

**FIELD INVESTIGATION AND SURVEY ON
DISEASES OF GLADIOLUS (*Gladiolus grandiflorus* L.)
IN SELECTED AREAS OF BANGLADESH**

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**FIELD INVESTIGATION AND SURVEY ON
DISEASES OF GLADIOLUS (*Gladiolus grandiflorus* L.)
IN SELECTED AREAS OF BANGLADESH**

BY

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CERTIFICATE

This is to certify that the thesis entitled “**FIELD INVESTIGATION AND SURVEY ON DISEASES OF GLADIOLUS (*Gladiolus grandiflorus* L.) IN SELECTED AREAS OF BANGLADESH**” submitted to the department of Plant Pathology, faculty of Agriculture, Sher-e-Bangla Agricultural University, Sher-e-Bangla nagar, Dhaka-1207, in partial fulfillment of the requirements for the degree of **Master of Science (MS) in PLANT PATHOLOGY**, embodies the result of a piece of bona fide research work carried out by **Farjana Anwar** Registration No.: **12-04841**, under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

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**DEDICATED
TO
SHAHIDA BEGUM
&
MD. ANWAR HOSSAIN
(MY BELOVED PARENTS)**

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Field Investigation and Survey on Diseases of Gladiolus (*Gladiolus Grandiflorus* L.) in Selected Areas of Bangladesh

BY
Farjana Anwar

ABSTRACT

Three experiments were conducted to investigate the diseases of gladiolus in Jashore, Dhaka and Manikganj districts of Bangladesh during February 2019 to May 2019. Eighteen villages from 4 Unions of Jhikorgacha Upazila of Jashore, two villages from Savar upazila of Dhaka and two villages from Singair upazila of Manikganj district were selected for investigation. The disease incidence and severity were recorded under natural epiphytic conditions. Seven diseases were identified from cultivated gladiolus in Bangladesh viz. leaf spot, leaf blight, stem rot, corm rot, flower rot, aster yellow and mosaic diseases. The identified causal organisms for leaf spot, leaf blight and flower rot disease are *Curvularia trifolii*, *Botrytis gladiolorum* and *Curvularia lunata*, respectively. However, stem rot and corm rot diseases are caused by *Fusarium oxysporum* f. sp. *gladioli*. Mycoplasma caused aster yellow and virus caused mosaic diseases of gladiolus were recorded in the field of Jashore. The incidence and severity of diseases varied significantly among the locations. In leaf spot disease, Incidence and severity varied significantly from 22% to 72.67% and 2.67 % to 15%, respectively. In case of leaf blight disease, the highest disease incidence and severity were recorded in Dhalipara, Jashore that were 77.33% and 11.67%, respectively. Severity of stem rot was observed highest in Nirbashkhola (11%) and the lowest in Baisha village (2.67%). Disease incidence was varied from 10.67% to 25.33% for corm rot disease. Incidence of flower rot disease varied significantly from 5.33% to 10%. In case of Aster yellow disease, the highest disease incidence (9.333%) was recorded in Mathuapara and Godkhali villages. The mosaic disease of gladiolus was found only in Sharifpur village of Jhikargacha union of Jashore. The disease incidence and disease severity were 3.33% and 20%, respectively. Farmer's saved corms of gladiolus were collected from Dhaka, Manikganj and Jashore districts and health status was also investigated by modified blotter paper method in this study. Five fungi viz. *Fusarium oxysporum*, *Aspergillus flavus*, *Aspergillus niger*, *Rhizopus stolonifer*, *Chaetomium* sp. were isolated and identified from corm of gladiolus. Apart from this, a survey was carried out on the socio-economic status of gladiolus farmers and problem related gladiolus cultivation in Bangladesh.

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LIST OF ABBREVIATIONS

Full word	Abbreviations
Agro-Ecological Zone	AEZ
And others	<i>et al.</i>
Bangladesh Bureau of Statistics	BBS
Centimeter	cm
Coefficient of Variance	CV
Degree Celsius	°C
Etcetera	etc.
Gram	g
Kilogram	Kg
Least Significant Difference	LSD
Meter	m
Millimeter	mm
Percentage	%
Videlicet (namely)	viz.
Disease incidence	DI
Disease severity	DS
Hectare	ha
Kilogram per hectare	Kg/ha
Cost per bigha per year	Cost/bigha/year
Production per bigha	Production/bigha
Taka per bigha	Tk/bigha
Asia Farming Rose Cultivation Information Guide	AFRCIG
International Floriculture Trade Statistics	IFTS

CHAPTER I

INTRODUCTION

Cut flowers are integral part of human life. The cut flower industry is globally a fast growing industry, which has achieved significant growth during the past few decades. At present, cut flower production focus has moved from traditional growers, such as the Netherlands, Germany and France, the countries where the climates are better and production costs are low (Zhao *et al.*, 2008). It has national and international value in respect to cut flowers. Gladiolus has a considerably high marketing rate with the production of bulbs (corms, cormels) in addition to cut flowers. In some countries, gladiolus corms are used in food and in ethno medicines. Flowers have a soft and supple texture because they hold enough moisture. Thus, fresh cut flowers are highly perishable and tend to lose their aesthetic appeal within a relatively short time. But gladiolus has been ranked as the uppermost position in cut flower considering long self-life.

Gladiolus (*Gladiolus grandiflorus* L.) is herbaceous, perennial, bulbous, popular and important ornamental flowering crop. It is commonly famous by the name “Sword Lily” for its sword shaped leaves. However, previously it was the name of ‘irises which ancient Greeks used to call as ‘xiphion’. It was introduced into cultivation towards the end of the 16th century (Parthasarathy and Nagaraju, 1999). In Indian subcontinent, its cultivation dates back to 19th century. Gladiolus occupies fourth place in international cut flower trade and second rank after tulip among the bulbous flowers in India (Singh *et al.*, 2012). It is now grown as a cut flower widely in Europe, particularly in the Netherlands, Italy and Southern France. Gladiolus being a potential cut flower has great demand and is cultivated all over the world for its attractive spikes having florets of huge forms, dazzling colors, varying sizes and long vase life. It is frequently used as cut flower in different social and religious ceremonies (Mitra, 1992). In international trade, gladiolus occupies fourth place (Bhattacharjee and De, 2010).

Gladiolus belongs to monocot family Iridaceae, having approximately one hundred and fifty known species (Negi *et al.*, 1982). This plant is commercially used for cut flowers and occasionally used for landscape purpose. Gladiolus produces very attractive flowers and there is high consumer demand for it. It is one of the few plants which produce pleasant cut flowers with long spikes. These spikes are an integral part of almost every cut flower arrangement ranging from table decoration to bucket formation. Gladiolus is

cultivated in most of the tropical and subtropical countries of the world. Its spikes takes 60 to 100 days after planting to be harvested depending upon the cultivars and time of year (Jenkins, 1976; Jenkins *et al.*, 1970).

Gladiolus is a tender herbaceous perennial. It occupies fourth of worlds bulbous flower plant area (Bose *et al.*, 2003). Bulbous flowering plants are one of the most wonderful creations of nature. The various bulbous flowering plants provide glamour, perfection and colour. Gladiolus (*Gladiolus grandiflorus* L.) easily tops the list and can rightly be called the “Queen of bulbous flower crops” grown in many parts of the world (Kaikal and Nauriyal, 1964).

Gladiolus is grown as flower bed in gardens and used in floral arrangements for interior decoration as well as making high quality bouquets (Lepcha *et al.*, 2007). Gladiolus spikes are most popular in flower arrangements and for preparing attractive bouquets (Mishra *et al.*, 2006). Apart from ornamental value, gladiolus have extensively utilized in medicines for headache, lumbago, diarrhea, rheumatism and allied pains (Bhattacharjee and De, 2010). Flower and corm of some gladiolus are used as food in many countries (Khan, 2009). The major gladiolus producing countries are the United States (Florida and California), Holland, Australia, Japan, Italy, France, Poland, Iran, India, Brazil, Poland, China, Malaysia and Singapore (Memon *et al.*, 2009).

In Bangladesh, commercial cultivation of gladiolus was introduced from India in 1985. In India, gladiolus was grown more than 1270 ha with an annual production of 150 million spikes (Arora, 2002). The major gladiolus growing area of India are Kalimpong (West Bengal), New Delhi, Srinagar (Jammu and Kashmir), Nainital (Uttaranchal), Pune and Nasik (Maharashtra), Bangalore (Karnataka), Hyderabad (Andhra Pradesh) and its cultivation is rapidly expanding in the states like Andhra Pradesh, Haryana, Karnataka, Kerala, Maharashtra, Punjab, Uttar Pradesh, Uttaranchal, Tamil Nadu and West Bengal (Naveen and Raju, 2007).

Commercial cultivation of gladiolus is gaining popularity in Bangladesh mainly concentrated only in few districts such as Jashore, Jenaidah, Rajshahi, Manikganj and Dhaka. Khan (2009) reported that the area of flower production appears to have increased significantly and estimated area of around 10,000 ha and the annual trade at wholesale level to be worth between 500-1000 million taka in Bangladesh. Momin (2006) reported that income from gladiolus flower production is six time higher than returns from rice.

However, cultivation of gladiolus is hampered due to pest infestation. Disease is one of the most important limiting factors for commercial cultivation of gladiolus in Bangladesh. Gladiolus plants are affected by fungal diseases along with bacteria, virus, nematodes and pests such as Corm rot, or Fusarium rot (*Fusarium oxysporum* f. sp. *gladioli*), Curvularia leaf spot (*Curvularia trifolli* f. sp. *gladioli*), Nematodes (*Meloidogyne*, *Pratylenchus*, *Trichodorus*, *Belonolaimus*, *Ditylenchus*, *Hemicycliophora*, *Rotylenchus*), Scab (*Pseudomonas marginata*), Stemphylium leaf Spot (*Stemphylium botryosum*), Stromatinia Dry Rot (*Stromatinia gladioli*), Viruses (Bean yellow mosaic, Cucumber mosaic, Tomato ring spot, Tobacco ring spot) (Sing, 1968). *Fusarium oxysporum* f. sp. *gladioli*, *Rhizoctonia solani* and *Alternaria alternata* were found pathogenic to on gladiolus plants, while *Curvularia lunata* showed non-pathogenic reaction to gladiolus (Sing *et al.*, 2005). Cucumber mosaic virus (CMV) and bean yellow mosaic virus (BYMV) are the most prevalent in commercial gladiolus (Stein 1995).

Corm rot and stem rot are the most serious diseases of gladiolus, affecting plants in the field and corms in storage. Corm rot is also called "yellows" on infected plants in the field. The causal organism is *Fusarium oxysporum* f. sp. *gladioli* (Armitage, 1993; Remotti *et al.*, 1997; Chandel and Bhardwaj, 2000). The pathogen is affecting plants in the field, causing corms to rot before digging, in storage, or after planting (Jones and Jenkins 1975). Symptoms of the disease include root, crown, stem rot, vascular wilts, foliage chlorosis, yellowing and necrosis, and discoloured and misshapen flowers (Heimann and Worf, 1997). The disease is also known as fusarium yellows where leaves tend to turn downward, yellow progressively, and die prematurely. Brown rot of corms begins in basal plate and core, and extends upward into the leaf bases via vascular strands. Corms may rot in ground or while in storage. The fungus survives in infected corms and in the soil as mycelium, chlamydospores, macro conidia and micro conidia. The infected corms show brownish to black dry rot symptoms. Foliage of affected plants first turns yellow and then brown. Infected roots remain small and are gradually killed. Despite of many attempts to control this disease, the problem is still widespread (Roebroek, 1992).

Among the diseases of gladiolus, leaf blight disease caused by *Botrytis gladiolorum* is a destructive disease that causes significant economic loss to the growers. Besides producing small to large, oval to round brown spots on leaves, the pathogen also produces water-soaked spots on flower petals (Mes, 1997). The disease is manifested by spots on leaf, flower bud, inflorescence and stem, and corm rot. Drayton (1928) reported *Botrytis* disease of gladiolus from Canada in 1928. The disease has also been

reported from Holland (Drayton 1929), England (Moore 1939), New York (Dodge and Laskaris, 1941), Australia (Wade, 1945), India (Sohi 1992, Singh *et al.*, 2005), Pakistan (Mirza and Shakir, 1991) and Iran (Mirzaei *et al.*, 2008). Mirza and Shakir 1991) reported *Botrytis gladiolorum* from corm and leaves of gladiolus in Pakistan. Sohi (1992) worked on diseases of ornamental plants and reported *Botrytis gladiolorum* from corms and leaves of gladiolus in India. Blight caused by *Botrytis gladiolorum* is noted as the major threat for gladiolus production in India (Singh *et al.*, 2005).

Curvularia leaf spot due to *Curvularia trifolli* f. sp. *gladioli* also cause economic losses in Gladiolus. The early sown gladiolus is mostly affected by leaf spot disease due to high temperature in Uttar Pradesh, India (Singh, 1968). It causes severe spotting in leaves, stems, spikes, flowers and even the corms. The characteristics spots are circular and elongated on the leaves, irregular on the spikes. The color of spot is tan, surrounded by a darker reddish brown ring and an outer yellow halo. Black spot masses are often seen on the central area of the spot. The brown or dead area of spot become sunken.

Flower plays an important role in people's celebration and everyday lives. Among the flowers, gladiolus is one of them. Cultivation of gladiolus flower produces huge emphasis due to less maintenance and high economic return. Even though, the diseases on gladiolus have major economic impact on quality and quantity of flower production.

Researches on detection, identification and management of diseases of gladiolus are very limited in Bangladesh. Thus, there is a need for systematic research works which including survey, isolation and identification, measurement of diseases of gladiolus in Bangladesh. It will help to manage diseases of gladiolus effectively in the field. That will increase production and ensures higher quality of flowers.

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

1. Detection, identification and measurement of diseases of gladiolus in Bangladesh
2. Detection of health status of corm as a planting materials of Gladiolus and
3. Survey on socio economic status of gladiolus grower, cultivation practices and problems related to gladiolus cultivation in Bangladesh.

CHAPTER II

REVIEW OF LITERATURE

Gladiolus is a popular cut flower, which easily gladden our hearts by 'their majestic flower spike'. Besides having aesthetic value, it represents and reflects the glory of collectivism, a 'symbol of beauty, love and tranquility in its arrangement as inflorescence on the spike, resulting and opening an avenue of immense commercial value in the present era of globalized economy. Many diseases attack in this flower. But very few researches works directly has been carried out in this area in Bangladesh. There is also a very limited significant research works on diseases of gladiolus in the South Asia. However, research works are found regarding diseases of gladiolus in the world. The literatures on diseases of gladiolus and their 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 Gladiolus (*Gladiolus grandiflorus* L.) Cultivation

Noor-un-Nisa *et al.* (2009) conducted a field experiment in Pakistan to investigate the effect of corm size on the vegetative, floral attributes, corm and cormel production in gladiolus. Corm and cormel production of gladiolus has a major role in the growth and development of the gladiolus. Large sized corms significantly increased the leaf breadth, length of flowering spike, and number of florets per spike. Regarding corm production, large sized corms produced significantly higher weight of corms per plant, cormels per plant and combined total weight of corms and cormels per plant.

Momin (2006) stated that, gladiolus (*Gladiolus communis*) is very popular flower and grown throughout the world in a wide range of climatic conditions. Its magnificent inflorescence with various colour have made it attractive in Bangladesh also. Income from gladiolus flower production is six times higher than from that of rice.

Al-Humaid (2004) tested all the isolated fungi for their pathogenic potential in gladiolus and observed that, *Botrytis gladiolorum*, *B. Cinerea*, *C. lunata* and *F. oxysporum* f. sp. *gladioli* were invariably pathogenic to the corms of gladiolus.

Mollah *et al.* (2002) stated that, gladiolus was introduced in Bangladesh around 1992 from India. It has recently been become popular in Bangladesh. Its demand has been

increasing day by day with the advancement of aristocracy and modernization of Bangladesh.

Parthasarathy and Nagaraju (1999) said that, the magnificent long-lasting spike of gladiolus come in a variety of colours and forms which makes it more attractive for use in herbaceous borders, bedding, rockeries, pots, as well as cut flowers.

Lu et al. (1996) stated that, the gladiolus plants thrive in warm weather conditions, good availability of water throughout the cycle, soil with good drainage, fertile and rich in organic matter, and soil pH in the range of 5.5 to 6.5.

McKay et al. (1986) conducted two experiments in South-East Queensland of Australia to investigate the effects of size and division of the mother corm on yield of gladiolus inflorescences, corms and cormels and inflorescence quality and noticed that, different factors such as corm size influence the production of corms.

2.2. About Diseases of Gladiolus (*Gladiolus grandiflorus* L.)

Praveen et al., (2017) stated that, one of the important constraints that limit the production of quality flowers in gladiolus 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.

Cantor (2006) conducted *Gladiolus* breeding programs attempt to improve gladiolus features such as the color, number and shape of flowers, flowering capacity in winter, multiplication and resistance to foliar and corm diseases. In Brazil, in addition to agronomic characteristics such as productivity and adaptability, breeding programs are focused on the search for genotypes that are resistant or tolerant to rust (*U. transversalis*), which is the most significant disease of gladiolus in this country (**Magie, 1960**).

Mollah et al. (2002) stated that, gladiolus suffers from many diseases such as corm rot, leaf spot and leaf blight. Now a days, leaf blight which is caused by *Botrytis gladiolorum* become severe in the farmer's field of Jashore region that thrives in high humidity and cool weather. No attention has been given on the diagnosis of botrytis blight and its control in hazardous to our environment.

Tomar (1997) reported that, in Himachal Pradesh of India, the disease incidence of gladiolus ranged between 7.12- 64.23%. The disease incidence is comparatively more in sub-mountainous regions than in temperate ones.

Roy et al. (1995) noticed that, gladiolus plant is affected by a number of diseases, out of which gladiolus corm rots. Fusarium wilt and leaf spots are most destructive diseases.

Sohi (1992) worked on diseases of ornamental plants and reported *Fusarium oxysporum* f. sp. *gladioli* from corms and roots and *Botrytis gladiolorum*, *curvularia* sp. and *Stemphylium* sp. from corms and leaves of gladiolus from India.

