SURVEY ON THE MAJOR DISEASES OF WATERMELON IN TWO SELECTED DISTRICTS OF BANGLADESH

Reg. No.: 19-10121

DEPARTMENT OF PLANT PATHOLOGY

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CERTIFICATE

This is to certify that the thesis entitled **"**SURVEY ON THE MAJOR DISEASES OF WATERMELON IN TWO SELECTED DISTRICTS OF BANGLADESH**"** submitted to the department of Plant Pathology, faculty of Agriculture, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207, in partial fulfillment of the requirements for the degree of **Master of Science (MS) in PLANT PATHOLOGY**, embodies the result of a piece of bona fide research work carried out by Registration No.: **19-10121,** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated:
Place: Dhaka, Bangladesh

Prof. Dr. Nazneen Sultana
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Dedicated To

My Family

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ABSTRACT

A field survey was conducted to identify the major diseases of watermelon in the year of 2020 and 2021 at Subarnachar Upazila in Noakhali district and Dashmina Upazila in Patuakhali district. The laboratory works has done at Central Laboratory of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. Twenty villages from Ten Unions of Noakhali and Patuakhali districts were considered for survey and investigation of major diseases of watermelon. Altogether, sixty farmers were interviewed from Noakhali and Patuakhali district of Bangladesh. The incidence and severity of diseases of watermelon varied significantly among the locations. Depending on the disease incidence and severity, the major diseases of watermelon were leaf curl, leaf spot, foot and root rot. In leaf spot disease in both districts, the highest disease incidence and severity were 35.10% and 10.33% which were recorded in West Charbata at Noakhali district, respectively. In case of leaf curl disease of watermelon the highest disease incidence and severity were recorded in South Kocchopiya and Char Aminul Haq that were 74.53% and 18.33%, respectively. The highest powdery mildew disease incidence 11.33% and severity 4% was observed in South Kocchopiya in Noakhali. In case of foot and root rot disease, the highest disease incidence and severity was recorded in Auliapur at Patuakhali district which were 20.66% and 15% in West Charbata, Noakhali district, respectively. The highest disease incidence of leaf mosaic were recorded in South Kocchopiya at Noakhali district and Gochani at Patuakhali district which were 16.67% and disease severity were 2.33% at Char Mujib and South Kocchopiya in Noakhali while the lowest severity of leaf mosaic 1.33% was recorded in Gochani, Patuakhali district. In total, five diseases were recorded and identified in field conditions viz. Leaf spot caused by *Alternaria alternata*, leaf curl caused by chlorotic stunt virus, powdery mildew caused by *Oidium* sp, foot and root rot caused by *Fusarium oxysporum* and leaf Mosaic caused by virus. Considering the amount of severity of diseases, foot and root rot and leaf curl were major diseases occurred in watermelon fields in Noakhali and Patuakhali district, respectively. Moreover, *in-vitro* conditions fungi viz. *Fusarium oxysporum*, *Aspergillus* spp., *Alternaria alternata*, *Rhizopus stolonifer and Chaetomium* sp. were isolated and identified from the seeds of watermelon mixed varieties revealed by seed health test. The socio-economic status of watermelon farmer's in Bangladesh revealed that the highest percent of farmers used 2 to 3 ha of land for watermelon cultivation and most of the money was used to prevent the watermelon from disease, insects and weeds which was about 28,000 Tk/ha.

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LIST OF ABBREVIATIONS

Full Name	Abbreviations
Agro-Ecological Zone	AEZ
And others	*et al.*
Bangladesh Bureau of Statistics	BBS
Centimeter	Cm
Coefficient of Variance	CV
Degree Celsius	°C
Etcetera	etc.
Least Significant Difference	LSD
Meter	M
Millimeter	Mm
Percentage	%
Videlicet (namely)	viz.
Disease incidence	DI
Disease severity	DS
Hectare	Ha
Kilogram per hectare	Kg/ha
Taka per bigha	Tk/bigha

CHAPTER I

INTRODUCTION

Watermelon (*Citrullus lanatus*) is a member of the family cucurbitaceae and this family are mostly used as vegetables, delicious annual fruits and also for medicinal. It is an important horticultural crop which is known for it's sweet and juicy fruit, grown in warm climates all over the world (Robinson and Decker Walters, 1997).Watermelon is a xerophytic plant that originated in the Kalahari Desert of Africa (Robinson and Decker-Walters 1997; Schaffer and Paris 2016). The first harvest occurred approximately 5,000 years ago in Egypt, and fruit were often placed in the tombs of kings to nourish them in the afterlife (Robinson and Decker-Walters 1997). By the 15th and 16th centuries, European colonists and Spanish or African slaves introduced watermelon to the New World, and subsequently the crop was grown throughout the world (Sutton.2016).

It is a crop with huge economic importance to human (Asuquo *et al*., 2017).The fresh fruit is relished by many people across the world not only to be low in calories but highly nutritious, sweet and thirst-quenching (Mangila *et al*., 2007).In addition to vitamin A, C and potassium, watermelon (*Citrullus lanatus*) also contains lycopene, citrulline, and arginine. It is also a highly efficient oxygen radical scavenger and has been implicated in human studies as providing protection against cardio-vascular disease and some cancers, particularly that of the prostate (Perkins-Veazie *et al.*, 2007). *Citrullus lanatus* (water melon) produces a fruit that is about 93% water, hence the name "water" melon. The scientific name of the watermelon is derived from both Greek and Latin roots. The *Citrullus* part comes from a Greek word "citrus" which is a reference to the fruit. The *lanatus* part is Latin, and has the meaning of being wooly, referring to the small hairs on the stems and leaves of the plant (Alka *et al*., 2018).

Bangladesh is a country of southern Asia and the area of the country is147570 sq. km with a population of about 160 million (BBS, 2012) which is predominantly an agricultural country. Agriculture is the single largest land resource exploring sector. (Sarker *et al*., 2017).The economy of Bangladesh is mostly dominated by agriculture. The most of the inhabitants directly or indirectly are involved in agriculture for their livelihood. Earlier more than 50% of GDP came from this agricultural sector then it gradually lessened for the rapid expansion of industrial sector and at present it comprises 15.96% (Islam *et al*., 2016). Bangladesh abounds with a large variety of tropical and sub-tropical fruits. The most widely cultivated fruits are mango, jackfruit, black berry, pineapple, banana, litchi, lemon and guava etc. There are many minor edible fruits that are locally available in the wild and are also cultivated, such as latkan, monkey jack, uriam, rattan, etc.(Banglapedia,2015).

Watermelon is a delicious fruit in Bangladesh (Rabbany *et al*., 2013). It is an important summer cash crop in Bangladesh which has great demand in the domestic market and a major portion of income of the farmer comes from marketing and distribution of watermelon (Sarker *et al*., 2017).Watermelon is a delicious fruit in Bangladesh. It contains 90 percent water and it is very useful fruit during summer season to fulfill the demand of water (Rabbany *et al*., 2013). The demand of watermelon consumption is increasing day by day in Bangladesh. Production status also increased compared to previous decades. At present 254000 acres of land was under watermelon cultivation and 274,000 tons watermelon was produced in 2016-17.The average yield of watermelon was 8646 kg/acre (BBS, 2017). In 2019, watermelon production in Noakhali district had grown to more than double i.e. 22,857 acres to be exact which estimated trades up to Tk250 crore from this fruit. However, in Patuakhali, 13,368 hectares of land has been brought under watermelon cultivation in which the highest 4,510 hactares of land in Rangabali upazila , Patuakhali was recorded in 2014 (DAE,2016).Nowadays, it is

cultivated commercially in our country, and we can earn a lot of foreign currency by exporting this. So, watermelon production can play an essential role in our economic development (Sarker *et al*., 2018).

Like other crops, disease and pest management is a significant limitation to watermelon production. Moreover, diseases play an important role in reducing the quality and quantity of cultivated crops, several diseases attack watermelon (*C. lanatus*), some of which include angular leaf spot (*Pseudomonas syringae pv. lachrymans*), bacterial fruit blotch/seedling blight (*Acidovorax avenae* pv. *citrulli*),bacterial leaf spot (*Xanthomonas campestri*s pv. *cucurbitae)* and bacterial soft rot (*Erwinia caratovora* pv. *caratovora*). Some fungal diseases include Alternaria leaf spot/blight (*Alternaria cucumerin*), anthracnose (stem, leaf and fruit) (*Colletotrichum orbiculare*), belly rot (*Rhizoctonia solani*), black root rot (*Theilaviopsis basicola*) and *Fusarium* fruit rot caused by *Fusarium equiseti* (Amadi *et al*., 2009). The level of management practices, whether organic or conventional, has been shown to affect watermelon quality. High input management practices in watermelon produced greater marketable yield, higher number of marketable fruit/plant and higher fruit weight than did low input management practices (Lu *et al*., 2003).

It is affected by several biotic and abiotic stresses, among the biotic factors fungal diseases like leaf spot, foot and root rot, powdery mildew are most destructive in nature. Leaf spot caused by *Alternaria alternata* produces a dark brown center and a yellow halo. 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 (Ekabote, 2019).

While *Fusarium* wilt and *Phytophthora* are considered the most devastating diseases to watermelon when fields become infested, foliar diseases such as anthracnose, gummy stem blight, and powdery mildew infect the crop on a yearly

basis forcing growers to make significant investments in cultural practices and crop protection to manage these diseases (Keinath, 2019).Watermelon mosaic virus infected plants showed distinct mottling of leaves and some vein clearing. In late stages of infection narrowing and distortion of leaves gave infected plants a stunted, non-spreading appearance (Thomas, 1971). Powdery mildew infection on watermelon are generally two types-chlorotic spots may appear on leaves with little or no sporulation and little mycelial growth. The fungus may also produce mycelial growth and conidial production on either leaf surface without accompanying chlorotic spots (*Thomas et al*., 2005).

Therefore, considering the above facts and points this research work was designed to achieve the following objectives:

1. To determine the disease incidence and severity of different major diseases of watermelon at Noakhali and Patuakhali District.
2. To determine the seed health status of watermelon mixed varieties

CHAPTER TWO

REVIEW OF LITERATURE

Watermelon (*Citrullus lanatus*) is one of the most popular fruits of tropical and sub-tropical areas having considerable importance in the world market that has got export potentiality. Many diseases attack in this fruit. But very few research works has been carried out in this area in Bangladesh. However, research works are found regarding diseases of watermelon in the world. The literatures on diseases of watermelon and their pathogens are accumulated in this section. This chapter is to review the previous studies that are related to the present study.

2.1. Watermelon (*Citrullus lanatus*) Cultivation

Loannou *et al*. (2000) reported that early yield, harvested in March and April, represented only a small fraction (up to 20%) of the total yield. They also found that grafted plants were much more vigorous, fruit quality, however, was better in un-grafted plants. But the main problems for off-season production were fruit abortion, early fruit drop and fruit deformation, apparently because of low temperatures and insufficient light.

According to Wehner (2008) three-fourths of the world production is grown in Asia, with China the leading country in production. The crop may be established in the field by planting seeds or using containerized transplants. Watermelons are grown in most states of the United States, but the major producers are in the South and West (Florida, Georgia, California, and Texas) where the warm production season lasts longer.

Adeoye *et al*. (2011) stated that watermelon was predominantly grown in Nigeria as sole crop by 52.8% while 47.2% of farmers engaged in intercropping.

Budgetary analysis revealed that watermelon intercropping with cassava had higher gross margin (258, 367.02/ha) than sole watermelon (N 232, 918.06/ha).

Park and Cho (2012) stated that the area used for watermelon cultivation in South Korea peaked at 45,207 hectares in 1995 and declined in each of the successive years. In 2011, watermelon ranked sixth highest in seed sales for vegetable crops in South Korea which are produced mainly by the private sector for both the domestic market and overseas export.

Shrefler *et al*. (2015) were worked on the production of watermelon in Oklahoma. They stated in their report that watermelon production requires a long and warm growing season. It grows best on sandy loam soils, with good drainage and a slightly acid pH. When planted in very heavy soils, the plants develop slowly and fruit size and quality are usually inferior; grows best where soil pH is between 6.0 and 6.8. Watermelons reach harvest maturity five to six weeks after pollination, depending upon variety and season. Varieties may differ in certain characteristics that indicate maturity.

Mohanta and Mandal (2016) were conducted a field study taking thirteen genotypes of watermelon in Horticulture Farm, Sriniketan during summer 2015 to find out their suitability of cultivation in this region. They stated that the soil and climatic condition of this sub-humid, sub-tropical and lateritic belt of West Bengal highly matches with the basic requirements to grow melons ;is being sporadically but successfully grown in this region. The result showed the highest TSS content was noted in Sugar Baby and KSP-1127.

Ho *et al*. (2017) discussed the cultivation techniques of watermelon starting from seed sowing, planting, to seedling protection. They had provided information on the insect pests and diseases management and post-harvesting handling.

Anwar *et al*. (2019) conducted on experiment to determine the effect of plant spacing and apical shoot pinching (ASP) stage on growth and productivity of watermelon under sandy soil conditions using drip irrigation system in Egypt. The results showed that planting watermelon at 45 cm and ASP at the 6th node increased average number of fruits/ plant, average fruit weight, yield/plant and total yield/faddan.

Imanudin *et al*. (2020) reported in their paper that watermelon is commonly planted in upland. The main problem in watermelon cultivation on tidal lowlands is a shallow groundwater table condition which caused the production fall up to 20-50 % when the ground water level is too shallow (about 10-20 cm under the soil surface. They work in South Sumatra region and the method of this research was surveying and monitoring. The results showed that the tertiary gate operation was maximum drainage option where water table depth was 25 cm in soil depth and the watermelon crops grew well and production reached 20 t/ha.

2.2. Watermelon (*Citrullus lanatus*) Cultivation in Bangladesh

Hoque *et al*. (2013) found that, per ha production cost of watermelon as maximum, minimum and mean were tk.150000, tk.117000 and tk.129500 respectively. The gross returns obtained as maximum, minimum and mean were tk.255000, tk.175000 and tk.202500 respectively. The net returns as maximum, minimum and mean were tk.114000, tk.47500 and tk.72500 respectively in Gopalgonj district but the commercial cultivation of watermelon is concentrated in the district of Chittagong, Raishahi, Natore, Jessore, Comilla and GopalGonj and it is considered as profitable crop to the growers of those areas.

Sarker *et al*. (2017) studied on the major sources of risk in producing watermelon in Bangladesh. They take a sample of 180 farmers from Patuakhali district due to

the production intensity of watermelon coverage among various districts of Bangladesh. The result showed that Natural calamity is the highest source of risk in watermelon production. The output elasticity corresponding to the significant ($p<0.05$) coefficients of the inputs viz., human labour, amount of fertilizer used, irrigation cost and pesticide cost are 0.04, 2.99, 22.74 and 19.25, respectively.

In the year, 2018, 10,860 acres of land was used for watermelon cultivation in Noakhali district; of which 10,501 acres were in Subarnachar and earned about Tk120 crore. In 2019,watermelon production in the district had grown to more than double i.e. 22,857 acres to be exact which estimated trades up to Tk250 crore from this fruit.

In the study of Alam *et al*. (2018) revealed that the watermelon requires much organic manures and nitrogenous fertilizer. Availability of fresh water sources may be also regarded as the key part for watermelon cultivation. It is the greatest and economic sign in coastal Paikgacha upazila of Khulna district is that watermelon cultivation is increasing day by day. Soil characteristics in this area are very much suitable for watermelon cultivation and a good number of canals there provide irrigation facility.

2.3. Major Diseases of Watermelon (*Citrullus lanatus*)

Watermelon (*C. lanatus*) is an important cucurbit crop, accounting for 7% of the worldwide area devoted to vegetable production. The annual world production of watermelon is about 90 million tons, making it among the top five most consumed fresh fruits.

Brown *et al*. (1989) reported that over the past few decades, several outbreaks of white flies have been observed worldwide in many vegetable and fruit crops. New whitefly-transmitted viruses, belonging mainly to the genus *Begomovirus* of the Geminiviridae family, have devastated crop production (Mansoor *et al*., 2000).In

2002, two new diseases—one affecting squash and the other affecting watermelon were detected in Israel. In both cases the diseases were associated with elevated whitefly populations in the field.

