thrown or dropped and in automated operations, all machinery should be padded where possible.

Jujube is a highly nutritional valued and an attractive fruit, is grown commercially in all over the country. Although the fruit can be stored at low temperature for two months, they are very perishable being highly susceptible to postharvest color fading, browning, decay, and water loss (Tian, 2000). Controlled atmosphere storage at low temperature had beneficial effects on various pathological and physiological problems of fruits occurring during storage (Ke *et al.*, 1990;

Tian *et al.*, 1996). Short term treatment with ultra low oxigen or high CO_2 concentrations could be effective in controlling decay (Beaudry, 1999; Tian *et al.*, 2001). However, Day (1996) found that high O_2 concentration played a major role in preventing browning and inhibiting decay of postharvest fruits and vegetables. In a previous study, we found that proper postharvest handling significantly reduced decay, prevented peel browning and extended storage life (Tian *et al.*, 2002). About 12% fruit loss of jujube was recorded for post harvest diseases (Tian *et al.*, 2001). The fruit is very perishable and highly susceptible to postharvest decay. Jujube fruit is susceptible to postharvest diseases caused by various pathogenic fungi. *Alternaria alternata* is the most important pathogen and causes latent infections and serious postharvest losses (Tian, 2000). Jujube fruit also can be infected by *Monilinia fructicola*, *Penicillium expansum* and *Rhizopus stolonifer* through wounds that occur during harvest or packing (Tian, 2000). This disease usually occurs in the end of storage and during shelf life and cause serious losses.

Under the above prospective, identification of post harvest diseases, causal organism and isolation of causal organism from diseased fruit of papaya and jujube is important. However, very little attention has been given in this area in Bangladesh. Therefore, the present study has been planned and designed with the following objectives:

i. Quantification (incidence and severity) of postharvest diseases in different phases of postharvest handling in Dhaka wholesale markets.

ii. Isolation and identification of postharvest pathogens causing diseases of selected fruits in different phases of postharvest handling.

CHAPTER II

REVIEW OF LITERATURE

Papaya and jujube are the two most familiar and nutritious fruit in our local and Dhaka wholesale market. *Rhizopus*, *Anthracnose*, *Fusarium*, *Stemphylium*, *Aspergillus* are the most common organisms for papaya post-harvest losses and *Phomopsis*, *Stemphylium*, *Anthracnose*, *Rhizopus*, *Alternaria* and *Monilinia* are the common organisms for jujube. But specific identification of post harvest disease, causal organism and isolation of causal organism from diseased of papaya and jujube is very limited have been done and reported elsewhere in the world. However, studies in this area appeared very limited in Bangladesh. For a better understanding the relevant available literature on these fruit and others have been reviewed and presented below-

2.1 Fruits of Bangladesh

Bangladesh is imbued with good natural resources of fertile sedimentary soils, pleasant climate and industrious people-criteria for sustainable agricultural development. These are particularly true for the production and marketing of valuable and nutritious tropical and sub-tropical fruits in different parts of the country. The country abounds with a large variety of tropical and sub-tropical fruits. The most widely cultivated fruits are mango, jackfruit, black berry, pineapple, banana, litchi, lemon, guava, custard apple, wood apple, elephant apple, golden apple, Indian berry, papaya, tamarind, melon watermelon, cashew nut, pomegranate, plum, rose apple, Indian olive, and Indian jujube. There are

many minor edible fruits that are locally available in the wild and are also cultivated, such as latkan, monkey jack, rattan, river ebony, garcinia, water coconut, wild date palm, etc. (Banglapedia, 2008). In fruit production, planted area and production in 2007-08 were 232,000 ha and 2.247 million ton. Banana constitutes about 40% of the total production of fruits in the country followed by mango, jackfruit and citrus (Haque, 2009). The horticultural crops, especially fruits, are playing a vital role in crop diversification and nutrition, economy and environment. Considerable successes have been achieved in the recent years in variety development and technology generation of fruits albeit their application is inadequate. Improved varieties of fruit like mango, guava, litchi, jackfruit, etc. are available in Bangladesh, which can contribute in the poverty ridden economy and nutrition sector significantly (Rahim, 2009). However, the availability of Quality Planting Materials (QPM) is inadequate.

The national consumption of fruits is still low. Bangladesh produces less than 30 percent of the fruits needed to meet the minimum daily requirements for its population. About 80% of families in the country consume less than the minimum recommended daily requirement of fruits. As a consequence, widespread nutritional deficiencies in vitamin 'A' and 'C' iron and other nutrients that cause debilitating illness among the population (HKI, 2005). The majority of rural farmers cannot afford to buy fruits regularly. Vitamin 'A' (VA) deficiency is among the major public health problems in Bangladesh. The World Health Organization (WHO) has estimated that VA deficiency along with its health and social consequences affects more than 250 million children worldwide

(WHO, 1995). In Bangladesh, more than 30,000 children under 60 months of age are estimated to suffer from Vitamin-A deficiency-related eye problems (Bloem *et al.*, 1996). The Bangladesh government has considered VA deficiency a major public health concern since the 1960s and has recently increased its efforts to control the problem. Promoting the production and consumption of vegetables and fruits is an important strategy for combating micronutrient malnutrition, and VA deficiency in Bangladesh. A homestead gardening project, the NGO Gardening and Nutrition Education Surveillance Project (NGNESP), was established by Helen Keller International (HLI) to improve the availability and consumption of vegetables and fruits, thus contributing to the reduction of VA deficiency in rural Bangladesh (HKI, 1999). During a one-year intervention period NGNESP/HKI became capable of establishing homestead gardens in nearly all target households. Shifting traditional gardening practices to improved or developed gardening was achieved due to the establishment of well-functioning, community-supported village nurseries. It may be commented that the homestead gardening has positive impact on improving consumption of pro-vitamin 'A' carotenoids, particularly among women and children, and on improving the food security of underprivileged rural people.

2.2 Diseases of fruit species

Diseases of fruit species have been reviewed by many workers throughout the world. Plant diseases play a major role in reducing yields of horticultural crops in the tropics (Rawal, 1990; Ploetz, *et al.*, 1998; Mariau, 2001). It has been estimated that the production could be increased at least by 28% if the crop could be

protected against various diseases. Many of these diseases have been reported to be transmitted through the planting material (Rawal, 1990). Six most import fruit species grown widely in Bangladesh have been selected for this study.

2.3 Studies on prevalence of post harvest diseases

Survey and collection of the marketed papaya fruit with rot symptoms were conducted by Baiyewu *et al.* (2007) in the South Western Nigeria in 2000 and 2001, respectively. Papaya fruits showing rot symptoms that are displayed for sale in three different market places in three major cities in south western Nigeria namely, Ibadan, Abeokuta and Akure were collected and examined for the presence of the inducing pathogens and for aflatoxin contamination. The most commonly fungi found in rotten papaya fruits were: *Rhizopus nigricans*, *Curvularia lunata*, *Aspergillus niger*, *Fusarium moniliforme*, *Colletotrichum capsici* and *Trichoderma viride*. *Rhizopus nigricans*, *F. moniliforme*, *A. flavus* and *A. niger* had the highest rate of occurrence among the isolated fungi while *C. lunata* was the least encountered. Pathogenicity tests revealed that of all the isolated fungi, *R. nigricans*, *C. lunata* and *F. moniliforme* were highly pathogenic with the first two leading to rapid disintegration of treated fruits in 3-5 days. *A. niger* was moderately pathogenic, while *A. flavus*, *T. viride* caused the least amount of rot on papaya fruits. Aflatoxins were detected from infected papaya fruits, both before and after autoclaving fruit for 15 min at 121^0C.

A survey was carried out by Pramod *et al.* (2007) in 3 markets of Coimbatore, Tamil Nadu, India, from June 1998 to March 1999 to assess the occurrence and

extent of losses caused by various postharvest diseases in papaya fruits. Twelve fungal species (*Colletotrichum gloeosporioides* [*Glomerella cingulata*], *Rhizopus stolonifer*, *Botryodiplodia theobromae*, *Phoma caricae-papayae*, *Fusarium moniliforme*, *F. solani*, *Alternaria alternata*, *Geotrichum candidum*, *Myrothecium roridum*, *Aspergillus niger*, *A. flavus* and *Sclerotium rolfsii* [*Corticium rolfsii*]) were isolated from papaya fruits. Tyagi Kumaran market recorded the maximum mean percentage disease incidence. A mean disease index of 7.18 was recorded due to various postharvest diseases in papaya. *R. stolonifer*, *C. gloeosporioides* and *B. theobromae* were the major postharvest pathogens isolated. *Aspergillus niger*, *A. flavus* and *Alternaria alternata* were also found to be responsible for postharvest losses. The maximum disease incidence for the major pathogens was observed during October and November. The association of *S. rolfsii* with papaya postharvest fruit rot is reported for the first time.

2.4 Post harvest management of diseases

Anthracnose, caused by *Colletotrichum gloeosporioides*, is a major post-harvest disease in papaya fruit reported by Capdeville *et al.* (2007). The major objectives of the present work were to isolate, select and test the in vitro and in vivo ability of epiphytic microorganisms, isolated from papaya fruit and leaf surfaces, in controlling anthracnose onset after harvest. A total of 75 bacteria, 67 yeasts and 22 mycelial fungi were isolated. Thirty yeast isolates were able to inhibit the mycelial growth of *C. gloeosporioide* in vitro and seven of those were used in in-vivo assays, resulting in the identification of two very effective isolates. Isolate CEN63, identified molecularly as *Cryptococcus magnus*, was the most effective in

controlling the disease and therefore was studied in more detail. The results of the assays with *C. magnus* provided evidence that when fruit were treated with the antagonists at concentrations of 107 to 108 cells/ml, as early as 24 h, preferentially 48 h, before inoculation with the pathogen, the development of disease was significantly reduced. *C. magnus* is a potential antagonist for the development of a commercial product.

Fruit of Sihongdazao jujube cultivar were treated with AnsiP-S (1-MCP) (10 kg fruit/chip by Yan *et al.* (2007) and found that the effective concentration of 1-MCP was 0.9 mg/L) for studying the effect on physiological and biochemical changes during cold storage ($\pm 1^0$C). The results indicated that AnsiP-S treatment inhibited the respiration rate. The respiration rate was 53% and 50% of the control, respectively after stored for 15 and 45 days, respectively. It remained high quality by delaying the decline of firmness and decreasing the loss of the content of Vc. It was 2 times of the control and the preservation rate of Vc was 84.3% at 60 days during storage; it delayed the fruit senescence by reducing the cell membrane permeability; and it inhibited the fruit rot, while the fruit of control rotted at 30 days during storage but the fruit of AnsiP-S treatment rotted till 60 days during storage; AnsiP-S treatment had on significant effects on the change of red colour.

Papaya cv. Co_2 fruits were treated with 1, 2, 3 and 4% calcium chloride or calcium nitrate and gibberellic acid at 50, 100, 150 and 200 ppm to determine the effects of the treatments on the postharvest behaviour of the fruits by Rajkumar *et*

al. (2005). The postharvest loss of fruit weight was reduced with the treatments, with gibberellic acid at 150 ppm resulting in the highest reduction in fruits weight losses even after 9 days of storage. The number of healthy fruits 9 days after treatment was highest with the application of 100 ppm gibberellic acid. Both gibberellic acid at 100 ppm and calcium chloride at 2% also resulted in high firmness of fruits, total soluble solids, ascorbic acid content and titratable acidity, as well as a high score for sensory evaluation.

The postharvest maturity of papaya fruits is influenced by several environmental factors including temperature, light and ventilation of the surrounding wall reported by Dembele *et al.* (2005). The maturity, presence and attacks of rots and the accumulation of fungicide residues was evaluated on papaya fruits treated with different fungicides (triadimefon, bitertanol, imazalil, abamectin, maneb, thiabendazole and Fongic Plus). Thiabendazole-treated fruits did not rot at 21 days after treatment and was most satisfactory with detected residues lower than the European Union's 2000/48/EC guideline.

Papaya fruits were treated with 3% cassava starch and subjected to a competitive ethylene antagonist, 1-MCP (1-methylcycloproprene) at 0.14% reported by Castricini *et al.* (2004). Fruits were stored at room temperature or at 12^0C under refrigeration for 7 days. Respiration rate was evaluated. 1-MCP reduced respiration rate during the storage period.

