INVESTIGATION AND MEASUREMENT OF FIELD DISEASES OF SELECTED TROPICAL SUGARBEET AND BEETROOT

Sonia Akter

DEPARTMENT OF PLANT PATHOLOGY

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

SHER-E-BANGLA NAGAR, DHAKA -1207, BANGLADESH

June, 2022

INVESTIGATION AND MEASUREMENT OF FIELD DISEASES OF SELECTED TROPICAL SUGARBEET AND BEETROOT

BY

SONIA AKTER

REGISTRATION NO. 15-06654

A Thesis

Submitted to the Faculty of Agriculture,

Sher-e-Bangla Agricultural University, Dhaka-1207,

In Partial fulfillment of the requirements

for the degree of

MASTER OF SCIENCE

IN

PLANT PATHOLOGY

SEMESTER: JANUARY - JUNE, 2022

Approved By:

Professor Abu Noman Faruq Ahmmed
Supervisor
Department of Plant Pathology
Sher-e-Bangla Agricultural University

Professor Dr. Khadija Akhter
Co-Supervisor
Department of Plant Pathology
Sher-e-Bangla Agricultural University

Professor Abu Noman Faruq Ahmmed
Chairman, Department of Plant Pathology
Sher-e-Bangla Agricultural University

Department of Plant Pathology **PABX: +88029144270-9**
Sher-e-Bangla Agricultural University **Fax: +88029112649**
Sher-e-Bangla Nagar, Dhaka-1207 **Web site: www.sau.edu.bd**

CERTIFICATE

This is to certify that the thesis entitled "**INVESTIGATION AND MEASUREMENT OF FIELD DISEASES OF SELECTED TROPICAL SUGAR BEET AND BEETROOT**" submitted to the Department of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in PLANT PATHOLOGY,** embodies the result of a piece of *bona fide* research work carried out by **SONIA AKTER,** REGISTRATION NO. **15-06654** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated:
Dhaka, Bangladesh

Prof. Abu Noman Faruq Ahmmed
Department of Plant Pathology
Sher-e-Bangla Agricultural University
Dhaka-1207
Supervisor

DEDICATED TO MY BELOVED PARENTS AND BROTHERS

ACKNOWLEDGEMENTS

First of all the author would like to express her deepest and heartfelt greatness to Almighty who enabled her to pursue his education in Agriculture discipline and to submit the thesis for the degree of MS in Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka- 1207.

The author wishes to express her heartfelt indebtedness, deepest sense of gratitude, sincere appreciation and profound respect to her honorable teachers and research supervisor ***Professor Abu Noman Faruq Ahmmed, Chairman,*** *Department of Plant Pathology, Sher-e- Bangla Agricultural University, Dhaka-1207, for his ingenious and scholastic guidance, constructive criticism, valuable advice and suggestions, constant encouragement and cordial help throughout the entire period of research work and preparation of the dissertation.*

The author also extends her sincere appreciation and immense indebtedness to her cosupervisor ***Professor Dr. Khadija Akhter****, Department of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka-1207, for her sincere co-operation, valuable suggestions and constructive criticism for improving the thesis.*

The author feels proud to express honor and cordial thanks to all teachers of the Department of Plant Pathology, Sher-e-Bangla Agriculture University, Dhaka-1207 for their valuable teaching, helpful suggestions and constant encouragement throughout the study. Thanks are also extended to all the laboratory staffs, Department of Plant Pathology, Sher-e- Bangla Agricultural University, Dhaka, for their time to time help during the experimental work.

The author is grateful to the Ministry of Science and Technology, GoB for providing ***National Science and Technology (NST) Fellowship*** *for this research work in the year of 2020-21.*

Finally, the author is grateful to her beloved parents, elder and younger brother for their heartiest blessings, sacrifice and encouragement throughout the entire period of academic life and special thanks to her friends ***Yobaida Afrin Ara Eti, Jannatul Mowya Nizhum*** *and* ***Rifat Ara Sultana*** *for their inspiration, advice, encouragement, and other help during the study period.*

June,2022 ***The Author***

SAU, Dhaka

INVESTIGATION AND MEASUREMENT OF FIELD DISEASES OF SELECTED TROPICAL SUGARBEET AND BEETROOT

ABSTRACT

An experiment was conducted for detection, identification and measurement of diseases of selected tropical sugarbeet and beetroot under natural field conditions at Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from December 2020 to April 2021.Three different varieties of sugarbeet viz. KWS Allanya, KWS Serenada, KWS Gregoria and three different varieties of beetroot viz. Rokto, Beet King and Red Ball were used in this experiment. Sugarbeet varieties were collected from Bangladesh Sugarcrop Research Institute, Ishurdi, Pabna and the beetroot varieties were collected from Siddiqbazar, Dhaka, Bangladesh. The experiment was laid out in a randomized complete block design with three replications. The disease incidence and severity were recorded under natural condition at different Days after sowing (DAS). Yield and yield contributing characters of sugarbeet and beetroot plant were also recorded as the part of this study. Three fungal diseases were found in sugarbeet field namely Sclerotium root rot caused by *Sclerotium roilfsii*, Fusarium yellows caused by *Fusarium oxysporum* and Cercospora leaf spot caused by *Cercospora beticola*. However, two diseases were found in beetroot field namely Alternaria leaf spot caused by *Alternaria alternata* and leaf blight caused by *Fusarium oxysporum*. At 100 DAS the highest sclerotium root rot disease incidence was recorded in KWS Serenada (32.37%). At 105 DAS, the highest disease incidence of Fusarium yellows was recorded in KWS Gregoria (25.73%). At 105 DAS the highest disease incidence of Cercospora leaf spot was recorded in KWS Allanya (29.43%). Plant height varied from 29.53 cm to 61.87 cm. Number of leaves varied from 9.87 to 20.33. Whole plant weight varied from 1.50kg to1.73kg from the selected three variety of sugarbeet. At 95 DAS, the disease incidence of Alternaria leaf spot was counted where the highest disease incidence was recorded in Red Ball (30.23%). At 100 DAS, the highest disease incidence of leaf blight of beetroot was recorded in Beet King (21.57%). Plant height varied from 22.27 cm to 37.70 cm. Number of leaves varied from 8.40 to 15.67. Whole plant weight varied from 0.57 kg to 0.67 kg from the variety of beetroot. Depending on the disease incidence and severity, the major diseases of inspected sugarbeet and beetroot plants were; Sclerotium root rot, Fusarium yellows, Cercospora leaf spot, Alternaria leaf spot and leaf blight.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

12	Infected beetroot plant. A. concentric ring present in the leaf, B. Leaf became blighted, C. The leaf turned zonate, D. Droped out leaf	61
13	Infected beetroot plant A. Initial symptom of leaf, B. Infected leaf attached to the crown, C. chlorotic leaf	67

LIST OF PLATES

LIST OF APPENDICES

LIST OF SYMBOLS AND ABBREVIATIONS

AEZ= Agro-Ecological Zone

BSRI = Bangladesh Sugarcrop Research Institute

cm = Centimeter

CV % = Percent Coefficient of Variation

DAS = Days After Sowing

DAI = Days After Inoculation

RCBD = Randomized Complete Block Design

et al., = And others

e.g. = exempli gratia (L), for example

etc. = Etcetera

g = Gram (s)

i.e. = id est (L), that is

Kg = Kilogram (s)

LSD = Least Significant Difference

m^2 = Meter squares

M.S. = Master of Science

No. = Number

SAU = Sher-e-Bangla Agricultural University

℃ = Degree Celceous

% = Percentage

PDA = Potato Dextrose Agar

CHAPTER 1

INTRODUCTION

Sugar beet (*Beta vulgaris* L.) of the family Chenopodiaceae is a biennial crop. It is a temperate crop whose root contains high concentration of sucrose and is successfully grown on a commercial scale for sugar production. The European Union, the United States, and Russia are the world three largest sugarbeet producers in the world. This crop is also a promising alternative energy crop for the production of ethanol (BSRI, 2005). Recently, some tropical sugarbeet varieties have been developed which can be grown in tropical as well as subtropical region of the world. Sugarbeet contributes about 30% of the world's sugar for human consumption (Bairagi *et al*., 2013). In Bangladesh, sugarbeet is a new crop and few farmers are growing in limited areas for vegetable purpose (Rashid, 1999). In Bangladesh, about 25% sugar demand meeting domestically from sugarcane and rest 75% sugar demand is fulfilled by importation (Rahman *et al*., 2016). Production of sugarbeet has got many benefits compared to sugarcane production. It is short duration crop (5-6 months) with high sucrose contents (14-20%) while sugarcane is a long duration crop (12-14 months) with low sucrose (10-12%) contents (Anon., 2004). Following that sugarcane is long duration crop thus farmers are moving to grow short duration crop for higher profit. Due to its short duration, drought and salt tolerance and relatively high sugar content (Abbasi *et al.,* 2018), this crop has the potential to replace sugarcane as an alternate sugar crop in Bangladesh (Paul *et al*., 2018). In Bangladesh, most of the sugar mills remain idle for a particular period of time due to acute shortage of sugarcane availability. So, sugarbeet might be an excellent alternative of sugarcane if processing facilities are developed in the sugar mills. On the other hand, sugarbeet crop matures in March-April when the crushing season of sugarcane is nearly over in our country. In this situation sugar beet is coming up as the best alternative of sugarcane for production of sugar and ethanol. From the above discussion it seems that suitable genotype and time of harvesting is very important for maximizing yield and quality of sugar beet.

From the earliest time of history, sugarbeet has established a basic food for man, animal and plant. It is an important part of the human diet, providing energy to maintain body temperature. it is also widely used as a sweetener and preservative for other foods like beverages, confectionaries, canned foods and pharmaceuticals. Composition wise a raw sugarbeet is 88% water, 10% carbohydrates, 2% protein, and less than 1% fat. The young leaves are often added raw to salads, whilst the mature leaves are most frequently served boiled or steamed, during which case they have a taste and texture similar to spinach (Kumar and Pathak, 2013).

The main constraints of growing sugarbeet is the insect infestation and disease infection. Establishing of a temperate crop in a tropical and sub-tropical climate poses many important pathological problems due to prevailing high temperature and that's the main complication. The conditions suitable for growth and development of the crop and the succulent nature of its foliage and roots are also favorable for quick development, proliferation and spread of the diseases. The major obstacles in culturing are diseases caused by fungi, of which seedling afflictions and root rot within the plains, leaf spots and nematode disorders both in the plains and the hills are most destructive. Fortunately, the extent of the damage caused by bacteria and viruses are negligible, while fungi and nematodes are proving limiting factors in the profitable cultivation of the crop in the country (Srivastava, 2000). About 16-20% of the crop is destroyed by diseases every year. The diseases of the sugarbeet have played an enormously important role within the current distribution of the beet sugar industry and sugarbeet crops in most of the sugarbeet growing countries (Diffus and Ruppel, 1993). The crop is subject to attack by these diseases from the time of seed-sowing, until the harvest of the crop. All parts of the sugarbeet plant (seeds, seedlings, roots and foliage) are susceptible to attack by a number of diseases which reduce the quantity and quality of roots and seed. World-wide over 50 diseases are known to affect sugarbeets, of which nearly 20 are of economic importance (Mukhopadhyay, 1987). With the expansion in the area under sugarbeet production world-wide, the diseases have increased in number and severity.

Some of the common diseases that affect sugarbeet include Cercospora leaf spot, Alternaria leaf spot, Powdery mildew, Colletotrichum leaf spot, Phoma leaf spot, Dry root rot, Fusarium, Sclerotium, Rhizoctonia crown and root rot etc. (Alam *et al*., 2017).

The sclerotial root rot due to *Sclerotium rolfsii* commonly known as "Southern stem and root rot" is of great economic importance causing much damage in the tropics and sub-tropics.The disease is a limiting factor in the cultivation of sugarbeet crop in Southern U.S.A., in warmer, humid areas of Europe, Middle East, India and Asia (Srivastava, 2000). Warm and humid conditions favor growth of this fungus with optimum temperatures ranging between 25˚C and 30˚C for hyphal growth and sclerotial germination. Along with temperature, soil pH also influences the growth and sclerotial germination of *S. rolfsii*. Although the pathogen can grow in a broader pH range, pH between 4 and 7 supports optimum growth (Fakher *et al*., 2018). The pathogen is characterized by the presence of abundant white mycelia and brown to black sclerotia on plant or soil surface. Sclerotia are the primary source of inoculum as these are considered as resting spores that can survive and overwinter in host tissue or soil for a long time (Paul *et al*., 2017).

Fusarium wilt or fusarium yellows of sugar beet is caused by *Fusarium oxysporum.* f. sp. *betae* (Stewart, 1931; Hanson and Jacobsen, 2009) and can result in significant reduction in sugar concentration, root yield and juice purity (Hanson and Jacobsen, 2009). The disease is seen most often in areas of fields that are low and compacted, especially during periods of high temperatures (Hanson and Jacobsen, 2009). Symptoms of this disease include interveinal yellowing, chlorosis, wilting and necrosis of the leaves and a grey to brown discoloration in the root tissue (Stewart, 1931; Ruppel, 1991).

Cercospora leaf spot of sugar beet is considered as the most important foliar disease of the crop, owing to its worldwide spread and high destructiveness. It is caused by the fungus *Cercospora beticola* Sacc, and its intensity and consequent damages strongly depend on climatic conditions, with the heaviest losses encountered in the most conducive warm and humid environments. *Cercospora beticola* most probably originated in the Mediterranean region and in Central Europe (Groenewald *et al*. 2005). Cercospora leaf spot, incited by the fungus *Cercospora beticola* Sacc., is the most widespread and damaging sugar beet (*Beta vulgaris* L.) foliar disease. Under favorable for the disease agro-climatic conditions, insufficient control of epidemics leads to significant sugar yield reduction and consequent heavy economic losses.