Sitterly and Keinath, (1996) stated that Gummy stem blight can affect most aboveground parts of the watermelon plant. On fruit, this disease caused by *Didymella bryoniae* (anamorph *Phoma cucurbitacearum* (Fr.:Fr.) Sacc.) is known as black rot whereas the foliage disease is known as gummy stem blight. Small, water-soaked spots develop on watermelon fruit, enlarge, and exude gummy material.

They also stated that Anthracnose was the most destructive disease of watermelon, it is still a relatively common disease of watermelon grown in humid regions throughout world. *Colletotrichum orbiculare* survives between crops on infected plant debris, volunteer plants and can be seed borne. Anthracnose symptoms can occur on all above-ground parts of the watermelon plant (Parris, 1952). Leaf lesions are brown to black, irregularly shaped, and usually limited by leaf veins.

Maynard *et al*. (1999) observed that the symptoms of fruit rot that begin as a water-soaked, often depressed, spot. *Phytophthora* fruit rot is caused by *Phytophthora capsici* and other *Phytophthora* sp. A wide range of vegetable crops, including all cucurbits, are susceptible to this fruit rot. All parts of the plant can be attacked, producing water-soaked lesions on leaves, stem lesions, and dieback of shoot tips in watermelon. However, all stages of watermelon fruit are highly susceptible. Early symptoms of fruit rot include rapidly expanding, irregular, brown lesions which become round to oval. Concentric rings may occur within a lesion.

Amadi *et al*. (2009) reported that several diseases afflict watermelon (*C. lanatus*). Some of these include angular leaf spot (*Pseudomonas syringae* pv. *lachrymans)*,

*b*acterial fruit blotch/seedling blight (*Acidovorax avenae* subsp. c*itrulli* = *Pseudomonas pseudoalcaligenes* subsp. *citrulli*), bacterial leaf spot *(Xanthomonas campestris* pv. c*ucurbitae*) *b*acterial rind necrosis (*Erwinia* spp.) and bacterial soft rot (*Erwinia carotovora* subsp. *carotovora*). Some fungal diseases include *Alternaria* leaf spot/blight (*Alternaria cucumerina*), anthracnose (stem, leaf and fruit) (*Colletotrichum orbiculare*), belly rot (*Rhizoctonia solani*), black root rot (*Thielaviopsis basicola)* and *Fusarium* fruit rot caused by *Fusarium equiseti* (Martyn *et al*., 1993; Roberts and Kucharek, 2006).They also reported in their study that a large area planted to watermelon was severely infected with both leaf and fruit blotches. Both diseases occurred together in all infected watermelon stands. Leaf and fruit samples were taken to the laboratory for investigation. A bacterial isolate identified as *Pseudomonas pseudoalcaligenes* Stanier (=*Acidovorax avenae*) was recovered from both infected leaf and fruit samples.

Kumar *et al*. (2010) stated that watermelon bud necrosis virus (WBNV) is an emerging *Tospovirus*, (family- *Bunyaviridae)* on cucurbits in India causing up to 100% crop loss in watermelon (Jain *et al*., 2010).Watermelon bud necrosis virus (WBNV) is an emerging *Tospovirus*, (family- *Bunyaviridae)* on cucurbits in India causing up to 100% crop loss in watermelon .

Mabagala (2012) examined on fungal diseases infecting watermelon (*Citrullus lanatus* Thunb.) plants.The results indicated that, watermelon samples were infected by *Alternaria alternata* (96.7%), *Cercospora citrullina* (93.3%), *Fusarium oxy1sporum* (40%), *Microphomina phaseolina* (38.3%) and *Cladosporium cucumevicum* (14.2%). 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.

Martyn (2014) mentioned in his paper that in the early 1890s, a mysterious wilt disease of watermelon caused heavy losses in the southern United States. E.F. Smith did seminal research on what became only the second plant wilt disease, described as *Fusarium* wilt of watermelon, caused by the soil borne fungus *Fusarium oxysporum* f. sp. *niveum*. *Fusarium oxysporum* f. sp. *niveum* was one of the first *Fusarium* wilt pathogens to be associated with seed, a problem that still exists today. Numerous control strategies have been investigated over the last 120 years and include nutritional, chemical, cultural, grafting, and other biological methods, but none has replaced genetic resistance as the preferred method of control.

Abu-Nasser *et al*. (2018) stated in their work that watermelon is more prone to diseases affecting roots, leaves and fruits in the summer. Sometimes these diseases are difficult, such as Downy Mildew and Anthracnose often treatment of these diseases is simple but the most important type of disease.

One of the most important bacterial diseases that infect watermelons is angular bacterial leaf spot caused by *Pseudomonas syringae* was reported by Ebrahim *et al*. (2018). It can caused losses to watermelons especially under wet and humid conditions. This disease and some other similar diseases could become epidemic and cause disease incidence up to 80-100 %, especially if disease is severe in the early stages of fruit development which can cause fruit drop, and could also cause up to 100% yield loss.

2.3.1. *Alteranria* Leaf Spot Diseases of Watermelon

Urbanszki *et al*. (2003) were studied in spring of 2002 and autumn of 2001, symptoms of *Alternaria* leaf spot on watermelons and cucumbers in greenhouses in Bács-Kiskun and Hungary. In both locations, *Alternaria alternata* f. sp. *cucurbitae* was identified as the causal organism of the disease. Inoculation tests

showed that the isolated pathogen was a primary pathogen of cucumbers and watermelons.

Bulajic (2008) stated that leaf spot and blight on watermelon and other cucurbits is economically very important disease wherever they are grown. Disease is caused by plant pathogenic fungus, *Alternaria* leaf spots usually appear in the oldest leaves and later spread to the newer leaves towards the tips of the vine. If disease becomes severe, defoliation, premature fruit ripening, lower yields, lower fruit sugar and fruit deformity are frequent consequence.

Zhou *et al*. (2008) experimented on *Alternaria alternata* f. sp. *cucurbitae*, the causal agent of *Alternaria* leaf spot which caused severe losses to greenhouse-grown cucumbers, melon and watermelon. Numerous dark brown, circular lesions were observed on leaves of watermelons in a field. The lesions gradually enlarged and coalesced into large, nearly circular, or irregularly shaped lesions, the center of the lesions was light tan, surrounded by a dark brown ring and a chlorotic halo, and tended to split in the later development stages. Lesions first started on old leaves and then developed on leaves in the middle part of the canopy.

Liu *et al*. (2010) studied the biological characteristics of *Alternaria cucumerina*. The results showed that the mycelium could grow better on PDA medium and medium of watermelon juice. For mycelial growth, the suitable carbon source was glucose, the suitable nitrogen source was sodium nitrate, and the suitable pH was 7. The Mycelium could grow in brightness, darkness and alternating light-dark, best in brightness. For spore germination of pathogen, suitable conditions were 25°C and pH 7.

Meheswari *et al*. (2010) examined on the toxin extracted from *Alternaria alternata* of watermelon and found that the causal agent for leaf spot in watermelon (*Citrullus lanatus*), produced the typical symptoms such as that of the pathogen on

detached watermelon leaves and also increased the loss of electrolytes from watermelon leaves. The toxin isolated was glycoproteinaceous in nature.

Zhao *et al*. (2016) stated that in seven districts in Beijing municipality of China the leaf blight symptoms consisting of dark brown lesions were observed on watermelon plants. A total of 64 *Alternaria* isolates were recovered and identified based on morphological characters and sequence analyses of rDNA-ITS regions and histone 3 genes. Amongst these isolates, *Alternaria tenuissima* was the most prevalent species representing 76.6% of the isolates, followed by *A. alternata* (23.4%). Representative *Alternaria* isolates of the two species induced dark brown lesions on detached watermelon leaves, with disease incidence ranging from 44.4-83.3%.

2.3.2. Leaf Curl Diseases of Watermelon

Brown *et al*. (1989) worked on the purified preparations of watermelon curly mottle virus (WCMoV), a whitefly- transmitted geminivirus which contained dimeric or geminate particles of 20 times 30 nm and the virus was transmissible by mechanical means. The infectivity was associated with two light- scattering, virus- containing bands following sucrose density gradient centrifugation.

Mansoor *et al*. (2000) reported that the evidence of leaf curl disease of watermelon in Pakistan is caused by Tomato leaf curl virus-India (TLCV-India). Leaf curl disease of watermelon, characterized by leaf curling and mottling and stunted plant growth, was observed at several locations in the Punjab Province of Pakistan. Symptomatic and asymptomatic leaf samples were collected from three locations, and total DNA was isolated by the cetyltrimethyl ammonium bromide method and resolved in Agarose gel.

Abudy *et al*. (2010) were found two new diseases with unknown etiologies crops in Israel. One disease was detected in squash fields throughout the country, while the second appeared in a single watermelon plot in the south. Both diseases were associated with whitefly populations. Indeed, it was found that both are transmitted only by whiteflies, and are incited by two begomoviruses. Both viruses were cloned and sequenced, and were identified as *Watermelon chlorotic stunt virus* (WmCSV) and *Squash leaf curl virus* (SLCV).

Rezk *et al*. (2019) were surveyed three locations in the Kingdom of Saudi Arabia during 2013-2014. The detection of begomovirus infection was commenced with serological assay, rolling circle amplification and PCR amplification with universal begomovirus primers. They isolated and characterized full-length WmCSV isolates from watermelon (*Citrullus lanatus*) and zucchini (*Cucurbita pepo*) leaves showing typical begomovirus infection symptoms.

2.3.3. Powdery Mildew Diseases of Watermelon

Devis *et al*. (2001) stated that powdery mildew has emerged as an important disease problem of watermelon in the major U.S. production areas. They reported there are at least two different types of symptoms seen on watermelon. One is a yellow blotching (chlorotic spots) that occurs on leaves accompanied by little or no sporulation and only a small amount of mycelial development. The other symptom is powdery mycelial and conidial development on either leaf surface without the associated chlorotic spots.

Han *et al*. (2016) stated in their paper that watermelon production is often limited by powdery mildew in areas with a large daily temperature range. In their study,

they performed the first characterization of the genus and pathotype of the causal fungi of powdery mildew on watermelon in South Korea based on morphological and molecular characteristics.

According to Keinath and Rennberger (2019) powdery mildew (caused by the fungus named *Podosphaera xanthii*) was consistently among the most prevalent diseases of watermelon in a survey of foliar diseases. Symptoms are found on leaves and petioles and, rarely, on fruits. In severe cases, most of the leaf surface will be covered with powdery mildew, leading to leaf death and smaller or sunburned fruit. In greenhouses, powdery mildew can be a serious problem on seedlings of watermelon.

2.3.4. Foot and Root Rot Diseases of Watermelon

Bruton *et al*. (1993) were found seedless watermelon cultivars are, for the most part, very susceptible to *Fusarium* wilt. With the increased emphasis on seedless watermelon production, the possibility that *Fusarium* wilt will again become a yield- limiting disease is a serious concern. Highly resistant cultivars, in conjunction with rotation, have provided good control to race 1 of *Fusarium oxysporum f. sp. niveum* which is widespread in Texas and Oklahoma watermelon production areas. Race 2, for which there is no acceptable level of resistance in commercial cultivars, does not appear to be widespread within the major watermelon production areas.

Larkin *et al*. (1993) were monitored on population dynamics and chlamydospore germination of *Fusrium oxysporum f.sp. niveum* as well as colonization of watermelon roots in relation to other microorganism population and incidence in different suppressive and conducive conditions.

Dau *et al*. (2009) found in their study that *Fusarium* wilt of watermelon caused by *Fusarium oxysporum* f. sp. *niveum* caused seedling losses in nurseries, as well as severe losses in many crops in Vietnam. Isolates of the fungus were shown to be pathogenic. They preliminary observations indicated that several fungal pathogens, including the *Fusarium* wilt pathogen, *Fusarium oxysporum* f. sp. *niveum* (Zitter *et al*. 1996), were responsible for seedling losses.

Nischwitz *et al*. (2013) reported *Ceratobasidium* was the causal agent of the root rot on watermelons. They said that this disease has been observed sporadically in different locations in Arizona, and its impact on yield is unknown. In most cases, plants either remained smaller but with no further symptom development or they recovered as temperatures increased in late May and early June.

Tran-Nguyen *et al*. (2013) were stated that the disease affected seedlings and plants from three triploid seedless watermelon varieties from six locations in Northern Territory, Australia. Pathogenicity tests were conducted and the fungus was shown to be pathogenic. *Fusarium oxysporum* f. sp. *niveum* was re-isolated in all symptomatic seedlings and verified using the *Fon* PCR specific test. Thus indicating that the causal organism isolated from watermelon was *Fon* and pathogenic.

Hussein *et al*. (2015) were research to identify the causal agent of crown and root rot disease of watermelon in some provinces in middle and south of Iraq, assess pathogenicity of the causal agent and control it by using bacteria (PGPR) isolated from the rhizosphere of healthy watermelon plants. *Fusarium solani f. sp. cucurbitae* was present in all the tested samples with frequency between 27-80%.Seventy one bacterial isolates were isolated from the rhizosphere of the healthy watermelon plants.

Salman *et al*. (2016) reported that due to high infestation rates of the disease in Palestine, farmers are avoiding growing water melon in different regions. They evaluate the efficacy of antagonistic bacteria as bio-control agents against the pathogen. Koch's postulates were then applied to recover pathogenic strains of the fungus. The antagonistic activity of the bacteria against Fon was determined using the dual culture technique.

Rentería *et al*. (2018) were analyzed the presence of phyto-pathogenic fungi associated to watermelon root rot in the Sonora, Maxico. The morphological analysis revealed three genera: Fusarium (73%), Ceratobasidium (20%) and Rhizoctonia (6%). In their works, *F. falciforme* is reported for the first time and anastomosic groups for *Rhizoctonia* and *Ceratobasidium* are defined as causal agents of watermelon root rot.

Hua *et al*. (2020) stated that *Fusarium* wilt caused by *Fusarium oxysporum f. sp. niveum* (FON) is a destructive soilborne disease commonly found in watermelon producing areas throughout the world. In their study, they isolated *fluorescent pseudomonads* from the rhizosphere of healthy watermelon and evaluated their bio-control capacity against FON race 2. Biochemical assays indicated that all *14 fluorescent Pseudomonas* strains were able to produce indole-3-acetic acid and at least one type of bio-surfactants.

2.3.5. Leaf Mosaic Diseases of Watermelon

Sikora (2011) reported that all cucurbits are susceptible to mosaic virus, but watermelon is rarely affected. Among many viruses that attack cucurbits, three commonly found viruses are cucumber mosaic virus (CMV), squash mosaic virus (SqMV) and watermelon mosaic virus-2.Theses 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. Leaves are often distorted, crinkled, curled and stunted. Virus may appear bunchy because of the shortening of the internodes. In severe cases, older leaves was died.

2.4. Health Status of Watermelon

Logaraj (2011) described the nutritional benefits of watermelon seed oils which are composed chiefly of polyunsaturated fatty acids such as oleic, linoleic, and traces of linolenic acids, along with saturated fatty acids like palmitic and stearic acids and storage glycerides. It helps in decreasing the levels of cholesterol and high blood pressure.

Braide *et al*. (2012) were evaluated watermelon seed for its phytochemical and antimicrobial potentials. Watermelon seed showed low antimicrobial activity when compared to the result of the commercial antibiotics. They stated that watermelon seeds are a source of protein, B vitamins, minerals (such as magnesium, potassium, phosphorous, sodium, iron, zinc, manganese and copper) and fat among others (Vandermark, 2011; Collins *et al*., 2007).

Adedeji and Oluwalana (2013) indicated that watermelon is a good source of minerals and vitamins since it contains 11 minerals and 19 vitamins. It has vitamins such as thiamine, riboflavin, niacin, and folate. They reported that minerals such as calcium and potassium play an important role in cell regulation, maintenance of the cell structure, and cell differentiation process.

Alam *et al.* (2013) indicated that watermelon is rich in vitamin B, which is responsible for the production of energy in the body. This fruit is also free from

cholesterol that elevates heart related problems hence preventing heart attacks. Watermelon juice, as a beverage, is found almost exclusively as an over-the-counter drink made by hand from the pink flesh of the watermelon fruit.

According to Erhirhie and Ekene (2014) *Citrullus lanatus* contains about 6% sugar and 92% water by weight. As with many other fruits, it is a source of vitamin C. The composition of dried egusi seed without shell per 100 g include: water 5.1 g, energy 2340 kJ (557 kcal), protein 28.3 g, fat 47.4 g, carbohydrate 15.3 g, Calcium 54 mg, Phosphorous 755 mg, iron 7.3 mg, thiamin 0.19 mg, riboflavin 0.15 mg. The seed being an excellent source of energy and contains no hydrocyanic acid, making it suitable as livestock feed. The seed oil contains glycosides of linoleic, oleic, palmitic and stearic acids.