The potential efficacy of a combination of the biocontrol agent Candida oleophila with a sodium bicarbonate-incorporated wax coating to control anthracnose

caused by *Colletotrichum gloeosporioides*, on papaya (*Carica papaya* L.) during storage was investigated by Gamagae *et al.* (2004). The survival of *C. olephila* was 100% in 2% sodium bicarbonate-incorporated wax coating for 60 min and the survival was over 90% in 2% sodium bicarbonate-incorporated wax coating for 7 and 14 days during storage at 13.5 degrees C and 95% RH. The combined application of 2% sodium bicarbonate in wax formulation and *C. oleophila* (2 × 108 cells) resulted in a significant reduction of anthracnose incidence and severity in naturally infected fruits stored at 13.5 degrees C and 95% RH for 14 days and for additional 2 days under simulated marketing conditions. The recovery of *C. gloeosporioides* and *C. oleophila* was, respectively, low and high from fruits coated with 2% sodium bicarbonate-incorporated wax coating and *C. oleophila.* Thus, the use of 2% sodium bicarbonate-incorporated wax coating with *C. oleophila* represents a commercially acceptable alternative to chemicals for post-harvest control of anthracnose of papaya during storage.

Postharvest fungal diseases of papaya (*Carica papaya*) fruits sold in Mile 3 Market, Port Harcourt were investigated by Echerenwa and Umechuruba (2004) bi-weekly for sixteen weeks using the Standard Blotter Method. The following fungi were isolated from the tissues of diseased fruits: *Fusarium solani*, *Phoma caricae-papayae*, *Aspergillus flavus*, *Aspergillus niger*, *Botryodiplodia theobromae*, *Cladosporium herbarum*, *Colletotrichum dematium*, *Fusarium moniliforme* [*Gibberella moniliformis*], *Phomopsis caricae-papayae*, *Penicillium* sp., and *Rhizopus stolonifer.* Seeds of diseased fruits were also tested for health using the Standard Blotter Method and all the fungi isolated from the fruit tissues

were found to be seed-borne except *F. moniliforme*. Pathogenicity test of all the fungi isolated from ripe fruit tissues and seeds were carried out on mature green papaya fruits and they were found to be pathogenic. *Rhizopus stolonifer* and *F. solani* caused the greatest rot on the fruits. Agar discs (3.0 mm, diameter) of these fungi were subjected to hot water treatment at varying periods of time, (40^0C for 30 mins, 50^0C for 20 mins, and 60^0C for 10 mins) to determine the efficacy of the treatments on the pathogens. The hot water treatments could not eliminate the pathogens; instead their lineal growths on PDA medium were just inhibited, when compared with the controls. A first report of seed-borne fungi of papaya and their pathogenicity is provided.

A study was conducted by Muniz *et al.* (2003) to identify the fungal diseases on eight different fruit cultivars commercialized in Maceio, Alagoas, Brazil. Samples were collected at 3-month intervals in 1998 to evaluate 20 units of each type of fruit from 5 different places, which resulted in 160 fruits per place or a total of 3200 fruits. Observations were performed on tomato, pepper, avocado, orange, lemon, passion fruit, guava and papaya fruits, which are important economic crops in Northeast Brazil. The fungi were isolated on PDA medium and their pathogenicity was tested by wound inoculation on several healthy fruits. Among the identified fungi, *Colletotrichum gloeosporioides* [*Glomerella cingulata*] was the most frequently isolated. Several others fungi were identified from the samples: *Acremonium* sp., *Fusarium anthophilum*, *F. semitectum* [*F. pallidoroseum*], *F. subglutinans* [*Gibberella fujikuroi* var. subglutinans] and *Stemphylium botryosum* [*Pleospora herbarum*] on tomato; *F. dimerum*

[*Microdochium dimerum*] and *S. botryosum* on pepper; *F. anthophilum* on avocado; *Trichoderma viride* on orange; *F. lateritium* [*Gibberella baccata*] and *F. subglutinans* on lemon; *Curvularia eragrostidis* [*Cochliobolus eragrostidis*], *F. equiseti* and *F. semitectum* on passion fruit; and *Acremonium* sp., *F. anthophilum* and *F. equiseti* on papaya. Although these fungi had been confirmed as the causal agents of diseases associated with postharvest decay on tropical fruits, their occurrence had not yet been reported in Brazil. The occurrence of these pathogens suggests the need for management of disease in pre- and postharvest which can contribute for the reduction of yield losses.

Distribution, importance and control of diseases of papaya (*Carica papaya*) together with characteristics, distribution and production of the fruit was reviewed by Persley and Ploetz (2003). Cultivated papaya is susceptible to a wide range of diseases, including bacterial canker (*Erwinia species*), papaya bunchy top (probably caused by a bacterium in the genus Rickettsia), alternaria fruit spot (*Alternaria alternata*), anthracnose (*Glomerella cingulata*), black rot (*Mycosphaerella caricae*) and Phytophthora fruit rots (*Phytophthora palmivora*). Disease can also be caused by nematodes (*Rotylenchulus reniformis* and Meloidogyne species), phytoplasmas (papaya dieback and yellow crinkle and mosaic) and viruses, such as papaya leaf curl virus, papaya leaf distortion mosaic virus and papaya ringspot virus.

Fungal diseases constitute one of the main causes of losses during commercialization of tropical fruits reported by Dantas *et al* (2003). Papaya

(*Carica papaya*) and orange (*Citrus* spp.) fruits were analysed in relation to disease incidence and frequency of the pathogenic species for 6 months, in Pernambuco, Brazil. Forty fruits of each species were evaluated monthly at 5 commercialization points, for a total of 200 fruits per month per species. A great diversity of diseases occurred in papaya fruits, where incidences ranged from 39.71 to 0.07%, with the higher level for stem end rot. In orange fruits, the disease incidence was 11.85 and 0.87%, for Lasiodiplodia stem end rot and antracnose, respectively. The pathogens that presented higher frequencies were *Colletotrichum gloeosporioides* [*Glomerella cingulata*] (44.95%) in papaya and *Lasiodiplodia theobromae* (11.85%) in orange. The diversity of diseases verified in this study suggests a need for more effective control measures during the production and postharvest phases of papaya and orange, seeking to propitiate reduction of the losses.

A study was conducted by Oliveira (2002) to evaluate the residue levels of benomyl in postharvest-treated papaya, dipped in 250, 500 and 1000 mg benomyl/litre with and without wax. After dipping, the fruits were stored at 12 degrees C with 85-90% relative humidity for 21 days. Benomyl levels were analysed by high performance liquid chromatography at 286 nm, in the pulp and peel after 0, 1, 4, 14 and 21 days of storage. No benomyl residues were detected in the pulp within the quantification limit of the applied method (0.3 mg/kg) but significant levels were detected in the peel, with degradation, ranging from 55 to 84% between 0 and 21 days of storage.

The influence of postharvest treatments with gibberellic acid (GA_3; at 100 ppm, 150 ppm and 200 ppm) and 2,4-dichloro phenoxy acetic acid (2,4-D; at 1.0 ppm, 2.5 ppm and 5.0 ppm) on the storage behaviour of 'Co-2' papaya was investigated by Ramakrishna *et al.* (2002). GA_3 at 150 ppm was more effective in reducing physiological weight loss and total sugar contents by maintaining fruit firmness. Further ripening parameters like colour and total carotenoid content were delayed, thereby increasing the shelf-life by 4 days more over the untreated control. 2,4-D was not effective in ripening and prolonging the shelf life.

Papaya (*Carica papaya*) cv. improved Sunrise Solo Line 72/12 fruits were treated with $CaCl_2$ and/or wrapped in PVC film prior to storage for 35 days at 10 +or- 2 degrees C and 85% RH by Bicalho *et al.* (2000) . Fruits treated with $CaCl_2$ had a better texture than non-treated fruits throughout the storage period, while fruits wrapped in PVC were firmer than control fruits only after 20 days of storage. Calcium + PVC film reduced the metabolic rate of fruits, decreasing the activity of pectin methylesterase [pectinesterase] and polygalacturonase, which are involved with in solubilization of pectins.

CHAPTER III

MATERIALS AND METHODS

The experiments were conducted during the period from November, 2009 to May 2010 to achieve the objectives.

3.1. Experiment I. Survey on the prevalence of post harvest diseases of papaya and jujube fruits imported from different parts of the country in the wholesale market of Dhaka

3.1.1. List of selected fruit species tested for the presence of post harvest diseases is given below:

English name	Local name	Scientific name
Papaya	Paypay	*Carica papaya*
Jujube	Boroi	*Zizyphus jujuba*

3.1.2. Locations

The following wholesale markets of Dhaka were surveyed and prevalence of post harvest diseases of selected fruit species was studied:

Name of Wholesale Market	Fruits were observed
▪ Kawran Bazar fruit wholesale market ▪ Zatrabari fruit wholesale market ▪ Mazar Road Mirpur-1 fruit wholesale market	o Papaya o Jujube

The survey was conducted in the wholesale markets of Dhaka in the area of Kawran Bazar, Zatrabari and Mazar Road Mirpur-1 the most important wholesale fruit market of Dhaka. The location situated at a distinct distance in the Dhaka metropolitan area and they collected most of the fruits from all over the country. They also supplied most of the fruits in other areas of Dhaka city.

3.1.3. Location and number of wholesale markets surveyed

Fruits	Name of wholesale fruit market	No. of surveyed wholesalers
Papaya	Kawran Bazar	15
	Zatrabari	15
	Mazar Road Mirpur-1	15
Jujube	Kawran Bazar	15
	Zatrabari	15
	Mazar Road Mirpur-1	15

3.1.4. Data collection

Experiments conducted on imported fruits from different parts of the country in the wholesale market of Dhaka. The size of the fruit lot was recognized and 1000 fruits of each lot considered for data collection. Data were recorded on the following parameters-

1. Types of fruit that the collected for sale
2. Source/point of collection
3. Distribution of the market
4. Frequency of fruit collection
5. Average time required for transportation
6. Mode of transportation
7. Average weight for every truck
8. Average buying price per kg
9. Average sales price per kg

10. Average parentage of fruit loss

11. Main causes of fruit loss

3.1.5. Data recording times

Assessment of the incidence and the severity of the diseases of each fruit species were observed five times in growing season for each fruit during the period of November, 2009 to April, 2010. The times of data collection was determined on the basis of harvesting time of the selected fruit in the growing season.

3.1.6. Assessment of disease incidence and severity

Disease incidence was assessed as percentage of fruits infected with at least one spot or visible symptom. Assessment of incidence and severity of the diseases of each fruit species were calculated by the following formula:

$$\text{Percent fruit infection} = \frac{\text{Number of diseased fruits}}{\text{Number of total fruits observed}} \times 100$$

Percent disease incidence (PDI) was calculated using the following formula:

$$\%\ \text{disease incidence (PDI)} = \frac{\text{Number of diseased fruits in each consignment}}{\text{Number of total fruits in each consignment}} \times 100$$

Disease severity was calculated using the formula of Johnston (2000) as:

$$\text{Disease severity} = \frac{\text{Area of fruit tissue infected by disease}}{\text{Total fruit (surface) area}} \times 100$$

Plate 1. Packaging condition of papaya and jujube for marketing

3.2 Experiment II. Identification of post harvest disease and causal organism of papaya and jujube

3.2.1 Identification of post harvest disease and causal organism

Fruits of selected fruits species was observed carefully and symptoms of the diseases were recorded following the description of Pathak (1986), Peterson (1986), Singh (1998) and Ploetz *et al.* (1998). To identify the pathogen, diseased fruits were collected using sterilized polythene bags and brought to the laboratory. The sample was washed thoroughly under running tap water (if required) and surface sterilized with 4% NaOCl. The diseased parts then placed on three layers of wet blotters equidistantly in Petriplates and another set placed on PDA

medium. Both sets were incubated for 7 days under 12/12hr. alternate cycles of near ultra violet light and darkness at 22±2^{0}C. After 7 days of incubation, the disease causal organism(s) were identified. The identification of the fungi was based on the colony character on PDA and on the morphological characters of fruiting bodies, spores or conidia under compound microscope.. Data on % presence of pathogen were recorded. Record was kept by keeping permanent slide of pathogenic structure, taking photograph of diseased sample and pathogenic structure under microscope.

3.2.2 Collection and preservation of fruit samples

Fruit species were collected from selected locations of Dhaka. 10 fruits of similar symptoms were collected from each location for isolation of causal pathogen. The collected fruit samples were brought to the laboratory and subject to a preliminary cleaning and then stored in paper packet in refrigerator for further study.

3.3 Experiment III. Evaluation of inoculation methods

Healthy papaya and jujube fruits were collected from different markets and inoculated mycelia by using block and scrap method. The healthy fruit (papaya and jujube) were inoculated by using agar block (containing pure culture of the pathogen) and by scrap of pure culture and inoculation were kept for 5 days.

