

INVESTIGATION AND SURVEY ON DISEASES OF MARIGOLD (*Tagetes* spp.) IN JASHORE DISTRICT OF BANGLADESH

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**INVESTIGATION AND SURVEY ON DISEASES OF
MARIGOLD (*Tagetes* spp.) IN JASHORE DISTRICT OF
BANGLADESH**

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CERTIFICATE

This is to certify that the thesis entitled “**Investigation and Survey on Diseases of Marigold (*Tagetes spp.*) in Jashore District 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 **Anannya Shome**, Registration No.: **13-05653**, 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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Place: Dhaka, Bangladesh

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DEDICATED TO

MY BELOVED PARENTS

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**By
Anannya Shome**

ABSTRACT

Three experiments were conducted for investigation and survey on diseases of marigold in 2019 at Jashore district of Bangladesh. Forty eight marigold fields of sixteen villages from four unions of Jhikargacha upazila were investigated for field diseases of marigold. The disease incidence and severity were recorded under natural epiphytic conditions. Seven diseases were recorded and identified in field conditions viz. leaf spot, botrytis blight, flower bud rot, stem rot, foliage blight, white mold, foot and root rot caused by *Alternaria alternata*, *Botrytis cinerea*, *Alternaria dianthi*, *Fusarium oxysporum*, *Curvularia lunata*, *Sclerotinia sclerotiorum*, respectively. However causal organism of foot and root rot was not identified. The incidence and severity of diseases of marigold varied significantly among the locations. In leaf spot disease, incidence and severity ranged from 30% to 54.33% and 9.33% to 18%, respectively. For Botrytis blight, disease incidence and severity were from 15.33% to 38.33% and 6.67% to 21%, respectively. However, incidence and severity of flower bud rot ranged from 12% to 40.66% and 6.03% to 18%, respectively. Moreover, incidence and severity of foliage blight were from 5.67% to 42% and 1% to 18%, respectively. The highest incidence and severity of stem rot disease were recorded in Nirbashkhola village (29% and 13%), respectively. In case of foot and root rot, the highest incidence and severity were recorded in Chandpur village (29.67% and 13%). Moreover the highest incidence and severity of white mold disease were recorded in Shiorda and these were 26.67% and 10.67%, respectively. Depending on the amount of disease, the major diseases of marigold were leaf spot, botrytis blight, foliage blight and flower bud rot. Farmer's saved seeds were collected from Dhaka and Jashore districts and seed health status was investigated by blotter method following rules of ISTA. Five fungi viz. *Fusarium oxysporum*, *Alternaria alternata*, *Aspergillus flavus*, *Aspergillus niger* and *Rhizopus stolonifer* were isolated and identified from seed of marigold. Apart from this, a survey was carried out on the socio-economic status of marigold farmers and problems related to marigold cultivation in Bangladesh. Altogether, 48 farmers were interviewed in Jashore district of Bangladesh. Among the farmers, 91.67% were male and 8.33 % were female. As per farmer's opinion leaf spot, botrytis blight, foliage blight and flower bud rot were major diseases of marigold.

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LIST OF ABBREVIATIONS

Full Name	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	<i>etc.</i>
Gram	g
Kilogram	Kg
Least Significant Difference	LSD
Meter	m
Millimeter	mm
Percentage	%
Videlicet (namely)	<i>viz.</i>
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
BCMAFF	British Columbia Ministry Of Agriculture
International Floriculture Trade Statistics	IFTS

CHAPTER I

INTRODUCTION

Flower symbolizes beauty and purity. Flowers have been regarded as an embodiment of human taste and aesthetics. For its beauty, demand for flower increasing day by day all over the world. People usually use flowers in all their ceremonies like wedding, birthday, and marriage day greetings, religious offerings and sometimes in social, political, and historical occasions (Haque *et al.*, 1992). In the present world flowers become important not only for its aesthetic social value, but also for its industrial use and economic contribution (Aditya, 1992; Dadlani, 2003).

Flower cultivation has emerged as a lucrative business which ensures higher potential to return compared to other agricultural crops. The flower market is an ever growing market in the world. Bangladesh is an agro based country, where the climate is very favorable to flower cultivation (Islam and Rahman, 2013). It is an emerging sector that has influenced in national GDP growth as well as employment generation in Bangladesh. Flower has an enormous international demand that creates huge opportunities for Bangladesh. There are more than 90 countries which are active in world floriculture (IFTS, 2004).

In Bangladesh, flower cultivation has developed commercially in the mid-eighties in Jhikargacha Upazila of Jashore district (Sultana, 2003). Now it speeded largely in Dhaka, Tangail, Gazipur, Mymensingh, Chuandanga, Jhenidah, Bogra, Rangpur, Kushtia, Chittagong, and Jashore districts of Bangladesh. The most common, commercially grown flower species in Bangladesh are rose, tuberose, gladiolus, marigold, orchids, sunflower, dahlia, cosmos, Arabian Jasmine, kathbeli, gerbera, belly etc. (Mitul, 2011). Flower markets turn out to be about 8000 to 10000 tons per annum (BBS, 2008). Almost 16 thousands farmers are engaged in floriculture, they are cultivating flower in 12 thousand acres in Bangladesh. Cultivation of flower is reported to give 3-5 times and 1.5-2 times more returns than obtained from rice and vegetable cultivation, respectively (Dadlani, 2003).

10,000 hectares of land covers flower cultivation in Jashore district taking the lead in the country (Chowdhury, 2010). About 70% of the total country's demand of flowers is supplied by Jashore (Mou, 2012). More than 5,000 resilient farmers are growing flower and foliage in the country and about 1,50,000 people are directly or indirectly involved in floriculture business as their sole livelihood (Chowdhury, 2010). The employment generation for both men and women are increasing with the increase in area at about 15.79% per year under floriculture industry. The country earned USD 1,530.22 from exports of cut flowers in the fiscal year 2015-2016.

Flower Society of Godkhali (Jashore) reported that flower of about USD 54 crores are produced in Godkhali, Jeshore alone every year and the total flower business amount stands at USD 100 crores. Gross margins of flower were Tk.1,359,824.20 per hectare (Rakibuzzaman *et al.*, 2018).

Flower marketing is not fully organized in Bangladesh. Major traders for flowers can be found in Shahbag, Farmgate and Gulshan in Dhaka. Substantial trade can also be found in Chittagong and other cities. A good number of flower shops are also established in district towns. There are reportedly around 4000 retail shops of flowers in the country. Forty percent of the retail shops are located in Dhaka, while Chittagong and Sylhet having 25% each and the remaining 10% of the shops are in other district towns. At a wholesale flower market (in Dhaka), some 700 traders do flower business worth at least \$16000 every day. Bangladesh has to spend roughly Tk. 2-3 million in importing flowers and ornamental plants from abroad (Ahmed, 1995). At least 20 business enterprises and 4 associations are directly engaged in growing and export of flowers in Bangladesh (Ahmed, 1995).

