PREVALENCE OF WATERMELON *(Citrullus vulgaris)* DISEASES IN PATUAKHALI DISTRICT

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DECEMBER, 2016

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REGISTRATION NO. : 15-06900

A Thesis
Submitted to the Department of Plant Pathology
Sher-e-Bangla Agricultural University, Dhaka
In partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE
IN
PLANT PATHOLOGY
SEMESTER: July-December, 2016

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CERTIFICATE

This is to certify that the thesis entitled "PREVALENCE OF WATERMELON *(Citrullus vulgaris)* DISEASES IN PATUAKHALI DISTRICT" submitted to the Department of Plant Pathology, 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 bona-fide research work carried out by REGISTRATION NO. 15-06900 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

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ACKNOWLEDGEMENTS

The author is much privileged to express his enormous sense of gratitude to the almighty Allah for His ever ending blessings for the successful completion of the research work.

The author feels proud to express his deep sense of gratitude, sincere appreciation and immense indebtedness to his supervisor Prof. Dr. M. Salahuddin M. Chowdhury, Department of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka, for his continuous guidance, cooperation, constructive criticism and helpful suggestions, valuable opinion in carrying out the research work and preparation of this thesis, without his intense co-operation this work would not have been possible.

The author feels proud to express his deepest respect, sincere appreciation and immense indebtedness to his co-supervisor Dr. Md. Belal Hossain, Associate Professor, Department of Plant Pathology, SAU, Dhaka, for his scholastic and continuous guidance during the entire period of course, research work and preparation of this thesis.

The author expresses his sincere respect to Dr. Md. Belal Hossain, Associate Professor and Chairman, Department of Plant Pathology, SAU, Dhaka.

Special thanks and indebtedness to all the respective teachers of theDepartment of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka, for their valuable suggestions, sympathetic cooperation and inspiration throughout during the period of the study.

The author expresses his sincere appreciation to his father and beloved mother and all of his well-wishers.

The Author

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ABSTRACT

The present study was conducted to determine the prevalence of watermelon diseases in nine selected locations of Patuakhali district. Three experiments were conducted on watermelon diseases and their prevalence and effect of temperature, relative humidity and rainfall on the diseases. Five different diseases *viz*. Alternaria leaf spot, Cercospora leaf spot, Anthracnose, Mosaic diseases and Rhizopus soft rot were recorded in the survey. Significant pathogens *Alternaria alternata*, *Cercospora citrullina*, *Colletotrichum lagenarium*, *Leaf mosaic virus* and *Rhizopus stolonifer* were isolated and identified. Results revealed that the highest disease incidence (20.84%) and severity (18.75%) of alternaria leaf spot disease and the lowest disease incidence (6.42%) and severity (4.50%) of rhizopus soft rot was found in selected locations of Patuakhali district. The highest disease incidence (19.14%) and disease severity (16.33%) was found in Galachipa upazilla of Patuakhali district where the lowest disease incidence (16.27%) and severity (14.73%) was found in Patuakhali Sadar Upazilla. Weather component (temperature, relative humidity and rainfall) had positive correlation with disease incidence and severity of watermelon. It was observed that with increasing in temperature, relative humidity and rainfall the disease incidence and severity were also increased.

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ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
BCSRI	=	Bangladesh Council of Scientific Research Institute
cm	=	Centimeter
CV %	=	Percent Coefficient of Variation
DAS	=	Days After Sowing
DMRT	=	Duncan's Multiple Range Test
et al.,	=	And others
e.g.	=	exempli gratia (L), for example
etc.	=	Etcetera
FAO	=	Food and Agricultural Organization
g	=	Gram (s)
i.e.	=	id est (L), that is
Kg	=	Kilogram (s)
LSD	=	Least Significant Difference
m^2	=	Meter squares
ml	=	MiliLitre
M.S.	=	Master of Science
No.	=	Number
SAU	=	Sher-e-Bangla Agricultural University
var.	=	Variety
^oC	=	Degree Celceous
%	=	Percentage
NaOH	=	Sodium hydroxide
GM	=	Geometric mean
mg	=	Miligram
P	=	Phosphorus
K	=	Potassium
Ca	=	Calcium
L	=	Litre
Mg	=	Microgram
NUV	=	Near Ultra violate radiation
USA	=	United States of America
WHO	=	World Health Organization

CHAPTER I

INTRODUCTION

Watermelon (*Citrullus vulgaris*) is a member of cucurbitaceae family. As a member of the cucurbitaceae, watermelon is related to the cantaloupe, squash and pumpkin and other plants that grows on vines on the ground. Africa is regarded as the origin of watermelon though living stone found it growing wild in 1854 on the continent of America. Watermelon is a good source of carotenoid and lycopene. Lycopene has been found to be protective against a growing list of cancer (Cho *et al*. 2004). It contains 90% of water. It is very useful fruit during summer season to fulfill the demand of water. Watermelon is reported to provide refreshment to many people across the globe being a fresh fruit because it has low calories, it is highly nutritious, quench-thirst and contain vitamin A and C inform of beta-carotene that fight against diseases. It also has potassium which helps to control blood pressure and possibly prevent strokes. The demand of watermelon consumption is increasing day by day in Bangladesh. Production status also increased compared to previous decades. At present 29,000 acres of land was under watermelon cultivation and 274,000 tons watermelon was produced in 2014-15. The average yield of watermelon was 9,357 kg/acre (BBS, 2016) which is very low compared to other watermelon producing countries. Low yield of watermelon in Bangladesh is due to cause of local varieties cultivation, lack of improved variety, lack of management practice knowledge, higher pest and disease incidence etc. (Saha, 2014).

Watermelon is one of the minor crops of Bangladesh. It occupies an important position among the fruits of the country not only for its the highest production among the fruits but also for its increasing popularity to many farmers as an economic crop. Watermelon is cultivated in several areas in the district of Bangladesh such Laxmipur, Patuakhali, Barguna, Faridpur, Nator, Gopalgonj,

Feni, Chittagonj and Jhinaidah etc. There are many variety of watermelon as hybrid big family, dragon, goalonda, potanga, sugar baby, sugar delicate, charles glory, stone gray etc. It needs 90-120 days for production (BARI, 2014). Watermelon grows well both in the humid and drier savanna agro ecologies zone because it requires warm climate and relatively long growing season, drier climates make foliar diseases less destructive. But now a day the growers feel discouraged in watermelon cultivation due to wilt disease, which results in the reduction of area and production of this important crop (BBS.1998).There are several diseases which are very harmful for successful production of watermelon like anthracnose, gummy stem blight, downy mildew, powdery mildew, alternaria leaf spot, cercospora leaf spot, myrothecium leaf spot, leaf mosaic virus, tobacco ring spot, squash leaf curl virus etc.

During the last two decades, considerable emphasis has been laid on increasing production of vegetable crops in Bangladesh. However, the diseases such as alternaria and cercospora leaf spot, anthracnose, mosaic diseases etc. are the major factors responsible for low production of cucurbitaceous, brassicaceous and solanaceous. The whole crop destroyed by the serious disease rapidly in a few days. Therefore, the problem deserves immediate and effective measures of control (Chadha, 2000).

Reported that Water melon, Carrot, Rape seed, Tomato etc. are alternate/major hosts of leaf spot disease caused by alternaria, therefore the disease could be very serious problemJeong *et al*., (2008). Cercospora leaf spot is one of the most important and destructive fungal diseases of fruit crop in many countries of the world. In the regions of warm and wet climate and Cercospora leaf spot damages more than 30% of the crops. (Jacobsen and Franc, 2009). Anthracnose disease is mainly a problem on leaves and mature fruits resulting in yield losses up to 50 percent and substantial deterioration in quality parameters (Pakdeevaraporn *et al*., 2005). Mosaic diseases are also a destructive disease for watermelon cultivation.

Symptoms of mosaic virus are vein chlorosis and banding and stunted growth (Krishnareddy *et al*., 2003). MV infection has been reported to cause yield losses of up to 90% (Alegbejo *et al*., 2008).

In view of the above facts the present study was conducted to investigate the incidence and severity of watermelon diseases in Patuakhali district, Bangladesh. To achieve these goals, three upazillas of Patuakhali district was selected with the following objectives-

1. To record the diseases of watermelon and isolate identify the causal organisms of diseases.
2. To determine the disease incidence (DI) and disease severity (DS) of watermelon in selected three Upazillas of Patuakhali district.
3. To study the effect of temperature, relative humidity and rainfall on disease incidence and severity of watermelon.

CHAPTER II

REVIEW OF LITERATURE

Watermelon (*Citrullus lanatus*) is a member of the family cucurbitaceae and this family are mostly used as vegetables. It is an important horticultural crop, mostly known for its sweet and juicy fruit, grown in warm climates all over the world (Robinson and Decker-Walters, 1997). The diseases of watermelon have been studied in Bangladesh to a limited extent. In this chapter an attempted has been made to reviewe the available literature about occurrence of diseases in watermelon leaf and fruit, their symptoms and causal organisms, diseases status and their epidemiology. The survey was conducted on watermelon diseases in Patuakhali district, four leaf diseases *viz.* alternaria leaf spot, cercospora leaf spot, anthracnose and leaf mosaic virus were identified and one fruit disease rhizopus soft rot was also identified. Literature on disease symptoms and prevalence of five watermelon diseases was reviewed and presented in this chapter.

Adaskaveg (2011) reported that alternaria leaf spot of almond caused by three very closely related species in the *Alternaria alternata* complex (*A. arborescens, A. alternata, and A. tenuissima*) occured mostly in the southern and northern production regions of California but continues to spread into new areas. Severe outbreaks occur in areas with dew, stagnant air, and where temperatures are high during the summer months. The disease can also be severe in high-density plantings or in orchards with soils with inadequate drainage and where trees require frequent and extended irrigations into the summer. Under favorable conditions for disease development, trees can be completely defoliated by early to mid-summer. Because alternaria leaf spot is greatly influenced by microclimatic conditions such as temperature and wetness.

Agrios (1997) obserbed that *rhizopus stolonifer*, causal organism of soft rot of fruits and vegetables, can be classified as a cosmopolitan filamentous lower

fungus living in the soil, decaying fruit and vegetables, animal feces, and old bread. R. *stolonifer* contains two other genera: *Choanephora* and *mucor*) known to cause diseases in plants. The spores of zygomycetes are often floating around in the air, they are either saprophytes or weak parasites of plants and plant products on which they cause soft rots or molds. Rhizopus exists everywhere, usually as a saprophyte and sometimes as a weak parasite on stored organs of plants. The mycelium of the fungus produces long, aerial sporangiophores at the tips of which black spherical sporangia develop.

Alvarez and Nishijima (1987) stated that rhizopus soft rot of fruits and vegetables occurs throughout the world on harvested fleshy organs of vegetables, fruits and flower crops during storage, transit, and marketing of these products. The disease, when occurs on wet or wounded fruits packed in card board boxes, can be an unsightly mess due to the watery leakage from fruits causing the boxes collapse.

Amadi *et al*. (2008) reported that it is a popular cash crop grown by farmers during the dry season due to its high returns in investment, especially those residing near the urban areas. Diseases play an important role in reducing the quality and quantity of cultivated crops, several diseases attack watermelon, some of which include Alternaria leaf spot, Alternaria leaf blight, Anthracnose, Cercospora leaf spot, Fusarium wilt, Downy mildew, Powdery mildew, damping-off, Bacterial leaf spot, Leaf mosaic etc.

Amenduini *et al*. (2003) reported that the symptoms of alternaria of infected leaves firstly start as light brown spot, then turn to concentric dark brown spots, varying in size, become necrotic. These spots spread to cover large areas of infected leaves. In case of severe infection, infected leaves become brown and died.

Arauz (2000) observed that anthracnose symptoms on leaves initially occur as small angular, brown to black spots that can coalesce to form large extensive

lesions on the leaf. This is particularly common around the edges of the leaves. On panicles, the symptoms first appear as small black or dark brown spots which may enlarge or coalesce to kill the flowers before fruits are produced. Blighted flowers are dry and their colour varies from brown to black.

Arauz (2000) aslo reported that disease incidence of anthracnose has been reported between 32% in South Africa and 64.6% in Costa Rica and can reach 100% when fruits are produced under wet or very humid conditions and disease severity of the anthracnose disease is related to weather and the pathogen is relatively inactive in dry weather.

Atia and Tohamy *et al.* (2004) reported that alternaria leaf spot was previously observed on okra plants under field conditions in USA. According to the available literature, alternaria leaf spot on okra, cucumber and watermelon in Egypt under natural infection in the field is the first recorded.

Atiri and Ibidapo (1989) worked on combined infections by okra mosaic virus and watermelon virus which reduced the growth of okra more than when the plants were infected singly by cither virus. They reported that the critical growth component responsible for low performance was leaf area in WMV infected plants and chlorophyll content in OMV infected plants. However, the 2 viruses had a synergistic effect in mixed infections. They also reported that in single infection of WMV caused higher yield loss than OMV.

Bertelsen *et al.* (1994) reported that anthracnose (caused by *Colletotrichum orbiculare*) was a serious disease in Florida watermelon production, but the use of resistant varieties has limited its impact. When it does occur, anthracnose can destroy the entire field if not controlled, particularly after several days of warm, rainy weather.

Bolton *et al*. (2012) reported that cercospora leaf spot is a polycyclic disease that causes multiple infections in a single crop season.

Bulajic *et al*., (2007) reported stated that apple, sunflower, cut flowers, strawberry, kiwifruit, citrus, cucumber, watermelon, marsh, Water weed plants, Pot plants, Spices, Carrot, Rape seed, Tomato as alternate/major hosts of leaf spot disease caused by *Alternaria alternata*, therefore the disease could be very serious problem.

Cannon *et al*. (2008) reported that *Colletotrichum* has been recently described by Hyde *et al*. (2009) to cause plant diseases. *C. gloeosporioides* is so far the most predominant *Colletotrichum* sp. and can attack about 470 different host genera.

Cerkauskas (2004) observed that caused by *Cercospora capsici* luxuriantly less than 28^0C temperature, 92% relative humidity and pH 5-6. Below 90% relative humidity, the disease does not develop. The fungus survives in plant debris, primary infection coming from air-borne spores derived from it. The disease is more severe in wet weather than in dry weather and becomes destructive in high relative humidity.

Duke (1983) have been reported in general, the Jatropha is considered to be free from different diseases and pests. However, some diseases *viz.*, Root rot (*Cilocybe tabescens*), Leaf spot (*Colletotrichum gloeosporides*) and Rust (*Phakospora jatrophicola*).

Enikuomehin *et al*. (2002) described that ercospora leaf spot (CLS) is considered to be one of the most prevalent diseases of sesame that could lead to about 22 to 53% reduction in yield.

El-Gali and El-Zahaf (2015) found that Alternaria leaf spot is one of the most important diseases in Libya. The overall mean disease incidence and disease intensity in the adjoining areas ranged from 54 to 96% and 14 to 43.6%

respectively. The highest disease incidence (96%) and intensity (43.6%) was recorded in the Balanage region, while lowest level of disease incidence (54%) and intensity (14%) was observed in the Ras Altrab region. The species associated with the disease was identified as *Alternaria alternate.*

Estrada *et al.* (2000) in areas where rain is prevalent during flowering and fruit set, anthracnose can cause destruction of the inflorescence and infection and drop of young fruits. Infection of the blossom or young fruits can result in total crop failure.

Franc and Jacobsen (2009) stated that cercospora leaf spot is one of the most important and destructive fungal diseases of sugar beet in many countries of the world. Cercospora leaf spot is a polycyclic disease capable of generating high disease pressure over a season.

Gilling (1986) observed that ANOVAs has been the fundamental method used by plant pathologist to determine the correlation between the prevalence and environmental parameters.

Guo *et al.* (2004) reported that *Alternaria alternata* isolates originating from *Pinus tabulaeformis* and *Alternaria alternate* appears to have the potential for relatively quick evolution which may lead to significant diversification.

Harveson (2013) reported that the disease progresses, severe leaf necrosis can occur when favourable weather conditions exist, causing reduced sugar production and aslo stated that cucumber mosaic virus (CMV) is an aphid-borne virus that infects a wide range of plant species including vegetable crops and weeds. In Western Australia CMV infection in capsicum causes yield and quality losses. CMV is spread by many aphid species including *Myzus persicae* (green peach aphid) and *Aphis gossypii* (melon aphid). CMV is non-persistently transmitted: an aphid picks up the virus within one or two seconds while probing an infected plant, but the virus is then lost again when the aphid probes one or two healthy

plants. CMV has a very wide host range that includes ornamentals and weeds (including nightshade, sowthistle, amaranthus) as well as other crops (pumpkins, zucchini, tomatoes). The hosts are often found in close proximity with capsicum crops and can provide a reservoir of infection. CMV is also reported to be seed borne in some weed species.

Hochmuth *et al*. (1997) observed that the most important fungal diseases are gummy stem blight (caused by Didymella bryoniae/Phoma cucurbitacearum) and downy mildew (caused by Pseudoperonospora cubensis). Some consider gummy stem blight to be the most troublesome disease on watermelons in Florida. Other occasional or minor diseases include phytophthora blight (caused by Phytophthora capsici), bacterial fruit blotch (caused by Acidovorax avenae subsp. citrulli), alternaria leafspot (caused by Alternaria cucumerina), seedling blight (caused by Pythium spp., Rhizoctonia solani, and Fusarium spp.), fusarium wilt (caused by Fusarium oxysporum f.sp. niveum), angular leafspot (caused by Pseudomonas syringae), anthracnose (caused by Colletotrichum orbiculare), rind necrosis (usually caused by Erwinia spp.), and powdery mildew (caused by Erysiphe cichoracearum). Blossom end rot, a physiological disorder related to calcium deficiency and water stress, is also an occasional problem. Finally, Cercospora leafspot (caused by Cercospora citrullina) and southern blight (also called southern stem rot or white mold and caused by Sclerotium rolfsii) are only rarely seen on watermelons in Florida.

Islam *et al*. (2015) conducted an experiments during 2009 to 2013 on diagnosis and prescriptions for management of Cercospora leaf spot of watermelon, cucumber and melon. The studies were undertaken in 250 grower's field of five upazillas viz. Mymensingh sadar, Kushtia sadar, Kumarkhali, Chandina and laxmipur. The highest disease incidence (38.6%) and severity (17.4%) of Cercospora leaf spot was recorded.

Jiskani and Kochhar (2005) reported that leaf spot is a serious fungal disease, were found on vegetable growing areas. In some cases, heavy infection has led to total loss of yield.

Khan *et al*. (2009) reported that disease incidence and severity can be affected by row closure, length of leaf wetness period, relative humidity (RH), and conidia concentration.

Koch and Weiland (2004) reported that the spots range in diameter from 0.5-6.0 mm and fruiting bodies, called stromata, are visible in the lesions with a hand lens. Typically, older, lower leaves exhibit symptoms first and have a more severe infection, with a greater number of lesions and increased spot size.

Kurowski *et al*. (2015) stated that the alternaria caused by *Alternaria Spp*. survives in crop debris or on weeds and other cucurbit hosts. Disease spread can occur with rain, irrigation, wind, cultivation, equipment and field workers. This disease is favored by warm temperatures and moisture from dew, rain or overhead irrigation. Infection can be initiated with two to eight hours of leaf wetness, but as the hours of leaf wetness increase infection level increases. The frequency of rain and the length of dew periods play a greater role in disease development than the volume of rain that falls. They also conducted an experiment on cercospora leaf spot occurs on all cucurbits but is most common on watermelon, cantaloupe, and cucumber. This disease is usually found only on the foliage, but if the environment is suitable, symptoms may also occur on petioles and stems. The fungus is not known to infect fruit. On watermelon, leaf spots manifest on young leaves as small grey or white spots with black margins. Larger leaf spots which are circular to irregularly circular develop on other cucurbits. The centers of these leaf spots are tan to light brown becoming transparent and brittle with time. Lesions with surrounding chlorotic halos may coalesce and turn leaves yellow. Although defoliation from the disease may reduce fruit size and quality, serious economic

losses are rare. Conidia of *Cercospora citrullina* become airborne and may be carried great distances on moist winds. Infection requires free moisture and is favored by temperatures of 26–32°C (80–90°F). *Cercospora citrullina* survives on crop debris, volunteers and cucurbit weeds.

Kumar (2008) conducetd field resistance/partial resistance to Alternaria (*Alternaria brassicae*) was assessed in nine genotypes of Indian mustard under field conditions. Three genotypes viz. PR 8988, PR 9024 and Kranti exhibited partial resistance and had lowest severity. The yield potential of the genotypes was negatively correlated with the disease severity.

Kurowski *et al*. (2015) reported that anthracnose disease is most commonly found on cucumber, melon and watermelon. Symptoms on leaves begin as water-soaked spots which typically become yellowish in appearance on cucumber and melon or dark brown to black on watermelon. These spots eventually turn brown and may expand over the leaf surface. Foliar lesions are not restricted by leaf veins and often have cracked centers. Infected petioles and stems may develop shallow, elongated, tan lesions on melon but the lesions are less obvious on cucumber. Stem lesions on melon can girdle the stem and cause plant wilting. Infected fruit develop circular, sunken, blackish lesions where tiny fruiting bodies (acervuli) may develop. Under humid conditions, the fruiting bodies produce conidia which give the lesions a pinkish-salmon color, which is very characteristic of this disease. When pedicels of young fruit become infected, the fruit may shrivel and abort. They also reported that *Colletotrichum orbiculare* can be associated with seed and infected crop debris. Spread of this fungus can occur by splashing rain, overhead irrigation, insects, field workers and equipment. Disease development is favored by warm, humid weather. Optimum temperature for disease development is 24°C (75°F). Late infection of the crop may result in fruit becoming unmarketable during storage, shipment or display.

Kurowski *et al*. (2015) reported that rhizopus soft rot caused by *Rhizopus stolonifer* which is on host of Cantaloupe, Cucumber, Squash and Watermelon. Mainly it is a fruit disease. Many symptoms are appeared in fruit. Large, water-soaked spots with defined margins develop on fruit. Later the water-soaked spots become soft and sunken. Gray fungal mycelium may grow in the seed cavity. They aslo stated that mosaic virus (MV) can infect both greenhouse and field-grown vegetable crops. MV has an extensive host range (>1200 species) facilitating its survival on weeds, ornamentals, and other cultivated crops. The primary mode of transmission is by aphids in a non-persistent manner, although the virus can also be mechanically transmitted through equipment and workers. Cucumber beetles (*Diabrotica* spp.) have also been shown to transmit MV, but aphids are the primary vector.

Maheshwari *et al*. (2000) observed that have grown *Alternaria alternata* at eleven different temperatures and sixteen pH levels ranging from 5ºC to 40ºC and 3.0 to 10.5 pH.

Mallek *et al*. (1995) pointed out that *R. stolonifer* from diseased tomatoes was isolated in a frequency of 35.9% only overcame by *A. alternata* in a frequency of 57.7%.