Kim *et al*. (2014) were worked on the anti-oxidative and anti- inflammatory effects of watermelon lycopene. They found that watermelon lycopene dose dependently inhibited the expressions of iNOS and COX- 2 mRNA levels and their proteins, suggesting that watermelon lycopene has strong anti- inflammatory activity. It was proved as a good source of antioxidant and anti- inflammatory agent.

Naz *et al*. (2014) reported in their study that watermelon is one of the unique sources having readily available cis-isomeric lycopene. Its consumption has been escalated owing to rich nutritional profile and allied health benefits. It is effective in reducing the extent of cancer insurgence, cardiovascular disorders, diabetes and macular diseases.

Hong *et al*. (2015) were stated in their study that the effects of watermelon powder consumption on lipid profiles, antioxidant capacity, and inflammation in dextran sodium sulfate (DSS)–treated rats fed an atherogenic diet .They said that watermelon, rich in antioxidants and other bioactive components, may be a viable method to improve CVD risk factors through reduced oxidative stress.

Bailey *et al*. (2016) reported that the hypothesis that watermelon juice supplementation would improve nitric oxide bioavailability and exercise performance. Watermelon juice supplementation increased baseline plasma [nitrite] and improved muscle oxygenation during moderate-intensity exercise, it increased resting blood pressure and did not improve time-to-exhaustion during severe-intensity exercise.

Oberoi *et al*. (2017) said watermelon reported 41.5–60% juice, 31–49.55% rind and 8.9–23.59% pomace (including seeds) on wet basis. They stated that watermelon pomace is a concentrated source of lycopene containing more pigment than juice (Perkins-Veazie et al. 2006). They said that the degradation of lycopene affects the sensory attributes, health promoting ability and natural appearance of the food products.

According to Abu-Nasser *et al*. (2018) many health benefits for watermelon, especially with regard to intestinal and kidney safety. It moisturizes the skin, refreshes the body and may serve as a powerful laxative for intestines, a substance that helps digestion, strengthens the blood, and breaks the kidney stones. The researchers also found that the natural compounds found in it help to reduce the severity of skin diseases, as well as its seeds in the reduction of high blood pressure, and can be used to stop bleeding.

Maoto *et al*. (2019) stated that watermelon contains phytochemicals such as lycopene, vitamin C, β-carotene, and total polyphenolic content that possess anti-inflammatory, anticancer, and antioxidant properties. Dietary intake of these products with antioxidants properties is important in maintaining human health and well-being. These reduces incidence of chronic diseases such as hypertension, diabetes, cancer, and some coronary heart diseases, through inhibiting formation of free radicals and reactive oxygen species.

CHAPTER III
MATERIALS AND METHODS

Diseases play an important role in suppressing the quality and quantity of cultivated crops. The present study was conducted to study the seedling diseases of watermelon in natural epiphytic condition at two different district i.e. Noakhali district and Patuakhali district respectively.

The experiments conducted under this research work were as following:

1. Determination of disease incidence and severity of different major diseases of watermelon at Noakhali and Patuakhali district.
2. Determination of Seed Health Status of Watermelon mixed varieties

3.1. Experimental Site

Laboratory works were conducted in Plant Disease Clinic of Sher-e-Bangla Agricultural University, Dhaka (Appendix III). The field investigation on diseases of watermelon was conducted at 60 fields from 20 villages of Subarnachar upazila in Noakhali and Dashmina upazila in Patuakhali district of Bangladesh.

3.2. Study and Survey Area

The field investigations and survey were conducted in the major watermelon regions of Noakhali and Patuakhali district in Bangladesh. Altogether 60 locations under 10 unions from 2 districts were intensively surveyed in both districts to collect data on diseases of watermelon in Bangladesh. A detail of the investigated locations is given in Table 1.

Table 1. Survey locations for major diseases of watermelon in Noakhali and Patuakhali district of Bangladesh

Locations			
Subarnachar Upazila		**Dashmina Upazila**	
Unions	**Villages**	**Union**	**Villages**
Charbata	Middle Charbata	Dashmina Sadar	Katakhali
	West Charbata		Golkhali
East Charbata	East Charbata	Bashbaria	Bashbaria
	Char Mujib		Gochani
Char Jubli	North Kocchopiya	Alipura	Chapura
	South Kocchopiya		Khalishakhali
Char Wapda	Char Wapda	Rangopaldi	Patarchar
	Char Aminul Hoq		Auliapur
Char Amanullah	Char Bajlul Karim	Bahrampur	Bagura
	27 Drone		Adampur

3.3. Experimental Period

The field investigation was carried out in the month of January to April, 2020 and December to January, 2021. However, laboratory experiment was conducted June to August, 2020 and January to February, 2021.

3.4. Climatic Conditions

The field investigation was conducted in the winter season. So the average temperature, precipitation and relative humidity of that month were 32℃, 0 mm and 92% respectively.

3.5. Characteristics of Soil

The investigated fields belong to the general type of soil i.e Sandy Loam and the land was above the flood level and ambient sunshine was available during the experimental period. Organic matter and fertility status were moderate.

3.6. 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 & II.

3.7. Sample size of field investigation for measurement of diseases

In case of investigation of seedling diseases of watermelon, thirty plants from each field were considered to measure data on disease incidence and severity. Out of 30 plants, 10 plants selected in the centre, ten plants in one corner and another 10 plants were selected from the opposite corner of the field.

3.8. Sample Size of Survey

In the survey program, three farmers from each location were interviewed under this study. Altogether, 30 farmers were interviewed from 10 villages of 5 Unions in each upazila of Noakhali and Patuakhali district (Table 1).

3.9. Data collection

Plant Disease Survey Sheet (Appendix I) was used to collect information on the symptomology of diseases and to record disease incidence and severity data. The survey was conducted under natural epiphytic condition. The questionnaire was used as the instruments for data collection. The questionnaire (Appendix II) were formulated and pre-tested prior to beginning the survey. During the survey in the selected study area, total numbers of leaves and roots of the crop as well as

number of diseased leaves and roots were counted. Infected area of leaf was also counted by visual observation.

3.10. By Symptomological Study (Visual assessment)

Symptomological study was done for all diseases. The development of symptoms was closely observed to confirm the disease. During survey, the diseased plant parts (leaf, stem and roots) were carefully examined visually of by magnifying glass to observe the disease symptom development, sign of the pathogen, source of infection, mode of dissemination and favorable environment. Idea about causal organisms (fungi, bacteria, nematode and virus) was taken from those information (Pernezny *et al*. 2008; Mullen, 2007; Waller *et al*., 1998; Shutleff and Averre, 1997; Putnam, 1995; Hensen and Wick, 1993).

3.11. Collection of Specimen

Diseased leaves and roots were collected from different diseased plants from the watermelon fields. The samples were preserved temporarily in air tight zip locked poly bags and tagged for later convenience. Then the samples were carried to the Plant Disease Clinic of SAU. The collected samples were preserved in the laboratory under the following standard procedure of preservation until isolation was made.

3.12. Isolation of Causal Organism

3.12.1. Blotter Method

The diseased leaves and roots were washed thoroughly to remove the dust particles and allowed to dry. Then surface sterilized with 0.1% NaOCl and then three times washed with distilled water. Then three or four cut pieces were placed on the moist filter paper (Figure.1).The petridishes with diseased specimens were

incubated at 22±2ºC under 12/12 alternating cycles of UV and darkness in the incubation room of the Mycology Laboratory for three to five days. After incubation the plates were examined under stereomicroscope for primary identification of the organisms. The fungi then transferred to PDA plate for proper sporulation and purification.

3.12.2. Preparation of Potato Dextrose Agar (PDA) Medium

At first, 200g potato was peeled and cut in a slice and boiled in 1litre water. After 20 minutes it was sieved. Then 20g dextrose, 18g Agar were mixed slowly with proper shaking to avoid coagulation. Adjusted in a conical flask and sterilized the media through autoclave by adjusting 121ºC temperature at 15PSI pressure for 50 minutes. The whole work was done under Laminar Flow Chamber .

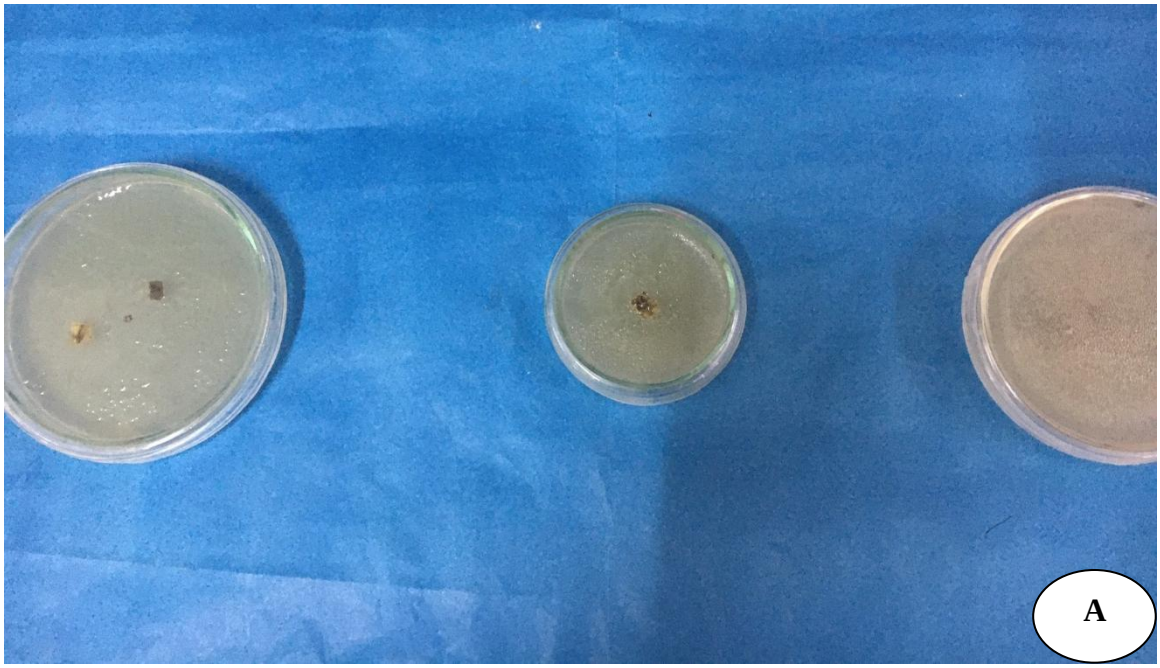
3.12.2.1. Agar Plate Method

Previously prepared autoclaved PDA media was used to culture and purification of fungi. This fungi grow over the infected cut pieces placed over the moist filter paper was transferred to the PDA plates (Plate.1). A bit of mycelia was taken with the help of a sterile needle and aseptically transferred on the centre of the PDA plates. Three replications were taken. The plates were observed daily upto seven days. When the pure culture was observed, a slides were prepared and observed under the compound microscope (Agrios, 2005; Mathur and Kongsdal, 2003;Barnett and Hunter,1972).

3.13. Isolation and Identification of Pathogen

After incubation when the whitish growth of fungus was observed on the PDA (Plate.1).Temporary slides were prepared for identification under compound microscope. The causal pathogens were identified according to reference materials and CMI Description (Mathur and Kongsdal, 2003; Riley, 2002).

Figure. 1. Isolation and Identification of Causal Organisms, (A & B). Incubation of diseased sample in Moist Blotter Paper;



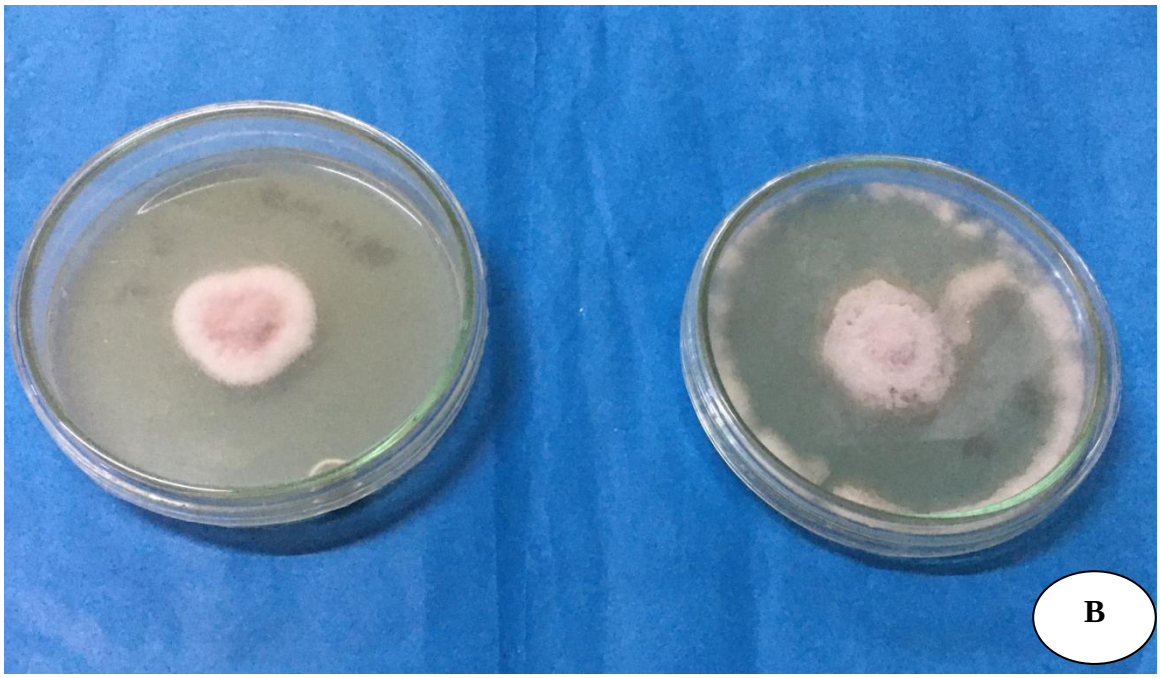


Plate.1. Isolation and Identification of Causal Organisms (*Fusarium* sp) ;(A) Incubation of diseased sample in PDA medium; (B)) Pure culture of causal organism (*Fusarium* sp.)

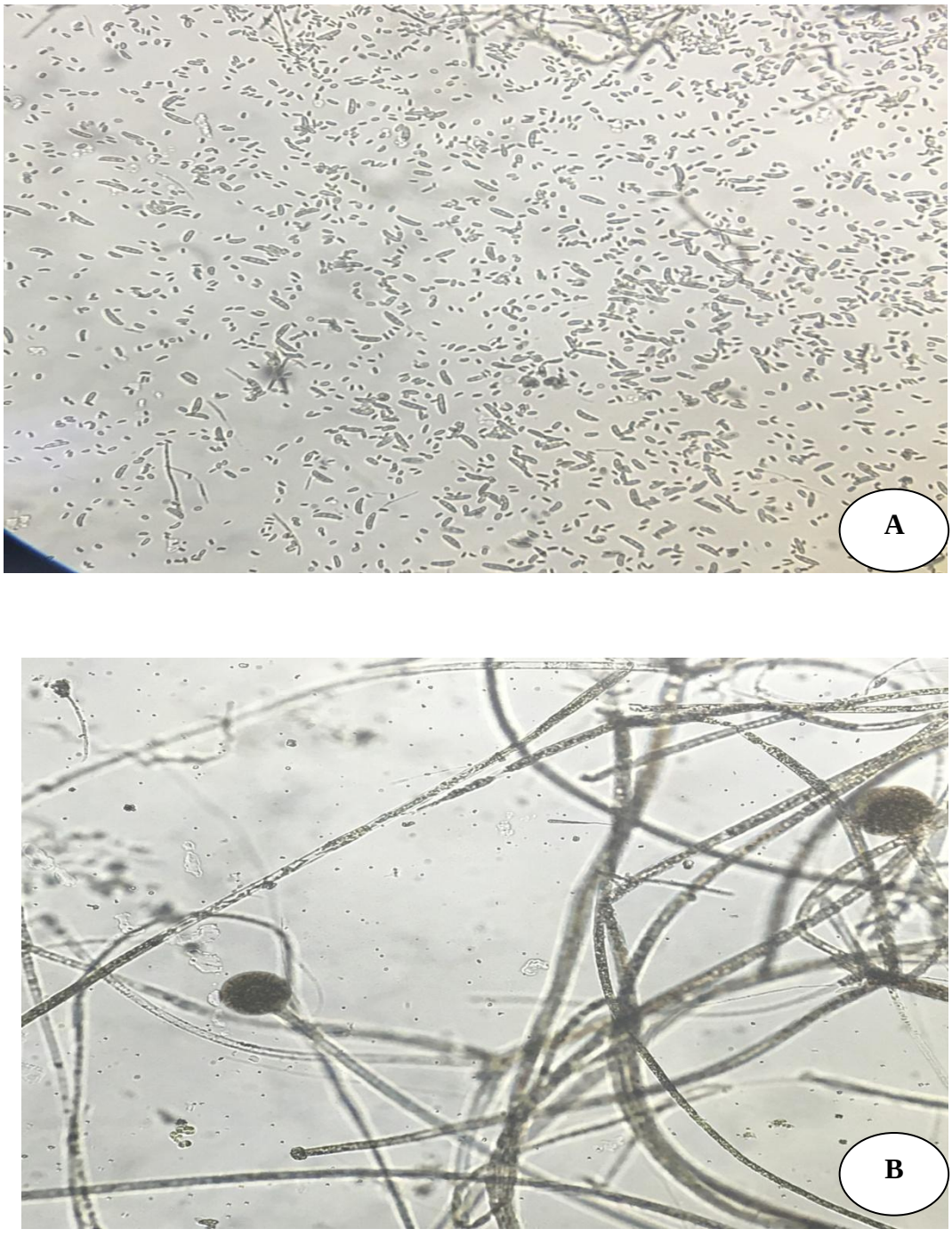


Plate.2. Microscopic view of *Fusarium* sp at 400x (A) and (B) *Aspergillus* sp. at 100x.