CHAPTER IV

RESULTS

The present experiment was conducted to find out the status of post harvest diseases of papaya and jujube fruits in Bangladesh. Consequently three experiments were conducted for identification of post harvest disease, causal organism and isolation of causal organism from diseased of papaya and jujube. The results have been presented and discussed, and possible interpretations have been given experiment wise under the following headings:

4.1 Experiment-I: Survey on the prevalence of post harvest diseases of papaya and jujube fruits imported from different parts of the country in the wholesale market of Dhaka

The survey was conducted in the wholesale market of Dhaka in the area of Kawran Bazar, Zatrabari and Mazar Road Mirpur-1 the most important wholesale fruit market of Dhaka.

The respondents wholesaler sold various types of locally produced fruits and they also imported from other countries. Papaya was available for the year round and jujube was available during winter season and in some extent imported jujube was available other than winter season. The commonly sold fruits were mango, jackfruit, jujube, papaya, guava, black berry, pineapple, banana, litchi, lemon, berry, custard apple, wood apple, golden apple, star apple, wild date palm, Indian berry, tamarind, melon, watermelon, cashew nut, pomegranate, plum, rose apple, Indian olive, Indian jujube etc. According to the response of the respondents of fruit wholesaler in different market of Dhaka city presented in Table 1.

Table 1. Data represents the type of fruits that the respondents sale in different market

Name of wholesale fruit market	Fruits that are sold in the wholesale market
Kawran Bazar	Mango, jackfruit, jujube, papaya, guava, black berry, pineapple, banana, litchi, lemon, custard apple, wood apple, elephant apple, golden apple, Indian berry, black berry, tamarind, melon, watermelon, cashew nut, pomegranate, plum, rose apple, Indian olive, Indian jujube, star apple, wild date palm
Zatrabari	Mango, jackfruit, jujube, papaya, guava, black berry, pineapple, banana, litchi, lemon, elephant apple, golden apple, tamarind, melon, watermelon, cashew nut, pomegranate, plum, rose apple, Indian olive, Indian jujube
Mazar Road Mirpur-1	Mango, jackfruit, jujube, papaya, guava, black berry, pineapple, banana, litchi, lemon, custard apple, wood apple, elephant apple, golden apple, tamarind, melon, watermelon

Papaya and jujube were collected from different division in Dhaka wholesale market (Figure 1 and 2). In case of papaya the highest percentage (32.33%) was collected from Dhaka division followed by Rajshahi division (28.86%). For jujube the highest percentage (37.22%) was collected from Dhaka division followed by Chittagong division (19.45%).

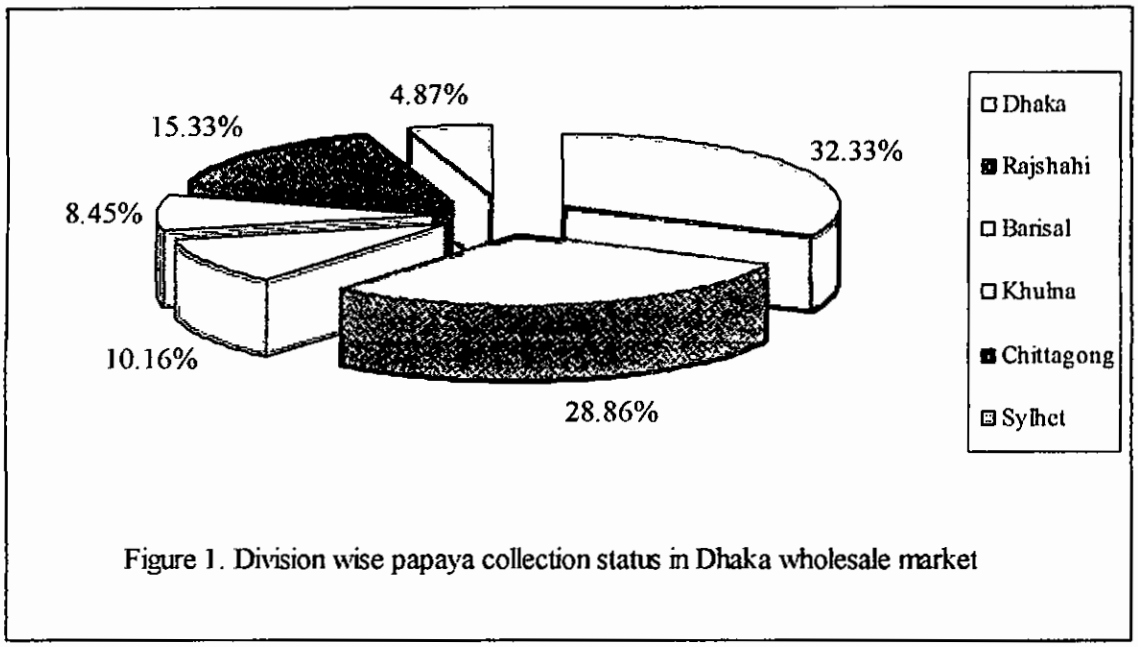

Figure 1. Division wise papaya collection status in Dhaka wholesale market

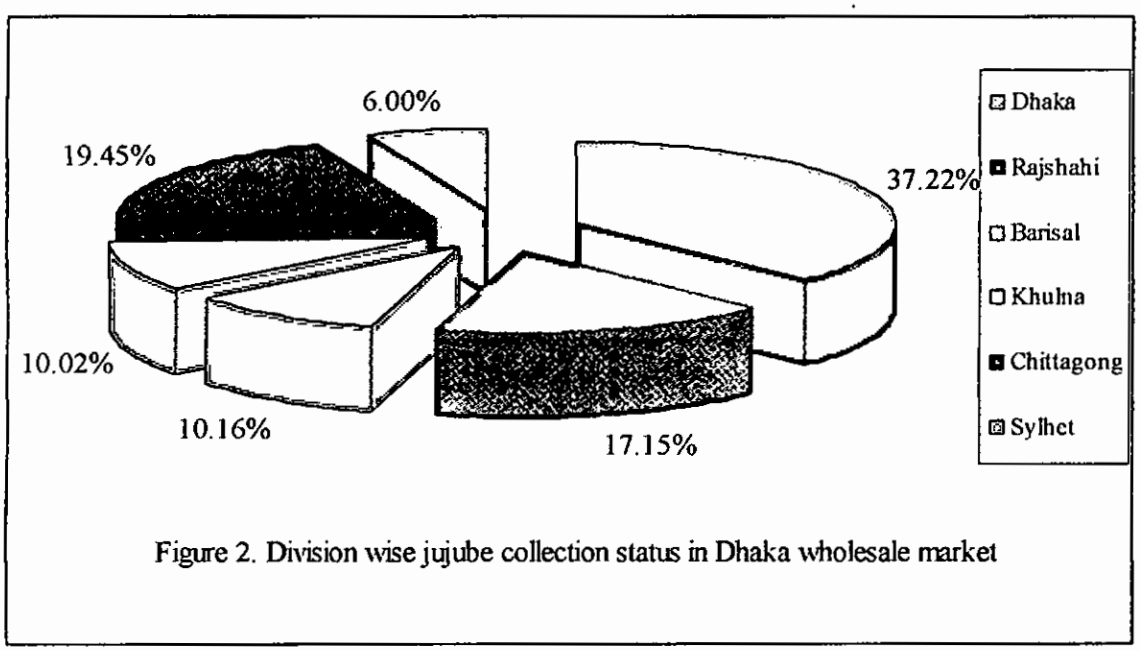

Figure 2. Division wise jujube collection status in Dhaka wholesale market

The point of origin i.e. the origin of papaya and jujube fruits according to the respondents was presented in Table 2.

Table 2. Point of origin of different fruits that the respondents transported in different market

Fruits	Point of origin
Papaya	Mymensingh, Gazipur, Norshingdi, Munshigong, Commilla, Chuddagram, Feni, Chittagong, Faridpur, Jessore, Kusthia, Jenidah, Magura, Rajshahi and Bogra
Jujube	Mymensingh, Gazipur, Norshingdi, Commilla, Chuddagram, Feni, Chittagong, Faridpur, Jessore, Kusthia, Jenidah, Magura, Barisal, Manikgonj, Rajshahi, Bogra, Rangpur and Dinajpur

According to the response of the respondents on frequency of fruit collection, average time required for transportation, mode of transportation, average weight for every truck, average buying price per kg, average sales price per kg, average parentage of fruit loss and main causes of fruit loss presented in Table 3.

Table 3. Data represents the type of fruits that the respondents sale in different market

Fruits	Papaya	Jujube
Frequency of fruit collection	4 days/week	2 days/week
Average time required for transportation	5.5 hours	5.5 hours
Mode of transportation	Truck/trolley	Truck/trolley
Average weight for every truck	5 ton	5 ton
Average buying price per kg	15 Taka	35 Taka
Average sales price per kg	45 Taka	75 Taka
Average parentage of fruit loss	25%	11%
Main causes of fruit loss	Rotten	Rotten

4.2 Experiment-II: Identification of post harvest disease and causal organism of papaya and jujube

Disease incidences and severity were assessed for the month of November, 2009 to March, 2010 for papaya and January to March, 2010 for jujube as percentage of fruits infected with at least one spot or visible symptoms. Assessment of incidence and severity of the diseases of each fruit species presented below:

4.2.1 Identification of the pathogen isolated from papaya and their incidence and severity

From the month of November, 2009 to March, 2010 total 50 fruits were observed for every month and identified the following diseases and their causal organisms:

A. Anthracnose of papaya

B. Soft rot of Papaya

C. Fruit rot of papaya

D. Stem end rot of Papaya

E. Aspergillus rot of papaya

4.2.1.1 Identification of pathogen isolated from Papaya

A. Anthracnose of papaya

The disease developed as the spots on fruits first appear as brown superficial discolouration of the skin which develops into circular, slightly sunken areas. Gradually the lesions coalesce and sparse mycelial growth appears on the margins of the spots (Plate 2 A). Pathogen isolated from the fruits was identifical as *Colletotrichum gloeosporioides*. *C. gloeosporioides* produced Acervula and conidia were hyaline, unicellular and cylindrical. They formed on faintly brown conidiophores in acervuli (Plate 2 B).

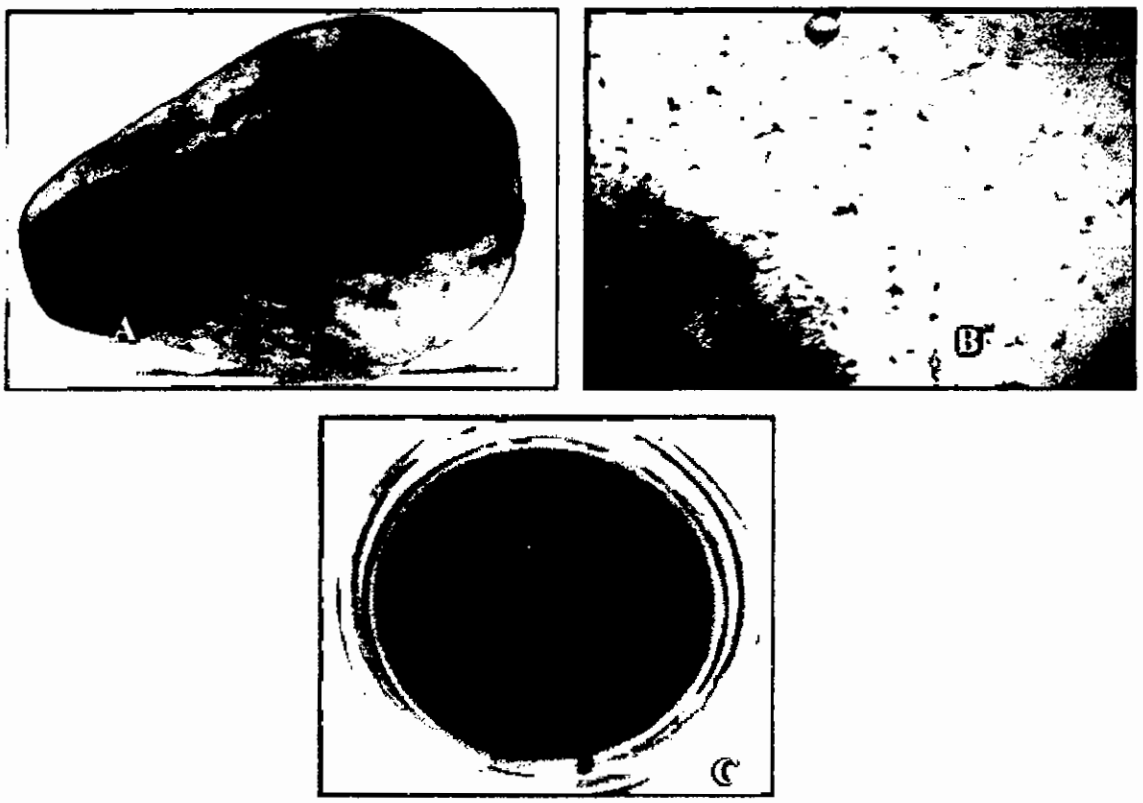

Plate 2. A. Anthracnose disease symptoms on fruits, B. Acervulus and conidia of *C. gloeosporioides* under microscope (40X) studied with cotton blue and C. Pure culture of the pathogen isolated from fruit sample

B. Soft rot of Papaya

Rhizopus soft rot of papaya was characterized by a soft and watery rot that quickly collapses the entire fruit, leaving the cuticle intact. The fungus can grow out through any break in the cuticle and spread rapidly to adjacent fruits. The infected fruit is often covered by coarse, gray, hairy mycelia that form a mass of black sporangia at their tips (Plate 3 A). Pathogen isolated from the fruits was identifical as *Rhizopus stolonifer*. Sporangium, sporangiophores and sporangiospores wre found. Sporangisporum were unicellular, round and brown in color (Plate 3 B and C).