Marigold (*Tagetes erecta*), a member of the family Asteraceae or Compositae, is a potential commercial flower that is gaining popularity on account of its easy culture, wide adaptability, and increasing demand in the Indian subcontinent (Asif, 2008). They are a group of perennial herbs of varying habit and exhibit both type of pollination. Marigold is native of Central and South America especially Mexico, from Mexico it spread to different parts of the world (Shukla and Thakur, 2018).

The name *Tagetes* was given after Tages ademigold known for his beauty. *Tagetes* species vary in size from 0.1 to 2.2 m tall (Rydberg, 1915). Most species have pinnate green leaves. Marigold is known as different names in different countries. French marigold, African marigold (English), sthulapushpa, sandu, ganduga (Sanskrit), gultera (Hindi), genda (Bengal), guljharo, makhanala (Gujarat), tangla, mentok, genda (Punjab). Out of 33 species, two important species viz. American or African marigold (*Tagetes patula*) is bushy, somewhat smaller plant as compare to *Tagetes erecta* and known as French marigold. Their flower color is brick red, orange red, yellowish or brownish yellow in color. French marigold is commonly planted in butterfly gardens as a nectar source.

Marigold (*Tagetes erecta*) is one of the commercial ornamental flowers commonly grown in Bangladesh. Commercial cultivation of marigold flowers found in the villages of Godkhali, Jhikargacha, Jhenaidah, Gazipur district, Hathazari and Patiya of Chittagong district and Savar in Dhaka district. It has huge demand as it is easily grown. Flowers of marigold are sold as loose flowers in the market, highly suitable as a bedding plant and it is also used for beautification.

Both leaves and flowers of marigold plant have phenolic and antioxidant activities due to which they are used for medicinal purposes (Tripathy and Gupta, 1991; Khalil *et al.*, 2007). Leaves paste is used externally to treat boils and carbuncles and leaf extract of the plant is good for ear ache. Extract of its flower is used as blood purifier, as a cure for bleeding piles and for treatment of eye diseases and ulcers (Bos and Yadav, 1998). It has bioactive compound like triophenes that are widely employed as insecticides particularly against *Aedes aegypti* (Wells *et al.*, 1992). Marigold plants have anti-nematicidal activity (Olabiya and Oyedunmade, 2007) and found most effective against the nematode species *Pratylenchus penetrans*. The flowers are used to make food pigments as they are rich in carotenoid pigment. The powder of flower petals are used in poultry feed which ensure a good coloration of egg yolks and broiler skin (Shukla and Thakur, 2018).

Marigold flowers are produced during winter months of Bangladesh. Generally, the moderate temperature of 20-25°C and a day length of 10 hours is the best for its production. Marigold can be grown in any type of soil but well drained loamy soil which has optimum water holding capacity is the best for marigold production. The planting time of marigold started from mid October and continued up to mid November, respectively. The harvesting time of marigold started from January and continued up to May. The area under marigold cultivation was about 344 ha producing about 1560 ton with an average yield of 4.54 t/ha (Haque *et al.*, 2012). The annual growth rate of area, production, and yield of marigold for the period from 2007-2008 to 2009-2010 were 12.44%, 11.12%, and 1.32% respectively (Haque *et al.*, 2012). They also reported that 95% farmers in some areas of Jashore and Jhenaidah districts of the country cultivate T-004 line and only 5% farmers cultivate T-003 line of marigold and at least 2,650,447 flowers are produced from one hectare of land. The gross margin and net return may be Tk. 1,62,186 and Tk. 1,17,812 per hectare, respectively. The net return was 80% higher than lentil, 85% higher than mustard and 6% lower than potato cultivation (Haque *et al.*, 2012).

The major problems in the floriculture are unorganized marketing, lack of support infrastructure and lack of technical knowledge (Hossain, 2010). There are several constraints to marigold cultivation are lack of knowledge about production technology, high cost of hybrid seeds, lack of good quality seed and disease and insects infestation including different biotic and abiotic disorders (Chandginam *et al.*, 1987). Diseases are an important reason for losses in agricultural crop commodities. It is estimated that world faces nearly 13% losses in agriculture produce because of plant diseases (Fletcher *et al.*, 2006).

Marigold it is affected by various pathogenic microorganisms such as fungi, virus, nematode and bacteria that causes diseases and damage to the plant which resulted yield loss. Some of the fungal disease are Botrytis blight /gray mold (*Botrytis*

cinerea), leaf spot and blight (*Curvularia lunata*), flower bud rot (*Alternaria dianthi*) Alternaria blight (*Alternaria alternata*, *A. tagetica*), Fusarium wilt (*Fusarium oxysporum*), flower blight (*Alternaria zinnae*), wilt and stem rot (*Phytophthora cryptogea*), white mold (*Sclerotinia sclerotiorum*), powdery mildew (*Oidium* spp.), damping off (*Pythium* sp.), collar rot (*Phytophthora* spp., *Pythium* spp.), Septoria leaf spot (*Septoria tagetica*), Cercospora leaf spot (*Cercospora megalopotamica*) (Sohi, 1983).

Leaf spot, foliage leaf blight, gray mold, powdery mildew and anthracnose are the common diseases of marigold in India (Dhilon and Arora, 1990; Mukerji and Bhasin, 1986). Reports on the occurrence of diseases of marigold in Bangladesh are inadequate (Aktar and Shamsi, 2014). The causal organism and the actual remedies of some diseases have not yet been evaluated. Reports on the yield loss of marigold due to diseases are not available in the country. Shamsi and Aktar (2017) isolated a total of 20 species of fungi from *Tagetes erecta* and *Tagetes patula*, out of which *Aspergillus fumigatus*, *Alternaria alternata* and *Curvularia lunata* were found to be pathogenic to *Tagetes erecta* and *T. patula*.

Among the diseases, leaf spot and flower blight caused by *Alternaria tagetica* is the most serious, prevalent all over the country (Cotty and Mishaghi, 1985). The disease was noticed on leaves, stem and flowers. The disease initiates as circular to oblong brownish spot, later turned dark brown to blackish, enlarged and coalesce to cover almost the entire leaf and part of branches made the plant a burnt appearance. On blooming, the inflorescence axis and flower heads were attacked severely and the entire foliage gets damaged and results in poor vegetative growth. According to an estimate the disease resulted in a loss of flower yield upto 55-60% in India (Cotty and Mishaghi, 1985). *Alternaria zinnae* cause inflorescence blight of marigold in which elongated lesions are formed on inflorescence. Light tan to dark brown, large irregular blotches appears on the leaves with zonation.

Botrytis blight or gray mold is a serious disease of marigold. It is caused by *Botrytis cinerea* (Sultana and Shamsi, 2011). It is also found in all locations of Jashore in Bangladesh. The gray mold fungus grows well under cool, humid conditions. Disease symptoms appeared as dead blotches on leaves, flowers and stems. Rotting of stems may cause plants to collapse, flower buds may fail to open and diseased flowers that open become decayed and drop prematurely. A covering of gray fuzzy fungal growth and spores appears on infected plant tissue (Anonymous, 2012).