3.14. Measurement of Plant Diseases

Measurement of diseases of watermelon was calculated by % disease incidence and % disease severity.

3.14.1. Disease Incidence

The plants under investigation were carefully observed for typical symptoms and sign of the concerned disease. The plants showing typical symptoms were considered as diseased plant. Disease incidence was calculated by the number of proportion of the plant units diseased in relation to the total number of units examined (Agrios, 2005). The disease incidence was calculated using the following formula:

$$\text{Disease Incidence (\%)} = \frac{\text{Plant units diseased} \times 100}{\text{Plant units examined}}$$

3.14.2. Disease Severity

Disease severity was calculated in the proportion of amount of plant tissues infected in relation to the total amount of tissue examined following the below formula (Agrios, 2005).

$$\text{Disease severity (\%)} = \frac{\text{Area of tissues infected} \times 100}{\text{Area of tissues inspected}}$$

3.15. Seed Health Study

Seed the planting materials of watermelon were collected from Dhaka and Noakhali districts. Five varieties sample were collected from these locations. The collected seed sample was analyzed for investigation of seed borne pathogens by

modified blotter method following the International Rules for Seed Testing Agency (ISTA, 2001).Seeds were sterilized by Sodium Hypochloride (NaOCl) (seeds dipped into 3% NaOCl solution for 1 minute then washed 3 times with distilled water).Two pieces of blotter paper sheet were shoaked in sterilized water and placed at the bottom of petridish. Ten seeds were randomly selected from each sample and placed in equal distance in each petridish using a pair of forceps (Plate.3).

The placed seeds were incubated at 20±2ºC for 21 days under 12 hours alternate cycle of light and darkness. After every 7 days of incubation period, individual seed was examined under stereomicroscope in order to record the incidence of different seed borne fungi. With flamed sterilized needles fungal growths on the seeds will be aseptically mounted in glycerine on slides and examined under the compound microscope for detection and identification of organism.

3.16. Analysis of Data

The collected data were analyzed in one factor randomized block design (RCBD) through Statistics 10 computer package program. Analysis of variance (ANOVA) will be used to find out the variation of result from experimental treatments. The mean differences were judged by Tukey Least Significant Difference (LSD) at the 5% level of significance. In case of disease incidence and severity, data were transformed by square root transformation. The survey data was analyzed by average mean test.

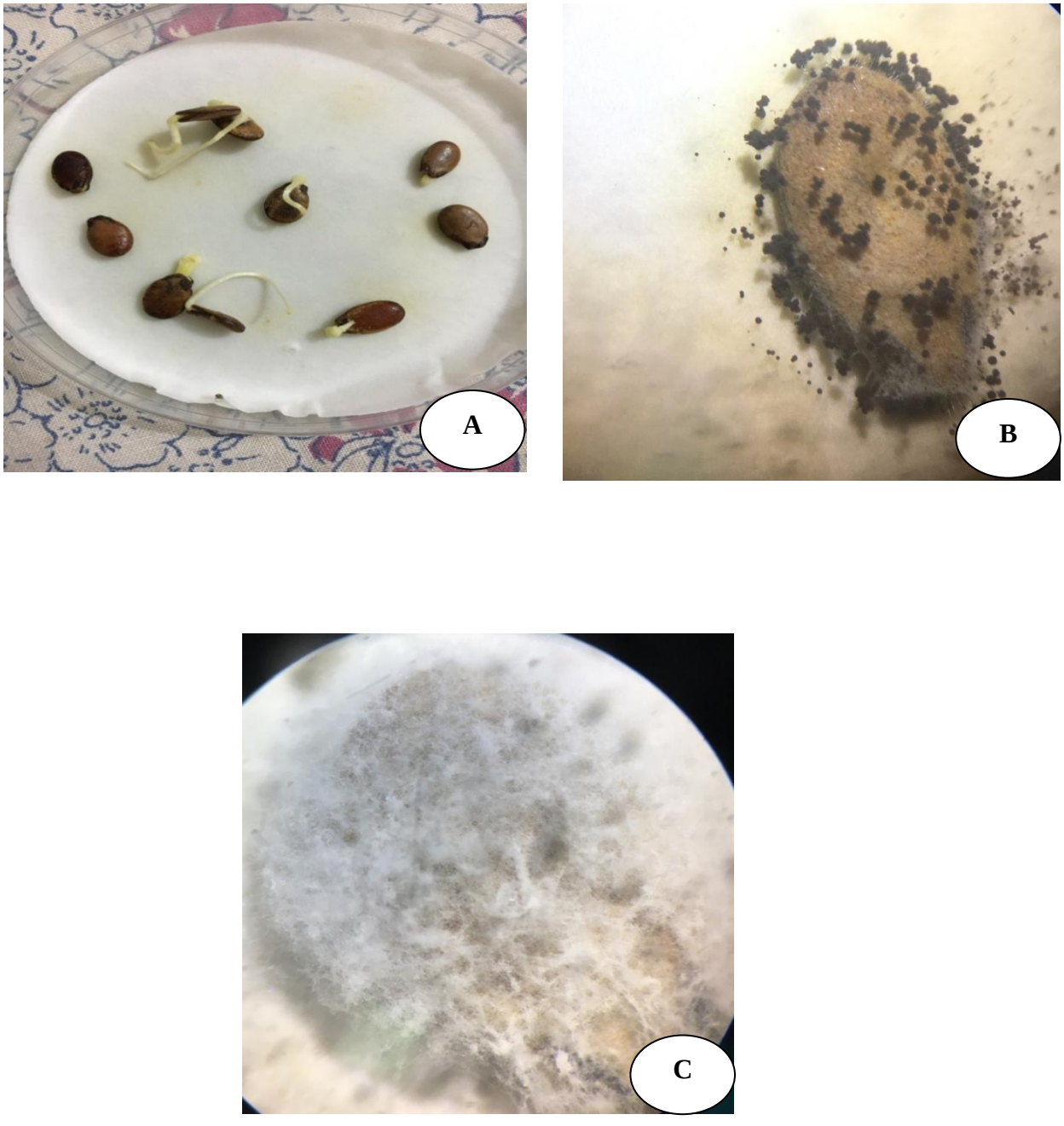


Plate.3.Seed health test of watermelon seed by blotter paper; (A) Washed seeds placed on moist blotter paper (B & C) Pathogenic structure under stereomicroscope.

CHAPTER IV

RESULTS AND DISCUSSION

This chapter encomprises the explanation about presentation of the results obtained from the study on diseases of watermelon through measurement of disease incidence and severity in selected locations (Unions) of Noakhali and Patuakhali district.

Symptoms of Diseases, Isolation and Identification of Pathogen

On the basis of typical symptoms five diseases viz. *Alternaria* leaf spot, foot and root rot, mosaic diseases, powdery mildew and leaf curl were recorded and the identified diseases are as follows-

4.1. Diseases of Watermelon

4.1.1. *Alternaria* leaf spot of watermelon

4.1.1.1. Symptomological Study

Irregular dark brown color scattered dot like small spots were observed on leaf surfaces. Gradually the leaf surface is covered with numerous such lesions, which form brown to black lesions later with concentric ring with yellow hallo (Figure 2).

Figure.2. Symptoms of *Alternaria* leaf spot disease showing on watermelon

4.1.1.2. Identification of Causal Organism

The identified organism was *Alternaria alternata.* In PDA medium, pure culture was cottony growth with grayish to blackish in color and moderately slow growing (Plate 4.A). Mycelium was septate, branched and hyaline in tender age. The conidiophore was simple, septate, short, colored. Conidia were dark, short beaked, multi-celled and muriform (both longitudinal and transverse septum was present) (Plate 4B) borne at the tip of conidiophores singly or in short chains. The conidia contained 4-8 transverse septa and few longitudinal septa.

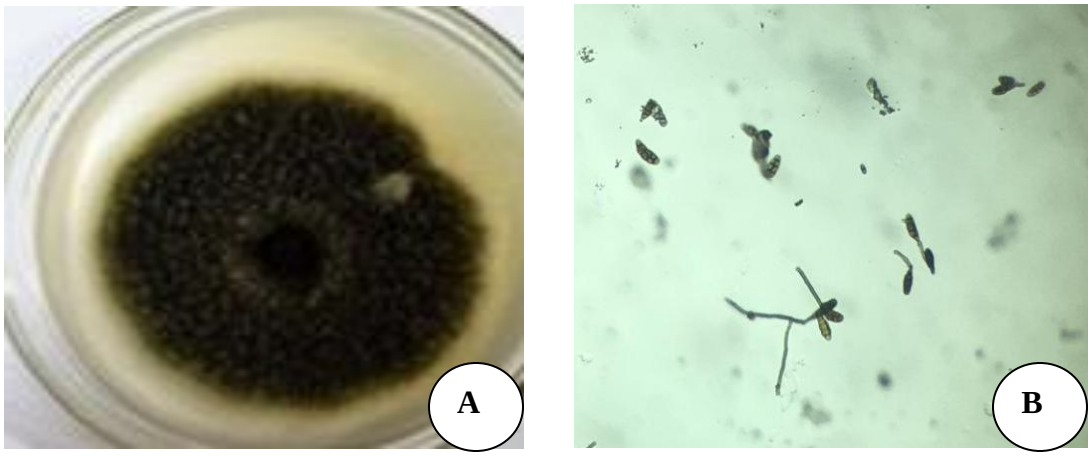


Plate.4. (A) Pure culture of *Alternaria alternata,* (B) Mycelium and conidia of *Alternaria alternata* (400x)

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). *Alternaria 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 plants and

found that watermelon samples were infected by *Alternaria alternata.* They found *Alternaria* leaf spot caused by the fungus *Alternaria alternata.*

4.1.1.3. Incidence and Severity of the Disease

Alternaria leaf spot disease of watermelon was observed in several locations of Subarnachar upazila of Noakhali district. Incidence of *Alternaria* leaf spot disease varied significantly among the locations from 0.00 to 35% (Figure 3). The highest disease incidence was recorded in West Charbata (35.10%). However, the lowest disease incidence was 0.00% observed in Char Bajlul Karim and 27 Drone. In case of disease severity, value ranged from 0.00 to 10.33 % (Figure 3). The highest disease severity was observed in West Charbata (10.33%) whereas; the lowest disease severity was observed 0.00% in Char Bajlul Karim and 27 Drone.

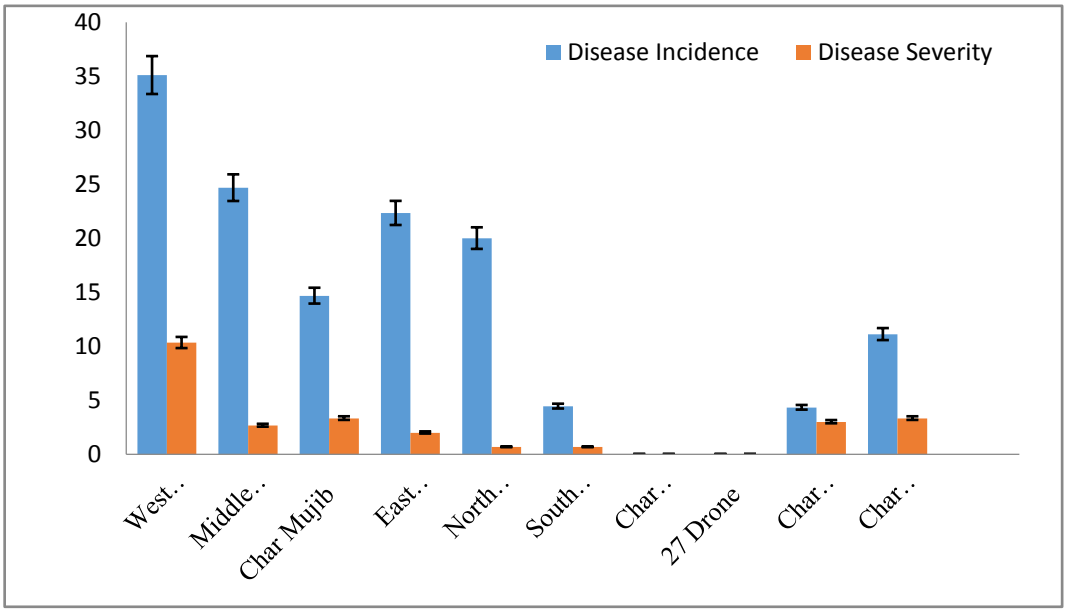


Figure.3. Disease incidence and severity of *Alternaria* leaf spot of watermelon at Subarnachar Upazila, Noakhali in 2020.

In case of Dashmina upazila, Patuakhali district ,the incidence of *Alternaria* leaf spot disease varied significantly among the locations from 0.00 to 11.33% .The highest disease incidence and disease severity was recorded 11.33% and 4.00% in Khalishakhali .However, the lowest disease incidence and severity in Dashmina Upazila's selected surveyed areas were 0.00% observed in Katakhali, Golkhali, Gochani, Patarchar, Auliapur,Bagura and Adampur (Figure 4).

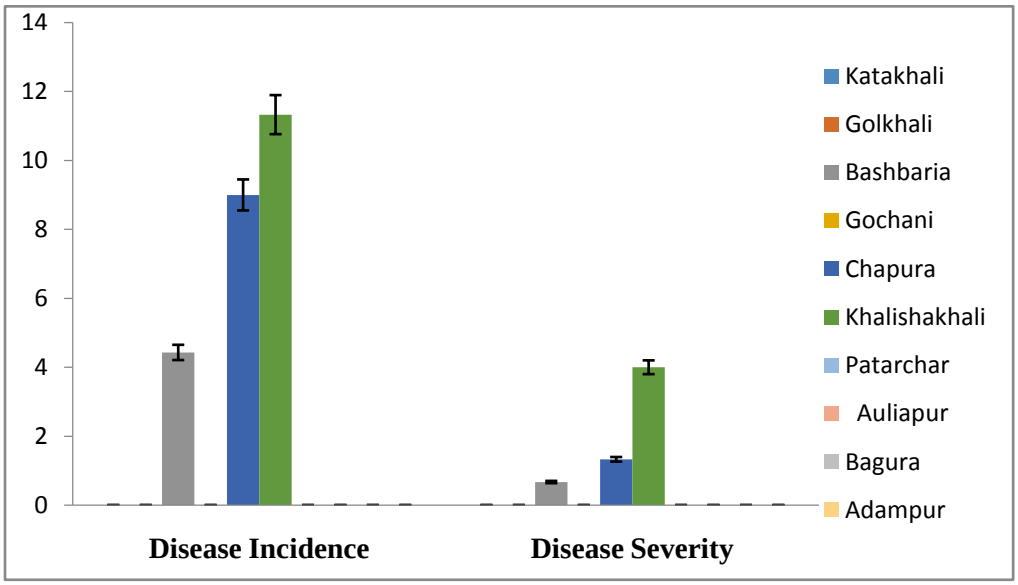


Figure.4. Disease incidence and severity of *Alternaria* leaf spot of watermelon at Dashmina Upazila,Patuakhali in 2021

4.1.2. Foot and Root Rot disease of watermelon

4.1.2.1. Symptomological Study

Foot and root rot disease of watermelon is one of the most serious diseases, affecting plants in the field and even in seeds. The infected plants show brownish to black dry rot symptoms. Brown streaks develop in the vascular system those eventually turn into black. Brown discoloration was observed in the vascular system of the root and stem. Diseased plants are initially stunted with chlorotic leaves (Figure 5). Foliage of affected plants first turns yellow and then brown.