Protsenko (1958); Vlasova and Shitan (1974); Chandel and Bhardwaj (2000) stated that, gladiolus is susceptible to a number of diseases incited by fungal, bacterial and viral pathogens such as Fusarium wilt, core or spongy rot, dry or neck rot, Curvularia blight, bacterial scab, grey mould, storage rot etc. Pathological problems, particularly diseases caused by fungal pathogens, take a heavy toll in terms of plant stand, quality and yield.

Buxton and Robertson (1953) found that, the four species of Fusarium namely, *F. oxysporum* f. sp. *gladioli*, *F. solani*, *F. moniliforme* and *F. roseum* have been reported to cause wilt or yellows in gladiolus. *Fusarium oxysporum* f. sp. *gladioli* has the widest world distribution and it can survive in infected corms and soil as mycelium, clamydospores, microconidia and macroconidia.

Magie (1953); Baiswar et al. (2007); Shakir et al. (2008); Tombolato et al. (2010) reported on several pathogens of gladiolus, such as *Botrytis gladiolorum*, *Curvularia* spp., *Fusarium oxysporum* f. sp. *gladioli*, *Fusarium solani*, *Geotrichum candidum*, *Septoria gladioli*, *Phyllosticta gladioloides*, *Stemphylium* sp. and *Uromyces transversalis* infect gladiolus and cause reduction in the yield and quality of the flowers and corms, as well as increasing the cost of production.

2.2.1. Leaf Spot Diseases of Gladiolus

Seipal (2010) reported that, *Curvularia* fungus infecting gladiolus can survive on infested corms or in the soil for several years. On fully expanded leaves, the first lesions were observed between 3 and 4 days after inoculation. There were differential responses among the genotypes. The most susceptible varieties showed circular to oval leaf spots, which were gray to dark brown with or without a yellow halo. The spots became

irregular in shape and extended along the vein of the leaf.

Torres *et al.* (2013a) stated that, curvulara leaf spot disease affects leaves, stems, and petals of gladiolus. Symptoms usually begin on leaves first as light to dark brown, oval spots. The symptomatic tissues show leaf spots that are oval to circular, brown with dark edges, and surrounded by a yellow halo. Often the lesions become necrotic and the leaves acquire a dry and wilted appearance.

Torres *et al.* (2013b) noticed that, *Curvularia*, the fungus produces a black, powdery mass of spores in the center of the spot. Symptoms were varied to varieties. For example, on *G. grandiflorus* var. Red Beauty, the spots were more irregular and necrotic and surrounded by yellow halos.

Sohi (1992) worked on diseases of ornamental plants and reported *Curvularia sp.* from leaves of gladiolus from India.

Pandey and Nigam (1985) observed that, the symptoms of *Curvularia sp.* in plant was the appearance of small light brown spot on leaves and flowers. Spot coalesces resulted in blight symptoms. In case of dieback disease, necrosis of tender twinges from the tip backwards was observed.

Goyal and Pathak (1982) stated that, the symptoms of *Curvularia sp.* disease appeared as small light brown spot involving almost whole of the surface of the leaf.

Khan and Karer (1974) found that, leaf spot of Gladiolus caused by *Curvularia trifolii* affected in gladiolus plant. The colour of the spot is tan, surrounded by a darker reddish brown ring and an outer yellow halo.

Singh (1968) reported *Curvularia* in gladiolus was found in Florida of USA in 1947. Since then, it has quickly become globally distributed. In Brazil, the curvularia leaf spot caused by *C. gladiolus* has recently been reported in *G. grandiflorum* vars. T-704. The symptomatic tissues showed leaf spots that were oval to circular, brown with dark edges, and surrounded by a yellow halo.

Kilpatrick (1958) isolated *Curvularia trifolii* from over-wintered clover leaves and observed that in nature the fungus apparently survives until leaves decompose. It causes severe spotting of the stems, leaves, spikes, flowers and even the corms of gladiolus. The characteristic spots are circular and elongated on the leaves, irregular on the spikes.

The colour of the spot is tan, surrounded by a darker reddish brown ring and an outer yellow halo. Black spore masses often seen on the central area of the spot. The brown or dead area is sunken.

Forsberg (1957) observed *Curvularia* spots were round and always surrounded by yellow halos in other species, such as *G. callianthus*. More tolerant cultivars of *G. grandifloras*, such as Amsterdam, Friendship Rose, Tradehorn, Veronica, and Gold Yester, reacted differently to *Curvularia* leaf spot and exhibited light to dark brown spots.

Luttrell (1956) noticed that, leaves, stems, and petals of gladiolus are affected by *Curvularia lunata*. At first, light to dark brown, oval spots are seen most frequently on the leaf. These become oval to circular, brown spots with dark edges and surrounded by a yellow halo. Lesions become necrotic with leaves looking dry and wilted. The fungus produces a black, powdery mass of spores in the center of the spot.

Magie (1948) first reported *Curvularia sp.* was from corm of gladiolus in United States in 1947. The symptoms are usually limited to the lowest part of the corm. Elongated, slightly roughened light brown to blackish-brown stripes and spots appear on the tunics. Dark-coloured margins and/or round to irregularly shaped blackish-brown dry spots can develop on the nodes. Sometimes, larger, depressed grey-brown to dark brown spots that may look like a symptom of *Fusarium* appear on the corm. Symptoms of *Curvularia* on a corm: stripes and spots on tunic and surface of the corm tissue.

2.2.2. Leaf Blight or *Botrytis* Blight Disease of Gladiolus

Sultana et al. (2017) noticed Botrytis blight symptoms appeared on Gladiolus grown in Mymensingh regions of Bangladesh during 2014-2015. The disease caused spots on leaves, stems/ spikes, buds and flowers. In severe infection, the disease caused both flower and leaf blight. In cool and moist weather Botrytis blight incidence was recorded up to 100% in some fields. The causal pathogen identified as *Botrytis gladiolorum*. The effect of temperature on mycelial growth, sporulation and sclerotial production of *B. gladiolorum* was investigated in different temperatures. The maximum radial was found $20 \pm 10^{\circ}\text{C}$. An excellent degree of conidial and sclerotial production also took place at 20 and $25 \pm 10^{\circ}\text{C}$. The optimum spore concentration for disease development on the leaf tissue was at 4×10^4 conidia/ml of water that was identical as recorded from the field. *Trichoderma harzianum* (2%) significantly reduced the growth of *B. gladiolorum*. Maximum plant height, total number of leaves, number of spikes, rachis length, and

number of florets, floret diameter and yield (flower stalk /ha) were obtained with the application of 2.0% *Trichoderma harzianum* followed by Bavistin (0.2%) in the field experiment.

Sehajpal et al. (2015) reported that, the progression of botrytis blight disease of gladiolus was more in cool weather and towards the winds and wind direction during January-February. The severely infected leaves become reddish-brown with grayish conidial masses and dried from the tips. As the disease progressed, the lesions developed and blighted completely the spike, petal, flower bud with grey rot of flowers.

Singh (2014) stated that, large oval to round, brown spots appear on leaves due to blight disease of gladiolus. Spots occur on flowers and stems also. At first the spots are pale brown and then become dark. A soft, brown rotting at the base of florets may develop after rainfall. In a moist, cool atmosphere, the whole flower becomes covered with brownish grey growth of the fungal spores.

Siddique et al. (2013) first report *Botrytis* Blight (*Botrytis gladiolorum*) disease of gladiolus in Bangladesh. Botrytis gray mold disease like symptoms appeared on gladiolus during 2012 and 2013 crop season grown in Jashore regions of Bangladesh. The disease caused spots on leaves, flower buds and inflorescence. In severe infection, the disease caused both flower and leaf blight and corm rot. *Botrytis gladiolorum* was consistently isolated from infected gladiolus plants. For confirmation of the disease, Kock's postulate was performed through artificial inoculation of healthy leaves of gladiolus grown in pots in a glass house. Conidial suspension of *B. gladiolorum* isolated from naturally infected plants used as inocula for inoculation. Characteristic symptoms of *Botrytis* blight developed on inoculated gladiolus plants were identical as recorded from the field. Based on inoculation test it was confirmed that the disease was *Botrytis* blight of gladiolus and the causal fungus was *B. gladiolorum*. This is the first record on the occurrence of *Botrytis* blight and its causal pathogen, *B. gladiolorum* in Bangladesh.

Tesfaye and Kapoor (2010) reported that, *Botrytis gladiolorum* can infect the corm, leaves and flowers. Sclerotia can form on all parts of the plant, including the corm. Under damp conditions, this fungus produces masses of spores above ground that are distributed by the wind. The sclerotia formed underground are large, black, and flat and range in size from 1-9 mm. Under excessively damp conditions, corms and harvested products in cold stores can also be infected. The infection of leaves and stem occurs at cool temperatures (approximately 10°C) and under damp conditions. If the plant

remains wet for too long, the infection spreads to other leaves. This disease occurs very often in a crop in which corms have been planted too closely together and also in unventilated greenhouses where the RH reaches excessively high levels.

Jegathambigati *et al.* (2009) also reported, due to blight disease in gladiolus, leaves develop large, round-to-oval brown spots, smaller pale brown spots with red-brown margins, and very small rusty-brown spots that usually show on the leaf's exposed side. Flowers develop pale brown, then dark-brown spots on the flower stem. Soft rotting at bases of florets may follow heavy rain. At first, petals develop translucent water-soaked spots. As petal spots enlarge, dead tissue turns light brown. Under moist conditions, the whole flower becomes slimy with rot.

Mirzaei *et al.* (2008) noticed that, the severely infected leaves of gladiolus become reddish-brown with grayish conidial masses and dried from the tips. As the disease progressed, the lesions developed and blighted completely the spike, petal, flower bud with grey rot of flowers.

Tesfaye and Kapoor (2007 & 2010) was recorded botrytis blight disease in gladiolus from all the surveyed 5 (five) fields of Sutiakhali and Babukhali of Mymensingh region and significantly the highest incidence (100%) was recorded at 75 days after sowing on 21 January, 2015 and lower incidence (6%) was found at the younger plants of 45 days on December, 2014. The similar trend was observed in case of disease severity that ranged from 8-60% (Table 1). Significantly the highest incidence (100%) and severity (60%) of Botrytis blight was observed at older plants than the younger ones.

Sung *et al.* (2003) also found Botrytis gray mold disease of gladiolus (*B. gladiolorum*) reached up to 50% in damaged fields in Korea and *B. gladiolorum* spores produced gray mold on older plants drifted onto the flowers before harvest. However, severe outbreaks of Botrytis blight in mature stage were induced may be due to low temperature 17.9 °C, high humidity (89%), Rainfall (15 mm) with wind speed (3.06 kmph) and no sunshine at that time.

Hermosa *et al.* (2000) also reported *Botrytis gladiolorum*, and possibly *B. cinerea*, fungi in gladiolus. The pathogens survive in soil as sclerotia and as mycelium on plant debris. The leaf and flower spot phase of the disease is most prevalent in Northern Washington, USA where weather often favors fungal buildup on flowers and old foliage late in the season.

Magie (1956) stated that, symptoms of Botrytis blight in gladiolus are characterized as three distinct spots: (1) very small, rust-colored spots that appear on only one side of the leaf; (2) small, yellowish brown spots that develop reddish brown margins; and (3) the large, oval spots that develop long, reddish margins . He also noticed that, pinpoint water-soaked lesions also appear on flowers if the flower spike stays wet for at least flower lesions enlarge and are first watery then dry and turn necrotic.

Magie (1951) reported that, *Botrytis gladiolorum*, is one of the major destructive diseases of gladiolus that causes significant economic loss to the growers. Besides producing small to large, oval to round brown spots on leaves, the pathogen also produces water-soaked spots on flower petals. Incipient floral infections cause flowers to rot during transit to market, reducing its market value.

2.2.3. Corm Rot Disease of Gladiolus

Bai et al. (2009) found that, in corm rot disease of gladiolus, at early stage the infection may be confined to surface only, but later on, it travels to the core as well. At high temperature, corms seal off infection, escaping further rotting. In the field, infection is characterized by circular brown leaf spots. The smallest spots are visible only on the upper surface of leaf.

Javaid and Amin, (2009); Riaz et al., (2009a, b) stated that, Fusarium corm rot is the most common and destructive fungal disease on gladiolus. The disease occurs wherever gladiolus is grown and can be lethal on certain cultivars. Characteristic symptoms of corm rot were first reported in 1912, but it took another 16 years before the disease and the pathogen were formerly described. The pathogen is the fungus *Fusarium oxysporum* f. sp. *gladioli*, which inhabits many soils as different biotypes. As a result, the disease occurs wherever gladiolus is grown, in part, due to resident populations of the pathogen and due to latent corm infections that are frequently present. About 30% annual losses have been estimated in Germany due to this disease.

In a recent study of **Bajwa et al. (2008)** reported that, Fusarium corm rot disease show dark brown to reddish-brown deeply sunken rotting spots, often containing concentric rings, develop from the basal plate of the corm.

Mancini et al. (2008) noticed that, the disease caused by *Fusarium oxysporum* f. sp. *gladioli* is characterized by rot of corms, stunted plant growth, late blooming or blind plants, greener and smaller buds and poor opening. The most serious loss is the

reduction in number and quality of flower spikes due to the infection. Despite many attempts to control this disease, the problem is still widespread.

According to **Huang *et al.* (2006)**, the symptoms are common to all three forms of corm rot disease of gladiolus are a firm, brownish to black corm rot; yellowing, browning, and premature dying of the leaves; and a browning and destruction of the roots. The corms may rot before digging, in storage, or after planting. In the vascular form of the disease, a corm that is cut vertically in half will reveal a brown discoloration of the core and dark vascular bundles that extend laterally into the flesh. In the brown-rot form of the disease, tan, brown, or blackish lesions appear anywhere on the corm, but are most common near the base.

Singh *et al.* (2003); Cuthbertson and Murchie (2005) found that, *Fusarium* corm rot of gladiolus had a large reddish brown lesions on the sides of the corm characterize the disease. Sometimes lesions may be covered with bluish green masses of fungal spores.

Cuthbertson and Murchie (2005) stated that, the *Fusarium* corm rot diseased tissue is sunken, dark brown to black, hard, rough, and often somewhat scaly. There is a sharp line between diseased and healthy tissues. When infected corms are planted, the more severely diseased corms rot in the soil without sprouting, or they produce weak, stunted, and yellowed leaves that soon die. The less severely infected corms may produce plants that grow normally until late in the season. Eventually, however, the tips of the leaves turn yellow and then die back gradually until the entire plant is dead.

Charmaine *et al.*, (2005) noticed that, roots may show discrete brown lesions or a general rotting, leaf infection is basal and associated with corm rot of gladiolus. Leaf yellowing, starting with oldest leaves, is seen occasionally. Corm rot in the field is soft, invaded by other organisms and is associated with brown wiry roots. In storage, rotting may begin anywhere on corm surface, but most spots are found at base next to the core, by scrapping, browning can be seen.

Hashim and Devi (2003) observed that, the rotted tissue often is quite thick and may extend completely through the corm. Vascular discoloration is not associated with this form of the disease. The basal dry-rot form differs from the brown-rot form mainly in the position and thickness of the lesions. The corm-rot lesions occur only on the base of the corms and usually are restricted to the first and second internodes. They rarely, if ever, extend more than 2 to 4 millimeters into the flesh.

Davey (1996) stated that, the symptoms and degree of infection can vary greatly in corm rot disease of gladiolus. In the least severe cases, the corm displays small, dark brown to black spots (1 - 2 mm) on the upper side of the corm. In more severe cases, the corms become completely soft and rotten and turn a reddish-brown colour (Botrytis corm rot). The corm then shrivels up on drying and mummifies. The infected corms sometimes look normal from the outside but will display a white mycelium, sometimes with black sclerotia, beneath their tunics.

Roebroek and Mes (1992) noticed that, the infected corms show brownish to black dry rot symptoms. Foliage of affected plants first turns yellow and then brown. Infected roots remain small and are gradually killed.

Sohi (1992) worked on diseases of ornamental plants and reported *Fusarium oxysporum* f. sp. *gladioli* from corms and roots of Gladiolus from India.

Mirza and Shakir (1991) reported Fusarium corm rot, or yellows, is caused by the fungus *Fusarium oxysporum* f. sp. *gladioli*. This is the most common and serious disease of gladiolus. Corm rot has three different forms—vascular, brown-rot, and basal dry rot—that are distinguished by the symptoms that each produces.

2.2.4. Stem Rot Disease of Gladiolus

Riaz et al. (2010) conducted an experiment to control Fusarium corm rot disease of gladiolus and found incorporation of leaves of some plant species in soil significantly reduced the disease incidence and number of lesions on root and enhanced shoot length and biomass.

Walid et al. (2010) proved that *Trichoderma harzianum* was more efficient to control *F. oxysporum* f. sp. *gladioli*, root rot disease of gladiolus and enhanced plant growth, increased flower production and quality. *Sesbania rostrata* compost was also effective in inhibiting the disease.

Mishra et al. (2004) reported that *Fusarium oxysporum* f. sp. *gladiolus* generally producing leaf spots and round, water-soaked reddish brown to brownish black spots in the roots. The lesions are usually not evident until the husks are removed. As the stem spots enlarge, the centers become sunken, dark brown to almost black, and hard. The margins become more definite, irregular, and somewhat angular. A diseased stem is

frequently reduced to a hard, wrinkled mummy. Plants arising from diseased corms are usually stunted to dwarfed, often fail to bloom, and may die early.

Partridge (2003) noticed that, *F. oxysporum* f. sp. *gladioli* cause three types of rot e.g. vascular corm rot, stem rot and basal rot. Stem rot is also called yellows and is characterized by a brown discoloration in the centre of the corm and extending into the flesh.

Lazarovits (2001) reported that, severely infected corms by *F. oxysporum* f. sp. *gladioli* will not emerge. A less severely infected corm will produce a plant that grows crookedly. At first, only the leaf tips turn yellow. Over time, the entire plant turns brownish yellow and finally dies. The infection can sometimes occur during the last phase of production; in this case, plants do not exhibit above-ground symptoms. The young corm can be infected through its contractile roots or by the older corm. The basal plate of the corm turns light to dark brown. This discoloration spreads to the central part of the corm and spreads outward from there. Different plants like *Sesbania rostrata* is used as soil amendment to control corm rot of gladiolus caused by *F. oxysporum* f. sp. *gladioli*.

