FIELD INVESTIGATION AND SURVEY ON DISEASES OF GERBERA (*Gerbera jamesonii* L.) IN JASHORE DISTRICT OF BANGLADESH

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CERTIFICATE

This is to certify that thesis entitled, "**Field Investigation and Survey on Diseases of Gerbera (*Gerbera jamesonii* L.) in Jashore District of Bangladesh**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **PLANT PATHOLOGY**, embodies the result of a piece of bona fide research work carried out by **UMMA RUMAN BRISHTY, Registration No. 17-08191** 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: June, 2018

Dhaka, Bangladesh

Abu Noman Faruq Ahmmed
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Dedicated

to My

Beloved Parents

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Date: June, 2018 ***The author***

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ABSTRACT

Two experiments were conducted for detection and identification of field diseases of Gerbera plants and flowers during February, 2019 to May, 2019 in Jashore and Dhaka, Bangladesh. Eighteen villages from 4 Unions of Jhikorgacha Upazila of Jashore district were considered for field survey, viz. Godkhali, Patuapara, Sadirali, Belemath, Dhalipara, Panisara, Syedpara, Nilkonthonogor, Kuliya, Krishnachandrapur, Hariya, Nimtola, Baisha, Sharifpur, Chadpur, Mathuapara, Nirbashkhola and Shiorda. The disease incidence and severity were recorded under natural epiphytic conditions. In Total, eleven diseases were identified in the field. These were Alternaria leaf spot caused by *Alternaria alternata*, Botrytis leaf blight caused by *Botrytis cinerea*, Fusarium stem rot caused by *Fusarium oxysporum* f. sp. *chrysanthemi*, Crown rot caused by *Rhizoctonia solani*, Foot and root rot caused by unknown pathogen, Leaf curl by unidentified virus, Flower curl caused by unidentified virus, Flower abnormality- a physiological disorder caused by nutrient deficiency, Flower blight caused by *Botrytis cinerea* and Petal spot caused by *Alternaria alternata* and *Bipolaris* sp. simultaneously. However, the Leaf blight disease caused by *Botrytis cinerea* was the most common disease in Jashore. The incidence and severity of the identified diseases varied significantly among these locations. The disease incidence and severity were varied 0-56% and 0-26%, respectively. In most cases, the farmers reported that the disease incidence and severity were higher in rainy season followed by summer and winter. Depending on the disease incidence and severity, the major diseases of inspected Gerbera plants were Leaf spot, Leaf blight, Flower blight and Flower abnormality. In case of Leaf blight, the highest incidence (50%) was in Patuapara and the lowest (8.33%) was in Chadpur village. However, the highest severity (16%) was observed at Sadirali and lowest was (0.83%) at Mathuapara. In Leaf spot disease, the highest incidence (43.33%) was observed at Kuliya and the lowest was recorded (8.33%) at Belemath. The severity was highest (11.66%) at Godkhali and Nilkonthonogor and lowest (1.33%) at Sharifpur and Mathuapara. Apart from this, a survey was carried out on the socio-economic status of Gerbera growers, production technology and the opinions of the farmers about field diseases to have a more clear view about Gerbera production in Jashore, Bangladesh. Most of the farmers were male and their age was between 30 to 40 years. Very few of them were highly educated and most of them are engaged in Gerbera cultivation from more than 5 years.

CHAPTER I

INTRODUCTION

Export earning is one of the most important driving forces for developing economies, of which Bangladesh is not an exception. The floral industry is one of the major industries in many developing and underdeveloped countries like Bangladesh. Bangladesh exports many products to different countries of the world. Cut flower is one of the promising export products and it would be a growing export product in near future among them. Export of cut flower is increasing every year. Over the past couple of years, the export of cut flowers and foliage has exceeded target by over 10% as long as it had turned out to be an emerging industry of high potentials for the entrepreneurs that would widen the country's export basket.

In Bangladesh, floriculture brought into a limelight by some innovative farmers in late seventies with Tuberose on a small-scale basis. Sher Ali pioneered commercial flower cultivation at Godkhali, Jashore in 1983. He demonstrated that cut flowers give three to four times' higher return than any other cash crop. Since then many farmers started to grow flowers in 4-5 villages of Godkhali Union. Large-scale commercial production started from mid eighties in Jhikargacha upazila of Jashore district (Sultana, 2003). Later it speeded largely in whole Jashore, Savar, Chuandanga, Mymensingh and Gazipur district which turned to be the major flower production belt in Bangladesh. Cultivation of flower is reported to give 3-5 times and 1.5-2 times more returns than obtained from rice and vegetable cultivation, respectively (Dadlani, 2003). At present, 10,000 hectares of land is covered by flower cultivation taking the lead by Jashore district. More than 5,000 resilient farmers are growing flower and foliage in the country and about 150,000 people are directly or indirectly involved in floriculture business as their livelihood (Chowdhury, 2010). Approximately 2000 to 3000 farmers are involved in ornamental plants on commercial basis. Women workers dominate the sector - mainly in flower collection, sorting and packaging. Commercial nurseries have covered approximately 2,000 to 2,500 hectares of land in our country (Momin, 2006).

Major traders of flowers can be found in Shahbag, Farmgate and Gulshan in Dhaka. Substantial trade can also be found in Chittagong and other big cities. There are reported that around 4000 retail shops of flowers in the whole country. 40 percent of the retail shops are located in Dhaka, while Chittagong and Sylhet having 25 percent each and the remaining 10 percent of the shops are in other district towns. At a wholesale flower market (in Dhaka), 700 traders do flower business worth at least $16,000 every day. Every year Bangladesh exports a large amount of flower by different intermediaries in the world market, which include mainly cut flowers and ornamental foliages. Nowadays new farmers are also getting involved in flower production. Because one bigha (30 decimals) of land can give at least BDT 40-45 thousand per year with three crops. And one bigha of Gerbera garden can give BDT 15 lac per year - and a Gerbera garden may live for 3-4 years. Therefore cultivating flowers is economically profitable for the farmers.

Gerbera (*Gerbera jamesonii* L.) is a genus of the family of Sunflowers, Daisies and Asters-Asteraceae, Order-Asterales, Class-Magnoliopsida, division-Magnoliophyta under the super-division Spermatophyta and Sub-kingdom Tracheobionta. It is a significant cut flower grown all over the world in a variety of weather circumstances and is famously known as 'Barberton daisy' or 'Transvaal daisy'. It was named in honor of the German botanist and naturalist Traugott Gerber (1743). The first scientific description of Gerbera was made by J. D. Hooker in Curtis's Botanical Magazine in 1889, where he described *Gerbera jamesonii* as a South African species. Genus *Gerbera* comprises of 30 varieties, which are of Asiatic and Southern African-American source. Among the different varieties, *Gerbera jamesonii* is the only variety under farming. Modern Gerbera occurred from *Gerbera jamesonii* hybridized with *Gerbera viridifolia* and possibly other varieties (Leffring, 1973).

Gerbera is very popular and widely used as a decorative garden plant or as cut flowers. Thousands of cultivars of it exist. They vary greatly in shape and size. Gerbera has a wide range of attractive flower colors which makes it a more valuable ornamental species. Colors include white, yellow, orange, red, and pink. Daisies are often used in floral arrangements. The meanings of Gerbera flowers include innocence and purity. The long-lasting simple structure and cheerful look make it easy to combine with other desirable flowers in arrangements. Gerbera is widely and commercially produced by the floral industry both as cut flower and potted plant. The flowers are hardy and can withstand

vigorous transportation. It stands among the top ten cut flowers of the world (Sujatha *et al*., 2002). It has a massive requirement in the flower industry as well as pot plants due to its beauty and long container life which rated it fifth among the top ten cut flowers in the entire globe (Parthasarathy *et al*., 1999). It has high market value in the western countries, Malaysia, Philippines, and India. It also has become a well-known decorative flower in Bangladesh and is ever-increasing flower particularly in towns. In Bangladesh Gerbera was first introduced in Godkhali of Jhikorgacha. It is commercially grown in Rajshahi and Jashore. Now the plants are cultivated throughout the country as garden plant.

Gerbera is very fashionable and widely used as a decorative garden flower or cut flowers (Kanwar *et al.*, 2008). It is an evergreen and herbaceous blooming plant. Plants are soft herbs with a height up to 18 to 24 inches and 4 to 10 inches in size of flowers. On an average, the annual production is 20-35 flower stick per plant and it directly related to the cultivar (Zhang *et al*., 2008). Gerberas can be propagated by both sexual and asexual methods. Most of the commercially grown cultivars are propagated through vegetative means, to maintain homogeneity and genetic pureness (Peper *et al*., 1971). Among the vegetative methods, multiplication through division of clumps has been used for several decades. These methods are however, too slow to be used commercially. Large-scale commercial production of Gerbera requires an easier, quicker, and economically viable method of propagation. Micro-propagation method has been successful for rapid, large-scale multiplication of Gerberas (Aswath *et al*., 2002).

Tissue culture allows the production of disease-free plants which are free from seasonal variations and can produce over one million plants per year of an elite variety. A tissue culture procedure has been proven to be commercially practical in Gerbera propagation. This method enables a million fold expansions per year of a desired plant (Aswath *et al*., 2002). Micro-propagation of Gerbera is being used in many countries from a range of different explants. Direct shoot regeneration using shoot tips as initial ex-plant is most convenient method for mass propagation of Gerbera. However, indirect shoot regeneration has been achieved from calli derived from different explants such as leaf, petals, and floral buds. Adventitious shoot regeneration from flower buds/ capitula is another favored method, followed by many researchers. Though Bangladesh has a great weather condition for Gerbera production of international standard, the supply of Gerbera plantlets is not adequate to meet up with the local requirement. Seed reproduction is not

always sufficient since impurity results significant amounts of difference. Also, this method is too slow for commercial purpose. Gerbera is mainly supplied to all over Bangladesh from the commercial perspective growing plant centers at Godkhali in Jashore.

Due to the varied agro-climatic conditions and relatively low cost of production, Bangladesh has tremendous opportunities not only to fulfill nearby requirements of both traditional and cut flowers but also a great risk of the trade sector. But the production of Gerbera is being hampered by different difficulties. Among them the unavailability of seed materials, shortage of storage, lack of company, technical know-how, consistent methods of accelerating and growing of decorative flowers of worldwide acceptable great quality, problem of packaging and transportation has been a significant obstacle in recognizing this goal. Moreover, Gerbera plants are prone to attack by various diseases, insects and lack of nutrients cause physiological disorders which hamper the lucrative flower production. Among the physiological disorders Flower bent, Pre-harvest stem break, Premature wilting of Gerbera flower, Double-faced Gerbera flower, non-uniform flower blooming, short stem length etc. are very common. Among the diseases the fungal diseases are usually leaf spot, leaf blight. Botrytis blight, powdery mildew, Fusarium stem rot, Rhizoctonia crown rot, Sclerotium rot, Thielaviopsis root rot, white rot and rust. The other common diseases are drying foot and root rot, leaf curl, mosaic, anthracnose, powdery mildew, wilt etc. which are generally caused by different bacteria, nematodes and other microorganisms. Generally the intensity of diseases is high at early growth stage and flowering stage (Mou, 2006).

Alternaria leaf blight is one of the most important diseases of Gerbera worldwide. The disease was prevalent in all the flower growing areas of Kashmir valley surveyed in 2009. The overall mean disease incidence and intensity ranged from 50.7 to 67.5% and 19.2 to 28.2%, respectively. The highest disease incidence (60.72%) irrespective of phonological stages and intensity 24.96% was recorded in district Srinagar. The lowest level of disease was in district Anantnag (20.0%). The pathogen associated with the disease was identified as *Alternaria alternata*. In early stages of disease development, spots were circular and brown with somewhat irregular margins; the lesion later turned into dark brown. Maximum disease development in the field was observed during June when spots attained a maximum size of 23 to 26 mm. (Bhat *et al*., 2013).

Potentially the disease Phytophthora rot can occur in any period of the year, nevertheless, it spreads much more quickly when there are high levels of humidity in the greenhouses and in the growing media the temperatures are in the range of 22-25 °C. The fungus prefers cool environments; with values higher than 25 °C it gradually becomes harmless (Flower Web, 2019).

In 2008, bacterial leaf spot of *Gerbera*, caused by the bacterium *Pseudomonas cichorii*, was recorded for the first time on *Gerbera.* The disease tends to be a problem not only during warm weather with periods of heavy rain, but also at the place where overhead watering is practiced. Symptoms of this disease are large black spots concentrated at the base of the plant. The spots often begin at the leaf margin but may also occur randomly. The spots are soft when tissue is wet and sunken and brittle when leaves are dry. From the leaf, the bacterium can move through the petiole and into the stem, resulting into a canker. The sepals of infected flower buds will become brown to black and up to several inches of pedicel may be killed. Key management practices include planting pathogen-free seed and cultivars or resistant varieties; good sanitation; and avoiding overhead irrigation or handling plants when they are wet. Once plants become infected with bacteria, it is best to rogue infected plants. The *P. cichorii* bacterium has been recorded as the cause of bacterial leaf spot of *Gerbera* overseas by Miller in1974 also and of a range of other hosts including, hibiscus, cyclamen, vinca, chrysanthemum, impatiens, lettuce and chicory (Iller, 1974).

Botrytis Blight disease can also cause damping-off, spotting and blighting of leaves and flowers and crown rot. Leaves develop lesions, and flower petals show tan spots and tip necrosis or are entirely blighted. *B. cinerea* may be seed borne in African daisy (Plant Health Progress, 2000).

In 2006, Gerbera plants, in two greenhouse farms in the region of Guarapuava, Paraná, Brazil, exhibited symptoms of a wilt disease. Affected plants were stunted and developed yellow leaves unilaterally with initially brown and eventually black streaks in the vascular system. The first symptoms occurred 2 months after transplanting during the hottest period of the summer with an average temperature of 27 °C. Vascular streaks in the yellow leaves were continuous with a brown discoloration in the vascular system of the crown and upper taproot. Occasionally, the leaves of affected plants turned red. The

pathogenicity test revealed that Gerbera wilt caused by *F. oxysporum* f. sp. *chrysanthemi* was recently reported in Italy and Spain. Gerbera plants grown in the soil and in soilless culture in Italy were observed exhibiting symptoms of wilt. In 2002, the causal agent was identified as *Fusarium oxysporum*. Pathogenicity tests on Gerbera confirmed the identity of the pathogen (Minuto *et al*., 2007).

A sampling survey conducted in Thrissur district of Kerala on the occurrence of root rot disease in Gerbera revealed that the disease was confined only to protected conditions. The disease was observed in a hydroponic unit which was more pronounced in July-August with a percent disease intensity of 69.44. Symptoms like stem or collar rot resulted in fatal infection with complete death of the plant. Pathogenicity of the isolate was carried out by soil inoculation and Microdroplet inoculation technique (MDIT). Cultural, morphological and molecular characterization along with the description of symptom of root rot disease confirmed the identity of the pathogen as *Phytophthora cryptogea* (*Parveen et al*., 2017).

Powdery mildews are one of the most common diseases of ornamental plants like Gerbera. Many nursery, flower, and woody plants are susceptible. The disease is easily recognizable as a white to gray powdery growth on leaves and sometimes stems and flowers. There may be grayish white, powdery spots develop on leaves. These may be scattered at first but can quickly cover entire leaves giving them a frosty appearance. All aboveground plant parts can become infected including the flower stalk and petals. Discolored patches may appear on petals but may not look white and powdery, thus being confused with *Botrytis* or spray injury. Occasionally, a colony may develop on the underside of a leaf with a small, subtle yellow blotch on the opposite side of the leaf. Heavily infected plants lack vigor and may be reduced in size (Moyer and Peres, 2008).

In a survey of Gerbera grown in floriculture fields at the Institute of Himalayan Bio-resource Technology (IHBT), Palampur and nearby nurseries, color break symptoms on the petals, asymmetrical ray florets, and deformed flowers were observed during 2003-2004. The virus evoked chlorotic local lesions on *Chenopodium album*, *C. amaranticolor*, and *C. quinoa*, while systemic mosaic was observed on *Cucumis sativus*, *Nicotiana benthamiana*, *N. clevelandii*, *N. glutinosa*, and *N. tabacum* cv. *samsun*. The virus was transmitted non-persistently by *Myzus persicae* and *Aphis gossypii* and was identified

as Cucumber Mosaic Virus (CMV) from symptomatic Gerbera leaves. Total RNA was isolated from the infected Gerbera plants and was used to detect the virus with reverse transcription-polymerase chain reaction. To our knowledge, this is the first report of CMV on Gerbera in India (Blas *et al*., 1994).

Greenhouse-grown Gerbera and Chrysanthemum have been observed displaying symptoms resembling those associated with Tomato Spotted Wilt Viruses. Symptomatic plants showed concentric rings, irregular chlorotic blotches, and deformation on leaves. To our knowledge, this is the first confirmed report of TSWV infecting Gerbera and Chrysanthemum in Venezuela (Mumford *et al.*, 1996).

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

1. Detection and identification of diseases of Gerbera in Jhikorgacha, Jashore;
2. Measurement of incidence and severity of diseases of Gerbera in Jhikorgacha, Jashore; and
3. Survey on problems and status of Gerbera cultivation in Jhikorgacha, Jashore.

CHAPTER II

REVIEW OF LITERATURE

Gerbera is one of the most important flowers among all flowers cultivated in Bangladesh. Many diseases attack this flower. Some are major some are minor. Very few research works directly has been carried out in this area in Bangladesh. There is also a very limited significant research works on diseases of Gerbera plant in the South Asia. However, some research works are found regarding diseases of few varieties of Gerbera plants in the world. The literatures on incidence, severity, disease lists, occurrence and isolation of pathogens are accumulated in this section. This chapter is to review the previous studies that are related to the present study. The review of some related studies are described below:

2.1. About Gerbera (*Gerbera jamesonii* L.)

Shafiullah *et al.* (2017) revealed that Gerbera is an evergreen and herbaceous blooming plant producing different colors of flower. It is under Asteraceae family. The genus Gerbera comprises of approximately forty varieties. It has become a well-known decorative flower in Bangladesh and needs for this flower is ever-increasing particularly in towns. Though Bangladesh has a great weather condition for Gerbera of international standard, the supply of Gerbera plantlets is not adequate to meet up with the local requirement. Gerbera is mainly supplied to all over Bangladesh from of the from the commercial perspective growing plant centers at Godkhali in Jashore. Deficiency of mother stock and their high cost, cost of fertilizer and pesticides, absence of scientific knowledge & training, attack by pest & disease, absence of extension work came out as significant financial and technical issues of the plant farm owners while insufficient & undeveloped transportation & communication program, low rate, absence of industry details, unstructured industry are among significant industry related issues. On the other hand promotion intermediaries specified cost uncertainty, the absence of adequate industry details, lacking storage space facilities, unsold plant, insufficient shop-space, demand variation, strikes as their issues and constraints.

However, Kanwar *et al.* (2008) reported that Gerbera is very fashionable and widely used as a decorative garden flower or cut flowers.

Kanwar and Kumar (2008) stated that Gerbera is a perennial herb which is native to tropical regions of South America, Africa and Asia belongs to *Asteraceae* family. Gerbera (*Gerbera jamesonii*) also known as Transvaal daisy is the most popular flower among florists with increasing commercial significance. It is cultivated throughout the world under a wide range of climatic conditions, especially in temperate and mountainous regions.

According to Zhang *et al.* (2008) and Singh and Mandhar (2004) on an average, the annual flower production is 20-35 flower stick per plant and is directly related to the cultivar.

Aswath and Rao (2006) observed that it is the most popular cut flower with increasing commercial significance. It fetches an excellent price in the international market and contributes greatly to the export earnings of the country because of its graceful appearance, hardiness and long shelf life.

Anonymous (2006) reported that average yield of the standard Gerbera is approximately 250 to 270 flowers per sqm/year when planting distance is 6 plants/sqm.

Another study of Anonymous (2006) revealed that Gerbera is one of the top cut flowers in Europe. A major portion of it is produced in various countries, including India.