Beet root, scientifically known as *Beta vulgaris* is one of the well- known plants belonging to Chenopodiaceae family. It is an erect annual herb with tuberous root stocks. There are basically four varieties of Beetroot namely known as Detroit dark red, Crimson Globe are commonly grown in India and another two varieties are Crosby Egyptian. It has numerous cultivated varieties, the most well -known of which is the root vegetable known as the beetroot or garden beet. Other cultivated varieties include the leaf vegetable chard; the sugar beet, used to produce table sugar; and mangelwurzel, which is a fodder crop. Three subspecies are typically recognized. All cultivated varieties fall into the subspecies *Beta vulgaris* subsp. *vulgaris*. *Beta vulgaris* subsp. Maritima, commonly known as the sea beet, is the wild ancestor of these and is found throughout the Mediterranean, the Atlantic coast of Europe, the Near East, and India. The ancient Babylonians were the first to use it for various applications. Early Greeks and Romans used the root for its medicinal properties and the leaves as vegetables. It is used in Indian traditional system of medicine, specifically used to enhance the activity of sex hormones. It is one of the natural food which boosts the energy in athletes as it has one of the highest nitrates and sugar contents plant. Beet root contains Betaine (Betacyanin pigment responsible for its red color) is used as natural food color in dairy and meat products. It can be taken as salad during pregnancy because it is helpful in the growth of fetus. Red beetroot is a rich source of minerals (magnesium, manganese, sodium, potassium, iron, copper) (Mathangi, 2019). Beetroot contributes to consumer's health and wellbeing because it has antioxidant property due to the presence of nitrogen pigment betalain. Beetroot also known for its antimicrobial and antiviral effects (Strack *et al.,* 2003). Several parts of this plant are used as antioxidant, antidepressant, antimicrobial, antifungal, anti-inflammatory, diuretic and carminative. (Yadav *et al*., 2016). The beetroot is an alkaline food with a pH 7.5-8 and it contains significant amount of vitamin C, vitamin B1, B2, niacin, B6, B12 and its leaves are excellent source of vitamin A. Beetroot is easy to grow and is always ranked as one of the top 10 vegetables grown in India. Beetroot is grown for food uses (pickles, salad, juice) rather than for sugar production. In contrast to other fruits, the main sugar in beetroot sucrose with only small amount of glucose and fructose (Bavec *et al*., 2010). Beetroot pigment is used as a food dye. It changes color when heated so can only be used in ice-cream and other confectionary, but it is both cheap and has no known allergic side effect. Beetroot juice is very potent, a beautiful rice ruby red color it is known to help purify the blood (Kumar *et al*., 2015).

Beetroot leaves are sometimes used for eating. The leaf blades are eaten as spinach beet while the midribs of chard are eaten boiled. In some rural parts of Africa, the whole leaf blades are usually prepared with the major as one dish (Grubben *et al*., 2004).

Beetroot is a cool-weather crop that is hardy and tolerates some freezing. It grows best in spring and autumn, but does well in summer on the Highland and in winter in the Low land. Beetroot needs a lot of water for fast growth. The volume needed could vary Beetroot needs a lot of water for fast growth. Beetroot does best on deep and well-drained, loose, loamy to sandy soils. Heavy clay soils or soils which crust after rain or irrigation may cause establishment problems and the production of misshapen roots. Beetroot prefers a soil pH of 5.8 to 7.0, but can tolerate a pH of up to 7.6. Acid soils are likely to create nutrient deficiency problems and should be avoided or limed to raise the p^H.

In Bangladesh, beetroot is a new crop and few farmers are growing in limited areas for vegetable purpose. The main constraints of not growing beetroot are the disease infection. The infected beetroot reduce the market value of the beet.This limitation can be increased by controlling the disease incidence.There are lots of diseases that attack to the beetroot. The major obstacles in culturing are diseases caused by fungi, of which seedling afflictions and Alternaria leaf spot, cercospora leaf spot, curly top and phoma leaf spot.

Alternaria leaf spot caused by *Alternaria* spp is a common foliar disease of sugar beet and other Beta vulgaris crop types. This symptoms covered approximately 5% on the lower leaves. Alternaria leaf spot can result in significant reductions in yield and quality when not managed properly. Alternaria leaf spot symptoms are comparable to other common foliar diseases of beets including Cercospora leaf spot and the early stages of phoma leaf spot. This disease is known to be present in the United States as well being reported as present everywhere beets are grown. (Naegele *et al*., 2022)

Cercospora leaf spot is a common disease in beetroots caused by a fungus which enters the leaves and causes small round spots of about 3 mm in diameter. These spots are also found on the flowers and seed on plants grown for seed production. Downy mildew (*Peronospora schachtii*) disease is seed-borne and it can affect the crop early in the season. Brown rust (*Uromyces betae*) Infected plants are recognised by large numbers of orange or red-brown pustules on the leaves. Root rot, damping-off (*Phoma betae*) this disease is common on compact soil. Germination of infected plants is weak. Young seedlings grow poorly, turn yellow, wilt, topple over and die and the roots turn black. Seedlings that are not severely affected produce small, malformed beetroots.

Sugarbeet and beetroot may be miracle for us if it can cultivate properly with proper agronomical and pathological practices with latest agro-technology. Bangladesh has extremely large or great potentiality for sugarbeet cultivation particularly northern part of the country which can take the production of sugar to a satisfactory level.

Considering above facts and points this research work is designed to achieve the following objectives:

1. Detection and identification of field diseases of sugar beet and beetroot, and
2. Measurement of disease incidence and severity of sugar beet and beetroot in the field.

CHAPTER 2

REVIEW OF LITERATURE

Sugar beet and beetroot suffers from many diseases that causes severe damage to the crop. Literature in relation to disease incidence and disease severity of sclerotium root rot, fusarium yellows disease and cercospora leaf spot disease of sugar beet and alternaria leaf spot and leaf blight of beetroot is reviewed and presented in this chapter.

2.1 Sugar beet

Alam *et al*., (2017) reported that generally the main constraints in sugarbeet cultivation around the world is insect infestation and disease infection. Sugarbeet is usually attacked by beet caterpillar, beet aphid etc. They also reported that some of the common diseases that affect sugarbeet include Cercospora leaf spot, Alternaria leaf spot, Powdery mildew, Colletotrichum leaf spot, Phoma leaf spot, Dry root rot, Fusarium, Sclerotium, Rhizoctonia crown and root rot etc.

Rahman *et al*., (2016) reported that top fifteen sugar beet producing countries are Russian Federation, Ukraine, United States of America, Germany, France, Turkey, China, Poland, Egypt, United Kingdom, Iran, Belarus, Netherlands, Italy and Belgium.

Kumar and Pathak (2013) described that composition wise a raw sugarbeet is 88% water, 10% carbohydrates, 2% protein, and less than 1% fat. The young leaves are often added raw to salads, whilst the mature leaves are most ordinarily served boiled or steamed, during which case they need a taste and texture similar to spinach. Also reported that sugar beet is grown in 57 countries mainly produced in Europe, and, to a lesser extent, in Asia and North America.

BSRI (2005) reported that the European union, the United States, and Russia are the world three largest sugar beet producers in the world. This crop is also a promising alternative energy crop for the production of ethanol.

Anon (2004) reported that production of sugar beet has got many benefits compared to sugarcane production. It is short duration crop (5-6 months) with high sucrose contents (14- 20%) while sugarcane is a long duration crop (12-14 months) with low sucrose (10-12%) contents.

Rashid (1999) reported that the weather of Bangladesh is suitable for sugar beet farming, its sweetness and yield rate are much above sugarcane and therefore the crop are often harvested in just five months than a year in case of sugarcane.

In India during 1972-1998, the crop was commercially grown within the Sriganganagar area of Rajasthan and was processed for sugar production during April and should per annum with a good recovery of sugar (Srivastava, 2000).

Mukhopadhay (1987) also reported that world-wide over 50 diseases are known to affect sugarbeets, of which nearly 20 are of economic importance.

2.1.1 Sclerotium root rot disease of sugarbeet

Islam *et al*., (2021) conducted an experiment in the field of Bangladesh Agricultural University to determine the characterization of *Sclerotium rolfsii* causing root rot of sugarbeet in Bangladesh. They also estimated 9.74% of plants in 144 sugar beet plots were infected with *Sclerotium rolfsii* that showed root rot symptom. They isolated causal fungus on PDA that produced fluppy cottony mycelia with clamp connections and brown sclerotia ranging from 0.5 to 1.5 mm, typical of *S. rolfsii* within 3 weeks of incubation at ambient laboratory temperature (22 ± 2℃). They confirmed the identity of two isolates BTSB2 and BTSB6 by performing phylogenetic analysis of the internal transcribed spacer sequences along with morphological features.

Srivastava (2000) proclaimed that the appearances of the sugarbeet diseases within the field include yellowing and wilting of leaves followed by rotting of roots of affected plants. On rotted basal portions of roots white cottony mycelium develops and causes gradual semi-watery decay. The affected leaves turn yellow and wither pre-maturely as the mycelial growth advances. At later stage mycelial growth becomes more profuse and almost covers the major portions of the fleshy root. Decomposition gives a deformed appearance to the roots. Such affected roots become unfit for sugar extraction also feeding animals. On rotted roots, numerous small, light to dark brown sclerotia of mustard seed size develop on the mycelium and sclerotia are also found in the soil, radiating outwards from affected roots. Such affected plants collapse on the ground. The diseased plants can easily be get off due to massive damage to the tap root system as a result of rotting. Seedling blight of sugarbeet also causes by the fungus resulting in a poor stand of crop.

Maiti *et al*., (2000) reported that saturated soil moisture conditions at higher frequency level of irrigations may cause lysis of hyphae and sclerotia of *S. rolfsii* which in turn reduces disease incidence.

Sugarbeet disease takes place in many sorts of soil, but it's often severe on light sandy soils followed by sandy loam or loam soils (Mukhopadhyay, 1987; Srivastava, 2000)

Srivastava (2000) found that the fungus survives in soil from one season to another by means of sclerotia formed abundantly on affected roots, crop debris, adjoining soil and other suitable substrates. Under favorable conditions, these sclerotia germinate and give rise to vegetative mycelium and a pathogenic phase. The fungal mycelium first grows near roots and form a network of strands in surrounding soil. As the strands extend through soil, they infect healthy roots and continue their destruction.

Sclerotium rolfsii on sugarbeet is characterized by the presence of abundant white mycelia and brown to black sclerotia on plant or soil surface. Sclerotia are the primary source of inoculum as these are considered as resting spores that can survive and overwinter in host tissue or soil for a long time (Paul *et al*., 2017).

However, with the increase in sugarbeet cultivation area, fungal diseases like crown and root rot, Cercospora leaf spot, Fusarium yellow have been showing up resulting in severe yield losses. Among the diseases, root rot is caused by the fungal pathogen *Sclerotium rolfsii* Sacc. appeared as the most important one causing approximately 50% yield loss. The fungus generally infects the crown area or junction of stem and root near the soil surface and causes rotting of infected tissues. Yellowing and wilting of sugarbeet leaves are the first visible symptoms of the disease followed by soft and water-soaked appearance of fleshy tap root. In case of severe infection, the disease may lead to death of the entire plant (Errakhi *et al*., 2009).

Duffus and Ruppel (1993) found that Sclerotia are the principal means of survival of *S. rolfsii* in soil even within the absence of suitable hosts or conditions favouring its active growth. The sclerotia which remains for a long period of time in soil serve as the source of primary infection. They spread from one location to another by means of cultivation and irrigation water for secondary infection. Disease severity is determined by the population of viable sclerotia (inoculum density) within the beet field and therefore the longevity of sclerotia in soil.

Singh *et al*., (1986) reported that moisture also influences the root rot development. It has been observed that fields receiving 16 irrigations during crop season show minimum root rot incidence and maximum root yield as compared to 12, 8 and 4 irrigations, respectively.

Punja *et al*., (1985) reported that the large number of sclerotia produced by *S. rolfsii* and their ability to continue the soil for several years, also because the profuse rate of growth of the fungus make it well compatible facultative parasite and a pathogen of major importance throughout the world.

Ahmed (1980) reported that, *Sclerotium rolfsii* is a facultative saprophyte and can survive generation to generation by formation of brown sclerotia.

Sclerotium rolfsii is a soil-borne plant pathogen of worldwide occurrence that infects quite 500 plant species (Aycock, 1966 and Punja, 1985).

Sen *et al*., (1979) recorded that inoculation of sugarbeet in first week of February using 750 g of sand maize-meal inoculum causes the very best and most uniform mortality of roots. Temperature influences root rot incidence of sugarbeet. The maximum disease development occurs at temperatures approximately favorable for the growth of the pathogen in culture, *i.e.* 30-35° C. As the temperature decreases disease incidence and severity gradually reduces. Minimum disease severity was noted at or below 15° C.

Backman and Rodriguez-Kabana (1972) reported that the disease is caused by fungus Sclerotium rolfsii (imperfect stage). *Pellicularia rolfsii* (Syn. *Corticium rolfsii*, *Athelia rolfsii*) is known as the perfect stage of sclerotium. The imperfect stage consists of mycelium and sclerotia. On potato dextrose agar (PDA) medium it can be grown easily under laboratory conditions.

Mukhopadhayay (1971), Sharma and Pathak (1994) and Waraitch *et al*., (1986) reported that Sclerotium root rot causes 14-59% loss in root yield and reduces sugar content up to 20% in certain varieties under favorable conditions in sugar beet.

Punja *et al*., (1958) reported that sclerotia of *Sclerotium rolfsii* is produced in large number on or adjacent to infected plant parts and can survive in soil for 1-3 years. They are also competent to infecting and can be stable without food base of organic matter. Also reported that the mycelial maturation of *Sclerotium rolfsii* was maximized under optimum temperature and moisture and range was 1-3cm.

2.1.2 Fusarium Yellows disease of sugarbeet

Burlakoti *et al*., (2012) reported that *F. secorum* was more aggressive than *F. oxysporum* f. sp. *betae* on sugar beet.

In 2005, a sugar beet pathogen was isolated from sugar beet plant in the Moorhead factory district field and in American Crystal Fusarium nursery in Sabin, MN (Burlakoti, 2007). Although this pathogen causes Fusarium yellows-like symptoms, it is also responsible for seedling infection, petiole vascular discoloration, and rapid death early in the growing season, which are distinct from Fusarium yellows (Burlakoti *et al*., 2012).

Panella *et al*., (2011) conducted an experiment about Genetic variability among isolates of *Fusarium oxysporum* from sugar beet. Also found that fusarium yellows, caused by the soil-borne fungus *Fusarium oxysporum* f. sp. *betae* , can lead to significant yield losses in sugar beet. *Fusarium oxysporum* was variable in morphology, pathogenicity, host range and symptom production, and was not a well characterized pathogen on sugar beet.

F. oxysporum f. sp. *betae* is a soil borne fungus that can survive as chlamydospores, macroconidia, and mycelium in plant debris. Under favorable conditions, *F. oxysporum* f. sp. *betae* starts to penetrate susceptible sugar beet root through wounds and moves toward the vascular system. Once this fungus successfully colonizes the plant, it moves upwards with the appearance of foliar symptoms. Initially, yellowing appears in the old leaves between the main veins. As the disease develops, the old yellow leaves become necrotic, while young leaves start to show yellowing.

Yellowing may occur on the entire leaf or just half of the leaf. Some diseased plants may show wilting during the daytime and recover with watering or overnight. A grayish brown discoloration was showed in the infected root vascular system. This discoloration may occur in the entire root vascular system or only on the area where the pathogen has penetrated. At last the whole leaves become dry and die, but remain attached to the disease infected plant. If infection occurs early seedlings may die, while old plants can stay alive with reduced yield. This disease was reported to significantly reduce sugar beet yield, sugar purity, and recoverable sucrose percentage. The survival structure of this fungi returns to the soil at the end of the growing season and serves as initial inoculum in the next growing season (Draycott, 2006; Hanson and Jacobsen, 2009; Khan *et al*., 2009).

Hanson and Jacobsen (2009) found that the disease is seen most often in the areas of low and compacted fields, especially during periods of high temperatures.

Hanson *et al*., (2009) reported that current research has shown that different cultivars express differing disease symptoms when inoculated with the same isolates.