Misra and Singh (1998) reported that, the *F. oxysporum* f. sp. *gladioli* caused leaf symptoms start at the tip of the leaf blade and gradually spread all over the leaf blade. If the plant is infected at later stage, it produces weak or small florets. When the plant is infected at early stage and infection is severe, whole plant becomes dry and dies within few days.

Davey (1996) stated that, *F. oxysporum* f. sp. *gladioli* is a soil borne pathogen. It can survive in soil for many days. Soil amendments with different organic matter play an important role to control the disease as well as to improve soil quality. As a result, stem rot cannot spread everywhere.

2.2.4. Aster Yellow Disease of Gladiolus

Koike et al. (2007) stated that due to aster yellow disease of gladiolus, an arrested root developed and have small or few corms during the season when they are first infected. In the next year, multiple thin and weak shoots arise from the corm giving the appearance of their nickname “grassy top”. The flower spike grows in a spiral pattern.

Treeful and Ash (2000) reported aster yellows disease of *Gladiolus* in the USA. The primary symptom of aster yellow diseases of *gladiolus* was characterized by distortion of newly emerged inflorescence. Sometime, flowers are clustered. When making clustered flower not to bloom. Lucrative look of the flower was interfered, and market value is decreased in a great extent. Aster yellows disease of *gladiolus* is caused by phytoplasmas formerly known as mycoplasma-like organisms and not by a virus. Phytoplasmas are microscopic organisms similar in size and composition to bacteria.

Beibel (1959) stated that symptoms of aster yellows may be variable depending on host plant, strain of the phytoplasma, etc. Initial symptoms may include vein clearing or yellowing progressing to an overall yellowing of the leaf. Infection early in the season will cause stunting, shortened internodes, and dwarfed, deformed or lopsided flower heads. The most diagnostic feature is adventitious shoot proliferation, which appears as a mass of leaves with a bushy or witch's broom effect. This may also occur in place of normal flower production. Because the phytoplasma is a systemic pathogen, plants will remain infected. Sensitive plants may be killed by the organism.

2.2.5. Mosaic Disease of *Gladiolus*

Katoch *et al.* (2002) observed the symptoms of mosaic disease in *gladiolus*. Silvery-white spots are distributed over the leaves. In a severe infestation, these spots will coalesce into large greyish to light brown areas with small black specks of thrip faeces. These spots appear first on places where the leaves overlap one another and between the sepals in the spike. The flowers can also be infested and will show definite visible spots. These flowers will usually open with difficulty.

Asjes (1997) stated that the symptoms of mosaic virus of *gladiolus* may vary depending upon the variety, the virus strain, the stage of growth at the time of infection, and environmental factors. Symptoms include striking dark green mottling and downward cupping along the main vein of each leaflet. Green vein banding, blistering and leaf malformation represent an advanced stage of the virus. Affected pods can become rough and smaller in size with spots.

Moran and Knoxfield (1996) *Gladiolus* plants infected with BYMV and/or CMV often have pale-yellow mottling of the leaves. Symptoms also include "flower break" and "colour break" of flowers, but not in white, cream or yellow cultivars. BYMV can reduce the production of *gladiolus* corms by about 33%. Infected plants may have a shortened life span and corms are also more susceptible to fungal attack.

UIE (1983) reported that the symptoms of mosaic disease of gladiolus have been described as faint, inconspicuous pencil-stripe break patterns that are lighter in color than the normal flower although it may be conspicuous on specific cultivars. The leaves and flower stems may have light or dark green mottling seen in the early summer.

2.2.6. Flower Rot Disease of Gladiolus

Siddique et al. (2013) observed flower rot disease in gladiolus in Bangladesh. She reported that, the flower rot disease of gladiolus occurred when flower lesions increased in size and coalesced to form patches within 7 to 10 days of infection. Shoots became blighted and died in 12-14 days. All the infected organs were covered with gray mold within 16-18 days. Re-isolation of the causal fungus from the inoculated plants consistently yielded the inoculated fungus. On petals and sepals translucent water soaked spots appeared with light brown margin and pale colored centre. As the spots enlarged, dead tissue turned into brown and the flowers became rotten. In severe cases entire flower can be rotted and gray mass of spore appeared on rotted portion.

Magie (1956) reported that *Botrytis gladiolorum* and possibly *B. cinerea*, fungi cause flower spot disease in gladiolus. Flowers develop pale brown, then dark-brown spots on the flower stem. Soft rotting at bases of florets may follow heavy rain. At first, petals develop translucent water-soaked spots. As petal spots enlarge, dead tissue turns light brown. Under moist conditions the whole flower becomes slimy with rot.

Magie (1951) estimated that the combination of *Botrytis* and *Curvularia* alone on leaves and flowers was responsible for a million-dollar loss in the United States in 1950.

2.3. Pathogens Associated with Corms of Gladiolus

Mancini et al. (2008) isolated *Fusarium oxysporum* f. sp. *gladioli* from rotten corm of gladiolus.

Magie (1960) stated that infected corm of gladiolus cause annual loss of 25 percent of the flowers and 15 percent of the corms of gladiolus. Corm infection caused mainly by *Fusarium oxysporum* f. sp. *gladioli* and *Curvularia trifolii* f. sp. *gladioli* Two other corm-borne fungi, *Stromatinia gladioli* and *Botrytis gladiolorum* Timm. are also cause infection in corm of gladiolus.

Parmelee (1954) reported *Curvularia lunata* and *Curvulria trifolii* from corms and leaves of Gladiolus.

Jackson (1961) conducted some studies on *Curvularia* diseases of Gladiolus and found that *Curvularia* was associated with corms and leaves.

Mirza and Shakir (1991) reported *Fusarium oxysporum* f. sp. *gladioli* from corms and roots and *Botrytis gladiolorum* and *Myrothecium roridum* from corms and leaves of Gladiolus for the first time from Pakistan.

Sohi (1992) worked on diseases of ornamental plants and reported *Fusarium oxysporum* f. sp. *gladioli* from corms and roots and *Botrytis gladiolorum*, *Curvularia sp.* and *Stemphylium sp.* from corms and leaves of Gladiolus from India.

2.4. Socio-Economic Study of Gladiolus Cultivation in Bangladesh

Hossain et al. (2014) conducted a socio-economic study on gladiolus cultivation in Bangladesh at the flower market in Agargaon and Shahbag, Dhaka during November 2013 to October 2014 to investigate the market demand, supply and price of different types of gladiolus flower. Data were collected from different wholesalers and farmers. The results indicated that the existence of wide variability among the types on their market demand, supply and price of different types of gladiolus flower. These indicators were varied among different month of the year, different days of the week and different special days of the year. The highest demand was observed in February (100%) and the lowest was in July (70%). The highest supply was observed in February (112%) while the lowest was in June and July (58%). The average highest price of gladiolus flower was observed in August (Tk. 11.40) and the lowest price was observed in March (Tk. 4.90). The highest and lowest price of different genotypes of gladiolus flower was ranged from Tk. 2.00 to Tk. 16.00 stick-1. The white genotype had the highest price Tk. 16.00 stick-1 while the orange genotype had the lowest price Tk. 2.00 stick-1. There was significant positive correlation between demand and supply (0.96). The price was negatively correlated with supply (-0.94).

Mou (2012) studied floriculture to identify the value chains and channels of flower marketing in Bangladesh. Stratified random sampling method was used to collect Primary data collected from the 32 farmers of Guptergaon under Phulpur Upazila in Mymensingh district and from the 21 flower traders, retailers and wholesalers of different flower trading zones in Dhaka city. The study reveals that gross margins of

flower and vegetables per hectare were Tk.1,359,824.20 and Tk.46,362.14, respectively. The average marketing margin of three intermediaries i.e., BRAC, wholesaler-cum-retailer and retailer in Dhaka city, were Tk. 187.56, Tk. 638.39 and Tk.689.72 per 100 flowers, respectively. Lack of mother stock and their high price, price of fertilizer and insecticides, lack of scientific knowledge & training, attack by pest & disease, lack of extension work came out as major financial and technical problems of the flower farmers while inadequate & underdeveloped transportation & communication system, low market price, lack of market information, unstructured market are among major market related problems.

Khandoker *et al.* (2012) conducted another study on gladiolus cultivation in Dhaka and Narayanganj districts of Bangladesh during 2010-2011 to assess the socioeconomic status and profitability of flower production. Based on area, production and market priority of gladiolus were selected for the study. A total of 60 farmers out of which 30 farmers from Dhaka district and 30 farmers from Narayanganj district were selected randomly to meet the objectives of the study. Per hectare gross cost of producing in gladiolus was Tk. 857524 where per hectare gross return from gladiolus amounted at Tk. 1488953. A net return from gladiolus was Tk. 631429. Benefit-cost ratio of gladiolus was 1.73 which implies that flower production was profitable in the study area.

Mou (2006) observed that, gladiolus flowers are grown round the year but large scale production is done during winter season. Farmers grow it in the field for commercial purpose. In recent past various kinds of flowers are imported from abroad. Bangladesh has spent roughly Tk. 2 - 3 million in importing flower and commercial plants to meet the market demand in every year. At present, Bangladesh is almost sufficient with her domestic flower. With increasing the demand of flower the production is also increasing day by day. The living standard of people is uprising in the urban areas which tend to increase the aesthetic sense. As a result the numbers of gladiolus flower lovers and flower buyers are increasing day by day. Recently, Bangladesh has started exporting a small amount of gladiolus flowers to the European and Middle East countries and earns foreign currencies.

Sultana (1995) reported some problems of gladiolus flower marketing which are unavailability of sufficient gladiolus flowers according to demand at right time, spoilage, lack of adequate and suitable transportation system. She suggested some measures to overcome these problems such as establishment of modern storage facilities, improvement of cultivation practices of flower for the whole year and arrangement of contract marketing.

CHAPTER III

MATERIALS AND METHOD

3.1.1. Experimental Site

The investigation and survey was conducted in Jashore, Manikganj and Dhaka districts. The survey on field diseases was conducted in Jhikargacha, Singair and Savar Upazilla of Jashore, Manikganj and Dhaka districts, respectively. Laboratory works and seed health study were carried out at Plant Disease Clinic, Department of Sher-e-Bangla Agricultural University, Dhaka.

3.1.2. Investigation and Surveyed Area

The field survey was conducted in the major Gladiolus growing regions of Bangladesh namely Jashore, Manikganj and Dhaka districts. Farmer's fields with standing gladiolus were selected for survey. Altogether 26 locations under 6 unions and 3 upazillas were intensively surveyed to collect data on diseases of gladiolus in Bangladesh (Table 1).

3.1.3. Experimental Period

The survey was carried out during the period from January, 2018 to April, 2019. Health study of corm was conducted in 2018. Moreover, survey on field disease was conducted in Manikganj and Dhaka districts in 2018 and field survey in Jashore was conducted in 2019.

3.1.4. Characteristics of Soil

The Savar regions belongs to Shallow Red Brown Terrace Soils under Tejgaon Series (Appendix. IV) under the agro-ecological region of "Madhupur Tract" (AEZ No. 28). The Jashore region occupies extensive low-lying areas between the Ganges river floodplain and the Ganges tidal floodplain under the agro-ecological region of "Gopalganj-Khulna Beels" (AEZ NO. 14).

3.5. Experiments

The following three experiments were carried out under this study:

- Exp.1: Detection, identification and measurement of diseases of gladiolus in Bangladesh.
- Exp. 2: Determine of health status of corm of gladiolus as planting materials.
- Exp. 3: Survey on socio economic status of gladiolus farmers, production technologies and problems related to gladiolus cultivation in Bangladesh.

Table 1. Survey locations for field investigation of diseases of Gladiolus

Sl. No.	Name of District	Name of Upazila	Name of Union	Name of Village	Number of Field
01.	Jashore	Jhikorgachha	Godkhali	Godkhali	3
				Patuapara	3
				Sadirali	3
				Belemath	3
				Dhalipara	3
			Panisara	Panisara	3
				Sayedpara	3
				Nilkanthanagar	3
				Kulia	3
				Krishnachandrapur	3
			Nabaron	Hariya	3
				Nimtola	3
				Baisa	3
				Sharifpur	3
				Chandpur	3
Mathuapara	3				
Nirbaskhola	Nirbaskhola	3			
	Shiorda	3			
2.	Manikganj	Singair	Singair	Singair	3
				Baliadangi	3
3.	Dhaka	Savar	Birulia	Bono Gram	3
				Sadullapur	3
Total	03	03	06	22	66



Plate 1.  Experimental sites under study

3.6. Sampling Size for Measurement of Diseases

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

3.7. Health Study of Corm of Gladiolus by Modified Blotter Method

Corms, the planting materials of gladiolus were collected from Dhaka, Manikganj and Jashore districts. Three samples were collected from each district. Each sample contains 50 corms. The collected corm samples was analyzed for investigation of seed borne pathogens by modified blotter method following the International rules for Seed Testing Agency (ISTA, 2001). Corms were surface sterilized by 3% chlorox (corms was

dipped into 3% chlorox solution for 1 minute then washed 3 times with distilled water). The earthen plate (25 cm) was used instead of petridish. Three piece of blotter paper sheet was soaked in sterilized water and placed at the bottom of earthen plate. Five corms were randomly selected from each sample and placed in each earthen plate in equal distance using a pair of forceps. Ten corms were places in the outer ring and another corm placed at center of earthen plate (Plate 3.E). To ensure moisture, earthen plate was covered with clear polythene bag during incubation period. The plated corm was incubated at $20\pm 2^{\circ}\text{C}$ for 21 days under 12 hours alternate cycle of Near Ultra Violet (NUV) light and darkness. After every 7 days of incubation period, individual gladiolus corm was examined under stereomicroscope in order to record the incidence of different seed borne fungi (Plate 3.F). With flamed sterilized needles fungal growths on the corm will be aseptically mounted in glycerine or laetophanol on slides and examined under the bionocular compound microscope for detection and identification of organisms. A list of morphological characters of taxonomic important such as spore size, shape, septation, color and their arrangement of the mycelium, density of the colony were compiled for each fungus. Identification of fungus was done considering morphological characteristics observed and using reference manuals of Booth (1971), Barnett and Hunter (1992). Percent pathogen incidence was recorded for each sample.

3.8. Interview of Farmers and Sample Size

In the survey program three farmers from each location were interviewed under this study (Plate 2. A&D). The interview was conducted to get information about diseases of gladiolus in different stages of plant and in different growing seasons of Bangladesh. The number of respondent was 66 as mentioned above.

3.9. Data Collection

Plant Disease Survey Sheet (Appendix. I) was used to collect information on symptomology of diseases and to record disease incidence and severity data (Plate 2.B&C). The surveys were conducted under natural epiphytic condition. Data were collected with three replications. However, the following information was recorded during field investigation –

1. Infected plant parts
2. Distribution of diseases
3. Status of diseases
4. Planting site
5. Symptomological study

Moreover, data were collected by interviewing of the respondents (farmers). The

questionnaires (Appendix. II), 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 gladiolus 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 gladiolus cultivation
13. Suggestion for management of diseases

3.10. Field Inspection and Symptomological Studies

Gladiolus plants of the selected farmer's field observed carefully and symptoms of the diseases were recorded in Plant Disease Survey Sheet (Appendix. I). In each village, three farmer fields were visited to find out present diseased condition of standing crops under natural epiphytic conditions. Different scientific articles were primarily used for disease identification in the 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.

Diseased plant samples and soil were collected from the infested field and examined in the laboratory. Diseased samples were brought to the laboratory to identify the causal organism. The causal organisms were then isolated, identified and recorded. The field investigation was conducted following Plant Disease Survey Sheet prepared by Department of Plant Pathology, Sher-e-Bangla Agricultural University. Farmer's

opinion on socio economic status of gladiolus farmers, production technologies, diseases and other problems related to gladiolus cultivation were also collected by using standard pre tested Questionnaires (Annex. 2).

3.11. Sample Collection

Diseased leaves and other infected plant parts showing different types of typical symptoms were collected from different gladiolus fields of Dhaka, Manikganj and Jashore to isolate causal organisms. In some cases, soil was collected and examined in the laboratory. The samples were carried to the Plant Disease Clinic of Sher-e-Bangla Agricultural University in individual snap locked plastic bags. The collected samples were then preserved in to the refrigerator at 4°C before investigation. In the laboratory, the samples were examined for visible symptoms as well as for microscopic examination and isolation of causal organism(s) have been done by tissue plating method.

3.12. Isolation of Causal organism(s) by Tissue Plating Method

Plant parts showing the typical disease symptoms were cut into small pieces aseptically, washed thoroughly in running tap water. Some samples were surface sterilized with 70% Ethanol for 30 seconds. Then with 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 hand washed three times in sterile distilled water each for 1 min. The surface sterilized leaf pieces were then aseptically plated on moistened Blotter paper and Potato Dextrose Agar (PDA) medium (Appendix. III), and incubated at 25±2 °C 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 (Plate 3.A , B & C). Microscopic examinations were carried out to study morphological characteristic of the fungus. The causal organisms were then re-isolated, identified and recorded. The pathogen was identified from all infected samples (Agrios, 2005).

3.13. Identification of Causal Organism(s)

Identification of causal organisms was done by the following methods:

3.13.1. Identification by Direct Observation (Microscopic Study)

The diseased leaves 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 and CMI Description (Mathur and Kongsdal, 2003; Riley, 2002; Carlile *et al.*, 2001; Ellis, 1971; Booth, 1971).

3.13.2. 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 and CMI description (Mathur and Kongsdal, 2003; Riley, 2002; Carlile *et al.*, 2001; Ellis, 1971).

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

The diseased leaves, stems, roots were cut into pieces (5 mm diameter) and collected samples were sterilized the surface 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 10% 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 (Mehrotra 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 tip culture method to obtain pure culture (Plate 3D). Then slides were prepared to observed under microscope and identified with the help of relevant literature and CMI Description (Agrios, 2005; Mathur and Kongsdal, 2003; Barnett and Hunter, 1972; Ellis, 1971; Booth, 1971).

3.13.4. Identification by Symptomological Study for Viral Disease

Symptomological studies were 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 using magnifying glass to observe the disease symptom development, sign of the pathogen. 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).