Mbega *et al*. (2012) conducted a study to examine fungal diseases infecting watermelon (*Citrullus lanatus* Thunb.) plants. Forty eight watermelon samples with necrotic symptoms collected from randomly selected home gardens were tested for infection using the Blotter method. Identification of the detected fungi was done based on morphological characters of the mycelia and conidia Observed under the stereo and compound microscopes. The results indicated that, watermelon samples were infected by *Alternaria alternata* (96.7%), *Cercospora citrullina* (93.3%), *Fusarium oxysporum* (40%), *Microphomina phaseolina* (38.3%) and *Cladosporium cucumevicum* (14.2%).

Meah and Khan (1987) observed that among the fungal diseases, cercospora leaf spot of cucurbitaceae family was one of the major problems in Bangladesh.

Padilla and Monterroso (1999) reported that also foliar diseases caused by *Alternaria sp., Dothiorella sp., Oidium sp.,* and *Fusarium sp.* were reported in addition to the bacterial angular spot caused by *Xanthomonas* sp. on *Jatropha curcas* in Nicaragua.

Prasad (2016) conducted a survey to assess the percent disease incidence of anthracnose of watermelon and chilli in five locations in Bulileka area. The percentage incidence of anthracnose affected fruits under field conditions was more in green fruits which ranges from 65.5% to 78.5%. Therefore the percent disease index (PDI) reveals that the predominance presence of anthracnose is a major constraints to profitable of watermelon and chilli in Bulileka area.

Rangaswamy *et al*. (2005) observed mosaic disease symptomatologically resembling Mosaic Virus (MV) disease on some naturally grown cucurbit plants during 2004 in Kolar and Bangalore districts of Karnataka state.

Rizzolli and Acter (2006) conducted an experiment on fungus overwinters in old cucurbit vines, in seed, or in weeds in the cucurbit family. Warm (75°F), wet conditions (frequent rains, poor drainage) favor rapid development and spread of the disease. Anthracnose can appear anytime during the season, but most damage occurs late in the season after the fruit is set. At least three races of *Colletotrichum* have been reported.

Roberts and Kucharek (2005) reported that alternaria leaf spot (caused by *Alternaria cucumerina*) is a minor disease on Florida watermelons. Symptoms begin on the upper surface of older leaves as very small yellow or tan spots that may be surrounded by light green or yellow halos or by a water-soaked area. The spots later grow up to ¾ of an inch (2 cm) in diameter and turn brown in color.

Similar in appearance to gummy stem blight, the lesions are the source of spores spread primarily by the wind. Under severe infestations, the disease produces leaf curling, defoliation (which leaves the fruit susceptible to sunscald), and premature ripening. Lower yields, lower fruit sugar, and fruit deformity may occur.
Scheffer (1992) reported that *A. alternata* is one of the most common saprotrophs or facultative parasites associated with various parts of plants.

Secor *et al*. (2010) stated that this diseases usually occurs later in the season and is unevenly distributed in a field, with higher incidence in areas near windbreaks, trees, taller crops and other protected areas that promote higher humidity.

Sikora (2011) reported that alternaria leaf spot, caused by the fungus *Alternaria alternate, Alternaria cucumerina*, affects cantaloupe and cucumber as well as other cucurbits. The fungus causes tan to brown leaf spots (1⁄2 inch in diameter) that contain dark concentric rings within the lesions. Spots merge and defoliation occurs, beginning with the crown leaves. Weak plants are most susceptible to Alternaria leaf spot. The fungus is spread by wind and rain and is favored by warm, wet conditions.

Sikora (2011) obserbed that anthracnose, caused by the fungus *Colletotrichum lagenarium*, can be a destructive disease of cucurbits during warm, wet growing seasons. The disease attacks watermelon, cantaloupe, cucumber, and gourds. Squash and pumpkin are almost immune to C. *lagenarium*. All above-ground plant parts are susceptible to infection, and plants can become infected at any stage in their development. Older leaves first show small, water-soaked, or yellowish areas that enlarge rapidly and turn tan to reddish brown (most cucurbits) or black (watermelon). Spots are often circular to angular.

Sikora (2011) reported that all cucurbits are susceptible to mosaic virus, but watermelon is rarely affected. Of the many viruses that attack cucurbits, three commonly found viruses are cucumber mosaic virus (CMV), squash mosaic virus

(SqMV), and watermelon mosaic virus-2 (WMV-2). These viruses differ in their host range, method of transmission, and in how they overwinter. Symptoms produced by these viruses are similar, making field identification impossible. Special laboratory testing is required for positive identification. Cucurbits are susceptible at any stage of growth. When plants become infected in the 6 to 8 leaf stage, symptoms first appear on the youngest, still expanding leaves. A mosaic pattern develops-healthy, dark-green leaf tissue intermingled with light-green and yellow tissue. Leaves are often distorted, crinkled, curled, and stunted. Vines may appear bunchy because of the shortening of the internodes. In severe cases, older leaves was died.

Singh *et al*. (2015) reported that vegetables belonging to family cucurbitaceae, brassicaceae and solanaceae are important due to their nutritional and have also cost-effective values. Farmers bearing heavy yield losses both in their quality and quantity of these crops due to various diseases. Diseases caused by *Altemaria* species are common and are worldwide in their occurrence. The different crops plants as a host wz. apples, broccoli, cauliflower, carrots, potatoes, Chinese cabbage, tomatoes, bok choy, citrus and many plants used as ornamentals and a no. of weeds. These oops inflicted serious damage as early blight diseases caused by fungal pathogen *Altemaria* spp. Different *Altemaria* spp. was found to be associated with various Angiospermic families but *A. altemata* (with a few morphological differences) usually infects members of these three vegetable providing families. Besides these pathogenic infections are reported due to A *tenuissima* and A *cucumerina* on cucurbifaceous; A *brassicae*, *A. brassidcola* and *A. raphani* on brassicaceous and A *solani,* A *longipes and A. crassa* on solanaceous plants

Singh *et al.* (1997) conducted a survey at Punjab in India and found that the highest incidence of rhizopus soft rot on watermelon (78.33%) and cucumber

(80.07) and the lowest incidence were recorded on cucumber 9.83% in arid irrigated zone.

Slavov *et al*. (2004) observed that the optimum temperature and pH for the growth of the fungus were found to be 28ºC and pH 6.5. Minimum growth of the fungus was recorded at the temperature of 5ºC and pH 10.5. Excellent sporulation was observed at 25ºC-30ºC and pH levels of 5.5 to 6.5. While some fungi belonging to genus *Alternaria* are plant parasites that easily can change when exposed under different conditions.

Smith and Rupple (1971) observed that this fungal diseases can cause significant economic losses due to decreased yield and sugar quality and increased storage rot.

Solfrizzo *et al*. (2005) Up to 68% of carrot root samples collected in several European countries were found to be contaminated with the fungus. As much as 70% of mature carrots can be rendered unmarketable if heavily infested or infected by *A. radicina* and *A. alternate.*

Talhinhasac and Mota-Capita (2010) observed that anthracnose is an important disease affecting mature olive fruits, causing significant yield losses, and poor fruit and oil quality. In Portugal, high anthracnose incidence was recorded during 2003–2007 with 41%of 908 orchards surveyed displaying disease symptoms. In another 14% of the orchards, the pathogen was recorded in symptomless plants. Disease severity was on average 36%, frequently reaching 100%. In Portugal, anthracnose is endemic to neglected orchards of susceptible cultivars, but under favourable conditions it can also severely affect less susceptible cultivars. Epidemiology and histopathology studies showed the presence of the pathogens on vegetative organs year-round, particularly on olive leaves and branches, and on weeds. These represent inoculum reservoirs where secondary conidiation occurs,

and conidia are then dispersed by spring rains reaching flowers and young fruits or by autumn rains reaching pre-mature fruits.

Windels *et al*. (1998) reported that cercospora leaf spot presents as circular, necrotic grey or beige spots with a purple or reddish-brown border and within 5-21 days post infection (dpi) the first symptoms can be seen. Disease severity shows a within row spatial dependence, meaning that disease severity of a plant is most strongly influenced by in-row neighbors, rather than across-row neighbors.

Webb (2003) reported that aphids damage watermelon plants directly by feeding, as well as indirectly by transmitting viruses. The three principal viruses affecting watermelons in Florida (i.e., papaya ringspot virus type W, watermelon mosaic virus 2, and zucchini yellow mosaic virus) can be transmitted by aphids that colonize watermelons and by a number of aphid species that do not reproduce on watermelons. These include *A. middletonii, A. spiraecola* (spirea aphid, also known as green citrus aphid), and *U. pseudambrosiae.*

Webb, Kok-Yokomi, and Voegtlin (1994) reported that watermelon mosaic virus 2 (WMV-2) is another potyvirus that caused regular problems for watermelon production, particularly in Central and North Florida during spring production. Incidence of watermelon mosaic virus 2 in Central Florida rarely exceeded 5% during the 1960s and 1970s. However, in the late 1980s, the virus caused severe losses to the spring watermelon crop in Central and North Florida, with incidence in fields of up to 100%. Infection early in the season results in yield loss and reduced fruit quality because of blemishes, particularly rings and spots on the watermelon rind. However, if the virus does not enter a field until the time of fruit set, little to no yield difference is likely.

Weiland and Koch (2004) studied that cercospora is the most destructive foliar pathogen. It is widely present in most beet and vegetable growing regions and can cause major yield losses if not properly controlled. This disease usually appears early in the season and is most severe in wet and warm areas in case of very early attacks. Cercospora, the impact of the disease on the yield and quality is two-fold. First there will be a reduction of the photosynthetic area due to the progressive increase of the necrotic leaf spots and the drying of leaves. Secondly, the plant will react to the leaf loss by canopy re-growth, which will cause additional yield losses which are more important than those due to necrotic spots. Cercospora has by far the greatest yield-harming potential. This disease may cause losses up to 50% for root yield and 5 to 10% for sugar content in case of very severe and nontreated attacks. Under moderate Cercospora pressure, 30% losses in root yield are fairly common. The earlier the attack of Cercospora, the higher the impact on yield.

Weiland and Koch (2004) reported that the pathogen overwinters on infected plant residue, left on the field in the fall, as conidia, pseudostroma, and stromata. Overwintering stromata produce conidia which are dispersed by wind and rain to land on susceptible leaf tissue. There has been evidence in the Netherlands that infection can originate in the root however, these results have not been reproducible in North America.

Watve (2006) reported that leaf spot disease of Jatropha caused by *Colletotrichum gloeosporioides* Penz. was found in “Jatropha plantation at Biodiversity cum Genomic Valley Park”, Dr.B.S.Konkan Krishi Vidyapeeth, Dapoli.

Ying (1987) reported that due to changing climatic condition of high humidity and moderate temperature may resulted in increased fruit rot (anthracnose), the climatic condition suit the growth and reproduction of the disease. The spreading of anthracnose disease is due to the direction of prevailing wind while rainfall

influence disease depending on the amount, duration, intensity and pattern of rainfall during a crop cycle.

Zitter *et al*. (1996) reported that foliar diseases are common on watermelon (*Citrullus lanatus* Thunb.). Historically, anthracnose, gummy stem blight, and downy mildew as predominant foliar diseases encountered by U.S. growers.

CHAPTER III

MATERIALS AND METHODS

Diseases play an important role in reducing the quality and quantity of cultivated crops. The present study was conducted to study the prevalence of disease ofwatermelon (*Citrullus vulgaris*) in Patuakhali district of Bangladesh. This chapter deals with three experiments throughout the study period in order to study the diseases of watermelon. The experiments were as follows:

1. Study the diseases of watermelon and isolate identify the causal organisms of diseases.
2. Determination of disease incidence (DI) and disease severity (DS) of watermelon in selected Upazillas of Patuakhali district.
3. Study the effect of temperature, relative humidity and rainfall on disease incidence and severity of watermelon.

3.1 Experiment-I: Study the diseases of watermelon and isolate and identify the causal organisms of diseases.

3.1.1 Location of survey area

Prevalence of diseases occurred on watermelon leaves and fruits raised in the selected areas was surveyed. The experiment was carried out in three Upazilla of Patuakhali district in Bangladesh. In total nine locations (Unions) under three Upazillas in Patuakhali district were selected. The selected locations (Unions) with total cultivable land (ha) and area under watermelon cultivation (ha) is presented in Table 1.

Table 1. Selected study location with total cultivated land and area under watermelon cultivation in Patuakhali district of Bangladesh

Sl. No.	Locations		Total cultivable land (ha)	Area under watermelon cultivation (ha)
	Name of Uapzilla	Name of Unions		
1.	Galachipa	Amkhola	3370	950
2.		Golkhali	4450	1450
3.		Panpatty	3690	1050
4.	Kalapara	Mithaganj	3050	305
5.		Dhankhali	2500	258
6.		Dhulaswar	2250	285
7.	Patuakhali Sadar	Auliapur	2250	24
8.		Lohalia	2115	15
9.		Chhota Bighai	2150	18

Source: DAE, 2017

3.1.2 Data collection

Data were collected from farmer's field during watermelon cultivation to observe disease incidence and severity in watermelon. Randomly 30 m^2 (5m × 6m) area was selected in farmers field. Total leaves and fruits were counted from 30 m^2 selected area and among them disease infested leaves and fruits were counted to calculate percent disease incidence. Infested area on leaves and fruits caused by disease pathogen was also measured to calculate percent disease severity. All data were collected from 9 selected locations followed by a prepared simple questionnaire.

3.1.3 Questionnaire of the study

Questionnaire was prepared for two levels viz. for DAE personnel and for farmer's field information. Questionnaire of study is presented in Appendix I.

3.1.4 Observation of the symptoms

Symptoms of the diseases were studied by visual observation. Sometimes hand lens was used for critical observation of the disease and sometimes a disease was identified based on matching the observed symptoms in the infected leaves and fruits with the symptoms. Identification of all the fungal diseases was finally confirmed by identification of the associated fungul organism through isolation.

3.1.5 Collection of diseased specimen

Diseased leaves were collected representing the different areas of survey. The specimens were preserved in the laboratory following standard procedure of preservation of disease specimens until isolation was made.

3.1.6 Isolation of causal organisms - Two methods

3.1.6.1 Moist blotter method

The pathogen associated with the diseased leaves were cut into several pieces by scissors and placed on the moist filter paper (Whatman no.1). Three pieces of filter paper were moistened by dipping in sterile water. The petridishes with the diseased specimens were incubated at 22±2°C under 12/12 alternating cycles of NUV and darkness in the incubation room of the mycology lab for five to seven days. After incubation the plates were examined under stereomicroscope for primary identification of the organisms (fungi). The fungi were transferred to PDA plate for proper sporulation and purification.

3.1.6.2 Agar plate method

Previously prepared autoclaved PDA media was used to culture and purification of fungi. For performing this work mycelial growth was transferred into PDA media from the moist blotter plate. The diseased plant parts were cut into 5mm pieces from advancing end of the leisons. This infected part were surface sterilized by dipping them in 0.001% $HgCl_2$ solution for 1.5 minutes and washed three times with sterile water and there after placed on PDA (Potato = 200g, Dextrose = 17g, Agar = 17 - 20g, Water = 1000ml) plates aseptically. The plates were incubated at 28°±1°C for several days and examined daily for any fungal growth and continued for 10 days. After incubation period the inoculated PDA plates were observed to identify the causal organisms.

3.1.7 Preparation of Potato Dextrose Agar (PDA) medium

At first, 200g potato was peeled and cut in a slice and boiled in 1 liter water. After 20 minute it was sieved. Then 20g dextrose, 18g Agar were mixed slowly with proper shaking to avoid coagulation. Adjusted the pH 6.5 with 1N NaOH. in a conical flask and sterilized the media through autoclave by adjusting 121^0C temperature at 15 PSI pressure for 50 minutes. The whole works were done under laminar air flow chamber.

3.1.8 Isolation and identification of pathogen

The surface of diseased leaf samples was sterilized by dipping in 0.1 % $HgCl_2$ solution for 30 second and rinsed in sterile water. Leaf samples were placed on moist blotter paper on petridish, incubated at 20 ± 2^0 C for 3-5 days in 12 hours with alternate light and darkness. For sporulation, the inocula was placed on PDA and incubated for 20 days at 20 ± 2^0 C in the normal lab condition. After incubation when the whitish growth of fungus was observed on the PDA, temporary slides were prepared for identification under compound microscope. The incubated PDA was also observed under stereoscopic microscope.

3.2 Experiment-II: Determination of disease incidence (DI) and disease severity (DS) of watermelon in selected Upazillas of Patuakhali district.

3.2.1 Survey period

Surveys were made during the period from January 2017 to Feburary 2017. Survey was done by 3 times in each study area at 15 days interval.

3.2.2 Data collection during survey

During the survey in the selected study area, total numbers of leaves and fruits of the crop as well as number of diseased leaves and fruits in the selected study area were counted. Primary identification disease was done by visual observation. Infected area on leafs was also counted by visual observation.

3.2.3 Determination of disease incidence and disease severity

For calculation of disease incidence in the crop fieldtotal number of leaves and infected leaves and fruits were counted from selected surveyed area and % disease incidence was measured by the following formula (Rai and Mamatha, 2005):

$$\text{Percent disease incidence (Leaves)} = \frac{\text{Number of diseased leaves plant}^{-1}}{\text{Number of total leaves plant}^{-1}} \times 100$$

Percent Disease severity was determined by the following formula (Rai and Mamatha, 2005):

$$\text{Percent disease Severity (Leaves)} = \frac{\text{Area of leaf tissue infected by disease}}{\text{Total area of inspected leaf}} \times 100$$

3.3 Experiment-III: Study the effect of temperature, relative humidity and rainfall on disease incidence and severity of watermelon.

3.4 Meterogical data collection

Generalized environmental variable were selected for their effect on the incidence and severity of watermelon diseases. Meterological data on temperature, relative humidity and rainfall of the experimental period were collected from Meterological Department, Agargaon, Dhaka-1207 (presented in Appendix II).

3.5 Statistical analysis

Data on different parameters were analyzed in one factor randomized block design (RCBD) through computer software MSTAT-C (Anonymous, 1989). Duncan's Multiple Range Test (DMRT) and Least Significant difference (LSD) test were performed to determine the level of significant differences and to separate the means within the parameters. Correlation and regression analysis were performed to find out the effect of different climatic factor, *viz*. temperature, relative humidity and rainfall on the incidence and severity of watermelon diseases.

CHAPTER IV

RESULTS AND DISCUSSION

This chapter comprises the explanation and presentation of the results obtained from the study on diseases of watermelon through measurement of disease incidence and severity in selected locations (Unions) of Patuakhali district. The data have been presented and discussed and possible interpretations are made in the following deleberation:

4.1. Symptom of the diseases and identification of the pathogen

On the basis of typical symptoms five diseases *viz*. alternaria leaf spot, cercospora leaf spot, anthracnose, mosaic diseases and rhizopus soft rot were recorded and the identified diseases are as follows:

4.1.1 Alternaria leaf spot

The symptoms observed on the upper surface of older leaves as very small yellow or tan spots that were surrounded by light green or yellow halos or by a water-soaked area (Plate 1. A and B). The spots later grow up to ¾ of an inch (2 cm) in diameter and turned brown in color.

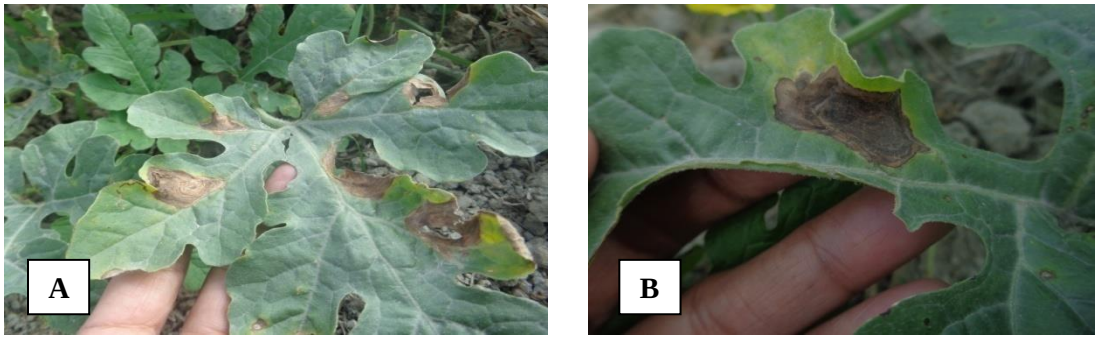

Plate 1. A and B showing symptoms of alternaria leaf spot

The pathogen isolated from the diseased sample was identified as *Alternaria alternata* (Plate 2 - A and B) by observing the conidia. The conidia were in long

chains, obclavate, obpyriform, ovoid and elipsoidal with up to 3-5 transverse and several longitudinal septa.

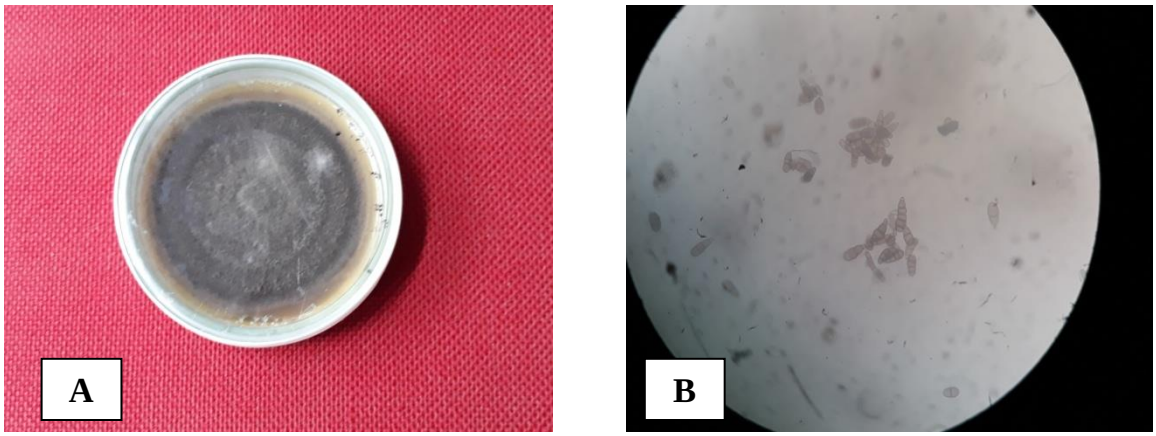

Plate 2. A – Pure culture of *Alternaria alternata*, B – Conidia of *Alternaria alternata* produced in culture.