To differentiate this disease from Fusarium yellows, it was named Fusarium yellowing decline (Rivera *et al*., 2008).

Martijn *et al.,* (2008) reported that *Fusarium oxysporum* is an asexual fungus that inhabits soils throughout the world. As a species, *F. oxysporum* can cause wilt or root rot disease and also can unroll disease a very broad range of plants. Single isolates of *F. oxysporum*, however, generally infect one or a few plant species only. Fusarium is one of the most economically dominant fungal genera because of yield loss due to plant pathogenic activity; mycotoxin contamination of food and feed products which often provide them unaccepted for marketing; and health impacts to humans and livestock, due to consumption of mycotoxins.

Hanson and Hill (2004) recorded that for long-term storage, mycelium from Fusarium isolates was stored desiccated on sterile glass fibre filter paper at 20˚C.

As leaves die, leaves generally endure attached to the crown with petioles that are tan in color Internal symptoms consist of brown or gray-brown vascular discoloration (Schneider and Whitney 1986, Franc *et al*., 2001).

Symptoms of this disease include interveinal yellowing, chlorosis, wilting and necrosis of the leaves and a grey to brown discoloration in the root tissue (Stewart 1931; Ruppel 1991).

There are no effective fungicides for managing this pathogen of sugar beet, and crop rotation is often ineffective because isolates pathogenic on beet can live on the other crops within the rotation without the appearance of symptoms, increasing levels of inoculum (Gordon *et al*., 1989).

Isolates of *F. oxysporum* f. sp. radicis-betae that cause root tip rot on sugar beet have been reported to be distinct from the isolates of *F. oxysporum* f. sp. *betae* that cause fusarium yellows with no external root symptoms (Martyn *et al*., 1989).

Schneider and Whitney (1986) reported that *Fusariurn oxvsporum* is the primary causal agent of Fusarium yellows in sugarbeet and it causes significant reduction in root yield, as well as reduced sucrose percentage and juice purity in affected sugarbeet (*Beta vulgaris* L.).

Fusarium isolates were identified to species according to the methods of Nelson *et al*., (1983). Also reported that *Fusarium oxysporum* is a significant pathogen on many important agricultural crops.

Armstrong and Armstrong (1981) reported that isolates are categorized into 'formae speciales' according to their ability to cause disease on specific host plants or specific symptoms on a specific host.

2.1.3 Cercospora leaf spot disease of sugarbeet

Cercospora leaf spot of sugar beet is considered as the most important foliar disease of the crop, because of its high destructiveness and worldwide spread.

Groenewald *et al*., (2005) found that *Cercospora beticola* most probably originated in the Mediterranean region and in Central Europe.

Holtschulte (2000) stated that in the most recent survey on the distribution and severity of cercospora leaf spot, it was revealed that moderate and high incidences of cercospora adversely affect more than a third of the global sugar beet cultivation area.

Cercospora leaf spot is specially damaging in Northern Italy, Greece, Northern Spain, Yugoslavia, Austria, southern France, Japan, China and parts of USA (Byford,1996; Holtschulte, 2000).

Rossi *et al*., (2000) reported that on the primary leaves the pathogen develops and, as necrotic spots spread and coalesce, photosynthetically the active leaf area is reduced. Secondly, as a result of a severe foliage loss, late season photosynthetic potential is also reduced and vegetative regrowth is stimulated at the expense of root sugar reserves.

Shane and Teng, 1992; Rossi *et al.,* (1995) proclaimed that in heavy epidemics, primary leaf destruction is followed by new foliage development.

Smith and Ruppel (1971) reported that root storage losses, as a result of increased respiration and decay predisposed by the disease.

Pool and McKay 1916; Giannopolitis 1978; Steinkamp *et al*., 1979; Jacobsen and Franc (2009) reported that under the most favorable conditions of high humidity (90%) and warm temperatures (day 27–32˚C, night 17˚C), symptoms on leaves may appear within 5–11 days after inoculation and spots are initially visible on the older leaves and later on the younger leaves. Mature lesions obtain reddish ring borders, depending on the variety and the amount of betacyanin accumulated in response to wounding. The number and size of spots increases as epidemics progresses, phytotoxins are accumulated, individual spots coalesce, leaves turn yellow and eventually complete leaf senescence occurs. Lesions may also form on petioles and found elongated while lesions also have been found on root crowns not covered with soil.

Pool and McKay (1916) reported that the fungus survives between sugar beet growing seasons primarily in the form of stromata in infected plant residues, structures that can carry over for as long as two years and constitute the main sources of original inoculum for the onset of epidemics.

2.2 Beetroot

Beetroot (*Beta vulgaris* L.) belongs to Chenopodiaceae family. It has bright crimson colour. Beets are native to the Mediterranean. Since before the written history the leaves have been eaten, and the beetroot generally used medicinally and did not become a popular food until French recognized their potential in the 1800's.

Beetroot is one of the natural food that boosts the energy as it has one of the highest nitrates and sugar contents plant. Several parts of this plant are used as antioxidant, antidepressant, antimicrobial, antifungal, anti-inflammatory, diuretic and carminative. (Yadav *et al*., 2016).

Kumar *et al*., (2015) found that their color can be white, yellow or red depending on the color of the flesh. The leafy peaks can also be used as a sweet spot for spinach.

Atamanova *et al*., (2005) reported that in spite of the industrial food exploitation of red beet, sugar beet is grown commercially for sugar production due to the high content of sucrose. Nitrogen is important to the processing of sugar, especially in the early stages of growth. (Mathangi and Balasaraswathi, 2019).

Strack *et al*., (2003) reported that due to the presence of nitrogen pigment betalain. Beetroot also known for its antiviral antimicrobial and antiviral effects.

Hill and Langer (1991) proclaimed that the Greek Peripatetic Theophrastus later describes the beet as similar to the radish, while Aristotle also mentions the plant.

German and later English sources show that beetroots were widely grown in Europe in the Middle Ages. (Hill and Langer, 1991 Hopf *et al*., 2000)

Most red beets are grown in India in the states of Haryana, Uttar Pradesh, Himachal Pradesh, West Bengal, and Maharashtra. Most beets are picked in September and October for processing and selling fresh.

Beetroot is a good tonic food for health. The market for beets isn't very big, but it's still important, and dealers get a lot of it. Over time, the sales period can be stretched out to the roots. (Boswell, 1967).

Across various dietary traditions, beetroot is typically ingested in the form of supplementary juice, powder, bread, gel, boiling, oven-dried, pickled, pureed, or jam-processed. One of the 10 plants with the highest antioxidant activity is beetroot.

2.2.1 Alternaria leaf spot disease of beetroot

Alternaria leaf spot is acquired by the fungi belonging to the *Alternaria* genus, particularly *A. alternata* (syn. *A. tenuis)* and *A. brassicae.*

Singh and Grewal (2020) conducted an experiment about Effect of cultural practices on the incidence and severity of Alternaria leaf spot of beet. This study evaluated the effect of cultural practices, such as irrigation frequency and plant density, on the development of Alternaria leaf spot of beet. The authors found that certain practices, such as reducing plant density, could help reduce the incidence and severity of the disease.

Host resistance and pathogenic variability of *Alternaria* spp. causing leaf spot of beet by Kalia *et al*., (2019) - This study evaluated the resistance of various beet cultivars to Alternaria leaf spot. The authors found that some cultivars were more resistant to the disease than others, suggesting that host resistance could be an effective strategy for managing the disease.

Rosa *et al*., (2018) evaluated the resistance of 24 beetroot cultivars to Alternaria leaf spot in Brazil. The researchers found that some cultivars, such as 'Rubidus' and 'Tall Top Early Wonder,' were highly resistant to the disease.

A study by Horsfield *et al*., (2017) investigated the incidence and severity of Alternaria leaf spot on beetroot in New Zealand. The researchers found that the disease was widespread in the country, with significant yield losses in some regions. They also identified the main environmental factors that favor disease development, such as high humidity and rainfall.

Several studies have investigated the genetic diversity of Alternaria species causing leaf spot on different crops. For instance, a study by Woudenberg *et al*., (2015) used molecular markers to analyze the genetic diversity of Alternaria species collected from different hosts, including beetroot. The researchers found that the genetic diversity of Alternaria varied depending on the host, with some hosts showing more diversity than others.

Russell (1965) and Franc (2009) reported that infection by *Alternaria* spp. and disease management has been considered historically a minor issue in beet production in North America, due to its opportunistic or secondary nature. From damaging Alternaria leaf spot usually does not significantly affect crop yield.

Alternaria species cause plant diseases on many crops, infecting the leaves, stems, flowers and fruits. Agrios (2005) noted that total losses caused by this genus rank among the highest caused by any plant pathogen.

Neergaard (1945) proclaimed that *Alternaria* spp. have been shown that it can cause disease on both seed and seedlings of sugarbeet. Additionally reported that *Alternaria* spp. can also spread to infect the inflorescence from which it passes to seeds and can lead to damping off of seedlings.

2.2.2 Leaf blight disease of beetroot

The infected leaves exhibit yellowing between the larger veins. Later entire leaves become dry, brittle and remain clustered around the crown. Typically only one side of the leaves is affected and appear scorched. The vascular tissues of infected plants become discolored. Plant appears wilted during day time and recover at night. The tip of taproot becomes black due to rotting.

The epidemiology and management of Fusarium leaf spot of beet by Agarwal *et al*., (2016) this study provides a comprehensive overview of the disease, including the causal organism, epidemiology, and management strategies. The authors discuss the importance of cultural practices, such as crop rotation and sanitation, as well as the use of resistant cultivars and biological control agents, in the management of the disease.

Verma *et al*., (2020) conducted an experiment about Assessment of genetic variability and pathogenicity of *Fusarium oxysporum* f. sp. *betae* causing leaf spot of beet.This study evaluated the genetic variability and pathogenicity of *Fusarium oxysporum* f. sp. *betae*, the causal agent of Fusarium leaf spot of beet. The authors found that the fungus exhibited high genetic variability, and some strains were more virulent than others.

CHAPTER 3

MATERIALS AND METHODS

The methods followed and materials used in the present research work were stated in this chapter. The experimental site, weather, land preparation, experimental design, layout, and data collection were included in the chapter.

3.1. Experimental site

The experiment was conducted at the field of Sher-e-Bangla Agricultural University, Dhaka. The location for the experimentation site was 23°75N latitude and 90°35E longitude with an elevation of 8.3 meter from sea level. The location of the experiment field had been shown in Appendix-I.

3.2. Experimental period

The field experiments were conducted during the Rabi season from December 2020 to April 2021. Laboratory research was done from January 2020 to May 2021.

3.3. Soil type

The area of the experimental site was in the sub-tropical zone. The soil of experimental site belongs to the agro-ecological regions of "Madhupur Tract" under AEZ No.28. The top soil of the region is clay loam in texture and olive gray with common fine to medium distinct black yellow brown 21 mottles. The area for the experiment was flat and had a system for irrigation and drainage. The experimental site was moderately elevated land. It was above flood level and sufficient sunshine was available during the experimental period. Samples of soil from 0 to 15 cm deep were taken from the experimental field. The analyses were done by Soil Resources and Development Institute (SRDI), Dhaka. The physicochemical properties of the experimental field soil are presented in Appendix II.

3.4. Weather conditions during the experiment

The experimental sites weather condition was under the sub-tropical monsoon climate, which is characterized by heavy rainfall during Kharif season (April to September) and in the Rabi season (November to March), low rainfall associated with moderately low temperature, low humidity and short day. There was little rain during the month of November, January and March. Rabi is the more favorable for vegetable production. Particular of the meteorological data in respect of temperature, rainfall and relative humidity during the study period were collected from Bangladesh Meteorological Department, Agargaon, Dhaka1207, Dhaka and have been presented in Appendix-III.

3.5. Variety

In total six (6) variety was considered in this experiment. Three tropical sugarbeet variety and three beetroot variety was used in this study (Plate 1 and 2). The tropical sugarbeet was collected from Bangladesh Sugarcrop Research Institute, Ishurdi, Pabna.The beetroot was collected from Siddiqbazar.

Three sugarbeet varieties were as followed.

1. KWS Gregoria

2. KWS Allanya

3. KWS Serenada

Three beetroot varieties were as followed.

1. Rokto

2. Red Ball

3. Beet King

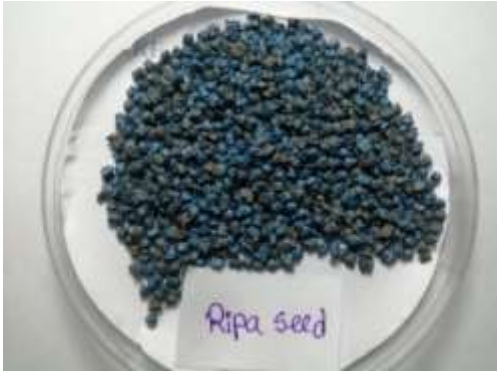
Table 1. List of varieties used in this study

Variety name	Company name	Origin	Source
Sugarbeet			
KWS Gregoria	German seed	German	BSRI
KWS Serenada	German seed	German	BSRI
KWS Allanya	German seed	German	BSRI
Beetroot			
Rokto	Ripa seed	Japan	Siddiqbazar
Beet King	Jannat Seed	Italy	Siddiqbazar
Red Ball	East Bengal seed	India	Siddiqbazar

A. KWS Gregoria **B. KWS Serenada**

C. KWS Allanya

Plate 1. Selected seed of Sugarbeet; A. KWS Gregoria, B. KWS Serenada C. KWS Serenada



A. Rokto **B. Beet King**

C. Red Ball

Plate 2. Seed of different varieties of Beetroot; A. Rokto, B. Beet King, C. Red Ball

3.6. Layout and design: The experiment composed of three (3) treatments for each crop and laid out in Randomized Complete Block Design (RCBD) with three replications. The whole experimental plot was divided into three equal blocks and each block consisted of 6 plots, altogether 18 unit plots. Each plot was 3 m^2 (2 m × 1.5 m) in size. The distance between plot to plot was 40 cm and plant to plant was 30 cm, and line to line was 50 cm. (Figure 1)

Figure 1. Layout of the field experiment

3.7. Manure and fertilizer application

The following doses of manure and fertilizers were used (BARC- 2020)

Table 2. Manure and fertilizer used in the field experiment.

Manure/Fertilizer	Dose/ha
Cow dung	200kg
Urea	5kg
TSP	3kg
MP	5kg
Gypsum	3kg
Zinc Sulphate	0.25kg
Boric Acid	0.5kg

3.8. Cultivation of sugar beet: The plants were always kept under close observation. Necessary intercultural operations were done throughout the cropping season to obtain proper growth and development of the sugar beet and beetroot plants.