Flower bud rot is caused by *Alternaria dianthi* causes significant loss to growers. During the disease young flower buds shrivel, turn deep brown in color and dry up while symptoms of the disease on mature buds are less prominent but these buds also fail to open due to the effect of pathogen (Mondal and Chaudhuri, 1976). The

pathogen also infects leaves of the plant causing blight and brown necrotic spots on margins and tips of older leaves. The pathogen also infects leaves causing blight. The infection is visible in the form of brown necrotic spots on margins and tips of older leaves (Kumar, 2012).

Wilt and Stem Rot is caused by the fungus *Fusarium oxysporum* and *Phytophthora cryptogea* which infect the collar portions of the plants. Plant become wilted and roots on the greatly reduced, root system are rotted. French marigold and dwarf varieties are less susceptible whereas the African types are highly susceptible to the disease. During wet weather, salmon-colored spore masses form on infected stems (Kumar, 2012).

White mold disease of marigold is caused by *Sclerotinia sclerotiorum*. The fungus causes white mold that gradually turns black. Infected plant parts also turn dark green and look watery or greasy. Rotten flowers of marigold covered with fluffy white mycelia were found in Rangpur, Bangladesh (Rahman *et al.*, 2015). Damping off is caused by *Pythium* sp. and *Rhizoctonia solani* and the disease is more frequent at the seedling stage (Singh *et al.*, 2012). It causes considerable loss if seedlings are not properly looked after and root system of the infected seedling appears partially or fully decayed (Subramanyan *et al.*, 1975).

Powdery mildew disease is caused by *Oidium* sp. and *Leveillula taurica* which produces whitish, tiny, superficial spots on leaves and later on whole aerial parts of plant is covered with whitish powder (Sreeramula, 1953). Aster yellow is caused by Aster yellows phytoplasma and infected leaves become discolored (light green, yellow, white, red or purple) and stunted. Flowers are small and deformed with improper coloration, stems become weak. Some virus disease-like symptoms developed naturally in marigold. The natural symptoms in marigold consisted of yellowing, mosaic, shoestring, mottling and curling of leaves resulting severe stunting of the infected plants. Marigold plant is naturally attacked by three different viruses viz. *Cucumber mosaic virus* (CMV) as reported by Hanson *et al.* (1951). *Marigold mosaic virus* (MMV) and *Marigold mottle virus* as reported by Naqvi *et al.* (1981). In Bangladesh, virus disease-like symptoms manifested in marigold plants had mixed infection of CMV (Cucumber mosaic virus) and PRSV (Papaya ring spot virus) (Sultana *et al.*, 2014).

Researches on detection, identification and management of diseases status of marigold are very limited in Bangladesh. Thus, there is a need for systematic research works which includes survey, isolation and identification, measurement of diseases of marigold in Bangladesh. It will help to manage diseases of marigold effectively in the field.

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

1. To detect, identify and measure the diseases status of marigold in Bangladesh
2. To determine the health status of marigold seed by blotter method and
3. To survey the socio economic status of marigold grower, cultivation practices and problems related to marigold cultivation in Bangladesh.

CHAPTER II

REVIEW OF LITERATURE

Marigold is one of the commercially exploited ornamental flower crops. It is one of the most commonly cultivated and used flower in Bangladesh. This flower is affected by many diseases. There is a very limited significant research works have been done on diseases of marigold plant in Bangladesh. However, research works are found regarding diseases of marigold in different countries in the world. The literatures on diseases of marigold and their causal organisms 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. Flower Cultivation in Bangladesh

Rakibuzzaman *et al.* (2018) stated that, Bangladesh earned USD 1,530.22 from exports of cut flowers in the fiscal year of 2015-2016. Flower Society of Godkhali (Jashore) reported that flower of about USD 54 crores are produced in Godkhali alone every year and the total business amount stands at USD 100 crores. Gross margin of flower cultivation were Tk.1,359,824.20 per hectare.

Islam and Rahman (2013) noticed that flower cultivation has emerged as a lucrative business which ensures higher potential to return compared to other agricultural crops. It is an emerging sector that has influenced in national GDP growth as well as employment generation in Bangladesh. Flower has an enormous international demand that creates huge opportunities for Bangladesh. Moreover, the climate of Bangladesh is very favorable for flower cultivation.

Chowdhury (2010) reported that 10,0000 hectares of land covers flower cultivation taking the lead by Jashore district. More than 5,000 resilient farmers are growing flower and foliage in the country and about 150,000 people are directly or indirectly involved in floriculture business as their sole livelihood.

Hossain (2010) argues that the commercial development of floriculture in Bangladesh is still at a very early stage. The major problems in the floriculture development are unorganized marketing, weak research, lack of support infrastructure and lack of educational base.

Sohel (2010) analyzed that the flower market is expanding day by day. Countries like Columbia, Israel, Kenya and Italy have made an entry and have created a good

position. But the world floriculture trade is still controlled by the Netherlands. The international floriculture market trade is estimated to be 40 billion US dollars of which cut-flowers account for nearly 25 billion US dollars. So Bangladesh has huge potential to capture the market. Through taking proper steps this opportunity can be utilized.

According to BBS (2008), flowers demand has been increased with increasing income of citizen in Bangladesh. Flower markets and the production of flowers turn out to be about 8000 to 10000 tons per annum.

Dadlani (2003) showed that flowers have gained an important position in society in present day. People utilize flowers in different ways and different purposes. Flowers are extremely popular at weddings as well as many religious and other festivals. Flowers are not just a part of the plant but they are a form of expressions. The aroma of the flowers is unique from one flower to another. Flowers are used in the manufacturing of green tea, perfumes, essential oils and many other products. Flower cultivation speeded largely in Jashore, Savar, Chuadanga, Mymensingh and Gazipur which turned to be the major flower production belt in Bangladesh. Cultivation of flower is reported to give 3-5 times and 1.5-2 times more returns than obtained from rice and vegetable cultivation, respectively.

Sultana (2003) reported that Bangladesh is one of the largest flower growing countries in South-East Asia. The scope, land, parent stocks, labor, and other natural resources are available and contribute towards making Bangladesh an exporter with great opportunities. In Bangladesh, floriculture brought into limelight by some innovative farmers in late seventies with marigold on a small-scale basis. Large scale commercial production started from mid-eighties in Jhikargacha upazila of Jashore district.

Hossain and Rahman (1994) reveals that the capital investment in flower business has been increasing, the total number of shop exhibits an increasing trend, merchandizing patterns have been diversified the scale of flower made products is rising and all sales are for cash.

Ahmed (1995) reported that Bangladesh has to spend roughly TK. 2-3 million in importing flowers and ornamental plants from abroad. Around 20 types of flowers are available in Bangladesh including Rose, Tuberose, Marigold, Lotus, Gladiolus and Chandramallika etc. At least 20 business enterprises and 4 associations are directly engaged in growing and export of flowers in Bangladesh.

Aditya (1992) reported that flowers became important not only for its aesthetic social value but also for its economic contribution. The floral industry is one of the major industries in many developing and underdeveloped countries.