Alternaria leaf spot disease in watermelon is also reported by many researchers around the world [Mbega *et al*. (2012); Sikora (2011); Jeong *et al*. (2008); Kochhar (2005) and Scheffer (1992)]. Leaf spot is a serious fungal disease, may be found on vegetable growing areas (Kochhar 2005; Jiskani 2006). *A. alternata* is one of the most common saprotrophs or facultative parasites associated with various parts of plants (Scheffer 1992). Mbega *et al*. (2012) conducted a study to examine fungal diseases infecting watermelon (*Citrullus lanatus* Thunb.) plants and found that, watermelon samples were infected by *Alternaria alternata*. They found alternaria leaf spot, caused by the fungus *Alternaria alternate, Alternaria cucumerina*, affects cantaloupe and cucumber as well as other cucurbits also. They also stated that the fungus caused tan to brown leaf spots (1⁄2 inch in diameter) that contain dark concentric rings within the lesions. Spots merge and defoliation occurs beginning from the crown leaves. Weak plants were most susceptible to alternaria leaf spot. The symptom observed in the present study is in accordance with findings of the reported literatures.

4.1.2 Cercospora leaf spot

The symptoms appeared leaf spots have a dark brown center and a yellow halo (Plate 3 – A and B). Infected leaves are first observed at the crown of the plant. When the disease is severe, foliage loss will restrict fruit development and result in sunburn of fruit.

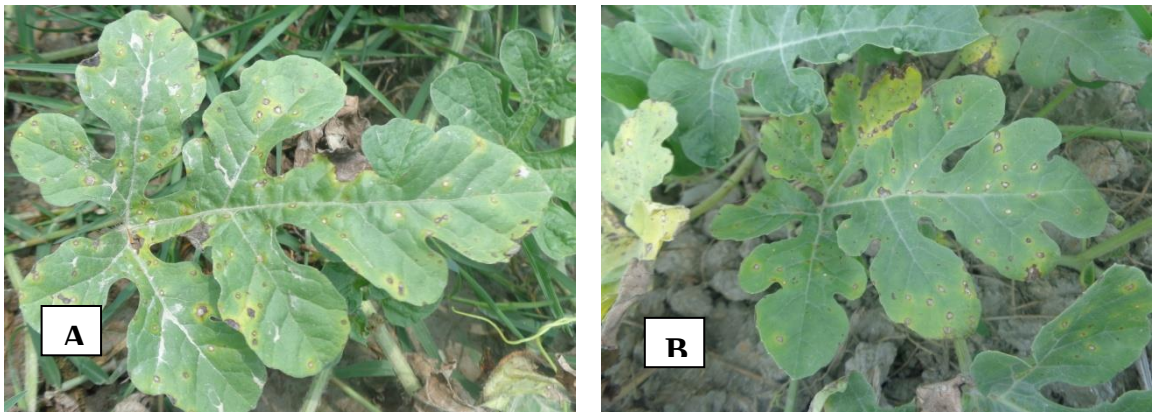

Plate 3. A and B showing symptoms of cercospora leaf spot

The pathogen isolated from the diseased sample was identified as *Cercospora citrullina* (Plate 4 – A, B and C). Conidia were solitary, hyaline, filiform, straight to slightly curved with obtuse to subacute at the apex and subtruncate bases, 1-16 septate, non-constricted at the septa.

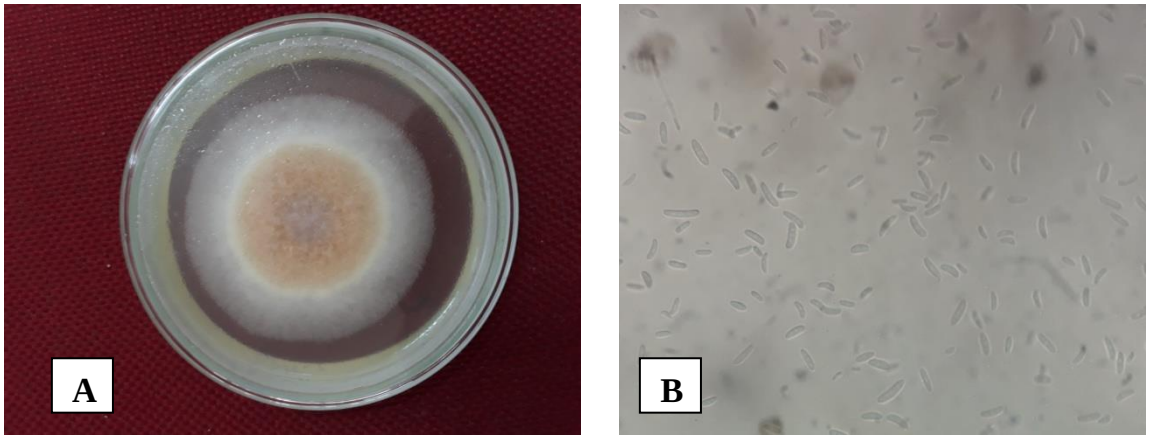

Plate 4. A – Pure culture of *Cercospora citrullina*, B – Conidia of *Cercospora citrullina* and C – Conidiophore produced in culture.

Cercospora leaf spot disease in watermelon is also reported by many researchers around the world [Bolton *et al*. (2012); Kurowski *et al*. (2015); Khan *et al*. (2009); Jacobsen and Franc (2009); Windels *et al*. (1998)]. Cercospora leaf spot is one of the most important and destructive fungal diseases in many countries in the world. Jacobsen and Franc (2009) stated that conducted a study to examined fungal diseases infecting watermelon (*Citrullus vulgaris*) plants and found that watermelon samples were infected by *Cercospora citrullina.* Meah and Khan (1987) stated that among the fungal diseases, cercospora leaf spot is one of the major problems in Bangladesh.

Cercospora leaf spot occured on all cucurbits but is most common on watermelon, cantaloupe, and cucumber. On watermelon, cercospora leaf spots manifested on young leaves as small grey or white spots with black margins. Larger leaf spots which are circular to irregularly circular developed on other cucurbits. The centers of these leaf spots are tan to light brown became transparent and brittle with time. Lesions with surrounding chlorotic halos were coalesce and turned leaves yellow. Typically, older, lower leaves exhibit symptoms first and have a more severe

infection, with a greater number of lesions and increased spot size (Weiland and Koch 2004). Cercospora leaf spot presents as circular, necrotic grey or beige spots with a purple or reddish-brown border (Weiland and Koch 2004, Harveson 2013) and within 5-21 days post infection (dpi) the first symptoms could be seen (Windels *et al*. 1998, Vereijssen 2004). The symptom observed in the present study is in accordance with findings of the reported literatures.

4.1.3 Anthracnose

The symptom of anthracnose appeared as small, dark-brown spots on the leaves and fruits of watermelon plants. Orange or pink spores formed in the center of large spots during wet weather, while gray spores formed during dry weather (Plate - 5 A and B).

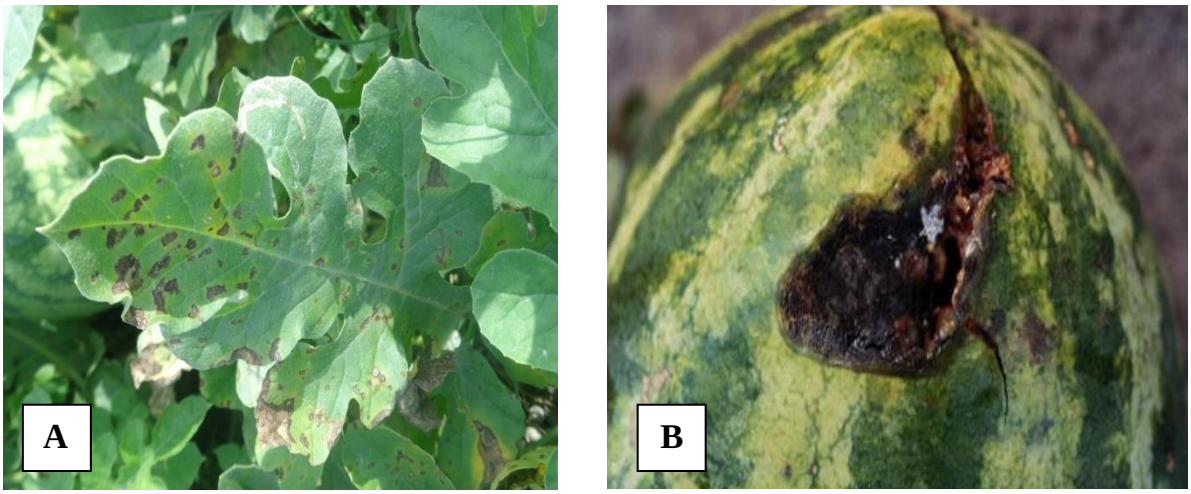

Plate 5. A and B showing symptoms of anthracnose on leaf and fruit

The pathogen isolated from the diseased symptom was identified as *Colletotrichum lagenarium* (Plate - 6 A, B and C) by observed the conidia were dark coloured, single cell barrel shaped.

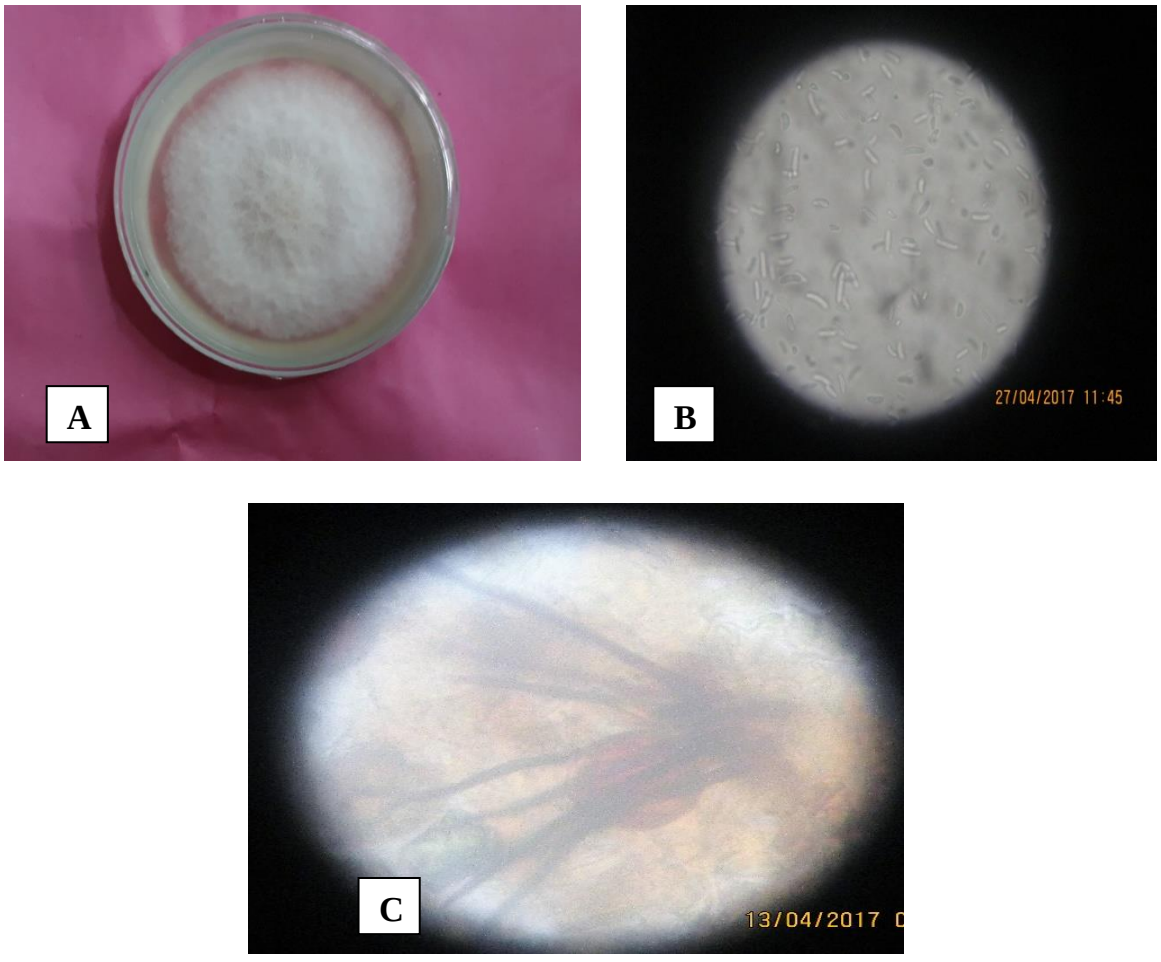

Plate 6. A – Pure culture of *Colletotrichum lagenarium*, B – Conidia and C – Conidiophore of *Colletotrichum lagenarium* produced in culture.

Anthracnose disease in watermelon is also reported by many researchers around the world [Bertelsen *et al*. (1994); Kurowski *et al*. (2015); Roberts and Kucharek (2005); Hyde *et al*. (2009) and Cannon *et al*. (2008)]. This disease is most commonly found on cucumber, melon and watermelon. Symptoms on leaves as water-soaked spots which typically became yellowish in appearance with dark brown to black on watermelon. These spots eventually turned brown and expanded

over the leaf surface. Foliar lesions are not restricted by leaf veins and often have cracked centers. Infected fruit developed circular, sunken, blackish lesions where tiny fruiting bodies (acervuli) were developed. When pedicels of young fruit became infected, the fruit may shrivel and abort (Kurowski *et al*. 2015). Anthracnose, caused by the fungus *Colletotrichum lagenarium*. This disease attacked with watermelon, cantaloupe, cucumber, and gourds. All above-ground plant parts are susceptible to infection, and plants became infected at any stage in their development. Older leaves first showed small, water-soaked, or yellowish areas that enlarge rapidly and turned tan to reddish brown (most cucurbits) or black (watermelon). Spots are often circular to angular (Sikora, 2011). The symptom observed in the present study is in accordance with findings of the reported literatures.

4.1.4 Mosaic

When plants became infected in the 6 to 8 leaf stage, symptoms first appeared on the youngest, still expanding leaves. A mosaic pattern develops-healthy, dark-green leaf tissue intermingled with light-green and yellow tissue. Leaves are often distorted, crinkled, curled, and stunted. In severe cases, older leaves were died (Plate – 7 A and B).

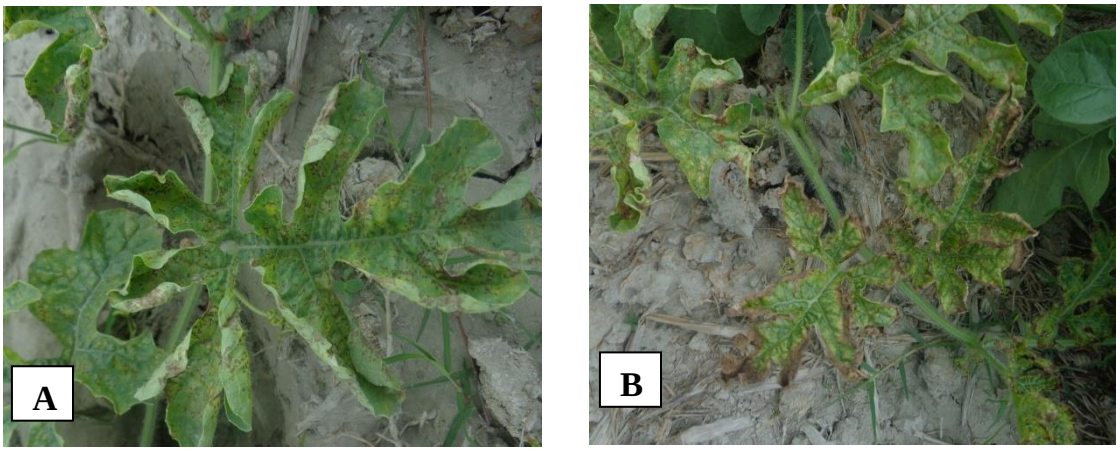

Plate 7. A and B showing symptoms of watermelon *Mosaic virus*

Mosaic disease in watermelon is also reported by many researchers around the world [Atiri and Ibidapo (1989); Sikora, 2011; Webb and Linda (1993);]. Watermelon are susceptible to mosaic virus at any stage of growth. Symptoms first appeared on the youngest, still expanding leaves. A mosaic pattern developed healthy, dark-green leaf tissue intermingled with light-green and yellow tissue. Leaves are often distorted, crinkled, curled, and stunted. Vines may appeared bunchy because of the shortening of the internodes. In severe cases, older leaves were died (Sikora, 2011). Mainly watermelon mosaic virus is transmitted by vectors. This virus is spread by many aphid species including *Myzus persicae* (green peach aphid) and *Aphis gossypii* (melon aphid). The primary mode of transmission is by aphids in a non-persistent manner, although the virus can also be mechanically transmitted through equipment but aphids are the primary vector (Kurowski *et al*. 2015). They aslo reported that mosaic virus is an aphid-borne virus that infects a wide range of plant species including vegetable crops and weeds. Mosaic virus is also reported to be seed borne in some weed species. (Atiri and Ibidapo 1989) reported that mosaic virus reduces the crop growth. The symptom observed in the present study corroborates the findings of the reported literatures.

4.1.5 Rhizopus soft rot

The symptom of rhizopus soft rot appeared as large, water-soaked spots with defined margins developed. Later the water-soaked spots became soft and sunken (Plate – 8).

Plate 8. Showing symptoms of Rhizopus soft rot of watermelon

Rhizopus species grew as filamentous, branching hyphae that lack crosswalls (i.e., they were coenocytic). Mass of mycelium, vegetative filaments and a fruiting structure of rhizopus soft rot were observed (Plate 9. A and B).

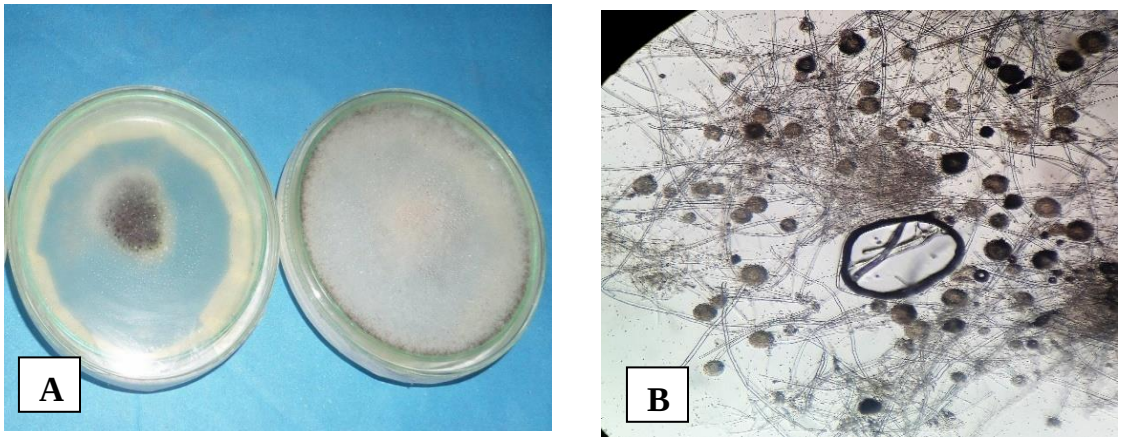

Plate 9. A – Pure culture of *Rhizopus stolonifer*, B – Sporangium and sporangiospore of *Rhizopus stolonifer* produced in culture

Rhizopus soft rot disease in watermelon is also reported by many researchers around the world [Agrios (1997); Alvarez and Nishijima (1987); Kurowski *et al.* (2015);]. Rhizopus soft rot caused by *Rhizopus stolonifer* which is on host of Cantaloupe, Cucumber, Squash, Watermelon. Many symptoms were appeared in fruit. Large, water-soaked spots with defined margins develop on fruit. Later the

water-soaked spots became soft and sunken. Gray fungal mycelium grew in the seed cavity (Kurowski *et al*. 2015). Agrios, (1997) conducted a study to examine fungal diseases infecting watermelon (*Citrullus lanatus* Thunb.) plants and found that, watermelon samples were infected by *Rhizopus stolonifer*. They also stated that the mycelium of the rhizopous soft rot produced long, aerial sporangiophores at the tips of which black spherical sporangia developed. The symptom observed in the present study is in accordance with findings of the reported literatures.

4.2. Survey on the prevalence of watermelon diseases in different study area of patuakhali district

Disease incidence and severity in watermelon leaves and fruits was recorded in different study locations of Patuakhali district (Table 2). In Amkhola and Panpatty unions of Galachipa uapzilla, 4 diseases were recorded on watermelon leaves and fruits which were alternaria leaf spot, cercospora leaf spot, anthracnose and mosaic. The same 4 diseases were also found in Mithaganj, Dhankhali and Dhulaswar unions of Kalapara uapzilla; and in Lohalia and Chhota Bighai unions of Patuakhali Sadar uapzilla. But in Golkhali union of Galachipa uapzilla and Auliapur union of Patuakhali Sadar uapzilla, 5 diseases were recorded on watermelon leaves and fruits which were alternaria leaf spot, cercospora leaf spot, anthracnose, mosaic virus and rhizopus soft rot.

Foliar diseases of watermelon (*Citrullus lanatus* Thunb.) are aslo reported by many researchers around the world [Amadi *et al*. (2008); Hochmuth et al. (1997); Maynard (2003); Roberts and Kucharek (2005); Zitter *et al*. (1996); Cannon *et al*. (2008) and Adaskaveg (2011)]. Zitter *et al*. (1996) reported that anthracnose, alternaria leaf spot, cercospora leaf spot, and downy mildew as predominant foliar diseases encountered by U.S. grewers. Amadi *et al*. (2008) reported that it is a popular cash crop grown by farmers during the dry season due to its high returns in investment, especially those residing near the urban areas. Diseases play an

important role in reducing the quality and quantity of cultivated crops, several diseases attack watermelon, some of which include Alternaria leaf spot, Alternaria leaf blight, Anthracnose, Cercospora leaf spot, Fusarium wilt, Downy mildew, Powdery mildew, damping-off, Bacterial leaf spot, Leaf mosaic etc. The most important fungal diseases are gummy stem blight (caused by *Didymella bryoniae/Phoma cucurbitacearum*) downy mildew (caused by *Pseudoperonospora cubensis*), bacterial fruit blotch (caused by *Acidovorax avenae* subsp. *citrulli*), alternaria leaf spot (caused by *Alternaria alternata*), fusarium wilt (caused by *Fusarium oxysporum* f.sp. *niveum*), anthracnose (caused by *Colletotrichum orbiculare*), and powdery mildew (caused by *Erysiphe cichoracearum*). Blossom end rot, a physiological disorder related to calcium deficiency and water stress, is also an occasional problem. Finally, Cercospora leaf spot (caused by *Cercospora citrullina*) and southern blight (also called southern stem rot or white mold and caused by *Sclerotium rolfsii*) *are* only rarely seen on watermelon diseases (Hochmuth et al. 1997; Maynard 2003; Roberts and Kucharek 2005).