3.8.1. Land preparation

The selected land for the experiment was first spread out in November, 2020 by power tiller and expose to the sun for a week. The land was ploughed after one week and cross-ploughed several times with a power tiller and obtain good tilth laddering was done properly for several times. Weeds and stubbles were removed and the large clods were broken into smaller pieces to obtain a desirable tilth of soil for sowing of seeds. After removal of the weeds, stubbles and dead roots, the land was leveled and the experimental plot was separated into the unit plots (Figure 2). Cow dung was applied as per production technology of sugar beet and beetroot before land preparation and one-third of the Urea and MP fertilizer were applied during land preparation. The remaining fertilizers were applied during earthing up as a form of top dressing.

A

B

Figure 2. (A) Preparation of land and (B) Sowing of seeds.

3.8.2. Sowing of seeds

The land was well prepared with spade and made into loose, friable and dried mass to obtain fine tilth. All the weeds and stubbles were removed and the soil was mixed with well decomposed cow dung. The seeds were sown on 1st December 2020, maintaining line to line and plant to plant distance 40 cm and 30 cm, respectively. There were 6 pits in a line and 3 seeds were sown in a pit (Figure 2). After sowing, the seeds were covered with light soil to a depth of about 0.6 cm. Flooded irrigation was given on the next day by using a long pipe in order to trigger the germination process. Complete germination of the seeds happened within 4-6 days of sowing. Weeding, thinning and irrigation were done from time to time as and when needed. In order to gap filling and to check the border effect, some extra seeds were also sown around the border area of the experimental field.

3.8.3. Intercultural operation: When it required in each plot intercultural operations like irrigation, weeding, thinning etc. were done properly.

a. Irrigation

The very first irrigation was done immediately after seed sowing. After, germination irrigation was done several times at 7 days interval or when it needed. Flood irrigation also given for its better growth. Proper drainage system was maintained in field.

Figure 3. Application of irrigation

b. Thinning

At 25 DAS thinning was done for maintain the distance from one plant to another plant for their proper growth and getting desirable yield. It is also important for proper collection of data.

Figure 4. Experimental plot after thinning

c. Gap filling

Gap filling was done in place of dead or wilted seedlings in the field using healthy seedlings of the same stock previously planted in the border area.

d. Weeding

Weeding was done to keep the crop free from weeds, for better soil aeration and to break the soil crust. Weeding was done manually at 20, 35, 50 and 65 DAS to keep the plots free from weeds.

Figure 5. The experimental plot after weeding

e. Top dressing and earthing up

In Sugar beet and Beetroot field, first Urea and MP top dressing and earthing up were done at 30 DAS and last were done at 50 DAS. It should be considered that the soil should not cover the collar region of the plant during earthing up. After top dressing and earthing up, light irrigation was applied in order to mix the fertilizer completely with soil.

Figure 6. Experimental plot after earthing up

f. Tagging of plants

Randomly 5 plants were selected from each plot tagged for data collection. Mean values were determined to get rating score of each treatment.

Figure 7. Tagging the plant in the experimental plot

3.9. Data collection

The data were collected on the following parameters:

1. Disease Incidence %

2. Disease Severity %

3. Plant Height (cm)

4. Number of leaf

5. Individual beet weight (kg)

3.10. Procedure of data collection

a. Disease incidence

The plants under observation were closely observed to investigate the typical symptoms and sign of the disease. The plant showing typical symptoms by the pathogenic infection were confirmed as diseased plant. In field, total number of diseased plants was recorded at 55 DAS, 70 DAS, 90 DAS, 105 DAS on the basis of the appearance of typical symptoms.

The following formulas were used to calculate the percent disease incidence,

Disease incidence (%) = $\frac{Xi}{X} \times 100$

X= Total number of plants in a unit

Xi= Number of infected plants in a unit plot

b. Disease severity

Disease severity was calculated by Townsend- Heuberger (2004) formula:

Disease severity (%) = $\frac{n \times V}{Z \times N} \times 100$

Where,

n = Number of selected plants with different disease severity in the scale

V = Scale value

Z = The highest scale value

N = Observed total number of plants

For calculation of disease severity, the following disease severity scale was used (Weiland and Koch, 2004):

0 – Whole plant is healthy

1 – Onset of disease; Appearance of first strains on outer leaves

2 – Increase in number of strains on outer leaves

3 – The strains also appeared on the intermediate leaves outside the central leaves

4 – Spots coming together apparently

5 – Large dead areas on the leaves

6 – Large dead areas on the leaves

7- Dead parts in at least half or more of the palms of the outer leaves

8- Dead leaves in almost all of the outer leaves and large dead areas in the middle leaves

9 – Forming new leaves in plants

c. Plant height

Plant height was measured by using centimeter scale at 55 DAS, 75 DAS, 95 DAS in plot. Here 5 plants were randomly selected for calculating final plant height.

d. Number of leaf

Unbiased 5 plants were taken from plots and counted the no. of leaf of each plant at 55, 75 and 95 days after sowing (DAS). The average number was used as final leaf no. per plant.

e. Individual plant weight

Weight was recorded at harvest from randomly collected plants of each plot from inner rows leaving the boarder row. Collected plant were weighed by using a digital electric balance and the mean was recorded and expressed in gram.

3.11. Statistical analysis

The collected data was statistically analyzed by Statistics 10 computer package program. Analysis of variance (ANOVA) was used to find out the variation of result from experimental varieties. Variety means were compared by least significant difference test (LSD) experiment.

3.12. Isolation and identification of causal organism

3.12.1. Sample collection

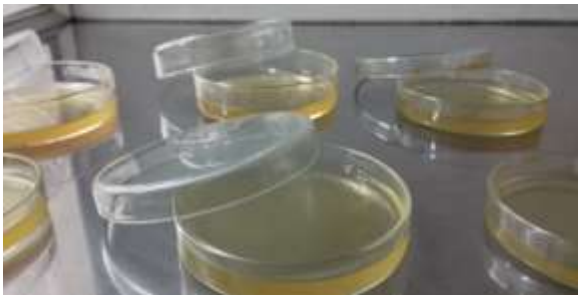
Diseased plants showing typical symptoms were collected from research field. Then the samples were carried to the central laboratory of Sher-e-Bangla Agricultural University, Dhaka to examine the visual symptoms and isolation of causal organism (s).

Figure 8. Observation on the infected plants at the time of counting disease incidence and measuring disease severity.

3.12.2. Isolation of causal organism (s) by Tissue Plating Method

Infected plant showing typical disease symptoms were cut into small pieces, washed thoroughly in running water. Some samples were surface sterilized with 70% Ethanol for 30 seconds. Then 1% sodium hypochlorite (NaOCl) for 30 seconds and washed three times in sterile distilled water each for 1min. Some samples were sterilized with 37.5% chlorox for 30 seconds washed three times in sterile distilled water each for 1 min. The surface sterilized leaves were placed on Blotter paper and Potato Dextrose Agar (PDA) medium and incubated at 25±20℃ for 6-7 days. Mycelial growth from each developing colony were re-cultured on PDA to get pure culture. The causal organism was isolated, identified and recorded. The pathogen was identified from all of the infected samples.

A



B

C

D

Plate 03. Preparation of PDA (Potato Dextrose Agar) plate; A= PDA media preparation, B= Media on petridish, C= Sample placement, D= After placement of sample.

3.12.3. Identification of causal organism

3.12.3.1. Identification by Symptomological Study (Visual Assessment)

In this study, the development of symptoms was closely observed to confirm disease. The diseased plants were closely and carefully examined by magnifying glass to observe the disease symptoms development, sign of the pathogen, source of infection, mode of dissemination and favorable environment. Idea about causal organism was taken from those information (Punja *et al*., 1985).

3.12.3.2 Identification by Growing on Blotter Paper (Incubation Method)

The diseased roots were cut into pieces and surface sterilized with 70% Ethanol for 30 seconds. Then the sodium hypochlorite (NaOCl) for 30 seconds and washed three times in sterile distilled water each for 1 min. Then the cut pieces were incubated at room temperature for seven days. When the fungus grew well mycelium and sclerotia were observed by visual observation. The identification of the causal organism was done with the help of relevant literature (Punja *et al*., 1985).

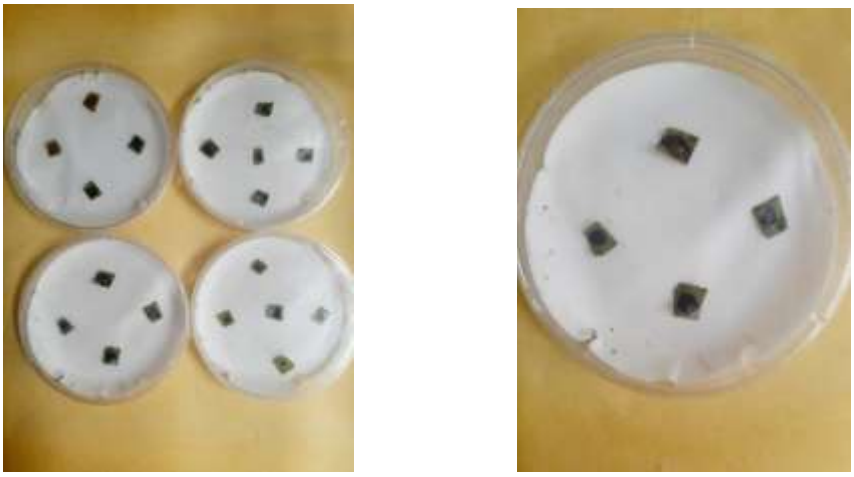


Plate 04. Growing fungi in moist blotting paper

3.12.3.3. Identification by Growing on Culture Medium (Tissue Plating Method)

Infected roots were cut into small pieces and some samples were surface sterilized with 70% Ethanol for 30 seconds. Then 1% sodium hypochlorite (NaOCl) for 30 seconds and washed three times in sterile distilled water each for 1min. Some samples were sterilized with 37.5% chlorox for 30 seconds washed three times in sterile distilled water each for 1 min. The surface sterilized roots were placed on Potato Dextrose Agar (PDA) medium in petridish (Mehrota and Aggarwal, 2003). The plates containing root pieces were incubated at room temperature for three days. When the fungus grew well, the organism was re-cultured by mycelium or sclerotia to obtain pure culture. The identification of the causal organism was done with the help of relevant literature (Punja *et al*., 1985).

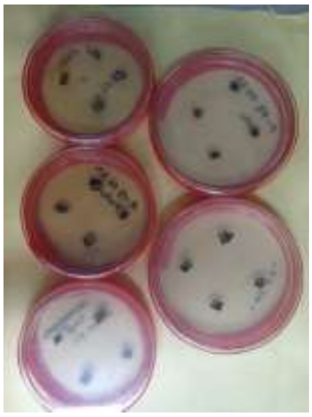
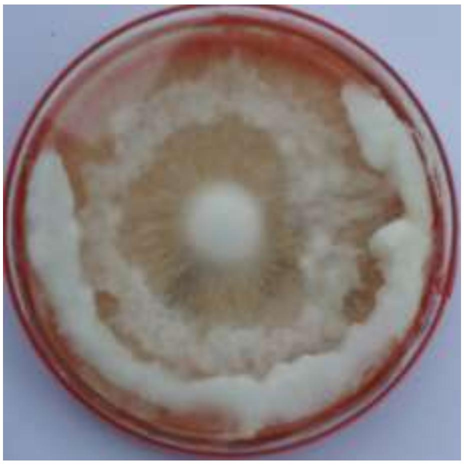


Plate 05. Placement of diseased sample on Potato Dextrose Agar (PDA) medium



A **B**

C

Plate 06. Growing different kind of fungi on Potato Dextrose Agar (PDA) medium; A = *Sclerotium rolfsii,* B = *F. oxysporum*, C = *Alternaria alternata.*

CHAPTER 4

RESULTS AND DISCUSSION

The experiment was conducted to identify the diseases of sugar beet and beetroot. Results were compiled based on disease incidence and severity, morphological and physiological parameters for Sclerotium root rot disease of sugarbeet at 55, 70, 85 and 100 days after sowing (DAS), Fusarium yellows of sugarbeet at 60, 75, 90, and 105 days after sowing and Cercospora leaf spot disease of sugarbeet at 60, 75, 90, and 105 days after sowing. Alternaria leaf spot disease of beetroot at 50, 65, 80, and 95 days after sowing, Leaf blight of beetroot at 55, 70, 85, and 100 days after sowing are presented in this chapter.

Sclerotium root rot, Fusarium yellows and Cercospora leaf spot diseases were found from selected tropical sugarbeet varieties (KWS Allanya, KWS Gregoria, and KWS Serenada).

Diseases of sugarbeet

4.1. Sclerotium root rot of sugarbeet

4.1.1. Symptoms of Sclerotium root rot disease of sugar beet

The mycelial growth of the fungi was found at the collar zone to root zone of sugar beet. The fungal mycelium along with mustard seed like sclerotia were observed associated with infected portion at soil level. The normal growth was arrested which was given a stunted appearance of plant. Plant showed brown discoloration and finally caused wilting and dying of infected plants. Bakr (1986) also found that, foot and root rot is mainly occurred during the seedling stage. The fungal stands along with mustard seed like sclerotia are generally observed associated with infected portion at soil level. He also explained that the tap roots are infected and normal growth is arrested which may give stunted appearance and finally causing wilting and dying of plants.

A. Immature sclerotia **B. Infected collar region**

C. Mature sclerotia **D. The death plants**

Figure 9. Disease infected plant in the field. A. Immature sclerotia, B. Infected collar region, C. Mature sclerotia, D. The death plants.

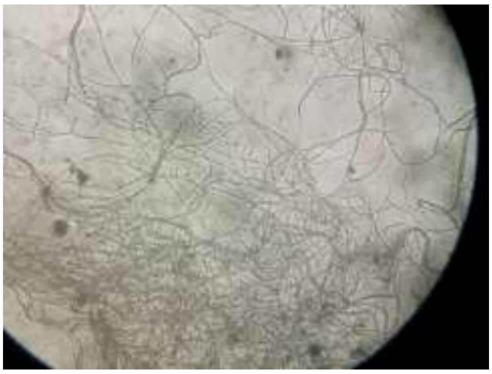
4.1.2. Identification of causal organism

The organism was re-cultured by mycelium or sclerotia to obtain pure culture after well growth of causal organism on Potato Dextrose Agar (PDA) medium. It was found that, mycelial growth of causal organism was formed from second days after incubation (DAI) and it took a week to fill the whole petri dish with mycelium of *Sclerotium rolfsii*. Mustard seed like sclerotia was formed in the pure culture of causal organism within the two weeks of incubation. Punja *et al.*, (1958) found that the mycelial growth rate of *Sclerotium rolfsii* was maximized under optimum temperature. Ahmed (1980) found that *Sclerotium rolfsii* is a facultative saprophyte and can survive generation to generation by formation of brown sclerotia.

A

B

C



D

Plate 07. Growth of *Sclerotium rolfsii* at different days after inoculation (DAI); A = 3DAI, B = 9DAI, C = 17DAI, D = Microscopic view of *Sclerotium rolfsii* (100X).

4.1.3. Incidence of Sclerotium root rot of sugarbeet

Disease incidence at different days after sowing (DAS) during field condition had been recorded on the basis of visible typical symptoms. Three different variety were compared with each other for disease incidence recorded at 55 DAS, 70 DAS, 85 DAS and 100 DAS (Table 3).