Haque *et al.* (1992) reported that people usually use flowers in all their ceremonies like wedding, birthday, and marriage day greetings, religious offerings and sometimes in social, political, and historical occasions.

2.2. Cultivation of Marigold (*Tagetes* spp.)

Haque *et al.* (2012) reported that marigold flowers are produced during winter months of Bangladesh. Generally, the moderate temperature of 20 – 25°C and a day length of 10 hours is the best for its production. Marigold can be grown in any type of soil. But well drained loamy soil which has optimum water holding capacity is the best for marigold production. The soil pH should be 7.0 – 7.5. The planting time of marigold started from mid October and continued up to mid November respectively. The harvesting time of marigold started from January and continued up to May. The area under marigold cultivation was about 344 ha producing about 1560 ton with an average yield of 4.54 t/ha. The annual growth rate of area, production, and yield of marigold for the period from 2007-2008 to 2009-2010 were 12.44%, 11.12%, and 1.32%, respectively. They also reported that 95% farmers in some areas of Jashore and Jhenaidah districts of the country cultivate T-004 line and only 5% farmers cultivate T-003 line of marigold. At least 2,650,447 flowers of marigold are produced from one hectare of land. The gross margin and net return may be Tk. 1,62,186 and Tk. 1,17,812 per hectare, respectively. The net return was 80% higher than lentil, 85% higher than mustard and 6% lower than potato cultivation.

Ahmad *et al.* (2011) said that marigold was first regarded with distrust due to its strong free flowering, short duration to produce marketable flowers, wide spectrum of attractive color, shape, size and good keeping quality attracted the attention of flower growers.

Asif (2008) reported that marigold is a group of perennial herbs of varying habit and exhibit both type of pollination. Out of the 33 species of marigold, two popularly grown species of marigold are African or Mexican marigold (*Tagetes erecta*) and French marigold (*Tagetes patula*). Marigold is native of Central and South America especially Mexico, from Mexico it spread to different parts of the world. In India, these were introduced by the Portuguese but for centuries this flower has been cultivated in Bangladesh and has become naturalized here.

Bos and Yadav (1998) reported that marigold plant is one of the most commonly grown flowers and extensively used on religious and social functions, in one forms or other.

Chandginam *et al.* (1987) found that inadequate supply of high quality seeds accounts for majority of yield loss in marigold and it remains as one of the major constraints in limiting the flower cultivation. Research reports revealed that 10-20 percent of yield could be increased by the use of quality seed alone.

Usman *et al.* (1972) said that the aerial parts of the marigold plant contain high quality of essential oil that can be used for scenting soaps, perfumery cosmetics and pharmaceuticals. It is also used for medicinal purpose. It is used for the treatment of rheumatism, cold, bronchitis, eye diseases, ulcers etc. Marigold is used to treat a number of skin diseases including eczema, juvenile acne and skin ulcerations. It is economically important for its showy flowers, *Tagetes* oil and anti-nematicidal properties.

Rydberg (1915) reported that the name *Tagetes* was given after Tages ademigold known for his beauty. *Tagetes* species vary in size from 0.1 to 2.2 m tall. Most species have pinnate green leaves. The flowers are yellow, orange, red, light yellow or have bi color sheds and have pungent aroma. Marigold (*Tagetes* spp.) belongs to Compositae family, its genus is *Tagetes*. This genus includes about 56 different species. Only few species like African and French marigold are important. Five species have been introduced into the Indian gardens viz. *Tagetes erecta* L. (Aztec or African Marigold), *Tagetes minuta* L. (*Tagetes landulifera* Schrank), *Tagetes patula* L. (French Marigold), *Tagetes lucida* Cav. (Sweet-Scented Marigold), *Tagetes tenuifolia* Cav. (Striped Marigold).

2.3. Diseases of Marigold (*Tagetes* spp.)

Shamsi and Aktar (2017) isolated a total of 20 species of disease causing fungi from *Tagetes erecta* and *T. patula*, out of which *Aspergillus fumigatus*, *Alternaria alternata*, and *Curvularia lunata* were found to be pathogenic to *Tagetes erecta* and *T. patula*.

Aktar and Shamsi (2014) noticed reports on the occurrence of diseases of marigold in Bangladesh are inadequate.

Sultana *et al.* (2014) reported a viral disease on marigold in Bangladesh. The results of the study revealed that the virus disease-like symptoms manifested in marigold plants had mixed infection of CMV (Cucumber mosaic virus) and PRSV (Papaya ring spot virus).

Fletcher *et al.* (2006) said that diseases are an important reason for losses in agricultural crop commodities. It is estimated that world faces nearly 13% losses in agriculture produce because of plant diseases.

Dhilon and Arora (1990); Mukerji and Bhasin (1986) reported that diseases are major problems for marigold cultivation. Leaf spot, foliage leaf blight, grey mold, powdery mildew and anthracnose are the common diseases of the plants in India.

Sohi (1983) reported that marigold is one of the most important commercial flower crops of Bangladesh in terms of cultivation and utilization. Though having repellent property, marigold is also affected by number of fungal diseases. Some of the important fungal diseases of marigold are flower blight (*Alternaria zinniae*), wilt and stem rot (*Phytophthora cryptogea*), Collar Rot (*Phytophthora sp.*; *Pythium sp.*), damping Off (*Pythium sp.*), Alternaria leaf spot (*Alternaria sp.*) Fusarium wilt (*Fusarium oxysporium*) and Cercospora leaf spot (*Cercospora megalopotamica*).

Naqvi *et al.* (1981) identified CMV as a member of cucumovirus which is transmitted by *Aphis gossypii*, *A. craccivora* and *Myzus persicae* and it was found to be seed transmitted in case of marigold plants. *Marigold mosaic virus* (MMV) and *Marigold mottle virus* may be found.

2.3.1. Leaf Spot Disease of Marigold

Shamsi and Aktar (2017) reported that Alternaria leaf spot disease in marigold caused by *Alternaria* spp. Out of these leaf spot and flower blight incited by *Alternaria tagetica* is the most serious, along with over the country.

Qui *et al.* (2009) revealed that *Alternaria tagetica* causes early blight of *T. erecta* and produces phytotoxic metabolites (alternaric acid) which have an adverse effect in plant.

Tomioka *et al.* (2000) reported that leaf spot or leaf blight of marigold overseas, is new to Japan. Foliar necrotic lesions were found on African marigold (*T. erecta*) and French marigold (*T. patula*) grown in Miyagi Prefecture, Japan.

Sen (1996) reported that Alternaria leaf spot and flower blight caused by *Alternaria zinniae* has emerged as a major constraint compared to other diseases by inducing 60% disease severity in African marigold.

Mukerji and Bhasin (1986) reported that leaf spot disease is caused by *Alternaria alternata*.

Cotty and Mishaghi (1985) found that leaf spot and flower blight disease (*Alternaria tagetica*) has become a major biotic constraint in the full exploitation of high yielding scented marigold varieties. The infection can lead to premature defoliation and finally death of the plant. *Alternaria zinnae* cause inflorescence blight of marigold in which elongated lesions are formed on inflorescence. Light tan to dark brown, large irregular blotches appears on the leaves with zonation.