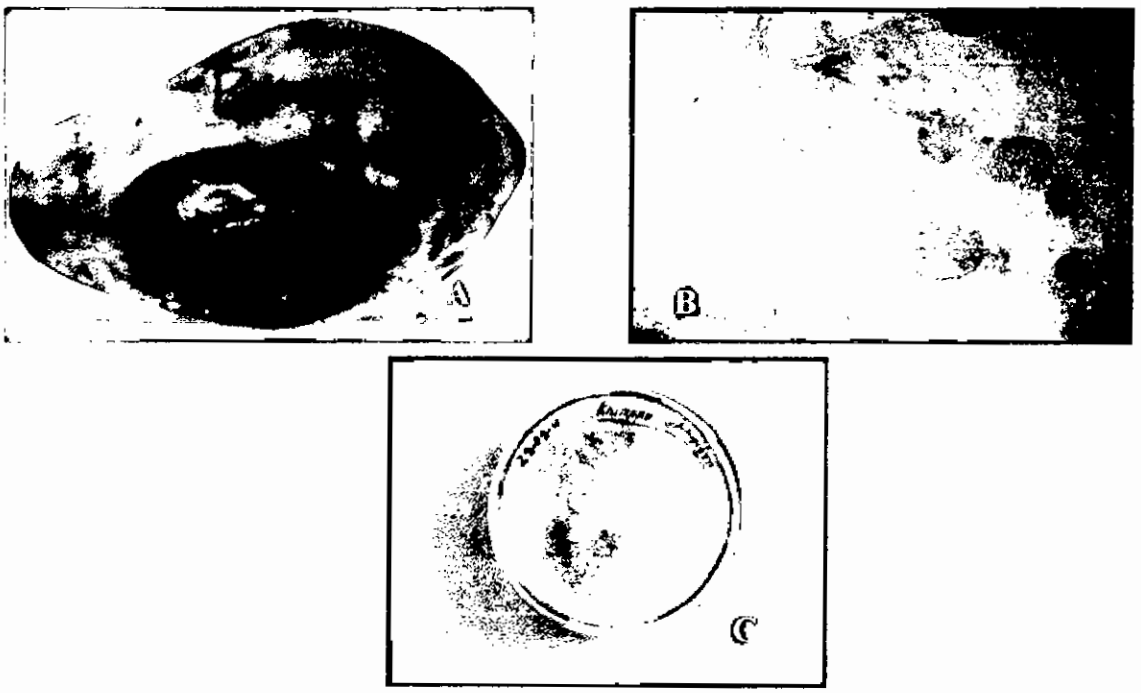

Plate 3. A. *Rhizopus* disease symptoms on fruits and B. Sporangiophore, sporangium, sporangiosporus of *Rhizopus* under microscope C. Pure culture of the pathogen isolated from fruit sample

C. Fusarium rot of papaya

The spots on fruits first appear as superficial blackish of the skin which develop into circular to semi-circular patches covered with mycelium and conidiophores, slightly sunken areas. Gradually the lesions coalesce and sparse mycelial growth appears on the margins of the spots (Plate 4 A). Pathogen isolated from the fruits was identified as *Fusarium solani* (Plate 4 B).

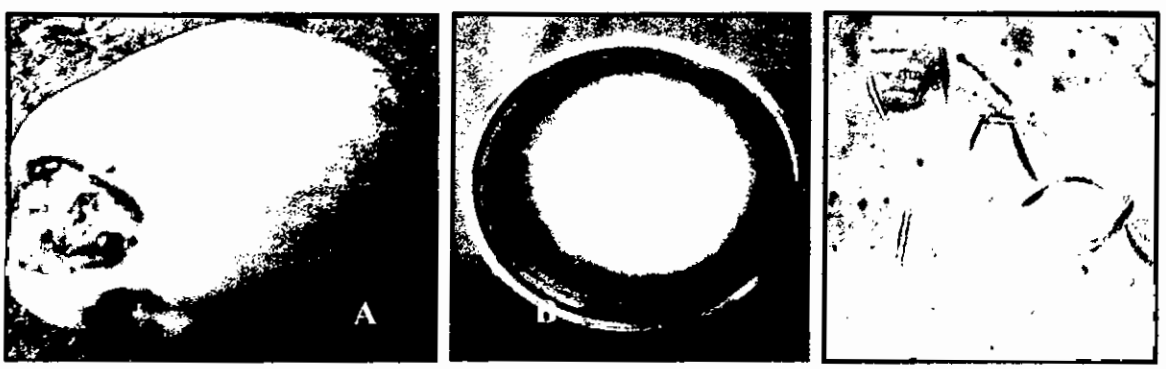

Plate 4. A. Fusarium rot disease symptoms on fruits and B. Pure culture of *Fusarium solani* on PDA C. Pure culture of the pathogen isolated from fruit sample

D. Stem end rot of Papaya

It incites a stem end rot and a surface fruit rot. It induced a wider and softer water-soaked margin and greater internal discolouration. Sporulating lesions of *B.theobromae* are black and have a rough surface caused by the erumpent, confluent arrangement of pycnidia. The rot begins as dark green, water-soaked spots. Later, the affected portion becomes shriveled and turned dark brown (Plate 5 A). Numerous pycnidia of the pathogen appeared on the diseased portion (5 B). Pathogen isolated from the fruits as *Botryodiplodia theobromae* (Plate 5 C).

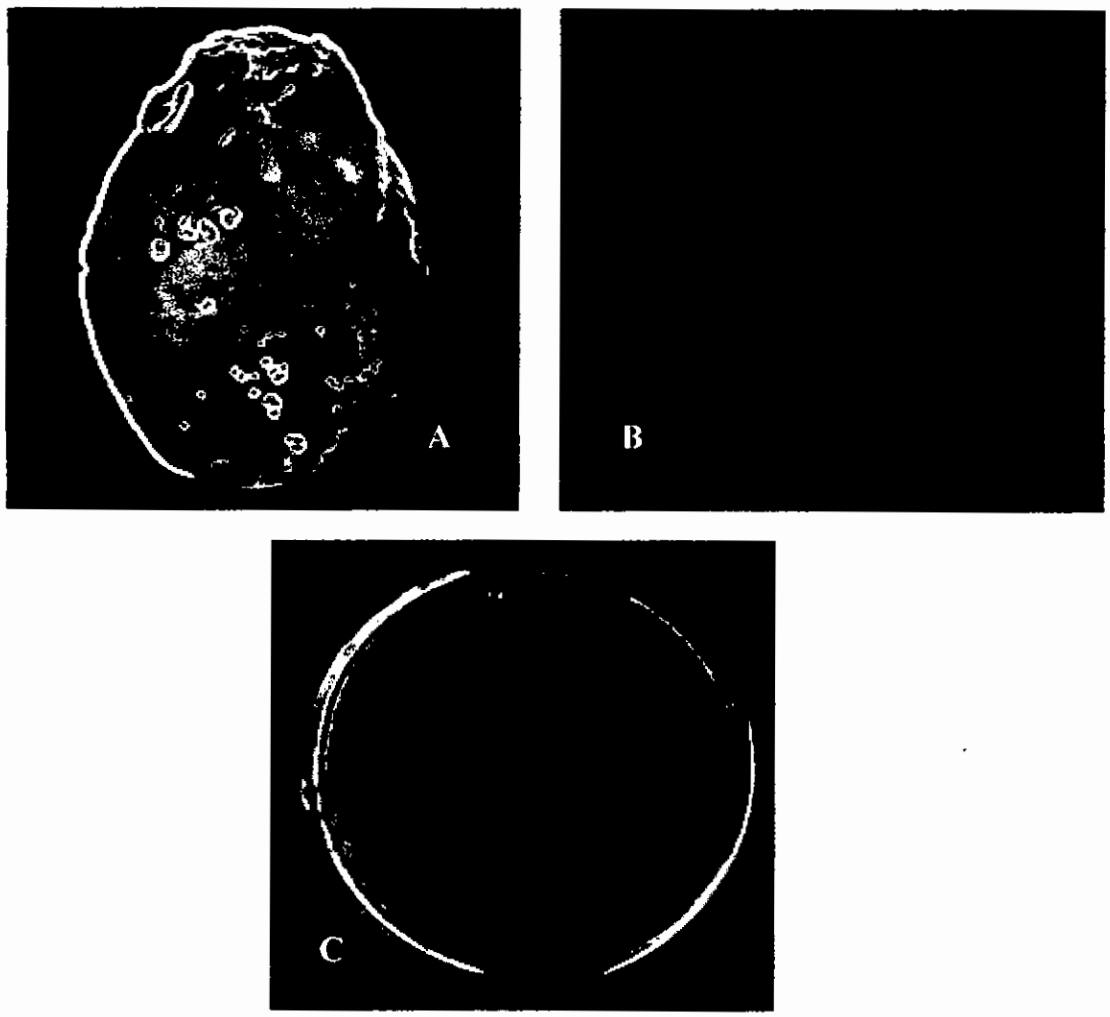

Plate 5. A. Stem end rot disease symptoms on fruits, B. Conidia under microscope and C. Pure culture of the *Botryodiplodia theobromae* isolated from fruit sample

E. Aspergillus rot of papaya

It usually induces a wider and softer water-soaked margin and greater internal discolouration. The disease development is more rapid on ripe and half ripe fruits. The rot begins as dark green, water-soaked and powdery spots. Later, the affected portion becomes shriveled and turns dark brown (Plate 6 A). Pathogen isolated from the fruits as *Aspergillus sp* (Plate 6 B and 6 C).