At 55 DAS, the highest disease incidence of Sclerotium root rot was recorded from (KWS Serenada) (13.80%) which was statistically similar to all the variety, whereas (KWS Gregoria) showed the lowest disease incidence (8.97%), followed (KWS Allanya) (9.37%) which were statistically similar with each other.

At 70 DAS, the highest disease incidence was recorded in (KWS Serenada) (19.10%) which was statistically different from other varieties and the lowest disease incidence was recorded in (KWS Gregoria) (13.77%) which was statistically similar to (KWS Allanya) (14.53%) variety.

At 85 DAS, the lowest disease incidence of Sclerotium root rot was recorded in (KWS Allanya) (17.23%) whereas sugarbeet variety (KWS Serenada) showed the highest disease incidence (26.57%) which was statistically different from other varieties.

At 100 DAS, the last disease incidence of Sclerotium root rot was recorded highest in (KWS Serenada) (32.37%) and lowest disease incidence was recorded in (KWS Allanya) (22.07%). All results are presented in Table 3.

Table 3. Incidence of Sclerotium root rot (*Sclerotium rolfsii*) on three varieties of sugarbeet recorded under natural field condition at different days after sowing (DAS).

Variety	Disease incidence (%)			
	55DAS	70DAS	85DAS	100DAS
KWS Grgoria)	**8.97a**	**13.77b**	19.67b	25.60b
KWS Serenada)	**13.80a**	**19.10a**	**26.57a**	**32.37a**
KWS Allanya)	9.37a	14.53b	**17.23b**	**22.07b**
CV (%)	21.55	11.10	6.26	6.59

Sugarbeet variety KWS Serenada showed the highest disease incidence which varied from (10.17% - 24.00%). Khettabi *et al.,* (2004) conducted an experiment and reported that, the soil borne fungal pathogen *Sclerotium rolfsii* attacks sugarbeet roots a couple of weeks before harvest, causing up to 50% - 80% losses in crop yield and quality. Islam *et al*., (2012) estimated that 9.74% of plants in 144 sugar beet plots were infected with *Sclerotium rolfsii* that showed root rot symptom. And also found that appeared as the most important one causing approximately 50% yield loss. The fungus generally infects the crown area or junction of stem and root near the soil surface and causes rotting of infected tissues. Through this disease severity percentage increases with the increase of DAS and that percentage varied from (15.00 - 24.00).

4.2. Fusarium Yellow disease of sugarbeet

4.2.1. Symptoms of Fusarium Yellows of sugar beet

Older leaves of plants affected by Fusarium yellows first showed one -sided wilting and interveinal chlorosis. Leaves ultimately became scorched, dry, and brittle. External root symptoms were not present. Fusarium root rot also exhibits symptoms that consist of wilting, yellowing, and vascular necrosis, but is additionally characterized by a tip rot at the distal end of the taproot. Symptoms of this disease include interveinal yellowing, chlorosis, wilting and necrosis of the leaves and a grey to brown discoloration in the root tissue (Stewart 1931; Ruppel 1991). Khan *et al*., (2009) also reported that this disease has no external root symptoms. A transverse section through the root shows a grayish-brown vascular discoloration. Mature plants rarely die, but yield is reduced.

A. Half of the leaf became dry

B. Died leaves remain attached

C.Necrotic lesion on older leaf

D. Necrotic lesion on younger leaf

Figure 10. Symptoms of Fusarium yellows A. Half of the leaf became dry, B. Died leaves remain attached, C. Necrotic lesion on older leaf, D. Necrotic lesion on younger leaf.

4.2.2. Identification of causal organism

For isolation of causal organism of fusarium yellows disease of sugar beet, infected portion of leaf were collected from infected plant and transfer on PDA media. After the mycelial growth, the cultural characteristics were studied, the fungus produced cottony, fluffy and whitish colony on PDA medium.

Mycelium of *Fusarium oxysporum* was hyaline, septate branched and aggregated. Conidiophores were simple or branched. The macroconidia were nearly straight, slender, thin-walled, several celled, slightly curved or bent at the pointed ends or sickle shaped (Plate 21). Microconidia were usually one celled, oval or oblong or reniform or elliptical in shape. This fungus produced asexual fruiting body called sporodochium by aggregation of short and branched conodiophore.

Plate 08. (A) Pure culture of *Fusarium oxysporum* and (B) Conidia of *F. oxysporum* (100X).

4.2.3. Incidence of Fusarium yellows disease of sugarbeet

Disease incidence at different days after sowing (DAS) during field condition had been recorded on the basis of visible typical symptoms. Three different varieties were compared with each other for disease incidence recorded at 60 DAS, 75 DAS, 90 DAS and 105 DAS (Table 4).

At 60 DAS, the highest disease incidence of Fusarium yellows was recorded from variety (KWS Gregoria) (13.83%) which was statistically different from other variety. And variety (KWS Serenada) showed the lowest disease incidence (7.67%), followed by variety KWS Allanya (8.47%) which was statistically similar to each other.

At 75 DAS, the highest disease incidence was recorded sugarbeet variety (KWS Gregoria) (17.47%) which was statistically different from other variety and the lowest disease incidence was recorded in variety (KWS Serenada) (11.40%) and sugarbeet variety (KWS Allanya) (12.50%) statistically showed the same disease incidence.

At 90 DAS, the lowest disease incidence of Fusarium yellows was recorded in beetroot variety (Beet King) (14.70%) whereas sugarbeet variety (KWS Gregoria) showed the highest disease incidence (21.67%). And the remaining variety of sugarbeet (KWS Serenada) (15.90%), (KWS Allanya) (15.60%) was statistically similar to each other.

At 105 DAS, the last disease incidence of Fusarium yellows was recorded highest in sugarbeet variety (KWS Gregoria) (25.73%) and lowest disease incidence was recorded in beetroot variety (KWS Allanya) (17.73%). And the remaining variety of sugarbeet (KWS Serenada) (19.77%) was statistically similar to each other. All results are presented in Table 4.

Table 4. Incidence of Fusarium yellows (*Fusarium oxysporum*) on three varieties of sugarbeet recorded under natural field condition at different days after sowing (DAS)

Variety	Disease incidence (%)			
	60DAS	75DAS	90DAS	105DAS
KWS Gregoria	**13.83a**	**17.47a**	**21.67a**	**25.73a**
KWS Serenada	**7.67c**	**11.40b**	15.90ab	19.77ab
KWS Allanya	8.47c	12.50b	**15.60ab**	**19.43ab**
CV (%)	11.86	14.87	16.11	14.22

4.2.4. Severity of Fusarium yellows disease of sugarbeet

Disease severity at different days after sowing (DAS) during field condition had been recorded on the basis of visible typical symptoms. Three different varieties were compared with each other for disease incidence recorded at 60 DAS, 75 DAS, 90 DAS and 105 DAS (Table 5).

At 60 DAS, in Fusarium yellows disease the lowest (3.02%) disease severity was recorded from sugarbeet variety (KWS Allanya) (1.42%), sugerbeet variety (KWS Gregoria) showed the highest disease severity (6.45%) which was statistically different from other variety. Variety of sugarbeet (KWS Serenada) (4.04%) was statistically different from other variety.

At 75 DAS, the lowest disease severity of Fusarium yellows was recorded in sugarbeet variety (KWS Serenada) (6.43%) whereas sugarbeet variety (KWS Gregoria) showed the highest disease severity (11.69%) which was statistically different from other variety. The remaining sugarbeet variety (KWS Allanya) showed moderate disease severity that were 6.82% respectively, which were statistically similar with each other.

At 90 DAS, the highest disease severity was recorded in sugarbeet variety (KWS Gregoria) (14.70%) which was statistically different from other variety. The lowest disease severity was recorded in sugarbeet variety (KWS Allanya) (9.23%) which was statistically different from sugarbeet variety KWS serenada (10.39%).

At 105 DAS, the last disease severity of Fusarium yellows was recorded highest in sugarbeet variety (KWS Gregoria) (17.78%) which was statistically different from other variety. And lowest disease severity was recorded in sugarbet variety (KWS Allanya) (12.62%) which was statistically similar to sugarbeet variety (KWS Serenada) (12.95%). All results are presented in Table 5.

Table 5. Severity of Fusarium yellows (*Fusarium oxysporum*) on three varieties of sugarbeet recorded under natural field condition at different days after sowing (DAS)

Variety	Disease severity (%)			
	60DAS	75DAS	90DAS	105DAS
KWS Gregoria	**6.45a**	**11.69a**	**14.70a**	**17.78a**
KWS Serenada	4.04ab	**6.43a**	10.39ab	12.95b
KWS Allanya	**3.02b**	6.82a	**9.23b**	**12.62b**
CV (%)	24.04	26.19	15.14	9.08

Sugarbeet variety KWS Gregoria showed the highest disease incidence varied from (13.83% - 25.73%) and beetroot variety Beet King showed the highest disease severity which varied from (1.42% - 11.64). Fusarium yellows disease found in the leaf area of the plant which is the main source of producing food for the plant. Fusarium wilt or fusarium yellows of sugar beet is caused by *Fusarium oxysporum*. f. sp. *betae* (Stewart, 1931; Hanson and Jacobsen, 2009). Hanson and Jacobsen (2009) estimated that this disease can result in significant reduction in sugar concentration. Schneider and Whitney (1986), also found that Fusarium yellows causes significant reduction in root yield, as well reduced sucrose percentage and juice purity in affected sugarbeet (*Beta vulgaris* L.). Because of disease incidence and disease severity is high this disease cause severe reduction in sugar concentration, which can impact the total production of sugarbeet. At initial stage disease incidence and disease severity was not that much significant but at the later stage it increased. And the percentage rate was high at KWS Serenada which was 25.73 and from disease severity its rate was 17.78.

4.3. Cercospora leaf spot disease of sugarbeet

4.3.1. Symptoms of Cercospora leaf spot of sugarbeet

Spots was first visible on the older leaves and later on the younger ones. Leaf spots were amphigenous (growing on both sides of leaves), circular, subcircular to slightly angular-irregular shaped was with narrow shaped. The spots were at first showed brown, but soon turned grey-white to white, margin narrow. Mature lesion was acquired reddish ring borders. As epidemics progresses, the number and size of spots increases, individual spots coalesce, leaves turn yellow and eventually complete leaf senescence occurs. Lesions was also formed on petioles and appear elongated while lesions also had been found on root crowns not covered with soil.

A. Circular lesions **B. Mature lesions with reddish ring border**

Figure 11. Infected sugarbeet plant, A. Circular lesions, B. Mature lesions with reddish ring border.

4.3.2. Causal organism of Cercospora leaf spot

The identified causal organism was *Cercospora beticola*. Conidiophores was small, moderately large and densely fascicles, arising from substomatal or intraepidermal hyphae or stromata, emerging through stomata or erumpent, erect, straight to curved, subcylindrical or somewhat attenuated towards the tip to moderately geniculate-sinuous, unbranched, 0-3-septate, pale olivaceous to olivaceous-brown, paler towards the tip, thin-walled and smooth. Conidia solitary and catenate, simple, narrowly cylindrical-fusiform, short obclavate, septate, hyaline.

A **B**

Plate 9. Microscopic (compound) view of *Cercospora beticola;* A = (100X), B = (400X).

4.3.3. Incidence of Cercospora leaf spot disease of sugarbeet

Disease severity at different days after sowing (DAS) during field condition had been recorded on the basis of visible typical symptoms. Three different varieties were compared with each other for disease incidence recorded at 60 DAS, 75 DAS, 90 DAS and 105 DAS (Table 6).

At 60 DAS, in Cercospora leaf spot disease the lowest (7.60%) disease incidence was recorded from sugarbeet variety KWS Serenada, whereas variety (KWS Allanya) showed the highest disease incidence (13.30%) which was statistically similar to other variety and (KWS Gregoria) showed the disease incidence (11.53%) which was statistically similar to other variety.

At 75 DAS, the lowest disease incidence of Cercospora leaf spot was recorded in sugarbeet variety (KWS Serenada) (13.27%) which was statistically different from other variety. Sugarbeet variety (KWS Allanya) showed the highest disease incidence (21.83%) which was statistically different from other variety. The remaining variety (KWS Gregoria) showed moderate disease incidence that were (17.50%) respectively, which was statistically different with other variety.

At 90 DAS, the highest disease incidence was recorded in sugarbeet variety (KWS Allanya) (27.13%) which was statistically different from other variety. The lowest disease incidence was recorded in variety of sugarbeet variety (KWS Serenada) (19.83%) which was statistically different from other variety. Among the selected variety, (KWS Gregoria) showed moderate disease incidence that were 23.80%.

At 105 DAS, the last disease incidence of Cercospora leaf spot was recorded highest in (KWS Allanya) (29.43%) which was statistically similar to other variety. And lowest disease incidence was recorded in sugarbeet variety (KWS Serenada) (24.03%)

which was statistically similar to variety of sugarbeet (KWS Gregoria) (26.47%). All results are presented in Table 6.

Table 6. Incidence Cercospora leaf spot (*Cercospora beticola*) on three varieties of sugarbeet recorded under natural field condition at different days after sowing (DAS)

Variety	Disease incidence (%)			
	60DAS	75DAS	90DAS	105DAS
KWS Gregoria)	11.53a	17.50b	23.80ab	26.47a
KWS Serenada)	**7.60a**	**13.27c**	**19.83a**	**24.03a**
KWS Allanya)	**13.30a**	**21.83a**	**27.13a**	**29.43a**
CV (%)	26.28	8.27	14.90	9.62

4.3.4. Severity of Cercospora leaf spot disease of sugarbeet

Disease severity at different days after sowing (DAS) during field condition had been recorded on the basis of visible typical symptoms. Three different varieties were compared with each other for disease incidence recorded at 60 DAS, 75 DAS, 90 DAS and 105 DAS (Table 7).

At 60 DAS, in Cercospora leaf spot disease the lowest (3.00%) disease severity was recorded from sugarbeet variety (KWS Gregoria), whereas variety (KWS Allanya) showed the highest disease severity (9.10%) which was statistically different from other variety. Variety of sugarbeet (KWS Serenada) (3.87%) showed the same disease severity to KWS Gregoria.

At 75 DAS, the lowest disease severity of Cercospora leaf spot was recorded in sugarbeet variety (KWS Gregoria) (8.07%). (KWS Allanya) showed the highest disease severity (15.80%) which was statistically different from other variety. The remaining variety (KWS Serenada) showed moderate disease incidence that were (9.23%).

At 90 DAS, the highest disease severity was recorded in sugarbeet variety (KWS Allanya) (20.80%) which was statistically different from other variety. The lowest disease severity was recorded in variety (KWS Gregoria) (11.37%) which was statistically similar to sugarbeet variety (KWS Serenada) which was (13.23%).

At 105 DAS, the last disease severity of Cercospora leaf spot was recorded highest in (KWS Allanya) (23.30%) which was statistically different from other variety. And lowest disease severity was recorded in (KWS Gregoria) (15.57%) which was statistically different from other variety. All results are presented in Table 7.