3.14. Measurement of Plant Diseases

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

3.14.1. 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:

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

3.14.2. Disease Severity

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

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

3.15. Analysis of Data

The collected data was analyzed by Statistics 10 computer package program. Analysis of variance (ANOVA) will be used to find out the variation of result from experimental treatments. The mean differences were judged by Least Significant Difference (LSD) at the 5% level of significance.



Plate 2. Investigation and measurement of diseases in the gladiolus field; (A) Interviewing of gladiolus farmer in the field of Savar; (B) Field disease investigation at Manikganj (C) Field disease investigation at Jashore; (D) Interviewing of gladiolus farmer in the field of Jhikargacha, Jashore



A



B



C



D



E



F

Plate 3. Isolation and identification of pathogens, (A) Isolation of causal organisms under Laminar Air Flow; (B) Incubation of disease sample; (C) Pure culture of pathogen and (D) Isolation of pathogen by tissue planting method; (E) Seed health study by modified blotter method; (F) Infected corm of gladiolus in blotting paper

CHAPTER IV

RESULTS

Experiment 1: Detection, Identification and Measurement of Diseases of Gladiolus in Bangladesh

4.1. Diseases of Gladiolus

During field investigation, in total seven diseases were identified in gladiolus plant at Dhaka, Jashore and Manikganj districts. The diseases were leaf spot, leaf blight, stem rot, corm rot, flower rot, aster yellow and mosaic diseases of gladiolus.

4.1.1. Leaf Spot Diseases of Gladiolus

A. Symptomological Study

Leaves, stems, and petals of gladiolus plants were generally affected by leaf spot. At first, light to dark brown, oval spots were seen most frequently on the leaf. Spots are characterized as oval to circular, brown spots with dark edges and surrounded by a yellow halo (Plate 4. C & D). Lesions become necrotic with leaves looking dry and wilted. The fungus produces a black, powdery mass of spores in the center of the spot.

B. Identification of Causal Organism

The identified causal organism of leaf spot of gladiolus was *Curvularia trifolii*. Though, it is a common inhabitants of dead material. Colonies display rapid growth and are olivaceous to grayish (bluish) black (Plate 4.E). The conidia of *C. trifolii*, the most frequently encountered species, typically have three septa and four cells. *Curvularia trifolii* produces large, upright stromareadily visible in culture with the naked eye. Their shape ware obclavate to elliptical or ovoid which were pointed at distal end (Plate 4.F). In the pure culture the colonies of *Curvularia* are moderately fast growing and produce dark white to blackish culture on PDA medium within 7 days.

C. Incidence and Severity of the Disease

Leaf spot disease was observed in all investigated locations. Incidence of *Curvularia* leaf spot varied significantly among the locations that ranged from 22% to 72.67% (Table 2). The highest disease incidence was recorded in Nimtola village (72.67%) and the lowest disease incidence was 22% in Panisara village of Jashore (Plate 4. A & B). In case of disease severity, similar trend were observed. Severity of *Curvularia* leaf spot also varied significantly among the location that ranged from 2.67 % to 15%. The highest disease severity was observed in Sharifpur which was 15%. Moreover, the lowest

disease severity was observed in Kuliya which was 2.67 %.

Table 2. Disease incidence and severity of leaf spot diseases of gladiolus

Location		Amount of Disease	
District and Upazilla	Village	Disease Incidence (%)	Disease Severity (%)
Jashore Jhikargacha	Godkhali	38.67 b-e	5.67 b-d
	Patuapara	40.67 a-e	6.00 b-d
	Sadirali	59.33 a-d	11.67 a-c
	Belemath	39.33 b-e	10.67 a-c
	Dhalipara	66.00 ab	12.67 ab
	Panisara	22.00 e	4.33 cd
	Syedpara	59.33 a-d	5.67 b-d
	Nilkanthanagar	40.67 a-e	5.00 b-d
	Kuliya	32.00 c-e	2.67 d
	Krisnachandrapur	49.33 a-e	6.33 b-d
	Hariya	31.33 c-e	10.00 a-d
	Nimtola	72.67 a	10.00 a-d
	Baisha	26.00 e	11.67 a-c
	Sharifpur	30.67 c-e	15.00 a
	Chadpur	28.67 c-e	7.33 a-d
	Mathuapara	34.00 b-e	6.66 b-d
Nirbashkhola	48.00 a-e	8.33 a-d	
Shiorda	62.00 a-c	8.33 a-d	
Dhaka Savar	Shadullapur	42.67 a-e	6.33 b-d
	Bonogram	44.00 a-e	8.67 a-d
Manikganj Singair	Singair	44.67 a-e	11.00 a-c
	Baliadangi	43.33 a-e	8.67 a-d
CV		44.99	57.60
LSD		32.19	7.88

Figures with similar letters of a column do not differ significantly.

** Means significant at the 0.05 probability level.

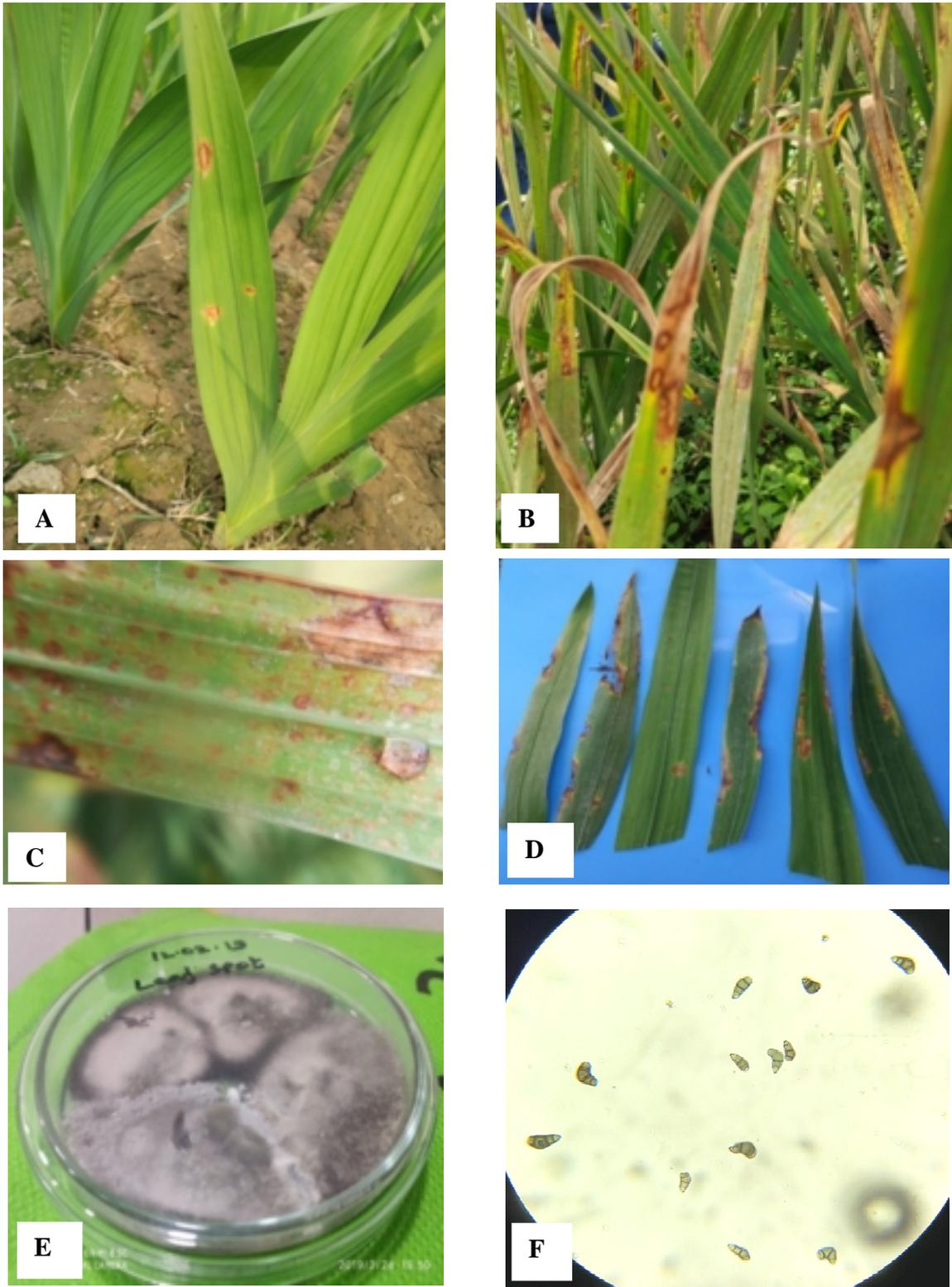


Plate 4. Symptoms and causal organism of leaf spot disease of gladiolus; (A & B) Field view of leaf spot disease; (C & D) Different stages of infection by leaf spot disease; (E) Pure culture of *Curvularia* sp.; (F) Compound microscopic view of *Curvularia* sp.

4.1.2. Leaf Blight Disease of Gladiolus

A. Symptomological Study

Symptoms of leaf blight or Botrytis blight are characterized as three distinct types of spots. One of them was very small, rust colored spots that appear on only one side of the leaf; another one was small, yellowish brown spots that develop reddish brown margins (Plate 5. C & D); and rest of the spot is large, oval spots that develop long, reddish margins.

B. Identification of Causal Organism

The identified causal organism of leaf blight disease of gladiolus was *Botrytis gladiolorum* (Plate 6. A & B). It is a hyphomycete with straight, brown, septate conidiophores, which are simple or, more commonly, alternately branched. The conidiophores bear botryose clusters of hyaline conidia, which appear grayish brown in mass. Conidia are budded off from a swollen, sporogenous cell at the tip of the conidiophore. It produced whitish cottony colony on PDA culture medium within 10 days. *Fusarium oxysporum* (Plate 6. C & D) and *Alternaria alternate* (Plate 6. E & F) were also isolated from the infected leaf samples.

C. Incidence and Severity of the Disease

Leaf blight disease of gladiolus was recorded in all locations of Jashore, Manikganj and Dhaka (Plate 5. A & B). Incidence of leaf blight disease varied significantly among the locations that ranged from 18.67 to 77.33% (Table 3). The highest disease incidence was recorded in Dhalipara (77.33%) that was statistically identical with other few locations. However, the lowest disease incidence was 18.67% observed in Baisha. In case of disease severity, similar trends were observed. Severity of leaf blight varied significantly among the locations that ranged from 2.33 to 11.67 % (Table 3). The highest disease severity was observed in Dhalipara (11.67 %) that was statistically identical with Shiorda and Nimtola (10%). The lowest disease severity was observed 2.33% in Baliadangi and Panisara villages.



Plate 5. Symptoms of leaf blight disease of Gladiolus; (A & B) Field symptoms showing leaf blight disease in gladiolus; (C & D) Different stages of leaf blight disease of gladiolus

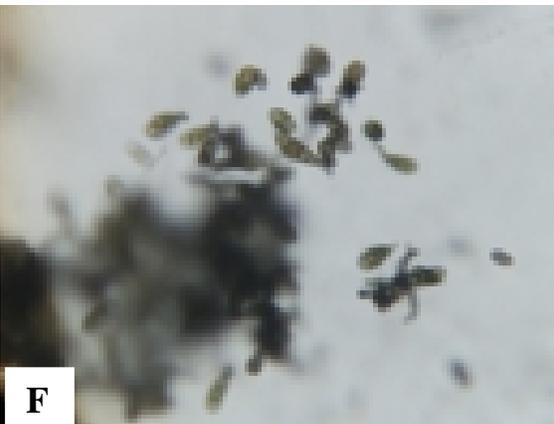
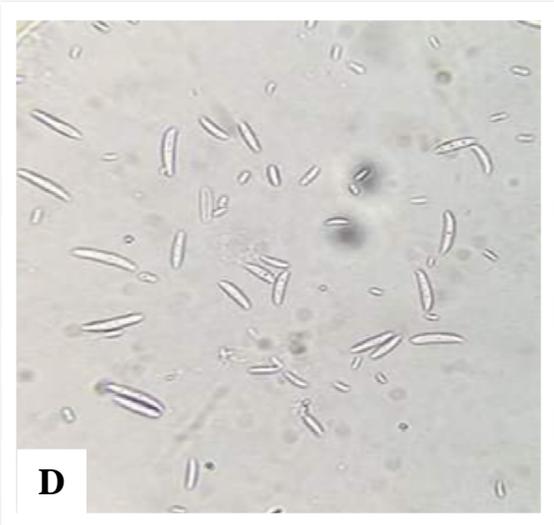
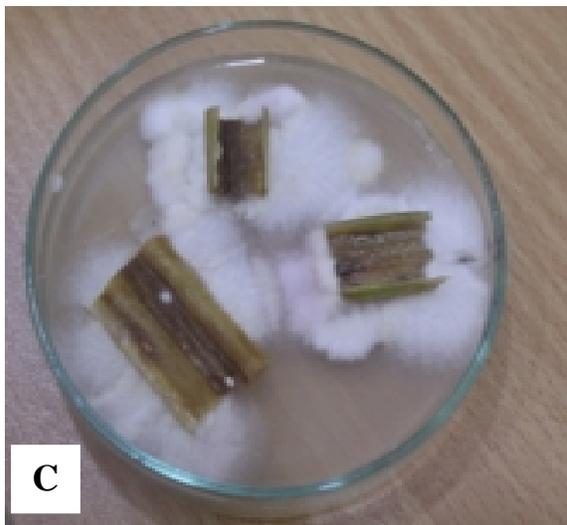
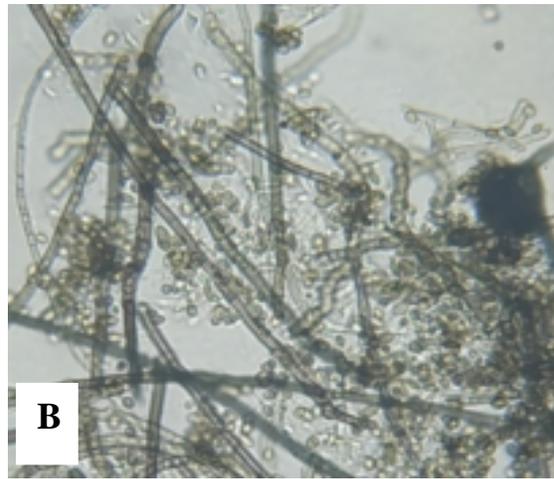
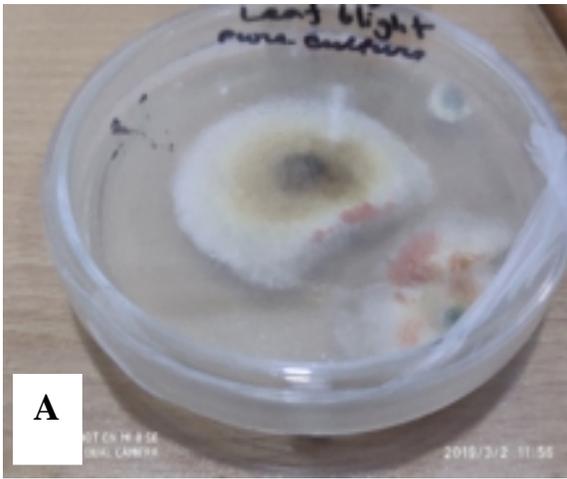


Plate 6. Causal organisms of leaf blight disease of Gladiolus; (A) Pure culture of *Botrytis gladiolorum*; (B) Conidia of *Botrytis gladiolorum*; (C) Culture of *Fusarium oxysporum*; (D) Conidia of *Fusarium oxysporum*; (E) Culture of *Alternaria alternata*; (F) Conidia of *Alternaria alternata*

Table 3. Disease incidence and severity of leaf blight disease of gladiolus

Location		Amount of Disease	
District and Upazilla	Village	Disease Incidence (%)	Disease Severity (%)
Jashore Jhikargacha	Godkhali	26.67 d-f	3.67 cd
	Patuapara	57.33 a-d	6.33 a-d
	Sadirali	64.00 a-c	9.67 a-c
	Belemath	48.67 a-f	5.00 b-d
	Dhalipara	77.33 a	11.67 a
	Panisara	26.67 d-f	2.33 d
	Syedpara	64.67 a-c	7.33 a-d
	Nilkanthanagar	40.00 b-f	3.00 d
	Kuliya	40.67 b-f	3.67 cd
	Krishnachandrapur	46.67 a-f	3.67 cd
	Hariya	28.00 d-f	3.00 d
	Nimtola	69.33 ab	10.00 ab
	Baisha	18.67 f	5.00 b-d
	Sharifpur	23.33 ef	3.67 cd
	Chadpur	50.67 a-f	5.67 a-d
	Mathuapara	44.67 a-f	6.33 a-d
	Nirbashkhola	25.33 d-f	5.00 b-d
Shiorda	53.33 a-e	10.00 ab	
Dhaka Savar	Shadullapur	32.00 c-f	3.00 d
	Bonogram	41.33 b-f	3.67 cd
Manikganj Singair	Singair	30.00 d-f	2.67 d
	Baliadangi	28.00 d-f	2.33 d
CV		46.78	70.29
LSD		32.84	6.14

Figures with similar letters of a column do not differ significantly.

** Means significant at the 0.05 probability level.

4.1.3. Stem Rot Disease of Gladiolus

A. Symptomological Study

At first brown spots appear on the stem and later necrosis start in the stem of gladiolus. Older leaves become yellow and gradually die. If infection occur after flowering, size, shape and color of flowers becomes abnormality. In advance of the disease, the infected stem becomes breakdown at the point of infection due to necrosis. Flowers are not developed while stalks are curved in an S-shaped. The symptoms are common to all three forms are a firm, brownish to black stem rot (Plate 7. A & B); yellowing, browning, and premature dying of the leaves; and a browning and destruction of the stem rots.

B. Identification of Causal Organism

The identified causal organism of stem rot disease of Gladiolus was *Fusarium oxysporum* f. sp. *gladioli*. Small, oval shaped, single or bicelled microconidia and hyaline, multicelled macroconidia with 3 septation were observed under microscope, which were sickle shaped with notched base at one end (Plate 7. E). White cottony mycelial growth was produced in pure culture within 7 days on PDA medium (Plate 7. C & D).