Hotchkiss and Baxter (1983) observed that *Alternaria* leaf spot may be increased to high moisture conditions for long time increased the severity of *Alternaria tagetica*.

Allen *et al.* (1982) found that *Alternaria* leaf spot of marigold is caused by *Alternaria* spp. Brown necrotic spots develop on leaves, which get enlarged at the later stage of infection. The entire foliage gets damaged and results in poor vegetative growth. The favourable temperature for germination of conidia of *Alternaria helianthi* is 25°C to 28°C and the presence of free water on leaf surface.

Shome and Mustafee (1966) reported leaf spot and flower blight of marigold incited by *Alternaria tagetica* a serious disease of marigold in the country and in northern Madhya Pradesh of India. It causes up to 50-60 % losses in flower yield.

2.3.2. Botrytis Blight Disease of Marigold

Sultana and Shamsi (2011) reported that botrytis blight or gray mold of *T. erecta* is caused by *Botrytis cinerea*. It causes 70% losses in crops.

According to Anonymous (2012), Botrytis blight or gray mold fungus grows well under cool, humid conditions. Disease symptoms appeared as dead blotches on leaves, flowers, and stems. Rotting of stems may cause plants to collapse, flower buds may fail to open and diseased flowers that open become decayed and drop prematurely. A covering of gray fuzzy fungal growth and spores appears on infected plant tissue of marigold.

Dhiman and Arora (1990) reported that this disease can be controlled by removing plant debris after appearance of disease symptoms, maintaining dry foliage and avoiding overhead watering. Other than these sanitary practices, use disease-resistant cultivars and fungicides can reduce the disease.

2.3.3. Flower Bud Rot Disease of Marigold

Kumar (2012) reported that flower bud rot is caused by *Alternaria dianthi*. The pathogen also infects leaves of the plant causing blight and brown necrotic spots on margins and tips of older leaves. The pathogen also infects leaves causing blight.

The infection is visible in the form of brown necrotic spots on margins and tips of older leaves.

Singh *et al.* (2012) found that spraying of 0.2% Mancozeb and 0.2% Dithane M-45 effectively controls the infection of flower bud rot.

Mondal and Chaudhuri (1976) reported that during the disease young flower buds shrivel, turn deep brown in color and dry up while symptoms of the disease on mature buds are less prominent but these buds also fail to open due to the effect of pathogen.

2.3.4. Wilt and Stem Rot Disease of Marigold

Kumar (2012) reported that wilt and stem rot disease of marigold is caused by the fungus *Fusarium oxysporum* and *Phytophthora cryptogea* which infect the collar portions of the plants. Seedlings are killed. In older plants, black streaks darken the vascular tissue up one side of the plant. Plants wilt. Roots on the greatly reduced root system are rotted. During wet weather, salmon-colored spore masses form on infected stems. French marigold and dwarf varieties of marigold are found less susceptible to the disease in comparison to African types of marigold.

Tomioaka *et al.* (2000) found that foliar necrotic lesions on African marigold (*T. erecta*) and French marigold (*T. patula*) grown in Miyagi Prefecture, Japan. Wilt disease of *Tagetes erecta* caused by *Fusarium oxysporum*. Wilting of plants of the orange variety was first noticed in the nurseries of the Botanic Garden. The plants were all flowering at the time, and showed varying degrees of wilt. Badly affected plants showed black, unilateral streaks extending up the stem from the soil line and pinkish sporodochia of spore masses on the lower portion of the stem.

2.3.5. White Mold Disease of Marigold

Rahman *et al.* (2015) reported that white mold disease is caused by *Sclerotinia sclerotiorum* on marigold. It was a minor disease. The fungus causes white mold that gradually turns black. Infected plant parts also turn dark green and look watery or greasy. In January 2011, rotten flowers of marigold covered with fluffy white mycelia were found in Rangpur, Bangladesh. Symptoms began from petals and subsequently expanded to the whole flower and the lower part of the plant. Dark brown lesions with necrotic tissues appeared on the infected leaves and stems. Seriously infected plants showed flower dropping and branch wilting.

2.3.6. Damping off Disease of Marigold

Singh *et al.* (2012) reported that damping off disease is caused by *Pythium* sp. and *Rhizoctonia solani* and the disease is more frequent at the seedling stage. Necrotic spots and rings develop on the young seedlings and cause pre-emergence mortality in seedlings while appearance of water soaked, brown, necrotic ring on lower part of hypocotyls are post emergence symptoms and due to these post emergence symptoms seedling collapse.

Singh *et al.* (2012) showed that soil sterilization by Formalin (2%) before sowing, spraying with Dithane Z-78 (0.2%) and soil drenching with 0.3% Brassicol and 0.1% Carbendazim are found effective in controlling damping off disease.

Subramanyan *et al.* (1975) reported that damping off disease causes considerable loss if seedlings are not properly looked after and root system of the infected seedling appears partially or fully decayed.

2.3.7. Powdery Mildew Disease of Marigold

According to Anonymous (2012), powdery mildew disease can be controlled by spraying Sulfex (3g/litre of water), 0.5% Karathane or by dusting with sulphur powder at regular intervals.

Sreeramula (1953) found that powdery mildew disease in marigold in some of the locations of Jashore. The causal organisms are *Oidium* sp. and *Leveillula taurica* which produces whitish, tiny, superficial spots on leaves and later on whole aerial parts of plant is covered with whitish powder which contains conidia and conidiospores of the pathogens.

2.3.8. Cercospora Leaf Spot Disease of Marigold

Chandel and Kumar (2017) reported that Bavistin and captan gave the best control against the Cercospora leaf spot of the marigold. A combination of the bio-formulation (garlic extract, cow urine, soap nut) was found effective in controlling Cercospora leaf spot disease.

Arora *et al.* (1992) reported that Cercospora leaf spot is caused by fungus *Cercospora megalopotamica* which causes the economic losses in term of yield and quality parameters of marigold crop. In Cercospora leaf spot, circular spots (Diameter of about 1/8 inch) with ash grey centres and dark brown or reddish-purple borders appear on leaves.

2.3.9. Septoria Leaf Spot Disease of Marigold

Shukla and Thakur (2018) firstly reported the septoria leaf spot of marigold from Himachal Pradesh, India. Symptoms of the disease mainly appear on leaves but these can also develop on petioles, stem and calyx. Small, water-soaked circular spots appear on older leaves of the infected plants. The centre of these spots turns into gray color and margins into dark brown color as the disease progress. In the tan centres of spots, there is some readily visible dark brown, tiny dot like structures appear which are known as Pycnidia. After appearance of many spots, the affected leaves turns yellow in colour and then turn brown, become shrivelled and ultimately drop off.

Aktar and Shamsi (2015) reported that Septoria leaf spot disease can be controlled by spraying Dithane M-45 fungicide at regular intervals after appearance of first disease symptoms.