Table 2. Prevalence of diseases found in watermelon diseasesin selected locations of Patuakhali district

Sl. No.	Location		Variety cultivated in inspected area	Identified diseases
	Name of Uapzilla	Name of Unions		
1.	Galachipa	Amkhola	Hybrid -Big family	Alternaria leaf spot, cercospora leaf spot, anthracnose and mosaic
2.		Golkhali	Hybrid – Dragon	Alternaria leaf spot, cercospora leaf spot, anthracnose, mosaic and rhizopus soft rot (fruit)
3.		Panpatty	Hybrid -Big family	Alternaria leaf spot, cercospora leaf spot, anthracnose and mosaic
4.	Kalapara	Mithaganj	Hybrid -Big family	Alternaria leaf spot, cercospora leaf spot, anthracnose and mosaic
5.		Dhankhali	Hybrid - Dragon	Alternaria leaf spot, cercospora leaf spot, anthracnose and mosaic
6.		Dhulaswar	Hybrid -Big family	Alternaria leaf spot, cercospora leaf spot, anthracnose and mosaic
7.	Patuakhali Sadar	Auliapur	Hybrid -Big family	Alternaria leaf spot, cercospora leaf spot, anthracnose, mosaic and rhizopus soft rot (fruit)
8.		Lohalia	Hybrid -Big family	Alternaria leaf spot, cercospora leaf spot, anthracnose and mosaic
9.		Chhota Bighai	Hybrid -Big family	Alternaria leaf spot, cercospora leaf spot, anthracnose and mosaic

4.2.1. Incidence and severity of watermelon diseases in Amkhola Union

Disease incidence on watermelon in Amkhola union caused by different pathogen found at different DAS (Table3 and Appendix III). Results showed that among the identified fungal diseases the maximum disease incidence was recorded in cercospora leaf spot which caused by *Cercospora citrullina* at all DAS (12.25, 21.60 and 36.60% at 30, 45 and 60 DAS respectively). Among the fungal diseases percent disease incidences of anthracnose was also higher. Mosaic disease caused by *mosaic virus* showed the minimum disease incidence at all DAS (7.40, 14.88 and 20.68% at 30, 45 and 60 DAS respectively).

Disease severity on watermelon in Amkhola union caused by different pathogen also found at different DAS (Table 3 and Appendix III). In case of disease severity, among the identified fungal disease cercospora leaf spot showed the maximum disease severity at all DAS (11.66, 18.75 and 32.41% at 30, 45 and 60 DAS respectively) where mosaic disease showed the lowest disease severity were recorded in all DAS (5.22, 11.80 and 16.50% at 30, 45 and 60 DAS respectively).

Table 3. Incidence and severity of different disease of watermelon in Amkhola Union under Galachipa Upazilla of Patuakhali district

Name of diseases	% Disease Incidence at			% Disease severity at		
	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS
Alternaria leaf spot	8.18	17.20	34.36	7.10	15.60	32.40
Cercospora leaf spot	12.25	21.60	36.60	11.66	18.75	32.41
Anthracnose	10.11	18.52	33.12	8.70	16.20	30.44
Mosaic	7.40	14.88	20.68	5.22	11.80	16.50
$LSD_{0.05}$	1.014	1.104	2.114	1.026	1.310	1.018
CV (%)	5.217	7.224	6.315	4.311	6.227	6.319

4.2.2 Incidence and severity of watermelon diseases in Golkhali Union

Disease incidence on watermelon in Golkhali Union caused by different pathogen found at different DAS (Table 4 and Appendix IV). Results showed that among the identified fungal diseases the highest disease incidence was recorded in anthracnose which caused by *Colletotrichum lagenarium* at all DAS (11.36, 22.71 and 35.80% at 30, 45 and 60 DAS respectively). Among the fungal diseases percent disease incidences of alternaria leaf spot was also higher. Rhizopus soft rot caused by *Rhizopus stolonifer* showed the lowest disease incidence at all DAS (2.90, 6.44 and 9.16% at 30, 45 and 60 DAS respectively).

Disease severity on watermelon in Golkhali Union caused by different pathogen found at different DAS (Table 4 and Appendix IV). In case of disease severity, among the identified fungal disease anthracnose showed the highest disease severity at all DAS (8.80, 20.14 and 29.74% at 30, 45 and 60 DAS respectively) caused by *Colletotrichum lagenarium*. Rhizopus soft rot caused by *Rhizopus stolonifer* showed the lowest disease severity in all DAS (1.10, 4.20 and 6.80% at 30, 45 and 60 DAS respectively).

Table 4. Diseases incidence and severity of watermelon in Golkhali Union under Galachipa Upazilla of Patuakhali district

Name of diseases	% Disease Incidence at			% Disease severity at		
	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS
Alternaria leaf spot	10.54	19.16	33.47	7.66	17.24	30.10
Cercospora leaf spot	8.40	20.60	30.18	5.66	15.74	25.52
Anthracnose	11.36	22.71	35.80	8.80	20.14	29.74
Mosaic	6.14	16.64	28.24	4.44	12.18	22.70
Rhizopus soft rot	2.90	6.44	9.16	1.10	4.20	6.80
$LSD_{0.05}$	0.617	1.073	1.058	1.019	2.317	1.324
CV (%)	5.820	6.389	6.446	6.311	8.247	5.214

4.2.3 Incidence and severity of watermelon diseases in Panpatty Union

Disease incidence on watermelon in Panpatty Union caused by different pathogen found at different DAS (Table 5 and Appendix V). Results showed that among the identified fungal diseases the highest disease incidence was recorded in alternaria leaf spot which caused by *Alternaria alternata*at at all DAS (13.20, 24.16 and 36.17% at 30, 45 and 60 DAS respectively). Among the fungal diseases percent disease incidences of anthracnose was also higher. Mosaic disease caused by *cucumber mosaic virus* showed the lowest disease incidence at all DAS (7.44, 14.32 and 21.44% at 30, 45 and 60 DAS respectively).

Disease severity on watermelon in Panpatty Union caused by different pathogen also found at different DAS (Table 5 and Appendix V). In case of disease severity, among the identified fungal disease alternaria leaf spot showed the highest disease severity at all DAS (10.60, 20.74 and 33.10% at 30, 45 and 60 DAS respectively). Mosaic disease showed the lowest disease severity in all DAS (4.88, 10.60 and 17.71% at 30, 45 and 60 DAS respectively).

Table 5. Disease incidence and severity of watermelon in Panpatty Union under Galachipa Upazilla of Patuakhali district

Name of diseases	% Disease Incidence at			% Disease severity at		
	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS
Alternaria leaf spot	13.20	24.16	36.17	10.60	20.74	33.10
Cercospora leaf spot	9.33	21.11	33.10	7.48	18.40	27.94
Anthracnose	11.91	20.27	31.42	8.74	19.18	29.20
Mosaic	7.44	14.32	21.44	4.88	10.10	17.71
$LSD_{0.05}$	2.017	0.861	1.524	1.046	0.773	1.521
CV (%)	6.317	4.119	5.324	5.118	4.724	6.311

4.2.4 Incidence and severity of watermelon diseases in Mithaganj Union

Disease incidence on watermelon in Mithaganj Union caused by different pathogen found at different DAS (Table 6 and Appendix VI). Results showed that among the identified fungal diseases the highest disease incidence was recorded in cercospora leaf spot which caused by *Cercospora citrullina* at all DAS (13.40, 22.18 and 34.50% at 30, 45 and 60 DAS respectively). Among the fungal diseases percent disease incidences of alternaria leaf spot was also higher. Mosaic disease caused by *mosaic virus* showed the lowest disease incidence at all DAS (5.62, 10.74 and 22.80% at 30, 45 and 60 DAS respectively).

Disease severity on watermelon in Mithaganj Union caused by different pathogen also found at different DAS (Table 6 and Appendix VI). In case of disease severity, among the identified fungal disease cercospora leaf spot showed the highest disease severity at all DAS (10.16, 20.40 and 31.77% at 30, 45 and 60 DAS respectively). Mosaic disease showed the lowest disease severity at all DAS (3.80, 8.36 and 20.20% at 30, 45 and 60 DAS respectively).

Table 6. Diseases incidence and severity of watermelon in Mithaganj Union under Kalapara Upazilla of Patuakhali district

Name of diseases	% Disease Incidence at			% Disease severity at		
	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS
Alternaria leaf spot	10.30	20.66	26.40	8.44	18.48	24.56
Cercospora leaf spot	13.40	22.18	34.50	10.16	20.40	31.77
Anthracnose	8.22	14.70	29.75	6.18	12.28	24.66
Mosaic	5.62	10.74	22.80	3.80	8.36	20.20
$LSD_{0.05}$	1.784	1.319	2.478	0.726	1.322	2.149
CV (%)	4.227	4.639	5.114	3.880	5.217	6.114

4.2.5 Incidence and severity of watermelon diseases in Dhankhali Union

Disease incidence on watermelon in Dhankhali Union caused by different pathogen found at different DAS (Table 7 and Appendix VII). Results showed that among th+e identified fungal diseases the highest disease incidence was recorded in alternaria leaf spot which caused by *Alternaria alternate* at all DAS (14.88, 24.36 and 36.20% at 30, 45 and 60 DAS respectively). Mosaic disease caused by *mosaic virus* showed the lowest disease incidence at all DAS (6.45, 12.54 and 23.60% at 30, 45 and 60 DAS respectively).

Disease severity on watermelon in Dhankhali Union caused by different pathogen also found at different DAS (Table 7 and Appendix VII). In case of disease severity, among the identified fungal disease alternaria leaf spot showed the highest disease severity at all DAS (12.40, 21.65 and 33.50% at 30, 45 and 60 DAS respectively) Mosaic disease showed the lowest disease severity at all DAS (4.22, 8.36 and 20.60% at 30, 45 and 60 DAS respectively).

Table 7. Diseases incidence and severity of watermelon in Dhankhali Union under Kalapara Upazilla of Patuakhali district

Name of diseases	% Disease Incidence at			% Disease severity at		
	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS
Alternaria leaf spot	14.88	24.36	36.20	12.40	21.65	33.50
Cercospora leaf spot	8.34	17.30	29.56	7.10	15.30	26.62
Anthracnose	11.40	22.71	33.45	10.18	19.74	30.52
Mosaic	6.45	12.54	23.60	4.22	8.36	20.60
$LSD_{0.05}$	1.544	2.071	2.349	0.866	1.172	1.068
CV (%)	3.216	5.114	6.076	3.078	4.834	5.866

4.2.6 Incidence and severity of watermelon diseases in Dhulaswar Union

Significant variation was found in Dhulaswar Union due to disease incidence on watermelon caused by different pathogen at different DAS (Table 8 and Appendix VIII). Results showed that among the identified fungal diseases the highest disease incidence was recorded in cercospora leaf spot which caused by *Cercospora citrullina* at all DAS (10.66, 21.87 and 33.70% at 30, 45 and 60 DAS respectively). Among the fungal diseases percent disease incidences of alternaria leaf spot was also higher. Mosaic disease caused by *mosaic virus* showed the lowest disease incidence at all DAS (5.32, 12.75 and 18.71% at 30, 45 and 60 DAS respectively).

Disease severity on watermelon in Dhulaswar Union caused by different pathogen also found at different DAS (Table 8 andAppendix VIII). In case of disease severity, among the identified fungal disease cercospora leaf spot showed the highest disease severity at all DAS (7.44, 18.75 and 29.88% at 30, 45 and 60 DAS respectively) where Mosaic disease showed the lowest disease severity in DAS (3.30, 10.18 and 15.710% at 30, 45 and 60 DAS respectively).

Table 8. Diseases incidence and severity of watermelon in Dhulaswar Union under Kalapara Upazilla of Patuakhali district

Name of diseases	% Disease Incidence at			% Disease severity at		
	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS
Alternaria leaf spot	8.78	20.14	31.84	7.14	18.12	30.56
Cercospora leaf spot	10.66	21.87	33.70	7.44	18.75	29.88
Anthracnose	7.10	16.62	27.40	5.20	14.40	24.70
Mosaic	5.32	12.75	18.71	3.30	10.18	15.71
$LSD_{0.05}$	0.877	1.215	1.083	0.742	1.526	1.066
CV (%)	4.715	6.219	5.711	4.627	5.834	7.229

4.2.7 Incidence and severity of watermelon diseases in Auliapur Union

Disease incidence on watermelon in Auliapur Union caused by different pathogen found at different DAS (Table 9 and Appendix IX). Results showed that among the identified fungal diseases the highest disease incidence was recorded in anthracnose which caused by *Colletotrichum lagenarium* at all DAS (13.60, 24.72 and 35.40% at 30, 45 and 60 DAS respectively). Among the fungal diseases percent disease incidence of alternaria leaf spot was also higher. Rhizopus soft rot disease caused by *Rhizopus stolonifer* showed the lowest disease incidence at all DAS (3.50, 7.12 and 9.36% at 30, 45 and 60 DAS respectively).

Disease severity on watermelon in Auliapur Union caused by different pathogen found at different DAS (Table 9 and Appendix IX). In case of disease severity, among the identified fungal disease anthracnose showed the highest disease severity at all DAS (10.42, 25.10 and 32.30% at 30, 45 and 60 DAS respectively) caused by *Colletotrichum lagenarium*. Rhizopus soft rot disease caused by *Rhizopus stolonifer* showed the lowest disease severity in all DAS (1.60, 5.10 and 8.20% at 30, 45 and 60 DAS respectively).

Table 9. Diseases incidence and severity of watermelon in Auliapur Union under Patuakhali Sadar Upazilla of Patuakhali district

Name of diseases	% Disease Incidence at			% Disease severity at		
	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS
Alternaria leaf spot	10.74	21.38	32.52	9.11	18.78	30.10
Cercospora leaf spot	8.80	17.36	28.60	7.20	15.16	29.50
Anthracnose	13.60	24.72	35.40	10.42	25.10	32.30
Mosaic	5.50	11.73	20.44	4.10	8.38	18.24
Rhizopus soft rot	3.50	7.12	9.36	1.60	5.10	8.20
$LSD_{0.05}$	0.744	1.316	2.014	1.119	2.188	1.705
CV (%)	5.712	4.934	7.137	5.117	5.614	7.831

4.2.8 Incidence and severity of watermelon diseases in Lohalia Union

Disease incidence on watermelon in Lohalia Union caused by different pathogen found at different DAS (Table 10 and Appendix X). Results showed that among the identified fungal diseases the highest disease incidence was recorded in mosaic which caused by *mosaic virus* at all DAS (8.66, 19.37 and 28.52% at 30, 45 and 60 DAS respectively). Among the fungal diseases percent disease incidences of anthracnose was also higher caused by *Colletotrichum lagenarium*. Cercospora leaf spot diseases caused by *Cercospora citrullina* showed the lowest disease incidence at all DAS (6.48, 14.75 and 22.67% at 30, 45 and 60 DAS respectively).

Disease severity on watermelon in Lohalia Union caused by different pathogen found at different DAS (Table 10 and Appendix X). In case of disease severity, among the identified fungal disease mosaic virus showed the highest disease severity at all DAS (6.17, 18.12 and 24.75% at 30, 45 and 60 DAS respectively) where cercospora leaf spot disease showed the lowest disease severity in DAS (5.30, 12.80 and 20.44% at 30, 45 and 60 DAS respectively).

Table 10. Diseases incidence and severity of watermelon in Lohalia Union under Patuakhali Sadar Upazilla of Patuakhali district

Name of diseases	% Disease Incidence at			% Disease severity at		
	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS
Alternaria leaf spot	7.10	16.88	24.32	6.44	15.28	22.10
Cercospora leaf spot	6.48	14.75	22.67	5.30	12.80	20.44
Anthracnose	8.17	18.20	24.71	5.55	16.48	20.94
Mosaic	8.66	19.37	28.52	6.17	18.12	24.75
$LSD_{0.05}$	0.612	1.552	1.715	0.541	0.876	1.319
CV (%)	5.319	6.248	5.119	5.221	4.316	7.118

4.2.9 Incidence and severity of watermelon diseases in Chhota Bighai Union

Disease incidence on watermelon in Chhota Bighai Union caused by different pathogen found at different DAS (Table 11 and Appendix XI). Results showed that among the identified fungal diseases the highest disease incidence was recorded in alternaria leaf spot which caused by *Alternaria alternate* at all DAS (8.88, 21.22 and 29.76% at 30, 45 and 60 DAS respectively). Among the fungal diseases percent disease incidences of anthracnose was also higher caused by *Colletotrichum lagenarium*. Mosaic diseases caused by *mosaic virus* showed the lowest disease incidence at all DAS (4.30, 8.92 and 16.60% at 30, 45 and 60 DAS respectively).

Disease severity on watermelon in Chhota Bighai Union caused by different pathogen found at different DAS (Table 11 and Appendix XI). In case of disease severity, among the identified fungal disease alternaria leaf spot showed the highest disease severity at all DAS (7.48, 20.66 and 26.90% at 30, 45 and 60 DAS respectively) where mosaic disease showed the lowest disease severity in all DAS (3.12, 7.24 and 14.77% at 30, 45 and 60 DAS respectively).

Table 11. Diseases incidence and severity of watermelon in Chhota Bighai Union under Patuakhali Sadar Upazilla of Patuakhali district

Name of diseases	% Disease Incidence at			% Disease severity at		
	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS
Alternaria leaf spot	8.88	21.22	29.76	7.48	20.66	26.90
Cercospora leaf spot	6.60	18.58	25.39	5.14	17.10	22.86
Anthracnose	8.66	22.40	28.10	6.84	20.71	24.38
Mosaic	4.30	8.92	16.60	3.12	7.24	14.77
$LSD_{0.05}$	0.745	1.068	1.417	0.634	2.119	1.512
CV (%)	4.337	5.689	7.116	4.312	6.551	6.418

It was observed that the incidence of alternaria leaf spot was found to be highest (20.84%) followed by anthracnose (20.39%), cercospora leaf spot (19.80%), mosaic (13.41%) and rhizopus soft rot (6.42%). Similarly, the highest disease severity (18.75%) was found for alternaria leaf spot followed by cercospora leaf spot (17.42%), anthracnose (16.47%), mosaic (11.30%) and rhizopus soft rot (4.50%).

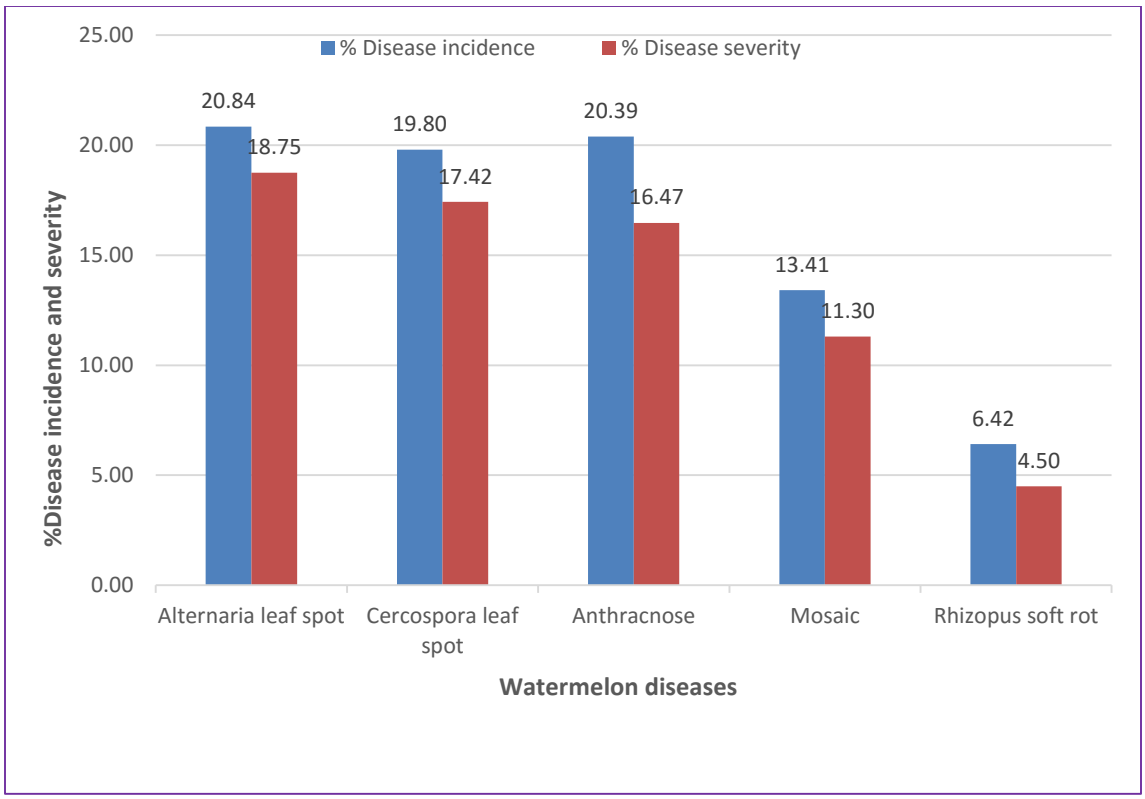

Fig. 1. Prevalence of disease incidence and severity of watermelon diseases at selected locations in Patuakhali district.

Regarding incidence and severity of watermelon diseases is also reported by many researchers throughout the world [El-Gali and El-Zahaf (2015); Islam *et al*. (2015); Mallek *et al*. (1995); Singh *et al.* (1997); Kok-Yokomi and Voegtlin (1994)]. El-Gali and El-Zahaf (2015) reported that alternaria leaf spot is one of the most important diseases. The overall mean disease incidence and disease severity in the adjoining areas ranged from 54 to 96% and 14 to 43.6% respectively. Among the fungal diseases, cercospora leaf spot of watermelon is one of the major problems in Bangladesh (Meah and Khan 1987). Islam *et al*. (2015) found that the highest disease incidence (38.6%) and severity (17.4%) of cercospora leaf spot of watermelon was recorded in Mymensingh district. Talhinhasac and Mota-Capita (2010) observed that anthracnose caused significant yield losses, and poor fruit quality. High anthracnose incidence was recorded with 41%. Disease severity was on average 36%, frequently reaching 100%. Watermelon mosaic virus infection in early season results in yield loss and reduced fruit quality (Webb, Kok-Yokomi, and Voegtlin 1994; Webb and Linda 1993). Singh *et al.* (1997) conducted a survey at Punjab in India and found that the highest incidence of rhizopus soft rot on watermelon (78.33%) and cucumber (80.07%) and the lowest incidence were recorded on cucumber 9.83% in arid irrigated zone. Mallek *et al*. (1995) pointed out that *R. stolonifer* from diseased watermelon was isolated in a frequency of 35.9% only overcame by *A. alternata* in a frequency of 57.7%.

4.3 Epidemiology of disease incidence and severity

4.3.1.1 Effect of different weather component on disease incidence and severity in Amkhola Union under Galachipa Upazilla of Patuakhali district

The incidence and severity of watermelon diseases was influenced by average temperature, relative humidity and rainfall (Fig. 2). The maximum incidence (31.19%) and severity (27.94%) was recorded in February (16-28), 2017 when the average temperature, relative humidity and rainfall were 23.60°C, 76.50% and 13.33 mm respectively. On the other hand, the minimum incidence(9.49%) and severity (8.17%) was recorded in January (15-30), 2017 when the average temperature, relative humidity and rainfall were 19.88°C, 73.80% and 4.52 mm respectively.