Broek *et al.* (2004) stated that the production of Gerbera was approximately US$ 220 million in 2001, representing 70 million stems sold in the US alone.

Sujatha *et al.* (2002) revealed that due to its beautiful colors, hardy, long-keeping quality and ability to rehydrate after long transportation, Gerbera ranks fourth among the top ten cut flowers of the world.

A study of Aswath *et al.* (2002) mentioned that a tissue culture procedure has been proven to be commercially practical in Gerbera propagation. This method enables a million fold expansions per year of a desired plant.

According to Anuradha *et al.* (2001) it is used in the floral industry as a cut flower and as a potted plant.

Parthasarathy *et al.* (1999) stated that Gerbera has a massive requirement in the flower industry as well as pot plants due to its beauty and long container life which rated it fifth among the top ten cut flowers in the entire globe.

However, Das and Singh (1989) reported that Gerbera is distributed in temperate Himalayas from Kashmir to Nepal with an altitude ranging from 1300 to 3200 m above mean sea level.

Leffring (1973) revealed that among the different varieties, *Gerbera jamesonii* is the only variety under farming. Modern Gerbera occurred from *Gerbera jamesonii* hybridized with *Gerbera viridifolia* and possibly other varieties.

Peper *et al.* (1971) revealed that most of the commercially grown cultivars of Gerbera are propagated through vegetative means, to maintain homogeneity and genetic pureness.

In Bangladesh, Gerbera flower has huge demand as cut flower. In Bangladesh, Gerbera was presented recently and it is becoming more popular. It has a great risk of regional as well as trade industry. A variety of colors available has grown to include a big selection of light shades. Plant breeder has done a wonderful job of creating outstanding place shades, including violet, Gerbera, pink, white, and various bicolor and presented dual and semi-double blooming forms, adding to the beauty of this place. Cultivation of Gerbera has grown considerably recently in Bangladesh but very few research works related to development and production of Gerbera have been carried out in our nation. There is a wide range of variation available in this flower.

2.2. Diseases of Gerbera

According to Praveen *et al.* (2017) one of the important constraints that limit the production of quality flowers in Gerbera is the severe incidence of diseases. The crop is affected by various fungal, bacterial and viral diseases which reduce the plant vigor, flower quality and market value, thus causing significant losses to the commercial cut.

Gary (2016) reported some diseases of Gerbera which are Alternaria leaf spot and leaf blight (*Alternaria* spp.), bacterial leaf spot (*Psudomonus cichorii*), Botrytis blight (*botrytis cinerea*), powdery mildew (*Podosphaera* spp.), Fusarium stem rot (*Fusarium solani*), Phytophthora crown rot (*Phytophthora ctyptogea*), Rhizoctonia crown rot (*Rhizoctonia solani*), Pythium root rot (*Pythium* spp.), Thielaviopsis root rot (*Thielaviopsis basicola*), viruses (Tobacco rattle virus, Gerbera mosaic virus and Cucumber mosaic virus) etc.

2.2.1. Alternaria leaf spot and leaf blight of Gerbera

Bhat *et al.* (2013) conducted an experiment in Kashmir and reported that maximum leaf spot disease development in the field was observed during June when spots attained a maximum size of 23 to 26 mm.

However, Shokooh *et al.* (2012) stated that Alternaria leaf blight is an important disease of Gerbera (*Gerbera jamisonii*) world over. Leaf Spot caused by *Alternaria alternata* on Gerbera. The symptoms at the initial stage of the infection were brown, small, scattered spots on the leaves that gradually become round or irregular. Spots coalesce to affect large areas of leaves and cause defoliation. Affected plants showed lower vitality, suppressed development and fewer, smaller, distorted in shape flowers. The fungus produced effuse, olivaceous black colonies with dark olive-green margins, and abundant branched septate, golden brown mycelium. The conidiophores were branched, straight, pale brown to olive brown. The pale brown conidia of the isolates were catenated in long, sometimes branched chains of 5-12 spores. The size of conidia varied from 20-63 µm in length and 9-18 µm in width and usually ovoid to ellipsoid or obclavate with short conical beak at the tip. Conidia had two to three transverse septa and usually several longitudinal septa**.**

In a study, Nagrale *et al.* (2012) said that lesions coalesce, leading to leaf chlorosis and defoliation. During severe infections, “shot holes” may also be produced.

Farhood and Hadian (2012) revealed that affected Gerbera plants show reduced vitality and suppressed development and have fewer, smaller flowers that are distorted in shape.

Again, Mirkova and konstantinova (2003) observed Alternaria leaf spots of Gerbera in different greenhouses on commercial plants in Bulgaria. The symptoms of the disease on the leaves were characterized by the development of brown, small, scattered dots, which gradually enlarged and coalesced to form a large, oval, circular or irregular, brown to black lesion with concentric ring. Affected plants showed lower vitality, suppressed development and fewer, smaller, distorted flowers.

Ghosh *et al.* (2002) reported that Alternaria leaf blight can be managed by using different fungicides and their combinations. The fungicides tridemorph (0.1 %), Ziram (0.25%) and Mancozeb (0.25 %) were effective. Among the plant extracts, *Piper nigram* and *Curcuma longa* at 7% concentration were found to be effective in controlling the disease in vitro conditions. The bioagents viz., *Trichoderma viridae, Aspergillus awamori* and *Trichoderma hamatum* were also observed to check the growth of the pathogen.

Daughtrey *et al.* (1995) found that Alternaria leaf spot first appears as small water-soaked spots on lower, older leaves. Spots become sunken and brown as they mature. They may also have a yellow halo or appear as concentric rings.

2.2.2. Bacterial leaf spot of Gerbera

Bacterial leaf spot, caused by *Pseudomonas cichorii,* tends to be a problem not only during warm weather with periods of heavy rain, but also where overhead watering is practiced.

Symptoms of this disease are large black spots concentrated at the base of the plant. The spots often begin at the leaf margin but may also occur randomly. The spots are soft when tissue is wet and sunken and brittle when leaves are dry. From the leaf, the bacterium can move through the petiole and into the stem, resulting in a canker. The sepals of infected flower buds will become brown to black and up to several inches of pedicel may be killed.

According to “Agriculture Victoria” (2019), once plants become infected with bacteria, it is best to rogue infected plants.

Reddy (2016) revealed that *P. cichorii* infection can cause a number of symptoms in Gerbera daisy. Small to large circular spots appear initially but will become irregular in shape and dark brown to black in color as the disease progresses.

Again Reddy (2016) and Miller and Knauss (1973) stated that the spots may or may not also be associated with concentric ring patterns. Brown discoloration has also been noted along the main vein. They also said that Bacterial leaf spot infection and spread can be minimized by maintaining low relative humidity within the crop.

However, Moorman (2016) revealed in one of his studies that propagation beds and media should also be pasteurized between crops.

Dicklow (2013) and Janse (1987) revealed that in addition to Gerbera, ornamental plant hosts can include *Hibiscus, Impatiens walleriana, Cyclamen persicum, primrose, Vinca* and *Chrysanthemum* of the organism. The pathogen growth is favored by high temperatures and moist conditions.

Dicklow (2013) alone mentioned that the bacteria are easily spread by splashing water and require wounds or natural entry points in order to infect plant hosts.

And Janse (1987) stated that *P. cichorii* has been found to survive below freezing temperature for up to 12 months. He also revealed that *P. cichorii* is a gram-negative bacterium that can infect and cause devastating symptoms on a wide range of host plants.

According to Alivizatos (1986) and subsequently in Greece according to Miller & Knauss (1973) in Gerbera plant, bacterial blight caused by *P. cichorii* was first described in Apopka, Florida.

Bazzi et al. (1984) conducted an experiment and found that the bacterium can also overwinter in plant debris, as noted by and they found surviving *P. cichorii* cells in lettuce debris after 115 days.

Miller (1974) recorded the *P. cichorii* bacterium as the cause of bacterial leaf spot of Gerbera.

Again Miller and Knauss (1974) said that eliminating the source of future inoculum by removing diseased plants and residue can reduce disease spread. They also mentioned

that large brown areas that extend from leaf margins and narrow as they reach the mid vein have been noted. Disease symptoms can be variable in seedlings.

2.2.3. Botrytis blight of Gerbera

Daughtrey and Benson (2005) conducted an experiment and found that temperature has little limiting effect on botrytis blight in Gerbera as petal spotting has been seen between 4 °C and 25 °C (39 °F and 77 °F), although higher incidence is associated with higher postharvest temperatures.

Plant Health Progress (2000) stated about Gerbera botrytis blight that it can also cause damping-off, spotting and blighting of leaves and flowers, and crown rot. Leaves develop lesions, and flower petals show tan spots and tip necrosis or are entirely blighted. *B. cinerea* may be seed borne in African daisy.

However, Brown *et al.* (1990) revealed that Gray mold is caused by the fungus *Botrytis cinerea*, which attacks dead plant parts, and, when conditions are favorable, spreads to living leaf and flower tissue. Botrytis blight or gray mold, one of the most common and destructive diseases of greenhouse-grown crops, is estimated to cause a greater economic loss of ornamentals and vegetables than any other disease. Botrytis blight frequently occurs on the same hosts in out-of-door plantings, especially during or following cool, damp, cloudy weather. It also causes damage on many fruits and vegetables and can be a serious problem during both short- and long-term cold storage and subsequent shipment of most types of horticultural commodities. The causal fungus can invade and damage many plant parts including flowers, pedicels, stems, leaves, buds, fruits, bulbs, corms, tubers, and roots. With some exceptions, however, Botrytis blight mainly attacks tender tissues (flower petals, buds, or seedlings), weakened or injured tissues (such as stubs or bases left on stock plants after cuttings), and aging and dead tissues. Actively growing tissues, other than flower petals, are seldom invaded. Botrytis infection first appears as a water-soaking and browning regardless of the tissue affected. A conspicuous, tan to gray fuzzy mold (composed of many thousands of spores borne in grapelike clusters) develops on rotted tissue under humid conditions. Flag to roundish, black resting bodies (sclerotia) of the fungus can appear on infected and sporulating tissue as the plant or plant part dies. The fungus becomes established in flower petals and sometimes appears as irregular, enlarged, tannish, water-soaked flecks or spots. Flowers are particularly susceptible as

they begin to age. Infected petals wither and turn tannish brown. The mycelium of Botrytis may continue to grow and invade the rest of the inflorescence, and, if moist conditions persist, spore production can occur. The petals of badly infected flowers often become matted and stick together. The fungus may invade the pedicel, which rots and leads to bud and flower collapse. Flowers can also become infected while still in the bud.

Hausbeck and Moorman (1996) revealed that reducing relative humidity can be very effective in managing botrytis blight outbreaks. Infrared heating systems or trickle, drip, trough, and flood and drain irrigation systems can assist in reducing the occurrence of free moisture. They also stated that Botrytis blight can infect leaves, stems, petioles, and blossoms of Gerbera daisy. Blighting is the most common symptom of botrytis infection but it can also include leaf spots and damping-off of seedlings.

Salinas *et al.* (1989) mentioned that when relative humidity is low, conidia can survive as long as 14 months and still germinate on Gerbera flowers to cause lesions when water is made available.

2.2.4. Fusarium stem rot and wilt of Gerbera

Meena *et al.* (2015) stated that the species of *Fusarium* was identified from stem rot of Gerbera based on the morphological characters. Observation under microscope revealed small, oval shaped, single or bi-celled microconidia and hyaline, multi-celled macroconidia with 3 septation which were sickle shaped with knotched base at one end.

Pegg and Manners (2014) suggested that all infected plants must be removed and destroyed as they cannot recover from systemic infection. They also said that irrigation water can also be an important source for the introduction of *Fusarium*. Water can be treated using chemical methods, heat (85 ℃), UV irradiation, and slow sand filtration.

Rajendran *et al*. (2014) found that controlled climatic condition in the green house favors the development of *F. oxysporum* in Gerbera and cause severe economic loss to the farmers which results in early death of the plant.

Dean *et al.* (2012) stated that a sexual cycle of *F. oxysporum* is unknown; therefore asexual spores and mycelia are responsible for plant disease. They again mentioned that chlamydospores of *Fusarium* will germinate when stimulated by root exudates of host

plants. The infectious hyphae will then penetrate the plant root system by directly growing into natural openings, such as wounds made when feeder roots emerge.

Troisi *et al.* (2010) reported that the stem rot is caused by *F. oxysporum* f. sp. *tracheiphilum.*

In a study Minuto *et al.* (2008) stated, for Gerbera plants grown in closed soilless systems, slow sand filtration, alone and in combination with the application of biocontrol agents, and a nutrient solution pH higher than 6.0 may significantly reduce *F. oxysporum* f. sp. *chrysanthemi* infections.

Garibaldi *et al.* (2008) and Troisi *et al.* (2010) mentioned that brown streaks develop in the vascular system and eventually turn into black. Brown discoloration also occurs in the vascular system of the crown and upper taproot. The leaves of affected plants can also occasionally turn red.

Garibaldi and Minuto (2007) stated that stem rot is caused by *Fusarium solani* and wilt is caused by *Fusarium oxysporum*. Wilt disease of Gerbera plants, grown for cut flowers, in a soilless cultivation system (coconut fiber substrate) in one farm in the Cadizarea, southwestern Spain caused by *F. oxysporum.*

Kishore (2007) reported that highest incidence of Gerbera wilt was noticed at Dhavaleswar polyhouse, Belgaum in Karnataka.

Minuto *et al.* (2007) said that specifically, Fusarium wilt of Gerbera is caused by *F. oxysporum* f. sp. *chrysanthemi.*

Garibaldi *et al.* (2004) observed wilting symptoms in Gerbera that were grown for cut flowers in a soilless cultivation system at Albenga (Savona) in northern Italy. During 2003, wilted plants were repeatedly observed in other commercial greenhouses located in the same area. From these plants, *Fusarium spp*. was consistently isolated onto Fusarium-selective medium and colonies were identified as *F. oxysporum*. Wilt affected Gerbera plants were stunted and developed yellow leaves with initially brown and eventually black streaks in the vascular system. The vascular streaks in the yellow leaves were continuous with a brown discoloration in the vascular system of the crown and upper taproot. In some cases, the leaves of affected plants turned red.

Takahashi *et al.* (1999) revealed when isolated outbreaks occur, the disease can be devastating leading to major losses.

But Kaewruang *et al.* (1989) stated that soil solarization may not be an effective strategy for controlling *F. oxysporum* infestations.

Pataky (1988) conducted an experiment and found that diseased plants are initially stunted with chlorotic leaves. Disease symptoms often commence at the base of the stem and progress upwards, causing the leaves and flower heads to wilt, wither, and die. Once it enters the plant, the pathogen will grow and multiply through its vascular system, spreading macro- and microconidia throughout the plant where they can germinate and affect new plant parts. Hence, he said the pathogen can overwinter as mycelia and chlamydospores, either in dead plant parts or in the soil indefinitely in the absence of a host plant. Maintaining temperatures in these cooler ranges can minimize symptoms in infected plants and reduce disease spread. He also said in addition, disease can be spread through infected transplants; therefore it is important to ensure transplants are disease-free before planting.

2.2.5. Phytophthora rot of Gerbera

"Flower Web" (2019) reported that potentially the disease can occur in any period of the year, nevertheless, it spreads much more quickly when there are high levels of humidity in the greenhouses and in the growing media the temperatures are in the range of 22-25°C. The fungus prefers cool environments; with values higher than 25°C it gradually becomes harmless. It's diffusion takes place very quickly through the zoospores, unicellular organisms, provided with flagella (small appendixes) that allow the pathogen to swim in a film of water to reach the roots and the crown. When conditions are wet and free water abounds, *Phytophtora* will produce zoosporangia that produce zoospores which infect roots and again produce more zoosporangia. This repeating cycle can increase the number of spores rapidly in soil so that epidemics and rapid loss of plants is very possible. When conditions are unfavorable for zoospore production (drying or lack of host roots) the fungus makes resting spores (Oospores and Chlamydospores) which will germinate when the time is right. The phenomenon flourishes when irrigation is carried out by means of large amounts of water being applied by hosepipe and then being allowed to spread of its own accord. Soilless cultivation, in bag or containers systems in

which more plants are into contact with each other by means of the root apparatus, also favors the spread of this pathogens. In soilless cultivation using a closed system (recirculation of the nutrient solution) the risk of possible infestation and diffusion of a high rate of the pathogen is much higher, so that, it is necessary to have very efficient systems of sterilization of the solution.

Rajendran *et al.* (2014); Ampuero *et al.* (2008) and Padghan and Gade (2006) revealed that *Phytophthora* rot is the most widespread and destructive disease of many ornamental crops, mainly caused by the pathogen named *Phytophthora cryptogea*. Weather conditions like temperature ranging from 15-30 °C and long, frequent soil saturation periods as in the case of hydroponics; favor the development of Phytophthora rot.

Granke *et al.* (2012) stated in one of their studies that the fungus forms a network of hyphae over the plant surface, and the leaves, flowers, and stems eventually become covered with white, talcum-like colonies.

Again Granke *et al.* (2012) and Song and Deng (2013) revealed that it is the most common foliar disease of Gerbera daisy and is considered the most destructive disease of commercial Gerbera production. They also said that initial infections are the result of airborne asexual spores (conidia) that land on the plant surface and germinate. Conidia will develop under conducive environmental conditions, and secondary spread can be the result of further movement of conidia through air currents and water splash. Relative humidity in the greenhouse can prevent sporulation of the pathogens. This can be accomplished by ensuring adequate ventilation and using wide plant spacing so that air can flow easily between plants.

Benson and Parker (2011) mentioned that *Phytophthora* spp. can cause devastating rot disease of both the crown and root of Gerbera daisy. Plants begin to wilt rapidly within 7–10 days of initial infection. Leaf symptoms include chlorosis and darkened midrib and veins followed by loss of turgor and desiccation.

Mueller *et al.* (2003) said, in addition, cool night and warm day temperatures, closed canopy, and poor air circulation will promote disease development. They also stated that overlapping leaves should also be removed.

However, Barnes (2000) mentioned that symptomatic plants will usually have significant root and crown discoloration and deterioration. According to him soil compaction can significantly reduce drainage, thereby promoting disease spread.

Arnold *et al.* (2000) stated that Gerbera are susceptible at all stages of production, but infection appears more common after flowering.

Hyeong *et al.* (1996) stated that symptoms like stem or collar rot resulted in fatal infection with complete death of the plant. The disease was initiated as dark brown water soaked lesion on the stem and later spread through collar portion extending up to root hairs. Foliar yellowing and defoliation were the general aerial symptoms noticed in the affected plants.

Erwin and Ribeiro (1996) reported that they produced uniformly dense white cottony growth known as mycelium. The hypha was branched, hyaline, coenocytic with oval to obpyriform sporangia, non-papillate borne either terminally or laterally on the sporangiophores in a simple sympodial fashion. Dimension of sporangia ranged from 32.5-57.5 x 25-35 μm.

Daughtrey *et al.* (1995) Environmental conditions most conducive for PM development include high relative humidity (80–90%) and moderate temperatures. The disease may cause the lower leaves to drop, and white powdery growth may be visible on both stems and flowers, thus making plants or cut flowers unsightly and unmarketable.

2.2.6. Pythium root rot of Gerbera

In a study Munera and Hausbeck (2016) revealed that *Pythium* spp. is responsible for causing root and stem rots in mature plants as well as damping-off in seedlings. Seeds and seedlings are more susceptible than mature plants with reduced vigor and subsequent limited growth and productivity.

However, Schroeder *et al.* (2013) stated that thick-walled chlamydospores of *Pythium* can also form under adverse conditions as survival mechanisms, but only in a few species (e.g., *P. tracheiphilum* and *P. dimorphum*).