C. Incidence and Severity of the Disease

Stem rot disease of gladiolus disease were found only in different locations of Jashore districts. Among the locations, incidence of stem rot ranged from 15.33% to 55.33% (Table 4). The highest disease incidence was recorded in Sharifpur village (55.33%) and the lowest disease incidence was observed in 15.33% in Belemath village.

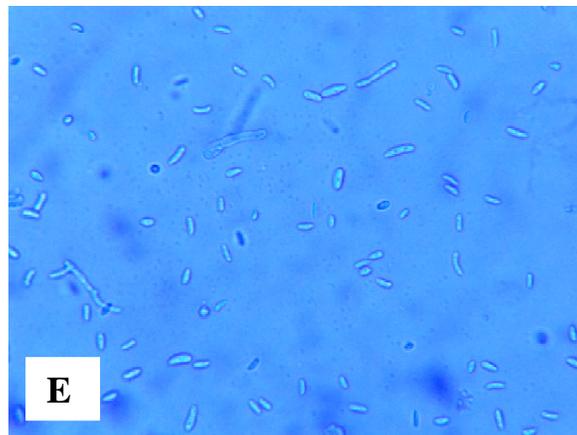


Plate 7. Stem rot disease of Gladiolus; (A & B) Completely rotten stems of gladiolus; (C) Isolation of causal organism by tissue planting method; (D) Pure culture of *Fusarium oxysporum* f. sp. *gladioli*; (E) Macroconidia and microconidia of *Fusarium oxysporum* f. sp. *gladioli*

Table 4. Disease incidence and severity of Stem rot of Gladiolus

Location		Amount of disease
District and Upazilla	Village	Disease Incidence (%)
Jashore Jhikargacha	Godkhali	16.00 bc
	Patuapara	32.00 ab
	Sadirali	21.33 bc
	Belemath	15.33 bc
	Dhalipara	22.67 bc
	Panisara	16.67 bc
	Syedpur	24.67 bc
	Nilkanthanagar	22.00 bc
	Kuliya	21.33 bc
	Krisnachandrapur	30.00 ab
	Hariya	19.33 bc
	Nimtola	36.00 ab
	Baisha	22.67 bc
	Sharifpur	55.33 a
	Chadpur	27.33 b
	Mathuapara	40.67 ab
Nirbaskhola	38.67 ab	
Shiorda	32.00 ab	
CV		70.62
LSD		26.13

Figures with similar letters of a column do not differ significantly.

** Means significant at the 0.05 probability level.

4.1.4. Corm Rot Disease of Gladiolus

A. Symptomological Study

Corm rot is one of the most serious diseases of Gladiolus, affecting plants in the field and corms in storage. The infected corms show brownish to black dry rot symptoms (Plate 8.B). The disease started from the center of corm to outward. At first, oval, sunken brown spots appear on the corm surface. Later tan, brown, or blackish lesions appear in infected corm. The rotted tissue often is quite thick and may extend completely through the corm. Foliage of affected plants first turns yellow and then brown. Infected roots remain small and are gradually killed. Ultimately the whole plant became dry (Plate 8. A).

B. Identification of Causal Organism

The identified causal organism of stem rot disease of Gladiolus was *Fusarium oxysporum* f. sp. *gladioli*. Small, oval shaped, single or bicelled microconidia and hyaline, multicelled macroconidia with 3 septation were observed under microscope, which were sickle shaped with knobbed base at one end (Plate 8. D). The pure culture of *Fusarium* was prepared. In the culture, the colonies were moderately fast growing and produced cottony white culture on PDA medium within 7 days (Plate 8. C).

C. Incidence and Severity of the Disease

Corm rot disease was observed in all locations of Jhikargacha, Jashore. corm rot of gladiolus, incidence and severity of the disease are same. Disease incidence was ranged from 10.67% to 25.33% among the investigated locations. The highest disease incidence was observed in Nimtola (25.33%) that was statistically identical with Dhalipara, Chadpur and Mathuapara. However, the lowest disease incidence was observed in Patuapara village (10.67%) of Gadkhali union of Jhikargacha upazilla (Table-5).



A



B



C



D

Plate 8. Corm rot disease of Gladiolus; (A) Gladiolus plant showing corm rot symptoms; (B) Rotten corms due to corm rot disease; (C) Pure culture of *Fusarium oxysporum* f. sp. *gladioli*; (D) Macroconidia and microconidia of *Fusarium oxysporum* f. sp. *gladioli*

Table 5. Disease incidence and severity corm rot of Gladiolus

Location		Disease Incidence (%)
District and Upazilla	Village	
Jashore Jhikargacha	Godkhali	12.00 de
	Patuapara	10.67 e
	Sadirali	16.00 b-e
	Belemath	15.33 b-e
	Dhalipara	22.67 ab
	Panisara	15.33 b-e
	Syedpara	13.33 c-e
	Nilkonthonogor	16.00 b-e
	Kuliya	14.67 c-e
	Krishnachandrapur	19.33 a-d
	Hariya	19.33 a-d
	Nimtola	25.33 a
	Baisha	14.00 c-e
	Sharifpur	12.00 de
	Chadpur	19.33 a-d
	Mathuapara	20.67 a-c
Nirbaskhola	16.00 b-e	
Shiorda	15.33 b-e	
CV		35.04
LSD		7.80

Figures with similar letters of a column do not differ significantly.

** Means significant at the 0.05 probability level.

4.1.5. Flower Rot Disease of Gladiolus

A. Symptomological Study

In the symptom of flower rot disease of gladiolus, light to dark brown, oval spots are most frequently seen on the petal and sepal (Plate 9. A-E). These become oval to circular, brown spots with dark edges and surrounded by a yellow halo. Lesions become necrotic. The fungus produces a black, powdery mass of spores in the center of the spot.

B. Identification of Causal Organism

The identified causal organism from flower rot disease of gladiolus was *Curvularia lunata*. It is a common inhabitants of dead material. Colonies display rapid growth and are olivaceous to grayish (bluish) black (Plate 9. F). Conidiophores are darkly pigmented and geniculate as a result of sympodial development. Curved conidia, sometimes subtle, result from an enlarged central cell, which is also darker than the other surrounding cells. The conidia of *C. lunata*, the most frequently encountered species, typically have three septa and four cells. *Curvularia lunata* var. *aeria* produces large, upright stromareadily visible in culture (Plate 9. G). Their shape were obclavate to elliptical or ovoid which were pointed at distal end. The pure culture of *Curvularia* sp. was prepared. In the culture, the colonies of *Curvularia* are moderately fast growing and produce dark brown to blackish culture on PDA medium within 7 days

C. Incidence and Severity of the Disease

Incidence of flower rot disease of gladiolus varied significantly among the locations of that ranged from 5.33 to 10% (Table 6). The highest disease incidence (10%) was recorded in Godkhali, Belemath, Nimtola and Nirbashkhola. The lowest disease incidence was 5.33% observed in Kuliya, Jashore. In case of disease severity, similar results were observed. Disease severity was also varied significantly. The highest disease severity was observed in Sadirali, Nimtola and Mathuapara which was 3 %. Moreover, the lowest disease severity (1%) was observed in Godkhali.

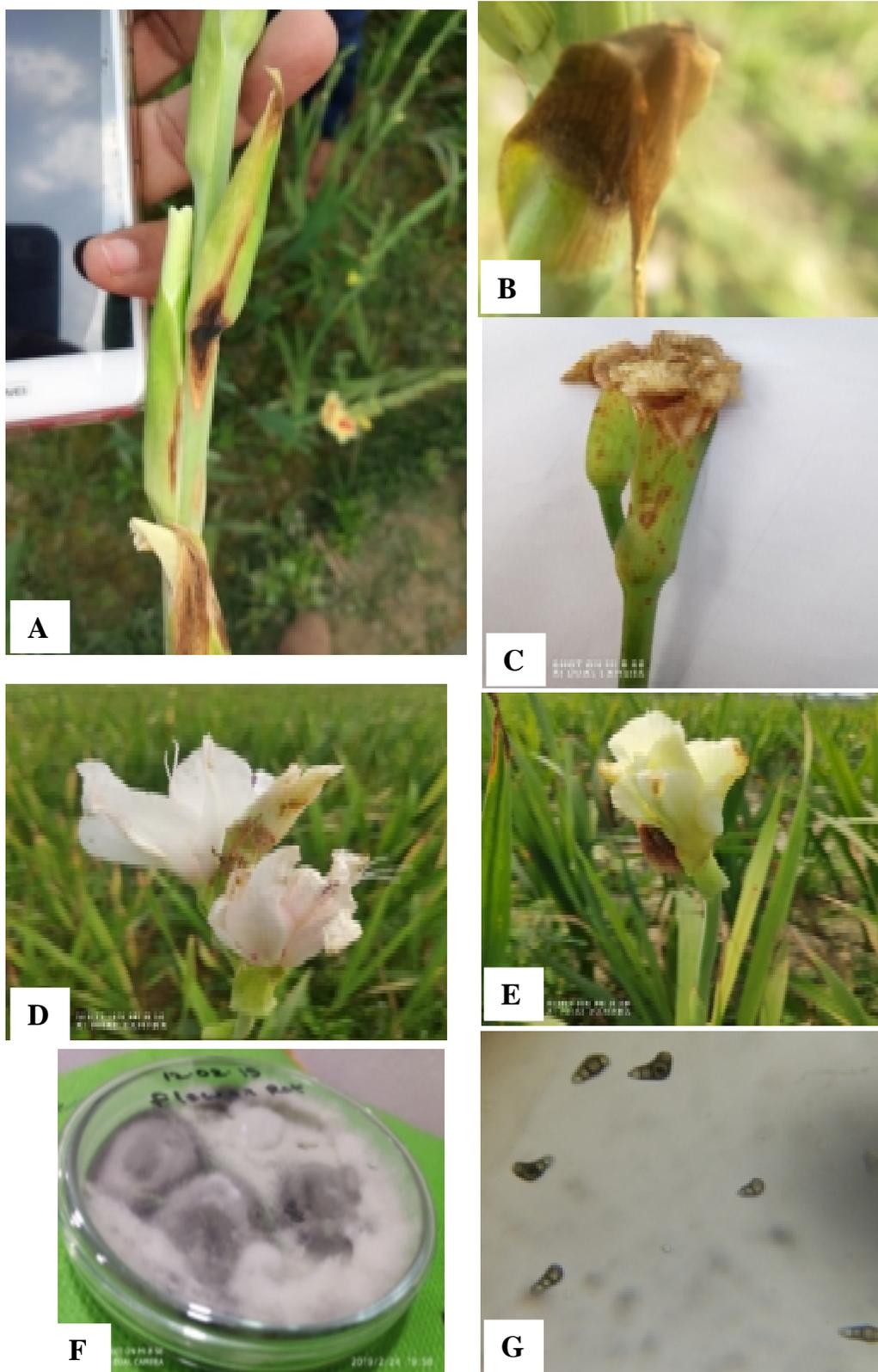


Plate 9. Symptoms and causal organism of flower rot disease of Gladiolus; (A) Infection start from sepal; (B) Completely rotten petal; (C) Infection showing in both petal and sepal; (D & E) Infection in sepal of gladiolus; (F) Pure culture of *Curvularia lunata* and (G) Compound microscopic view of *Curvularia lunata*

Table 6. Disease incidence and severity of Flower rot of Gladiolus

Location		Amount of Disease	
District and Upazilla	Village	Disease Incidence (%)	Disease Severity (%)
Jashore Jhikargacha	Godkhali	9.33 ab	1.00 cd
	Patuapara	9.33 ab	1.33 b-d
	Sadirali	9.33 ab	3.00 ab
	Belemath	10.00 a	1.67 b-d
	Dhalipara	6.67 ab	1.67 b-d
	Panisara	7.33 ab	1.67 b-d
	Syedpara	8.67 ab	2.67 a-c
	Nilkonthonogor	6.67 ab	2.33 a-c
	Kuliya	5.33 b	3.67 a
	Krishnachandrapur	9.33 ab	1.67 b-d
	Hariya	9.33 ab	2.33 a-c
	Nimtola	10.00 a	3.00 ab
	Baisha	9.33 ab	1.00 cd
	Sharifpur	8.00 ab	1.67 b-d
	Chadpur	9.33 ab	1.67 b-d
	Mathuapara	8.00 ab	3.00 ab
	Nirbaskhola	10.00 a	1.67 b-d
	Shiorda	9.33 ab	2.00 a-c
CV		37.90	66.33
LSD		4.41	1.83

Figures with similar letters of a column do not differ significantly.

** Means significant at the 0.05 probability level.

4.1.6. Aster Yellow Diseases of Gladiolus

A. Symptomological Study

The primary symptom of aster yellow diseases of gladiolus was characterized by distortion of newly emerged inflorescence. Sometime, flowers are clustered (Plate 10. A-C) , when making clustered no or partial blossom of flower was observed. (Plate 10. D). Lucrative look of the flower was interfered and market value is decreased in a great extent. Gladiolus plants mature early, have an arrested root development and have small or few corms during the season when they were first infected. The next year, multiple shoots that were thin and weak shoots may develop from the corm. The disease is confirmed by following description of **Koike et al. (2007)**

B. Identification of Causal Organism

No organism was identified from aster yellow diseases of gladiolus. Aster yellows

disease of gladiolus is caused by phytoplasma formerly known as mycoplasma-like organisms (Treeful and Ash, 2000).

C. Incidence and Severity of the Disease

Aster yellow disease was found in Jhikargacha upazilla of Jashore. No disease was recorded in Kuliya, Krishnachandrapur, Nirbaskhola, Shiorda and Hariya villages. Disease incidence and severity were ranged from 0 to 9.33% and 0 to 1.67%, respectively. The highest disease incidence (9.333%) was recorded in Mathuapara and Godkhali villages (Table -7).

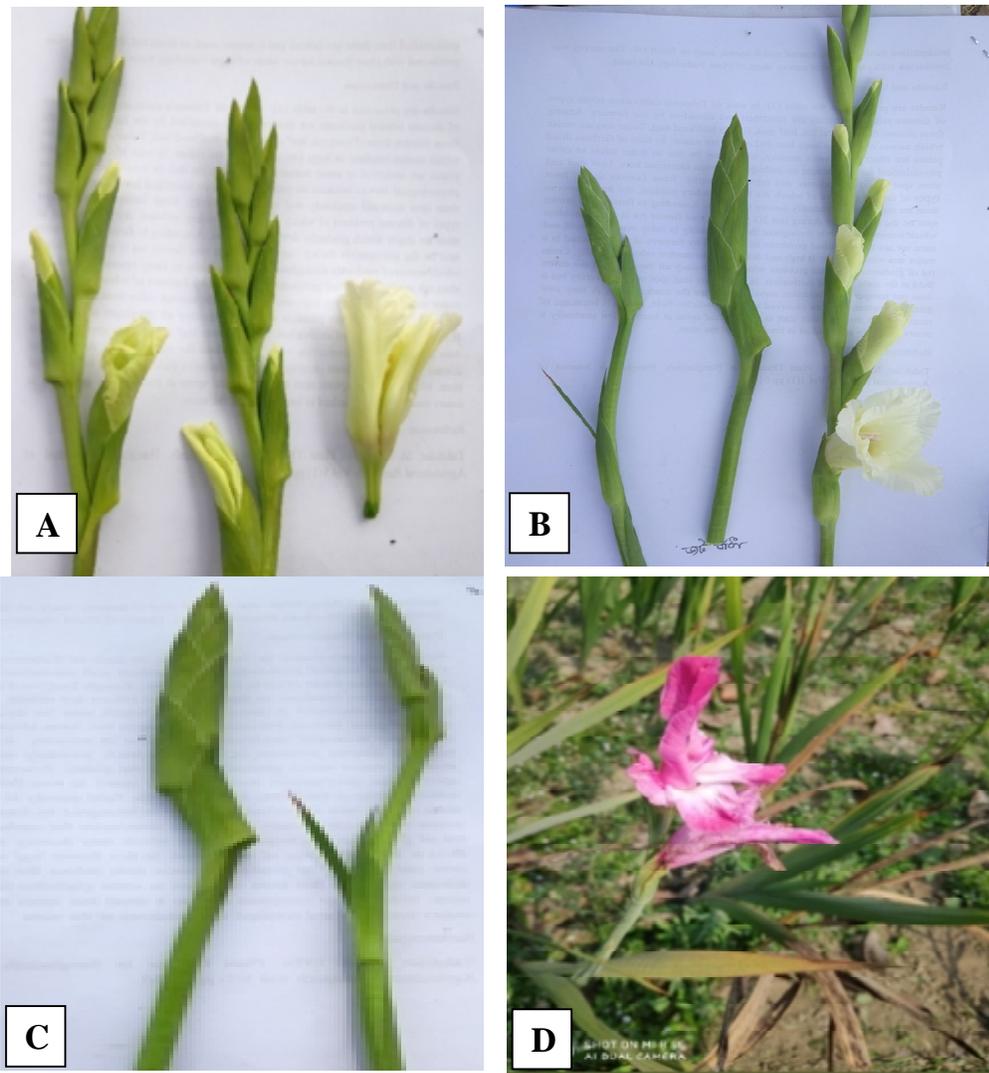


Plate 10. Symptoms of Aster yellows disease of Gladiolus; (A) Clustered of flowers; (B&C) Flowers became bend and clustered; (D) Abnormal bloom of flower

Table 7. Incidence and severity of aster yellow disease of gladiolus in field condition

Location		Amount of disease
District and Upazilla	Village	Disease Incidence (%)
Jashore Jhikargacha	Godkhali	9.33 a
	Patuapara	7.33 a-d
	Sadirali	8.00 a-c
	Belemath	6.00 a-d
	Dhalipara	4.67 cd
	Panisara	4.00 d
	Syedpara	5.33 b-d
	Nilkonthonogor	8.00 a-c
	Kuliya	0.00 e
	Krishnachandrapur	0.00 e
	Hariya	0.00 e
	Nimtola	8.67 ab
	Baisha	6.00 a-d
	Sharifpur	6.67 a-d
	Chadpur	5.33 b-d
	Mathuapara	9.33 a
Nirbashkhola	0.00 e	
Shiorda	0.00 e	
CV		53.02
LSD		3.52

Figures with similar letters of a column do not differ significantly.