2.3.10. Collar Rot Disease of Marigold

Sohi (1984) reported that collar rot disease is caused by a number of pathogens viz. *Rhizoctonia solani*, *Phytophthora* sp. and *Sclerotium rolfsii*. The occurrence of disease in nursery stage or in grown up plants depends upon type of soil, moisture content and other environmental factors. In this disease black lesions developed on the main stem and rotting at the collar regions causes plant death.

According to Anonymous (2012), the disease can be reduced by soil sterilization and controlled watering.

2.3.11. Aster Yellow Disease of Marigold

According to Anonymous (2018), aster yellow disease is caused by Aster yellows phytoplasma and infected leaves become discolored (light green, yellow, white, red or purple) and stunted; flowers are small and deformed with improper coloration; stems become weak and may form a clump. Infected plants cannot be recovered so infected plants should be completely removed and destroyed as well as nearby perennial weeds should be removed as they can be a source of inoculums.

2.3.12. Bacterial Leaf Spot of Marigold

Shane and Baumer (1984) reported that bacterial leaf spot of marigold is caused by *Pseudomonas syringae* pv. *tagetis*. It was found in greenhouses in North Carolina in 1983 and again in 1984. It is a very destructive of immature marigold plants. They also found that the pathogen that causes bacterial leaf spot of marigold also causes diseases of zinnia, common ragweed, sunflower and *Jerusalem artichoke*.

Styer *et al.* (1980) reported that bacterial leaf spot of marigold is caused by *Pseudomonas syringae* pv. *tagetis*, the disease is seed borne and very destructive in immature marigold plants. It was observed for the first time in the United States (1978) in the field of Wisconsin. The symptoms of the disease are appearance of black spots on cotyledon of seedlings, necrotic spots on leaves surrounded by chlorotic tissues in an irregular pattern, chlorotic and distorted apical growth and in some cases the disease cause mortality of the infected plant.

Hellmers (1955) found that the symptoms appear under the leaf surface as tiny, watery, dark-green spots in the starting of infection and then appear on upper leaf surface after one or two days as a brownish diffuse discoloration.

2.3.13. Viral Diseases of Marigold

Sultana *et al.* (2014) conducted an experiment on virus diseases of marigold in Bangladesh. The results of the study revealed that the virus disease-like symptoms manifested in marigold plants had mixed infection of CMV (*Cucumber mosaic virus*) and PRSV (*Papaya ring spot virus*).

Naqvi *et al.* (1981) reported that CMV is identified as a member of cucumovirus which is transmitted by *Aphis gossypii*, *A. craccivora* and *Myzus persicae* and it was found to be seed transmitted in case of marigold plants.

Hanson *et al.* (1951) found some of the marigold plants affected by viral disease and their symptoms comprises of yellowing, mosaic, vein chlorosis and mild curling. The infected plants were stunted and yielded poor number of twisted and deformed flowers and the reduction in growth appeared as the production of small leaves clustering around the main stem. Growth ceases and necrosis at the top observed in the severely infected plants. Marigold plant is naturally attacked by three different viruses viz. *Cucumber mosaic virus* (CMV).

2.3.14. Nemic Disease of Marigold

Rhoades (1980) reported that marigold plant as described earlier has nematicidal activities but all *Tagetes* varieties are unable to resist all types of nematodes. For example, Cracker Jack marigold can control the southern root-knot nematode but this variety serves as a host for other nematodes such as stubby-root and reniform nematodes and other nematodes like Sting and awl nematodes can increase on *Tagetes* species.

2.4. Seed-borne Pathogens of Marigold

According to Wu and Wu (2019), *Alternaria patula*, the cause of French marigold leaf black spot and flower blight, was first isolated from seeds of French marigold cv. Queen Sophia. It is described as a new species of *Alternaria*. The management of *Alternaria* blight caused by *A. patula* via the application of pyrifenoxy and antagonistic *Bacillus amyloliquefaciens* effectively reduced disease severity, without adverse effects on French marigold in both *in vitro* and *in vivo* bioassays.

Wu *et al.* (2006) identified *Cladosporium sphaerospermum*, *Drechslera halodes*, *Ulocladium botrytis*, *Alternaria cosmosa*, *C. sphaerospermum*, *Curvularia eragrostidis*, *C. penniseti*, *C. ovoidea*, *Drechslera maydis*, *A. alternate*, *A. alternaria*, *D. australiensis*, *Colletotrichum dematium* and *Stachybotrys* spp. from seeds of 15 different ornamental flower plants. Moreover, *A. patula*, *Stemphylium vesicarium* and *Ulocladium atrum* was found in the seeds of French marigold. *Alternaria*, *Curvularia* and *Drechslera* provided more diversified species than other genera among the flower seeds tested.

Wu and Wu (2005) identified a new species of *Alternaria* named *Alternaria patula* from seeds of French marigold.

Wu *et al.* (2001) were isolated *Nimbya gomphrenae*, *Stemphylium vesicarium* and *Alternaria tagetica* for the first time from seeds of diseased globe amaranth (*Gomphrena globosa*), pot marigold (*Calendula officinalis*) and marigold (*Tagetes erecta*), respectively, in Taiwan. The amount of seed-borne *Alternaria alternata* or *S. vesicarium* was negatively correlated ($P=0.05$) with the emergent rate of pot marigold. *Stemphylium* contaminated pot marigold seeds responded to 200 ppm. Iprodione treatment by increasing significantly ($P=0.05$) in seed emergence over untreated control. For seed-borne *A. tagetica*, treating marigold seeds with *Bacillus azotoformans* (1×10^9 CFU/ml) was found effective and Mancozeb highly effective. Chou and Wu (1995) detected twenty-four fungi from 22 seed samples of 13 species of flower crops. Among these fungi, *Alternaria carthami* isolated from zinnia seed, *Colletotrichum dematium* isolated from seeds of celosia and globe amaranth, *Curvularia lunata* isolated from French marigold and globe amaranth, *Drechslera rostrata* isolated from French marigold, and *Phoma* sp. isolated from globe amaranth. These fungi were the first reported seed-borne fungal pathogens of related flower crops internationally. Several other unreported seed-borne fungi exist among flower seeds, but found to be non-pathogenic.

2.5. Socio-economic Study of Marigold Cultivation in Bangladesh

Hossain *et al.* (2016) conducted a socio economic study on marigold cultivation in Bangladesh at the flower market in Agargaon, Shahbag and other retail shops at Dhaka and different flower growing areas of Bangladesh during June 2015 to May 2016 to investigate the present scenario of market demand and price of marigold flowers in Bangladesh. Data were collected from different wholesalers, retailers and farmers. The results indicated that the market demand, supply and price of different types of marigold flowers was varied in different days of the week, different month of the year and different special days of the year. The highest demand starts to increase from the month of November and superseded demand in the month of February and March. The highest price of marigold flower was observed in August and September (Tk. 100 per hundred pieces) and the lowest price was observed in March (Tk. 40 per hundred pieces). Average price of marigold was 70.83 Tk. per hundred pieces in different month of the year. Average price of marigold was 80.00 Tk. per hundred pieces in the days of the week. The highest price was observed in both Valentine's Day and Bengali New Year's Day which was Tk. 120. per hundred pieces. The price was observed in English New Year (Tk. 90 per hundred pieces) which was followed by National Victory Day (Tk. 100 per hundred pieces) and International Mothers' Language Day (Tk. 90 per hundred pieces).