Sutton *et al.* (2006) mentioned that *Pythium* attacks the root systems of the plant causing the above-ground tissue to wilt and die as the roots rot. Infected roots will turn various shades of brown to yellow, depending on the species of the pathogen, generally initiating at the root tips and progressing to the rest of the root system. They also stated that inoculum can be introduced by dust particles, soil and planting media, residue on tools and equipment, footwear, and irrigation water. Again they said that the *Pythium* oospores have also been detected in the digestive tracts and frays of fungus gnats (*Bradysia* spp.) and shore flies (*Scatella stagnalis* Fallen), demonstrating that *Pythium* can also be spread by insect vectors. They also said that zoospores are particularly important for disease spread in hydroponic or ebb and flow systems. Moreover, they added that infection by zoospores is caused by direct penetration of unwounded root surfaces by penetration pegs, fine hyphae, and enzymatic action, although wounded tissues are also highly susceptible to *Pythium spp*. Invasion.

Moorman *et al.* (2002) stated that depending on the species of the pathogen, Pythium root rot can be spread by either zoospores, oospores, or mycelia.

Barnes (2000) revealed that excessive irrigation as well as excessive drought can cause plant stress which can weaken plant roots making them more susceptible to infection.

Arnold *et al.* (2000) suggested that transplants should be disease-free and not planted with the crown below the media surface and, if possible, do not grow plants on the ground.

Martin and Loper (1999) mentioned that oospores of all *Pythium* spp. can be found in soil and other planting media and can survive in field soil for months to years. Oospores and sporangia of *Pythium* spp. do not germinate in the soil unless exposed to chemical stimulants present in root and seed exudates, plant debris, or organic matter. In high moisture conditions, some *Pythium* spp. sporangia will produce motile zoospores instead of germinating directly. They again said, Pythium root rot is highly correlated with high soil moisture and can be more severe under lower soil temperatures. Moreover, they told that Pythium root rot requires high levels of free water for infection and spore dispersal; therefore, water management is crucial in controlling this disease. Overwatering can provide prolonged periods to free water for zoospore dispersal and are associated with increased disease severity.

2.2.7. Powdery mildew of Gerbera

Moyer and Peres (2011) revealed that Powdery mildew is one of the most destructive fungal diseases of Gerbera causing significant economic losses under poly house conditions. It is caused by two fungal species viz. *Erysiphe cichoracearum* and *Podosphaera fusca* (Fr.) *S. Blumer*. They are the obligate parasite (they live always living matter) and can affect all parts of the plants. Powdery mildew is easy to identify since to noticeable white spots or powder like appearance or white patches appear on the upper and lower surfaces of the leaves or flowers. These spots are enlarge to form a white, powder like mat, which can spread to stems and flowers also This disease reduced plant growth and lesser flower quality which contribute to economic losses. Severely infected leaves turn pale yellow or brown and the plants eventually die. Some environmental conditions like high relative humidity (80-95%), moderate temperature (20-28 °C) and low light intensities or shade are most congenial for powdery mildew development.

Moyer and Peres (2008) reported that acidic-electrolyzed oxidizing water has been shown to effectively reduce the percentage of PM when sprayed twice a week and when sprayed every other week, alternating with fungicides. Weekly applications can be phyto-toxic.

2.2.8. Crown Rot of Gerbera

Flower Web (2019) revealed that potentially the crown rot disease can occur in any period of the year, nevertheless, it spreads much more quickly when there are high levels of humidity in the greenhouses and in the growing media the temperatures are in the range of 22-25 °C. The fungus prefers cool environments; with values higher than 25 °C it gradually becomes harmless. It also stated that in the cases of severe infestation causes the death of the plants in the space of 10-15 days. Its diffusion takes place very quickly through the zoospores, unicellular organisms, provided with flagella (small appendixes) that allow the pathogen to swim in a film of water to reach the roots and the crown. When conditions are wet and free water abounds, *Phytophthora* will produce zoosporangia that produce zoospores which infect roots and again produce more zoosporangia. The phenomenon flourishes when irrigation is carried out by means of large amounts of water being applied by hosepipe and then being allowed to spread of its own accord. Soilless

cultivation, in bag or containers systems in which more plants are into contact with each other by means of the root apparatus, also favors the spread of the pathogens.

PennState Extension (2016) revealed that the causal organism of the crown rot disease of Gerbera is *Rhizoctonia solani*. The primary symptom of the disease is the stems at the soil level have usually a brown lesion initially. At the advanced stage the plants wilt and die. To avoid the disease it's better to plant the seedlings in pasteurized media. A fungicide may be applied to protect plants.

2.2.9. Flower Abnormality of Gerbera

Hossain (2018) mentioned that flower bent is an abnormality in Gerbera which is caused by loss of cell turgidity and under nutrition (lack of Calcium).He also stated about double-faced Gerbera flower which is also a physiological disorder caused by imbalance of nutrients. Too much growth too little flower buds.

TNAU Agritech portal Horticulture (2015) reported that an abnormality characterized by numerous leaves, short petioles and small laminae was observed in greenhouse Gerbera which gives some cultivars of Gerbera a bushy appearance known as bushiness. Nodes are not clearly distinguished and no inter-node elongation is seen.

Edge India (2015) revealed that the center petals of the bud remain only partly developed and the bud appears flat which is called as 'Bull Head'. They are common on very vigorous shoots, particularly bottom breaks, and it is possible that there is a lack of carbohydrates to develop the petals. The cause of bull heading is as yet unknown; however, thrips infestation will also cause malformed flowers. It also mention about flower color fading that off- colored flowers present a problem with some yellow varieties in that the petals may be green or a dirty white instead of a clear yellow. Raising the night temperature several degrees will reduce the number of off-colored flowers. Occasionally the pink or red varieties develop bluish-colored flowers. This is very often associated with use of organic phosphate and various other kinds of insecticides. It again stated about an abnormality named 'Stem break' that it is common post harvest disorder in cut Gerberas. This is mainly caused by water imbalances. It could be ethylene controlled and associated with early senescence associated with water stress. It also

revealed about a disorder named yellowing and purple margin which is caused by Nitrogen deficiency and causes yellowing along with early senescence of leaves. Phosphorus deficiency causes pale yellow color with purple margin. Increase in levels of nitrogen and phosphorus were found to promote development of suckers and improve flowering in Gerbera.

2.2.10. Viral diseases of Gerbera

Promi (2018) conducted an experiment and reported that infection by both bacteria and viruses cause a wide range of plant disease. In fact, the rates of viral infection in Gerbera plants are much higher than any other plant. Tobacco rattle, Gerbera mosaic, impatiens necrotic spot, and cucumber mosaic viruses can infect Gerbera plants, but the rate of infection is low, and they can infect the plant only at a large concentration of pathogen. Once infected, these diseases show symptoms of discoloration of the flower, line or ring spots to the leaves and sometime even form mottled leaves.

Whipker (2014) stated that symptomatic plants showed concentric rings, irregular chlorotic blotches and deformation on leaves. The virus was transmitted non-persistently by *Myzus persicae* and *Aphis gossypii*. Once a plant has INSV or Tomato Spotted Wilt Virus, it cannot be cured. So discarding infected plants is the only option. Note some plants may be asymptomatic but still have INSV or TSWV. Thus with the primary method of spreading these viruses is by Western Flower thrips feeding, it is critical to keep them under control. He also reported that INSV symptoms typically begin as a light green mottling with ring spots also possibly present. As the disease progresses, a distinct necrotic line pattern becomes evident on leaves.

Gautum *et al.* (2014) revealed that Cucumber Mosaic Virus symptoms vary depending on the plant host, environment, and other conditions. However, severe chlorotic mosaic patterns as well as floret and flower deformations have been reported in CMV-infected Gerbera plants.

Whipker (2014); German *et al.* (1992) and Kaminska and Korbin (1994) mentioned in their studies that TSWV and INSV are both transmitted primarily by the western flower thrips (*Frankliniella occidentalis*), although other thrips species have been reported.

Jacquemond (2012) conducted an experiment and found that when the insect feeds on CMV-infected plants, the virus will attach to its mouthparts and then be spread when the insect moves to feed on neighboring uninfected plants. Once the plant has been inoculated by the feeding aphid, CMV, like other plant viruses, uses the phloem-assimilate pathway to systemically invade the rest of the plant (Seed transmission of CMV is unknown in Gerbera.

However, Stankovic *et al.* (2011) and Marys *et al.* (2014) reported that TSWV has been found to be the cause of up to 30% loss in Gerbera greenhouse crops in Serbia and Venezuela. They also reported that viral infection symptoms can vary significantly depending on the host. Symptoms of TSWV infection in Gerbera initially appear as chlorotic oak-leaf patterns on leaves which are followed by necrosis and leaf distortion as the disease progresses.

Kazinczi *et al.* (2007) and Moyer *et al.* (1999) stated that Tospoviruses, like other members of the family Bunyaviridae, require an insect vector to transmit the disease. Most are vectored by thrips species (Thysanoptera: Thripidae), a common polyphagous insect pest of most horticulture crops worldwide. They also said in their different studies that seed transmission of tospoviruses is currently unknown, but the disease can be spread easily through infected propagation material.

Kazinczi *et al.* (2007) alone mentioned that these viruses are persistent, meaning that they survive and replicate within the gut of their vector host. However, thrips can only acquire tospoviruses during the immature larval stage where it is transstadially. They suggested to remove all plant debris as well as weeds and flowering plants growing near production areas as these can be sources of new infections and Infestations.

Verma *et al.* (2004) and Finlay (1975) reported that only one virus of significance in the *Bromoviridae* is reported to cause disease in Gerbera: Cucumber mosaic virus (CMV, genus *Cucumovirus*) has been reported to cause disease symptoms in Gerbera daisy production in Australia and India.

Verma *et al.* (2004) again stated that viruses in the *Bromoviridae* family are transmitted by aphid vectors (Hemiptera: Aphididae). CMV is transmitted non-circulatively (non-

persistently) primarily by green peach aphids (*Myzus persicae)* and cotton aphids (*Aphis gossypii).* They revealed that color breaking has also been noted.

However, Mavric and Ravnikar (2001) mentioned in a study that includes a number of viruses that cause disease in ornamental plants. Within this classification are the tospoviruses, two of which are important in Gerbera production: Tomato spotted wilt virus (TSWV) and Impatiens necrotic spot virus (INSV). TSWV is considered one of the most important plant viruses and has been linked to over 1 billion US dollars in crop losses globally.

Moreover, Mumford *et al.* (1996) found greenhouse-grown Gerbera and Chrysanthemum have been observed displaying symptoms resembling those associated with Tomato Spotted Wilt Viruses. Symptomatic plants showed concentric rings, irregular chlorotic blotches, and deformation on leaves in Venezuela. This is the first confirmed report of TSWV infecting Gerbera and Chrysanthemum in Venezuela.

2.3 Socio-economic status of Gerbera growers of Bangladesh

Hossain (2018) stated that along with nursery cultivation, biotechnological approach might be a prospective alternative for mass propagation of Gerbera. As the economy of Bangladesh is largely dependent on agriculture, this flowering plant can have a great contribution to the economic growth as well as for opening a new dimension in the field of agriculture in Bangladesh.

Prodhan *et al.* (2017) revealed that there is a great market requirement for plant throughout the year. Besides greater productivity and trade perspective is favoring floriculture in Bangladesh. They also stated that in Bangladesh, Gerbera was presented recently and it is becoming more popular. It has a great risk of regional as well as trade industry.

Ali *et al.* (2016) reported that flowers are now cultivated in about 10 thousand hectares of land, mainly in the Godkhali Union of Jhikorgacha Upzilla under Jashore district. About 4000 farmers produce mainly various types of Rose, Tube Rose, Gerbera, Gladiolus and some orchids.

Rahman *et al.* (2014) stated that in Bangladesh, Gerbera is presented recently becoming more popular day by day. Due to the increasing demands of flower in local and international market; floriculture became very popular in recent years especially in the urban areas. Gerbera is a foreign flower and it has a huge demand in Bangladesh. To meet up the local demand, many nurseries started to cultivate this plant from cutting imported from India.

Mou (2012) mentioned that to satisfy the market demand, various flowers, such as Gerbera, chrysanthemum, tuberose, gladiolus have been imported from India and orchids, anthurium and Thai rose from Thailand every year. Bangladesh has to spend roughly Tk. 2-3 million in importing flowers and ornamental plants from abroad.

CHAPTER III

MATERIALS AND METHODS

Two experiments were conducted under this research work. These were-

1. Investigation on field diseases of Gerbera in Jhikorgacha, Jashore district.
2. Survey on socio-economic status of Gerbera farmers, production technologies and diseases of Gerbera in Jhikorgacha, Jashore district.

Experiment 1. Investigation on field diseases of Gerbera in Jashore

3.1.1. Experimental site

Laboratory works were conducted in Plant Disease Clinic of Sher-e-Bangla Agricultural University, Dhaka. The field investigation was conducted at 18 villages of Jhikorgacha upazila in Jashore for field diseases. The instrument for the survey and data collection was questionnaires and was pre-tested in two upazilas of two districts namely Savar and Manikganj prior to beginning of the ultimate survey. The survey locations were as follows:

Table 1. Experimental sites under survey at Jhikorgacha Upazila in Jashore District

Unions	Villages	Number of field
Godkhali	Godkhali	3
	Patuapara	3
	Sadirali	3
	Belemath	3
	Dhalipara	3
Panisara	Panisara	3
	Syedpara	3
	Nilkonthonogor	3
	Kuliya	3
	Krishnachandrapur	3
Navaron	Hariya	3
	Nimtola	3
	Baisha	3
	Sharifpur	3
	Chadpur	3
	Mathuapara	3
Nirbashkhola	Nirbashkhola	3
	Shiorda	3
Total: 4	**Total: 18**	**Total: 54**

The experimental field was located at 89°08′E longitudes and 23°06′N latitude at an altitude of 9 meters above the sea level and under the agro-ecological region of "High Ganges River Floodplain" (AEZ NO. 11). The experimental site is shown in the map of AEZ of Bangladesh in Plate 1.

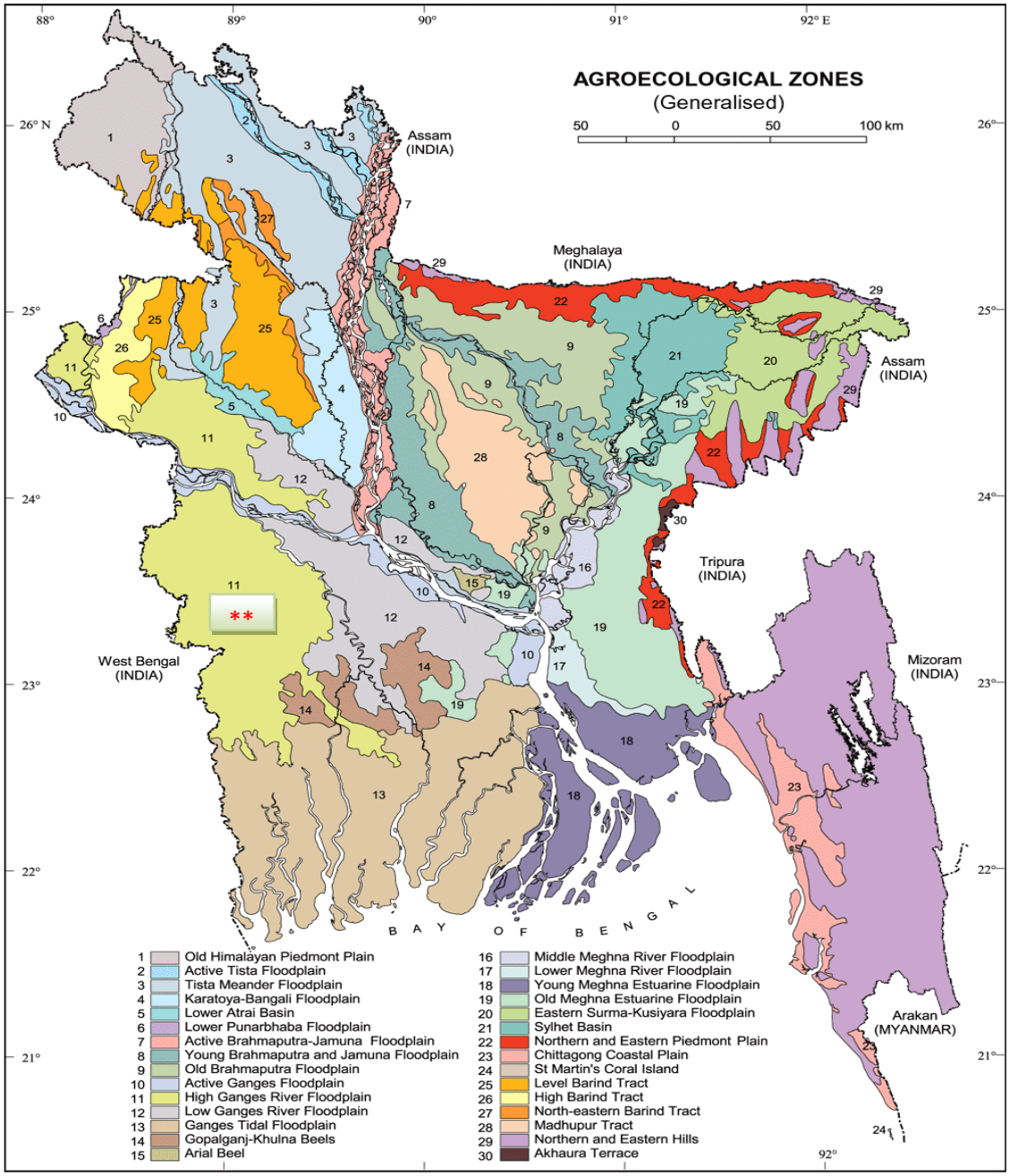


Plate 1. ** Experimental site under study

3.1.2. Experimental period

The field investigation was carried out during the month of February, 2019. Lab experiment was conducted February, 2019 to May, 2019.

3.1.3. Weather conditions

The experiment was carried out during the period from February, 2019. So the average temperature, precipitation and relative humidity of that month were 22 ℃, 0 mm and 45% respectively.

3.1.4. Characteristics of soil

The fields belong to the general soil type. The land was above flood level and sufficient sunshine was available during the experimental period. Organic matter and fertility status were moderate.

3.1.5. Test materials

In this study, 54 Gerbera fields were selected for survey to investigate the field diseases.

3.1.6. Sampling Size for Measurement of Diseases

The data were collected in winter season. In case of field diseases thirty plants from each field was considered to measure data on disease incidence and severity.

3.1.7. Data collection

Plant Disease Survey Sheet (Annex. 1) was used to collect information on symptomology of diseases and to record disease incidence and severity. The field investigation was conducted under natural epiphytic condition. Data was collected with three replications. Data were collected by using Plant Disease Survey Sheet on the following parameters:

1. Disease Incidence (%)
2. Disease severity (%)

Moreover, the following information was also recorded during data collection:

a) Symptoms (Symptomological study)
b) Infected plant parts
c) Distribution of disease
d) Status of disease

3.1.8. Field inspection and Identification of disease

Gerbera plants of the selected farmer's field observed carefully and symptoms of the diseases were recorded in Plant Disease Survey Sheet (Annex. 2). In each village, three farmer fields were visited to find out present diseased condition of standing crops under natural epiphytic conditions. Different scientific articles on Gerbera diseases were primarily used for disease identification in field. Survey sheet was used to write details symptoms of plant diseases and also for recording disease incidence and disease severity percentage. Current field condition, present disease status and farmer's opinion has been taken as an important consideration for recording data. Farmers and fields were selected randomly. The overall conditions of the selected fields were taken in consideration. The disease severities were counted on the basis of eye estimation and direct opinion of the concern farmer. The land area and pesticides that used by the farmers were also taken as an important consideration.

Disease was quantified in three categories such as, Major: where these disease symptoms causes total flower damage and it is impossible to sold them in market to earn money, Medium: where symptoms causes partial damage of flower, the flowers can be sold in market but reduce the market price, Minor: these symptoms never cause any damage or loss of flower parts, only reduce the market value of the flower. Diseased plant samples and soil were collected and examined in the laboratory. Some of the disease problems were identified previously their names were recorded. Some diseased samples were brought to the laboratory to identify the causal organism. The causal organisms then isolated, identified and recorded. Very few are unidentified than these symptoms were named as it seems, such as floret rot. The survey was conducted with Plant Disease Survey Sheet prepared by Department of Plant Pathology, Sher-e-Bangla Agricultural University. Data on land area utilization under some major flower cultivation were also collected by using standard questionnaires (Annex. 1) to study the economic importance of selected flower in the mentioned region.