Table 7. Severity of Cercospora leaf spot (*Cercospora beticola*) on three varieties of sugarbeet recorded under natural field condition at different days after sowing (DAS)

Variety	Disease severity (%)			
	60DAS	75DAS	90DAS	105DAS
KWS Gregoria	**3.00b**	**8.07b**	**11.37b**	**15.57b**
KWS Serenada	3.87b	9.23b	13.23b	17.37ab
KWS Allanya	**9.10a**	**15.80a**	**20.80a**	**23.30a**
CV (%)	20.48	22.46	18.49	17.99

Cercospora leaf spot disease showed highest disease incidence in sugarbeet variety (KWS Allanya) which varied from (13.30 to 29.83) and highest disease severity showed in sugarbeet variety (KWS Allanya) which varied from (9.10% to 23.30). Skaracis *et al*., (2011) conducted an experiment and found out that Cercospora leaf spot, caused by the fungus *Cercospora beticola* Sacc., that is the most widespread and damaging sugar beet (*Beta vulgaris* L.) foliar disease. The present study also revealed that, it is most damaging foliar disease of sugarbeet. In this study also found that this the the fungus (*cercospora beticola*) which caused this disease and this is a foliar disease. In cases of severe epidemics without any control measures, primary foliage destruction is complete early, extended regrowth takes place and gross sugar losses have been reported ranging from 25 to 50% or more (Smith and Ruppel 1973). At initial stage disease incidence and disease severity was not that much significant but at the later stage it increased. And the percentage rate was high at KWS Allanya which was 29.43 and from disease severity its rate was 23.30.

4.4. Yield and yield contributing character of sugarbeet

Plant height, leaf number, at different days after sowing during growth period had been recorded. Three different variety of sugarbeet were compared with each other for plant height, leaf number and weight were recorded at 55,75 and 95 days after sowing (DAS) (Table 8).

At 55 DAS the highest (36.93 cm) plant height was recorded from sugarbeet variety (KWS Serenada), followed by variety (KWS Gregoria) (35.40 cm). whereas (KWS Allanya) variety showed the lowest plant height (29.53 cm).

At 75 DAS, the highest (61.87 cm) plant height was recorded from sugarbeet variety (KWS Serenada) which was the highest from all of the variety and was statistically different from other variety. The lowest plant height was observed from variety KWS Allanya which was (45.93) cm.

At 95 DAS, the highest (57.00) plant height was recorded sugarbeet variety (KWS Serenada) which was statistically different from other variety. And the lowest plant height was observed from variety (KWS Allanya) which was (49.73).

At 55 DAS the highest (10.60) leaf number was recorded from sugarbeet variety (KWS Gregoria) which was statistically different from variety, whereas KWS Serenada variety showed the lowest leaf number (9.87).

At 75 DAS, the highest (19.47) plant leaf number was recorded from sugarbeet variety (KWS Gregoria) which was statistically different from other variety. The lowest leaf number was observed from variety KWS Serenada which was (17.07).

At 95 DAS, the lowest (19.60) plant leaf number was recorded in sugarbeet variety (KWS Gregoria) which was statistically similar to sugarbeet variety (KWS Serenada) (19.00). And the highest plant height was observed from variety (20.33).

At 160 DAS, the highest sugarbeet weight was found from variety KWS Gregoria which was 1.73 kg and the lowest weight was found from variety KWS Allanya 1.50kg.

Table 8. Yield and yield contributing characters of three sugarbeet varieties recorded under natural field condition

Variety	Plant height (cm)			Leaf number			Yield (kg)
	55DAS	75DAS	95DAS	55DAS	75DAS	95DAS	160DAS
KWS Gregoria	35.40a	52.33ab	51.63a	**10.60a**	**19.47a**	19.60a	**1.73a**
KWS Serenada	**36.93a**	**61.87a**	**57.00a**	**9.87a**	**17.07a**	**19.00a**	1.70a
KWS Allanya	**29.53a**	**45.93b**	**49.73a**	10.20a	17.47a	**20.33a**	**1.50a**
CV%	12.13	8.47	15.67	4.49	7.84	22.34	25.01

***DAS = Days After Sowing**

Plant height varied from 29.53 to 61.87 and the highest plant height found from sugarbeet variety KWS Serenada, which varied from 36.93 to 61.87. At 75DAS KWS Serenada showed the highest plant height which was 61.87cm. And the lowest height found in variety KWS Allanya which was 29.53 cm. Islam *et al*., (2012) conducted an experiment and found that plant height varied from 26.8 cm to 55.0 cm at 165 DAS. Leaf number varied from 9.87 to 19.60 and the highest number of leaves found in sugarbeet variety KWS Gregoria which was 19.60 and lowest leaf number found in variety KWS Serenada, which was 9.87. Whole plant weight varied from 1.50kg to1.73kg and the highest weight found from sugarbeet variety KWS Gregoria which was 1.73kg. Lowest plant wight found from variety KWS Allanya, which was 1.50kg. Islam *et al*., (2012) also found that whole plant weight for the genotype SB001 was the highest (1.6 kg), which was very close to SB005 (1.45 kg). The genotype SB010 had the lowest whole plant weight (0.76 kg).

Diseases of beetroot

Alternaria leaf spot and Leaf blight diseases were found from the selected beetroot varieties (Rokto, Red Ball, Beet King).

4.5. Alternaria leaf spot disease of beetroot

4.5.1. Symptoms of Alternaria leaf spot of beetroot

Symptoms of Alternaria leaf spot was initially found on the older leaves of the infected plant as dark brown in color, and the spots were circular to irregular. As they became older the spots enlarged. The centers of the spot turned gray with age and may became slightly zonate. The dead centers later teared and partially droped out. Pandey *et al*; (2020) also found that leaf symptoms also included small circular, brown, necrotic spots with a chlorotic halo. Because of severe infections, leaf spots coalesced and resulted in leaf blight.

A. Concentric ring present in the leaf

C. The leaf turned zonate

B. Leaf became blighted

D. Droped out leaf

Figure 12. Infected beetroot plant. A. concentric ring present in the leaf, B. Leaf became blighted, C. The leaf turned zonate, D. Droped out leaf.

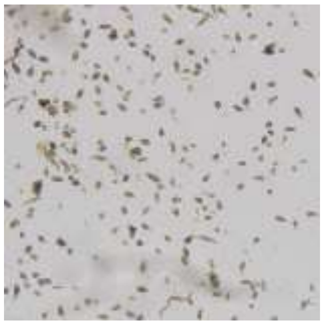
4.5.2. Identification of causal organism

For isolation of causal organism of Alternaria leaf spot disease of beetroot, infected portion of leaf were collected from infected plant and transfer on PDA media. After the fungus grew well, the organism was re-cultured by mycelium and the cultural characteristics were studied the mycelium was septated, branched, hyaline in tender age. The conidiophore was simple, short, septated, colored and beard conidia at the top. Conidia were dark, beaked, multicelled and muriform (both longitudinal and transverse septum was present), borne at the tip of conidiophores singly or in short chains. The conidia contained 5-8 transverse septa and few longitudinal septa. Their shape ware obclavate to elliptical or ovoid which were pointed at distal end. In the culture the colonies of Alternaria are moderately fast growing and produce dark brown to blackish culture on PDA medium within 7 days.

A

B

C



D

Plate 10: Growth of *Alternaria alternata* at different days after inoculation (DAI); A = 4DAI, B = 7DAI, C = 15DAI, D = Microscopic view of conidia (100X).

4.5.3. Incidence of Alternaria leaf spot disease of beetroot

Disease incidence at different days after sowing (DAS) during field condition had been recorded on the basis of visible typical symptoms. Three different varieties were compared with each other for disease incidence recorded at 50 DAS, 65 DAS, 80 DAS and 95 DAS (Table 09).

At 50 DAS, in Alternaria leaf spot the lowest (8.10%) disease incidence was recorded from beetoot variety (Rokto), whereas beetroot variety (Red Ball) showed the highest disease incidence (16.90%) which was statistically different from other variety. Beetroot variety (Beet King) (12.60%) showed the disease incidence which was statistically different from other variety.

At 65 DAS, the highest disease incidence of Alternaria leaf spot was recorded in beetroot variety (Red Ball) (19.70%) which was statistically different from other variety, whereas beetroot variety (Rokto) (13.63%) showed the lowest disease incidence which was statistically different from other variety. The remaining variety (Beet King) showed moderate disease incidence that was 15.97% which was statistically different from other variety.

At 80 DAS, the disease incidence was counted where the lowest incidence of disease was also recorded from beetroot variety (Rokto) (20.10%) and the highest disease incidence was recorded in beetroot variety (Red Ball) (25.47%) which was statistically similar from other variety.

At 95 DAS, the final disease incidence was counted where the highest disease incidence was recorded in beetroot variety (Red Ball) (30.23%) which was statistically similar to other variety. And the lowest disease incidence was recorded from beetroot variety (Rokto) (21.10%) which was statistically similar along with the variety of beetroot (Beet King) (23.83%). All results are presented in Table 09.

Table 09. Incidence of Alternaria leaf spot disease (*Alternaria alternata*) on three varieties of beetroot recorded under natural field condition at different days after sowing (DAS)

Beetroot Variety	Disease Incidence (%)			
	50DAS	65DAS	80DAS	95DAS
Beet King	12.60ab	15.97ab	21.26a	23.83a
Rokto	**8.10b**	**13.63b**	**20.10a**	**21.10a**
Red Ball	**16.90a**	**19.70a**	**25.47a**	**30.23a**
CV (%)	24.28	12.73	16.83	20.94

4.5.4. Severity of Alternaria leaf spot disease of beetroot

Disease severity at different days after sowing (DAS) during field condition had been recorded on the basis of visible typical symptoms. Three different variety were compared with each other for disease severity recorded at 50 DAS, 65 DAS, 80 DAS and 95 DAS (Table 10).

At 50 DAS, the lowest (3.30%) disease severity was recorded from beetroot variety (Beet King) which was statistically similar from other variety, whereas beetroot variety (Red Ball) showed the highest disease severity (5.69%) which was statistically similar from other variety. Among all the variety (Rokto) (3.53) also showed statistically similar disease severity.

At 65 DAS, the highest disease severity was recorded in beetroot variety (Red Ball) (8.77%) which was statistically similar from other variety. The lowest disease severity was recorded in variety (Rokto) (6.90%) which was statistically similar from other variety. Among the selected varieties, beetroot variety (Beet King) showed moderate disease severity that were 5.87% repectively, which were statistically similar with each other.

At 80 DAS, the lowest disease severity of Alternaria leaf spot was recorded in beetroot variety (Beet King) (7.90%) which was statistically similar to variety (Rokto) (10.67%), whereas beetroot variety (Red Ball) showed the highest disease severity (12.73%).

At 95 DAS, the last disease severity of Alternaria leaf spot was recorded highest in beetroot variety (Red Ball) (18.03%) which was statistically similar from other variety. And lowest disease severity was recorded in beetroot variety (Beet king) (11.70%). All results are presented in Table 10.

Table 10. Severity of Alternaria leaf spot disease (*Alternaria alternata*) on three varieties of beetroot recorded under natural field condition at different days after sowing (DAS)

Beetroot Variety	Disease Severity (%)			
	50DAS	65DAS	80DAS	95DAS
Beet King	**3.30a**	**5.87a**	**7.90a**	**11.70a**
Rokto	3.53a	6.90a	10.67a	12.73a
Red Ball	**5.69a**	**8.77a**	**12.73a**	**18.03a**
CV (%)	39.65	35.30	31.11	26.11

In Alternaria leaf spot disease beetroot variety Red Ball showed the highest disease incidence which varied from (16.90% – 30.23%) and disease severity also showed the beetroot variety which varied from (5.69% - 18.03%). An article about Alternaria leaf spot of table beet, found that Alternaria leaf spot is caused by fungi belonging to the *Alternaria* genus, mostly *A. alternata* (syn. *A. tenuis)* and *A. brassicae.* Pandey *et al*; (2020) also found that leaf symptoms also included small circular, brown, necrotic spots with a chlorotic halo. The present study also found the leaf symptoms with necrotic spots and a chlorotic halo. And the leaf spot disease was caused by the fungus of *Alternaria alternata.* At the initial stage of this disease the leaf was found with a concentric ring which also indicates that this disease is Alternaria leaf spot. This disease also found on petioles. Under favorable condition this disease caused in a rapid necrosis of the leaf. At initial stage disease incidence and disease severity was not that much significant but at the later stage it increased. And the percentage rate was high at Red Ball which was 30.23 and from disease severity its rate was 18.03.

4.6. Leaf blight disease of beetroot

4.6.1. Symptoms of leaf blight of beetroot

At the initial point this disease was firstly appeared on older leaves as chlorosis (yellowing) between the larger veins. As the disease progresses, the younger leaves also became chlorotic, and the older, symptomatic leaves became necrotic. Sometimes, only half of a leaf is chlorotic or necrotic. At later stage, the leaves eventually died but remain attached to the plant and collapse in a heap around the crown.

A. Initial symptom on leaf

B. Infected leaf attached to the crown

C. Chlorotic leaf

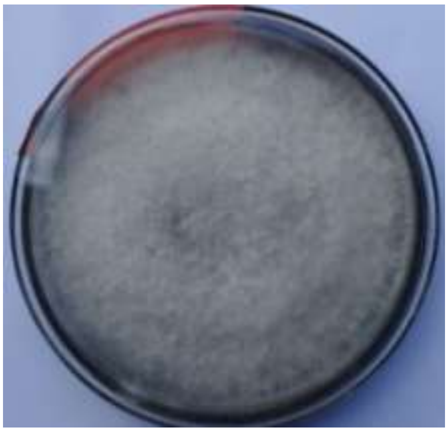
Figure 13. Infected beetroot plant A. Initial symptom of leaf, B. Infected leaf attached to the crown, C. chlorotic leaf.

4.6.2. Identification of causal organism

For isolation of causal organism of leaf blight disease of beetroot, infected portion of leaf were collected from infected plant and transfer on PDA media. After the mycelial growth, the cultural characteristics were studied, the fungus produced cottony, fluffy and whitish colony on PDA medium.

Mycelium of *Fusarium* sp. was hyaline, septate branched and aggregated. Conidiophores were simple or branched. The macroconidia were nearly straight, slender, thin-walled, several celled, slightly curved or bent at the pointed ends or sickle shaped. Microconidia were usually one celled, oval or oblong or reniform or elliptical in shape. This fungus produced asexual fruiting body called sporodochium by aggregation of short and branched conodiophore.

A



B

C

Plate 11. Growth of *Fusarium oxysporum* at different days after inoculation (DAI); A= 3DAI, B= 17DAI, C= Microscopic view of conidia (100X).

4.6.3. Incidence of leaf blight disease of beetroot

Disease incidence at different days after sowing (DAS) during field condition had been recorded on the basis of visible typical symptoms. Three different variety were compared with each other for disease incidence recorded at 55 DAS, 70 DAS, 85 DAS and 100 DAS (Table 11).