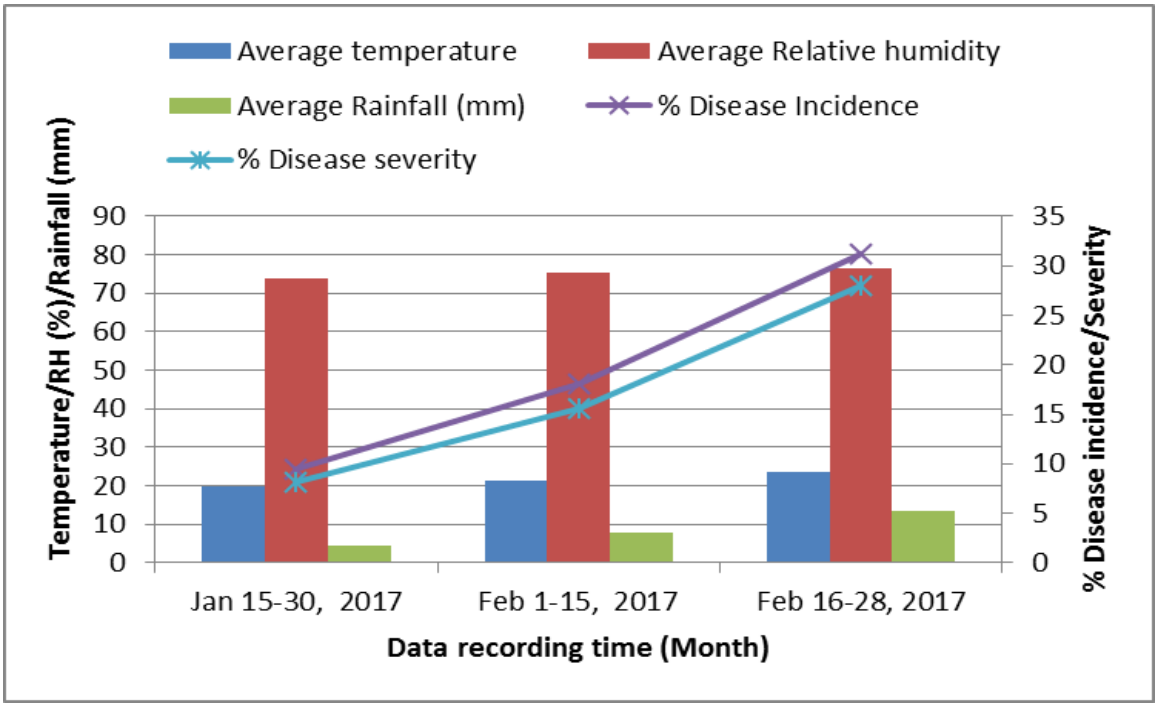

Fig. 2. Effect of temperature, relative humidity and rainfall on disease incidence and severity of watermelon in Amkhola Union under Galachipa Upazilla of Patuakhali district

4.3.1.2 Relationship between disease incidence as well as severity of watermelon and weather components in Amkhola Union under Galachipa Upazilla of Patuakhali district

A positive correlation was found between disease incidence of watermelon and weather component. The relationship between disease incidence with temperature, relative humidity and rainfall could be expressed by the equation Y=5.8463x-106.9(R^2=0.9995),Y=7.8427x-570.45 (R^2=0.949) and y=2.4556x-1.4433 R^2 = 0.9995, where x= temperature, relative humidity and rainfall and y= disease incidence. Here the R^2 value indicates that the contribution of weather components to the incidence in Amkhola Union. During the cropping period it was observed that disease incidence was increased with the increase of temperature, relative humidity and rainfall (Fig. 3). On the other hand, the relationship between disease severity with temperature, relative humidity and rainfall could be expressed by the equation Y=5.3379x-98.242 (R^2=0.9981), Y=7.128x-519.03 (R^2=0.939) and Y=2.2442x-1.9769 (R^2=1), where x= temperature, relative humidity and rainfall and y= disease severity. Here the R^2 value indicates that the contribution of weather components to the severity in Amkhola Union. During the cropping period it was also observed that disease severity was increased with the increase of temperature, relative humidity and rainfall (Fig. 3).

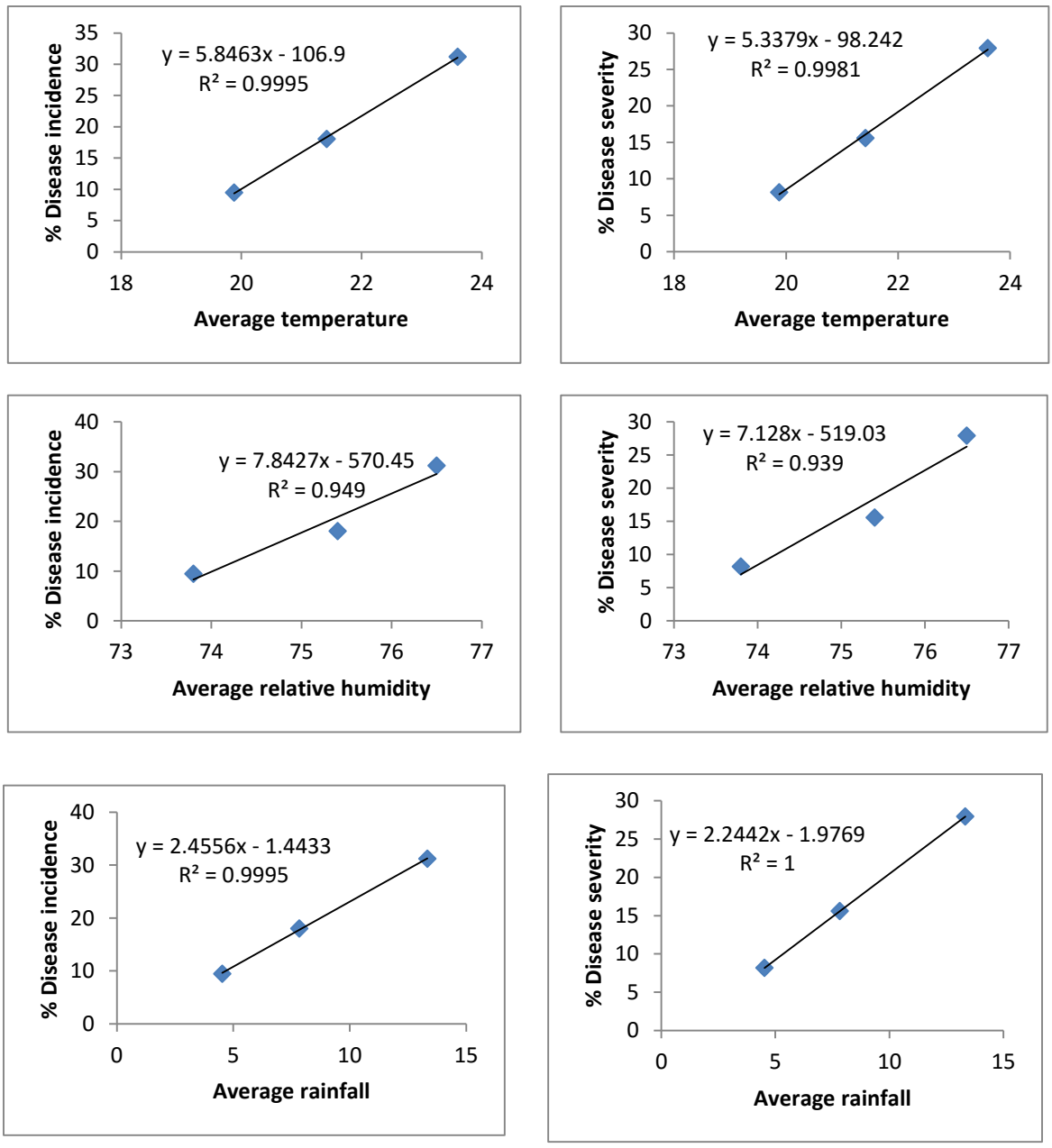

Fig. 3. Relationship between disease incidence and severity of watermelon with temperature, relative humidity and rainfall in Amkhola Union under Galachipa Upazilla of Patuakhali district

4.3.2.1 Effect of watermelon disease at different weather component on disease incidence and severity in Golkhali Union under Galachipa Upazilla of Patuakhali district

The incidence and severity of watermelon diseases was influenced by average temperature, relative humidity and rainfall (Fig. 4). The maximum incidence (27.37%) and severity (22.97%) was recorded in February (16-28), 2017 when the average temperature, relative humidity and rainfall were 23.60°C, 76.50% and 13.33 mm respectively. On the other hand, the minimum incidence (7.87%) and severity (5.53%) was recorded in January (15-30), 2017 when the average temperature, relative humidity and rainfall were 19.88°C, 73.80% and 4.52 mm respectively.

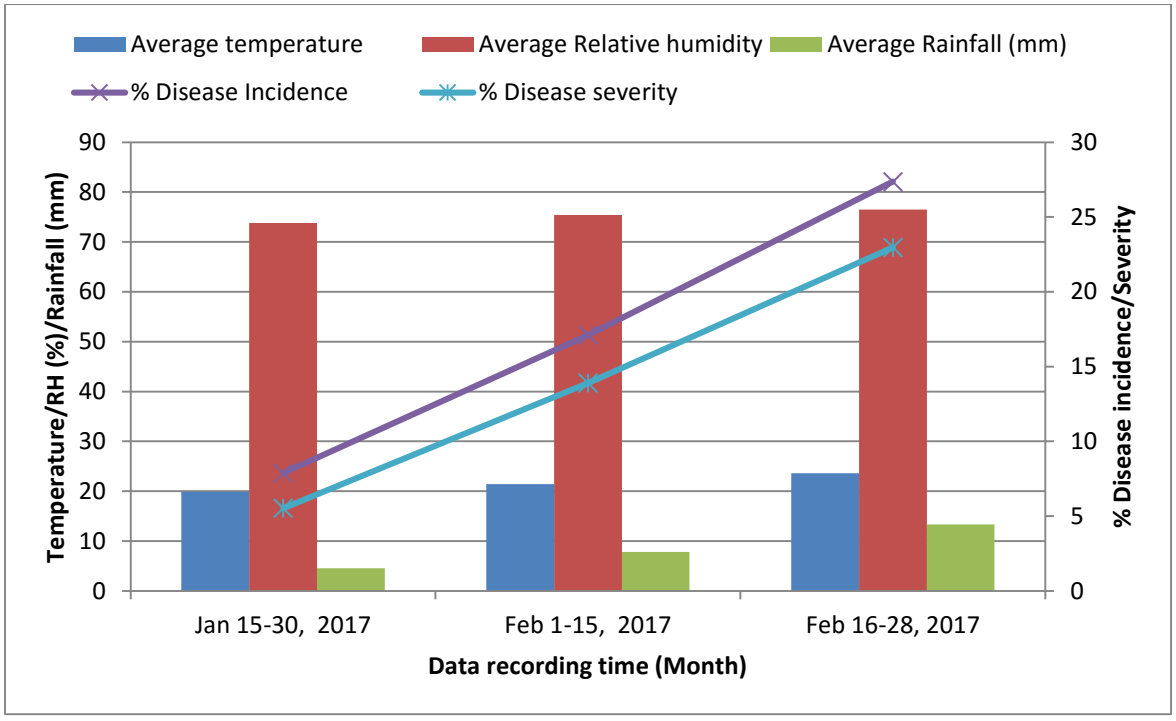

Fig. 4. Effect of temperature, relative humidity and rainfall on disease incidence and severity of watermelon in Golkhali Union under Galachipa Upazilla of Patuakhali district

4.3.2.2 Relationship between disease incidence as well as severity of watermelon and weather components in Golkhali Union under Galachipa Upazilla of Patuakhali district

A positive correlation was found between disease incidence of watermelon and weather component. The relationship between disease incidence with temperature, relative humidity and rainfall could be expressed by the equation Y=5.2063x-95.179 (R^2=0.9953), Y=7.1175x-518.03 (R^2=0.9814) and Y=2.178x-1.195 (R^2=0.9874), where x= temperature, relative humidity and rainfall and y= disease incidence. Here the R^2 value indicates that the contribution of weather components to the incidence in Golkhali Union. During the cropping period it was observed that disease incidence was increased with the increase of temperature, relative humidity and rainfall (Fig. 5). On the other hand, the relationship between disease severity with temperature, relative humidity and rainfall could be expressed by the equation Y=4.6531x-86.528 (R^2=0.9943), Y=6.3704x-465.14 (R^2=0.9833) and Y=1.9461x-2.525 (R^2=0.9858), where x= temperature, relative humidity and rainfall and y= disease severity. Here the R^2 value indicates that the contribution of weather components to the severity in Golkhali Union. During the cropping period it was also observed that disease severity was increased with the increase oftemperature, relative humidity and rainfall (Fig. 5).

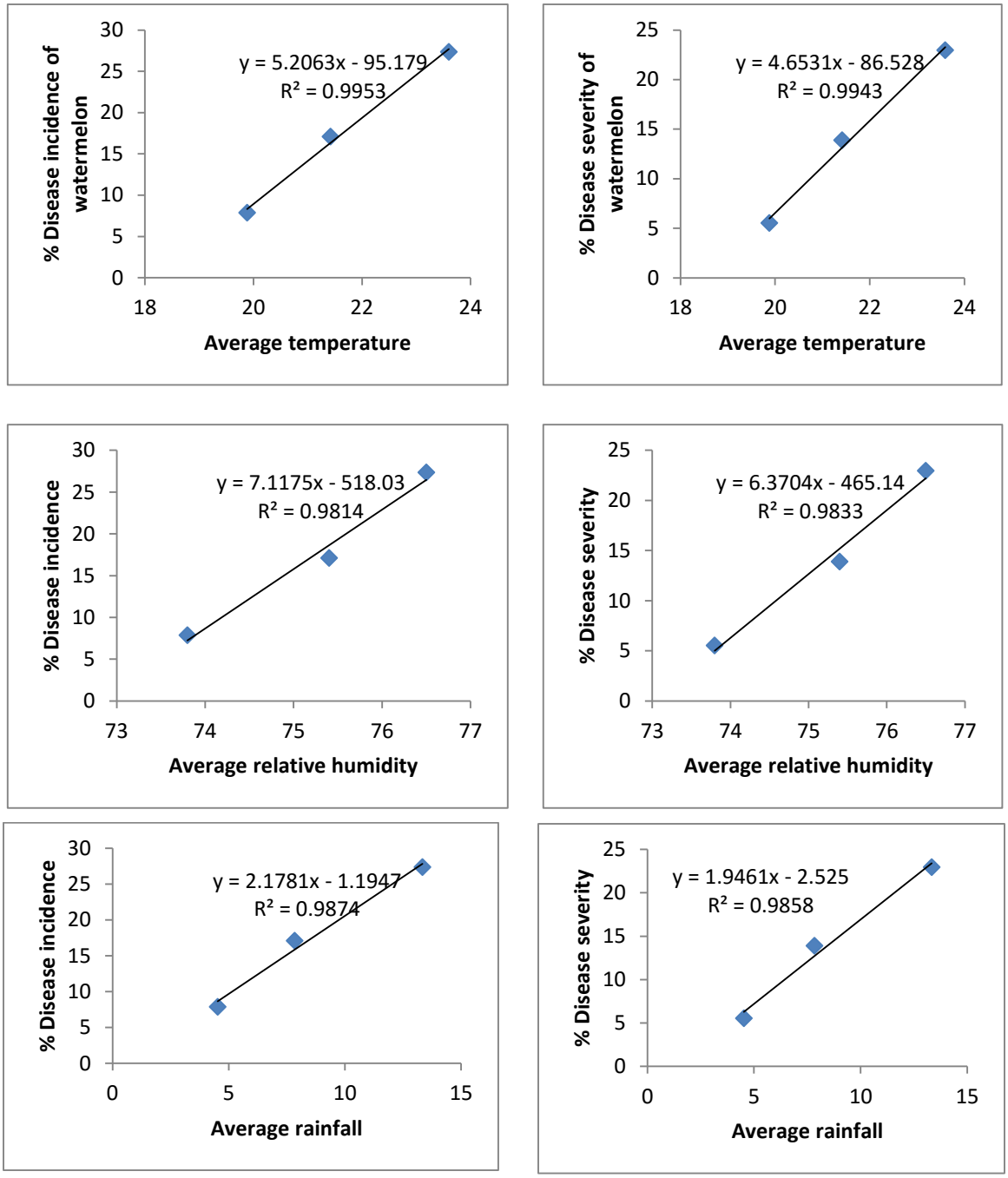

Fig. 5. Relationship between disease incidence and severity of watermelon with temperature, relative humidity and rainfall in Golkhali Union under Galachipa Upazilla of Patuakhali district

4.3.3.1 Effect of different weather component on disease incidence and severity in Panpatty Union under Galachipa Upazilla of Patuakhali district

The incidence and severity of watermelon diseases was influenced by average temperature, relative humidity and rainfall (Fig. 6). The maximum incidence (30.53%) and severity (26.99%) was recorded in February (16-28), 2017 when the average temperature, relative humidity and rainfall were 23.60°C, 76.50% and 13.33 mm respectively. On the other hand, the minimum incidence 10.47%) and severity (7.93%) was recorded in January (15-30), 2017 when the average temperature, relative humidity and rainfall were 19.88°C, 73.80% and 4.52 mm respectively.

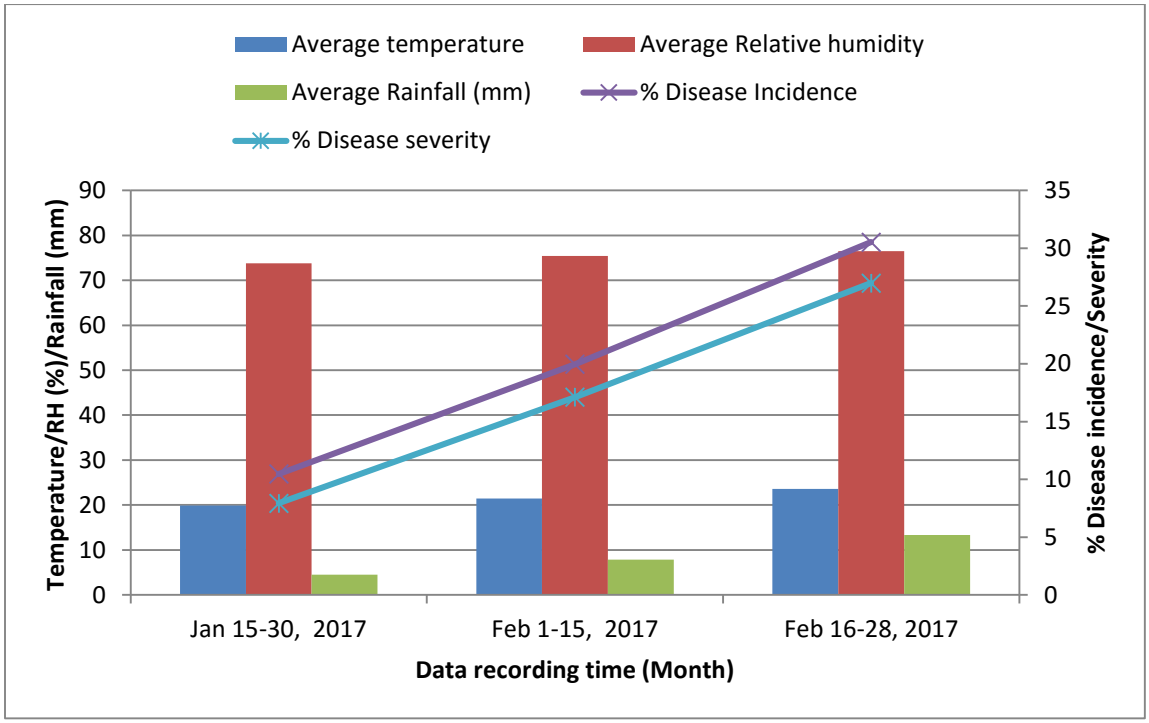

Fig. 6. Effect of temperature, relative humidity and rainfall on disease incidence and severity of watermelon in Panpatty Union under Galachipa Upazilla of Patuakhali district

4.3.3.2 Relationship between disease incidence as well as severity of watermelon and weather components in Panpatty Union under Galachipa Upazilla of Patuakhali district

A positive correlation was found between disease incidence of watermelon and weather component. The relationship between disease incidence with temperature, relative humidity and rainfall could be expressed by the equation Y=5.356x-95.544 (R^2=0.9953), Y=7.3217x-530.51 (R^2=0.9813) and Y=2.2408x-1.1423 (R^2=0.9875), where x= temperature, relative humidity and rainfall and y= disease severity. Here the R^2 value indicates that the contribution of weather components to the incidence in Panpatty Union. During the cropping period it was observed that disease incidence was increased with the increase of temperature, relative humidity and rainfall (Fig. 7). On the other hand, the relationship between disease severity with temperature, relative humidity and rainfall could be expressed by the equation Y=5.0843x-92.647 (R^2=0.994), Y=23.173x-49.705 (R^2=0.9872) and Y=2.1262x-0.8573 (R^2=0.9853), where x= temperature, relative humidity and rainfall and y= disease severity. Here the R^2 value indicates that the contribution of weather components to the severity in Panpatty union.. During the cropping period it was also observed that disease severity was increased with the increase of temperature, relative humidity and rainfall (Fig. 7).