3.1.9. Sample collection

Diseased leaves exhibited different types of typical symptoms were collected from different diseased plants from the Gerbera fields. The samples were preserved temporarily in air tight zip locked poly bags and tagged for later convenience. Then the samples were

carried to the Plant Pathology Laboratory of SAU. The collected samples were preserved in refrigerator at 4 °C before investigation. In the laboratory they were examined for visible symptoms as well as for microscopic examination and isolation of causal organism(s).

3.1.10. Isolation of causal organism(s) by tissue planting method

Plant parts showing the typical disease symptoms were cut into small pieces aseptically, washed thoroughly in running tap water, then surface sterilized with 1% Mercuric Chloride ($HgCl_2$) for 30 seconds to one minute and washed three times in sterile distilled water. The surface sterilized leaf pieces were then aseptically plated on Potato Dextrose Agar (PDA) medium and incubated at 25±2 ºC for 6-7 days under 12 hours light and dark conditions. Hyphal tips from the margin of each developing colony were sub-cultured on PDA to get pure culture. Microscopic examinations were carried out to study morphological characteristics. The pathogen was identified from most of the infected samples.

3.1.11. Identification of causal organism(s)

Identification of causal organisms was done by the following methods:

3.1.11.1. Identification by Direct Observation (Microscopic Study)

The diseased leaves of plants were collected and kept in polythene bags and tagged. The samples were then taken to the laboratory. The collected sample was observed under stereoscopic microscope. The temporary slides were prepared from the diseased samples to observe under compound microscope. The causal pathogens were identified according to reference materials (Mathur and Kongsdal, 2003; Riley, 2002; Carlile *et al*., 2001; Ellis, 1971; Booth, 1971) and CMI Description.

3.1.11.2. Identification by Growing on Blotter Paper (Incubation Method)

The diseased leaves, stems, roots were cut into pieces (5 mm diameter) and surface sterilized with 70% Ethanol for 30 seconds. Then in sodium hypochlorite (NaOCl) for 30 seconds and washed three times in sterile distilled water each for 1 min. Then the cut pieces were placed in sterile blotting paper. The plates containing leaf pieces were

incubated at room temperature for seven days. When the fungus grew well and sporulated it was observed under stereo-microscope, to observe the growth characteristics. The slides were prepared from the pathogenic structures and observed in compound microscope and identified with the help of relevant literature (Mathur and Kongsdal, 2003; Riley, 2002; Carlile *et al*., 2001; Ellis, 1971) and CMI description.

3.1.11.3. Identification by Growing on Culture Medium

The diseased leaves, stems and roots were cut into pieces (5 mm diameter) and surface sterilized. Some samples were surface sterilized with 70% Ethanol for 30 seconds. Then in 1% sodium hypochlorite (NaOCl) for 30 seconds and washed three times in sterile distilled water each for 1 min. Some samples were sterilized with 37.5% Chlorox for 30 seconds washed three times in sterile distilled water each for 1 min. Then the cut pieces were placed on to acidified PDA medium in petridish (Mehrota and Aggarwal, 2003). The plates containing leaf pieces were incubated at room temperature for three days. When the fungus grew well and sporulated, the organism was re-cultured by single spore or tip culture method to obtain pure culture. Then slides were prepared from pathogenic structures and observed under microscope and identified with the help of relevant literature (Agrios, 2005; Mathur and Kongsdal, 2003; Barnett and Hunter, 1972; Ellis, 1971; Booth, 1971) and CMI Description.

3.1.11.4. Identification by Symptomological Study (Visual Assessment)

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

3.1.12. Measurement of Plant Diseases

Measurement of plant disease was calculated by measuring disease incidence (%) and disease severity (%).

3.1.12.1. Disease Incidence (%)

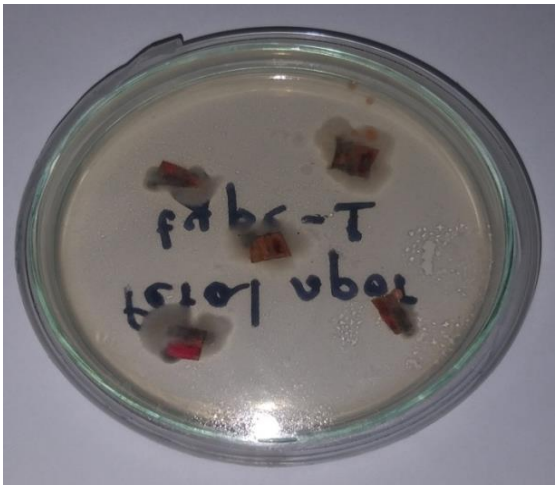
The plants under investigation were keenly observed to watch the typical symptoms and sign of the disease concerned. The plants showing typical symptoms by the pathogenic infection were considered as diseased plant. Disease incidence was calculated by the number of proportion of the plant units diseased in relation to the total number of units examined (Agrios, 2005). Plant units mean the leaves, stems, fruits, tubers, rhizomes, bulb etc. that show any symptoms. The disease incidence was calculated using the following formula:

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

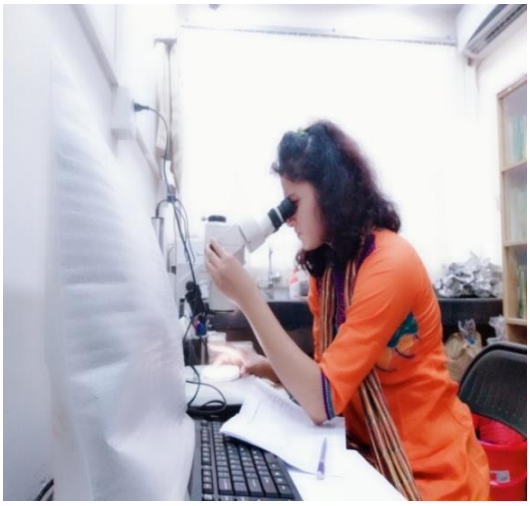
3.1.12.2. Disease severity (%)

Disease severity was calculated in the proportion of amount of plant tissues infected in relation to the total amount of tissue examined. Disease severity data were collected on the following parameters (Agrios, 2005).

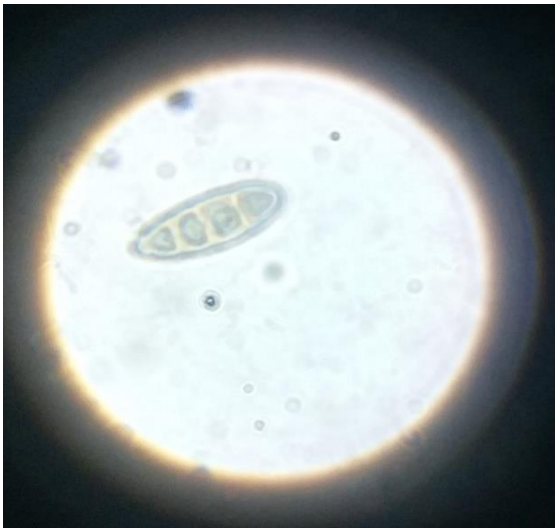
$$\text{Disease severity (\%)} = \frac{\text{Area of plant part infected}}{\text{Total area of plant part inspected}} \times 100$$



(A)



(B)



(C)

(D)

Plate 2. (A) Incubation of diseased sample in PDA medium; (B) Observation under stereo microscope; (C) Identification of causal organism by direct observation; (D) Isolation of causal organisms in laminar airflow cabinet

Experiment 2. Survey on socio-economic status of Gerbera farmers, production technologies and diseases of Gerbera in Jashore district.

3.2.1. Experimental site

The survey was conducted at 18 villages of Jhikorgacha upazila in Jashore for field diseases. The experimental field was located at 89°08′E longitudes and 23°06′N latitude at an altitude of 9 meters above the sea level and under the agro-ecological region of "High Ganges River Floodplain" (AEZ NO. 11). For better understanding, the experimental site is shown in the map of AEZ of Bangladesh in Plate 1. The instrument for the survey and data collection was questionnaires and was pre-tested in two upazilas of two districts namely Savar and Manikganj prior to beginning of the ultimate survey. The survey locations were as follows:

Table 2. Experimental sites under survey at Jhikorgacha Upazila in Jashore District

Unions	Villages	Number of field
Godkhali	Godkhali	3
	Patuapara	3
	Sadirali	3
	Belemath	3
	Dhalipara	3
Panisara	Panisara	3
	Syedpara	3
	Nilkonthonogor	3
	Kuliya	3
	Krishnachandrapur	3
Navaron	Hariya	3
	Nimtola	3
	Baisha	3
	Sharifpur	3
	Chadpur	3
	Mathuapara	3
Nirbashkhola	Nirbashkhola	3
	Shiorda	3
Total: 4	**Total: 18**	**Total: 54**

3.2.2. Experimental period

The survey was carried out during the month of February, 2019.

3.2.3. Test materials

In this study, 54 Gerbera farmers were interviewed for survey to understand the status Gerbera cultivation in Jashore, Bangladesh (Plate 3).

3.2.4. Interview of respondents and Sample Size

The sample size was 54. Therefore, 54 farmers were interviewed. In total, 18 villages of 4 Unions from Jhikorgacha upazila of Jashore were selected for the survey and 3 farmers from each village were the respondents.

3.2.5. Data collection

Data were collected by interview of the respondents (farmers). The questionnaires (Annex. 2), the instruments for data collection, were formulated and pre-tested in two districts namely Dhaka and Manikganj prior to beginning the survey. Data and information on Gerbera cultivation were collected by using the questionnaire on the following topics:

1. Land information
2. Cultivation area and time
3. Planting materials
4. Benefit cost ratio
5. Cost involved in pest management
6. Fertilizer application
7. Insect infestation
8. Disease infestation
9. Weed infestation
10. Relationship among insect, disease and weed
11. Action taken against pest infestation
12. Major problems in Gerbera cultivation
13. Suggestion for management of diseases

3.2.6. Analysis of data

The recorded data were analyzed using computer based software STATISTIX-10. For the experiment field was designed in RCBD single factor. The mean differences were judged by Least Significant Difference (LSD) at the 5% level of significance.

Plate 3. Survey and investigation on diseases in the Gerbera filed

CHAPTER IV

RESULTS

Experiment 1: Field Investigation on Diseases of Gerbera in Jhikorgacha, Jashore of Bangladesh

4.1. Diseases of Gerbera

4.1.1. Leaf spot disease of Gerbera

4.1.1.1. Symptomological study

Irregular dark brown color scattered dot like small spots were observed on leaf surfaces. Gradually the leaf surface is covered with numerous such lesions, which form brown to black lesions later with concentric ring with yellow hallo (Plate 4). Affected plants showed less vitality, low development, smaller and distorted flowers. During severe infections, 'Shoot Hole' symptom may be appeared.

4.1.1.2. Identification of causal organism

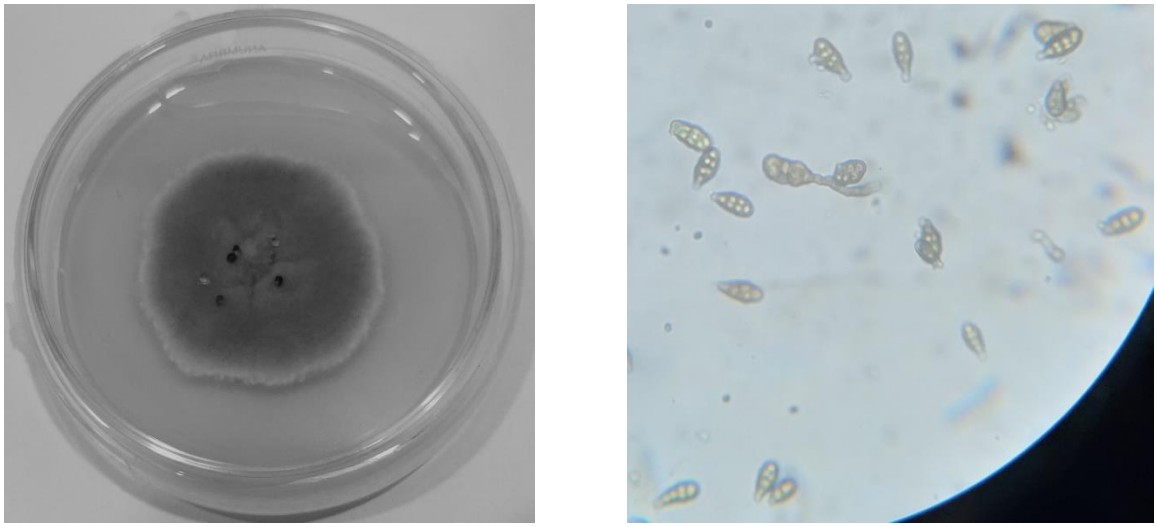
The identified causal organism of leaf spot disease of Gerbera was *Alternaria alternata.* The mycelium was septated, branched, hyaline in tender age. The conidiophore was simple, short, septated, colored and beard conidia at the top. Conidia were dark, beaked, multi-celled and muriform (both longitudinal and transverse septum was present), borne at the tip of conidiophores singly or in short chains. Their shape ware obclavate to elliptical or ovoid which were pointed at distal end (Plate 5B). The pure culture of *Alternaria* sp. was prepared (Plate 5A). In the culture the colonies of *Alternaria* are moderately fast growing and produce dark brown to blackish culture on PDA medium within 7 days.

4.1.1.3. Incidence and severity of the disease (%)

Incidence of Alternaria leaf spot varied significantly among the locations and that ranged from 8.333 to 43.33% (Table 3). The highest disease incidence was recorded in Kuliya (43.33%) and the lowest disease incidence was 8.33% in Belemath. In case of disease severity, similar results were observed. Severity of Alternaria leaf spot also varied significantly. The highest disease severity was observed in Godkhali and Nilkonthonogor

which is 11.66%. Moreover, in Sharifpur and Mathuapara the lowest disease severity was observed which is 1.33%.

Plate 4. Symptoms of Alternaria leaf spot disease of Gerbera



(A) **(B)**

Plate 5. (A) Pure culture of *Alternaria alternata* and (B) Compound microscopic view of *Alternaria alternata*

Table 3. Disease incidence and severity of Leaf spot of Gerbera

Locations	Disease Incidence (%)	Disease Severity (%)
Godkhali	23.33 ab	**11.66 a**
Patuapara	15.00 b	1.83 b
Sadirali	21.66 ab	9.00 ab
Belemath	**8.33 b**	2.83 ab
Dhalipara	25.00 ab	10.66 ab
Panisara	11.66 b	6.66 ab
Syedpara	16.66 b	6.00 ab
Nilkonthonogor	26.66 ab	**11.66 a**
Kuliya	**43.33 a**	6.33 ab
Krishnachandrapur	10.00 b	5.33 ab
Hariya	25.00 ab	5.33 ab
Nimtola	10.00 b	3.33 ab
Baisha	13.33 b	2.33 ab
Sharifpur	11.66 b	**1.33 b**
Chadpur	15.00 b	2.66 ab
Mathuapara	10.00 b	**1.33 b**
Nirbashkhola	26.66 ab	8.33 ab
Shiorda	13.33 b	3.33 ab
LSD (0.05)	23.36	9.70
CV (%)	41.90	56.83

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

4.1.2. Leaf blight disease of Gerbera

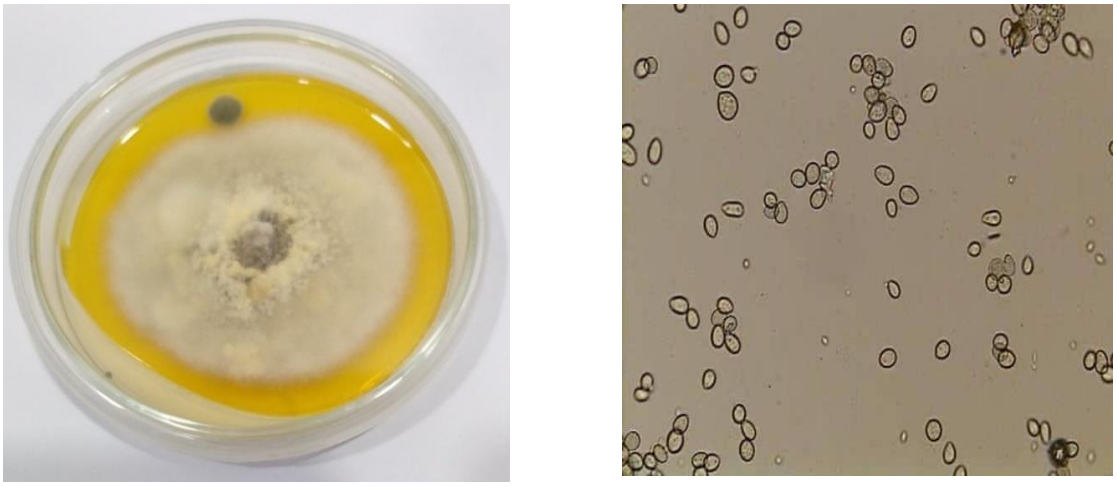
4.1.2.1. Symptomological study

Infection first appears as a water-soaking and browning regardless of the tissue affected. It sometimes appears as irregular, enlarged, tannish, water-soaked flecks or spots. Infected leaves wither, turn tannish brown and blighted (Plate 6). Flag to roundish, black resting bodies (sclerotia) of the fungus can appear on infected and sporulating tissue as the plant or plant part dies. The petals of badly infected flowers often become matted and stick together. The fungus may invade the pedicel, which rots and leads to bud and flower collapse. Flowers can also become infected while still in the bud.

4.1.2.2. Identification of causal organism

The identified causal organism of leaf blight disease of Gerbera was *Botrytis cinerea.* Fuzzy gray mass of spores were observed. Threadlike branched hyphal structures were found with brown tree like conodiophore which are long and smooth. Globose conidia were found which were hyaline and non septate (Plate 7B). Pure culture of *Botrytis* was (Plate 7A) made in which the fungus was moderately fast growing. It produced whitish cottony colony on PDA culture medium within 7 days.

Plate 6. Symptoms of *Botrytis* blight disease of Gerbera



(A) **(B)**

Plate 7. (A) Pure culture of *Botrytis cinerea* (B) Spores of *Botrytis cinerea* under compound microscope

4.1.2.3. Incidence and severity of the disease (%)

Incidence of leaf blight varied significantly among the locations. It ranged from 8.33 to 50.00% (Table 4). The highest disease incidence was recorded in Patuapara (50.00%) and the lowest disease incidence was 8.33% in Chadpur. In case of disease severity, similar results were observed. The highest disease severity was observed in Sadirali which was 16.00% and in Mathuapara the lowest disease severity was observed 0.83%.