At 55 DAS, the highest disease incidence of leaf blight was recorded from variety of beetroot (Beet King) (11.47%) which was statistically different from other variety, whereas variety of beetroot (Red Ball) showed the lowest disease incidence (6.83%) which was statistically different from other variety. Followed by beetroot variety (Rokto) (7.47%) showed the similar disease incidence.

At 70 DAS, the highest disease incidence was recorded in beetroot variety (Beet King) (15.87%) which was statistically similar to other variety. And the lowest disease incidence was recorded in beetroot variety (Rokto) (10.63%) which was statistically similar with beetroot variety (Red Ball) (11.90%).

At 85 DAS, the lowest disease incidence of leaf blight was recorded in beetroot variety (Rokto) (16.87%) which was statistically similar to other variety, whereas beetroot variety (Red Ball) showed the highest disease incidence (20.80%) which was statistically similar to other variety.

At 100 DAS, the last disease incidence of leaf blight was recorded highest in beetroot variety (Beet King) (21.57%) which was statistically similar to beetroot variety (Red Ball) (24.70%) and lowest disease incidence was recorded in beetroot variety (Rokto) (21.57%) which was statistically similar to other variety. All results are presented in Table 11.

Table 11. Incidence of leaf blight (*Fusarium oxysporum*) on three varieties of beetroot recorded under natural field condition at different days after sowing (DAS)

Beetroot Variety	Disease incidence (%)			
	55DAS	70DAS	85DAS	100DAS
Beet King	**11.47a**	**15.87a**	19.97a	**24.83a**
Rokto	7.47b	**10.63a**	**16.87a**	**21.57a**
Red Ball	**6.83b**	11.90a	**20.80a**	24.70a
CV (%)	19.78	19.79	15.37	10.96

4.6.4. Severity of leaf blight disease of beetroot

Disease severity at different days after sowing (DAS) during field condition had been recorded on the basis of visible typical symptoms. Three different variety were compared with each other for disease severity recorded at 55 DAS, 70 DAS, 85 DAS and 100 DAS (Table 12).

At 55 DAS, the lowest (2.20%) disease severity of leaf blight disease was recorded from variety of beetroot (Rokto) which was statistically not similar to other variety, whereas beetroot variety (Beet King) showed the highest disease severity (5.40%), followed by beetroot variety (Red Ball) (3.37%) showed the different disease severity.

At 70 DAS, the highest disease severity was recorded in beetroot variety (Beet King) (10.93%) which was statistically similar to other variety and the lowest disease severity was recorded in beetroot variety (Rokto) (5.77%) which was statistically similar to beetroot variety (Red ball) which was (7.33%).

At 85 DAS, the lowest disease severity of leaf blight recorded in beetroot variety (Rokto) (7.87%) which was statistically different from other variety, whereas beetroot variety (Beet King) showed the highest disease severity (15.13%) which was statistically different from other variety. And the remaining variety (Red Ball) showed the disease severity (9.67%) which was also statistically different from other variety.

At 100 DAS, the last disease severity of leaf blight was recorded highest in variety of beetroot (Beet King) (19.50%) which was statistically different from other variety and lowest disease severity was recorded in beetroot variety (Rokto) (7.87%) which was statistically different from other variety. And the remaining variety (Red Ball) showed the disease severity (12.93%) which was also statistically different from other variety.

Table 12. Severity of leaf blight (*Fusarium oxysporum*) on three varieties of beetroot recorded under natural field condition at different days after sowing (DAS)

Beetroot Variety	Disease severity (%)			
	55DAS	70DAS	85DAS	100DAS
Beet King	**5.40a**	**10.93a**	**15.13a**	**19.50a**
Rokto	**2.20b**	**5.77a**	**7.87b**	**7.87b**
Red Ball	3.37ab	7.33a	9.67ab	12.93ab
CV (%)	28.40	29.86	25.13	21.62

Leaf blight disease showed the highest disease incidence in beetroot variety Beet King which varied from (11.47% - 24.83%) and disease severity showed highest in beetroot variety Beet King, which varied from (5.40% - 19.50%). At initial stage disease incidence and disease severity was not that much significant but at the later stage it increased. And the percentage rate was high at Beet King which was 24.83 and from disease severity its rate was 19.50.

4.7. Yield and yield contributing character of beetroot

Plant height, leaf number, at different days after sowing during growth period had been recorded. Three different variety of beetroot were compared with each other for plant height, leaf number and weight were recorded at 55,75 and 95 days after sowing (DAS). (Table 13)

At 55 DAS the highest (27.67 cm) plant height was recorded from beetroot variety (Red Ball), whereas beetroot variety (Rokto) showed the lowest plant height (22.27 cm).

At 75 DAS, the highest (37.70 cm) plant height was recorded from beetroot variety (Red Ball) which was the highest from all of the variety and was statistically different from other variety. The lowest plant height was observed from variety of beetroot (Beet King) which was (32.53 cm).

At 95 DAS, the highest (31.93) plant height was recorded from beetroot variety (Rokto) which was statistically different from other variety. And the lowest plant height was observed from beetroot variety (Beet King) which was (28.95).

At 55 DAS the highest (8.93) leaf number was recorded from beetroot variety (Rokto) which was statistically different from variety, whereas beetroot variety (Beet King) showed the lowest leaf number (8.40).

At 75 DAS, the highest (15.67) plant leaf number was recorded from sugarbeet variety (KWS Gregoria) which was statistically different from other variety. The lowest leaf number was observed from beetroot variety (Red Ball) which was statistically same with variety (Beet King).

At 95 DAS, the highest (11.53) plant height was recorded in beetroot variety (Rokto) which was statistically different from other variey. And the lowest plant height was observed from beetroot variety (Red Ball) (7.67).

At 160 DAS, the highest beetroot weight was found from variety Red Ball which was 0.67 kg and the lowest weight was found from variety Beet King 0.57 kg.

Table 13. Yield and yield contributing characters of three beetroot varieties recorded under natural field condition.

Variety	Plant height (cm)			Leaf number			Yield (kg)
	55DAS	75DAS	95DAS	55DAS	75DAS	95DAS	160DAS
Beet King	**23.67b**	**32.53a**	**28.95a**	**8.40a**	14.80a	11.53a	**0.57b**
Rokto	**22.27b**	33.93a	**31.93a**	**8.93a**	**15.67a**	**11.53a**	0.63b
Red Ball	**27.67a**	**37.70a**	31.52a	8.47a	**14.13a**	**7.67b**	**0.67b**
CV%	7.16	6.77	16.16	5.78	6.07	14.14	25.01

***DAS = Days After Sowing**

Plant height varied from 22.27 to 31.93 and the highest plant height found from beetroot variety Red Ball, which varied from 27.67 to 31.93. At 75 DAS Red Ball showed the highest plant height which was 31.93cm. And the lowest height found in beetroot variety Rokto which was 22.27cm. Leaf number varied from 8.40 to 15.67 and the highest number of leaves found in variety Rokto which was 15.67 and lowest leaf number found in beetroot variety Red Ball, which was 7.67. Whole plant weight varied from 0.57kg to 0.67kg and the highest weight found from beetroot variety which was 0.67kg. Lowest plant weight found from beetroot variety Beet King, which was 0.57kg. Beetroot variety Rokto showed 0.63 kg weight. At 55 DAS the height was minimum and at 75 DAS beetroot plant showed the highest height from the three different DAS. Because of dropping of some leaves and death of some plants the average height of the plant at 95 DAS decreased. In case of leaf number at 75 DAS the leaf number per plant was highest but death of some plants and dropping of older leaves at 95 DAS the leaf number became 1decreased.

The most common disease of sugarbeet plant was leaf spot and root rot. The disease name was Sclerotium root rot, Fusarium yellows, and Cercospora leaf spot. And they caused by *Sclerotium rolfsii, Fusarium oxysporum, Cercospoea beticola.*

In field condition, in case of Sclerotium root rot, the highest disease incidence wa 32.37% at 100 DAS, respectively. However, the lowest incidence was 22.07% at 100 DAS. At the initial point of the disease the fungi appeared at the collar region of sugarbeet and also found the immature sclerotia which was white in color. At the later stage the sclerotia became mature like mustard seed like structure. At the final stage of the disease many plants were died because of its severe infection.

In field condition, in case of Fusarium yellows disease, the highest disease incidence and severity were 25.73% and 17.78% at 105 DAS, respectively. However, the lowest incidence and severity were 19.43% and 12.62% at 105 DAS. Fusarium yellows disease mainly appeared on the older leaves of the plant. One sided wilting and interveinal chlorosis was found and also the leaves turned to scorched, dry, and brittle. Sometimes gery to brown discoloration also appeared in the root tissue. Rarerly mature plants died but yield is reduced due to its infection.

In field condition, in case of Cercospora leaf spot, the highest disease incidence and severity were 29.43% and 23.30% at 105 DAS, respectively. However, the lowest incidence and severity were 24.03% and 15.57% at 105 DAS. This disease caused in the leaf and this leaf spot disease caused huge damage to the leaf area of the plant. This leaf spot found on both sides of the leaf. The spots were circular and sub-circular to slightly angular irregular shaped was with narrow shaped. Mature lesions were found with reddish ring borders. Severe infected leaves of the plant first became yellow and eventually turn brown and necrotic.

The most common disease of beetroot plant was leaf spot which was caused by two pathogens namely *Alternaria alternata, Fusarium oxysporum.*

In field condition, in case of Alternaria leaf spot, the highest disease incidence and severity were 30.23% and 18.03% at 95 DAS, respectively. However, the lowest incidence and severity were 21.10% and 11.70% at 95 DAS. At the initial point this disease was appeared on the older leaves. The shape of the leaf spots was circular to irregular with dark brown in color. The spots were enlarged as the age of the plant increased. Dead centers of the infected leaf teared and partially droped out. Because of the severe infection the leaf became blighted.

In field condition, in case of Leaf blight, the highest disease incidence and severity were 24.83% and 19.50% at 100 DAS, respectively. However, the lowest incidence and severity were 21.57% and 7.87% at 100 DAS. At the initial point half of the leaf became yellow and necrotic. Leaves died at the later stage but attatched to the plant.

Depending on the disease incidence and severity, the major diseases of infected sugarbeet and beetroot plants are; Sclerotium root rot, Fusarium yellows, and cercospora leaf spot, Alternaria leaf spot and leaf blight.

CHAPTER 5

SUMMARY AND CONCLUSION

Sugar beet (*Beta vulgaris* L.) belongs to the family of the Chenopodiaceae which is also consider as the second source of sugar in all over the world. It is a temperate crop whose root contains high concentration of sucrose and is successfully grown on a commercial scale for sugar production. In addition to sugar production, it can also be used as a vegetable. In Bangladesh, about 25% sugar demand meeting domestically from sugarcane and rest 75% sugar demand is fulfilled by importation.

Beetroot (*Beta vulgaris* L.) belongs to the Chenopodiaceae family. Beetroot is one of the natural food which boosts the energy as it has one of the highest nitrates and sugar contents plant.

But production of sugarbeet and beetroot is low due to various diseases. Proper management practices should be developed to control diseases of beet crops. The experiments were conducted to investigation and measurement of field diseases of selected tropical sugarbeet and beetroot.

In this study, experiments were conducted in the Central Farm of Sher-e-Bangla Agricultural University, Dhaka-1207, during December 2020 to April 2021. Sugarbeet (KWS Allanya, KWS Gregoria, KWS Serenada) and beetroot (Beet King, Red Ball, Rokto) variety was assessed against the disease. Field experiment was followed by Randomized Complete Block Design (RCBD) with three replications.

Investigation was carried out to detection and identification of field diseases of sugar beet, and to measure the amount of diseases (disease incidence and severity) of sugar beet and beetroot in Bangladesh. Yield and yield contributing characters of sugarbeet and beetroot plant was also the part of this study.

During this experiment three diseases were found from sugarbeet variety in field condition. The diseases were Sclerotium root rot caused by *Sclerotium roilfsii,* and the second one was Fusarium yellows caused by *Fusarium oxysporum* and the last one was Cercospora leaf spot caused by *Cercospora beticola*, and from beetroot two diseases were found in natural field condition. The diseases were Alternaria leaf spot caused by *Alternaria alternata.;* Leaf blight caused by *Fusarium oxysporum.*

In case of sugarbeet, at 100 DAS, the last disease incidence of Sclerotium root rot was recorded highest in (KWS Serenada) (32.37%) and lowest disease incidence was recorded in (KWS Allanya) (22.07%). From fusarium yellow disease, at 105 DAS, the last disease incidence of Fusarium yellows was recorded highest in sugarbeet variety (KWS Gregoria) (25.73%) and lowest disease incidence was recorded in beetroot variety (KWS Allanya) (17.73%). At 105 DAS, the last disease severity of Fusarium yellows was recorded highest in sugarbeet variety (KWS Gregoria) (17.78%) which was statistically different from other variety. And lowest disease severity was recorded in sugarbet variety (KWS Allanya) (12.62%). From cercospora leaf spot disease, at 105 DAS, the last disease incidence of cercospora leaf spot was recorded highest in (KWS Allanya) (29.43%) which was statistically similar to other variety. The lowest disease incidence was recorded in sugarbeet variety (KWS Serenada) (24.03%). At 105 DAS, the last disease severity of cercospora leaf spot was recorded highest in (KWS Allanya) (23.30%) which was statistically different from other variety. And lowest disease severity was recorded in (KWS Gregoria) (15.57%). In case of plant height, the highest (61.87 cm) plant height was recorded from sugarbeet variety (KWS Serenada) which was the highest from all of the three varieties and was statistically different from other variety. In case of leaf number, the highest (19.60) leaf number was recorded in sugarbeet variety (KWS Gregoria). At 160 DAS, the highest sugarbeet weight was found from variety KWS Gregoria which was 1.73 kg and the lowest weight was found from variety KWS Allanya 1.50kg.

From beetroot disease of Alternaria leaf spot, at 95 DAS, the final disease incidence was counted where the highest disease incidence was recorded in beetroot variety (Red Ball) (30.23%) which was statistically similar to other variety. And the lowest disease incidence was recorded from beetroot variety (Rokto) (21.10%). At 95 DAS, the last disease severity of Alternaria leaf spot was recorded highest in beetroot variety (Red Ball) (18.03%) which was statistically similar from other variety. And lowest disease severity was recorded in beetroot variety (Beet king) (11.70%). From leaf blight disease, at 100 DAS, the last disease incidence of leaf blight was recorded highest in beetroot variety (Beet King) (21.57%) which was statistically similar to beetroot variety (Red Ball) (24.70%) and lowest disease incidence was recorded in beetroot variety (Rokto) (21.57%). At 100 DAS, the last disease severity of leaf blight was recorded highest in variety of beetroot (Beet King) (19.50%) which was statistically different from other variety and lowest disease severity was recorded in beetroot variety (Rokto) (7.87%). In case of plant height, at 95 DAS, the highest (31.93) plant height was recorded from beetroot variety (Rokto) which was statistically different from other variety. And the lowest plant height was observed from beetroot variety (Beet King) which was (28.95). At 160 DAS, the highest beetroot weight was found from variety Red Ball which was 0.67 kg and the lowest weight was found from variety Beet King 0.57 kg.