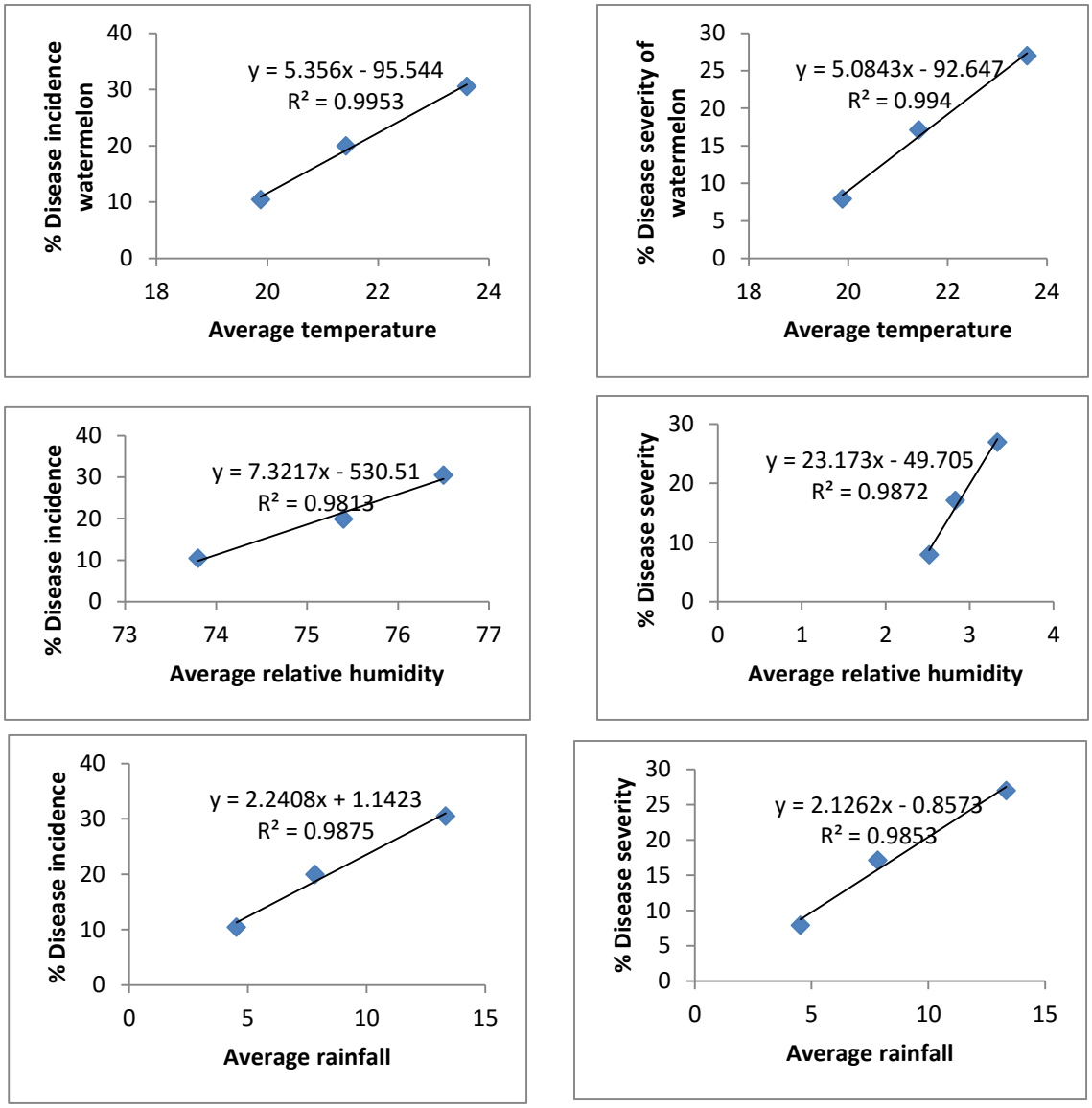

Fig. 7. Relationship between disease incidence and severity of watermelon with temperature, relative humidity and rainfall in Panpatty Union under Galachipa Upazilla of Patuakhali district

4.3.4.1 Effect of different weather component on disease incidence and severity in Mithaganj Union under Kalapara Upazilla of Patuakhali district

The incidence and severity of watermelon diseases was influenced by average temperature, relative humidity and rainfall (Fig. 8). The maximum incidence (28.36%) and severity (25.30%) was recorded in February (16-28), 2017 when the average temperature, relative humidity and rainfall were 23.60°C, 76.50% and 13.33 mm respectively. On the other hand, the minimum incidence (9.39%) and severity (7.15%) was recorded in January (15-30), 2017 when the average temperature, relative humidity and rainfall were 19.88°C, 73.80% and 4.52 mm respectively.

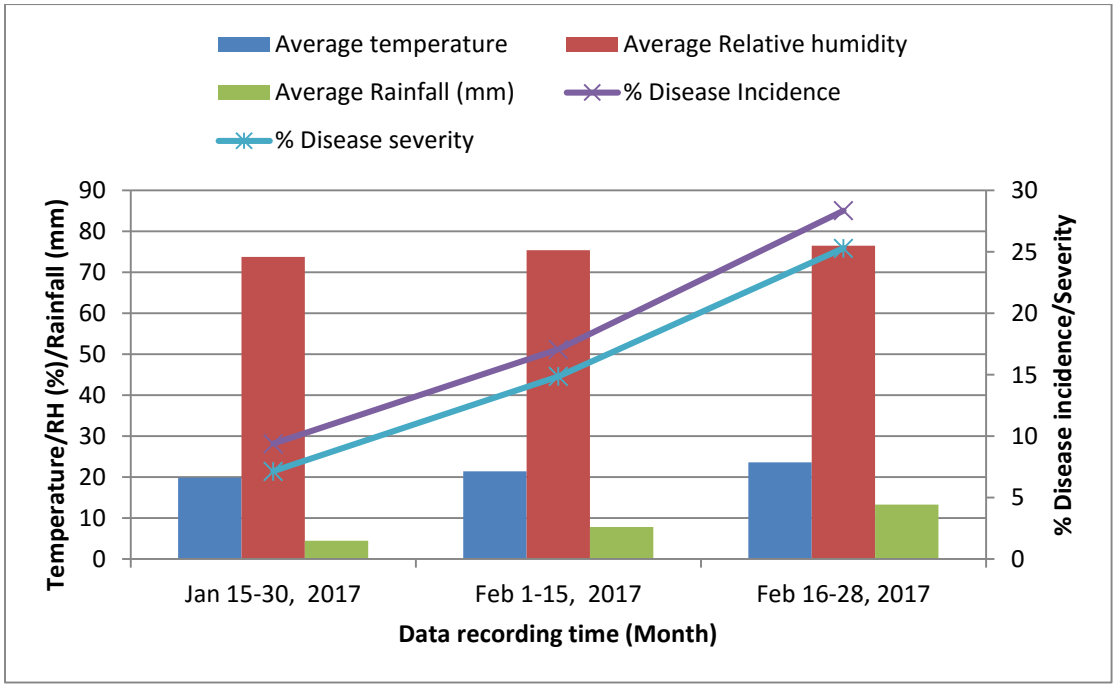

Fig. 8. Effect of temperature, relative humidity and rainfall on disease incidence and severity of watermelon in Mithaganj Union under Kalapara Upazilla of Patuakhali district

4.3.4.2 Relationship between disease incidence as well as severity of watermelon and weather components in Mithaganj Union under Kalapara Upazilla of Patuakhali district

A positive correlation was found between disease incidence of watermelon and weather component. The relationship between disease incidence with temperature, relative humidity and rainfall could be expressed by the equation Y=5.104x-92.159 (R^2=0.9999), Y=6.8649x-498.2 (R^2=0.9541) and Y=2.143x-0.0711 (R^2=0.9989), where x= temperature, relative humidity and rainfall and y= disease incidence. Here the R^2 value indicates that the contribution of weather components to the incidence in Mithaganj Union. During the cropping period it was observed that disease incidence was increased with the increase of temperature, relative humidity and rainfall (Fig. 9). On the other hand, the relationship between disease severity with temperature, relative humidity and rainfall could be expressed by the equation Y=4.8724x-86.528 (R^2=0.9998), Y=6.5854x-479.67 (R^2=0.9636) and Y=2.043x-1.7146 (R^2=0.9967), where x= temperature, relative humidity and rainfall and y= disease severity. Here the R^2 value indicates that the contribution of weather components to the severity in Mithaganj Union. During the cropping period it was also observed that disease severity was increased with the increase of temperature, relative humidity and rainfall (Fig. 9).

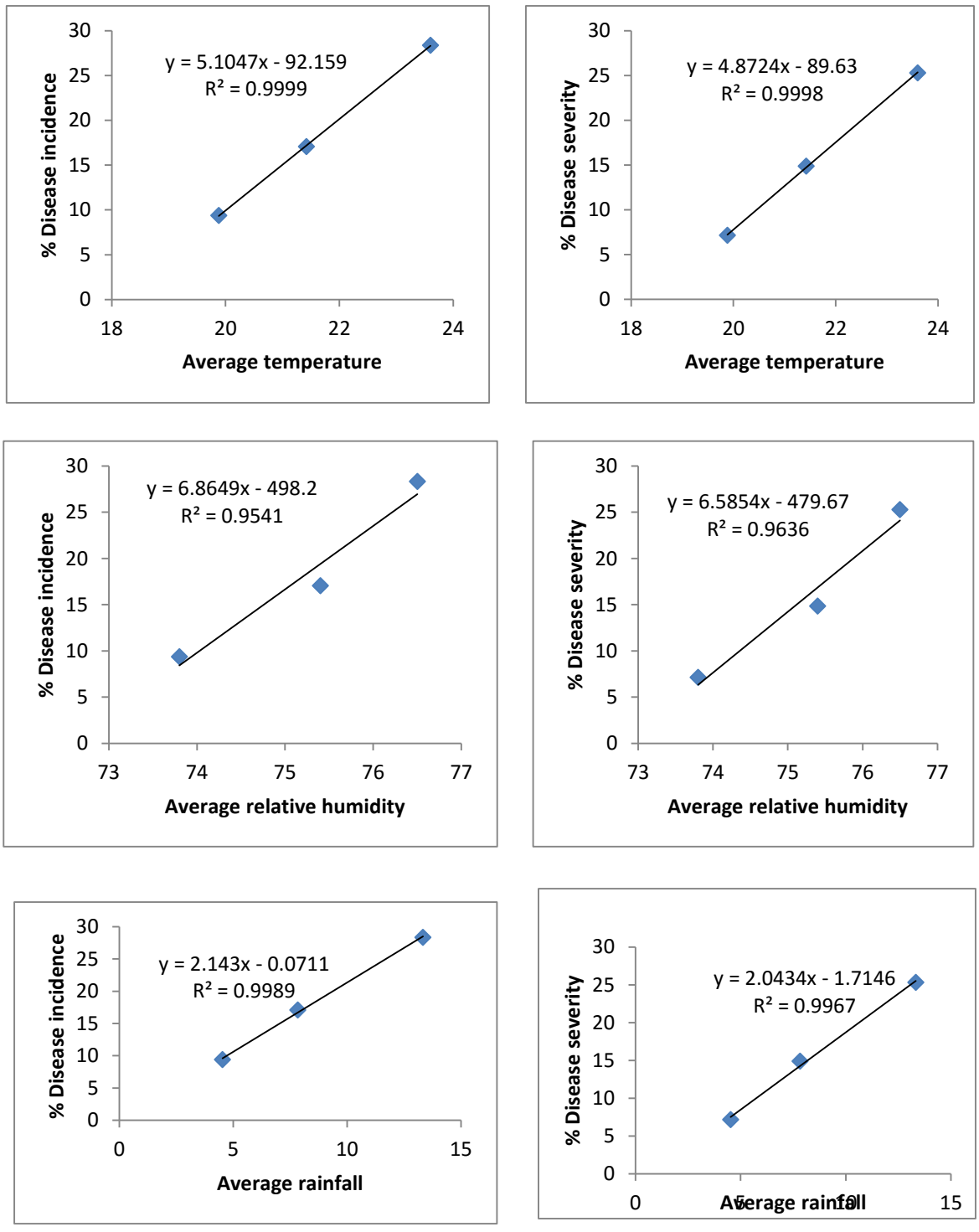

Fig. 9. Relationship between disease incidence and severity of watermelon with temperature, relative humidity and rainfall in Mithaganj Union under Kalapara Upazilla of Patuakhali district

4.3.5.1 Effect of different weather component on disease incidence and severity in Dhankhali Union under Kalapara Upazilla of Patuakhali district

The incidence and severity of different diseases in watermelon was influenced by average temperature, relative humidity and rainfall (Fig. 10). The maximum incidence (30.70%) and severity (27.81%) was recorded in February (16-28), 2017 when the average temperature, relative humidity and rainfall were 23.60°C, 76.50% and 13.33 mm respectively. On the other hand, the minimum incidence (10.27%) and severity (8.48%) was recorded in January (15-30), 2017 when the average temperature, relative humidity and rainfall were 19.88°C, 73.80% and 4.52 mm respectively.

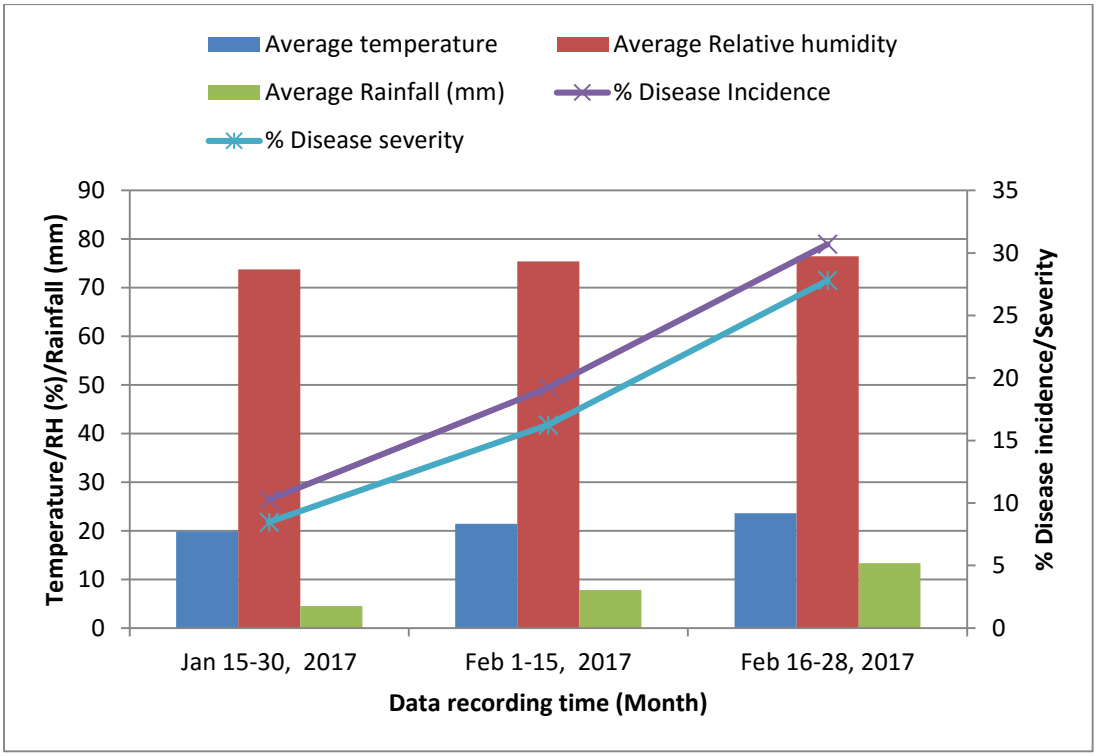

Fig. 10. Effect of temperature, relative humidity and rainfall on disease incidence and severity of watermelon in Dhankhali Union under Kalapara Upazilla of Patuakhali district

4.3.5.2 Relationship between disease incidence as well as severity of watermelon and weather components in Dhankhali Union under KalaparaUpazilla of Patuakhali district

A positive correlation was found between disease incidence of watermelon and weather component. The relationship between disease incidence with temperature, relative humidity and rainfall could be expressed by the equation Y=5.4766x-98.41 (R^2=0.9992), Y=7.4244x-538.5 (R^2=0.9689) and Y=2.2953x+0.419 (R^2=0.9949), where x= temperature, relative humidity and rainfall and y= disease incidence. Here the R^2 value indicates that the contribution of weather components to the incidence in Dhankhali Union. During the cropping period it was observed that disease incidence was increased with the increase of temperature, relative humidity and rainfall (Fig. 11). On the other hand, the relationship between disease severity with temperature, relative humidity and rainfall could be expressed by the equation Y=5.203x-95.042 (R^2=0.9998), Y=6.9931x-508.6 (R^2=0.953) and Y=2.1846x-1.1832 (R^2=0.9991), where x= temperature, relative humidity and rainfall and y= disease severity. Here the R^2 value indicates that the contribution of weather components to the severity in Dhankhali Union. During the cropping period it was also observed that disease severity was increased with the increase of temperature, relative humidity and rainfall (Fig. 11).

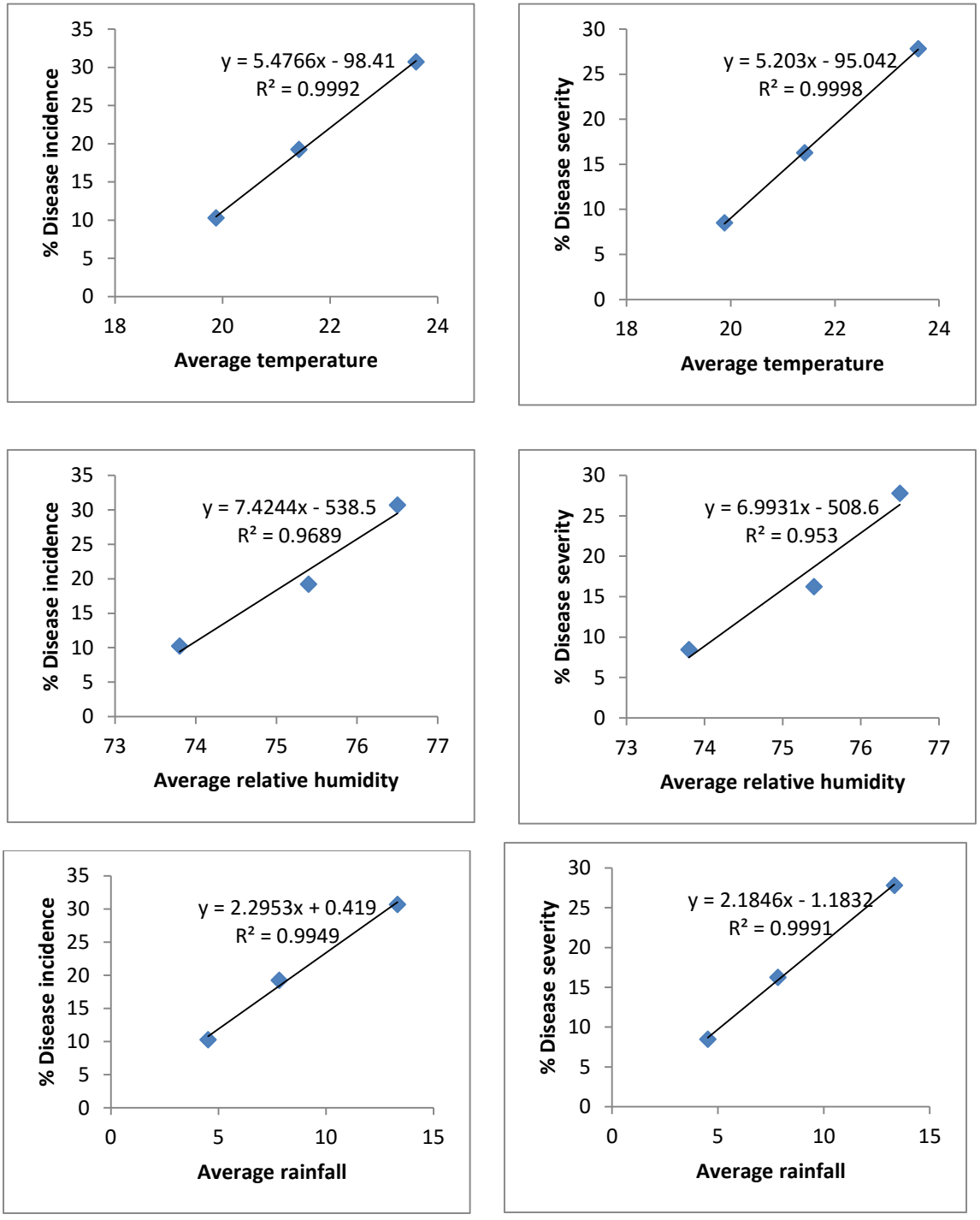

Fig. 11. Relationship between disease incidence and severity of watermelon with temperature, relative humidity and rainfall in Dhankhali Union under Kalapara Upazilla of Patuakhali district

4.3.6.1 Effect of different weather component on disease incidence and severity in Dhulaswar Union under Kalapara Upazilla of Patuakhali district

The incidence and severity of watermelon diseases was influenced by average temperature, relative humidity and rainfall (Fig. 12). The maximum incidence (27.91%) and severity (25.21%) was recorded in February (16-28), 2017 when the average temperature, relative humidity and rainfall were 23.60°C, 76.50% and 13.33 mm respectively. On the other hand, the minimum incidence (7.97%) and severity (5.77%) was recorded in January (15-30), 2017 when the average temperature, relative humidity and rainfall were 19.88°C, 73.80% and 4.52 mm respectively.

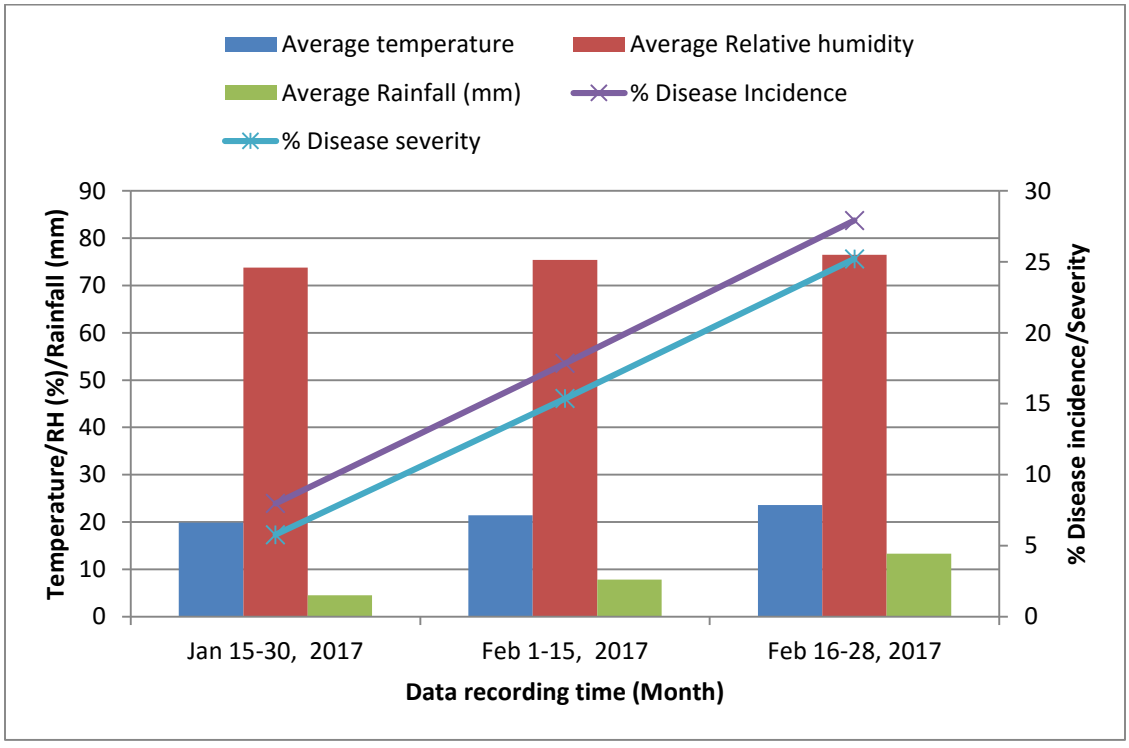

Fig. 12. Effect of temperature, relative humidity and rainfall on disease incidence and severity of watermelon in Dhulaswar Union under Kalapara Upazilla of Patuakhali district

4.3.6.2 Relationship between disease incidence as well as severity of watermelon and weather components in Dhulaswar Union under Kalapara Upazilla of Patuakhali district

A positive correlation was found between disease incidence of watermelon and weather component. The relationship between disease incidence with temperature, relative humidity and rainfall could be expressed by the equation Y=5.3106x-96.976 (R^2=0.9912), Y=7.2976x-531.12 (R^2=0.9876) and Y=2.2193x-1.0874 (R^2=0.9813), where x= temperature, relative humidity and rainfall and y= disease incidence. Here the R^2 value indicates that the contribution of weather components to the incidence in Dhulaswar Union. During the cropping period it was observed that disease incidence was increased with the increase of temperature, relative humidity and rainfall (Fig. 13). On the other hand, the relationship between disease severity with temperature, relative humidity and rainfall could be expressed by the equation Y=5.1787x-96.586 (R^2=0.9917), Y=7.1127x-519.67 (R^2=0.987) and Y=2.1644x-3.081 (R^2=0.9819), where x= temperature, relative humidity and rainfall and y= disease severity. Here the R^2 value indicates that the contribution of weather components to the severity in Dhulaswar Union. During the cropping period it was also observed that disease severity was increased with the increase of temperature, relative humidity and rainfall (Fig. 13).