Table 4. Disease incidence and severity of Leaf blight of Gerbera

Locations	Disease Incidence (%)	Disease Severity (%)
Godkhali	30.00 a-d	8.00 a-d
Patuapara	**50.00 a**	8.33 a-d
Sadirali	38.33 ab	**16.00 a**
Belemath	11.66 cd	4.00 b-d
Dhalipara	26.66 a-d	12.66 ab
Panisara	16.66 b-d	8.00 a-d
Syedpara	15.66 b-d	5.50 a-d
Nilkonthonogor	18.33 b-d	8.33 a-d
Kuliya	18.33 b-d	1.50 cd
Krishnachandrapur	10.00 d	3.00 b-d
Hariya	23.33 b-d	5.00 b-d
Nimtola	11.00 cd	2.00 cd
Baisha	18.33 b-d	3.33 b-d
Sharifpur	17.33 b-d	2.33 b-d
Chadpur	**8.33** d	1.33 cd
Mathuapara	10.00 d	**0.83 d**
Nirbashkhola	36.66 a-c	11.66 a-c
Shiorda	12.33 b-d	1.16 cd
LSD (0.05)	26.20	10.59
CV (%)	41.15	60.26

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

4.1.3. Stem rot disease of Gerbera

4.1.3.1. Symptomological study

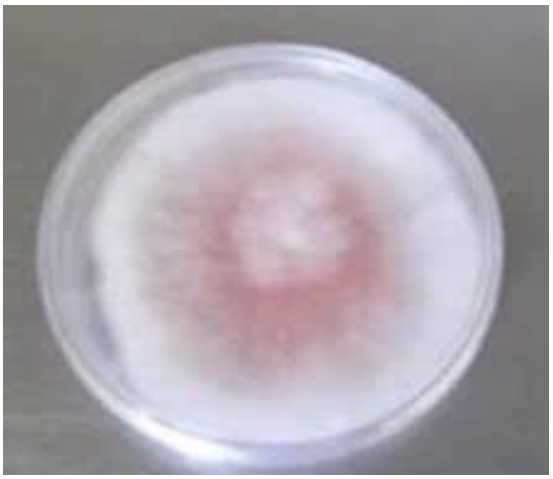
Brown streaks develop in the vascular system those eventually turn into black. Brown discoloration was observed in the vascular system of the stem and crown. The leaves of

affected plants can also occasionally turn red. Diseased plants are initially stunted with chlorotic leaves. Disease symptoms often commence at the base of the stem and progress upwards, causing the leaves and flower heads to wilt, wither, rot and die (Plate 8A).

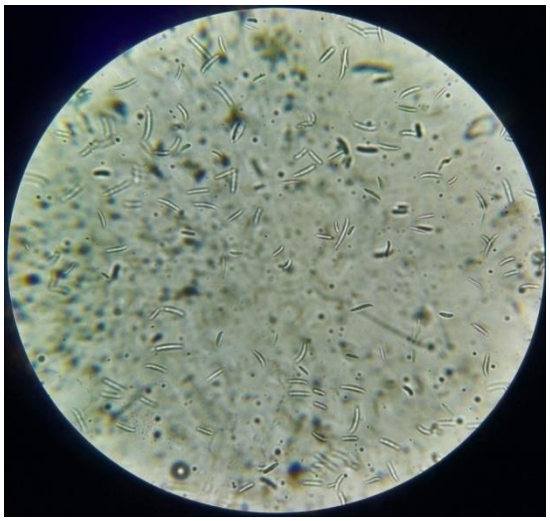
4.1.3.2. Identification of causal organism

The identified causal organism of stem rot disease of Gerbera was *Fusarium oxysporum* f. sp. *chrysanthemi*.

(A)



(B)



(C)

Plate 8. Symptoms and causal organism of *Fusarium* rot disease of Gerbera; (A) *Fusarium* rot disease in Gerbera plant; (B) Pure culture of *Fusarium oxysporum* f. sp. *chrysanthemi*; (C) Compound microscopic view of *Fusarium oxysporum* f. sp. *chrysanthemi*

Small, oval shaped, single or bi-celled microconidia and hyaline, multi-celled macroconidia with 3 septation were observed under microscope, which were sickle shaped with knotched base at one end (Plate 8C). The pure culture (Plate 8B) of *Fusarium* was prepared. In the culture the colonies were moderately fast growing and produced orangy white culture on PDA medium within 7 days.

4.1.3.3. Incidence and severity of the disease (%)

The Fusarium stem rot disease was found in only 2 villages of Jhikorgacha viz. Patuapara and Syedpara. Incidence of Fusarium stem rot ranged from 0 to 11.66%. The highest disease incidence was recorded in Syedpara (11.66%) and the lowest disease incidence was 10% in Patuapara. Similarly severity of stem rot was observed in Syedpara was 4.33% and in Patuapara was 4.66%. Other locations were fully free from the disease.

4.1.4. Crown rot of Gerbera

4.1.4.1. Symptomological study

Symptom starts from the stems at the soil level with a brown lesion and with time the whole plant is dried out. Affected plants shows less vigor, leaves become discolored and dried, initially whole plant may seem wilted and eventually die (Plate 9).

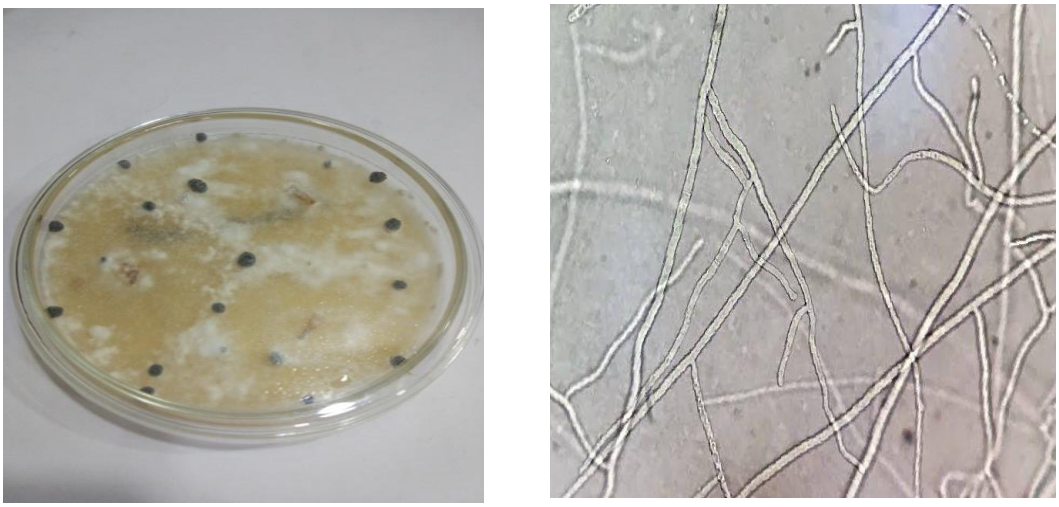
4.1.4.2. Identification of causal organism

The identified causal organism of crown rot disease of Gerbera was *Rhizoctonia solani*. Hypha with septation was observed under microscope, which had perpendicular branching that means the fungi had a characteristic of 90 degree branching (Plate 10B). The pure culture (Plate 10A) of *Rhizoctonia* was prepared. In the culture the colonies were moderately fast growing and produced white culture with dark brown to black sclerotia on PDA medium within 7 days which were visible with naked eyes.

4.1.4.3. Incidence and severity of the disease (%)

Drying was observed in 3 villages of Jhikorgacha union viz. Syedpara, Nilkonthonogor and Krishnachandrapur. Incidence varied significantly among them which ranged from 0 to 10.66%. The highest disease incidence was recorded in Syedpara (10.66%) and the lowest disease incidence was 5.33% in Nilkonthonogor. In case of disease severity, the highest disease severity was observed in Syedpara and the lowest was observed 0.83% in Krishnachandrapur. Other locations were fully free from the disease.

Plate 9. Symptom of Crown rot disease in Gerbera plant



(A) **(B)**

Plate 10. (A) Pure culture of *Rhizoctonia solani* and (B) Mycelium of *Rhizoctonia solani* under compound microscope

4.1.5. Flower blight disease of Gerbera

4.1.5.1. Symptomological study

The symptoms appears as brown to blackish spot on the flower from the tip of the petals. As the disease advances, these spots enlarge and take a look of blight. Finally the whole flower becomes distorted and blighted (Plate 11).

4.1.5.2. Identification of causal organism

The identified causal organism of flower blight disease of Gerbera was *Botrytis cinerea*.

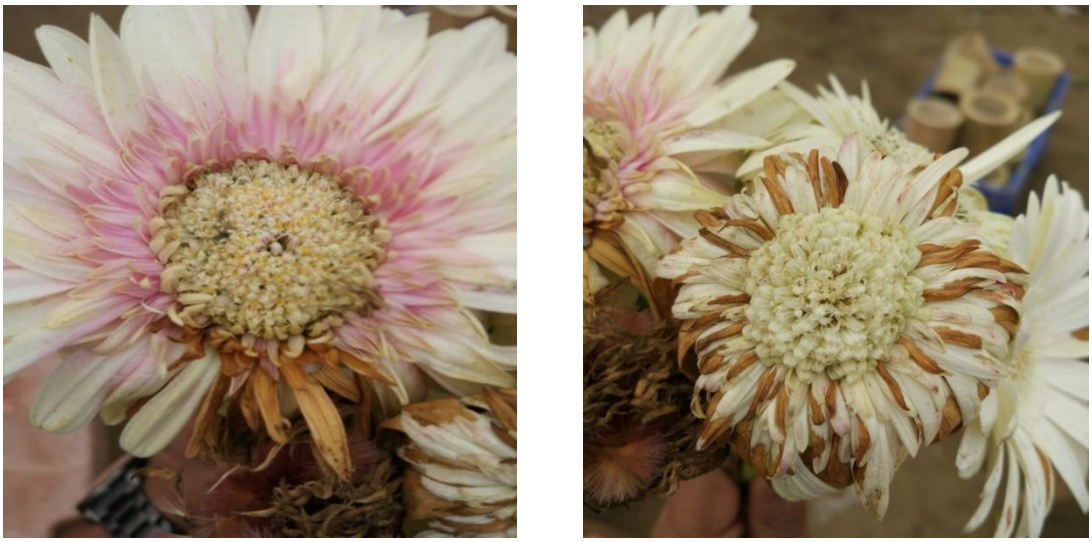
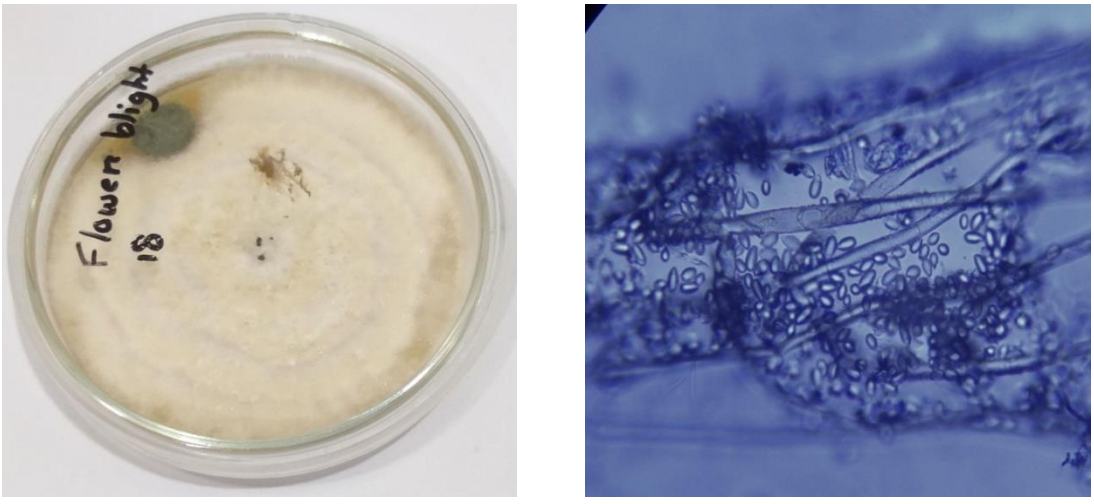


Plate 11. Symptoms of Flower blight disease of Gerbera



(A) **(B)**

Plate 12. (A) Pure culture of *Botrytis cinerea* and (B) Compound microscopic view of *Botrytis cinerea*

A hyphal mass with brown branched conidiophores was observed. Several hyaline and non-septate globose conidia were found under microscope. The spores were single celled and free (Plate 12B). The pure culture of *Botrytis cinerea* (Plate 12A) was prepared and in the culture the colonies of were moderately fast growing and produced whitish culture on PDA medium within 7 days.

4.1.5.3. Incidence and severity of the disease (%)

The disease was observed in 7 villages out of 18 in Jhikorgacha. Incidence of Flower Blight of Gerbera varied significantly among the locations from Godkhali to Syedpara and that ranged from 0 to 53.33% (Table 5). The highest disease incidence was recorded in Godkhali (53.33%) and the lowest disease incidence was 11.66% in Sharifpur. In case of disease severity, similar results were observed. Severity of Flower Blight of Gerbera also varied significantly. The highest disease severity was observed in Godkhali which is 21.66%. Moreover, in Sharifpur the lowest disease severity was observed which is 1.66%. Some locations were fully free from this disease.

Table 5. Disease incidence and severity of Flower blight of Gerbera

Locations	Disease Incidence (%)	Disease Severity (%)
Godkhali	**53.33 a**	**21.66 a**
Patuapara	0.00 e	0.00 d
Sadirali	0.00 e	0.00 d
Belemath	0.00 e	0.00 d
Dhalipara	23.33 cd	7.33 b-d
Panisara	0.00 e	0.00 d
Syedpara	0.00 e	0.00 d
Nilkonthonogor	30.00 bc	15.00 ab
Kuliya	0.00 e	0.00 d
Krishnachandrapur	16.66 cd	5.33 cd
Hariya	0.00 e	0.00 d
Nimtola	23.33 cd	10.00 bc
Baisha	0.00 e	0.00 d
Sharifpur	**11.66 de**	**1.66 d**
Chadpur	0.00 e	0.00 d
Mathuapara	40.00 ab	15.00 ab
Nirbashkhola	0.00 e	0.00 d
Shiorda	0.00 e	0.00 d
LSD (0.05)	14.97	8.11
CV (%)	44.23	62.52

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

4.1.6. Petal spot disease of Gerbera

4.1.6.1. Symptomological study

Circular to oval from dark brown to black color small spots were observed on petal surface. Gradually the petal surface is covered with numerous such lesions, which become rotten and dried within few days with a central cup shaped water soaked depression having a depth of 5-8 mm. After progression of this disease a concentric ring is appeared (Plate 13).

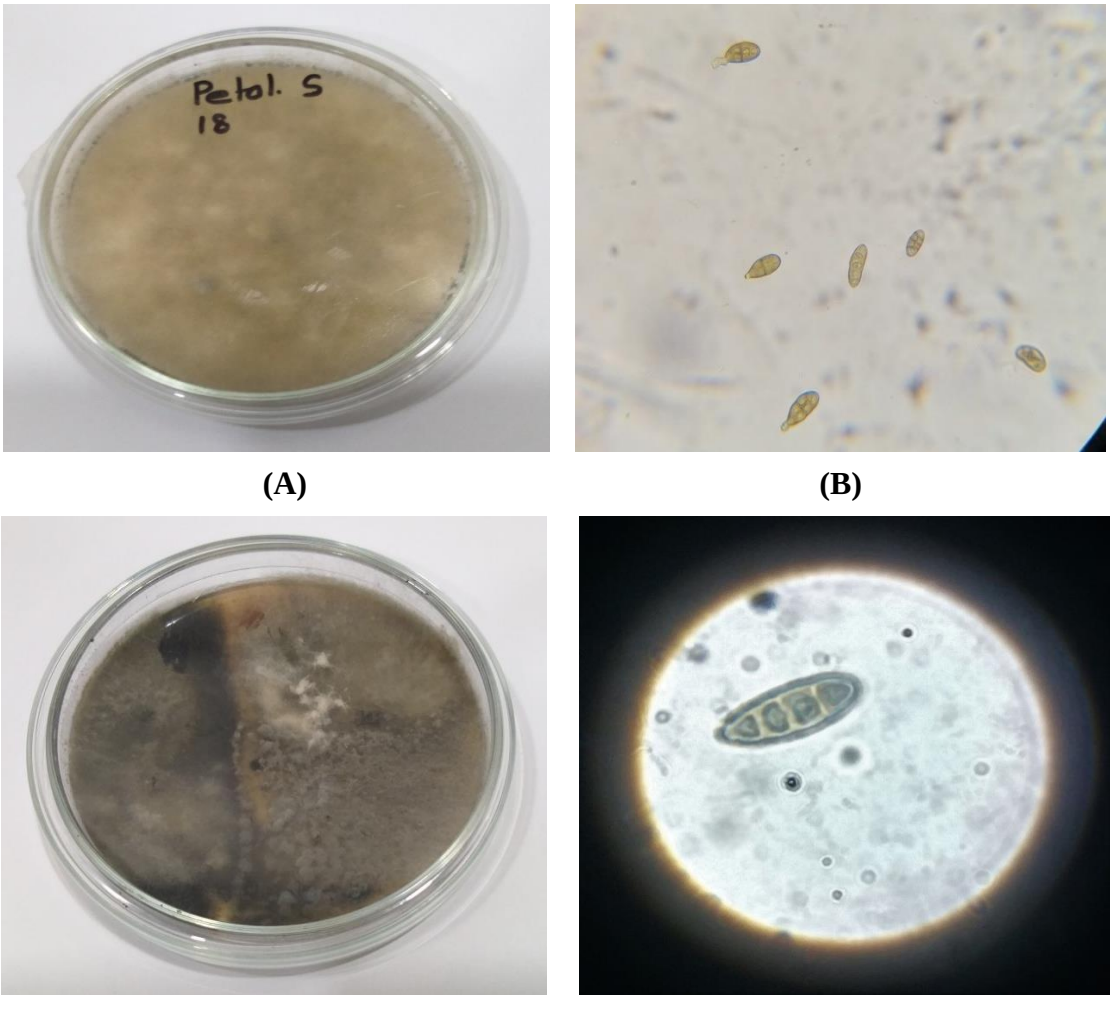
4.1.6.2. Identification of causal organism

The identified causal organism of petal spot disease of Gerbera was *Alternaria alternata*. 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 atthe 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 (Plate 14B). The pure culture of *Alternaria alternata* was prepared (Plate 14A). In the culture the colonies of *Alternaria* are moderately fast growing and produce dark brown to blackish culture on PDA medium within 7 days. An another fungus *Bipolaris* sp. was also found associated with the *Alternaria*. A pale brown colored, sympodial, straight and ellipsoid conidia were found which was fusiform and both ends were rounded (Plate 14D). The pure culture of *Bipolaris* sp. was prepared (Plate 14C). In the culture the colonies of were moderately fast growing and produce blackish culture on PDA medium within 7 days.

4.1.6.3. Incidence and severity of the disease (%)

This disease was recorded in only one location named Mathuapara. The Disease Incidence was 50% and Disease Severity was 17.66%. Other locations were fully free from this disease

Plate 13. Symptoms of Petal spot disease of Gerbera;



(A) **(B)**

(C) **(D)**

Plate 14. (A) Pure culture of *Alternaria alternate;* (B) Compound microscopic view of *Alternaria alternate;* (C) Pure culture of *Bipolaris* sp. and (D) Compound microscopic view of *Bipolaris* sp. (40X)

4.1.7. Foot and root rot disease of Gerbera

4.1.7.1. Symptomological study

Plants were observed failed to grow adequately and remained stunted. The foliage developed an off color. The fungus forms a network of hyphae over the plant surface, and the leaves, flowers, and stems eventually become covered with white, talcum-like colonies. Leaf symptoms include chlorosis and darkened midrib and veins followed by loss of turgor and desiccation. Symptomatic plants will usually have significant root and crown discoloration and deterioration (Plate 15). Infection appears more common after flowering. The disease was initiated as dark brown water soaked lesion on the stem and later spread through collar portion extending up to root hairs. Foliar yellowing and defoliation were the general aerial symptoms noticed in the affected plants. As the disease progresses the entire plant wilts and dies. No organism was isolated from this disease.

Plate 15. Symptoms of Foot and root rot disease of Gerbera

4.1.7.3. Incidence and severity of the disease (%)

Incidence of Foot and root rot disease varied significantly among the locations of Jhikorgacha and that ranged from 0 to 28.33% (Table 6). No disease was recorded in Hariya. The highest disease incidence was recorded in Godkhali (28.33%) and the lowest disease incidence was 2.66% in Chadpur. In case of disease severity, similar results were observed. Severity also varied significantly. The highest disease severity was observed in Godkhali. Moreover, in Syedpara the lowest disease severity was observed 0.66%.