Infected roots remain small and are gradually killed. Ultimately the whole plant became die.

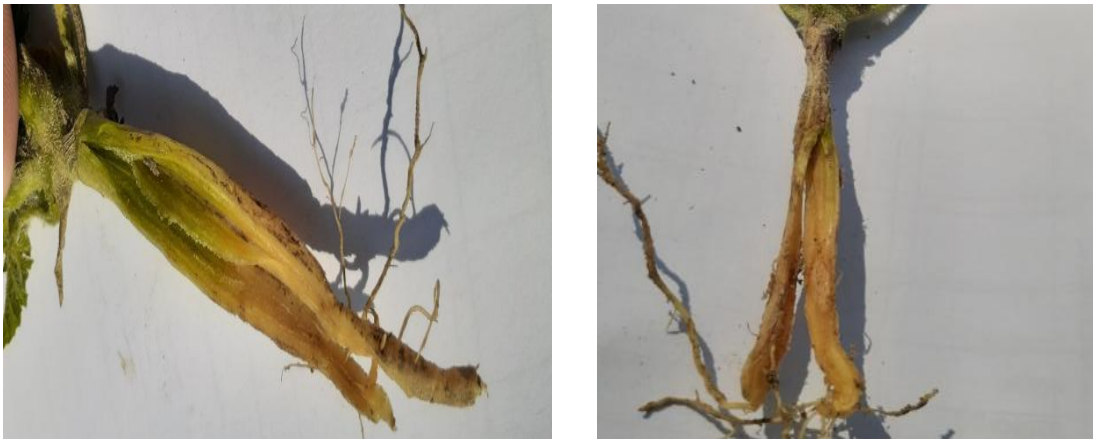


Figure.5. Symptoms of Foot and Root Rot disease showing on Watermelon

4.1.2.2. Identification of Causal Organism

The identified causal organism of foot and root rot disease of watermelon was *Fusarium oxysporum* .White cottony mycelial growth was produced in pure culture within 5 days of incubation on PDA medium. Later the culture forms dark pinkish (Plate 5.A). Small, oval shaped, single or bi-celled micro-conidia and hyaline, multi-celled macro-conidia with 3 septation were observed under microscope, which were sickle shaped with knotched base at one end (Plate 5.B).

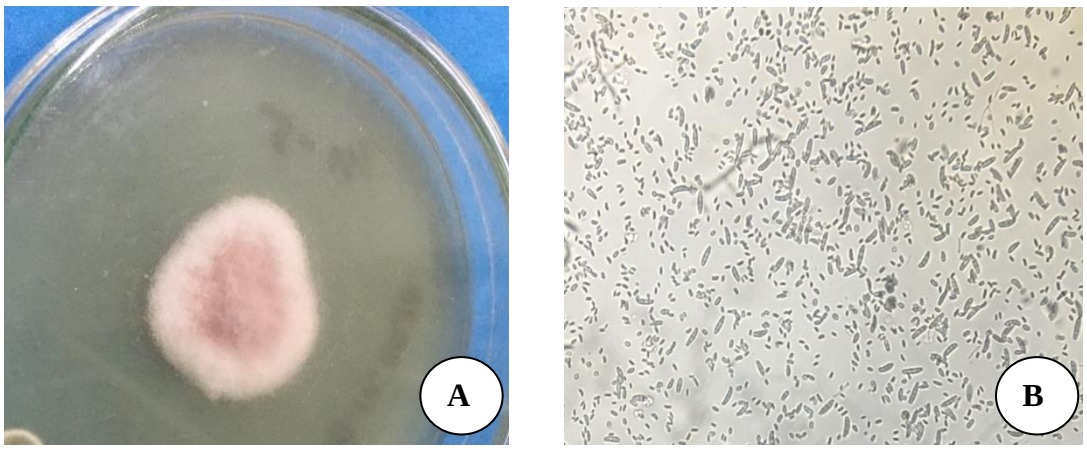


Plate 5. Causal Organism of foot and root rot disease of watermelon; A) Pure culture of *Fusarium oxysporum* and B) Macro and micro conidia of *Fusarium oxysporum*.

Fusarium wilt caused by *Fusarium oxysporum* is a destructive soil borne disease commonly found in watermelon producing areas throughout the world (Hua *et al*., 2020).The single spored isolates produced flat, round and light purple mycelia growth on the surface and reverse of PDA plates (Alam *et al*., 2020). Foot and root rot disease of watermelon caused by *Fusarium oxysporum* caused seedling losses in nurseries, as well as severe losses in many crops was found in the study of Dau *et al*., 2009. Even it was recorded that *Fusarium oxysporum* were responsible for seedling losses (Zitter *et al*., 1996).

4.1.2.3. Incidence and Severity of the Disease

Foot and root rot disease of watermelon was observed in several locations of Subarnachar upazilla of Noakhali district. The highest disease incidence and severity were 9% and 15% respectively which were recorded in West Charbata .However, foot and root ro were present in most of the locations (Figure 6).

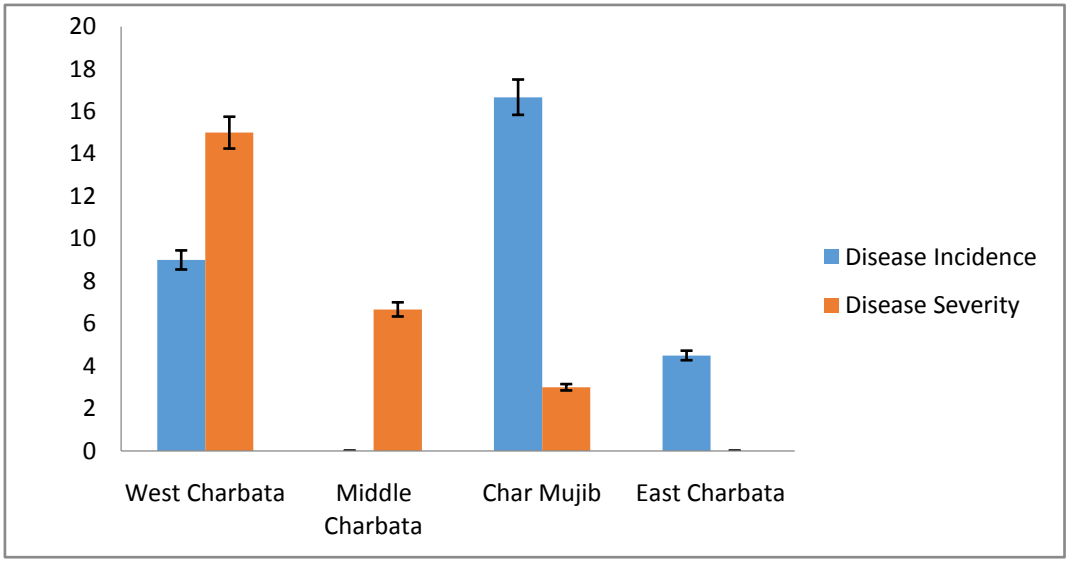


Figure.6. Disease incidence and severity of Foot and Root Rot of watermelon at Subarnachar Upazila, Noakhali in 2020.

In case of Dashmina Upazila, Patuakhali district ,the highest disease incidence was recorded in Patarchar (25.67%) while the highest disease severity was observed also in Patarchar that was 6.33% (Figure 7).However most of the areas had recorded no disease of foot and root rot.

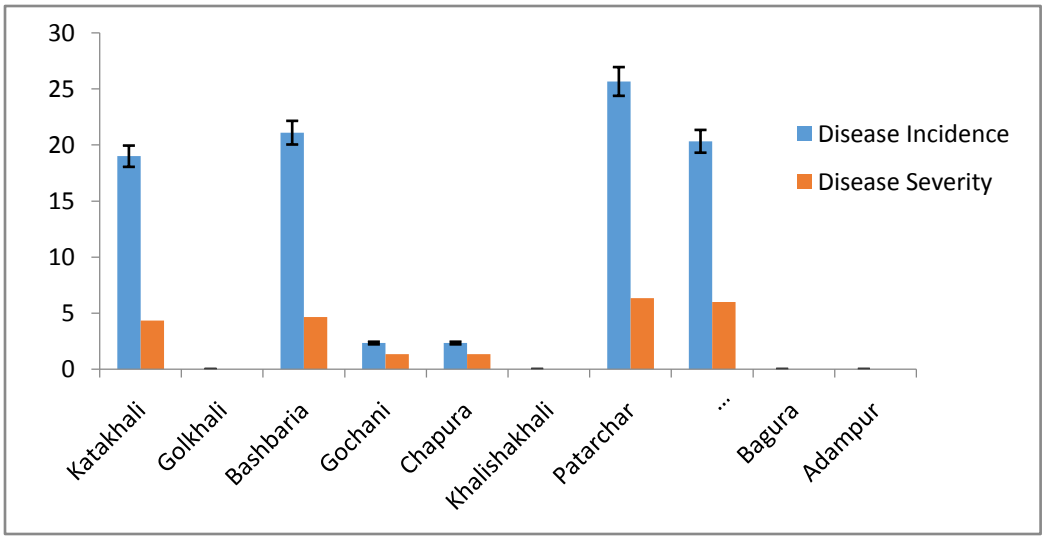


Figure.7. Disease incidence and severity of Foot and Root Rot of watermelon at Dashmina Upazila,Patuakhali in 2021.

4.1.3. Powdery Mildew disease of watermelon

4.1.3.1. Symptomological Study

A white, powdery fungal growth on the leaves was noticed. It affected mainly lower side of the leaves (Figure 8B).In some cases, both leaf surfaces were affected (Figure 8A & B). Heavily infected parts were failed to open properly. The heavily infected young leaves were curled and distorted. The mildew growth on all parts had been turned browner as it ages. Sometimes, rotting start in powdery mildew infected areas.

Figure.8. Symptoms of powdery disease of watermelon; A) Upper Leaf Surface and B) Lower Leaf Surface.

4.1.3.2. Identification of Causal Organism

The identified causal organism of powdery mildew disease of watermelon was *Podosphaera xanthii* (*Oidium* sp.). It cannot live without living host. A semi-permanent slide was made from the fresh sample. The oidia of the fungus are oval shaped, hyaline, formed chains. Each chain contained 3-5 cells, arised from septate stalk (Figure 9).

Figure.9. Microscopic view of *Oidium* sp. the causal organism of powdery mildew disease of Watermelon

The seedling disease of powdery mildew was consistently among the most prevalent diseases of watermelon in a survey of foliar diseases done by Keinath and Rennberger (2019) and they said that the symptoms are found on leaves and petioles and, rarely, on fruits. There are at least two different types of symptoms seen on watermelon. One is a yellow blotching (chlorotic spots) and the other symptom is powdery mycelial and conidial development on either leaf surface without the associated chlorotic spots reported by the research work (Devis *et al*., 2001).

4.1.3.3. Incidence and Severity of the Disease

Incidence of powdery mildew disease of watermelon varied significantly among the locations that ranged from 0.00% to 11.33% (Figure 10 & 11) in both upazila at Noakhali and Patuakhali District .The highest incidence was recorded in South Kocchopiya in Noakhali which was 11.33% and the severity also highest among other locations that was 4%.On the other hand lowest incidence and severity recorded other surveyed locations in both districts.

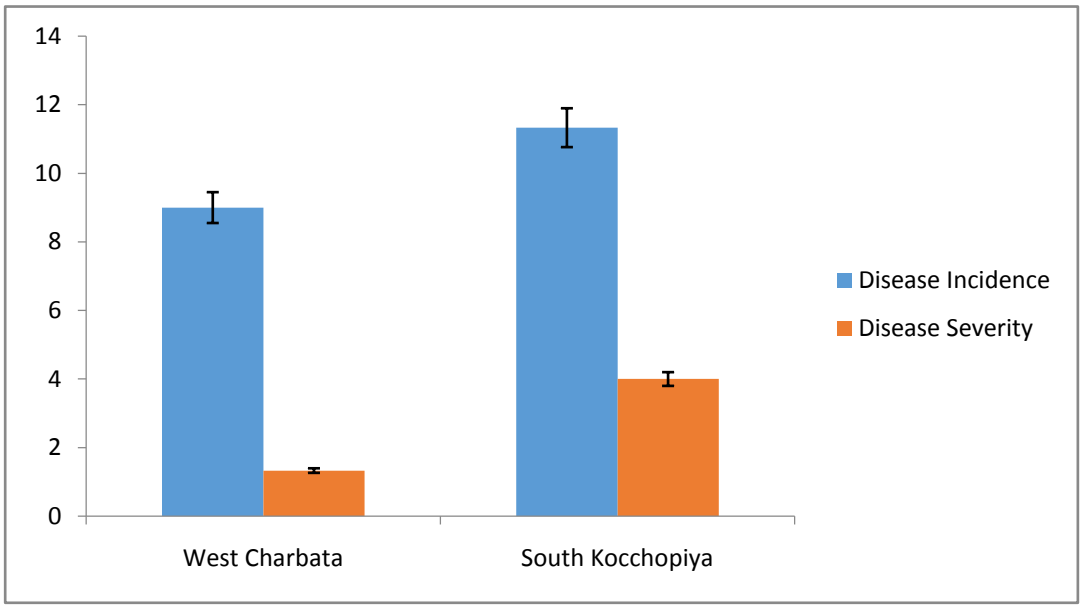


Figure.10. Disease incidence and severity of Powdery Mildew of watermelon at Subarnachar Upazila,,Nokhali in 2020.

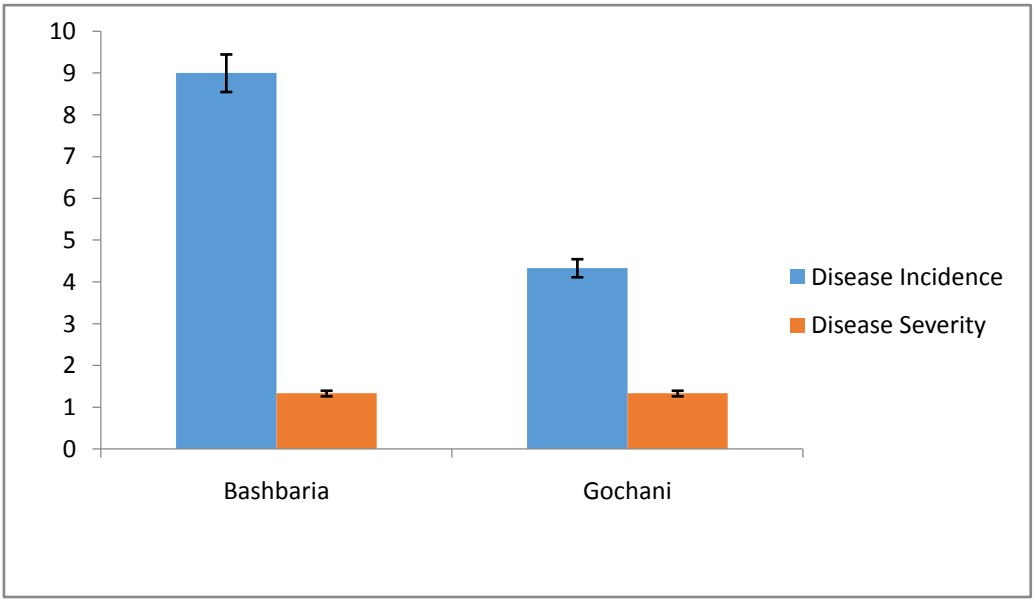


Figure.11. Disease incidence and severity of Powdery Mildew of watermelon at Dashmina Upazila, Patuakhali in 2021.