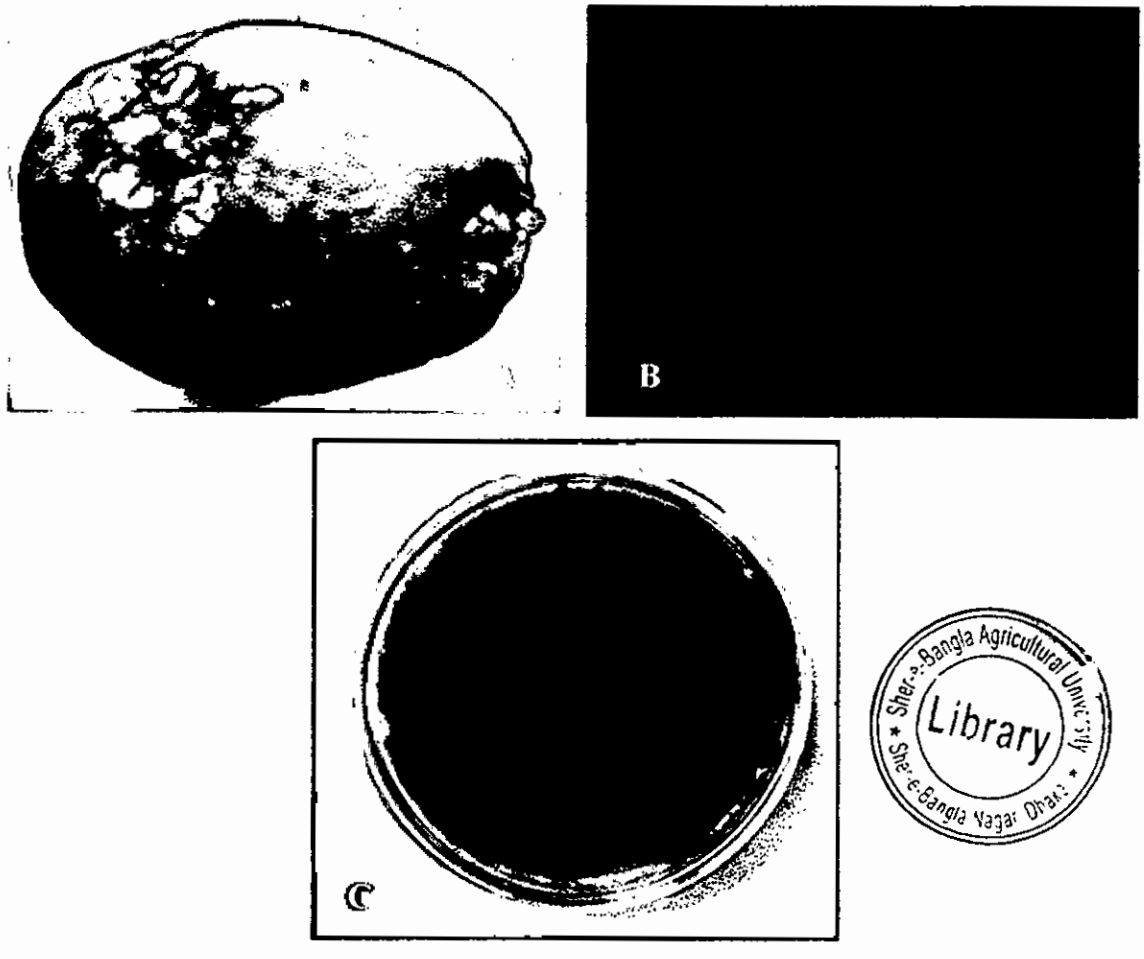

Plate 6. A. *Aspergillus* rot disease symptoms on fruits, B. Conidiophores and conidia of *Aspergillus* sp. under microscope (10X) and C. Pure culture of *Aspergillus* sp. on PDA

4.2.1.2 Incidence of papaya diseases

The incidence of post harvest diseases of papaya viz., anthracnose, soft rot, fruit rot, stem end rot and aspergillus rot disease of papaya showed significant differences in different month starting from November, 2009 to March, 2010 (Table 4). In case of anthracnose, the highest incidence (22%) was recorded in the month of March, 2010 followed by the month of February, 2010 (15%) whereas the lowest incidence (10%) was recorded in the month of November, 2009 followed by December, 2009 (12%) and same for January, 2010. In case of soft rot the highest incidence (25%) was recorded in the month of March, 2010 followed by the month of February, 2010 (20%) whereas the lowest incidence (15%) was recorded in the month of November, 2009 followed by December, 2009 (18%) and same for January, 2010. Considering fruit rot, the highest incidence (20%) was recorded in the month of March, 2010 followed by the month of February, 2010 (15%) whereas the lowest incidence (12%) was recorded in the month of November, 2009 which was identical with December, 2009 and same. In case of stem end rot the highest incidence (15%) was recorded in the month of March, 2010 followed by the month of February, 2010 (12%) while the lowest incidence (8%) was recorded in the month of November, 2009 followed by December, 2009 (9%) and January, 2010 (9%). For Aspergillus rot the highest incidence (10%) was recorded in the month of March, 2010 followed by the month of February, 2010 (8%) whereas the lowest incidence (5%) was recorded in the month of November, which was statistically identical with December, 2009 (5%) and same. Month wise average disease incidence is presented in Figure 3.

Table 4. Month wise incidence of post harvest diseases of papaya

Month	Disease incidence (%) for different pathogen of papaya				
	Anthracnose of papaya	Soft rot of Papaya	Fruit rot of papaya	Stem end rot of Papaya	Aspergillus rot of papaya
November, 2009	10 d	15 d	12 d	8 e	5 d
December, 2009	12 c	18 c	12 d	9 d	5 d
January, 2010	12 c	18 c	13 c	10 c	6 c
February, 2010	15 b	20 b	15 b	12 b	8 b
March, 2010	22 a	25 a	20 a	15 a	10 a
$LSD_{(0.05)}$	1.391	0.917	0.871	0.693	0.871
Significance level	0.01	0.01	0.01	0.01	0.05
CV(%)	8.73	12.76	7.33	9.11	10.05

4.2.1.3 Severity of papaya diseases

Disease severity of post harvest diseases of papaya (anthracnose, soft rot, fruit rot, stem end rot and aspergillus rot disease of papaya showed significant differences at different months starting from November, 2009 to March, 2010 (Table 5). In case of anthracnose, the highest severity (30%) was recorded in the month of March, 2010 followed by the month of February, 2010 (20%) whereas the lowest severity (15%) was recorded in the month of November, 2009 which was identical with December, 2009 (17%) and same for January, 2010. For soft rot the highest severity (32%) was recorded in the month of March, 2010 followed by the month of February, 2010 (25%) whereas the lowest severity (20%) was recorded in the month of November, 2009 followed by December, 2009 (22%) and same for January, 2010. Considering fruit rot, the highest severity (23%) was recorded in the month of March, 2010 followed by the month of February, 2010 (17%) and the lowest severity (14%) was recorded in the month of November, 2009 and the lowest severity also recorded in the month of December, 2009 and January, 2010. In case of stem end rot the highest severity (18%) was recorded in the month of March, 2010 followed by the month of February, 2010 (15%) while the lowest severity (11%) was recorded in the month of November, 2009 followed by December, 2009 (12%) and same for January, 2010. For Aspergillus rot the highest severity (15%) was recorded in the month of March, 2010 followed by the month of February, 2010 (10%) whereas the lowest severity (6%) was recorded in the month of November, which was identical with December, 2009 (7%). Month wise average disease severity is presented in Figure 4.

Table 5. Month wise post harvest disease severity of papaya

Month	Disease severity (%) for different pathogen of papaya				
	Anthracnose of papaya	Soft rot of Papaya	Fruit rot of papaya	Stem end rot of Papaya	Aspergillus rot of papaya
November, 2009	15 c	20 d	14 c	11 d	6 e
December, 2009	17 c	22 c	14 c	12 c	7 d
January, 2010	17 c	22 c	14 c	12 c	8 c
February, 2010	20 b	25 b	17 b	15 b	10 b
March, 2010	30 a	32 a	23 a	18 a	15 a
$LSD_{(0.05)}$	2.032	1.893	2.145	0.791	0.843
Significance level	0.05	0.01	0.01	0.01	0.01
CV(%)	13.34	7.89	9.33	5.66	8.55

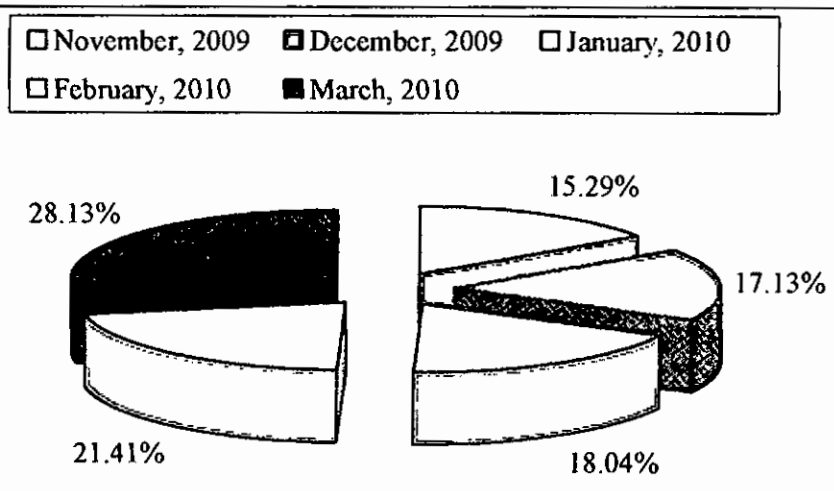

Figure 3. Month wise average post harvest disease incidence of papaya as per identified pathogens

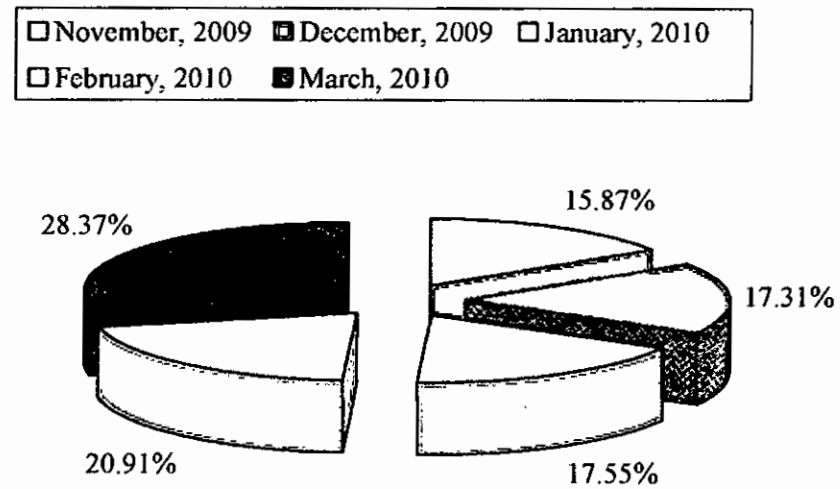

Figure 4. Month wise average post harvest disease severity of papaya as per identified pathogens

4.2.2 Identification of the pathogen isolated from Jujube and their incidence and severity

From the month of January to March, 2010 total 50 fruits were observed in each month and identified the following diseases after isolation of causal organism from the infected fruits:

A. Phomopsis rot of Jujube

B. Stemphylium rot of Jujube

C. Rhizopus rot of Jujube

D. Anthracnose of Jujube

E. Alternaria Fruit rot

4.2.2.1 Identification of pathogen isolated from Jujube

A. Phomopsis rot of Jujube

The disease affected fruit develops a water-soaked spot which increases in size. The whole area becomes soft and pulpy. The rotten area turned dark brown and get depressed and cracks at later stage. Water-soaked lesion is seen in the area surrounding the diseased portion (Plate 7 A). All the stages of fruit are infected by the pathogen. Pathogen isolated from the fruits as *Phomopsis* spp (Plate 7 B and 7 C).

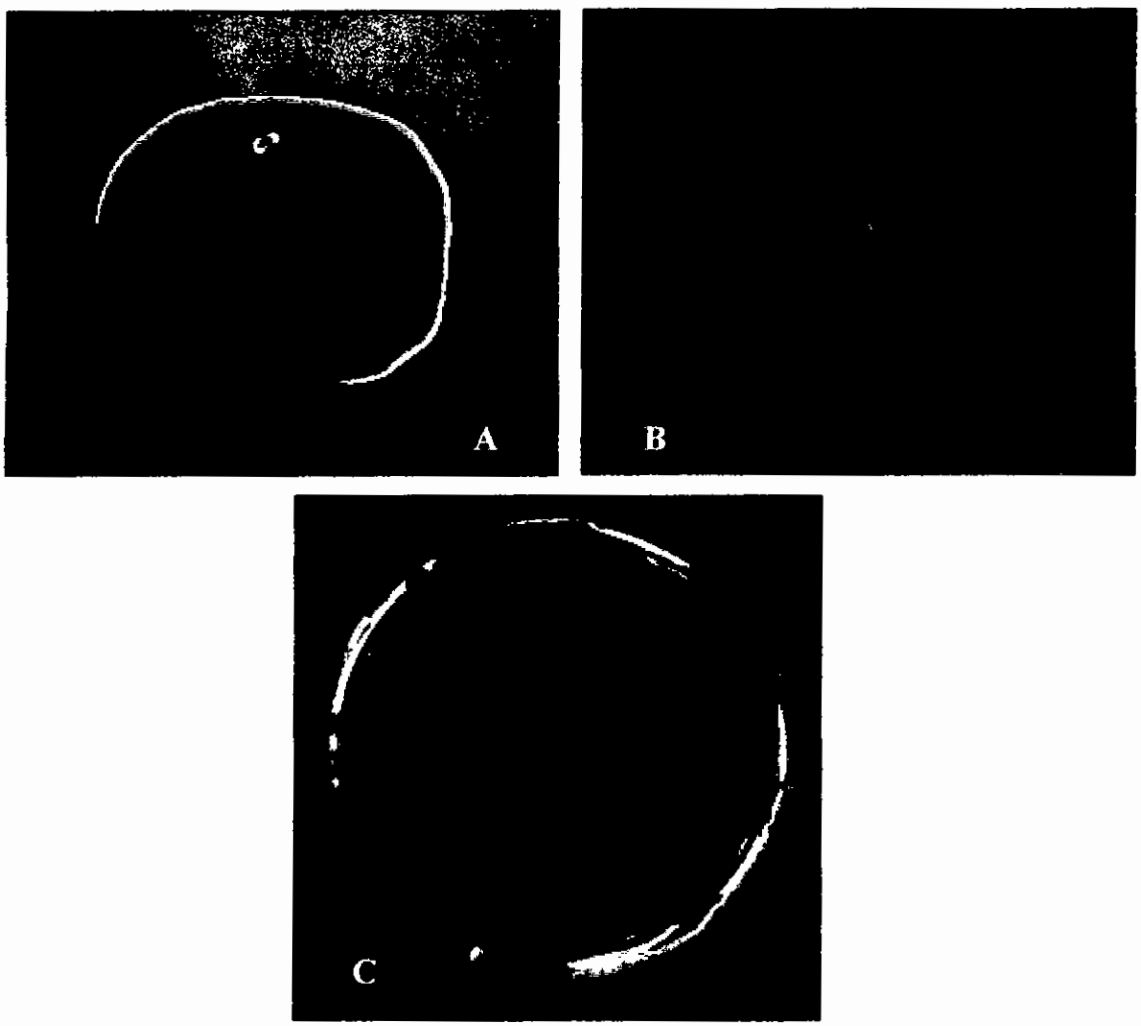

Plate 7. A. *Phomopsis* rot disease symptoms on fruits, B. Conidia under microscope and C. Pure culture of *Phomopsis* isolated from fruit sample