Haque *et al.* (2012) conducted another socio economic study on marigold cultivation in Bangladesh at Jashore and Jhenaidah district during February to identify agronomic practices, analyze relative profitability, and input-output relationship. Primary data were collected from 100 randomly selected farmers from Jashore and Jhenaidah districts. The results indicated that 95% farmers cultivated T- 004 line and only 5% farmers cultivated T- 003 line of marigold. The per hectare costs of marigold cultivation were Tk. 1,47,234 and Tk. 1,02,858 on full cost and variable cost, respectively. The major share of full cost was for human labor (34%), land use (18%), fertilizer (15%), and irrigation (10%). The yield of marigold was 2,650,447 flowers per hectare. The gross margin and net return were Tk.1, 62,186 and Tk.1, 17,812 per hectare, respectively. The net return was 81% higher than lentil, 85% higher than mustard, and 6% lower than potato cultivation. The benefit cost ratios were 2.57 and 1.80 on variable cost and full cost basis, respectively. Cobb-Douglas production function revealed that human labor, land preparation, seedling, urea, TSP, MoP, and irrigation had positive effect on marigold cultivation. The lack of technical knowledge, non- availability of high yielding variety, and infestation of insects and diseases were major problems for marigold cultivation.

Jagoroni Chokkro Foundation (2012) conducted a report on flower cultivation at Jashore district in Bangladesh. Jashore district has a reputation for commercial

flower cultivation. At present, 9,000 hectares of land covers flower cultivation taking the lead by Jashore district. The cultivation duration of Marigold is less than one year. Marigold makes profit ranging from about Tk. 45,000 to Tk.70,000 in a year. During the peak season, per piece price of marigold is at 500-300Tk. per hundred. On the other hand, in off-peak season, the price of marigold is sold at 50-100 Tk. per hundred.

Sultana (1995) identified some problems of marigold flower marketing which are - unavailability of sufficient 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.

Hossain and Rahman (1994) revealed that the capital investment in flower business has been increasing, the total number of shop exhibits an increasing trend, merchandizing patterns have been diversified, the scale of flower made products is rising and all sales are for cash. The positive attitude of respondents toward flowers, multipurpose uses of flowers, increasing uses of flower made products and an unsatisfied demand of some flowers are all positive indicators of the business boom.

CHAPTER III

MATERIALS AND METHOD

3.1. Experimental Site

The investigation and survey was conducted in Jashore district of Bangladesh. Laboratory works and seed health study were carried out in Plant Disease Clinic of Department of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka. The field investigation and survey were conducted at 16 locations under 4 unions of Jhikargacha Upazila of Jashore district. The locations were intensively surveyed to collect data on diseases of Marigold in Bangladesh. The experimental field was located at 89°08'E longitudes and 23°06'N latitude at an altitude of 9 meters above the sea level and under the agro-ecological region of "High Ganges River Floodplain" (AEZ NO. 11). For better understanding, the experimental site is shown in the map of AEZ of Bangladesh in Appendix I. The details of surveyed locations are given in Table 1.

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

Sl. No.	Name of Union	Name of Village	Number of Field/ Farmer
01.	Godkhali	Godkhali	3
		Patuapara	3
		Sadirali	3
		Belemath	3
		Dhalipara	3
	Panisara	Panisara	3
		Sayedpara	3
		Nilkanthanagar	3
		Kuliya	3
		Gaburapur	3
	Navaron	Hariya	3
		Nimtola	3
		Chandpur	3
		Mathuapara	3
	Nirbaskhola	Nirbaskhola	3
		Shiorda	3
Total	04	16	48

3.2. Experimental Period

The experiment was carried out during the period from February to May, 2019. Seed health test was conducted in February to April of 2019. Moreover, survey on field disease was conducted at Jashore in February, 2019.

3.3. Weather Conditions

The field investigation was conducted in the winter season (February) of 2019. The average temperature, precipitation and relative humidity of that month were 22 °C, 0 mm and 45%, respectively.

3.4 .Characteristics of Soil

The Jashore region occupies extensive low-lying areas between the Ganges river floodplain and the Ganges tidal floodplain. The soil of this region contains dark gray clay mixed with peat calcareous dark clay loam. General soil types include mainly peat and non-calcareous dark grey floodplain soils. Organic matter and fertility status were moderate.

3.5. Experiments

The following three experiments were carried out under this study:

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

3.6. Sample Size of Field Investigation for Measurement of Diseases

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

3.7. Sample Size of Survey for Interview of Respondents

In the survey program, three farmers from each location were interviewed under this study. Altogether, 48 farmers were interviewed from 16 villages of 4 Unions of Jhikargacha upazila (Table 1). The interview was conducted to get information about diseases of marigold in different stages of plant and in different seasons of Bangladesh.

3.8. Determination of Seed Health Status of Marigold

Blotter method was used to determine the seed health status and to find out the occurrence of seed borne fungi associated with marigold seeds following the rules of International Seed Testing Association (ISTA, 2001). Seed samples were collected from Dhaka and Jashore districts of Bangladesh. Seeds of two marigold varieties viz. African marigold and French marigold were assessed in this experiment. Four hundred seeds were tested for each variety. Seeds were surface sterilized by 1% chlorax. Seeds were dipped into 1% chlorax for 30 seconds then washed 3 times with distilled water). Three piece of blotter paper were soaked in sterilized water and were placed at the bottom of 9 cm well labeled plastic petri dish. Twenty five seeds of each marigold variety selected at random from each sample and were placed in each plastic petri dish using a forceps, making sure that seeds were placed equidistantly. The petri dishes containing seeds were kept in Incubation Chamber for 7-10 days. Then individual marigold seed was examined under stereomicroscope in order to record the incidence of different seed borne fungi. Moreover, semi-permanent slides were prepared and examined under the binocular compound microscope for proper identification. Fungi were identified following the keys of reference manuals (Mathur and Kongsdal, 2003; Barnett and Hunter, 1992; Booth, 1971). Percent germination also recorded along with the percent pathogen incidence.

3.9. Data Collection

Plant Disease Survey Sheet (Appendix II) was used to collect information on the symptomology of diseases and to record disease incidence and severity data. The survey was conducted under natural epiphytic condition following three replications. Data were collected on the following parameters:

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

Moreover, the following informations were also recorded during data collection:

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

For survey, data were collected by interview of the respondents (farmers). The questionnaire (Appendix III) was used as the instruments for data collection. The questionnaire were formulated and pre-tested in two districts namely Dhaka and Manikganj prior to beginning of the survey. Data and information on marigold 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 Marigold cultivation
13. Suggestion for management of diseases

3.10. Field Inspection and Identification of Disease

Marigold plants of the selected farmer's field were 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 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 considered with importance.