** Means significant at the 0.05 probability level.

4.1.7. Mosaic Disease of Gladiolus

A. Symptomological Study

Mosaic diseases were observed in flower and leaves of gladiolus. Flowers become small, distorted or have color breaking. Leaf tissue may be mottled, have white flecks, or reddish blotches (Plate 11. A&B).

A. Identification of Causal Organism

No organism was identified from viral diseases of gladiolus. Most possibly any kind of virus is responsible for the disease. Moreover, physiological disorder, nutrient imbalance, uneven distribution of water, soil aggregates or any other component of the climate may produce similar symptoms.

B. Disease Incidence and Severity of Viral Diseases

The mosaic disease of gladiolus are found only Sharifpur village in Jhikargacha union of Jashore. The disease incidence was 3.33% and disease severity was 20%.



Plate 11 (A & B). Symptoms of mosaic disease in gladiolus plant

Experiment 2:

4.2. Detection of Health Status of Corm of Gladiolus by Modified Blotter Method

Farmer's saved corms of gladiolus were collected from Dhaka, Manikganj and Jashore districts of Bangladesh. Three samples were collected from each district. Modified blotter paper method was used to determine the health status of planting material (corms) of Gladiolus. All together five fungi viz. *Fusarium oxysporum*., *Aspergillus flavus*, *Aspergillus niger*, *Rhizopus stolonifer*, *Chaetomium* sp. were isolated and identified from corm of gladiolus.

4.2.1. Incidence of Pathogen in Corm of Gladiolus

Incidence of pathogens of corm of gladiolus was identified by modified blotter method and presented in Table 8. In samples of Manikganj, 30% corms were infected by *Aspergillus niger* followed by *Chaetomium* sp. (28%), *Aspergillus flavus* (25.4%), *Rhizopus stolonifer* (14%) and *Fusarium* sp. (12%). Similarly, *Aspergillus niger* showed the highest infection (40%) in corm collected from Dhaka followed by *Fusarium* sp. (22%), *Chaetomium* sp. (22%), *Rhizopus stolonifer* (20%) and *Aspergillus flavus* (12%). However, in case of corm collected from Jashore, *Chaetomium* sp. cause maximum corm infection (24%) followed by, *Aspergillus flavus* (22%), *Rhizopus stolonifer* (20%), *Fusarium* sp. (18%) and *Aspergillus niger* (14 %).

Table 8. Pathogen incidence by modified blotter paper method

Source Name	% Pathogen Incidence				
	<i>Fusarium oxysporum</i>	<i>Aspergillus flavus</i>	<i>Aspergillus niger</i>	<i>Rhizopus stolonifer</i>	<i>Chaetomium</i> sp.
Dhaka	22.0	12.0	40.0	20.0	22.0
Manikganj	12.0	25.4	30.0	14.0	28.0
Jashore	18.0	22.0	14.0	20.0	24.0

4.2.2. Description of Identified Pathogen

A. *Fusarium oxysporum* f. sp. *gladioli*

The fungus produces sparse to abundant growth, covering part or whole corm (Plate 12 A). Mycelium can be white to cream colored. Slimy masses of conidia which are seen along the hyphae are characteristic of the species. Pale orange, very slimy pionnotes, full of macroconidia can also be produced. Pionnotes are much bigger in size as seen. Macroconidia are generally produced in abundance, they vary a lot in size and are oval-shaped, elliptical or reniform (kidney- shaped), usually non-septate but one septate conidia found. Microconidia can also be formed in false-heads on

short monophialides. Macroconidia are hyaline, thin-walled, 3-5 septate, falcate to almost straight. Chlamydospores intercalary or terminal on short lateral branches (Plate 12. B).

B. *Aspergillus niger*

Brown to Black globose conidial heads on long, erect, hyaline conidiophores are characteristic of the fungus. Conidiophores solitary or in small groups. They cover parts of seed or whole seed. Conidia more or less globose, dark brown often rough or echinulate (Plate 12. E & F).

C. *Aspergillus flavus*

The growth of the fungus on corn is characterized by immature, while heads and mature heads in shades ranging from yellowish cream to green. Conidiophores bearing the heads are clearly seen when the growth is light. They are long hyaline terminating in bulbous heads. Conidia globose to subglobose, usually rough (echinulate) and yellowish-green (Plate 13. C & D).

D. *Rhizopus stolonifer*

Often the growth of the fungus covers the whole corms and extends to blotter paper. This is because of the fast spreading nature of the fungus. Even from one infected corm the dense mycelium can cover the whole petri dish. The brown sporangiophores are long, solitary or arise. The rhizoids at the base of sporangiophores can be seen in some cases. They are more clearly visible on the blotter. Sporangia spherical and black, contain numerous sporangiospores. Sporangiospores are one celled, spore shape may vary from globose to oval, ellipsoid, polygonal or angular, even striate (Plate 13. A & B).

E. *Chaetomium sp.*

Chaetomium is a fungus belonging to Ascomycota of the family Chaetomiaceae. *Chaetomium* species are traditionally identified by the type of terminal hair and lateral hairs or ascotal hairs (straight, hooked, spiral, coiled etc.) covering the ascomata, the shape and size of asci and ascospores. Long, slender, circular or flexuous, dark conidiophores of the fungus develop singly or in groups bearing few to many dark conidia. Conidia smooth-walled, three septate, mostly curved, third cell from the base the largest and darkest, hilum protuberant (Plate 13. C & D).

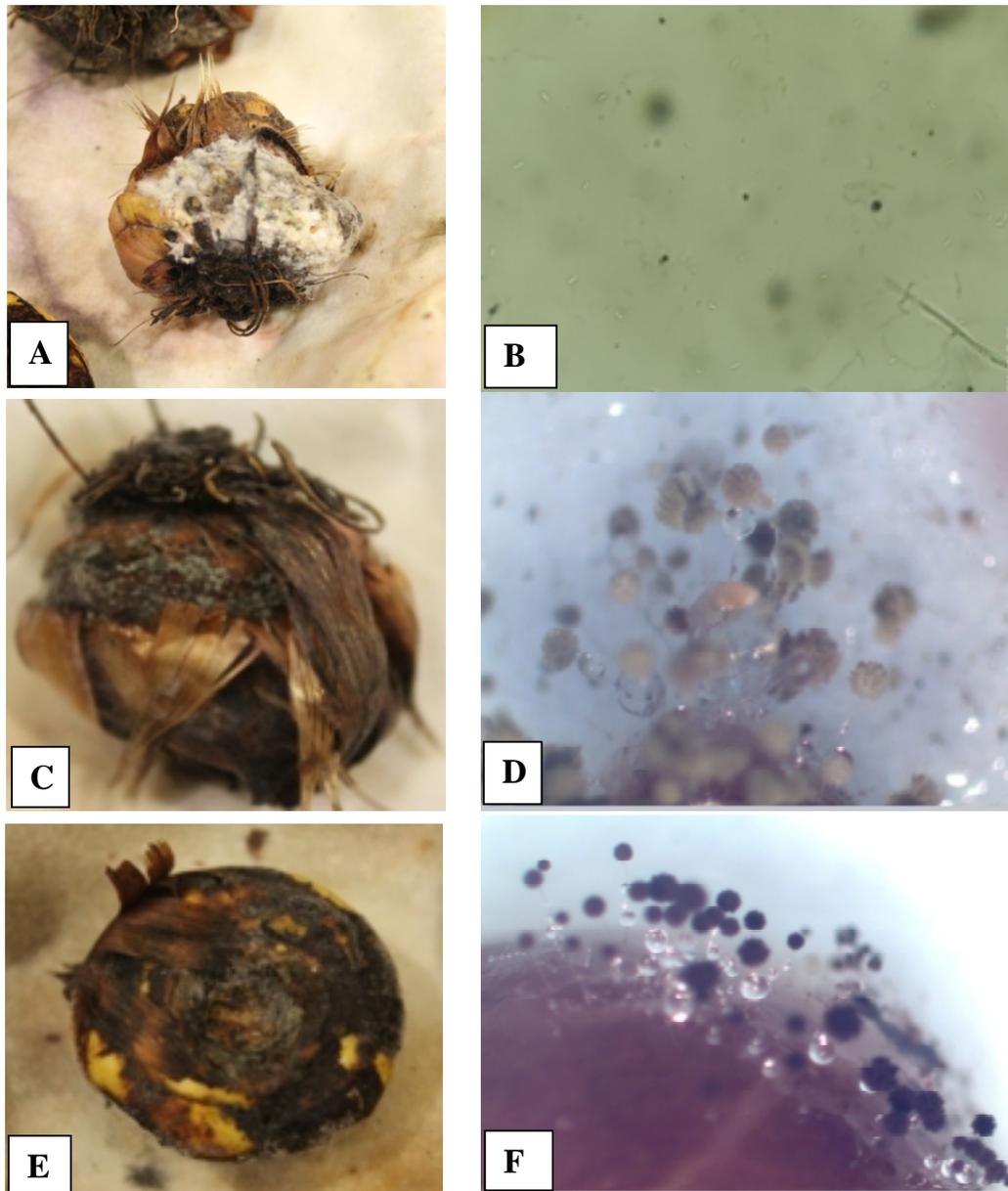


Plate 12. Pathogens isolated from corms of gladiolus by modified blotter method; (A) Infected corm by *Fusarium*; (B) *Fusarium oxysporum* under compound microscope; (C) Infected corm by *Aspergillus flavus*; (D) *Aspergillus flavus* under stereo microscope; (E) Infected corm by *Aspergillus niger*; (F) *Aspergillus niger* under stereo microscope

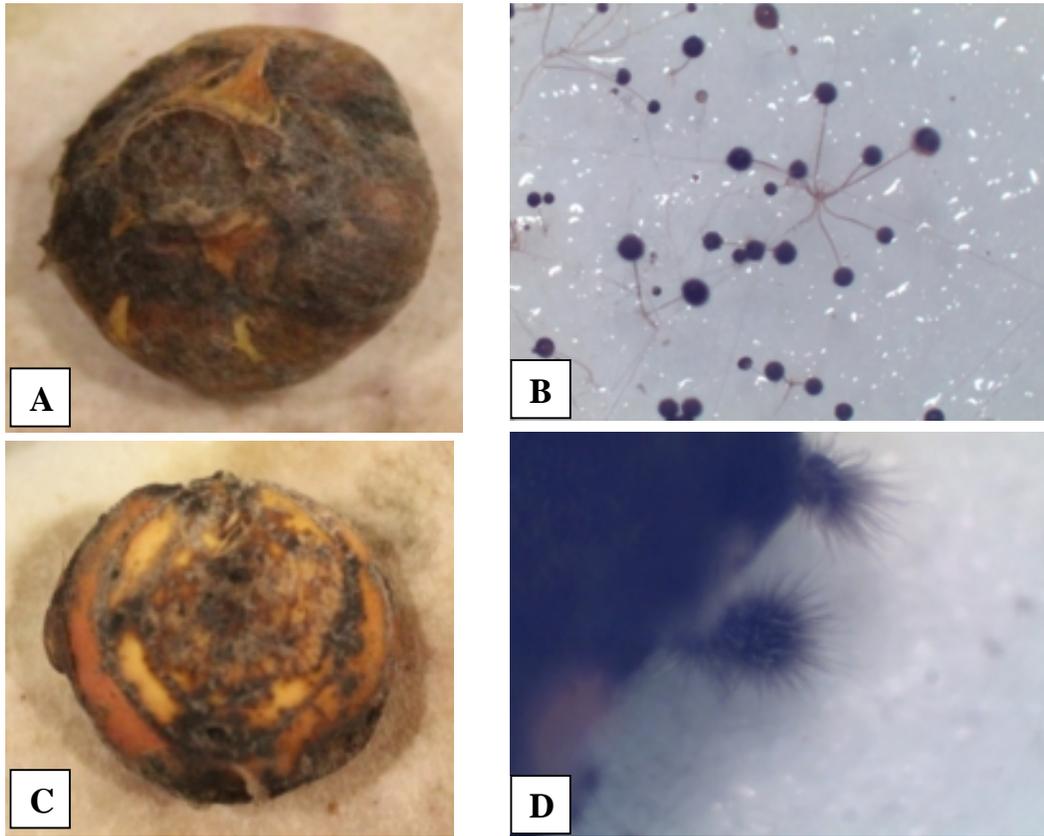


Plate 13. Different fungal pathogens detected from infected corm by modified blotter paper method; (A) Infected corm by *Rhizopus stolonifer*; (B) *Rhizopus stolonifer* under compound microscope; (C) Infected corm by *Chaetomium* sp.; (D) *Chaetomium* sp. under stereo microscope

Experiment 3

4.3. Survey on socio-economic status of gladiolus farmers, production technologies and problems related to Gladiolus cultivation

A details survey was conducted on socio economic status of gladiolus farmers, existing production technology, diseases and other problems related to gladiolus cultivation in Bangladesh. The findings are given below:

A. Survey on Socio-Economic Status of Gladiolus Farmers

4.3.1. Gender of the Farmers

There were 66 gladiolus farmers had been interviewed among whom 54 were from Jhikargacha Upazila of Jashore, six were from Dhaka and rest six were from Manikganj districts. Out of 66 respondents, 58 were male and 8 were female (Table 9). Most of the interviewed gladiolus farmers were male who occupied 87.88 % out of 100. The rest 12.12% respondents were female.

Table 9. Gender of the gladiolus flower farmers

Gender	No. of the respondent	Response (%)
Male	58	87.88
Female	8	12.12
Total	66	100.0

4.3.2. Age of Gladiolus Farmers

Altogether 66 farmers were participated in the field survey at Jashore, Dhaka and Manikganj districts in Bangladesh. Most of the farmers were 30 to 40 years old and the percentage was 53.03. Whereas, 25.76% gladiolus farmers were 40-50 years old and 10.60 % farmers were above 50 years old. Only 7 farmers (10.61%) were below 30 years old (Table 10).

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

Ages (years)	No. of respondent [N=66]	% Response
<30	7	10.61
30-40	35	53.03
40-50	17	25.76
50<	7	10.60
Total	66	100.0

4.3.3. Education of Gladiolus Farmers

Most of the farmers (33.33%) participated in the survey were illiterate. However, 25.76% gladiolus farmers completed primary education and 16.67% completed secondary education. Among the respondent, 7.58% completed Degree and 9.08% completed Masters (Table 11).

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

Education level	No. of respondent	% Response
Illiterate	22	33.33
Class 1-5	17	25.76
Class 6- SSC	11	16.67
HSC	5	7.58
Degree	5	7.58
Masters	6	9.08
Total	66	100.0

4.3.4. Land Utilization under Gladiolus Cultivation

Land utilization by farmers under gladiolus cultivation ranges from 2 to 8 bigha was 65.14% (Table 12). Most of the farmers (51.51%) cultivated gladiolus from 2 to 5 bigha of land. However, around one fourth farmers cultivated gladiolus in below 2 bigha lands. Around 10% farmers cultivate gladiolus in more than 8 bigha lands.

Table 12. Land utilization under gladiolus flower cultivation

Land utilization (Bigha)	No. of respondent (N=66)	% Response
<2	16	24.24
2-5	34	51.51
5-8	9	13.63
8<	7	10.62
Total	66	100

4.3.5. Farmers' Opinion on Land Utilization Pattern for gladiolus Cultivation

According to the farmers opinion, on an average total land area owned of 66 farmers was 0.94 ha, of which cultivable land under total land owned was 0.80 ha. The land under gladiolus flower cultivation was 0.40 ha. From these findings it was revealed that a large portion of the cultivable lands of investigated farmers was engaged under gladiolus flower cultivation (Table 13).

Table 13. Farmers’ opinion on the land utilization pattern for gladiolus cultivation

Land utilization pattern	Land size (Trimmed Mean)	
	Bigha	Hectare
1. Total land area owned	7.07	0.94
2. Cultivable land under total land owned	6.03	0.80
3. Land area under gladiolus flower cultivation	3.01	0.40

*1 hectare = 7.5 bigha

4.3.6. Duration (year) engaged in gladiolus flower cultivation

Out of 66 farmers, most of them were cultivating gladiolus in below 5 years which ranked first 92.42% (Table 14). About 3.03 % of the farmers are cultivating gladiolus from 10 to 15 years.

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

Duration (year)	No. of respondent	% Response
<5	61	92.42
5-10	3	4.54
10-15	2	3.04
Total	66	100

B. Survey on Production Technology Used by Gladiolus Farmers

4.3.7. Source of Planting Materials (corms) Used by Gladiolus Farmers

Farmers were collecting planting materials of gladiolus (corm) from different sources (Table 15). Out of 66 farmers, most of them use corm from their own preservation (80.96%). Moreover, farmers also collected corms (planting materials of gladiolus) from importer, dealer, neighbor and local market were 12.12%, 9.09%, 6.06% and 3.03%, respectively.

Table 15. Farmers’ opinion on the source of planting materials used for gladiolus cultivation

Source of gladiolus planting materials	Response	
	No. of respondent [N=66]	% Response
1. Directly from importer	8	12.12
2. Personal Preservation	46	69.69
3. Local market	2	3.03

4. Farmers neighbor	4	6.06
5. Seed Dealer	6	9.09

4.3.8. Fertilizer application on gladiolus fields

Application of organic manure is of paramount importance for both flowering and corm development. However, use of too much manure should be avoided as this tends to make the flower spikes too tall and slender. Total amount of farm yard manure was applied once during land preparation @ 50,00 kg/ha with Urea, TSP, MOP, Zinc, Zypsum @ 250 kg/ha, 200 kg/ha, 200 kg/ha, 7 kg/ha and 20 kg/ha, respectively (Table 16).

Table 16. Fertilizer application on gladiolus fields

Manure/Fertilizer	Dose per/ha (kg)
Farm Yard Manure	5000
Urea	12.25
TSP	36.25
MOP	27.50
Zinc	7.00
Zypsum	20.00

4.3.9. Cost Involved in Pest Management of Gladiolus Cultivation

As per farmer's opinion, total cost involved for pest management of Gladiolus is 4500 taka per year per bigha (Table 17). In which, 1200 taka is for disease management and 1000 Tk. for insect pest management and 1500 Tk. for weeding. Moreover, another 800 taka is required for other protection purposes.