B. Stemphylium rot of Jujube

The disease is characterized by dark brown sunken lesions with distinct reddish brown margins (Plate 8 A and 8 B). Pathogen isolated from the fruits was identified as *Stemphylium lycopersici.*

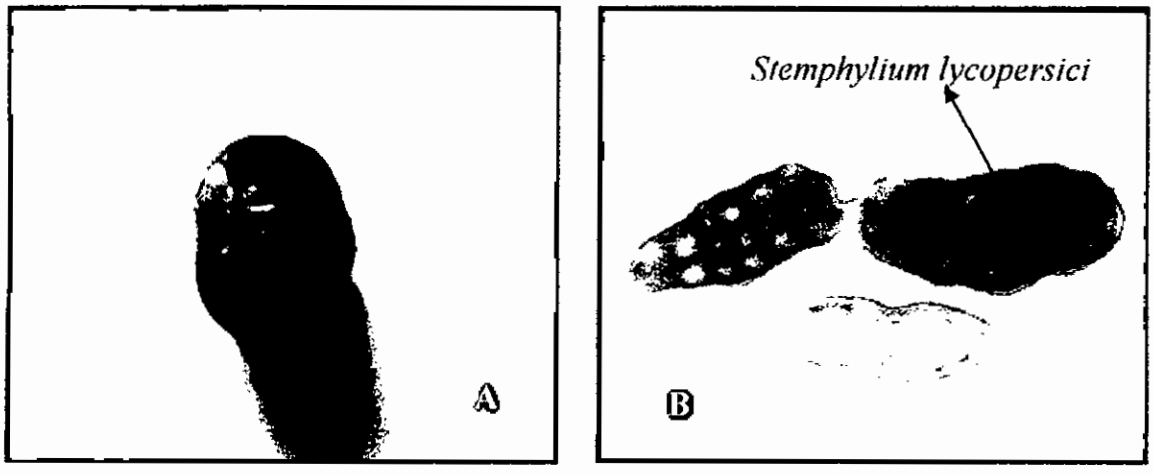

Plate 8. A. Stemphylium rot disease symptoms on fruits, B. Conidia under microscope

C. Rhizopus rot of Jujube

The disease is characterized by Irregular, water-soaked lesions which gradually enlarge and get covered by white and dark brown fungal growth and sporangiophores. The fruits become watery and emit a foul odour. Invasion occurs through wounds. Pathogen isolated from the fruits as *Rhizopus stolonifer* (Plate 9 A, 9 B and 9 C).

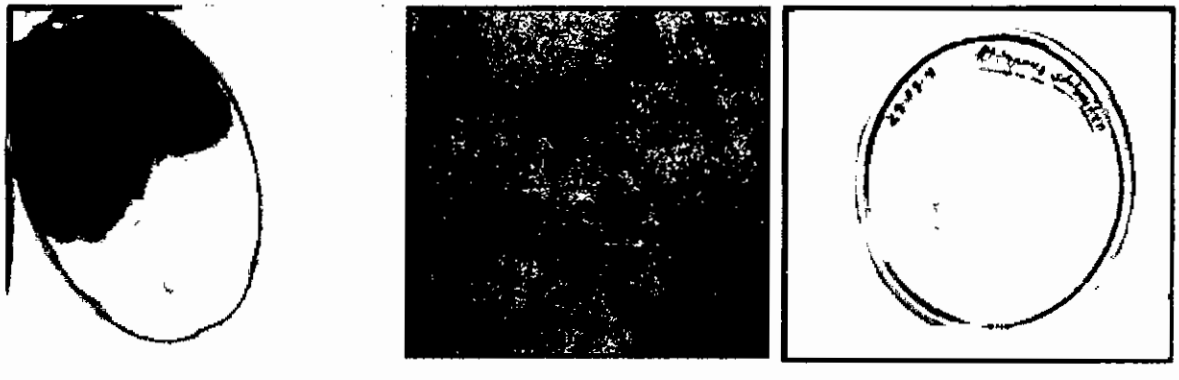

Plate 9. A. Rhizopus rot disease symptoms on fruits, B. Conidia under microscope C. Pure culture of *Rhizopus stolonifer* isolated from fruit sample

D. Anthracnose of Jujube

The anthracnose infected spots on fruits first appear as brown superficial discolouration of the skin which develops into circular, slightly sunken areas and 1 to 3 cm in diameter. Gradually the lesions coalesce and sparse mycelial growth appears on the margins of the spots (Plate 10 A). Under humid conditions, encrustations of salmon pink spores are released. Pathogen isolated from the fruits as *Gloeosporium spp.* Conidia was hyaline, unicellular and cylindrical (Plate 10 B). They formed on faintly brown conidiophores in acervuli (Plate 10 C).

Plate 10. A. *Anthracnose* symptoms on fruits, B. Conidia under microscope and C. Pure culture of the *Anthracnose* isolated from fruit sample

E. Alternaria Fruit rot

It is characterized by grey-brown, circular to semi-circular patches covered with mycelium and conidiophores (Plate 11 A). Pathogen isolated from the fruits was *Alternaria alternata.*

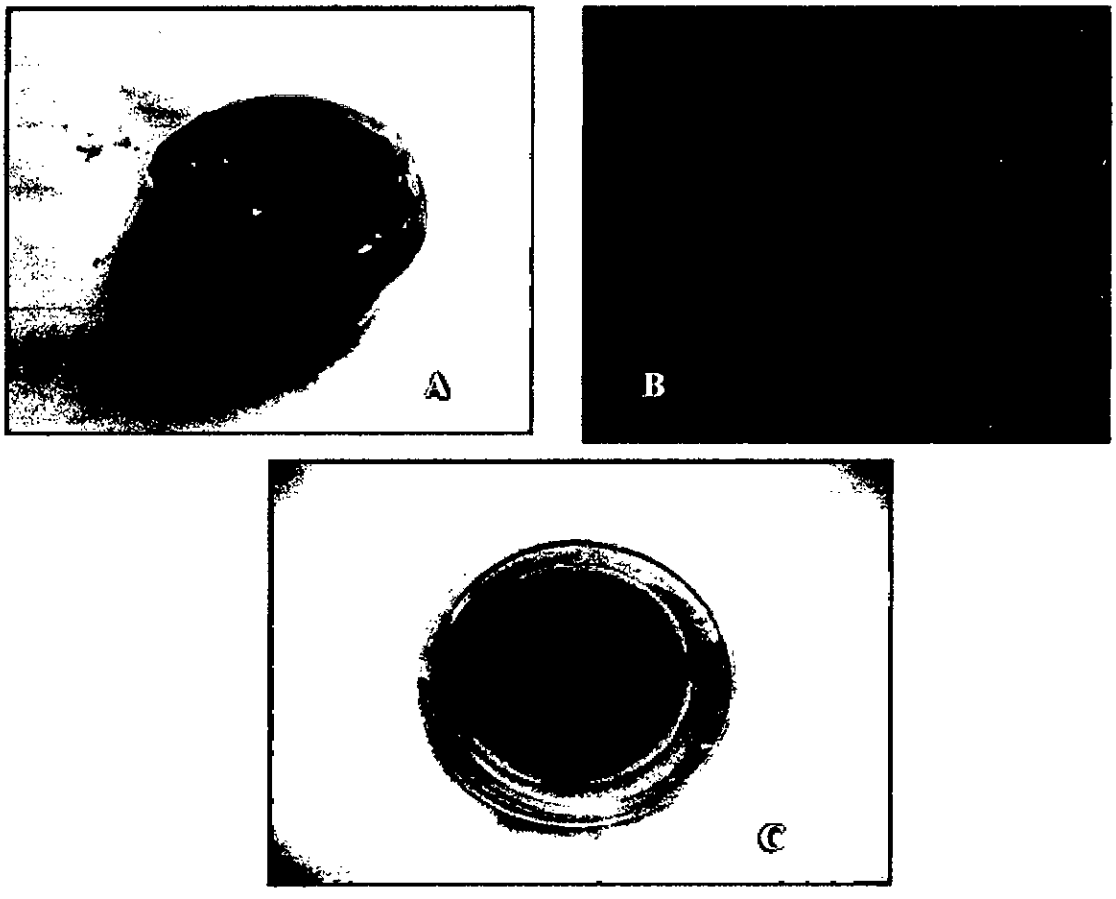

Plate 11. A. Alternaria fruit rot disease symptoms on fruits, B. Conidia under microscope and C. Pure culture of the pathogen isolated from fruit sample

4.2.2.2 Incidence of Jujube diseases

Phomopsis rot, Stemphylium rot, Rhizopus rot, Anthracnose Alternaria fruit rot disease of jujube showed significant differences for different month starting from January to March, 2010 (Table 6). In case of Phomopsis, the highest incidence (15%) was recorded in the month of March, 2010 followed by the month of February, 2010 (10%) whereas the lowest incidence (8%) was recorded for the month of January, 2010. Considering Stemphylium, the highest incidence (10%) was recorded in the month of March, 2010 followed by the month of February, 2010 (8%) while the lowest incidence (6%) was recorded for the month of January, 2010. For Rhizopus rot the highest incidence (12%) was recorded in the month of March, 2010 followed by the month of February, 2010 (8%) whereas the lowest incidence (5%) was recorded for the month of January, 2010. In case of jujube Anthracnose the highest incidence (10%) was recorded in the month of March, 2010 whereas the lowest incidence (2%) was recorded for the month of January, 2010 which was identical with the month of February, 2010 (3%). For Alternaria fruit rot the highest incidence (20%) was recorded in the month of March, 2010 followed by the month of February, 2010 (15%) whereas the lowest incidence (10%) was recorded for the month of January, 2010. Month wise average disease incidence is presented in Figure 5.

Table 6. Month wise incidence of post harvest diseases of jujube as per identified pathogen

Month	Disease incidence (%) for different pathogen of Jujube				
	Phomopsis rot of Jujube	Stemphylium rot of Jujube	Rhizopus rot of Jujube	Anthracnose of Jujube	Alternaria Fruit rot
January, 2010	8 c	6 c	5 c	2 b	10 c
February, 2010	10 b	8 b	8 b	3 b	15 b
March, 2010	15 a	10 a	12 a	10 a	20 a
$LSD_{(0.05)}$	1.876	0.915	1.056	1.021	1.631
Significance level	0.05	0.01	0.01	0.01	0.01
CV(%)	8.29	14.22	5.79	9.11	13.02

4.2.2.3 Severity of jujube diseases

Phomopsis rot, Stemphylium rot, Rhizopus rot, Anthracnose Alternaria fruit rot disease of jujube showed significant differences from January to March, 2010 (Table 7). In case of Phomopsis, the highest severity (20%) was recorded in the month of March, 2010 followed by the month of February, 2010 (7%) while the lowest severity (5%) for the month of January, 2010. Considering Stemphylium, the highest severity (12%) was recorded in the month of March, 2010 followed by the month of February, 2010 (8%) while the lowest severity (5%) was recorded for the month of January, 2010. For Rhizopus rot the highest severity (15%) was recorded in the month of March, 2010 followed by the month of February, 2010 (8%) whereas the lowest severity (6%) was recorded for the month of January, 2010. In case of Anthracnose the highest severity (8%) was recorded in the month of March, 2010 whereas the lowest severity (3%) was recorded for the month of January, 2010 which was identical with the month of February, 2010 (5%). For Alternaria fruit rot the highest severity (30%) was recorded in the month of March, 2010 followed by the month of February, 2010 (20%) whereas the lowest severity (7%) for the month of January, 2010.Month wise average disease severity is presented in Figure 6.