4.1.4. Leaf Curl Disease of Watermelon

4.1.4.1. Symptomological Study

The primary symptom was characterized by distortion and discoloration of leaves followed by curling of leaves from their edge. The curled area became thick and puckered (Figure 12).

Figure.12. Symptoms of leaf Curl of watermelon

4.1.4.2. Identification of Causal Organism

The disease is caused by a virus Watermelon Chlorotic Stunt Virus which is transmitted by a vector. No organism was identified as the cause of this disease. Most possibly any kind of virus is responsible for the disease.

Leaf curl disease of watermelon, characterized by leaf curling and mottling and stunted plant growth, was observed at several locations were reported by Mansoor *et al*., (2000) in their experiment in Pakistan. The virus that caused leaf curl was transmissible by mechanical means (Brown *et al*., 1989) as well as transmitted by two another virus viz. Watermelon Chlorotic Stunt Virus (WmCSV) and *Squash Leaf Curl Virus* (SLCV) reported by Abudy *et al*., (2010).

4.1.4.3. Incidence and Severity of the Disease

The highest incidence was recorded in Char Aminul Haq in Noakhali which was 55.57% and the severity also highest among other locations that was 18.33%.On the other hand, lowest incidence and severity observed in Char Mujib and East Charbata which was 0.00%.The result showed that leaf curl disease is a prominent disease in these areas (Table 2).

Table.2. Disease incidence and severity of Leaf Curl of watermelon at Subarnachar Upazila,Noakhali in 2020

Locations	Disease Incidence (%)	Disease Severity (%)
West Charbata	3.33bc	5.66cd
Middle Charbata	33.33bc	5.66cd
Char Mujib	0.00c	0.00d
East Charbata	0.00c	0.00d
North Kocchopiya	31.33bc	8.00c
South Kocchopiya	**74.53a**	16.67ab
Char Bajlul Karim	44.67ab	10.00bc
27 Drone	26.76bc	4.67cd
Char Aminul Haq	55.76ab	**18.33a**
Char Wapda	34.43bc	8.00c
LSD (0.05)	36.26	7.06
CV (%)	63.25	53.51

Means followed by the same letters in a column do not differ at 5% level of significance by LSD.

In Dashmina upazila, the incidence and severity among locations varied significantly. In Bashbaria, the highest incidence recorded while the maximum severity was observed in Auliapur which were 50.67% and 14% respectively. The range of incidence was 17-50.67% and severity was 3.33- 14% (Table.3).

Table.3. Disease incidence and severity of Leaf Curl of watermelon at Dashmina Upazila, Patuakhali in 2021.

Locations	Disease Incidence (%)	Disease Severity (%)
Katakhali	46.77a	9.67ab
Golkhali	43.43ab	7.67ab
Bashbaria	**50.67a**	12.00ab
Gochani	17.00ab	5.00ab
Chapura	47.67a	8.67ab
Khalishakhali	24.66ab	**3.33b**
Patarchar	34.33ab	9.33ab
Auliapur	46.43a	**14.00a**
Bagura	20.10ab	7.00ab
Adampur	**9.00b**	3.67b
LSD (0.05)	36.09	9.93
CV (%)	61.88	72.13

Means followed by the same letters in a column do not differ at 5% level of significance by LSD.

4.1.5. Leaf Mosaic Disease of Watermelon

4.1.5.1. Symptomological Study

When plants became infected in the 5 to 7 leaf stage, symptoms first appear on the younger leaves, even expending leaves. A mosaic pattern develop, dark green leaf tissue intermingled with light green and yellow tissue. Leaves are often curled, crinkled. distorted and stunted. In severe cases, older leaves were died (Figure 13).

Figure.13. Symptoms of Leaf Mosaic of Watermelon

4.1.5.2. Identification of Causal Organism

No organism was identified from this disease. A kind of virus is responsible for the disease which is transmitted by aphids, white flies and leafhoppers common pests.

Mosaic disease in watermelon is also reported by many researcher around the world [Atiri and Ibidapo (1989); Sikora, 2011] Watermelon are susceptible to mosaic virus at any stage of growth. 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 transitted 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 aphid although the virus can also be mechanically transmitted through equipment but aphis are the primary vector (Kurowski *et al.*,

2015).Mosaic virus is also reported to be seed borne in some species (Atiri and Ibidapo, 1989)

4.1.5.3. Incidence and Severity of the Disease

Incidence of mosaic of watermelon varied significantly among the locations of Noakhali and Patuakhali that ranged from 6.66% to 42.33% (Table 4& 5). The highest disease incidence was recorded in Adampur (42.33%) at Patuakhali district and even the highest disease severity also was observed in same area. which is 8% followed by Gochani (5%) at Patuakhali. Moreover, No disease was found in some of the locations in Noakhali and Patuakhali districts selected experimental sites.

Table.4. Disease incidence and severity of Leaf Mosaic of watermelon at Subarnachar, Noakhali in 2020.

Locations	Disease Incidence (%)	Disease Severity (%)
West Charbata	27.83a	2.67a
Middle Charbata	11.33ab	1.66a
Char Mujib	6.66ab	2.33a
East Charbata	9.00ab	1.33a
North Kocchopiya	9.00ab	1.33a
South Kocchopiya	**16.67ab**	**2.33a**
Char Bajlul Karim	0.00b	0.00a
27 Drone	0.00b	0.00a
Char Aminul Haq	0.00b	0.00a
Char Wapda	0.00a	0.00a
LSD (0.05)	25.30	3.73
CV (%)	183.23	186.41

Means followed by the same letters in a column do not differ at 5% level of significance by LSD.

Table 5. Disease incidence and severity of Leaf Mosaic of watermelon at Dashmina Upazila,Patuakhali in 2021.

Locations	Disease Incidence (%)	Disease Severity (%)
Katakhali	0.00c	0.00c
Golkhali	0.00c	0.00c
Bashbaria	0.00c	0.00c
Gochani	16.67abc	5.00abc
Chapura	11.33bc	1.33c
Khalishakhali	9.00bc	2.66bc
Patarchar	0.00c	0.00c
Auliapur	0.00c	0.00c
Bagura	31.00ab	8.00ab
Adampur	**42.33a**	**9.33b**
LSD (0.05)	28.97	5.98
CV (%)	153.11	132.50

Means followed by the same letters in a column do not differ at 5% level of significance by LSD.

From the survey result it can be observed that most of the cases, disease incidence and severity were varied significantly among the locations. Moreover, the disease incidence varied due to susceptibility of the host, seasonal factors, over wintering and over summering, presence of secondary host, life cycle of host and pathogen, proximity and availability of the host and pathogen etc. In maximum locations there is no disease infestation recorded.

Determination of Seed Health Status of Watermelon

4.2. Study of Health Status by Modified Blotter Method

Modified blotter paper method was used to determine the health status. All together five fungi species viz. *Fusarium oxysporum.*, *Aspergillus flavus*, *Aspergillus niger*, *Rhizopus stolonifer*, *Chaetomium* sp., *Aspergillus* sp. were isolated and identified from the seed of watermelon.

4.2.1. Incidence of Pathogen in seed of Watermelon

Incidence of pathogens of seeds of watermelon is presented in Table 6. *Rhizopus stolonifer* caused maximum infection (42%) followed by *Aspergillus flavus* (38%), *Fusarium* sp. (34%), *Aspergillus spp.* (9%) and *Chaetomium* sp. (9%).

Table 6. Incidence of Seed borne fungi by Modified Blotter Paper Method

Variety Name	**% of Incidence**				
Diamond Sweet Dragon Black Teer Amrita Darbesh	***Fusarium oxysporum***	***Aspergilus spp.***	***Aspergilus flavus.***	***Rhizopus stolonifer***	***Chaetomium sp.***
	34.00	9.00	38.00	42.00	9.00

4.2.2. Description of Identified Pathogen

A. *Fusarium* sp.

The fungus produces sparse to abundant growth, covering part or whole seed (Plate 6.A). Mycelium can be white to pink colored. Conidiophore slender short, simple or branched and bear conidia terminally.Conidia variable in size.

Macro-conidia and micro-conidia are produced Chlamydospores intercalary or terminal on short lateral branches (Plate 6.B).

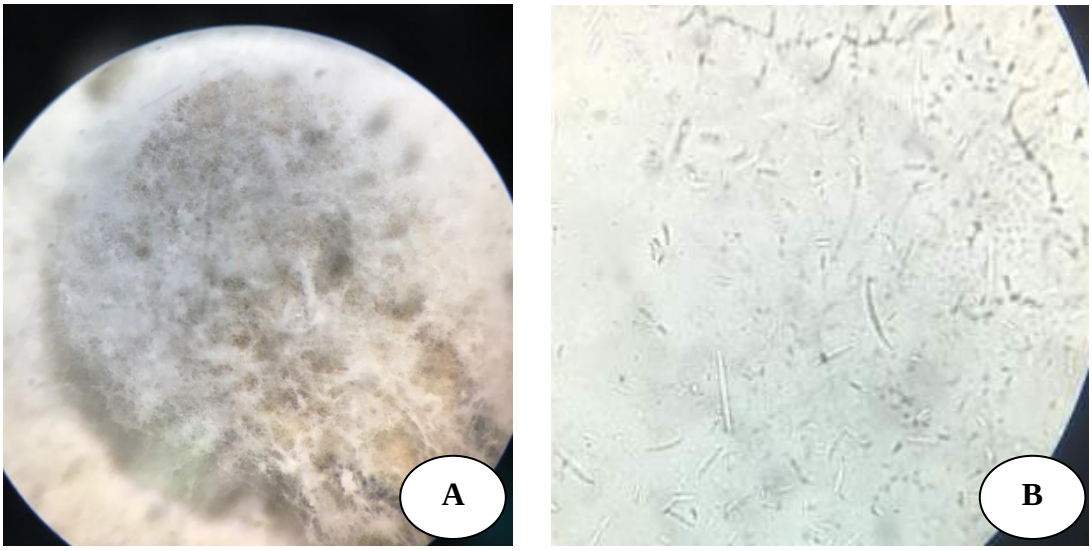


Plate.6. Growth of *Fusarium* sp. over incubated seed. A) Infected seed by *Fusarium* sp. B) *Fusarium* sp. under compound microscope

B. *Aspergillus niger*

Brown to Black globose conidial heads on long, erect, hyaline conidiophores are characteristic of the fungus. Conidiophores long, erect, arise singly from the somatic hyphae. They cover parts of seed or whole .Conidia more or less globose, dark brown to black thus often rough or echinulate (Plate 7).

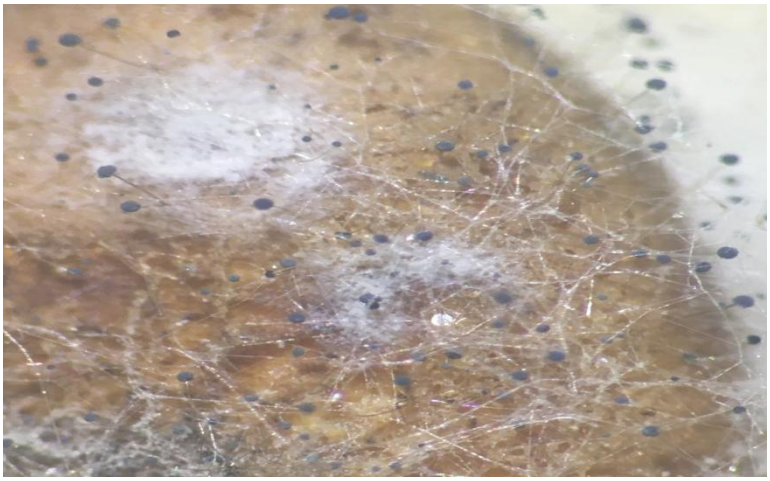


Plate 7. Growth of *Aspergillus nigar*.over incubated seed

C. *Aspergillus flavus*

The growth of the fungus is characterized by immature white heads and mature heads in shades ranging from yellowish cream to green (Plate 8.A). Conidiophores bearing the heads are clearly seen when the growth is light. Conidia globose to sub-globose, usually rough (echinulate) and yellowish-green (Plate 8.B).

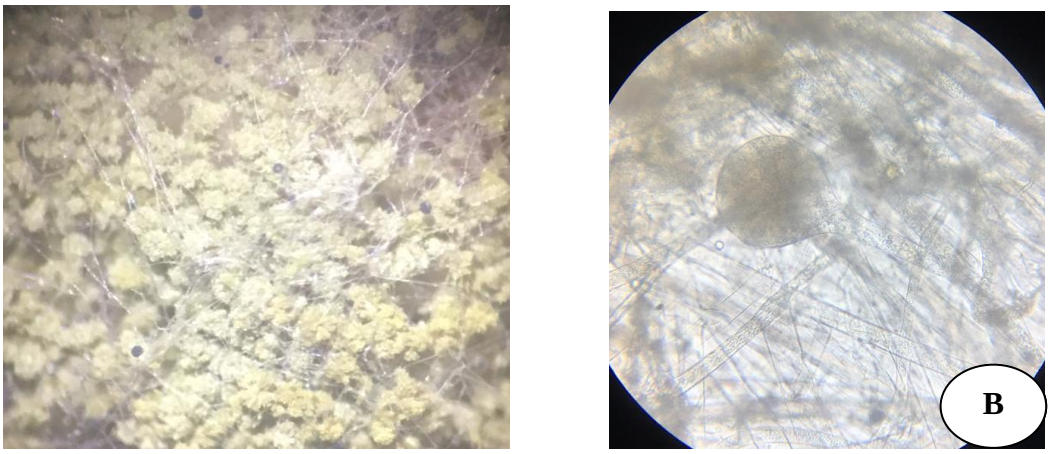


Plate 8. Growth of *Aspergillus flavus* over incubated seeds; A) Infected seed by *Aspergillus flavus*; B) *Aspergillus flavus* under stereo microscope.

D. *Rhizopus stolonifer*

Often the growth of the fungus covers the whole seeds and extends to blotter paper (Plate 9.). This is because of the fast spreading nature of the fungus. Even from one infected bulb the dense mycelium can cover the whole petri dish. The brown sporangiophores are long, solitary or arise. The rhizoids at the base of sporangiophores can be seen in some cases. They are more clearly visible on the blotter. Sporangiospores are one celled, spore shape may vary from globose to oval, ellipsoid, polygonal or angular, even striate.

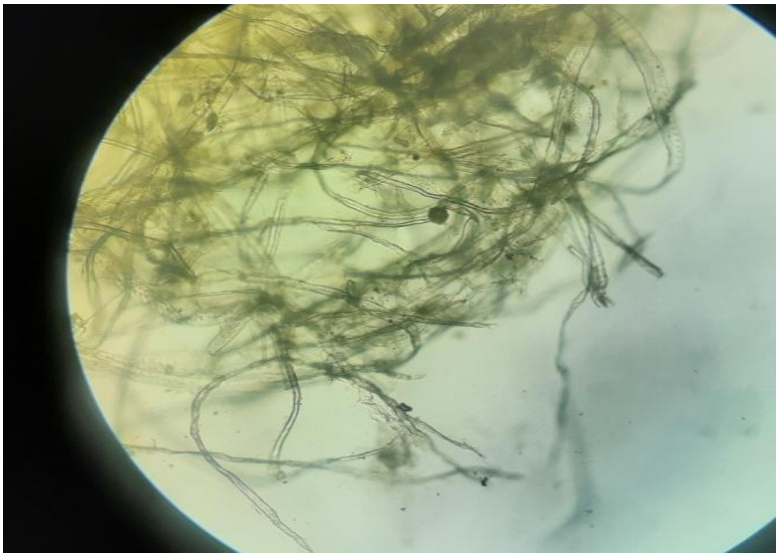


Plate.9. Growth of *Rhizopus stolonifer* over incubated seed

E. *Chaetomium* sp.

Chaetomium is a fungus belongs to Ascomycota division under the family of Chaetomiaceae. *Chaetomium* species are traditionally identified by the type of terminal hair and lateral hairs or ascomatal hairs (straight, hooked, spiral, coiled etc.) (Plate 10) covering the ascomata, the shape and size of asci and ascospores.