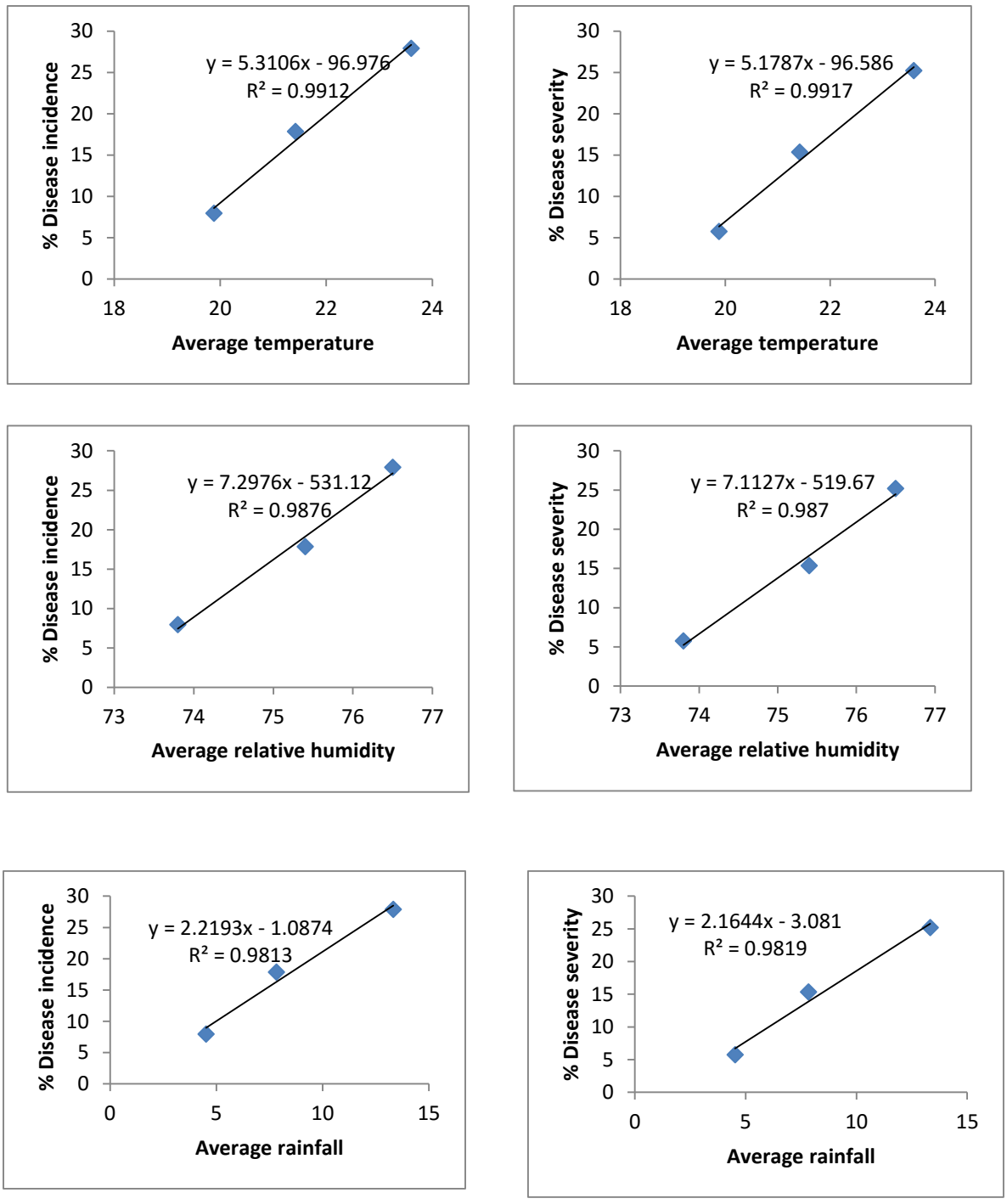

Fig. 13. Relationship between disease incidence and severity of watermelon with temperature, relative humidity and rainfall in Dhulaswar Union under Kalapara Upazilla of Patuakhali district

4.3.7.1 Effect of different weather component on disease incidence and severity in Auliapur Union under Patuakhali Sadar Upazilla of Patuakhali district

The incidence and severity of different diseases in watermelon was influenced by average temperature, relative humidity and rainfall (Fig. 14). The maximum incidence (25.26%) and severity (23.67%) was recorded in February (16-28), 2017 when the average temperature, relative humidity and rainfall were 23.60°C, 76.50% and 13.33 mm respectively. On the other hand, the minimum incidence (8.43%) and severity (6.49%) was recorded in January (15-30), 2017 when the average temperature, relative humidity and rainfall were 19.88°C, 73.80% and 4.52 mm respectively.

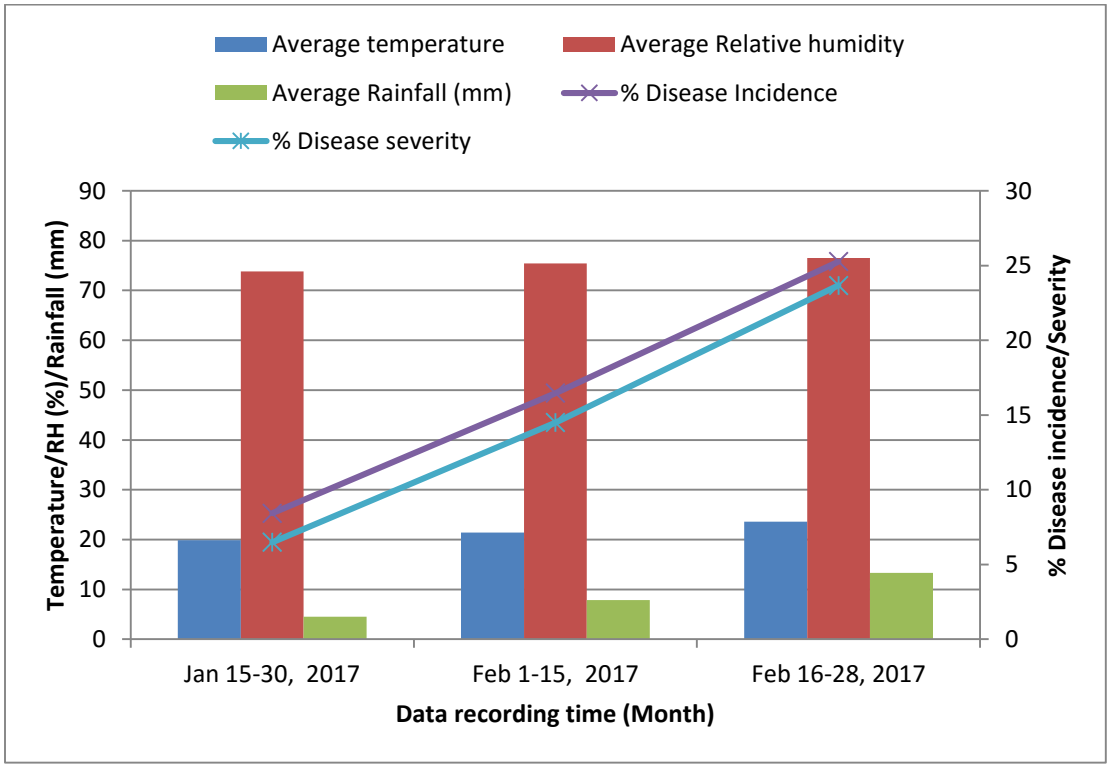

Fig. 14. Effect of temperature, relative humidity and rainfall on disease incidence and severity of watermelon in Auliapur Union under Patuakhali SadarUpazilla of Patuakhali district

4.3.7.2 Relationship between disease incidence as well as severity of watermelon and weather components in Auliapur Union under Patuakhali Sadar Upazilla of Patuakhali district

A positive correlation was found between disease incidence of watermelon and weather component. The relationship between disease incidence with temperature, relative humidity and rainfall could be expressed by the equation Y=4.4917x-80.455 (R^2=0.9947), Y=6.1455x-445.63 (R^2=0.9824) and Y=1.8789x+0.6335 (R^2=0.9866), where x= temperature, relative humidity and rainfall and y= disease incidence. Here the R^2 value indicates that the contribution of weather components to the incidence in Auliapur Union. During the cropping period it was observed that disease incidence was increased with the increase of temperature, relative humidity and rainfall (Fig. 15). On the other hand, the relationship between disease severity with temperature, relative humidity and rainfall could be expressed by the equation Y=4.5909x-84.429 (R^2=0.9964), Y=6.2648x-456.44 (R^2=0.979) and Y=1.9214x-1.5604 (R^2=0.9893), where x= temperature, relative humidity and rainfall and y= disease severity. Here the R^2 value indicates that the contribution of weather components to the severity in Auliapur Union. During the cropping period it was also observed that disease severity was increased with the increase of temperature, relative humidity and rainfall (Fig. 15).

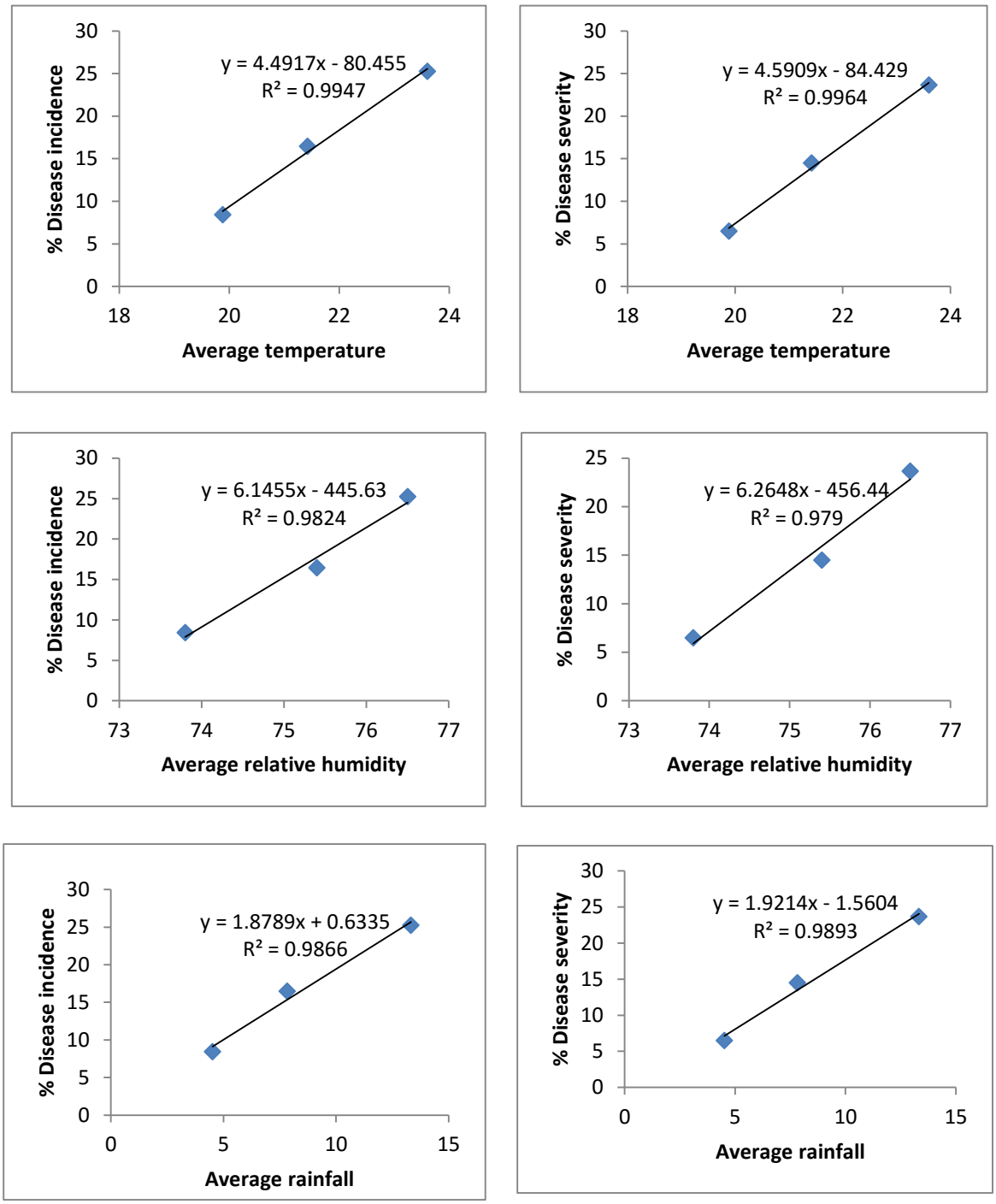

Fig. 15. Relationship between disease incidence and severity of watermelon with temperature, relative humidity and rainfall in Auliapur Union under Patuakhali Sadar Upazilla of Patuakhali district

4.3.8.1 Effect of different weather component on disease incidence and severity in Lohalia Union under Patuakhali Sadar Upazilla of Patuakhali district

The incidence and severity of watermelon diseases was influenced by average temperature, relative humidity and rainfall (Fig. 16). The maximum incidence (25.06%) and severity (22.06%) was recorded in February (16-28), 2017 when the average temperature, relative humidity and rainfall were 23.60°C, 76.50% and 13.33 mm respectively. On the other hand, the minimum incidence (7.60%) and severity (5.87%) was recorded in January (15-30), 2017 when the average temperature, relative humidity and rainfall were 19.88°C, 73.80% and 4.52 mm respectively.

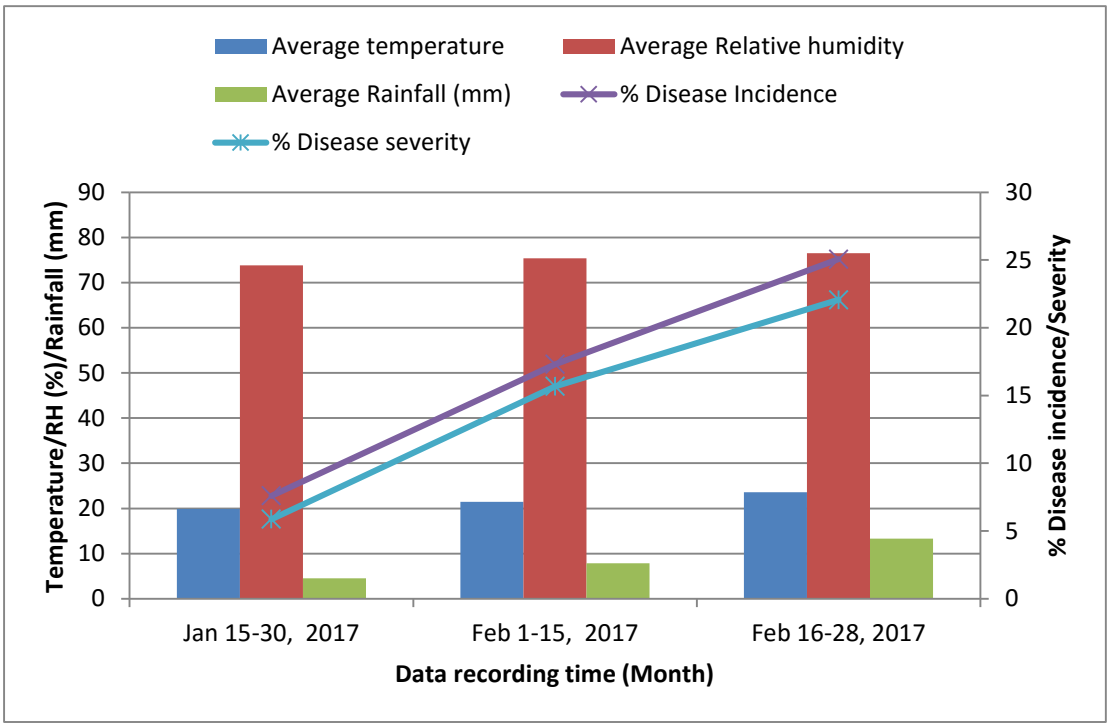

Fig. 16. Effect of temperature, relative humidity and rainfall on disease incidence and severity of watermelon in Lohalia Union under Patuakhali Sadar Upazilla of Patuakhali district

4.3.8.2 Relationship between disease incidence as well as severity of watermelon and weather components in Lohalia Union under Patuakhali Sadar Upazilla of Patuakhali district

A positive correlation was found between disease incidence of watermelon and weather component. The relationship between disease incidence with temperature, relative humidity and rainfall could be expressed by the equation Y=4.6181x-83.251 (R^2=0.9736), Y=6.4374x-467.66 (R^2=0.9) and Y=1.924x+0.1842 (R^2=0.9579), where x= temperature, relative humidity and rainfall and y= disease incidence. Here the R^2 value indicates that the contribution of weather components to the incidence in Lohalia Union. During the cropping period it was observed that disease incidence was increased with the increase of temperature, relative humidity and rainfall (Fig. 17). On the other hand, the relationship between disease severity with temperature, relative humidity and rainfall could be expressed by the equation Y=4.2576x-77.572 (R^2=0.9524), Y=6.0056x-437.29 (R^2=0.9998) and Y=1.7692x-0.36108 (R^2=0.9321), where x= temperature, relative humidity and rainfall and y= disease severity. Here the R^2 value indicates that the contribution of weather components to the severity in Lohalia Union. During the cropping period it was also observed that disease severity was increased with the increase of temperature, relative humidity and rainfall (Fig. 17).

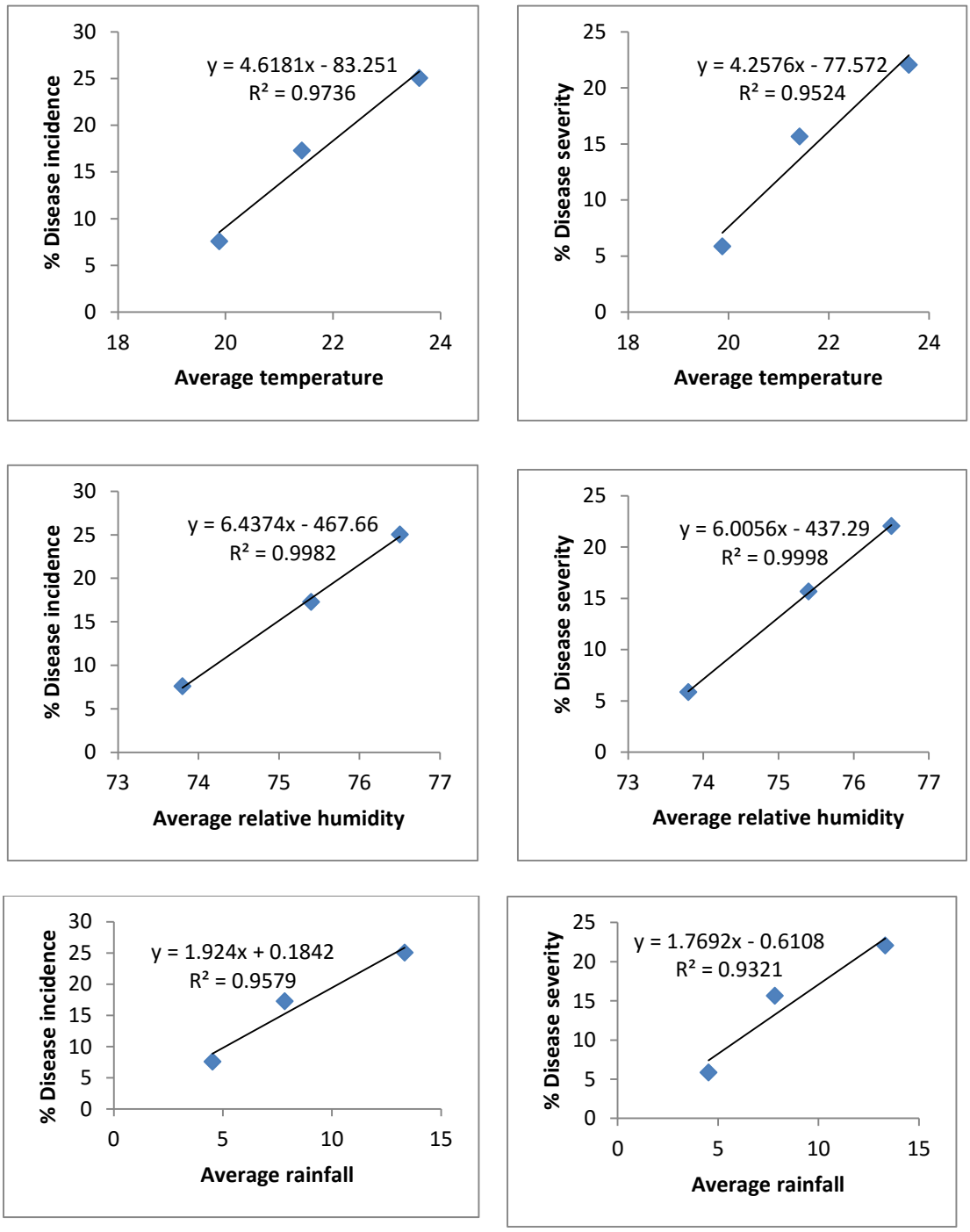

Fig. 17. Relationship between disease incidence and severity of watermelon with temperature, relative humidity and rainfall in Lohalia Union under Patuakhali SadarUpazilla of Patuakhali district

4.3.9.1 Effect of different weather component on disease incidence and severity in Chhota Bighai Union under Patuakhali Sadar Upazilla of Patuakhali district

The incidence and severity of watermelon diseases was influenced by average temperature, relative humidity and rainfall (Fig. 18). The maximum incidence (24.96%) and severity (22.23%) was recorded in February (16-28), 2017 when the average temperature, relative humidity and rainfall were 23.60°C, 76.50% and 13.33 mm respectively. On the other hand, the minimum incidence (7.11%) and severity (5.65%) was recorded in January (15-30), 2017 when the average temperature, relative humidity and rainfall were 19.88°C, 73.80% and 4.52 mm respectively.