Table 6. Disease incidence and severity of Foot and root rot of Gerbera

Locations	Disease Incidence (%)	Disease Severity (%)
Godkhali	**28.33 a**	**7.00 ab**
Patuapara	13.33 a-c	4.33 b-c
Sadirali	6.66 c	3.33 a -d
Belemath	5.33 c	3.00 b-d
Dhalipara	9.33 bc	4.33 a-c
Panisara	6.00 c	3.33 a-d
Syedpara	3.00 c	**0.66 cd**
Nilkonthonogor	3.00 c	2.83 cd
Kuliya	10.00 bc	1.33 cd
Krishnachandrapur	23.33 ab	7.33 a
Hariya	**0.00 c**	**0.00 d**
Nimtola	5.33 c	1.50 cd
Baisha	13.33 a-c	1.50 cd
Sharifpur	8.00 bc	1.00 cd
Chadpur	**2.66 c**	0.83 cd
Mathuapara	4.33 c	0.83 cd
Nirbashkhola	9.33 bc	2.66 cd
Shiorda	6.00 c	1.00 cd
LSD (0.05)	16.12	4.15
CV (%)	60.04	52.01

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

4.1.8. Leaf curl disease of Gerbera

4.1.8.1. Symptomological study

The primary symptom was characterized by distortion and discoloration of leaves followed by curling of leaves from their edge. The curled area became thick and puckered. Flowers of the infected plants were found under-developed and deformed in shape (Plate 16).

4.1.8.2. Identification of causal organism

No organism was identified as the cause of this disease. Most possibly any kind of virus is responsible for the disease.

Plate 16. Symptoms of Leaf curl disease of Gerbera

4.1.8.3. Incidence and severity of the disease (%)

The leaf curl disease was found in only one village which is Panisara. The disease incidence was recorded 2.33**%** and the severity was 1.16**%**. The other locations were totally free from this disease.

4.1.9. Mosaic disease of Gerbera

4.1.9.1. Symptomological study

Symptoms of infection in Gerbera initially appear as chlorotic mosaic patterns on leaves which are followed by necrosis and leaf distortion as the disease progresses (Plate 17).

4.1.9.2. Identification of causal organism

No causal organism was identified from this disease.

Plate 17. Symptoms of Mosaic disease of Gerbera

4.1.9.3. Incidence and severity of the disease (%)

The disease was observed in 9 villages out of 18 villages investigated in Jhikorgacha.

Table 7. Disease incidence and severity of Mosaic of Gerbera

Locations	Disease Incidence (%)
Godkhali	0.00 b
Patuapara	0.00 b
Sadirali	6.00 b
Belemath	4.00 b
Dhalipara	0.00 b
Panisara	2.33 b
Syedpara	**1.33 b**
Nilkonthonogor	0.00 b
Kuliya	9.33 ab
Krishnachandrapur	0.00 b
Hariya	7.66 b
Nimtola	0.00 b
Baisha	9.33 ab
Sharifpur	0.00 b
Chadpur	**20.00 a**
Mathuapara	0.00 b
Nirbashkhola	0.00 b
Shiorda	9.33 ab
LSD (0.05)	10.93
CV (%)	92.35

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

Incidence of Mosaic varied significantly among the locations that ranged from 0 to 20% (Table 7). The highest disease incidence was recorded in Chadpur (20%) and the lowest disease incidence was 1.33% in Syedpara. No disease was recorded in Godkhali, Patuapara, Dhalipara, Nilkonthonogor, Krishnachandrapur, Nimtola, Sharifpur, Mathuapra and Nirbashkhola.

4.1.10. Flower curl disease of Gerbera

4.1.10.1. Symptomological study

Initially the symptom appears as undersized and mal shaped flowers followed by curling of some of the petals. As the disease progresses entire flower is curled and wilted which can't be sold out (Plate 18).

4.1.10.2. Identification of causal organism

No causal organism was definitely identified for the development of the disease. Most possibly viruses are responsible for the disease.

Plate 18. Symptoms of Flower curl disease of Gerbera

4.1.10.3. Incidence and severity of the disease (%)

This disease was recorded in only one location named Godkhali. The Disease Incidence was 4.66% and Disease Severity was 0.83%. Other locations were fully free from this disease.

4.1.11. Flower abnormality disease of Gerbera

4.1.11.1. Symptomological study

Flowers were observed undersized and mal shaped. Distribution of petals was irregular surrounding pedicel. Lucrative look of the flower was interfered and market value is decreased in a great extent (Plate 19). Farmers' opinion is as the age of the plants increases, the disease also increases. Older plants showed more flower abnormalities than the new plants.

4.1.11.2. Identification of causal organism

It is a physiological disorder which may be caused by several factors like: Environmental adversity, nutrient imbalance, uneven distribution of water, soil aggregates or any other component of the climate.

Plate 19. Symptoms of Flower abnormality of Gerbera

4.1.11.3. Incidence and severity of the disease (%)

Incidence of Flower Abnormality disease of Gerbera varied significantly among the locations from Godkhali to Syedpara and that ranged from 0 to 5.33% (Table 8). The highest disease incidence was recorded in Godkhali (56.66%) and the lowest disease incidence was 5.33% in Syedpara. In case of disease severity, similar results were observed. Severity of Flower Abnormality disease of Gerbera also varied significantly. The highest disease severity was observed in Godkhali which is 26.66%. Moreover, in Syedpara the lowest disease severity was observed which is 2.5%. Baisha,Shiorda and Nirbashkhola were fully free from this disease.

Table 8. Disease incidence and severity of flower abnormalities of Gerbera

Locations	Disease Incidence (%)	Disease Severity (%)
Godkhali	**56.66 a**	**26.66 a**
Patuapara	41.66 a-c	16.33 a-c
Sadirali	8.33 ef	5.33 b-d
Belemath	21.66 c-e	6.66 b-d
Dhalipara	23.33 c-e	8.33 b-d
Panisara	23.33 c-e	10.00 b-d
Syedpara	**5.33 ef**	**2.50 d**
Nilkonthonogor	35.00 b-d	16.66 ab
Kuliya	13.33 ef	4.00 b-d
Krishnachandrapur	15.00 d-f	5.00 b-d
Hariya	11.66 ef	3.66 b-d
Nimtola	53.33 ab	16.66 ab
Baisha	0.00 f	0.00 d
Sharifpur	21.66 c-e	4.66 b-d
Chadpur	16.66 d-f	3.33 cd
Mathuapara	21.66 c-e	10.00 b-d
Nirbashkhola	0.00 f	0.00 d
Shiorda	0.00 f	0.00 d
LSD (0.05)	21.62	13.05
CV (%)	34.37	54.71

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

Experiment 2: Survey on socio-economic status of Gerbera farmers, production technologies and diseases of Gerbera in Jhikorgacha, Jashore district

The study was done through questionnaires and interviews. Physical field visits were also conducted to make a real picture of the diseases in Gerbera. The data collecting from the fields were analyzed through computer based software Statistix 10. The results obtained from the studies conducted in the survey areas are presented below sequentially in various forms and thus discussed as to extract the findings systematically in line with the objective of the research work.

4.2. Knowledge of Farmers on the Gerbera flower cultivation, Disease of Gerbera and their severity

The results of the farmers' knowledge on the Gerbera flower cultivation, Disease of Gerbera and their severity have been placed under the following sub-headings:

4.2.1. Survey on socio-economic status of Gerbera farmers

4.2.1.1. Gender of the farmers

There were 54 Gerbera farmers have been participated in the field survey at Jhikorgacha upazila in Jashore. Among them 90.74 % were male and rest 9.26 % of the farmers were female respectively (Table 9).

Table 9. Gender of the Gerbera flower farmers

Gender	No. of the respondent	Response (%)
Male	49	90.74
Female	5	9.26
Total	**54**	**100.0**

4.2.1.2. Age of Gerbera Farmers

Most of the farmers (51.85%) participated in the field survey at Jashore were 30 to 40 years old, which ranked first in the table (Table 10) and least (11.11%) of the farmers were below 30 years old. 24.08 % farmers were 40-50 years and 12.96 % farmers were above 50 years old respectively.

Table 10. Age of the farmers engaged in Gerbera flower cultivation

Ages (years)	**No. of respondent [N=54]**	**% Response**
<30	6	11.11
30-40	28	51.85
40-50	13	24.08
50<	7	12.96
Total	**54**	**100.0**

4.2.1.3. Education of the Gerbera flower farmers

Education level of most (35.19 %) of the farmers participated in the survey of Gerbera at Jashore were class I-V which ranked first in the Table no 11. Least (5.55%) studied up to HSC. 7.41 % of the farmers were post graduate. But a big portion (20.37%) of them was illiterate.

Table 11. Education level and their percentage of the Gerbera flower farmers

Education level	**No. of respondent**	**% Response**
Illiterate	11	20.37
Class 1-5	19	35.19
Class 6- SSC	12	22.22
HSC	3	5.55
Degree	5	9.26
Masters	4	7.41
Total	**54**	**100.0**

4.2.1.4. Land utilization under Gerbera flower cultivation

Most (53.70%) of the Land utilized by the farmers of Jashore ranges from 2 to 5 bigha, among those land utilization ranging from 2 to 5 bigha ranked first (53.70%) (Table 12). Below 8 bigha land area is utilized by least (5.56 %) number of farmers.

Table 12. Land utilization under Gerbera flower cultivation

Land utilization (Bigha)	**No. of respondent**	**% Response**
<2	14	25.93
2-5	29	53.70
5-8	8	14.81
8<	3	5.56
Total	**54**	**100**

4.2.1.5. Farmers' opinion on the land utilization pattern for Gerbera flower cultivation

According to the farmers opinion, on an average total land area owned of 54 farmers at Jashore was 71.77 ha, of which cultivable land under total land owned was 65.48 ha. The land under Gerbera flower cultivation was 30.5 ha. From these findings it was revealed that a large portion (46.58%) of the cultivable lands of the farmers was engaged under Gerbera flower cultivation (Table 13).

Table 13. Farmers' opinion on the land utilization pattern for Gerbera flower cultivation

Land utilization pattern	Land size (Trimmed Mean)	
	Bigha	Hectare
1. Total land area owned	538.03	71.77
2. Cultivable land under total land owned	491.10	65.48
3. Land area under Gerbera flower cultivation	229.50	30.5

***1 hectare = 7.5 bigha**

4.2.1.6. Duration (year) engaged in Gerbera flower cultivation

At Jashore the farmers were engaged in Gerbera cultivation for more than 15 years. 12.96% of the total farmers are cultivating Gerbera from more than 15 years which ranked last in the table (Table 14). Out of 54 farmers, most of them were cultivating Gerbera ranging from 5 to 10 years (44.45%) which ranked first. About 22.22% of the farmers has been recently engaged in Gerbera cultivation who are cultivating from below 5 years.

Table 14. Duration (year) engaged in Gerbera flower cultivation

Duration (year)	No. of respondent	% Response
<5	12	22.22
5-10	24	44.45
10-15	11	20.37
15<	**7**	12.96
Total	**54**	**100**

4.2.1.7. Plant age status of the surveyed field

At Jashore, in most of the fields (57.41%) plant age was between 2 to 3 years which is ranked first in the table. A few (9.26%) field were observed with less than 1 year old plants. 3-4 years aged plants were observed in 14.81% field (Table 15).

Table 15. Plant age status of Gerbera

Plant age (year)	No. of field	% field
<1	5	9.26
1-2	10	18.52
2-3	31	57.41
3-4	8	14.81
Total	**54**	**100**

4.2.2. Survey on production technology used by Gerbera farmers

4.2.2.1. Source of planting materials used by the Gerbera farmers for cultivation

Farmers were collecting planting materials of Gerbera from very limited sources. Out of 54 farmers at Jashore, most (31.48%) of them were collecting planting materials of Gerbera from nursery. The importers and seed dealers import Gerbera planting materials mostly from India of different hybrid varieties. Quality hybrid Gerbera varieties were found less in numbers comparatively in lower price than imported seedlings and some farmers collected there Gerbera seedlings from importers (11.1%) where they found rich quality hybrid Gerberas (Table 16). A certain number (27.78 %) of farmers have started to preserve plantlets personally as it is more reasonable in production cost. Few (7.41%) collects materials from local market too.

Table 16. Farmers' opinion on the source of planting materials used for Gerbera cultivation

Source of Gerbera planting materials	Response	
	No. of respondent [N=54]	% Response
1. Nursery	17	31.48
2. Directly from importer	6	11.1
3. Personal Preservation	15	27.78
4. Local market	4	7.41
5. Farmers neighbor seed	5	9.26
6. Dealer (Tissue Culture)	7	12.97

4.2.2.2. Fertilizer application on Gerbera fields

Total amount of Cow dung is applied once during land preparation @7000kg/ha with TSP and MOP @35kg/ha and 30kg/ha respectively as basal dose. P and K are applied again with N, Boron and zinc as top dressing in first three months after plantation @1 month interval. From the fourth month when flowering starts rest of NPK ,boron and zinc are applied @ 60, 35, 65, 1 and 2 kg/ha @2 weeks interval respectively (Table 17).

Table 17. Fertilizer application on Gerbera fields

Manure/Fertilizer	Dose per ha (kg)	Basal Dose per ha (kg)	Top dressing(kg/ha)	
			First*	Second**
Cow dung	7000	Entire amount	-	-
Urea	115	-	55	60
TSP	130	35	60	35
MOP	160	30	65	65
Boron	3	-	2	1
Zinc	4	-	2	2

*First three months after plantation @ 1 month interval
**From fourth month when flowing starts @ 2 weeks interval

4.2.2.3. Cost involved in pest management of Gerbera cultivation

According to the farmers opinion total cost involved for pest management of Gerbera is around 24000 taka per year per bigha (Table 18). 5000 taka is for disease management and the rest is for insects and weeds. Insect and weed management each needs 8000 taka per year per bigha. 3000 taka is needed for other pest management.

Table 18. Cost involved in pest management of Gerbera cultivation

Cost/bigha/year (Tk.)			Other pest control cost tk./bigha/year
Disease	**Insects**	**Weeds**	3000
5000	8000	8000	
			Total: 24000

4.2.2.4. Buyer of Gerbera from farmers

Among the 54 farmers 46.29% reported that they sell the flowers through middle man. Least (3.70%) number of farmers can sell directly to the export company (Table 19). Some (38.89%) of the farmers can sell directly too. Companies buy from some (7.42%) farmers too.

Table 19. Buyer of Gerbera from farmers

Buyer	No. of respondent [N=54]	% Response
Directly	21	38.89
Middle man	25	46.29
Company	4	7.42
Association	2	3.70
Others	2	3.70
Total	**54**	**100.0**

4.2.2.5. Cost Involved for Gerbera flower Production/bigha

At Jashore, cost of production of Gerbera cultivation was more or less same of all farmers. Most of the farmers practice shade culture for what the Gerbera is most costful cultivation among all the cut flowers. The open culture has less cost for production, but there produced less quality flower sticks, more diseases infested and farmers got less market price than these which produced in shade culture. Moreover, the Gerbera plants can not withstand with scorching sunlight. Again, in shade culture, there produced very high quality flowers, less infested by diseases and very easy for managements and farmers got more market price. On average 3,00,000 tk/bigha was involved in shade culture during first year of planting (Table 20). Shade preparation is a big portion of the total production cost of Gerbera. The cost was varied year to year. Generally the farmers keep the Gerbera plants in the shade up to 3 to 4 years. After that they replanted the seedlings. Another big cost goes for the planting material. Gerbera plantlet is the most costly planting materials among all the cut flowers. On average, the farmers purchase the plantlets at maximum 100 taka and minimum 80 taka depending on the sources and other factors.

Table 20. Cost involvement in Gerbera Cultivation (Bigha/year)

Cost involvement	**1st year Taka/Bigha**	**2nd year Taka/Bigha**	**3rd year Taka/Bigha**	**4th year Taka/Bigha**
Land preparation	15,000	-	-	-
Shade preparation	3,00,000	-	-	-
Planting Materials	7,80,000	-	-	-
Weeding (2 times/month) * 8 persons(300 Tk/person)	57,600	57,600	57,600	33,000
Irrigation	10,000	10,000	8,000	6,500
Pesticide	15,000	15,000	18,000	13,000
Picking and packaging	32,400	43,200	43,200	32,400
Other cost	5,000	5,000	5,000	5,000
Total cost	**12,15,000**	**1,26,000**	**1,31,800**	**89,900**

[Weeding -2 times/month * 8 persons, 300 Tk/person, Planting Materials : 7 plants/ m^2 * 100tk/plant, Picking and packaging 1st and 4th year: 3 times/month , 3 person*300tk, 2nd and 3rd year:4 times/month , 3 person*300tk]

Therefore, around 7,80,000 taka cost involves initially for the purpose of planting materials per bigha. Weeding is a must doing inter cultural operation of Gerbera as it is considered as a major pest of this flower which costs 51000 taka/bigha/year on an average. Except the irrigation, pesticides, picking and packaging, some other costs also may be involved which assumed 5000 taka/year. So according to the farmers opinion, a total cost of production is assumed which is figured as 15,62,700 taka/bigha/4 year.

4.2.2.6. Benefit Cost analysis of Gerbera (Bigha/year)

The production of flower sticks was varied and depended upon different factors. The flower sticks productions was lower initially and gradually increased with time. Generally Gerbera plants gave higher and quality sticks at 2nd and 3rd year. After that the production was decreased. About on average 2,40,000 sticks/year/bigha was produced in first year. 27,00,000 sticks/year/bigha was produced in 2nd year and 60,000 sticks/year/bigha was produced in the 4th year. In the peak season farmers got about 12 Tk/stick, in off peak they got about 4 Tk/stick and on average 8 Tk/stick. On some special days and occasions such as international mother language day, victory day, valentine's day the demand of flowers was high and farmers get more price of flowers. They got upto 15 Tk/stick on these occasions. On average the Net profit comes from Gerbera cultivation is about 49,17,300 Tk/Bigha/4 years (Table 21).

Table 21. Benefit Cost analysis of Gerbera (Bigha/year)

Cultivation Year	Production (Sticks/year)	Price (Tk/stick)	Total cost Tk (Bigha/year)	Total Income Tk (Bigha/year)	Net profit Tk (Bigha/year)
1st	2,40,000	Peak: 12 off Peak:4 Average:8	12,15,000	19,20,000	7,05,000
2nd	2,70,0000	Peak: 12 off Peak:4 Average:8	1,26,000	21,60,000	20,34,000
3rd	2,40,000	Peak: 12 off Peak:4 Average:8	1,31,800	19,20,000	17,89,000
4th	60,000	Peak: 12 off Peak:4 Average:8	89,900	4,80,000	3,90,100
Total			**15,62,700**	**64,80,000**	**49,17,300**

4.2.3. Survey on farmers opinion on diseases of Gerbera

4.2.3.1. Incidence of disease infections in the Gerbera field

Considering the opinion expressed by the farmers, the incidence of diseases of Gerbera in field were leaf spot, leaf blight, flower blight, mosaic, drying, leaf curl, flower curl, flower abnormality ,foot and root rot, stem rot, petal spot (Table 22). Among these diseases Leaf blight, Leaf spot, Flower abnormality, Flower blight and Stem rot ranked first, second, third, fourth and fifth expressed by the 53.7 %, 44.4%, 31.4 %, 25.9 % and 16.6 % farmers, respectively. More or less all stages of the Gerbera crop were attacked by the diseases, where the dominating disease such as leaf spot, leaf blight and flower blight caused infections at seedling, vegetative and reproductive stages.

Table 22. Farmers' response on the incidence of disease infections in the Gerbera field

Name of the diseases	No. of respondent N=54	% of respondent	Stage of crop infected	Farmers' opinion on disease Infection intensity			
				High	Medium	Low	Total
1. Leaf spot	24	44.4	Seedling, vegetative, reproductive	8.00	14.00	78.00	100.0
2. Leaf blight	29	53.7	Seedling, vegetative, reproductive	1.40	31.00	67.60	100.0
3. Stem rot	9	16.6	Vegetative and reproductive stage	4.60	13.80	81.60	100.0
4. Crown rot	6	11.1	Vegetative and reproductive stage	6.60	35.60	57.80	100.0
5. Flower blight	14	25.9	Seedling, vegetative, reproductive	12.50	12.50	75.00	100.0
6. Petal spot	6	11.1	Vegetative stage	-	25.30	74.70	100.0
7. Foot and root rot	14	25.9	Vegetative and reproductive stage	3.10	30.50	66.40	100.0
8. Leaf curl	4	7.4	Vegetative and reproductive stage	13.50	32.40	54.10	100.0
9. Mosaic	8	14.8	Reproductive stage	19.60	20.00	60.40	100.0
10. Flower curl	7	12.9	Reproductive stage	-	30.00	70.00	100.0
11. Flower abnormality	17	31.4	Reproductive stage	-	20.70	79.30	100.0

The infestation intensity of the maximum diseases was low to medium expressed by the most of the farmers. On the other hand, Leaf blight caused damage with high intensity expressed by the 53.7% farmers.