Table 17. Cost involved in pest management of gladiolus cultivation

Cost/Bigha/Year (Tk.)			Other pest control cost Tk./Bigha/Year
Disease	Insects	Weeds	800
1200	1000	1500	
Total: 4500 Tk./Bigha/Year			

4.3.10. Buyer of Gladiolus from Farmers

Among 66 farmers, most farmers 42.42 % sold gladiolus flower through middleman (Table 18). However, 40.91% farmers were sold gladiolus directly to the businessmen. Moreover, 12.12% farmers sold flower to different companies.

Table 18. Buyer of gladiolus from farmers

Buyer	No. of respondent [N=66]	% Response
Directly	27	40.91
Middleman	28	42.42
Company	4	6.06
Export company	4	6.06
Others	3	4.55
Total	66	100.0

4.3.11. Cost Involved for Gladiolus Flower Production/Bigha

In Dhaka, Manikganj and Jashore, cost of production for gladiolus cultivation was almost same. Though, the cost was varied year to year. Maximum cost goes for purchasing corms. Gladiolus corm is the planting materials of this cut flower. On average, the farmers purchase the corms at maximum 5 taka and minimum 3 taka depending on the sources and other factors. Therefore, around 24000 Taka cost involves initially for the purpose of planting materials per bigha. Weeding is a must doing intercultural operation of Gladiolus as 1500 taka. Moreover, irrigation, pesticides and picking of flowers required 1500, 3000 and 1000 Taka/bigha, respectively. Some other costs also may be involved which assumed 1000 Taka/year. As per farmers opinion, a total cost of production of gladiolus was 34,500 Tk/Bigha (Table 19).

Table 19. Cost involvement in gladiolus Cultivation (Bigha/year) at Jashore

Cost involvement	Taka/Bigha
Land preparation	2500
Planting Materials	24000
Weeding	1500
Irrigation	1500
Pesticide	3000
Picking flowers	1000
Other cost	1000
Total cost	34,500

4.3.12. Benefit Cost Analysis of Gladiolus (Bigha/year)

The benefit cost analysis of gladiolus varied production of flower sticks which depended upon different factors. Generally gladiolus plants gave higher and quality sticks in first six month. After that the production was decreased. On an average 40,000 sticks/year/bigha was produced in a year. In the peak season farmers got about 8 Tk/stick, in off peak they got about 4Tk/stick and on average 6Tk/stick flower. 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. Total income from gladiolus cultivation per year/Bigha was 2,40,000 Tk. However, total cost of production was only 34,500 Tk. On average the net profit comes from gladiolus cultivation was about 2,05,500 Tk/Bigha/years (Table 20).

Table 20. Benefit cost analysis of gladiolus (Bigha/year)

Production (sticks/year)	Price (Tk/stick)	Total cost Tk (Bigha/year)	Total Income Tk (Bigha/year)
40,000	Peak: 8 off Peak:4 Average:6	34,500	2,40,000

C. Survey on Farmers Opinion on Diseases of Gladiolus

4.3.13. Incidence of Disease Infections in the Gladiolus Field

Considering the opinion expressed by the farmers, the diseases of gladiolus in field were leaf spot, leaf blight, aster yellow, flower rot, root rot and stem rot (Table 21). Among these diseases leaf blight, leaf spot and corm rot were considered as major disease and the incidence were 37.87%, 33.33% and 12.12%, respectively. As per farmer’s opinion, the minor disease of Gladiolus was stem rot and aster yellow or flower abnormalities. The infestation intensity of the diseases was low to medium to high expressed by most of the farmers.

Table 21. Farmers’ response on the incidence of disease intensity in the gladiolus field

Name of disease	No. of respondent N={66}	% of disease	Infection intensity			
			High	Medium	Low	Total
1. Leaf spot	25	37.87	65.79	26.32	7.89	100.0
2. Leaf blight	22	33.33	61.29	29.03	9.68	100.0
3. Flower rot	3	4.54	9.68	29.03	61.29	100.0
4. Aster yellow	2	3.03	-	14.29	85.71	100.0
5. Stem rot	6	9.09	7.89	26.32	65.79	100.0
6. Corm rot	8	12.12	39.13	26.09	34.78	100.0

4.3.14 Relationship among Insect Pest, Disease and Weed Infestation in Gladiolus Field

Farmers expressed their different opinion about relationship among insect pest, disease and weed infestation in Gladiolus field. Maximum farmers expressed their opinion in a positive site and the ranges were (89.39%), whereas only 10.61% farmers expressed their negative view on this issue (Table 22).

Table 22. Farmers' opinion on the relationship among insect pests, diseases and weed infestation in the gladiolus field

Types of response	Response on the relationship	
	No. of respondents	% Response
Yes	59	89.39
No	7	10.61
Total	66	100

4.3.15. Degree of Relationship among Insect Pests, Diseases and Weed Infestation in the Gladiolus 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 gladiolus field (Table 23). This result indicates insect infestation and disease infection become high when weed infestation become high expressed by the by the 57.41% and 57.41% farmers respectively, i.e., insect infestation and disease infection increased with the increase of the weed infestation. Similarly, disease infection become high when insect vector populations are high expressed by the 34.84% farmers, i.e., disease infection was increased with the increase of the vector population. Caterpillar and grasshopper were the major insect pest of gladiolus as per farmer's opinion. Some other insect pests such as mealy bug, aphid, leaf miner, white fly, caterpillars, Dhora poka, Jowo poka etc were also destroy the quality production of gladiolus.

Table 23. Farmers' response on the degree of relationship among insect pest, disease and weed infestation in the gladiolus field

Relationship	Degree of relationship	No. of respondents [N=66]	% Response
Insect infestation high when weed infestation	High	38	57.41
	Medium	16	24.21
	Low	7	10.61
	Don't Know	5	7.57
	Total	66	100
Disease infestation high when weed infestation	High	37	56.06
	Medium	16	24.24
	Low	8	12.13
	Don't Know	5	7.57
	Total	66	100
Disease infestation high when vector insect	High	23	34.84
	Medium	22	33.33
	Low	14	21.22
	Don't Know	7	10.61
	Total	66	100

4.3.16. Probable Sources of Pests and Diseases of Gladiolus

Around 59% gladiolus farmers think that, corm are the main source of pest and diseases (Table 24). Moreover, 12.12% farmers think soil are the source of pest and diseases. Local planting materials, use of imbalanced fertilizer were also influence pest and disease of gladiolus.

Table 24. Farmer's response on the probable sources gladiolus of disease

Probable sources	Response	
	No. of respondents	% Response
Local planting material (corm)	39	59.09
Imported corm	7	10.61
Soil borne	8	12.12
Air borne	4	6.06
Water borne	2	3.03
Use of imbalanced fertilizer	1	1.51
Insect	2	3.03
Rain splash	1	1.51
Other sources (if any)	2	3.04
Total	66	100

4.3.17. Probable Ways of Spreading of Gladiolus Disease

Around 57% farmers believe, diseases are spreading by infected planting materials (Table 25). Another probable ways of spreading of gladiolus diseases were imported planting material (6.09%), weeds and grasses (13.64%), irrigation water, insects, winds, crop debris and manure etc.

Table 25. Farmer's response on the probable ways of spread of gladiolus disease

Probable ways of spread of Gladiolus disease	No. of respondents [N=66]	% of Responded farmers
Infected planting materials	38	57.58
Imported planting material	4	6.09
Weed and Grasses	9	13.64
Insects	2	3.03
Wind	3	4.53
Irrigation water	1	1.51
Crop debris and Manure	2	3.03
Rain splashing	1	1.51
Through human being	1	1.51
Through intercultural with other crops	5	7.57
Total	66	100

4.3.18. Measures Taken to Control Diseases and Pest of Gladiolus in the Field

Among 66 farmers of Jashore, Dhaka and Manikganj, majority (68.18%) of them said that they took measures to control diseases and pest of gladiolus in the field (Table 26). However, (22.73%) did not take any control measures for diseases and pests in the field.

Table 26. Farmers' response on measures taken to control pest and disease of gladiolus of in the field

Types of response	Response on the measures taken to control pests	
	No. of respondents	% Response
Yes	45	68.18
No	15	22.73
Not replied	6	9.09
Total	66	100

4.3.19. Types of Measures Taken to Control Disease of Gladiolus in the Field

Two types of measures were taken to control disease of Gladiolus in the field. Preventive and curative both are important control measure for disease. Among 66 farmers, majority (34.84 %) of them were taken both preventive and curative measures to control diseases of Gladiolus in the field (Table 27).

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

Types of measures	Response (%) on the types of measures taken	
	No. of respondent [N=66]	% Response [100%]
Preventive	23	34.84
Curative	20	30.32
Both	23	34.84

4.3.20. Farmers Response on Management of Disease of Gladiolus

Corms, the planting materials play very important role in cultivation of gladiolus. It considered as the main sources of disease of gladiolus. Thus 59% of the interviewed farmers were preferred to treat corms with fungicides as preventive method of disease management (Table 28). However, 31.81% farmers give importance on cultural practices to control diseases. Considering the farmers' opinion, the better management practices were the spraying of pesticides such as Dithane M-45, Tilt, Mancozeb, Mactiven, Aroster, Reclaim, Proclaim, Gilte, Antracol, Endrophil, Sunfighter, Amister Top, Score etc.

Table 28. Farmers’ response on the methods of disease control applied in the gladiolus field

Methods of disease control	Response on the methods applied	
	No. (N=66)	% Response
Through use of pesticides	6	9.09
Use of resistant variety	2	3.03
Treatment of planting materials	33	50.00
Cultural practices & control measures	21	31.81
IPM method	1	1.51
Others (if any)	3	4.56

4.3.21. Farmer’s Response on Receiving Assistance and Service for Controlling Diseases of Gladiolus

Respondent farmers were received assistance and other services for controlling disease of gladiolus from different sources. Farmers were highly inspired to attend in the meeting with field level officers of DAE which was 46.95% (Table 29). Farmers also received services from experts, field day and field demonstration.

Table 29. Farmer’s response on receiving assistance and service for controlling diseases of gladiolus

Assistance and Service	No. of Respondent [N=66]	% Response
Visit by the field level officers	19	28.78
Experts suggestion	3	4.54
Field day	7	10.63
Field demonstration	4	6.06
Meeting with the field level officers	31	46.95
No opinion	2	3.04
Total	66	100.0

4.3.22. Major Problems of Gladiolus Cultivation

There are 66 farmers attending in the survey of gladiolus disease in the district of Dhaka, Manikganj and Jashore. Maximum farmers (48.48%) were considered disease as major problem for gladiolus cultivation (Table 30). Rest of the problems were faced by the farmers are high price of planting materials, pest and insect attack, transportation problem, natural hazard, low price of flower, unrecognized market etc. in gladiolus cultivation.

Table 30. Farmer's response on different problems in gladiolus cultivation

Problems	No. of respondent [N=66]	% Response
High price of planting materials	13	19.61
Insect pest	8	12.12
Diseases	32	48.48
Transportation	9	13.65
Natural hazards	7	10.62
Low price of the products	16	24.24
Unorganized market	11	16.67

4.3.23. Farmers Suggestions for Better Management of Gladiolus Diseases

There are some important suggestions gave the farmers for better managements diseases of gladiolus. Maximum suggestions (31.48%) were related to use of healthy planting materials (Table 31). Rest of the suggestions given by the farmers were effective use of insecticides & pesticides, proper inter-culture operation, regular field visit, more research on disease management, assistance from Department of Agricultural Extension (DAE), loan for flower cultivation, use of resistant variety etc.

Table 31. Farmer's suggestions for better management of diseases of gladiolus

Suggestions	No. of respondent [N=66]	% Response
Use of healthy planting materials	21	31.81
Effective use of pesticides	4	6.06
Proper inter-culture operation	5	7.57
Regular field visit	12	18.18
More research on disease management	8	12.12
Assistance from DAE	11	16.69
Loan	3	4.54
Use of resistant variety	2	3.03

CHAPTER V

DISCUSSIONS

Gladiolus (*Gladiolus grandiflorus* L.) is a herbaceous, perennial, bulbous ornamental flowering crop belongs to monocot family Iridaceae, having approximately one hundred and fifty known species. *Gladiolus* was introduced in Bangladesh in 1985. Commercial cultivation of *gladiolus* is gaining popularity in Bangladesh mainly concentrated only in few districts such as Jashore, Jenaidah, Rajshahi, Manikganj and Dhaka. Three experiments were conducted to find out diseases of corms and *gladiolus* plants in field condition.

First experiment was conducted on investigation and survey of field diseases of *gladiolus* at three districts of Bangladesh. Twenty two locations were selected from Jhikorgacha upazila of Jashore, Savar and Sadar upazila of Dhaka and Singair upazila of Manikganj districts for survey and field investigation. Field investigation was done from three fields of each location. Disease samples were collected from investigated areas and causal organisms were isolated and identified. Amount of diseases were recorded in terms of disease incidence and disease severity. Second experiment was conducted on health study of corms (the planting materials of *gladiolus*) by modified blotter method following ISTA rules. Three corm samples were collected from each district and altogether nine corm samples were collected from Jashore, Dhaka and Manikganj for investigation. Third experiment was conducted on a Survey on socio economic status of *gladiolus* farmers, production technologies, diseases and problems related to *gladiolus* cultivation in Bangladesh. Three *gladiolus* farmers were interviewed from each location to take their opinion on *gladiolus* diseases by using a pre tested questionnaire.

Plant Disease Survey Sheet was used to collect information on symptomology of diseases and to record disease incidence and severity data. The surveys were conducted under natural epiphytic condition. Data was collected with three replications. Moreover, data were collected by interview of the respondents (*gladiolus* farmers). Questionnaire, the instruments for data collection, were formulated and pre-tested in two districts namely Dhaka and Manikganj prior to the survey. The data were collected in normal epiphytic condition and analyzed by computer software STATISTIX-10.

In first experiment, field diseases of *gladiolus* were investigated. During field investigation, in total seven diseases were identified in *gladiolus* plant at Dhaka, Jashore and Manikganj districts. The diseases were leaf spot, leaf blight, stem rot, corm rot, flower rot, aster yellow and mosaic diseases of *gladiolus*.

Leaf spot disease was found in all investigated fields of gladiolus. At first, light to dark brown, oval spots were seen most frequently on the leaves. Spots are characterized as oval to circular, brown spots with dark edges and surrounded by a yellow halo. Lesions become necrotic and leaves are gradually dry and wilted. The identified causal organism of leaf spot disease of gladiolus was *Curvularia trifolii*. The conidia of *C. trifolii*, typically have three septa and four cells. Curved conidia have an enlarged central cell, which is also darker than the other surrounding cells. Incidence of leaf spot varied significantly among the locations that ranged from 22% to 72.67%. The highest disease incidence was recorded in Nimtola village (72.67%) and the lowest disease incidence was 22% in Panisara village. Severity of leaf spot also varied significantly among the locations that ranged from 2.67% to 15%. The highest disease severity was observed in Sharifpur which was 15% and the lowest disease severity was observed in Kuliya which was 2.67%. Leaf spot disease in gladiolus was also recorded by Torres *et al.* (2013a), Singh (1968); Kilpatrick (1958) and Khan and Karer (1974). Torres *et al.* (2013a) stated that, curvulara leaf spot disease affects leaves, stems, and petals of gladiolus. Khan and Karer (1974) found that, leaf spot of gladiolus caused by *Curvularia trifolii* affected in gladiolus plant. The colour of the spot is tan, surrounded by a darker reddish brown ring and an outer yellow halo. Singh (1968) reported *Curvularia* in gladiolus was found in Florida of USA in 1947.

Leaf blight is the major disease of gladiolus in Bangladesh. Symptoms are characterized as three distinct types of spots. One of them was very small, rust colored spots that appear on only one side of the leaf; another one was small, yellowish brown spots that develop reddish brown margins; and rest of the spot is large, oval spots that develop long, reddish margins. The identified causal organism of leaf blight disease of gladiolus was *Botrytis gladiolorum*. *Fusarium oxysporum* and *Alternaria alternate* were also isolated from the infected leaf samples. The highest disease incidence was recorded in Dhalipara (77.33%) that was statistically identical with other few locations. However, the lowest disease incidence was 18.67% observed in Baisha. In case of disease severity, similar trends were observed. Severity of leaf blight varied significantly among the locations that ranged from 2.33 to 11.67 %. The highest disease severity was observed in Dhalipara (11.67 %) that was statistically identical with Shiorda and Nimtola (10%). The lowest disease severity was observed 2.33% in Baliadangi and Panisara villages. Leaf blight disease in gladiolus was also reported in Bangladesh. Sultana *et al.* (2017) noticed botrytis blight symptoms appeared on gladiolus grown in Mymensingh regions of Bangladesh during 2014-2015. The disease caused spots on leaves, stems/ spikes, buds and flowers. In severe infection, the disease caused both flower and leaf blight. The causal pathogen identified as *Botrytis gladiolorum*. Siddique *et al.* (2013) first report *Botrytis* blight disease of gladiolus in Bangladesh during 2012 and 2013 crop season grown in Jashore regions of Bangladesh. The disease caused spots on leaves,

flower buds and inflorescence. In severe infection, the disease caused both flower and leaf blight and corm rot. *Botrytis gladiolorum* was consistently isolated from infected gladiolus plants.

In stem rot disease, brown spots appear on the stem and later necrosis start in the stem of gladiolus. Older leaves become yellow and gradually die. In advance of the disease, the stem becomes breakdown due to necrosis. The identified causal organism of stem rot disease of Gladiolus was *Fusarium oxysporum* f. sp. *gladioli*. Incidence of stem rot ranged from 15.33% to 55.33%. The highest disease incidence was recorded in Sharifpur (55.33%) and the lowest incidence was observed in 15.33% in Belemath village. This disease is also reported by Mishra *et al.* (2004), Partridge (2003) and Lazarovits (2001). Mishra *et al.* (2004) reported that *Fusarium oxysporum* f. sp. *gladiolus* diseased stem is frequently reduced to a hard, wrinkled mummy. Partridge (2003) noticed that, *F. oxysporum* f. sp. *gladioli* cause three types of rot e.g. vascular corm rot, stem rot and basal rot. Stem rot is also called yellows and is characterized by a brown discoloration in the centre of the corm and extending into the flesh.