From the study, it may be concluded that among all the varieties, sclerotium root rot shows the highest disease incidence from other identified diseases (Fusarium yellows Cercospora leaf spot, Alternaria leaf spot, Leaf blight). However, further investigations may be carried out to clarify and justify the results. It is required to check out the findings of this investigation in different places of our country as well as in Dhaka. In this study the causal organism was only identified up to genus but it is not enough mare morphological and cultural study is not enough to identify a pathogen accurately. To identify the pathogen species properly pathogenicity test, like Kotch's postulates and molecular level examination should be conducted. Moreover, it may be a great source of employment and a good product for exportation. More Research should be going on to develop the management practices of this sugar containing plants. Proper management and cultural practices may increase the production rate and help to reduce the threat of extinct.

CHAPTER 6

REFERENCES

Abbasi, Z., M. Golabadi, S. Khayamim, and M. Pessarakli. (2018). The response of drought-tolerant sugar beet to salinity stress under field and controlled environmental conditions. *Journal of Plant Nutrition* **41**(20): 2660–2672.

Agrios, G. N. (2005). Plant Pathology, 5th Edition, Elsevier Academic Press, Burlington, Mass. pp. 952.

Alam, M.J., Rahman, M.S., Islam, A.K.M.R., Sohel, A.T. and Roy, H.M. (2017). Tropical Sugarbeet Production Technology in Bangladesh. 3rd edition, Bangladesh Sugarcrop Research Institute, Ishurdi, Pabna, Bangladesh.

Anonymous. (2004). Sugarbeet cultivation in Bangladesh. Syngenta Bangladesh Ltd. p. 4.

Armstrong, G.M. and J.K. Armstrong. (1976). Common hosts for *Fusarium oxysporum* formae speciales spinaciae and *betae*. *Phytopatholog*y. **66**:542-545.

Atamanova A, Brezhneva T.A. Slivkin A.I. Nikolaevskii V.A. Selemenev V.F. Mironenko N.V. (2005) Isolation of saponins from table beetroot and primary evaluation of their pharmacological activity. Pharma. Chem. J. **39**(12):650-652.

Backman, P.A. and Rodriguez Kabana, R. (1972). Development of selective medium for isolation of *Sclerotium rolfsii*. *Phytopathology*. **62**: 744-745.

Bakr, M. A., and Zahid, M. I. (1986). Stemphylium blight: a new foliar disease of lentil in Bangladesh. *Bangladesh Journal of Plant Pathology*. **2** (1): 69-70.

BSRI. (2005). Sugar beet cultivation in Bangladesh. 5th edition, Bangladesh Sugarcrop Research Institute, Ishurdi, Pabna, Bangladesh.

Burlakoti, P. (2007). Fusarium species associated with sugar beet grown in the Red River Valley: pathogenicity, cultivar response, and baseline sensitivity to fungicides. M.S.Thesis,. North Dakota State Univ. Fargo, ND, USA.

Burlakoti, P., Rivera, V., Secor, G. A., Qi, A., Rio-Mendoza, L. D., and Khan, M. F. (2012). Comparative pathogenicity and virulence of Fusarium species on sugar beet. *Plant Dis*. **96**: 1291-1296.

Byford, W.J. (1996). A survey of foliar diseases of sugar beet and their control in Europe. In Proceedings of the 59th IIRB conference, 10.

Diffus, J.D. and Ruppel, E.G. (1993). Diseases of Sugarbeet. In: The sugarbeet crop: Science into Practice. D.A. Cooke and R.K. Scott, (ed.). Chapman and Hall, London, UK. p. 675.

Draycott, A.P. (2006). Introduction. In A.P. Draycott (Eds.), Sugar beet. pp. 1-8. Blackwell, Oxford, UK.

Franc, G.D., R.M. Harveson, E.D. Kerr, and B.J. Jacobsen. (2001). Disease Management. In Sugarbeet Production Guide. R.G Wilson, (ed.). University of Nebraska. Lincoln,NE. pp. 131-160

Giannopolitis, C.N. 1978. Lesions on sugar beet roots caused by *Cercospora beticola*. *Plant Disease Reporter* **62**: 424–427.

Groenewald, M., J.Z. Groenewald, and P.W. Crous. (2005). Distinct species exist within the *Cercospora apii* morphotype. *Phytopathology* **95**: 951–959.

Hanson LE, Hill AL, (2004). Fusarium species causing Fusarium yellows of sugar beet. *Journal of Sugar Beet Research* **41**, 163–78.

Hanson LE, Hill AL, Jacobsen BJ, Panella L, (2009). Response of sugarbeet lines to isolates of *Fusarium oxysporum* f. sp. *betae* from the United States. *Journal of Sugar Beet Research* **44***,* 11–26.

Hanson, L. E. and Jacobsen, B. J. (2009). Fusarium Yellows. In R. M. Harveson, L. E. Hanson, and G. L. Hein (Eds.). Compendium of beet diseases and pests. pp. 28-29. *American Phytopathological Society*, St. Paul, MN, USA.

Hill G, Langer RHM. Agricultural plants. Cambridge, UK: Cambridge University Press, 1991, 197-199. ISBN 0-521-40563-7.

Holtschulte, B. (2000). *Cercospora beticola* worldwide distribution and incidence. In *Advances in sugar beet research Vol. 2: Cercospora beticola Sacc. biology,agronomic influence and control measures in sugar beet*, ed. M.J.C. Asher, B. Holtschulte, M. Richard Molard, F. Rosso, G. Steinruecken, and R. Beckers, 5–16. Brussels: International Institute for Beet Research.

Hopf Maria; Zohary Daniel. Domestication of plants in the old world: the origin and spread of cultivated plants in West Asia, Europe, and the Nile Valley. Oxford Oxfordshire: Oxford University Press. 2000, 200. ISBN 0-19-850356-3.

Khan, M. F., Bradley, C. A., and Windels, C. E. (2009). Fusarium yellows of sugar beet. PP-1247. North Dakota State University. Ext. Serv., Fargo, ND, USA.

Khan, N.S. and Minhas, S. (2006). Selection and development of sugarbeet varieties for tonnage, pol% and sugar yield. *Pak. Sugar J.* **21**(4): 10-13.

Kumar, R. and Pathak, A.D. (2013). Recent trend of sugarbeet in world. Souvenir- IISR- Industry Interface on Research and Development Initiatives for Sugarbeet in India. May. 28-29, Sugarbeet Breeding Outpost of IISR IVRI Campus, Mukteswar, Nainital, India, pp. 46-48

Maiti, D., Das, S., Mandal, B. and Chakraborty, P.B. (2000). Influence of irrigation on growth and disease incidence of sugarbeet (*Beta vulgaris* L.). *Indian Agriculturist.* **44**: 63-69.

Martyn RD, Rush CM, Biles CL, Baker EH, (1989). Etiology of a root rot disease of sugarbeet in Texas. *Plant Disease* **73**, 879– 84.

Mathangi S, Balasaraswathi M. (2019). Formulation of horsegram cake enriched with beetroot powder: *International Journal of Applied Home Science*. **6**(1):61-65.

Mukhopadhyay, A.N. (1987). Hand book on diseases of sugarbeet. Volume I and II. CRC Press, Boca Raton, Florida, U.S.A.

Nelson. P.E., T.A. Toussoun, and W.F.O. Marasas. (1983). *Fusarium species*: An illustrated Manual for Identification. The Pennsylvania State University Press. University Park, PA. 193 pp.

Paul, N.C., E.J. Hwang, S.S. Nam, *et al*. (2017). Phylogenetic placement and morphological characterization of *Sclerotium rolfsii* (Teleomorph: *Athelia rolfsii*) associated with blight disease of *Ipomoea batatas* in Korea. *Mycobiology* **45**(3): 129–138.

Pool, V.W., and M.B. McKay. (1916). Climatic conditions as related to *Cercospora beticola*. *Journal Agricultural Research* **6**: 21–60.

Punja, Z.K., Smith, V.L., Campbell, C., Lee and Jenkins, S.F. (1985). Procedure to estimate numbers, spatial pattern and temporal distribution of sclerotia of *Sclerotium rolfsii* in soil. *Plant Disease*. **69**: 467-473

Rahman, M.S., S. Khatun, and M.K. Rahman. (2016). Sugarcane and sugar industry in Bangladesh: An Overview. Sugar Tech **18**: 627–635.

Rashid, M.M. (1999). SabjiBiggan (in Bengali). Rashid Publishing House, 94 Old DOHS, Dhaka. p. 455.

Rivera, V., Rengifo, J., Khan, M., Geiser, D. M., Mansfield, M., and Secor, G. (2008). First report of a novel Fusarium species causing yellowing decline of sugar beet in Minnesota. *Plant Dis*. **92**: 1589-1589.

Rossi, V., P. Racca, and S. Giosue. (1995). Geophytopathological analysis of Cercospora leaf spot on sugar beet in the Mediterranean area. *Phytopathologia Mediterranea* **34**: 69–82.

Rossi, V., P. Meriggi, E. Biancardi, and F. Rosso. (2000). Effect of Cercospora leaf spot on sugar beet growth, yield and quality. In *Advances in sugar beet research Vol. 2: Cercospora beticola Sacc. biology, agronomic influence and control measures in sugar beet*, ed. M.J.C. Asher, B. Holtschulte, M. Richard Molard, F. Rosso, G. Steinruecken, and R. Beckers, 49–76. Brussels: International Institute for Beet Research.

Ruppel, E.G. (1991). Pathogenicity of Fusarium spp. from diseased sugar beets and variation among sugar beet isolates of *F. oxysporum. Plant Disease*. **75**:486-489

Schneider, C.L. and E.D. Whitney. (1986). Fusarium Yellows, in Compendium of Beet Diseases and Insects,El). Whitney and J.E. Duffus, (ed.) APS Press. St. Paul, Minn.Pg. 18.

Srivastava, S.N. (2000). Management of Sugarbeet Diseases in India. In: Advances in Plant Disease Management. Udit Narain, Kumud Kumar and Mukesh Srivastava, (ed.). Advance Publishing Concept, New Delhi, India. pp. 123-148.

Shane, W.W., and P.S. Teng. (1992). Impact of Cercospora leaf spot on root weight, sugar yield, and purity of *Beta vulgaris. Plant Disease* **76**: 812–820

Smith, G.A., and E.G. Ruppel. (1971). Cercospora leaf spot as a predisposing factor in storage rot of sugar-beet roots. *Phytopathology* **61**: 1485–1490.

Stewart, D. (1931). Sugar-beet yellows caused by *Fusarium conglutinans* var. betae. *Phytopathology*. **21**:59-70.

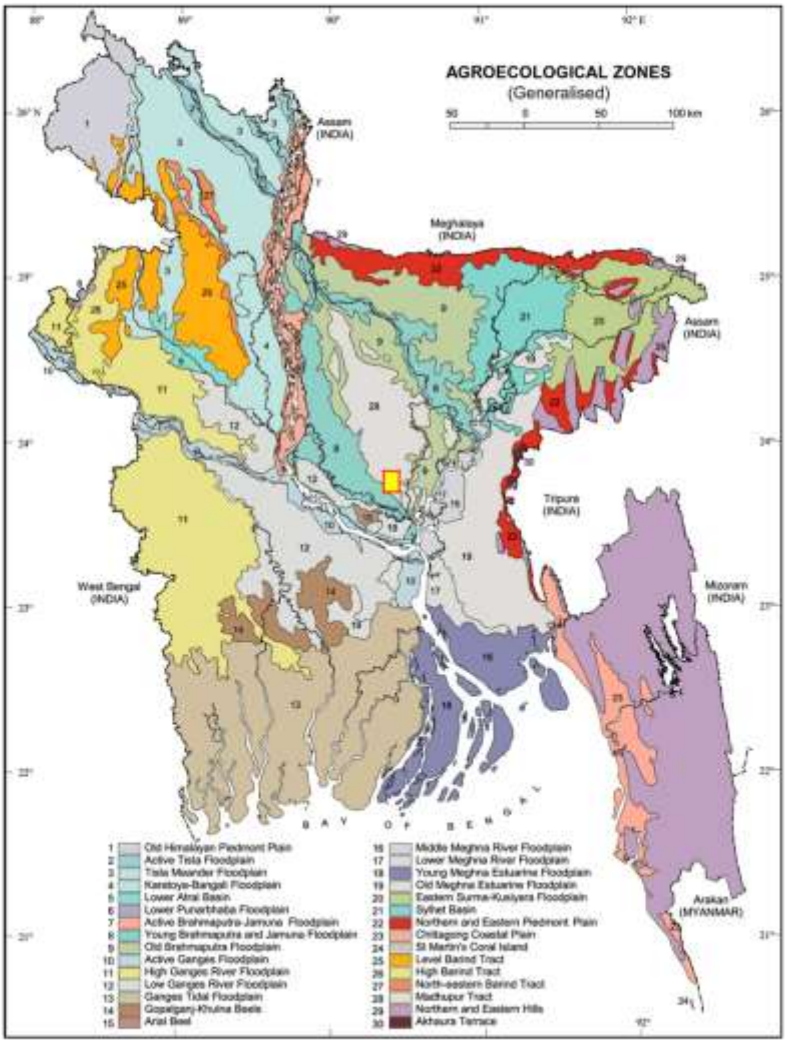
Strack D, Vogt T, Schliemann W. "Recent advances in betalain research". (2003). *Phytochemistry*. **62**(3):247-269.

Yadav A, Gretter S, Hambrusch S, Sands P. (2016) Expanding computer science education in schools: understanding teacher experiences and challenges. *Computer Science Education*. **26**(4):235-254

CHAPTER 7

APPENDICES

Appendix I. Agro-Ecological Zone of Bangladesh showing the experimental location.



Agro-Ecological zone of experimental location.

Appendix II. Characteristics of experimental soil analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Central Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Not Applicable

Source: Soil Resource Development Institute (SRDI)

Appendix. III

	Sugarbeet					
	T_2R_1		T_3R_2		T_1R_3	
	T_1R_1		T_2R_2		T_3R_3	
	T_3R_1	1m	T_1R_2		T_2R_3	
	Beetroot					
	T_5R_1	1m	T_6R_2		T_4R_3	
	T_4R_1		T_5R_2		T_6R_3	
0.5m	T_6R_1		T_4R_2		T_5R_3	

Layout of the design

Appendix IV. Monthly records of air temperature, relative humidity and rainfall during the period from December 2020 to April 2021

Month	RH %	Air Temperature (˚C) (Mean)	Rainfall (mm)
December, 2020	72	19.2	5.0
January, 2021	75	18.9	22.0
February, 2021	57	23.1	1.0
March, 2021	55	28.3	32.0
April, 2021	50	33.1	27.9

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1207.

Appendix V. Experimental signboard in the field.