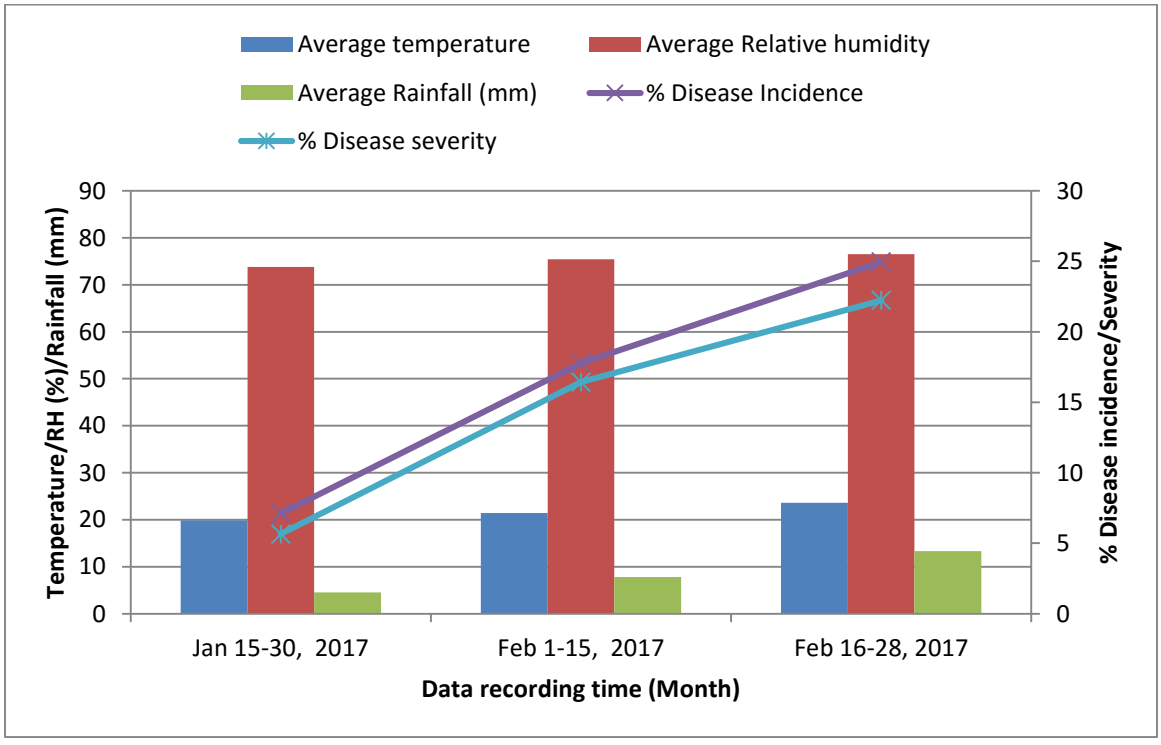

Fig. 18. Effect of temperature, relative humidity and rainfall on disease incidence and severity of watermelon in Chhota Bighai Union under Patuakhali Sadar Upazilla of Patuakhali district

4.3.9.2 Relationship between disease incidence as well as severity of watermelon and weather components in Chhota Bighai Union under Patuakhali Sadar Upazilla of Patuakhali district

A positive correlation was found between disease incidence of watermelon and weather component. The relationship between disease incidence with temperature, relative humidity and rainfall could be expressed by the equation Y=4.6982x-85.022 (R^2=0.956), Y=6.6153x-481.07 (R^2=1.00) and Y=1.9531x-0.1015 (R^2=0.9364), where x= temperature, relative humidity and rainfall and y= disease incidence. Here the R^2 value indicates that the contribution of weather components to the incidence in Chotta Bighai Union. During the cropping period it was observed that disease incidence was increased with the increase of temperature, relative humidity and rainfall (Fig. 19). On the other hand, the relationship between disease severity with temperature, relative humidity and rainfall could be expressed by the equation Y=4.3374x-79.063 (R^2=0.9285), Y=6.1839x-450.47 (R^2=0.9958) and Y=1.7981x-0.6215 (R^2=0.9045), where x= temperature, relative humidity and rainfall and y= disease severity. Here the R^2 value indicates that the contribution of weather components to the severity in Chotta Bighai Union. During the cropping period it was also observed that disease severity was increased with the increase of temperature, relative humidity and rainfall (Fig. 19).

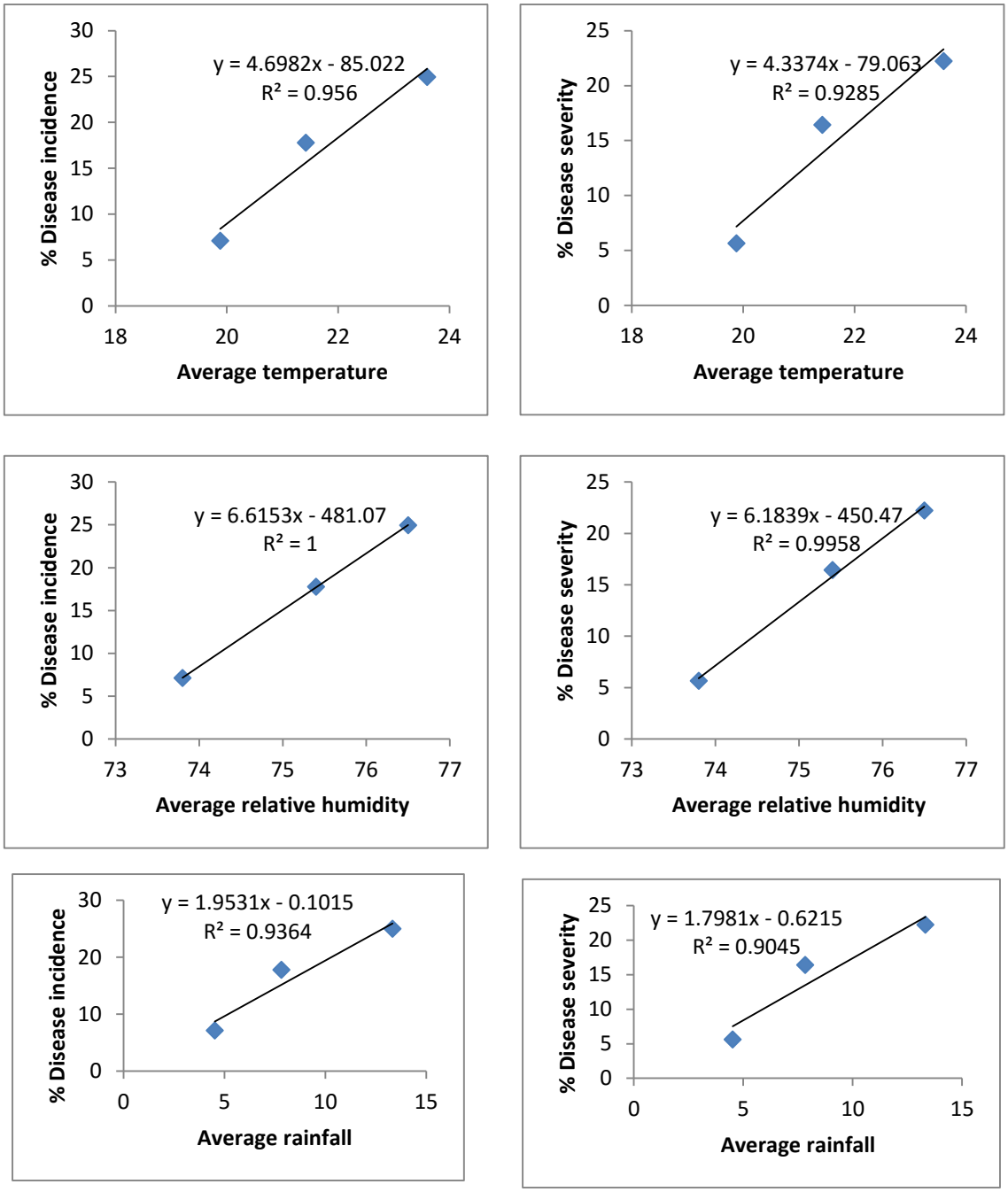

Fig. 19. Relationship between disease incidence and severity of watermelon with temperature, relative humidity and rainfall in Chhota Bighai Union under Patuakhali Sadar Upazilla of Patuakhali district

The effect of temperature, relative humidity and rainfall on the incidence and severity of noted diseases of watermelon in selected locations were observed. The climate of Bangladesh is characterized by high temperature, heavy rainfall and excessive humidity with the fairly marked seasonal variation (Anonymous 1995). ANOVAs, Correlation and linear regression analysis were performed to determine the relationship between different components of climatic factor (temperature, relative humidity and rainfall) and incidence as well as severity of watermelon diseases. Gilling (1986) observed that ANOVAs has been the fundamental method used by plant pathologist to determine the correlation between the prevalence and environmental parameters. Determining the Effects of temperature, relative humidity and rainfall on the incidence and severity of watermelon diseases is also reported by many researchers around the world [Kurowski *et al*. (2015); Slavov *et al*. (2004); Maheshwari *et al*. (2000); Alvarez and Nishijima (1987); Gilling (1986)]. Correlation regression analysis of prevalence of watermelon diseases along with generalized environmental parameters revealed that this increased the effect of temperature, relative humidity and rainfall. A positive correlation was observed between prevalence of watermelon diseases with temperature, relative humidity and rainfall. With the increase of temperature, relative humidity and rainfall both incidence and severity increased significantly. Maheshwari *et al*., (2000) stated that *Alternaria alternata* at eleven different temperatures and sixteen pH levels ranging from 5ºC to 40ºC and 3.0 to 10.5 pH. The optimum temperature and pH for the growth of the fungus were recorded to be 28ºC and pH 6.5. Minimum growth of the fungus were recorded at the temperature of 5ºC and pH 10.5. Excellent sporulation was observed at 25ºC-30ºC and pH levels of 5.5 to 6.5. While some fungi belonging to genus *Alternaria* are plant parasites that easily can change when exposed under different conditions (Slavov *et al*., 2004). *Alternaria* spp. survives in crop debris or on weeds and other cucurbit hosts. Disease spread occured with rain, relative humidity, wind, cultivation, equipment and field workers. This disease is favored by warm temperatures and moisture from dew,

rain or overhead irrigation. Infection can be initiated with two to eight hours of leaf wetness, but as the hours of leaf wetness increase infection level increases. Conidia of *Cercospora citrullina* became airborne and may be carried great distances on moist winds. Infection required free moisture and is favored by temperatures of 26–32°C (80–90°F). *Cercospora citrullina* survives on crop debris, volunteers and cucurbit weeds (Kurowski *et al*. 2015). They also stated that *Colletotrichum lagenarium* can be associated with seed and infected crop debris. Spread of this fungus can occur by splashing rain, overhead irrigation, insects, field workers and equipment. Sikora (2011) reported that disease development is favored by warm, humid weather. Optimum temperature for disease development is 24°C (75°F). Warm (75°F), wet conditions (frequent rains, poor drainage) favor rapid development and spread of the disease. Anthracnose appeared anytime during the season, but most damage occured late in the season after the fruit is set. The mosaic virus survives in plant debris, became primary infected in the 6 to 8 leaf stage, symptoms first appeared on the youngest, still expanding leaves. This disease is more severe in wet weather than in dry weather and became destructive in high relative humidity (Cerkauskas, 2004). Rhizopus soft rot caused by *Rhizopus stolonifer*. The frequency of rain and the length of dew periods play a greater role in disease development than the volume of rain that falls and temperature at 24 °C (75 °F) and high relative humidity of 90% (Alvarez and Nishijima, 1987). They also stated that rainfall was held greatly responsible for the severity of infection and disease development. The disease developed at a temperature range of 15-25^{0}C and 100% relative humidity for 10-12 hrs.

CHAPTER V

SUMMARY AND CONCLUSION

Watermelon is popular fruit crop in Bangladesh. It suffers from various diseases but least concrete information regarding their distribution, prevalence and epidemiology is available in Bangladesh. Therefore, the present study has been designed to study the prevalence of diseases of watermelon (*Citrullus vulgaris*) in Patuakhali district. Nine locations were selected from nine Unions of three Upazills *viz*. Amkhola, Golkhali and Panpatty Unions of Galachipa Upazilla, Mithaganj, Dhankhali and Dhulaswar Unions of Kalapara Upazilla and Auliapur, Lohalia and Chhota Bighai Unions of Patuakhali Sadar Upazilla. Three experiments were carried out throughout the study period from January 2017 to Feburary 2017. Survey was done by 3 times in each study area at 15 days interval.

The diseases were identified based on matching the observed symptoms in the infected leaves and fruits with the symptoms. The disease also identified by observed the symptoms on the seedlings during survey and determination of presence of fungi was made either directly by preparation of slides and examining them under compound microscope or indirectly by isolation to agar culture following keys outline by (Singh, 1998 and Ploetz *et al*., 1998). Five different diseases v*iz*. Alternaria leaf spot, Cercospora leaf spot, Anthracnose, Mosaic and Rhizopus soft rot were recorded during the survey period from selected location on incidence and severity of noted diseases were observed.

Incidence and severity of alternaria leaf spot, cercospora leaf spot, anthracnose, mosaic and rhizopus soft rot of watermelon varied from location to location. Significant variations were observed on disease incidence and severity in different locations. The highest (25.15%) incidence of alternaria leaf spot disease was found in Dhankhali Union, the highest(23.48%) incidence of Cercospora leaf spot was observed in Amkhola Union, the highest (23.29%) incidence of anthracnose

disease was observed in Golkhali Union and the highest (18.85%) incidence of mosaic disease was observed in Lohalia Union where the lowest (16.10%) incidence of alternaria leaf spot disease was found in Lohalia Union, lowest (14.63 %) incidence of cercospora leaf spot was observed in Lohalia Union, lowest (17.03 %) incidence of anthracnose disease was observed in Lohalia Union and lowest (9.94%) incidence of leaf mosaic disease was observed in Chhota Bighai Union. The highest (22.52%) severity of alternaria leaf spot disease was found in Dhankhali Union, highest (20.93%) severity of cercospora leaf spot was observed in Amkhola Union, highest (22.61%) severity of anthracnose disease was observed in Golkhali Union and highest (16.35%) severity of leaf mosaic disease was observed in Lohalia Union where the lowest (14.61%) severity of alternaria leaf spot disease was found in Lohalia Union, lowest (12.85%) severity of cercospora leaf spot was observed in Lohalia Union, lowest (14.32%) severity of anthracnose disease was observed in Lohalia Union and lowest (8.38%) severity of leaf mosaic disease was observed in Chhota Bighai Union. In case of rhizopus soft rot disease, it was found in only in two Unions and the rest of selected location showed no rhizopus soft rot disease.

Different weather components *viz*. temperature, relative humidity and rainfall influenced disease and severity of watermelon diseases in selected areas of Patuakhali district. It was observed that temperature, relative humidity and rainfall had positive correlation with disease incidence and severity of watermelon.

From the above findings it can be concluded that among the selected locations of Patuakhali district, the highest disease incidence of alternaria leaf spot was recorded at (20.84%) and the lowest disease incidence of rhizopus soft rot was recorded (6.42%). Similarly, the highest disease severity of alternaria leaf spot was recorded at (18.75%) and the lowest disease severity of rhizopus soft rot was recorded at (4.50%) in the selected locations of Patuakhali district.

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APPENDICES

Appendix I. Questionnaire of the study

Questionnaire was prepared for two levels *viz*. for DAE personnel and for farmer's field information.

A. DAE personnel interview Date: ……..

Name of the DAE Officials: …… Designation: ……..

Name of Upazila: …… District: …….

1. Total Area under
   a) Field crop cultivationin your upazila Area (ha): ……
   b) Watermelon cultivation in your upazila Area (ha): ……

2. Name of major leaf disease of watermelon in your upazilla:

Name of watermelon leaf diseases	**% incidence**	**% severity**

B. Farmers Interview Date: **……..……...……**

1. Name of Farmer: ……..
   Village: …… Union: …… Upazila: …… District: …….
2. Male/Female: ……
3. Agricultural Farming Experience (No of years.): Years: ……
4. Name the variety of watermelon that you cultivated: ……..
5. Area of watermelon crop cultivated by you (in decimal): ……
6. Did you find any leaf diseases in your watermelon crop field? Yes: ….. No: …..
7. Data recorded from surveyed areas by the researcher (data were collected 3 times at 30, 45 and 60 days after sowing)

Sample ID.	External symptoms of the diseased sample	Total number of leaves in surveyed areas	Number of infected leaves by diseases	Area of infection on leaves (%)
1.				
2.				
3.				
4.				
5.				

Appendix II. Average temperature, relative humidity and rainfall of Patuakhali district from January to February 2017

Month and year	Average temperature (^{0}C)	Average Relative humidity (%)	Average Rainfall (mm)
Jan 15-30, 2017	19.88	73.80	4.52
Feb 1-15, 2017	21.42	75.40	7.83
Feb 16-28, 2017	23.60	76.50	13.33

Appendix III. Diseases incidence and severity of watermelon diseases in Amkhola union under Galachipa upazilla of Patuakhali district

Source of variation	Degrees of freedom	Mean square of disease incidence				Mean square of disease severity			
		30 DAS	45 DAS	60 DAS	Mean	30 DAS	45 DAS	60 DAS	Mean
Replication	2	2.75	3.44	2.49	0.313	0.17	0.538	0.229	0.076
Factor A	3	6.29*	7.61*	5.87**	4.11*	4.19*	8.82*	9.521*	8.454*
Error	6	1.871	2.71	2.62	1.061	1.042	1.112	2.213	3.236

Appendix IV. Diseases incidence and severity of watermelon diseasesin Golkhali union under Galachipa upazilla of Patuakhali district

Source of variation	Degrees of freedom	Mean square of disease incidence				Mean square of disease severity			
		30 DAS	45 DAS	60 DAS	Mean	30 DAS	45 DAS	60 DAS	Mean
Replication	2	0.31	1.89	0.837	1.73*	2.59	5.76	0.446	0.31
Factor A	3	1.93*	3.64*	16.25*	8.61*	1.32*	2.17*	8.66*	7.47*
Error	6	0.61	1.25*	2.131	1.731*	2.54	5.70	1.147	1.34

Appendix V. Diseases incidence and severity of watermelon diseasesin Panpattyunion under Galachipa upazilla of Patuakhali district

Source of variation	Degrees of freedom	Mean square of disease incidence				Mean square of disease severity			
		30 DAS	45 DAS	60 DAS	Mean	30 DAS	45 DAS	60 DAS	Mean
Replication	2	1.08	1.06	2.08	0.313	3.68	0.50	2.97	2.50
Factor A	3	12.05*	4.09*	9.27*	5.148*	7.28**	4.80*	9.44*	5.88**
Error	6	1.68*	18.27*	1.371	2.051	1.141	2.017	2.773	2.016

Appendix VI. Diseases incidence and severity of watermelon diseases in Mithaganjunion under Kalapara upazilla of Patuakhali district

Source of variation	Degrees of freedom	Mean square of disease incidence				Mean square of disease severity			
		30 DAS	45 DAS	60 DAS	Mean	30 DAS	45 DAS	60 DAS	Mean
Replication	2	2.40	2.42	5.467	3.46	1.92	1.32	1.37	0.648
Factor A	3	4.43*	11.44*	14.48*	13.47*	8.79*	3.46**	2.09*	6.532*
Error	6	1.115	2.283	1.138	2.314	1.444	3.211	1.226	1.424

Appendix VII. Diseases incidence and severity of watermelon diseasesin Dhankhali union under Kalapara upazilla of Patuakhali district

Source of variation	Degrees of freedom	Mean square of disease incidence				Mean square of disease severity			
		30 DAS	45 DAS	60 DAS	Mean	30 DAS	45 DAS	60 DAS	Mean
Replication	2	3.44	1.27	0.14	0.728	2.58	1.45	2.86	0.847
Factor A	3	12.80*	10.48*	6.54*	8.287*	31.26*	6.32*	5.58*	9.377*
Error	6	0.392	1.116	1.037	1.246	7.189	2.292	4.363	1.327

Appendix VIII. Diseases incidence and severity of watermelon diseases in Dhulaswar union under Kalapara upazilla of Patuakhali district

Source of variation	Degrees of freedom	Mean square of disease incidence				Mean square of disease severity			
		30 DAS	45 DAS	60 DAS	Mean	30 DAS	45 DAS	60 DAS	Mean
Replication	2	1.04	1.34	1.11	0.953	1.114	0.836	1.526	0.869
Factor A	3	7.57*	4.07**	5.88*	8.113*	6.242*	4.01*	6.36*	5.221*
Error	6	2.476	1.162	2.266	1.362	2.663	2.586	1.693	2.227

Appendix IX. Diseases incidence and severity of watermelon diseases in Auliapur union under Patuakhali Sadar upazilla of Patuakhali district

Source of variation	Degrees of freedom	Mean square of disease incidence				Mean square of disease severity			
		30 DAS	45 DAS	60 DAS	Mean	30 DAS	45 DAS	60 DAS	Mean
Replication	2	0.366	1.142	2.314	2.25	0.21	3.36	2.92	1.56
Factor A	3	7.224*	3.316*	8.841*	8.70*	6.22*	2.61*	7.21*	7.91*
Error	6	2.346	2.611	1.332	3.210	2.72	1.13	2.12	4.579

Appendix X. Diseases incidence and severity of watermelon diseases in Lohalia union under Patuakhali Sadar upazilla of Patuakhali district

Source of variation	Degrees of freedom	Mean square of disease incidence				Mean square of disease severity			
		30 DAS	45 DAS	60 DAS	Mean	30 DAS	45 DAS	60 DAS	Mean
Replication	2	0.018	0.850	0.917	1.064	1.012	0.36	0.41	0.53
Factor A	3	7.514*	8.221*	6.412*	8.322*	8.432*	4.02*	9.27*	10.64*
Error	6	1.131	2.016	2.722	1.946	1.714	1.34	1.06	2.11

Appendix XI. Diseases incidence and severity of watermelon diseasesin Chhota Bighai union under Patuakhali Sadar upazilla of Patuakhali district

Source of variation	Degrees of freedom	Mean square of disease incidence				Mean square of disease severity			
		30 DAS	45 DAS	60 DAS	Mean	30 DAS	45 DAS	60 DAS	Mean
Replication	2	0.22	0.36	1.115	0.56	1.17	2.33	1.31	0.323
Factor A	3	8.23*	8.63*	5.77*	8.25*	8.17*	7.14*	5.15**	7.646*
Error	6	2.871	3.781	1.621	2.87	1.02	4.05	2.06	2.136