Table 7. Month wise post harvest disease severity of jujube as per identified pathogen

Month	Disease severity (%) for different pathogen of Jujube				
	Phomopsis rot of Jujube	Stemphylium rot of Jujube	Rhizopus rot of Jujube	Anthracnose of Jujube	Alternaria Fruit rot
January, 2010	5 c	5 c	6 c	3 c	7 c
February, 2010	7 b	8 b	8 b	5 b	20 b
March, 2010	20 a	12 a	15 a	8 a	30 a
$LSD_{(0.05)}$	1.790	0.893	1.291	1.563	3.781
Significance level	0.01	0.01	0.01	0.05	0.01
CV(%)	10.34	6.77	9.05	12.98	7.22

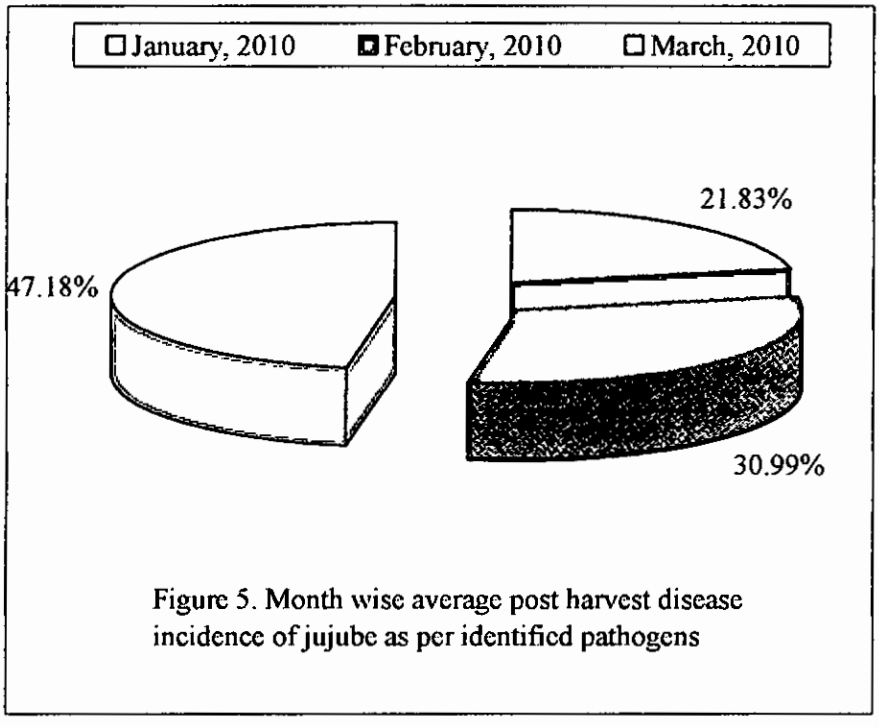

Figure 5. Month wise average post harvest disease incidence of jujube as per identified pathogens

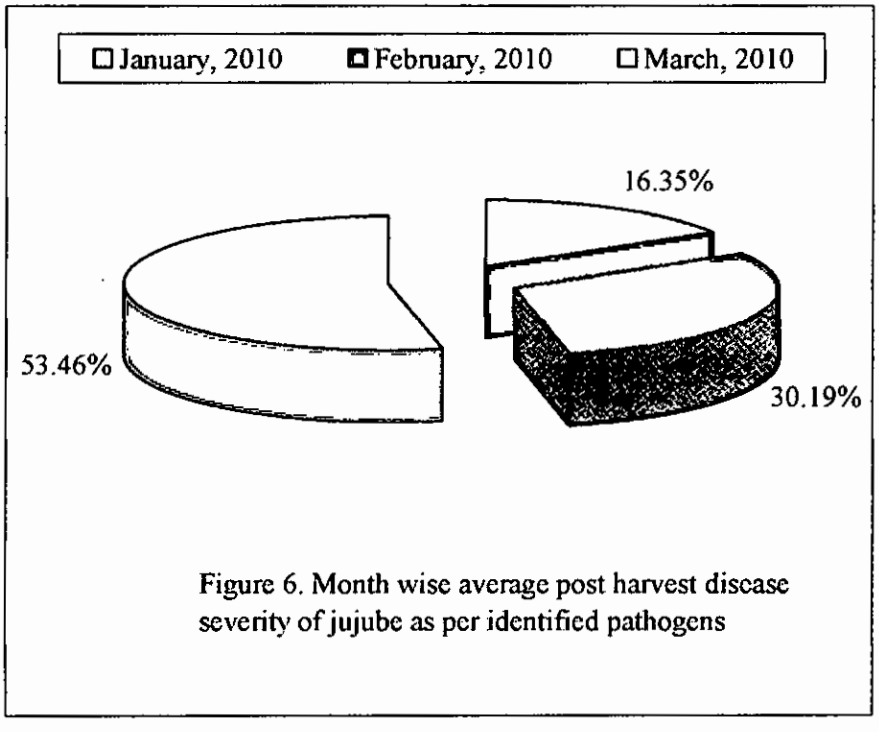

Figure 6. Month wise average post harvest disease severity of jujube as per identified pathogens

4.3 Experiment-III: Evaluation of inoculation methods

In laboratory condition fruit infestation status for papaya was recorded by infected tissue using block, scrap and normal collected fruits after 5 days. In case of tissue infection it was found that 100% fruit were infected by *Anthracnose*, *Rhizopus*, *Fusarium*, *Stemphylium* and *Aspergillus* pathogen (Table 8). In case of tissue inoculation by using block significant variation was recorded for different pathogen. The highest infected tissue (30%) was recorded for *Anthracnose* which was followed by *Rhizopus* rot (23%) and then fruit rot (18%). On the other hand, the lowest infected tissue was observed for *Aspergillus* rot (5%) which was followed by *Stemphylium* rot (12%). For tissue infection using scrap significant variation was recorded for different pathogens. The highest infected tissue (35%) was recorded for *Anthracnose* which was followed by *Rhizopus* (30%) and then *Fusarium* (25%) and *Stemphylium* (22%), while the lowest for *Aspergillus* (6%).

In case of control condition it was found that 33% fruit were infected by *Anthracnose*, *Rhizopus*, *Fusarium*, *Stemphylium* and no infestation was recorded for *Aspergillus* pathogen (Table 8). In case of tissue infection in control condition was recorded for different pathogen and the highest infected tissue (15%) was recorded for *Anthracnose* which was followed by *Rhizopus* (12%), then *Fusarium* (10%) and *Stemphylium* (8%), whereas no infection was observed for *Aspergillus*.

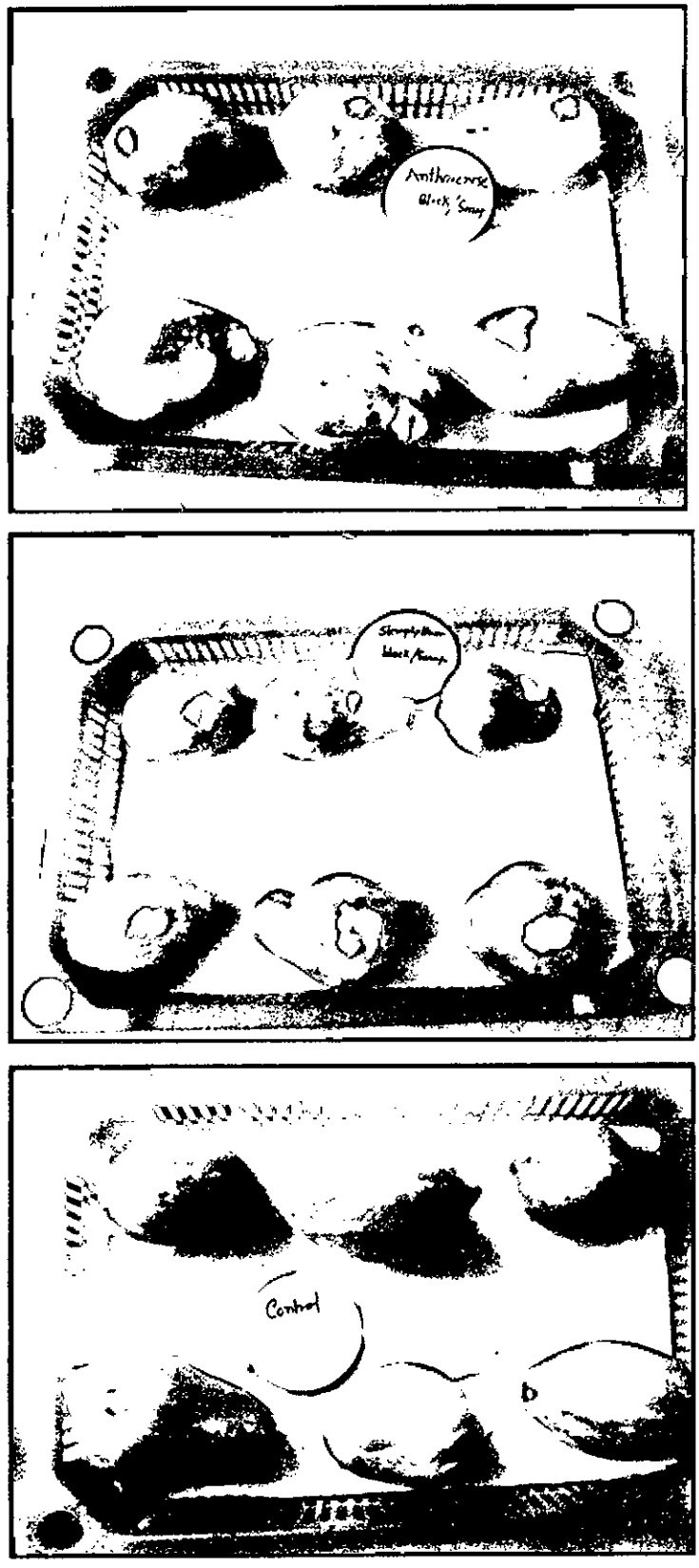

Plate 12. Photograph showing inoculated papaya by using block and scrap of mycelia

Table 8. Infestation status of different pathogen in different condition in papaya fruit under laboratory condition

Diseases	Inoculated			Control	
	Infected fruit (%)	Block	Scrap	Infected fruit (%)	Tissue infected (%)
Anthracnose	100	30 a	35 a	33 a	15 a
Rhizopus rot	100	23 b	30 b	33 a	12 b
Fusarium rot	100	18 c	25 c	33 a	10 c
Stemphylium rot	100	12 d	22 d	33 a	8 d
Aspergillus rot	100	5 e	6 e	0 b	0 e
$LSD_{(0.05)}$	--	3.023	2.098	4.541	1.267
Level of Significance	NS	0.01	0.01	0.01	0.01
CV(%)	--	14.23	7.56	18.78	12.12

In laboratory condition fruit infestation status for jujube was recorded by infected tissue using block, scrap and normal collected fruits after 5 days. In case of tissue infection significant variation was recorded for different pathogen (Table 9). The highest infected fruit was recorded for *Phomopsis* (90%) followed by *Alternaria* (80%), *Rhizopus* (50%) and *Anthracnose* (50%), whereas the lowest was recorded for *Stemphylium* (30%). In case of tissue infection using block, significant variation was recorded for different pathogen. The highest infected fruit was recorded for *Alternaria* (32%) which was followed by *Phomopsis* (17%), Anthracnose (17%) and *Stemphylium* (15%), while the lowest was recorded for *Rhizopus* (10%). In case of tissue infection using scrap, significant variation was recorded for different pathogen. The highest infected fruit was found for *Alternaria* (37%) which was followed by Anthracnose (33%), *Phomopsis* (31%), and *Stemphylium* (22%), while the lowest was recorded for *Rhizopus* (15%).