4.2.3.2. Relationship among insect pest, disease and weed infestation in Gerbera field

At Jashore, most of the farmers (87.04%) expressed their opinion that there was positive relationship among insect pest, disease and weed infestation in the field, whereas only 12.96% farmers expressed their negative opinion (Table 23).

Table 23. Farmers' opinion on the relationship among insect pests, diseases and weed infestation in the Gerbera field

Types of response	Response on the relationship	
	No. of respondents	% Response
Yes	47	87.04
No	7	12.96
Total	**54**	**100**

4.2.3.3. Degree of relationship among insect pests, diseases and weed infestation in the Gerbera field

There was a positive and high degree of relationship among insect pest and disease incidence with weed infestation; as well as disease infection with the incidence of insect vector in the Gerbera field (Table 24). This result indicates insect infestation and disease infection become high when weed infestation become high expressed by the 57.41% and 53.70% farmers at Jashore i.e., insect infestation and disease infection increased with the increase of the weed infestation. Similarly, disease infection become high when insect vector populations become high expressed by the 25.92% i.e., disease infection was increased with the increase of the vector population. The minimum number of farmers (25.93%) did not reply about the degree of relationship between disease infection and vector population. From this finding it was revealed that weed infestation enhanced the insect pest population and disease incidence; similarly, insect vector also enhanced the incidence of disease infection in the Gerbera field. Thrips and Red Spider Mites are the major pest of Gerbera and act as vectors. Some other pests such as Mealy bug, Aphid, leaf miner, White fly, Caterpillars, sawfly etc are also damaged Gerbera.

Table 24. Farmers' response on the degree of relationship among insect pest, disease and weed infestation in the Gerbera field

Relationship	degree of relationship	No. of respondents [N=54]	% Response
Insect infestation high when weed infestation	High	31	57.41
	Medium	15	27.78
	Low	5	9.26
	Don't Know	3	5.56
	Total	**54**	**100**
Disease infestation high when weed infestation	High	29	53.70
	Medium	12	22.22
	Low	8	14.81
	Don't Know	5	9.26
	Total	**54**	**100**
Disease infestation high when vector insect	High	14	25.92
	Medium	23	42.59
	Low	11	20.37
	Don't Know	6	11.11
	Total	**54**	**100**

4.2.3.4. Probable sources of Gerbera pests and disease comings

The probable sources of diseases were from seed borne diseases in seedlings (cuttings), imported hybrid seedlings, within country, soil borne, local planting materials, use of imbalanced fertilizer, Ineffectiveness of Pesticides (Table 25). Among these within country was ranked first which played role as source of pest and disease infestation on Gerbera expressed by the maximum (25.93%) farmers participated in the program. Second most important source was the seedlings expressed by the maximum (20.3%) farmers.

Table 25. Farmers response on the probable sources of Gerbera disease

Probable sources	Response	
	No. of respondents	% Response
1. Local seedlings	11	20.3
2. Imported seedlings	4	7.4
3. Air borne	14	25.93
4. Soil borne	9	24.06
5. Insects	6	11.11
6. Use of imbalanced fertilizer	1	1.85
7. Through irrigation water	1	1.85
8. Other sources (if any)	4	7.42
Total	**54**	**100**

4.2.3.5. Probable ways of spreading of Gerbera disease

The probable ways of spread out of Gerbera diseases as depicted in Table 26.

Table 26. Farmer's response on the probable ways of spread of Gerbera disease

Probable ways of spread of Gerbera disease	No. of respondents [N=54]	% Response
1. Affected seedlings	14	25.93
2. Infested soil	4	7.41
3. Weed and Grasses	6	11.11
4. Insects	6	11.11
5. Wind	3	5.56
6. Irrigation water	1	1.85
7. Crop debris and Manure	12	22.22
8. Rain splashing	1	1.85
9. Agricultural implements	2	3.7
10. During intercultural operations	5	9.26
Total	**54**	**100**

Affected seedlings and Crop debris and Manure were the most important ways those were ranked first and second respectively expressed by the maximum (25.93% and 22.22%, respectively) farmers. Other important ways of spread of Gerbera pests and disease were weeds, wind, grasses, and Rain splashing expressed by the 11.11%, 5.56% and 1.85% farmers at Jashore. Irrigation water, Crop debris and Manure, inter-culture with other crops were also played role as probable ways in spreading Gerbera pests and disease.

4.2.3.6. Measures taken to control diseases and pest of Gerbera in the field

At Jashore, among 54 farmers, majority (70.37%) of them said that they took any measures to control diseases and pest of Gerbera in the field. A small portion (9.26%) of the farmers did not reply the matter, i.e., whether they took any measures or not to control Gerbera diseases and pests in the field (Table 27).

Table 27. Farmers' response on measures taken to control disease of Gerbera in the field

Types of response	Response on the measures taken to control pests	
	No. of respondents	% Response
Yes	38	70.37
No	11	20.37
Not replied	5	9.26
Total	**54**	**100**

4.2.3.7. Types of measures taken to control disease of Gerbera in the field

Among 54 farmers at Jashore, majority (58.64%) of them had taken both preventive and curative measures to control diseases of Gerbera in the field.

Table 28. Farmers' response on the types of measures taken to control disease of Gerbera in the field

Types of measures	Response (%) on the types of measures taken	
	No. of respondent [N=54]	% Response [100%]
1. Preventive	17	31.48
2. Curative	14	25.93
3. Both	23	42.59

Whereas 31.48% farmers said that they took preventive measures and 25.93% farmers took curative measures for the control Gerbera diseases in the field (Table 28).

4.2.3.8. Measures and ways of pest and disease control

At Jashore, among different methods applied for the management of Gerbera pests and diseases in the field, most of the farmers applied pesticides to control insect pests, diseases and weeds (98.15%) i.e., application of pesticides was the most widely used method to control Gerbera pests and diseases in the field (Table 29). They consider it the better management practices for disease and pest control. Considering the farmers' opinion, the better management practices for disease control in Gerbera were the spraying of fungicides such as Dithane M-45, Tilt, Mancozeb, Acrobat MZ, Amamectin benzoid, Abamectin etc. The concentration was used about 2ml/L of water in case of liquid fungicide and insecticide (Amamectin benzoid, Abamectin) and for Mancozeb they used 3gm/L water as spray.

Table 29. Farmers' response on the methods of disease control applied in the Gerbera field

Methods of disease control	Response on the methods applied	
	Nos.	% Response
1. Through use of pesticides	53	98.15
2. Use of resistant variety	0	0
3. Use of imported hybrid Gerbera	29	53.70
4. Tissue culture seedling	18	33.33
5. Cultural practices	41	75.93
6. Controlled cultivation (under poly-shed)	25	46.30
7. IPM method	9	16.67
8. Others (if any)	6	11.11

4.2.3.9. Farmers response on receiving assistance and service for controlling diseases of Gerbera

Most of the farmers responded positive about receiving assistance and other services from different sources. 29.63% of the farmers said that the field level officers visit the fields regularly and observe the disease development (Table 30). 11.11% farmers reported to have suggestions from the experts about different diseases. 37.07% of the 54 farmers mentioned that the field level officers often sit in meetings about their problems. 3.71% farmers have given no opinion.

Table 30. Farmers response on receiving assistance and service for controlling diseases of Gerbera

Assistance and service	No. of respondent [N=54]	% Response
1. Visit by the field level officers (DAE)	16	29.63
2. Experts suggestion	6	11.11
3. Field day	6	11.11
4. Field demonstration	4	7.41
5. Meeting with the field level officers (SAAO)	20	37.03
6. No opinion	2	3.71
Total	**54**	**100.0**

4.2.3.10. Major problems of Gerbera cultivation

Most of the farmers responded had faced various problems like high price of planting materials, pest and insect attack, diseases, transportation problem etc on Gerbera cultivation. Among these about 77.77% of the farmers said that they were facing High price of planting materials. 16.66% farmers reported to have unorganized market. 61.11% of the 54 farmers mentioned that insect and pest are attack on their field during cultivation (Table 31).

Table 31. Major problems of Gerbera cultivation

Problems	No. of respondent [N=54]	% Response
1. High price of planting materials	42	**77.77**
2. Insect pests	33	61.11
3. Diseases	26	48.14
4. Transportation	18	33.33
5. Natural hazards	17	31.48
6. Low price of the flower	29	53.70
7. Unorganized market	9	16.66

4.2.3.11. Farmer's suggestions for better managements of diseases of Gerbera

Some operations should be involved for better management of disease of Gerbera like Use of healthy planting materials, Effective use of insecticides & pesticides, Proper inter-culture operation, Regular field visit, more research. Most (88.88%) of the farmers responded were positive about Effective use of insecticides & pesticides for better management of disease of Gerbera. About 66.77% farmers suggested about use of healthy planting materials and least (16.66%) number of farmers emphasized on more research (Table 32).

Table 32. Farmer's suggestions for better managements of diseases of Gerbera

Suggestions	No. of respondent [N=54]	% Response
1. Use of healthy planting materials	36	66.77
2. Effective use of insecticides & pesticides	48	88.88
3. Proper inter-culture operation	11	20.37
4. Regular field visit	18	33.33
5. More research on disease management	9	16.66

CHAPTER V

DISCUSSION

Between the two experiments under this study, the first one was field investigation on Gerbera diseases in Jashore district. The data were collected in normal epiphytic condition and analyzed by computer software STATISTIX-10. In total, there 11 diseases were identified. The diseases were Alternaria leaf spot, Botrytis leaf blight, Fusarium stem rot, Drying, Foot and root rot, Leaf curl by, Flower curl, Flower abnormality-a physiological disorder, Flower blight and petal spot. In case of Alternaria leaf spot, dark brown color, scattered and small dot-like spots were observed initially which turned blackish later with formation of concentric ring. It was one of the common diseases of Gerbera which is caused by *Alternaria alternata*. The disease was found on all the 18 locations of Jhikorgacha Upazila. All the fields were affected almost more or lesion same extent. Kuliya had the highest disease incidence which is 43.33% whether the highest disease severity was found at Nilkonthonogor and Godkhali which is 11.66%. Belemath under Godkhali union had the lowest (8.33%) disease incidence, whether the lowest disease severity was found at Sharifpur and Mathuapara under Navaron Union. Both the disease incidence and severity varied significantly with the locations. Similar observation was found by Bhat *et al.* in Kashmir in the year of 2013. The disease was prevalent in all the flower growing areas of Kashmir valley surveyed in 2009. The overall mean disease incidence and intensity ranged from 50.7 to 67.5% and 19.2 to 28.2%, respectively. The highest disease incidence (60.72%) irrespective of phonological stages and intensity 24.96% was recorded in district Srinagar. The lowest level of disease was in district Anantnag (20.0%).

Again the Botrytis leaf blight disease was found as water soaked lesion which blighted the whole leaf later. It also was recorded at all the locations. In Godkhali union, Patuapara was reported with the highest incidence which was 50%. But the highest (16%) severity was found at Sadirali. Chadpur under Navaron union had the lowest incidence which was 8.33% and the lowest (0.83%) severity found at Mathuapara of the same union.

However, the stem rot disease caused by *Fusarium oxysporum* f. sp. *chrysanthemi* was found as brown discoloration with stunted and chlorotic leaves.It was found at only two locations. Incidence ranged from 10.00 to 11.66%. The highest disease incidence was recorded in Syedpara (11.66%) and the lowest disease incidence was 10% in Patuapara. Similarly severity of stem rot was observed in Syedpara was 4.33% and in Patuapara was 4.66%. Other locations were fully free from the disease. Drying was another disease which was observed in only 3 villages of Jhikorgacha union. Other locations were free from this disease. The disease starts from the leaves and with time the whole plant dries out. It is caused by *Rhizoctonia solani*. The highest incidence of this disease was recorded in Syedpara (10.66%) and the lowest was 5.33% in Nilkonthonogor. In case of disease severity, the highest disease severity was observed in Syedpara and the lowest was observed 0.83% in Krishnachandrapur. Rather, the foot and root rot disease is also a very common disease of Gerbera. Plants were observed failed to grow adequately and remained stunted due to this disease. The highest disease incidence was recorded in Godkhali (28.33%) and the lowest was 2.66% in Chadpur. In case of disease severity, similar results were observed. Severity also varied significantly. The highest disease severity was observed in Godkhali. Moreover, in Syedpara the lowest disease severity was observed 0.66%. No disease was recorded in Hariya. In 2006, Minuto *et al.* also observed that two greenhouse farms in the region of Guarapuava, Paraná, Brazil, exhibited symptoms of a wilt disease. Affected plants were stunted and developed yellow leaves unilaterally with initially brown and eventually black streaks in the vascular system. The first symptoms occurred 2 months after transplanting during the hottest period of the summer with an average temperature of 27 °C.

Moreover, Foot and root rot disease was observed. Plants were observed failed to grow adequately and remained stunted. Incidence of foot and root rot disease varied significantly among the locations of Jhikorgacha and that ranged from 2.667 to 28.33%. No disease was recorded in Hariya. The highest disease incidence was recorded in Godkhali (28.33%) and the lowest disease incidence was 2.66% in Chadpur. In case of disease severity, similar results were observed. Severity also varied significantly. The highest disease severity was observed in Godkhali. Moreover, in Syedpara the lowest disease severity was observed 0.66%. A same type of sampling survey was conducted by Bhat *el al.* in Thrissur district of Kerala on the occurrence of root rot disease in Gerbera which revealed

that the disease was confined only to protected conditions. The disease was observed in a hydroponic unit which was more pronounced in July-August with a percent disease intensity of 69.44. Symptoms like stem or collar rot resulted in fatal infection with complete death of the plant. Pathogenicity of the isolate was carried out by soil inoculation and Microdroplet inoculation technique (MDIT). Cultural, morphological and molecular characterization along with the description of symptom of root rot disease confirmed the identification of the pathogen as *Phytophthora cryptogea*.

Leaf curl, a viral disease was also identified in only one location which is Panisara. It seemed a very rare disease in Jashore. The primary symptom of this disease was characterized by distortion and discoloration of leaves followed by curling of leaves from their edge. Flowers of the infected plants were found under-developed and deformed in shape. The disease incidence was recorded 2.33**%** and the severity was 1.16**%**. Mosaic is an another viral disease which was found at 9 locations of Jhikorgacha Upazila. Symptoms of infection initially appear as chlorotic patterns on leaves which are followed by necrosis and leaf distortion as the disease progresses. The highest incidence of this disease was recorded in Chadpur (20%) and the lowest disease incidence was 1.33% in Syedpara. In case of severity, similar results were observed. The highest severity was recorded in Chadpur which was 7.67 and the lowest disease severity was observed 0.66% in Syedpara. No disease was observed in Godkhali, Patuapara, Dhalipara, Nilkonthonogor, Krishnachandrapur, Nimtola, Sharifpur, Mathuapra and Nirbashkhola. Another viral disease, flower curl was identified in only one location which is Godkhali. The Incidence was 4.66% and Severity was 0.83%. Other locations were fully free from this disease. Mumford et al. (1996) reported about the same disease in greenhouse grown Gerbera and Chrysanthemum. They displayed symptoms resembling associated with Tomato Spotted wilt Virus. Symptomatic plants showed irregular chlorotic blotches. Whipker (2014) and Marvic and Ravnikar (2001) also observed the same disease. They both reported that TSWV is responsible for the disease.

Flower abnormality is a physiological disorder, which was much more major in some fields like Godkhali, Patuapara and Nimtola. Flowers were observed undersized and mal shaped. The highest disease incidence was recorded in Godkhali (56.66%) whether the lowest disease incidence was 5.33% in Syedpara. Moreover, the highest disease severity

was observed in Godkhali which is 26.66% and in Syedpara the lowest severity was observed which is 2.5%. Baisha, Shiorda and Nirbashkhola were fully free from this disease. Again a symptom appeared as brown to blackish spot on the flower from the tip of the petals was observed which was named as flower blight later. Finally the whole flower becomes distorted and blighted. The highest incidence of this disease was recorded in Godkhali (53.33%) and the lowest 11.66% in Sharifpur. Severity of Flower Blight of Gerbera also varied significantly. The highest severity was observed in Godkhali which is 21.66%. Moreover, in Sharifpur the lowest disease severity was observed 1.66%. Some locations were fully free from this disease. Again, Circular to oval from dark brown to black color small spots were observed on petal surface which was identified as petal spot later and *Alternaria* sp. and *Bipolaris* sp. were isolated from there in form of association. This disease was recorded in only one location named Mathuapara. The Disease Incidence was 50% and Disease Severity was 17.66%. Other locations were fully free from this disease

The second experiment was survey on socio-economic status of Gerbera farmers, production technologies and diseases of Gerbera in Jashore district which was carried out through questionnaires and interviews. 54 farmers were selected from 18 villages for the interview. Physical field visit was also done to make a real picture. Among the farmers 90.74% were male and rest 9.26% of the farmers were female. Most of the farmers (51.85%) participated in the field survey at Jashore were 30 to 40 years old and least (11.11%) of them were below 30 years old. 24.08 % farmers were 40-50 years and 12.96% farmers were above 50 years old respectively.

However, the education level was also taken in consideration on the survey. 4 of the farmers were post graduate. But education level of most (35.19%) of them was class I-V. Again, a considerable portion (20.37%) of them was illiterate. Most (53.70%) of the Land utilized by the farmers ranges from 2 to 5 bigha, among those land utilization ranging from 2 to 5 bigha ranked first (53.70%). Below 8 bigha land area is utilized by least (5.56%) number of farmers. But on an average total land area owned of 54 farmers at Jashore was 71.77 ha, of which cultivable land under total land owned was 65.48 ha. The land under Gerbera flower cultivation was 30.5 ha. From these findings it was revealed that a large portion (46.58%) of the cultivable lands of the farmers was engaged under Gerbera flower cultivation.

However, the farmers were engaged in Gerbera cultivation for more than 15 years. 12.96% of the total farmers are cultivating Gerbera from more than 15 years. Out of 54 farmers, most of them were cultivating Gerbera ranging from 5 to 10 years (44.45%). About 22.22% of the farmers have been recently engaged in Gerbera cultivation who are cultivating from below 5 years. During the survey, in most of the fields (57.41%) plant age was between 2 to 3 years. A few (9.26%) field were observed with less than 1 year old plants. 3-4 years aged plants were observed in 14.81% field.

The farmers were collecting planting materials of Gerbera from very limited sources for cultivation. Out of 54 farmers, most (31.48%) of them were collecting planting materials from nursery. The importers and seed dealers import planting materials mostly from India of different hybrid varieties. Quality hybrid varieties were found less in numbers comparatively in lower price than imported seedlings and some farmers collected there seedlings from importers (11.1%) where they found rich quality hybrid Gerberas. A certain number (27.78%) of farmers have started to preserve plantlets personally as it is more reasonable in production cost. Few (7.41%) collects materials from local market too.

During the survey, the fertilizer application pattern was also recorded as per the opinion of the farmers. Total amount of Cow dung is applied once during land preparation @ 7000kg/ha with TSP and MOP @ 35kg/ha and 30kg/ha respectively as basal dose. P and K are applied again with N, Boron and zinc as top dressing in first three months after plantation @ 1 month interval. From the fourth month when flowering starts rest of NPK ,boron and zinc are applied @ 60, 35, 65, 1 and 2 kg/ha @ 2 weeks interval respectively. Again, a definite amount of cost is involved for pest management too. According to the farmers opinion total cost involved for pest management of Gerbera is around 24000 taka per year per bigha. 5000 taka is for disease management and the rest is for insects and weeds. Insect and weed management each needs 8000 taka per year per bigha. 3000 taka is needed for other pest management.