Corm rot is one of the most serious diseases of gladiolus, affecting corms in the field and storage. The infected corms show brownish to black dry rot symptoms. The tissue of corm are completely rotten. Foliage of affected plants first turns yellow and then brown and finally died. The identified causal organism of corm rot disease of Gladiolus was *Fusarium oxysporum* f. sp. *gladioli*. It was observed in all locations of Jhikargacha, Jashore. Disease incidence was ranged from 10.67% to 25.33%. The highest disease incidence was observed in Nimtola (25.33%) that was statistically identical with Dhalipara, Chadpur and Mathuapara. However, the lowest disease incidence was observed in Patuapara village (10.67%) of Gadkhali union of Jhikargacha upazilla. This disease is also reported by many scientists. Javaid and Amin, (2009); Riaz *et al.*, (2009a,b) stated that, *Fusarium* corm rot is the most common and destructive fungal disease on gladiolus. Mancini *et al.* (2008) noticed that, the disease caused by *Fusarium oxysporum* f. sp. *gladioli* is characterized by rot of corms, stunted plant growth, late blooming or blind plants, greener and smaller buds and poor opening. Sohi (1992) worked on diseases of ornamental plants and reported *Fusarium oxysporum* f. sp. *gladioli* from corms and roots of Gladiolus from India.

In the symptom of flower rot disease of gladiolus, light to dark brown, oval spots are most frequently seen on the petal and sepal. The causal organism was *Curvularia lunata*. Incidence of flower rot disease of gladiolus varied significantly among the locations of that ranged from 5.33 to 10%.

Aster yellow disease was also recorded in Jashore. The primary symptom was

characterized by distortion of newly emerged inflorescence. Sometime, flowers are clustered and flower not to bloom. No organism was identified from aster yellow diseases of gladiolus. Most possibly any kind of virus is responsible for the disease. Disease incidence and severity were ranged from 0 to 9.33% and 0 to 1.67%, respectively. The highest disease incidence (9.333%) was recorded in Mathuapara and Godkhali villages. No disease was recorded in Kuliya, Krishnachandrapur, Nirbaskhola, Shirda and Hariya villages.

Another viral disease, mosaic of gladiolus was observed in leaves of gladiolus plant. No organism was identified from viral diseases of gladiolus. Most possibly any kind of virus is responsible for the disease. The disease of gladiolus are found only Sharifpur village in Jhikargacha union of Jashore. The disease incidence was 3.33% and disease severity was 20%.

In the second experiment, farmer's saved corms of gladiolus were collected from Dhaka, Manikganj and Jashore districts of Bangladesh. Three samples were collected from each district. Modified blotter paper method was used to determine the health status of planting material (corms) of Gladiolus. All together five fungi viz. *Fusarium oxysporum.*, *Aspergillus flavus*, *Aspergillus niger*, *Rhizopus stolonifer*, *Chaetomium* sp. were isolated and identified from corm of gladiolus. In samples of Manikganj, 30% corms were infected by *Aspergillus niger* followed by *Chaetomium* sp. (28%), *Aspergillus flavus* (25.4%), *Rhizopus stolonifer* (14%) and *Fusarium* sp. (12.0%). Similarly, *Aspergillus niger* showed the highest infection (40%) in corm collected from Dhaka followed by *Fusarium* sp. (22.0%), *Chaetomium* sp. (22%), *Rhizopus stolonifer* (20%) and *Aspergillus flavus* (12.0%). However, in case of corm collected from Jashore, *Chaetomium* sp. cause maximum corm infection (24%) followed by, *Aspergillus flavus* (22%), *Rhizopus stolonifer* (20%), *Fusarium* sp. (18.0 %) and *Aspergillus niger* (14 %).

In third experiment, a details survey was conducted on socio economic status of gladiolus farmers, existing production technology, diseases and other problems related to gladiolus cultivation in Bangladesh. There were 66 gladiolus farmers had been interviewed among whom 54 were from Jhikargacha Upazila of Jashore, six were from Dhaka and rest six were from Manikganj districts. Out of 66 respondents, 58 were male and 8 were female. Most of the farmers were 30 to 40 years old and were illiterate. However, 25.76% farmers completed primary education and 16.67% completed secondary education. Most of the farmers (51.51%) cultivated gladiolus from 2 to 5 bigha of land. According to the farmers opinion, on an average total land area owned of 66 farmers was 0.94 ha, of which cultivable land under total land owned was 0.80 ha. The land under gladiolus flower cultivation was 0.40 ha and most of them were cultivating gladiolus in below 5 years.

Farmers were collecting planting materials of gladiolus (corm) from different sources. Most of them use corm from their own preservation (80.96%). Moreover, farmers also collected corms (planting materials of gladiolus) from importer, dealer, neighbor and local market were 12.12%, 9.09%, 6.06% and 3.03%, respectively. In cultivation, total amount of farm yard manure was applied once during land preparation @ 50,00kg/ha with Urea, TSP, MOP, Zinc, Zypsum @ 250 kg/ha, 200 kg/ha, 200 kg/ha, 7 kg/ha and 20 kg/ha, respectively. As per farmer's opinion, total cost involved for pest management of Gladiolus is 4500 taka per year per bigha. Most farmers (42.42%) sold gladiolus flower through middleman. However, 40.91% farmers were sold gladiolus directly to the businessmen. In Dhaka, Manikganj and Jashore, cost of production for gladiolus cultivation was almost same. Maximum cost goes for purchasing corms. On average, the farmers purchase the corms at maximum 5 taka and minimum 3 taka depending on the sources and other factors. Therefore, around 24000 Taka cost involves initially for the purpose of planting materials per bigha. As per farmers opinion, a total cost of production of gladiolus was 34,500 Tk/Bigha. The benefit cost analysis of gladiolus varied production of flower sticks which depended upon different factors. Generally gladiolus plants gave higher and quality sticks in first six month. After that the production was decreased. On an average 40,000 sticks/year/bigha was produced in a year. 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. Total income from gladiolus cultivation per year/Bigha was 2,40,000 Tk. However, total cost of production was only 34,500 Tk. On average the net profit comes from gladiolus cultivation was about 2,05,500 Tk/Bigha/years.

Considering the opinion expressed by the farmers, the diseases of gladiolus in field were leaf spot, leaf blight, aster yellow, flower rot, root rot and stem rot. Farmers expressed their positive opinion on relationship among insect pest, disease and weed infestation in Gladiolus field. Insect infestation and disease infection become high when weed infestation are high. Similarly, disease infection become high when insect vector populations are high. Around 59% gladiolus farmers think that, corm are the main source of pest and diseases. Around 57% farmers believe, diseases are spreading by infected planting materials and 68.18% farmers took measures to control diseases and pest of gladiolus in the field. Among 66 farmers, majority (34.84 %) of them were taken both preventive and curative measures to control diseases of Gladiolus in the field. Corms, the planting materials play very important role in cultivation of gladiolus. It considered as the main sources of disease of gladiolus. Thus, 59% of the interviewed farmers were preferred to treat corms with fungicides as preventive method of disease management. However, 31.81% farmers give importance on cultural practices to control diseases. Respondent farmers were received assistance and other services for controlling disease of gladiolus from different sources. Maximum farmers (48.48%) were considered disease as major

problem for gladiolus cultivation. Rest of the problems were faced by the farmers are high price of planting materials, pest and insect attack, transportation problem, natural hazard, low price of flower, unrecognized market etc. in gladiolus cultivation. There are some important suggestions gave the farmers for better managements diseases of gladiolus. Maximum suggestions (31.48%) were related to use of healthy planting materials. Rest of the suggestions given by the farmers were effective use of insecticides & pesticides, proper inter-culture operation, regular field visit, more research on disease management, assistance from DAE, loan for flower cultivation, use of resistant variety etc.

CHAPTER V

SUMMARY AND CONCLUSION

Flower plays an important role in people's celebration and everyday lives. Among the floriculture, gladiolus is one of them. Cultivation of gladiolus flower produces huge emphasis due to less maintenance and high economic return. Even though, the diseases on gladiolus have major economic impact on quality and quantity of flower production. Commercial cultivation of gladiolus was introduced in Bangladesh around 1992 from India. It has recently been become popular in Bangladesh. Its demand has been increasing day by day with the advancement of aristocracy and modernization of Bangladesh. But the flower suffers from many diseases such as corm rot, leaf spot and leaf blight become severe in the farmer's field of Jashore region. However, researches on diseases of gladiolus are very limited in Bangladesh.

Three experiments were conducted to investigate diseases of gladiolus in Jashore, Dhaka and Manikganj districts of Bangladesh during February 2019 to May 2019. The first experiment was detection, identification and measurement of diseases of gladiolus in Bangladesh. Second experiment was detection of health status of corm of gladiolus. The third experiment was survey on socio economic status of gladiolus farmers, production technologies and disease and other problems related to gladiolus cultivation in Bangladesh. For field investigation, 18 villages from 4 Unions of Jhikorgacha Upazila of Jashore, 2 villages of one union of Savar, Dhaka and 2 villages of one union of Manikganj district were selected. Disease samples were collected and causal organisms were isolated and identified in the laboratory. Amount of disease was recorded in terms of disease incidence and disease severity. Health study of corms (the planting materials of gladiolus) was done by modified blotter method following ISTA rules. Three corm samples were collected from each district and altogether nine corm samples were collected from Jashore, Dhaka and Manikganj for investigation. Moreover, a survey was conducted on socio economic status of gladiolus farmers, production technologies, diseases and problems related to gladiolus cultivation in Bangladesh. Three gladiolus farmers were interviewed from each location to take their opinion on gladiolus diseases by using a pre tested questionnaire.

Plant Disease Survey Sheet was used to collect information on symptomology of diseases and to record disease incidence and severity data. The surveys were conducted under natural epiphytic condition. Data was collected with three replications. Moreover, data were collected by interview of the respondents (gladiolus farmers). Questionnaire, the instruments for data collection, were formulated and pre-tested in two districts namely Dhaka and Manikganj prior to the

survey. The data were collected in normal epiphytic condition and analyzed by computer software STATISTIX-10.

Seven diseases were identified from gladiolus in Bangladesh. The diseases were leaf spot, leaf blight, stem rot, corm rot, flower rot, aster yellow and mosaic diseases of gladiolus. *Curvularia trifolii* was identified as causal organism of leaf spot disease of gladiolus. Disease incidence and severity of leaf spot disease were varied significantly among the locations that ranged from 22% to 72.67% and 2.67% to 15%, respectively. Leaf blight is the major disease of gladiolus in Bangladesh. *Botrytis gladiolorum*, *Fusarium oxysporum* and *Alternaria alternate* were isolated from leaf blight disease. Severity of leaf blight disease varied significantly that ranged from 2.33 to 11.67 %. The identified causal organism of stem rot disease of Gladiolus was *Fusarium oxysporum* f. sp. *gladioli*. Incidence of stem rot ranged from 15.33% to 55.33%. Corm rot is one of the most serious diseases of gladiolus, affecting corms in the field and storage. The identified causal organism of corm rot disease was *Fusarium oxysporum* f. sp. *gladioli*. Disease incidence was ranged from 10.67% to 25.33%. In flower rot disease of gladiolus, light to dark brown, oval spots are most frequently seen on the petal and sepal. The causal organism was *Curvularia lunata*. Incidence of flower rot disease of gladiolus varied significantly among the locations of that ranged from 5.33 to 10%. Aster yellow disease was also recorded in Jashore and incidence and severity were ranged from 0 to 9.33% and 0 to 1.67%, respectively. Another viral disease, mosaic of gladiolus was observed in leaves of gladiolus plant. No organism was identified from viral diseases of gladiolus. Most possibly any kind of virus is responsible for the disease.

Farmer's saved corms of gladiolus were collected from Dhaka, Manikganj and Jashore districts of Bangladesh. Three samples were collected from each district. Modified blotter paper method was used to determine the health status of planting material (corms) of Gladiolus. All together five fungi viz. *Fusarium oxysporum*., *Aspergillus flavus*, *Aspergillus niger*, *Rhizopus stolonifer*, *Chaetomium* sp. were isolated and identified from corm of gladiolus.

There were 66 gladiolus farmers had been interviewed among whom 54 were from Jhikargacha Upazila of Jashore, six were from Dhaka and rest six were from Manikganj districts. Out of 66 respondents, 58 were male and 8 were female. Most of the farmers were 30 to 40 years old. Most of the farmers use their own preserved planting materials. As per farmer's opinion, a total cost of production of gladiolus was 34,500 Tk/Bigha. On an average 40,000 sticks/year/bigha was produced in a year. Total income from gladiolus cultivation per year/Bigha was 2,40,000 Tk. Farmers expressed their positive opinion on relationship among insect pest, disease and weed infestation in Gladiolus field. Around 57% farmers believe, diseases are spreading by infected planting materials. Among 66 farmers, majority (34.84 %) of

them were taken both preventive and curative measures to control diseases of Gladiolus in the field. Maximum farmers (48.48%) were considered disease as major problem for gladiolus cultivation.

In most of the cases disease incidence and severity were varied significantly among the locations. Farmers reported that some plant diseases were occurred highly in rainy season, some diseases were 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 seasoning of pathogens, presence of secondary host, life cycle of both host and pathogen, proximity and availability of the host and pathogen etc. During the survey it was observed that farmers mainly faced problem of corm rot, leaf blight and leaf spot diseases.

Gladiolus is considered as high value crop in Bangladesh. To ensure export of this flower, proper pest risk analysis should need to dome. Research on diseases of gladiolus is very few in Bangladesh. Thus, further research should be carried out to accelerate this type of outstanding research. In this study, the causal organisms were isolated by tissue planting method and identified. But pathogenicity test of causal organisms by Kotch's Postulates and molecular identification of pathogens are necessary for more confirmation of causes. Moreover, proper management and cultural practices may ensure quality flower with increase of the production.

CHAPTER VI

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APPENDICES

Appendix I. Plant Diseases Survey Sheet for Gladiolus

**Department of Plant Pathology
Sher-e-Bangla Agricultural University
Plant Diseases Survey Sheet for Gladiolus**

Name of the growers/farmers:

Date of Data collection:

Address: Village:

Union:

Upazilla:

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						
Corm Rot														
Leaf Spot														
Leaf Blight														
Leaf Streak														
Stem Rot														
Floret spot														
Flower blight														

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 Rust														
Leaf/ flower curl														

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

Symptomological Study

Symptoms	Corm Rot	Leaf Spot	Floret spot	Leaf Streak	Stem Rot	Leaf Blight	Rust	Leaf/Flower curl	Flower blight	
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: / /2019

Name and Signature of Supervisor
Date: / /2019

Appendix II. Questionnaire for Survey on Diseases of Gladiolus

Department of Plant Pathology
Sher-e-Bangla Agricultural University, Dhaka
Questionnaire for Survey on Diseases of Gladiolus in Bangladesh

Field / Nursery / Post Harvest

Serial				
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Cell Phone													
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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 Gladiolus

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

3. Sources of purchasing planting materials of Gladiolus

Age of plant/field	Name of planting materials Seed/seedling/bulb	Sources of planting materials	Do you preserve planting materials? (v)	
			Yes	No
	Corm			

(উর্ট / চর্টেক/ ঙ্কব=ঊবর্ট/ ্রবর্ট/ e`emvqv/ GbWR1 / Avg` vbx/ MteI by চর্টZôib)

4. Benefit Cost analysis of Gladiolus (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)
4 Months		Pick- Off pick-			

5. Cost involved for pest management of Gladiolus

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

6. Fertilizer application in Gladiolus field

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

7. Insect's infestation in Gladiolus in field (please put v)

Name of Insects pest	Stage of infestation			Incidence/severity		
	Seedling	Vegetative	Flowering	High	Moderate	Low
1. লেদা পোকা						
2. Thrips						
3. Caterpillar/বিছা পোকা						
4. Mealybug/ছাতরা পোকা						
5. Grasshopper/ঘাসফড়িং						
6. Leaf roller/পাতামোড়ানো পোকা						
7. Aphid/ জাব পোকা						
8. কুঁড়ি/ফুল ছিদ্রকারী পোকা						
9. পাতার উইভিল						
10. Mites/ মাকড় বা লাল মাকড়						
11. পাতাথেকো পোকা						
12. Leaf minor						
13. White fly/ সাদা মাছি						
14. মাছি পোকা						
15.						
16.						
17.						
18.						

8. Disease infestation in Gladiolus in field (please put v)

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. Corm Rot কন্দ পচা																					
2. Leaf Spot/পাতায় দাগ																					
3. Leaf Blight/পাতার ব্লাইট																					
4. Leaf Streak																					
5. Stem Rot কান্ড পঁচা																					
6. Floret spotকুঁড়ি পঁচা রোগ																					
7. Flower blightফুল পচা																					
8. Leaf Rust মরিচা রোগ																					
9. Leaf or flower curl/পাতা ফুল কুকড়ে রোগ																					
10.																					
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 Gladiolus in field (please put v)

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

(দুর্বা, মুখা, চাপড়া, বখুয়া, ভাদাইল, শ্যামা, ধুতুরা, তিতবেগুন, বনবেগুন, ফোস্কাবেগুন, হেলেষ্ঠা, বনকফি, চেচরা, শুশনি, বনশরিষা, নাকফুল, শাকনটে, কাটানটে, বিষকাটালী, আংগুলীগাস, হাতিশুড়, *Yp Zi, cit. 10qvg*)

10. Is there any relationship among insect, disease and weed pest infestations in the crop field?

[Yes = v, No=X]

11. If yes, what is the relationship among insect, disease and weed incidence in crop field?

[Yes = v, 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 Gladiolus field? (Please put v)

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

13. Pests infestation in Gladiolus after harvest/ in stored condition (please put v)

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.			

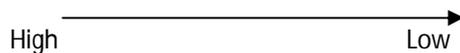
14. Action taken against pest infestation for Gladiolus cultivation (please put v)

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 Gladiolus?

Diseases:

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

16. Who purchase Gladiolus from farmer/grower? (Please put v)

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

17. Mention major problems on cultivation of Gladiolus 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 Gladiolus.

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

Name and Signature of Surveyor
 Date: / /2019

Name and Signature of Supervisor
 Date: / /2019