Plate 13. Photograph showing inoculated papaya by using block and scrap of mycelia

In case of control condition no infected fruit and no infected tissues were observed for *Phomopsis*, *Stemphylium*, *Rhizopus*, *Anthracnose* and *Alternaria* pathogen (Table 9).

Table 9. Infestation status of different pathogen in different condition in jujube fruit under laboratory condition

Pathogen	Inoculated			Control	
	Infected fruit (%)	Block	Scrap	Infected fruit (%)	Tissue infected (%)
Phomopsis	90 a	17 b	31 b	0	0
Stemphylium rot	30 d	15 b	22 c	0	0
Rhizopus rot	50 c	10 c	15 d	0	0
Anthracnose rot	50 c	17 b	33 b	0	0
Alternaria rot	80 b	32 a	37 a	0	0
$LSD_{(0.05)}$	8.913	2.542	3.762	--	--
Level of Significance	0.01	0.01	0.01	NS	NS
CV(%)	7.98	12.11	14.09	--	--

CHAPTER V

DISCUSSION

The present experiment was conducted to find out the status of post harvest diseases of papaya and jujube fruits in Dhaka city. Consequently three experiments were conducted for identification of post harvest disease, causal organism and isolation of causal organism from diseased of papaya and jujube and determination of infection status under laboratory condition.

The survey was conducted in the wholesale market of Dhaka in the area of Kawran Bazar, Zatrabari and Mazar Road Mirpur-1 the most important wholesale fruit market of Dhaka. Papaya was available for the year round and jujube was available during winter season and in some extent imported jujube was available other than winter season. Papaya and jujube were collected from different division in Dhaka wholesale market. In case of papaya the highest percentage (32.33%) was collected from Dhaka division followed by Rajshahi division (28.86%). For jujube the highest percentage (37.22%) was collected from Dhaka division followed by Chittagong division (19.45%).

Incidence and severity of post harvest diseases were assessed in the month of November, 2009 to March, 2010 and on the basis of physical symptoms and isolated pathogen the following diseases were identified in case of papaya *Anthracnose*, *Rhizophus*, fruit rot, *Stemphylium* and *Aspergillus* rot. Diseases of fruit species have been reported by many workers throughout the world. Baiyewu

et al. (2007) reported that the most commonly fungi found in rotten papaya fruits were: *Rhizopus nigricans*, *Curvularia lunata*, *Aspergillus niger*, *Fusarium moniliforme*, *Colleto-trichum capsici* and *Trichoderma viride*. *Rhizopus nigricans*, *F. moniliforme*, *A. flavus* and *A. niger* had the highest rate of occurrence among the isolated fungi while *C. lunata* was the least encountered. Pramod *et al.* (2007) reported twelve fungal species (*Colletotrichum gloeosporioides* [*Glomerella cingulata*], *Rhizopus stolonifer*, *Botryodiplodia theobromae*, *Phoma caricae-papayae*, *Fusarium moniliforme*, *F. solani*, *Alternaria alternata*, *Geotrichum candidum*, *Myrothecium roridum*, *Aspergillus niger*, *A. flavus* and *Sclerotium rolfsii* [*Corticium rolfsii*]) which were isolated from papaya fruits.

From the month of January to March, 2010 total 50 jujube fruits were observed for every month observation and identified the pathogens from infected fruit. The following diseases were identified as per physical symptom: *Phomopsis* rot, *Stemphylium*, *Anthracnose*, *Rhizophus* rot and *Alternaria* rot. In the month of January, the highest incidence and severity (10% and 7%) was obtained for *Alternaria*, while the lowest incidence and severity (2% and 3%) was recorded for *Anthracnose*. In the month of February, the highest incidence and severity which was 15% and 20%, respectively was observed for *Alternaria*, again the lowest incidence and severity 3% and 5%, respectively was found for *Anthracnose*. In the month of March, the highest incidence and severity (20% and 30%) was found for *Alternaria*, whereas the lowest incidence and severity (10% and 8%) for *Anthracnose*.

In case of evaluation inoculation method it was observed that 100% papaya fruit were infected by *C. gloeosporioides*, *Rhizopus*, *Fusarium*, *Stemphylium* and *Aspergillus* pathogen. In case of tissue infection by using block the highest infected tissue (30%) was recorded for *Anthracnose* and the lowest infected tissue was observed for *Aspergillus* (5%) For tissue infection using scrap the highest infected tissue (35%) was recorded for *Anthracnose*, while the lowest for *Aspergillus* (6%). In case of control condition it was found that 33% fruit were infected by *Anthracnose*, *Rhizopus*, *Fusarium*, *Stemphylium* and no infestation was recorded for *Aspergillus* pathogen. In case of tissue infection in control condition was recorded for different pathogen and the highest infected tissue (15%) was recorded for *Anthracnose*, whereas no infestation was observed for *Aspergillus*. Gamagae *et al.* (2004) reported similar findings earlier.

In case of evaluation inoculation method it was observed that 100% jujube fruit were infected by *Phomopsis*, *Stemphylium*, *Rhizopus*, *Anthracnose* and *Alternaria*. In case of tissue infection by using block the highest infected fruit was recorded for *Phomopsis* (90%), whereas the lowest was recorded for *Stemphylium* (30%). In case of tissue infection using block, the highest infected fruit was recorded for *Alternaria* (32%), while the lowest was recorded for *Rhizopus* (10%). In case of tissue infection using scrap, the highest infected fruit was found for *Alternaria* (37%), while the lowest was recorded for *Rhizopus* (15%). In case of control condition no infected fruit and no infected tissues were observed for *Phomopsis*, *Stemphylium*, *Rhizopus*, *Anthracnose* and *Alternaria* pathogen. Echerenwa and

Umechuruba (2004) isolated from the tissues of diseased fruits like *Fusarium solani*, *Phoma caricae-papayae*, *Aspergillus flavus*, *Aspergillus niger*, *Botryodiplodia theobromae*, *Cladosporium herbarum*, *Colletotrichum dematium*, *Fusarium moniliforme* [*Gibberella moniliformis*], *Phomopsis caricae-papayae*, *Penicillium* sp., and *Rhizopus stolonifer*. Muniz *et al.* (2003) to identified the fungal pathogens on eight different fruit cultivars samples. They isolated *Acremonium* sp., *Fusarium anthophilum*, *F. semitectum* [*F. pallidoroseum*], *F. subglutinans* [*Gibberella fujikuroi* var. subglutinans] and *Stemphylium botryosum* [*Pleospora herbarum*] from tomato; *F. dimerum* [*Microdochium dimerum*] and *S. botryosum* from pepper; *F. anthophilum* from avocado; *Trichoderma viride* from orange; *F. lateritium* [*Gibberella baccata*] and *F. subglutinans* from lemon; *Curvularia eragrostidis* [*Cochliobolus eragrostidis*], *F. equiseti* and *F. semitectum* from passion fruit; and *Acremonium* sp., *F. anthophilum* and *F. equiseti* from papaya.

CHAPTER VI

SUMMARY AND CONCLUSION

The present experiment was conducted during the period from November, 2009 to March, 2010 to find out the status of post harvest diseases of papaya and jujube fruits in Dhaka city. Consequently two experiments were conducted for identification of post harvest disease, causal organism and isolation of causal organism from diseased of papaya and jujube.

Experiment-I: Study on prevalence of post harvest diseases of papaya and jujube fruits imported from different parts of the country in the wholesale market of Dhaka

Experiment-II: Identification of post harvest diseases of papaya and jujube and causal organisms

Experiment III: Evaluation of inoculation methods

The survey was conducted in the wholesale market of Dhaka in the area of Kawran Bazar, Zatrabari and Mazar Road Mirpur-1. Papaya and jujube were collected from different divisions in Dhaka wholesale markets. In case of papaya the highest percentage (32.33%) was collected from Dhaka division. For jujube the highest (37.22%) was collected from Dhaka division.

In case of anthracnose of papaya, the highest incidence (22%) was recorded in the month of March, 2010 whereas the lowest incidence (10%) was recorded for the month of November, 2009. For papaya soft rot the highest incidence (25%) was recorded in the month of March, 2010 whereas the lowest incidence (15%) was recorded for the month of November, 2009. Considering fruit rot of papaya, the

highest incidence (20%) was recorded in the month of March, 2010 whereas the lowest incidence (12%) was recorded for the month of November, 2009. In case of stem end rot of papaya the highest incidence (15%) was recorded in the month of March, 2010 while the lowest incidence (8%) was recorded for the month of November, 2009. For Aspergillus rot in papaya the highest incidence (10%) was recorded in the month of March, 2010 whereas the lowest incidence (5%) was recorded for the month of November.

In case of anthracnose of jujube, the highest severity (30%) was recorded in the month of March, 2010 whereas the lowest severity (15%) was recorded for the month of November, 2009. For jujube soft rot the highest severity (32%) was recorded in the month of March, 2010 whereas the lowest severity (20%) was recorded for the month of November, 2009. Considering Fusarium rot of jujube, the highest severity (23%) was recorded in the month of March, 2010 and the lowest severity (14%) was recorded for the month of November, 2009. In case of stem end rot the highest severity (18%) was recorded in the month of March, 2010 while the lowest severity (11%) was recorded for the month of November, 2009. For Aspergillus rot the highest severity (15%) was recorded in the month of March, 2010 whereas the lowest severity (6%) was recorded for the month of November.

In case of Phomopsis, the highest incidence (15%) was recorded in the month of March, 2010 whereas the lowest incidence (8%) was recorded in the month of January, 2010. Considering Stemphylium, the highest incidence (10%) was

recorded in the month of March, 2010 while the lowest incidence (6%) was recorded for the month of January, 2010. For Rhizopus rot the highest incidence (12%) was recorded in the month of March, 2010 whereas the lowest incidence (5%) was recorded for the month of January, 2010. In case of Anthracnose the highest incidence (10%) was recorded in the month of March, 2010 whereas the lowest incidence (2%) was recorded in the month of January, 2010. For Alternaria fruit rot the highest incidence (20%) was recorded in the month of March, 2010 whereas the lowest incidence (10%) was recorded in the month of January, 2010.

In case of Phomopsis rot of jujube, the highest severity (20%) was recorded in the month of March, 2010 while the lowest severity (5%) for the month of January, 2010. Considering Stemphylium, the highest severity (12%) was recorded in the month of March, 2010 while the lowest severity (5%) was recorded in the month of January, 2010. For Rhizopus rot the highest severity (15%) was recorded in the month of March, 2010 whereas the lowest severity (6%) was recorded for the month of January, 2010. In case of Anthracnose the highest severity (8%) was recorded in the month of March, 2010 whereas the lowest severity (3%) was recorded for the month of January, 2010. For Alternaria fruit rot the highest severity (30%) was recorded in the month of March, 2010 whereas the lowest severity (7%) for the month of January, 2010.

At five days after inoculation (5 DAI) by using block it was observed that 100% papaya fruit were infected by *C. gloeosporioides*, *Rhizopus*, *Fusarium*, *Stemphylium* and *Aspergillus* pathogen. In case of tissue infection using block the

highest infected tissue (30%) was recorded for *Anthracnose* and the lowest for *Aspergillus* (5%) For tissue infection using scrap the highest infected tissue (35%) was recorded for *Anthracnose*, while the lowest for *Aspergillus* (6%). In case of control condition it was found that 33% fruit were infected by *C. gloeosporioides*, *Rhizopus*, *Fusarium*, *Stemphylium* and no infection was recorded for *Aspergillus* pathogen. In case of tissue infection in control condition was recorded for different pathogen and the highest infected tissue (15%) was recorded for *Anthracnose*, whereas no infection was observed for *Aspergillus*.

At five days after inoculation in the highest infected fruit was recorded for *Phomopsis* (90%), whereas the lowest was recorded for *Stemphylium* (30%). In case of tissue infection using block, the highest infected fruit was recorded for *Alternaria* (32%), while the lowest was recorded for *Rhizopus* (10%). In case of tissue infection using scrap, the highest infected fruit was recorded for *Alternaria* (37%), while the lowest was recorded for *Rhizopus* (15%). In case of control condition no infected fruit and no infected tissues were observed for *Phomopsis*, *Stemphylium*, *Rhizopus*, *Anthracnose* and *Alternaria* pathogen.

Conclusion

Identified post harvest diseases of papaya were Anthracnose of papaya, Soft rot of papaya, Fruit rot of papaya, Stem end rot of papaya and Aspergillus rot of papaya. On the other hand, identified post harvest diseases of jujube were Phomopsis rot of jujube, Stemphylium rot of jujube, Rhizopus rot of jujube, Anthracnose of jujube and Alternaria fruit rot of jujube.

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