Moreover, Among the 54 farmers 46.29% reported that they sell the flowers through middle man. Least (3.70%) number of farmers can sell directly to the export company. Some (38.89%) of the farmers can sell directly too. Companies buy from some (7.42%) farmers too.

Again, the production cost of Gerbera cultivation was more or less same of all farmers. Most of the farmers practice shed culture what made the Gerbera cultivation most costly among all the cut flowers. The open culture has less cost for production, but there produced less quality flower sticks, more diseases infested and farmers got less market price than these which produced in shade culture. Moreover, the Gerbera plants can not withstand with scorching sunlight. Again, in shade culture, there produced very high quality flowers, less infested by diseases and very easy for managements and farmers got more market price. On average 3,00,000 tk/bigha was involved in shade culture during first year of planting. Shade preparation is a big portion of the total production cost of Gerbera. The cost was varied year to year. Generally the farmers keep the Gerbera plants in the shade up to 3 to 4 years. After that they replanted the seedlings. Another big cost goes for the planting material. Gerbera plantlet is the most costly planting materials among all the cut flowers. On average, the farmers purchase the plantlets at maximum 100 taka and minimum 80 taka depending on the sources and other factors. Therefore, around 7,80,000 taka cost involves initially for the purpose of planting materials per bigha. Weeding is a must doing inter cultural operation of Gerbera as it is considered as a major pest of this flower which costs 51000 taka/bigha/year on an average. Except the irrigation, pesticides, picking and packaging, some other costs also may be involved which assumed 5000 taka/year. So according to the farmers opinion, a total cost of production is assumed which is figured as 15,62,700 taka/bigha/4 year.

The production of flower sticks was varied and depended upon different factors. The flower sticks productions was lower initially and gradually increased with time. Generally Gerbera plants gave higher and quality sticks at 2nd and 3rd year. After that the production was decreased. About on average 2,40,000 sticks/year/bigha was produced in first year. 27,00,000 sticks/year/bigha was produced in 2nd year and 60,000 sticks/year/bigha was produced in the 4th year. In the peak season farmers got about 12 Tk/stick, in off peak they got about 4 Tk/stick and on average 8 Tk/stick. On some special days and occasions such as international mother language day, victory day, valentine's day the demand of flowers was high and farmers get more price of flowers. They got upto 15 Tk/stick on these occasions. On average the Net profit comes from Gerbera cultivation is about 49,17,300 Tk/Bigha/4 years.

Considering the opinion expressed by the farmers, the incidence of diseases of Gerbera in field were leaf spot, leaf blight, flower blight, mosaic, drying, leaf curl, flower curl, flower abnormality, foot and root rot, stem rot, petal spot. Among these diseases Leaf blight, Leaf spot, Flower abnormality, Flower blight and Stem rot ranked first, second, third, fourth and fifth expressed by the 53.7%, 44.4%, 31.4%, 25.9% and 16.6% farmers, respectively. More or less all stages of the Gerbera crop were attacked by the diseases, where the dominating disease such as leaf spot, leaf blight and flower blight caused infections at seedling, vegetative and reproductive stages. The infestation intensity of the maximum diseases was low to medium expressed by the most of the farmers. On the other hand, Leaf blight caused damage with high intensity expressed by the 53.7% farmers.

However, most of the farmers (87.04%) expressed their opinion that there was positive relationship among insect pest, disease and weed infestation in the field, whereas only 12.96% farmers expressed their negative opinion. There was a positive and high degree of relationship among insect pest and disease incidence with weed infestation; as well as disease infection with the incidence of insect vector in the Gerbera field. This result indicates insect infestation and disease infection become high when weed infestation become high expressed by the 57.41% and 53.70% farmers at Jashore i.e., insect infestation and disease infection increased with the increase of the weed infestation. Similarly, disease infection become high when insect vector populations become high expressed by the 25.92% i.e., disease infection was increased with the increase of the vector population. The minimum number of farmers (25.93%) did not reply about the degree of relationship between disease infection and vector population. From this finding it was revealed that weed infestation enhanced the insect pest population and disease incidence; similarly, insect vector also enhanced the incidence of disease infection in the Gerbera field. Thrips and Red Spider Mites are the major pest of Gerbera and act as vectors. Some other pests such as Mealy bug, Aphid, leaf miner, White fly, Caterpillars, sawfly etc are also damaged Gerbera.

The probable sources of diseases were from seed borne diseases in seedlings, imported hybrid seedlings, within country, soil borne, local planting materials, use of imbalanced fertilizer, Ineffectiveness of Pesticides. Among these Seed borne was ranked first which played role as source of pest and disease infestation on Gerbera expressed by the

maximum (20.3%) farmers participated in the program. Second most important source were the within country expressed by the maximum (16.67%) farmers. Among the probable ways of spread out of Gerbera diseases, Affected seedlings, Imported seedlings, Weed and Grasses, Insect vectors, Wind, Irrigation water, Crop debris and Manure, Rain splashing, spreads through human being, spreads through inter-culture with other crops are remarkable. Affected seedlings and Crop debris and Manure were the most important ways those were ranked first and second expressed by the maximum (25.93% and 22.22%, respectively) farmers. Other important ways of spread of Gerbera pests and disease were weeds, wind, grasses, and Rain splashing expressed by the 11.11%, 5.56% and 1.85% farmers at Jashore. Irrigation water, Crop debris and Manure, inter-culture with other crops were also played role as probable ways in spreading Gerbera pests and disease.

Among 54 farmers, majority (70.37%) of them said that they took any measures to control diseases and pest of Gerbera in the field. A small portion (9.26%) of the farmers did not reply the matter, i.e., whether they took any measures or not to control Gerbera diseases and pests in the field. Again, majority (58.64%) of the farmers had taken both preventive and curative measures to control diseases of Gerbera in the field. Whereas 31.48% farmers said that they took preventive measures and 25.93% farmers took curative measures for the control Gerbera diseases in the field. Different methods were applied for the management of Gerbera pests and diseases in the field. Most of the farmers applied pesticides to control insect pests, diseases and weeds (98.15%) i.e., application of pesticides was the most widely used method to control Gerbera pests and diseases in the field. They consider it the better management practices for disease and pest control. Considering the farmers' opinion, the better management practices for disease control in Gerbera were the spraying of fungicides such as Dithane M-45, Tilt, Mancozeb, Acrobat MZ, Amamectin benzoid, Abamectin etc. The concentration was used about 2ml/L of water in case of liquid fungicide and insecticide (Amamectin benzoid, Abamectin) and for Mancozeb they used 3gm/L water as spray.

Again, most of the farmers responded positive about receiving assistance and other services from different sources. 29.63% 0f the farmers said that the field level officers visit the fields regularly and observe the disease development. 11.11% farmers reported to have suggestions from the experts about different diseases. 37.07% of the 54 farmers

mentioned that the field level officers often sit in meetings about their problems. 3.71% farmers have given no opinion. And most of them had faced various problems like high price of planting materials, pest and insect attack, diseases, transportation problem etc on Gerbera cultivation. Among these about 77.77% of the farmers said that they were facing High price of planting materials. 16.66% farmers reported to have unorganized market. 61.11% of the 54 farmers mentioned that insect and pest are attack on their field during cultivation.

However, according to the farmers' suggestion, some operations should be involved for better management of disease of Gerbera like Use of healthy planting materials, Effective use of insecticides & pesticides, Proper inter-culture operation, Regular field visit, more research. Most (88.88%) of the farmers responded were positive about Effective use of insecticides & pesticides for better management of disease of Gerbera. About 66.77% farmers suggested about use of healthy planting materials and least (16.66%) number of farmers emphasized on more research.

CHAPTER VI

SUMMARY AND CONCLUSION

Gerbera is a well-known cut flower grown all over the world in a variety of weather circumstances. Among the different varieties, *Gerbera jamesonii* is the only variety under farming. It is an evergreen and herbaceous plant producing different colors of flowers. It has a massive requirement in the flower industry as cut flower as well as plants in pots due to its beauty and long container life which rated it fifth among the top ten cut flowers in the entire whole world. So, nowadays Gerbera is widely commercially produced by the floral industry both as cut flower and potted plant. The flowers are hardy and can withstand vigorous transportation. They have long-keeping quality and fetch high market price. Gerbera has a wide range of attractive flower colors which makes it a valuable ornamental species. It is a rising cash crop in Bangladesh. It's also a remarkable cut flower in the floriculture of this country. The floral industry is one of the major industries in many developing and underdeveloped countries like Bangladesh. And the Gerbera is a vital part of it now a day. In Bangladesh, Gerbera was first introduced in Godhkhali of Jhikorgachaa. It is commercially grown in Rajshahi and Jashore. Now the plants are cultivated throughout the country as garden plant. But the demand of this flower in floral industry is met upby the Jashore region. And Jhikorgacha Upazila is the most flower cultivated region in Jashore. Thus, this study was targeted into this area specially.

Two experiments were conducted in field and lab in Jashore and Dhaka during February 2019 to May 2019. Very few research works were done on the diseases of Gerbera in Bangladesh. The main objectives of these experiments were to survey on problems and status of Gerbera cultivation, detection and identification of diseases of Gerbera and measurement of disease incidence and severity of diseases of Gerbera in Bangladesh. In field condition,18 villages from 4 Unions of Jhikorgacha Upazila of Jashore district were considered for disease survey. The disease incidence and severity were measured in three consecutive days in winter season considering the weather conditions. Then the samples were incubated in PDA nutritive media following tissue planting method to isolate the causal organisms. The pathogens were observed in stereo and compound microscope and transferred into pure culture. The diseases were identified based on the symptomological

study and identified causal organisms. The causal organisms of the disease were detected and identified as CMI (Commonwealth Mycological Institute) description and other related articles. However, repeated isolation and observation was carried out to confirm the pathogen. But Kotch's postulates were not done because of limitation of time and materials. The data of disease incidence and severity was analyzed by using STATISTIX-10 and the mean difference was judged by Least Significant Difference (LSD).

During this survey, eleven diseases were found and they were Alternaria leaf spot, Botrytis leaf blight, Fusarium stem rot, Drying, Foot and root rot, Leaf curl by, Flower curl, Flower abnormality-a physiological disorder, Flower blight and petal spot. Their causal organisms were identified *Alternaria alternata*, *Botrytis cinerea*, *Fusarium oxysporum* f. sp. *chrysanthemi*, *Rhizoctonia solani* and the rest were some unidentified viruses and fungi respectively. Analyzed report showed that most of the cases disease incidence and severity were varied significantly in the locations. Farmers reported that some plant diseases occurred highly in rainy season, some diseases occurred more in winter and some were in summer season. Again, the variation may be occurred due to susceptibility of the host, seasonal factors, over wintering and over summering, presence of secondary host, life cycle of both host and pathogen, proximity and availability of the host and pathogen etc.

The second part of this study was survey on socio-economic status of Gerbera farmers, production technologies and diseases of Gerbera in Jashore district. For this purpose, 54 farmers from 18 locations at Jhikorgacha Upazila were interviewed with a pre-tested questionnaire. The survey was done on the basis of three angles which were the socio-economic status of the farmers, the production technology used by them and their opinions on diseases of Gerbera. From the socio-economic point of view gender, age, education level and the land utilization pattern of the farmers were studied. Again, on the basis of production technology of the farmers, various information related to it such as planting materials, fertilizer application, pest management, benefit cost ratio etc. were recorded and analyzed. In this way, farmers' opinion on different disease related parameters were also taken in consideration along with their suggestions for better management of the diseases. For example, according to the farmers' opinion the leaf spot disease is the most common disease in Gerbera. They also said that the wilt, foot and root rot and crown rot are more common in rainy season. They also reported about powdery

mildew disease. But there was no powdery mildew was observed in the field as it frequently occurs in the summer season and the field investigation was carried out in the winter season. In case of flower abnormality, the older plants are mostly affected. Farmers said that the intensity increases with the age of the plants. The viral and bacterial disease was very rare.

However, further research should be carried out to accelerate this type of outstanding research. It is necessary to check the findings of this investigation in different places of our country as well as in Dhaka. Here the causal organism only identified up to genus but it is not sufficient, mare morphological and cultural study is not enough to identify a pathogen accurately. So pathogenicity test, like Kotch's postulates and molecular level examination should be conducted to identify the pathogen species. Again, the sample size for the survey was very small to have an over-all view about the whole district or whole country. So, further survey on a large scale basis should be done to get a clear image about the Gerbera cultivation in our country. Moreover, it may be a great source of employment and a good product for exportation. Pest risk analysis also essential to make a quarantine certificate. Research should be going on to develop the management practices of Gerbera plants. Proper management and cultural practices may increase the production rate and help to reduce the threat of extinct.

All aesthetic needs and decorations are fulfilled with the ornamental plants specially the Gerbera daisy. Perfume industry also is a beneficiary of this flower. It has also some financial contributions in sale of flowers, removal of essential sebum and, making of monetary products like perfume. Perfume sectors can be established in the country which can help enhance the nationwide economic system. It also can be considered as an industrial product. Professional plant production may be helpful in increased making of the farmers. Establishment of plant and flower production along with perfume sectors can help fixing the lack of employment problem to a large level. It provides an opportunity to bring more rarely used land under plant farming. There is a great market requirement for this flower throughout the year. Besides greater productivity and trade perspective is favoring floriculture in Bangladesh. So this flower can be a blessing for Bangladesh. Moreover, every creature of the world has aesthetic need which can be met up by this flower. It is not only used for its beauty but also used as an industrial raw product and garden plant. This research is a primary research about the field diseases of Gerbera. As a

fundamental research it will be a more fruitful work, when the Gerbera will be cultivated as a cash crop countrywide. Then these types of findings may pave the way of higher research. Who knows, that in future this research may be considered as the pioneer of Gerbera disease investigation and management?

CHAPTER VII

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Annex 1
Department of Plant Pathology
Sher-e-Bangla Agricultural University

Plant Diseases Survey Sheet for Gerbera

Name of the growers/farmers: **Date of Data collection:**
Address: Village: **Union:** **Upazila:** **District:**
Host common name: **Scientific name:** **Age of Plant/Crop**: Seedling/Vegetative/Flowering

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

Name of disease/ symptom		Infected plant part(s)	Distribution			Planting		Status		Plant Incidence%	Leaf Incidence %	Stem/Twig incidence %	Bud/ Flower Incidence %	Other incidence %	Disease Severity %
			EF	Edge	R	N	F	New	Old						
Anthracnose															
Powdery mildew															
Wilt															

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

Symptomological Study

Symptoms	Leaf spot	Leaf blight	Stem rot	Foot & Root rot	Drying of plant	Leaf curl	Mosaic	Anthracnose	Powdery mildew	Wilt
Size										
Shape										

Margin										
Yellow hello										
Appearance										
Wet/dry										
Sunken/raised										
Sign										
Scattered/ coalesce										
F/B/V/Unknown										
Upper/lower surface of leaf										
Older/middle/ younger leaf										
Others										
Figure										

Name and Signature of Surveyor
Date: / /20

Name and Signature of Supervisor
Date: / /20

Annex 2
Department of Plant Pathology
Sher-e-Bangla Agricultural University, Dhaka

Questionnaire for Survey on Diseases of Gerbera in Bangladesh

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Field / Nursery / Post Harvest

Serial					Cell Phone											

Name of Respondent:…… Village:……..…
Union: …….. Upazila…….. District: …….
Education: ……..…….. Age……. Sex…… Profession……..

1. Land Information

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

2. Cultivation of Gerbera

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

3. Sources of purchasing planting materials of Gerbera

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

(wb‡Ri / cÖwZ‡ekx/ ‡Kv¤úvbxi/ ¯’vbxq/ e¨emvqx/ GbwRI/ Avg`vbx/ M‡elbv cÖwZôvb)

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

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

5. Cost involved for pest management of Gerbera

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

6. Fertilizer application in Gerbera field

Total cultivated Land	Fertilizers (Kg)						
	Urea	TSP	MOP	Boron	Zinc	Cowdung	Others
When?							
Which stage?							

7. Insects infestation in Gerbera in field/ Nursery (please put √)

Name of Insects pest	**Stage of infestation**			**Incidence/severity**		
	Seedling	Vegetative	Flowering	High	Moderate	Low
পাতাসুড়ঙ্গকারীপোকা						
লেদাপোকা						
1. Caterpillar/বিছাপোকা						
2. Mealybug/ছাতরাপোকা						
3. Grasshopper/ঘাসফড়িং						
4. Leaf roller/পাতামোড়ানোপোকা						
5. Aphid/ জাবপোকা						
6. কুঁড়ি/ফুলছিদ্রকারীপোকা						
7. পাতারউইভিল						
8. Mites/ মাকড়বালালমাকড়						
9. পাতাখেকোপোকা						
10. Leaf minor						
11. White fly/ সাদামাছি						
12. Thrips						
13. মাছিপোকা						
14.						
15.						
16.						

8. Disease infestation in Gerbera in field/ Nursery (please put √)

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

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

9. Weeds Infestation in Gerbera in field/ Nursery (please put √)

Name of Weeds	Infestation stage			Incidence/severity		
	Seedling	Vegetative	Flowering	High	Moderate	Low
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						

(দূর্বা, মুথা, চাপড়া, বথুয়া, ভাদাইল, শ্যামা, ধুতুরা, তিতবেগুন, বনবেগুন, ফোস্কাবেগুন, হেলেঞ্চা, বনকফি, চেচরা, শুশনি, বনশরিষা, নাকফুল, শাকনটে, কাটানটে, বিষকাটালী, আংগুলীগাস, হাতিশুড়, ¯^Y©jZv, cv‡_©wbqvg)

10. Is there any relationship among insect, disease and weed pest infestations in the crop field?
[Yes = √, No=X]

11. If yes, what is the relationship among insect, disease and weed incidence in crop field?
[Yes = √, No=X]

9.1 Insect population high when weed incidence is high:

9.2 Disease incidence high when weed incidence is high:

9.3 Disease incidence high when incidence of insect vector is high:

12. When the pest infestations become high in the Gerbera field / Nursery? (please put √)

Pests	Summer	Rainy	Winter	Season	
				Rabi	Kharif
1. Insect					
2. Disease					
3. Weed					

13. Pests infestation in Gerbera after harvest/ in stored condition(please put √)

Insect pests/ Diseases	**Extent of Damage**		
	High	**Medium**	**Low**
A. Insect pests			
1.			
2.			
3.			
4.			
B. Diseases			
5.			
6.			
7.			
8.			

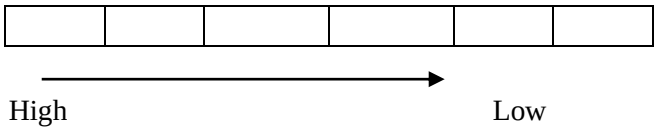
Others			
9.			
10.			

14. Action taken against pest infestation for Gerbera cultivation(please put √)

Insect pests/ Diseases/Weed	**When taken?**			**Which action taken? If spray, mention the frequency?**
	Prev.	Curative	Both	
A. Insect pests				
1.				
2.				
3.				
4.				
5.				
6.				
B. Diseases				
7.				
8.				
9.				
10.				
11.				
12.				
C. Weed				
13.				
14.				
15.				
16.				
17.				
18.				

15. From where you receive Assistance and Services in controlling diseases of Gerbera?

Diseases:



[From, DAE= 1, other farmers =2, Dealers =3, NGO=4, Company=5, Others=6]

16. Who purchase Gerbera from farmer/grower? (please put √)

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

17. Mention major problems on cultivation of Gerbera according to importance.

Sl. No.	Problems
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	
9.	
10.	

18. Put your suggestions for better management of disease of Gerbera

Sl. No.	Suggestions
1.	
2.	
3.	
4.	
5.	
6.	
7.	

Name and Signature of Surveyor
Date: / /2019

Name and Signature of Supervisor
Date: / /2019