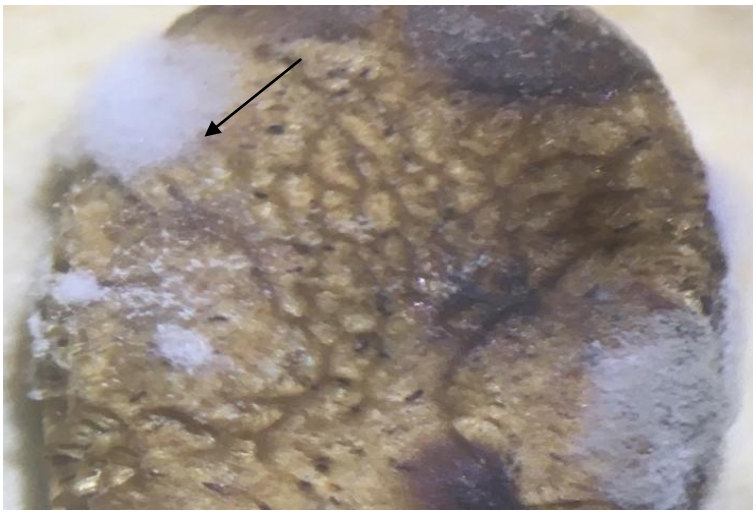


Plate 10. Growth of *Chaetomium* sp.over incubated seed

Altogether five fungi were isolated from the seeds of watermelon.

Survey on socio-economic status of watermelon grower, cultivation practices in Noakhali and Patuakhali district of Bangladesh.

A details survey was conducted on socio economic status of farmers, existing production technology, diseases .The findings are given below:

4.3.1. Land Utilization under Watermelon Cultivation

Survey result showed that most (36.67%) of the watermelon farmers utilized less or equal two ha of land in Noakhali District. After that 33.33%, 13.33% and 3.33% watermelon farmers cultivate watermelon 3 to 5 hectare, 2 to 3 hectare, 5 to 6 and more than 6 hectare respectively (Table 7a).

Table 7(a). Land utilization under watermelon cultivation in Noakhali

Land utilization (hectare)	No. of respondent	% Response
<2	11	36.67
2-3	4	13.33
3-5	10	33.33
5-6	4	13.33
6<	1	3.33
Total	**30**	**100**

In case of Patuakhali surveyed area most (40%) of the watermelon farmers utilized 2 to 3 hectare of land in Dashmina upazila at Patuakhali district. After that 33.33% used 3 to 5 hectare land and 20% watermelon farmers cultivate watermelon in less than 2 hectare whereas 5 to 6 hectare and more than 6 hectare were utilized by 3.33% farmers respectively (Table 7b).

Table 7(b). Land utilization under watermelon cultivation in Patuakhali District

Land utilization (hectare)	No. of respondent	% Response
<2	6	20.00
2-3	12	40.00
3-5	10	33.33
5-6	1	3.33
6<	1	3.33
Total	**30**	**100**

4.3.2. Source of Planting Materials (seeds) Used by Watermelon Farmers

All 60 farmers of the surveyed locations were collecting seeds from different sources. Most of the watermelon farmers around 81.67% use seed from retailer. Moreover, farmers also collect seed from middle men and seed dealer were 5% and 5% respectively while some farmers use own preserved seedling which was around 8.33% (Table 8).

Table.8. Farmers' opinion on the source of planting materials used for Watermelon Cultivation at Noakhali and Patuakhali District

Source of planting materials	Response	
	No. of respondent [N=60]	% Response
1. Directly from Retailer	49	81.67
2. Personal Preservation	5	8.33
3. Middle Men	3	5
4. Seed Dealer	3	5
Total	**60**	**100**

4.3.3. Buyer of Watermelon from Farmers

From the 60 farmers, greater portion 55% sold watermelon through middleman (Table 9). However, 35% farmers were sold directly to the businessmen. Moreover, 10% farmers sold fruits to different companies.

Table 9. Buyer of Watermelon from farmers

Buyer	No. of Respondent [N=60]	% Response
Retailer	21	35.00
Middle Men	33	55.00
Company	6	10.00
Total	**60**	**100.0**

4.3.4. Benefit Cost Analysis of Watermelon

Benefit cost analysis of production of watermelon fruit depends upon different multiplier. Generally 15 ton/ season/hectare produced from watermelon field. In the peak season farmers got about 120Tk/fruit, in off peak they got about 50 Tk/fruit. Total return from watermelon cultivation per hectar/season calculated around 1,76, 600 Tk. But, total cost of production was only 86,650 Tk. So the net profit comes from watermleon cultivation was about 89,9500 Tk/hectare/season (Table 10).

Table 10. Benefit Cost Analysis of Watermelon (Hectar/season)

Location	Production (ton/season/hectar)	Total Cost Hectar/ Season (tk.)	Total Income (Hectar/season/tk.)	Net Profit (tk)
Noakhali And Patuakhali	15	86,650	1,76,600	89,950

4.3.5. Cost involved in Pest Management in Watermelon Cultivation

According to the farmer's opinion, total cost involved for pest management of watermelon is around 28,000 taka per year /hectare (Table 11). 9,000 taka is for disease management and the rest is for insects and weeds. Insect and weed management each needs 6000 taka year/hacter.5000 taka is needed for other pest management.

Table .11. Cost involved in Pest Management of Watermelon Cultivation

Cost for Disease,Insect and Weeds (hectare/year) (Tk.)			Other Pest Control Cost (tk./hactere/year)
Disease	**Insects**	**Weeds**	5,000
9,000	6,000	6,000	
Total: 28,000Tk			

4.3.6. Survey on the Prevalence of Watermelon Diseases in Different Study area

Disease incidence and severity in watermelon seedling stage was recorded in different locations of Noakhali and Patuakhali district respectively (Table 12a &

Table 12b).In Subarnachar Upazila at Noakhali district , 5 diseases were recorded on watermelon leaves and roots in seedling stage which were alternara leaf spot, foot and root rot, leaf curl, leaf mosaic and powdery mildew. The same diseases ,without powdery mildew disease, were also found in 5 union of Dashmina Upazila at Patuakhali district. The recorded disease were alternara leaf spot, foot and root rot, leaf curl and leaf mosaic.

Table.12(a).Prevalence of diseases found in selected locations in Noakhali

SI.No	Name of Villages	Identified Disease	Variety Cultivated
1	West Charbata	Alternaria Leaf Spot,Foot and Root Rot,Leaf Curl,Mosaic, Powdery Mildew	Glory Jumbu, Sweet Dragon
2	Middle Charbata	Alternaria Leaf spot,Leaf Curl	Big Dragon, King Daimond, Glory Jumbu
3	Char Mujib	Foot and Root Rot,Alternaria Leaf spot	Glory Jumbu Sweet Dragon
4	East Charbata	Alternaria Leaf Spot,Leaf Mosaic	Glory Jumbu Sweet Dragon
5	North Kocchopiya	Alternaria Leaf spot,Leaf Curl	Glory Jumbu Field Master
6	South Kocchopiya	Alternaria Leaf Spot,Foot and Root Rot,Leaf Curl,Mosaic,	Black Giant Glory Jumbu
7	Char Bajlul Karim	Leaf Curl	Glory Jumbu Sweet Dragon
8	27 Drone	Leaf Curl	Glory Jumbu
9	Char Aminul Haq	Alternaria Leaf Spot,Foot and Root Rot,Leaf Curl	Glory Jumbu,Banglalink
10	Char Wapda	Leaf Curl	Glory Jumbu Field Master

Table.12(b).Prevalence of diseases found in selected locations in Patuakhali

SI.No	Name of Villages	Identified Disease	Variety Cultivated
1	Katakhali	Foot and Root Rot,Leaf Curl,Mosaic, Powdery Mildew	Big Dragon, Black Lal Teer
2	Golkhali	Leaf Curl	Hybrid Dragon
3	Bashbaria	Foot and Root Rot,Alternaria Leaf spot,Powdery Mildew,Leaf Curl	Hybrid Big Family
4	Gochani	Foot and Root Rot ,Leaf Mosaic,Powdery Mildew	Hybrid Big Family
5	Chapura	Foot and Root Rot ,Alternaria Leaf spot,Leaf Curl	Hybrid Big Family Field Master
6	Khalishakhali	Alternaria Leaf Spot, ,Leaf Curl,Mosaic,	Hybrid Dragon
7	Patarchar	Foot and Root Rot ,Leaf Curl	Hybrid Dragon
8	Auliapur	Foot and Root Rot ,Leaf Curl	Hybrid Big Family
9	Bagura	Leaf Curl	Hybrid Big Family
10	Adampur	Leaf Curl	Hybrid Big Family

4.3.7. Disease Intensification in the Field

According to the farmers opinion, the diseases of watermelon infested in field were leaf mosaic ,root and root rot, powdery mildew, leaf curl and leaf mosaic disease . Among those diseases leaf mosaic, foot and root rot and leaf curl were considered as major disease as the incidence found 30 %, 31.66% and 75% respectively.(Table 13).

Table 13. Farmers' response on the incidence of Disease Intensity in the field

Name of disease	No. of respondent N=[60]	% of respondent	Level of Infection intensity			
			High	Medium	Low	Total
1.Alternaria Leaf Spot	16	26.67	78.15	0	21.85	100
2. Foot and Root Rot	19	31.66	81.60	13.80	4.60	100
3. Leaf Curl	45	**75.00**	3.10	30.50	66.40	100
4. Leaf Mosaic	18	30.00	61.22	13.46	25.33	100
5. Powdery Mildew	2	**3.33**	0	30.00	70.00	100

4.3.8. Incidence of Insects Infections in the Field

According to the surveyed area in subarnachar upazila at Noakhali district,most of the watermelon were infected by the aphid insect, which was recorded 46.67% followed by thrips insect that was observed in 23.24 % among the respondents (Table 14a &b)). In dahsmina upazila at Patuakhali district,most were infected by aphids insect also which was recorded 36.67%.

In both surveyed locations the other insects those responsible for the hamper of watermelon production were red fly, white fly, leaf mites respectively.

Table. 14 (a).Insect Infestation in Watermelon Plant in Subarnachar, Noakhali District.

Name of Insect	No. of Respondents	% Response
Aphids	14	46.67
Red Fly	1	3.33
White Fly	1	3.33
Leaf Mites	3	10.00
Thrips	7	23.33
No insect	4	13.33
Total	**30**	**100.00**

Table 14 (b). Insect Infestation in Watermelon Plant in Dashmina, Patuakhali District.

Name of Insect	No. of Respondents	% Response
Aphids	11	36.67
Red Fly	0	0.00
White Fly	1	3.33
Leaf Mites	6	20.00
Thrips	9	30.00
No insect	3	10.00
Total	**30**	**100.00**

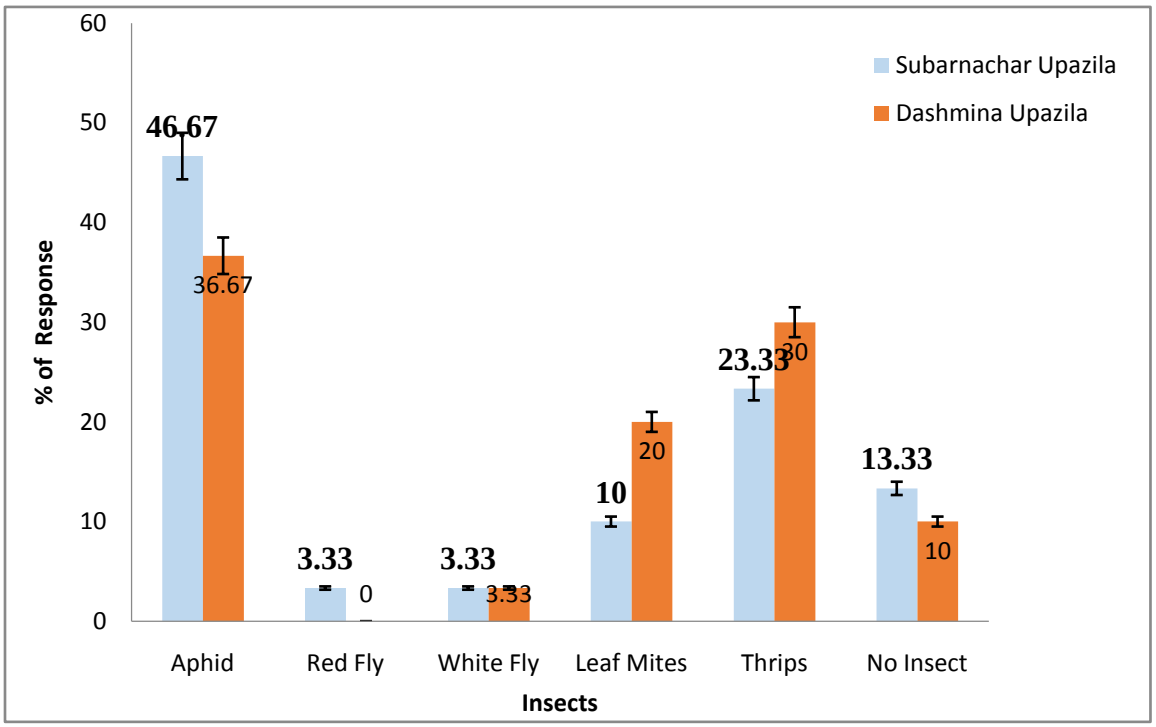


Figure.14. Comparison of Insect Infestation in Watermelon Surveyed Locations

CHAPTER V

SUMMARY AND CONCLUSION

Watermelon is a famous fruit in Bangladesh. However, it suffers from several major diseases but there are not enough information regarding their prevalence, severity and epidemiology are available towards farmers as well as peoples in Bangladesh. Therefore, the present study has been designed to identify the prevalence of major diseases of watermelon (*Citrullus)* in two different agro ecological zone locations viz. Noakhali district and Patuakhali district in Bangladesh. Thirty locations were selected from Subarnachar upazila in Noakhali and another thirty sites were surveyed from Dashmina upozila in Patuakhali district individually. Three experiments were carried out throughout the study period from January, 2020 to January, 2021. Survey were done by one time in each study areas and laboratory works had been done two times in which first time worked had been done to find out seed health status and the second time, to isolate and identify different diseases of watermelon found from the locations. Nevertheless, the watermelon farmers are lacking of improved technology and deprived from fair prices of their produces for various reasons that need to be explored. Besides, the scientists, research managers, and policy makers in the country are also lacking of socio-economic data and information regarding watermelon cultivation which are very much important for further development of the crop. In spite of that watermelon cultivars faced many devastating diseases like; leaf spot, fusarium wilt, leaf curl, leaf mosaic, powdery mildew.

Three experiments were carried out to investigate the major diseases of watermelon at Subarnachar Upazila under Noakhali district during 2020 and Dashmina Upazila under Patuakhali district in 2021.The first experiment was detection, identification and measurement of diseases of watermelon in

Bangladesh. Second experiment was determination of health status of seed as a planting materials of watermelon. The third experiment was survey on socio-economic status of farmers, production technologies and other related to watermelon cultivation in these two districts. In case of field investigation,60 fields from 10 Unions of Subarnachar Upazila, Noakhali and Dashmina upazila in Patuakhali districts were selected. Field seedling diseases were recorded as per view in the fields and disease samples were collected. Amount of disease was recorded based on percent disease incidence and percent disease severity. Plant disease survey sheet was used to collect information on symptomological study of the diseases and to record the disease incidence and severity. The data was recorded from naturally infected fields.

From the field investigation, 5 diseases of watermelon were recorded from Subarnachar Upazila under Noakhali district. They were alternaria leaf spot, foot and root rot, powdery mildew, leaf curl and mosaic disease. The causal organisms associated with these diseases were identified as *Alternaria alternata, Fusarium oxysporum*, Leaf Curl, Powdery Mildew, respectively. Four diseases were recorded without powdery mildew from Dashmina Upazila. Considering the disease incidence and severity, two diseases were major and other diseases were minor in both locations. The major diseases were foot and root rot and leaf curl .And the minor diseases were *alternaria* leaf spot, leaf mosaic and powdery mildew diseases. Seed health status revealed that pathogen incidence was varied significantly. The samples were collected from Dhaka and Noakhali districts. Modified blotter paper method was used to determine the health status of planting material (seeds) of watermelon. The incidence of *Rhizopus stolonifer* was 42% which was the highest among other pathogen incidence i.e. *Fusarium oxysporum* (34%), *Aspergillus flavus* (38%), *Aspergillus niger* (19%), *Aspergillus* spp. (9%) and *Chaetomium* sp. *(*9%).

A details survey was conducted on socio economic status of watermelon farmer's, existing production technology, diseases and other problems related to watermelon cultivation in Bangladesh. There were 60 watermelon farmer's had been interviewed among them 30 were from Subarnachar Upazila of Noakhali and rest 30 were from Dashmina Upazila of Patuakhali district. Most of the farmer's (36.67% to 40%) cultivated watermelon from 2 to 3 ha of land. Total income from watermelon cultivation per year/hecter was 1, 76,600 Tk. However, the total cost of production was only 86,650 Tk. On average the net profit comes from watermelon cultivation was about 89,950 Tk./hectar/season.

From the above findings it can be said that among the selected experimental sites of both districts the incidence and severity of *Alternaria* leaf spot, foot and root rot, powdery mildew, leaf curl and leaf mosaic of watermelon seedling diseases varied from place to place. Disease incidence of leaf spot disease were varied significantly among the locations that ranged 4.33% to 35.10% and 4.45% to 11.33% respectively. The severity of leaf spot disease ranged 0.67% to 11.33% and 0.67% to 4% respectively. The identified causal organism of foot and root rot disease of watermelon was *Fusarium oxysporum*. The incidence ranged 2.33% to 25.67% and severity was 3% to 15% at both locations. Apart from these two diseases, incidence of powdery mildew was ranged 4.33% to 11.30% and the severity was 1.33% to 4% individually. Leaf curl disease was recorded 3.33% to 74.53% in case of disease incidence while the severity was observed 0.67% to 8.33% respectively. In addition, 9% to 16.67% disease incidence was found with the severity 1.33% to 9.33% individually from the selected locations.

This research work was a baseline for further researches o watermelon seedling diseases. Moreover, pathogenicity test by following Kotch's postulates and molecular identification of pathogens should be conducted to identify the pathogens accurately.

CHAPTER IV
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APPENDICES

Appendix I: Plant Diseases Survey Sheet

Department of Plant Pathology

Sher-e-Bangla Agricultural University

Name of the growers/farmers: **Date of Data collection:**

Address:

Village: **Union:** **Upazila:** **District:**

Host common name:

Scientific name: **Age of Plant/Crop**: Seedling/Vegetative/Flowering

Name of disease/ symptom	Infected plant part(s)		Distribution			Planting		Status		Plant Incidence %	Leaf Incidence %	Stem/Twig incidence %	Bud/ Flower Incidence %	Other incidence %	Disease Severity %
			EF	Edge	R	N	F	New	Old						
Leaf spot															
Leaf blight															
Stem rot															
Drying of plant															
Foot & Root rot															
Leaf curl															
Mosaic															
Wilt															
Powdery Mildew															
Anthracnose															

Distribution: Entire field / Edge of field /Random; **Planting:** N= Nursery, F=Field

Symptomological Study

Symptoms	Leaf spot	Leaf blight	Stem rot	Foot & Root rot	Drying of plant	Leaf curl	Mosaic	Anthracnose	Powdery mildew	Wilt
Size										
Shape										
Margin										
Yellow hello										
Appearance										
Wet/dry										
Sunken/raised										
Sign										
Scattered/ Coalesce										
F/B/V/Unknown										
Upper/lower surface of leaf										
Older/middle/ younger leaf										
Others										
Figure										

…….. ……

Name and Signature of Surveyor **Name and Signature of Supervisor**

Date: / / 20 **Date: / /20**

Appendix II: Questionnaire for Survey on Seedling Diseases of Watermelon

Department of Plant Pathology

Sher-e-Bangla Agricultural University, Dhaka

Questionnaire for Survey on Diseases of Watermelon in Bangladesh

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Field / Nursery / Post Harvest

Serial					Cell Phone												

Name of Respondent: …… **Village:……**

Union: …….. Upazila…….. **District: ……**

Education: …… **Age…… Sex……** **Profession……**

1. Land Information

Land Use Pattern (s)	Area (decimal)
1. Total land owned	
2. Cultivable land	
3. Land cultivation under flowers	
4. How long cultivating flowers?	
5. Which flowers are you cultivated?	

2. Cultivation of Watermelon

Area 1 bigha =33 decimals	Self	Lease	Time of Cultivation		
			Rabi	Kharif	Year Round

3. Sources of planting materials

Age of plant/garden	Name of planting materials Seed/seedling	Sources of planting materials	Do you preserve planting materials? (√)	
			Yes	No

4. Benefit Cost analysis of Watermelon (Pick: December – March; Off pick: April –November)

Cultivation Duration (month/year)	Production: stick / year or season/ Bigha	Price (Tk) per fruit	Total Cost (Tk)/ Bigha/Year or Season	Total Income (Tk)/ Bigha/Year or Season	Net Profit (Tk)
2 Years		Pick- Off pick-			

5. Cost involved for Pest Management of Watermelon

Total cultivated Land	Cost/ bigha (Taka)			Other pest control cost /bigha (TK
	Diseases	Insects	Weeds	
Total cost				

6. Who purchase Watermelon from farmer/grower? (please put √)

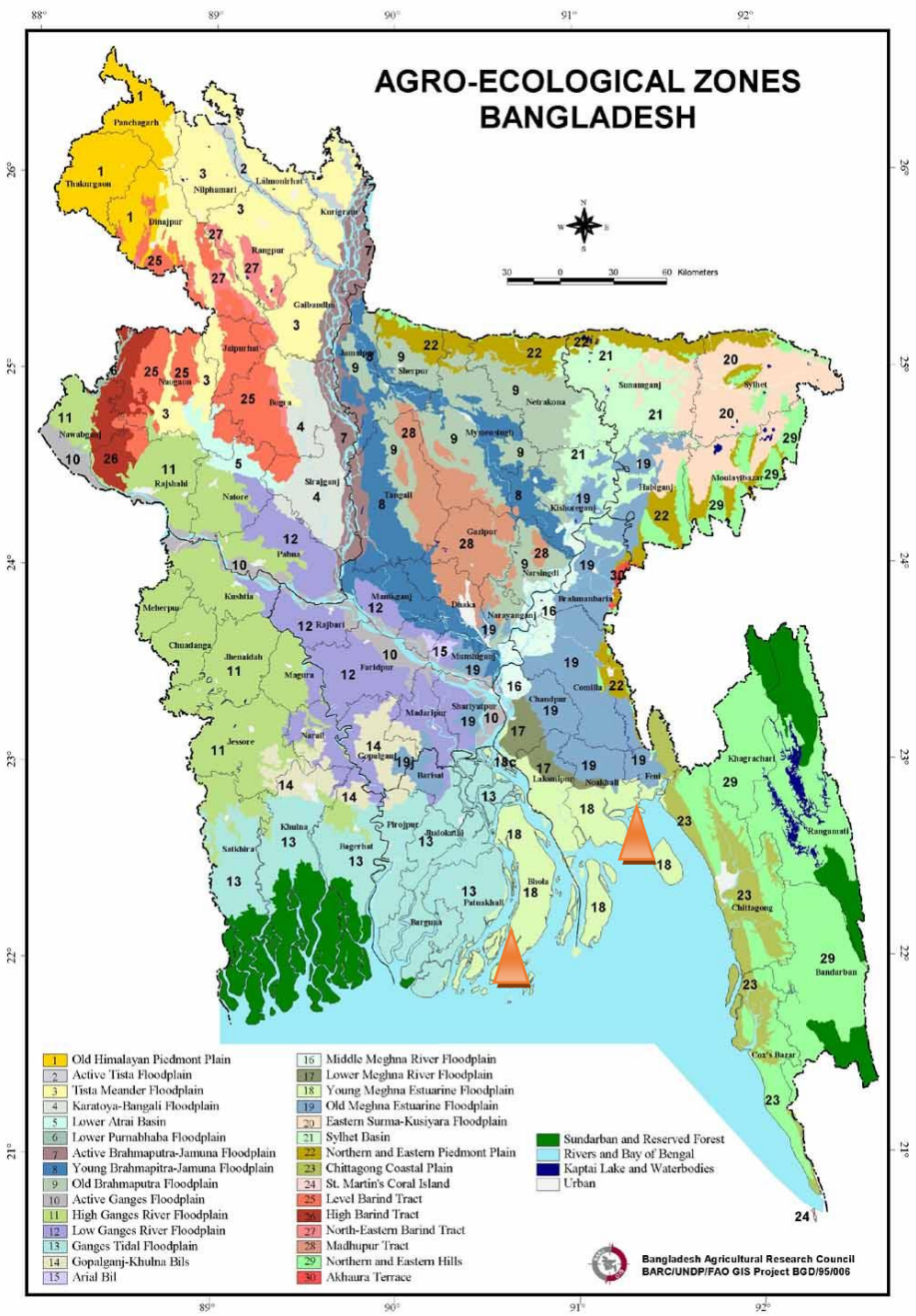
Sl. No.	**Directly**	**Middle man**	**Company**	**Export Company**	**Others (specify)**
1.					

7. Disease infestation in Watermelon in field/ Nursery (please put √)

Name of Diseases	Stage of infection			Incidence/ severity			Infected Parts of Plant							Distribution		Status		Seasons		
	S	V	F	H	M	L	L	S	T	B	F	FP	Others	EF	R	New	Old	S	R	W
1. Leaf spot																				
2. Foot and Root Rot																				
3. Stem rot/spot																				
4. Drying																				
5. Downy Mildew																				
6. Leaf curl																				
7. Mosaic																				
8. Anthracnose																				
9. Powdery mildew																				
10. Wilt																				
11.																				
12.																				
13.																				

S= Seedling, V= Vegetative, F= Flowering; H= High, M=Medium, L=Low; L=Leaf, S=Stem, T=Twig, B=Bud, F=Flower, FP= Full Plant; EF= Entire Field, R= Random; S= Summer, R= Rainy Season, W= Winter

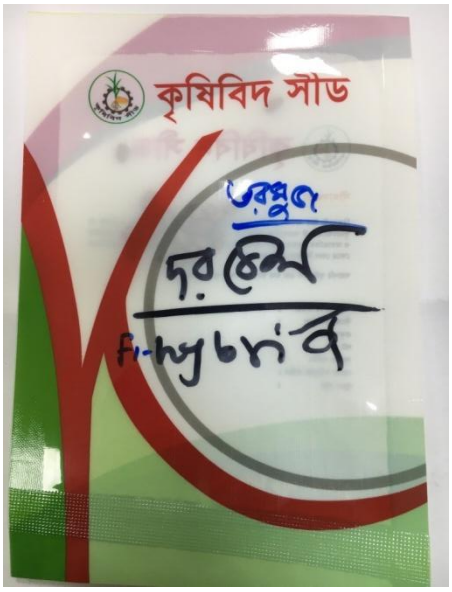
Appendix III: Experimental Sites of the Survey

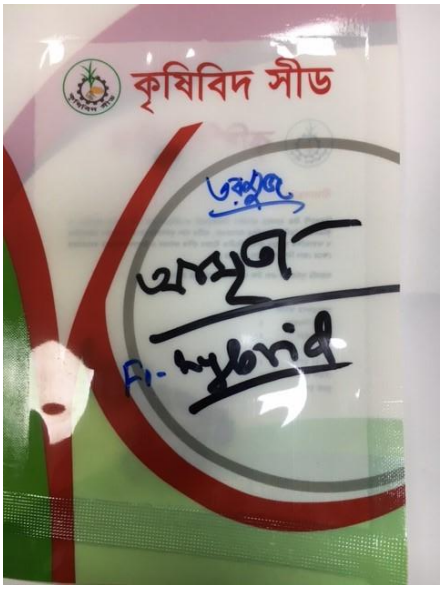


Appendix IV. Survey and Investigation on diseases of watermelon at Noakhali District; A) Field investigation, B) Interviewing of watermelon farmer at field.

Appendix V. Survey and Investigation on seedling diseases of watermelon at Patuakhali District A) Field investigation; A.1) Interviewing of watermelon farmer at field; B) Meeting with AEO's about Watermelon Cultivation.

Appendix.VI. Watermelon Varieties used for Seed Health Test Study





Appendix VII. Disease incidence and Severity of *Alternaria* Leaf Spot at Subarnachar Upazila, Noakhali in 2020.

Locations	Disease Incidence (%)	Disease Severity (%)
West Charbata	**35.10a**	**10.33a**
Middle Charbata	24.67ab	2.67b
Char Mujib	14.67ab	3.33b
East Charbata	22.33ab	2.00b
North Kocchopiya	20ab	0.67b
South Kocchopiya	4.44ab	0.67b
Char Bajlul Karim	**0.00a**	**0.00**
27 Drone	**0.00a**	**0.00**
Char Aminul Haq	4.33ab	3.00b
Char Wapda	11.11ab	3.33b
LSD (0.05)	12.26	3.41
CV (%)	52.70	76.60

Means followed by the same letters in a column do not differ at 5% level of significance by LSD.

Appendix.VIII. Disease incidence and severity of *Alternaria* leaf spot of watermelon at Dashmina Upazila,Patuakhali in 2021.

Locations	Disease Incidence (%)	Disease Severity (%)
Katakhali	0.00a	**0.00a**
Golkhali	0.00a	0.00a
Bashbaria	4.43a	0.67a
Gochani	0.00a	0.00a
Chapura	9.00a	1.33a
Khalishakhali	**11.33a**	**4.00a**
Patarchar	0.00a	0.00a
Auliapur	0.00a	0.00a
Bagura	0.00a	0.00a
Adampur	0.00a	0.00a
LSD (0.05)	14.36	4.02
CV (%)	338.08	390.74

Means followed by the same letters in a column do not differ at 5% level of significance by LSD.

Appendix.IX. Disease incidence and severity of Foot and Root Rot of watermelon at Subarnachar Upazila,Noakhali in 2020

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Locations	Disease Incidence (%)	Disease Severity (%)
West Charbata	**9.00a**	**15.00a**
Middle Charbata	0.00a	6.67b
Char Mujib	16.67a	3.00b
East Charbata	0.00a	0.00b
North Kocchopiya	0.00a	0.00b
South Kocchopiya	0.00a	0.00b
Char Bajlul Karim	0.00a	0.00b
27 Drone	0.00a	0.00b
Char Aminul Haq	0.00a	0.00b
Char Wapda	0.00a	0.00b
LSD (0.05)	2.69	3.89
CV (%)	39.14	92.15

Means followed by the same letters in a column do not differ at 5% level of significance by LSD.

Appendix X. Disease incidence and severity of Foot and Root Rot of watermelon at Dashmina Upazila,Patuakhali in 2021.

Locations	Disease Incidence (%)	Disease Severity (%)
Katakhali	19.00ab	4.33ab
Golkhali	0.00b	0.00b
Bashbaria	21.10ab	4.66ab
Gochani	2.33ab	1.33ab
Chapura	2.33ab	1.33ab
Khalishakhali	0.00b	0.00b
Patarchar	**25.67a**	**6.33ab**
Auliapur	20.33ab	6.00a
Bagura	0.00b	0.00b
Adampur	0.00b	0.00b
LSD (0.05)	23.34	5.04
CV (%)	149.93	122.64

Means followed by the same letters in a column do not differ at 5% level of significance by LSD.

Appendix XI. Disease incidence and severity of Powdery Mildew of watermelon at Subarnachar Upazila,,Noakhali in 2020.

Locations	Disease Incidence (%)	Disease Severity (%)
West Charbata	9.00a	1.33ab
Middle Charbata	0.00a	0.00b
Char Mujib	0.00a	0.00b
East Charbata	0.00a	0.00b
North Kocchopiya	0.00a	0.00b
South Kocchopiya	**11.33a**	**4.00b**
Char Bajlul Karim	0.00a	0.00b
27 Drone	0.00a	0.00b
Char Aminul Haq	0.00a	0.00b
Char Wapda	0.00a	0.00b
LSD (0.05)	3.99	0.78
CV (%)	114.64	86.15

Means followed by the same letters in a column do not differ at 5% level of significance by LSD.

Appendix XII. Disease incidence and severity of Powdery Mildew of watermelon at Dashmina,Patuakhali in 2021.

Locations	Disease Incidence (%)	Disease Severity (%)
Katakhali	0.00a	0.00a
Golkhali	0.00a	0.00a
Bashbaria	**9.00a**	**1.33a**
Gochani	4.33a	1.33a
Chapura	0.00a	0.00a
Khalishakhali	0.00a	0.00a
Patarchar	0.00a	0.00a
Auliapur	0.00a	0.00a
Bagura	0.00a	0.00a
Adampur	0.00a	0.00a
LSD (0.05)	3.04	0.91
CV (%)	132.99	198.96

Means followed by the same letters in a column do not differ at 5% level of significance by LSD.