Disease was quantified in three categories such as, Major: where these disease symptoms causes total flower damage and it is impossible to sell them in market, Medium: where symptoms causes partial damage of flower, the flowers can be sold in market but in reduced price, Minor: these symptoms never cause any damage or loss of flower parts, only reduced the market value of the flower. Diseased plant samples and soil were collected and examined in the laboratory. Some of the disease problems were identified based on previous records. Some diseased samples were brought to the laboratory to identify the causal organism. The causal organisms then isolated, identified and recorded. The survey was conducted with Plant Disease Survey Sheet prepared by Department of Plant Pathology, Sher-e-Bangla Agricultural University. Data on socio economic parameters on marigold farmers were also collected by using standard questionnaires to study the economic importance of marigold in the mentioned region (Appendix II).

3.11. Sample Collection

Diseased leaves exhibited different types of typical symptoms were collected from different diseased plants from the marigold fields. The samples were preserved temporarily in air tight zip locked poly bags and tagged for later convenience. Then the samples were carried to the Plant Disease Clinic of SAU. The collected samples were preserved in refrigerator at 4°C before investigation. In the laboratory, these samples were examined for visible symptoms as well as for microscopic examination and isolation of causal organism. Symptomological study was done for all diseases. The development of symptoms was closely observed to confirm the disease. During survey, the diseased plant parts (leaf, stem, bud, collar region, bulb and flower) were carefully examined visually of by magnifying glass to observe the disease symptom development, sign of the pathogen, source of infection, mode of dissemination and favorable environment. Idea about causal organisms (fungi, bacteria, nematode and virus) was taken from those information (Pernezny *et al.* 2008; Mullen, 2007; Waller *et al.*, 1998; Shutleff and Averre, 1997; Putnam, 1995).

3.12. Isolation and Identification of Causal Organism(s)

Isolation and Identification of causal organisms was done by the following methods:

3.12.1. By direct observation (Microscopic study)

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).

3.12.2. By growing on blotter paper (Moist incubation method)

The diseased leaves, stems, flowers and bulbs were cut into pieces (5 mm diameter) and surface sterilized with 70% Ethanol for 30 seconds. Then dipped in sodium hypochlorite (NaOCl) for 30 seconds and washed three times with sterile distilled water each for 1 min. Then the cut pieces were placed in moister sterile blotting paper. When the fungus grew well and sporulation starts it was observed under stereo microscope for look on 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).

3.12.3. By growing on culture medium (Tissue plating method)

The diseased leaves, stems, flowers and bulbs were cut into pieces (5 mm diameter) and surface sterilized. Samples were surface sterilized with 70% Ethanol for 30 seconds. Then dipped in 1% sodium hypochlorite (NaOCl) for 30 seconds and washed three times in sterile distilled water each for 1 min. Some samples were

sterilized with 37.5% Chlorax for 30 seconds washed three times in sterile distilled water each for 1 min. Then the cut pieces were placed on to acidified Potato Dextrose Agar (PDA) medium in petri dish and incubated at 25 °C for 7 days under 12 hours light and dark conditions (Mehrota and Aggarwal, 2003). When the fungus grew well and sporulation starts the organism was re-cultured by hyphal tip culture method to obtain pure culture. Hyphal tips from the margin of each developing colony were sub-cultured on PDA to get pure culture. Microscopic examinations were carried out to study morphological characteristics. The pathogen was identified from most of the infected samples. Slides were prepared from pathogenic structures and 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. Measurement of Plant Diseases

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

3.13.1. Disease Incidence

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

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

3.13.2. Disease severity

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

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

3.14. Analysis of Data

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



Plate 1. Investigation and measurement of diseases in marigold fields; (A) Marigold field in Jashore; (B) Field disease investigation at Jashore; (C) Data recording in marigold field; (D) Interviewing of marigold farmer in the field of Jhikargacha, Jashore.

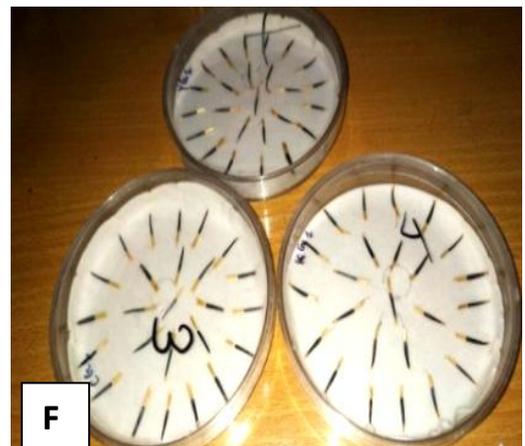


Plate 2. Isolation and identification of causal organisms; (A) Isolation of causal organisms under Laminar Air Flow Cabinet; (B) Observation of pathogens under compound microscope; (C) Incubation of diseased sample in PDA medium; (D) Pure culture of causal organism (E) Identification of causal organism by microscopic study; (F) Seed health study by blotter method.

CHAPTER IV

RESULTS AND DISCUSSION

Experiment 1: Detection, identification and measurement of diseases of marigold at Jashore district of Bangladesh

4.1. Diseases of Marigold

During field investigation, in total seven diseases were recorded and identified in marigold plant at Jashore district. The diseases were leaf spot, Botrytis blight, flower bud rot, stem rot, foliage blight (leaf blight, flower blight), foot and root rot, white mold caused by *Alternaria alternata*, *Botrytis cinerea*, *Alternaria dianthi*, *Fusarium oxysporum*, *Curvularia lunata*, *Sclerotinia sclerotiorum*, respectively. Considering disease incidence and severity, four diseases viz. leaf spot, Botrytis blight, foliage blight and flower bud rot are major diseases of marigold in Bangladesh. Moreover, another three diseases are minor diseases of marigold.

4.1.1. Leaf Spot Disease of Marigold

A. Symptomological Study

Leaves, stems, and flowers of marigold plant were generally affected by leaf spot disease. At first, irregular shaped smoky gray to black spots were seen most frequently on the leaf. Dark-brown necrotic spots formed initially which were surrounded by a chlorotic halo. Chlorotic to brownish spots initially appeared, then gradually enlarged and coalesced. They turned dark brown with brownish purple margins, dried and often became perforated in the center, resulting in early blight of the affected leaves. Infections usually started on lower leaves and progressed to higher leaves (Plate 3.A & B). The leaf spots expanded and coalesced resulting to wilting and drying of the leaves with eventual plant death (Plate 3.C & D). Plants with numerous lesions withered rapidly. Dark gray to dark brown, velvety molds appeared on the lesions under moist conditions.

B. Identification of Causal Organism

The identified causal organism of *Alternaria* leaf spot disease of marigold was *Alternaria* spp. In case of *Alternaria alternata* the mycelium was septate, branched, hyaline in tender age. The conidiophore was simple, septate, short, colored and bear conidia at the top. Conidia were dark, both short and long beaked, multicelled and muriform (both longitudinal and transverse septum was present), borne at the tip of conidiophores singly or in short chains (Plate 3.F). The conidia contained 4-8 transverse septa and few longitudinal septa. Conidial shape was elliptical to obclavate or ovoid which were pointed at distal end. The pure culture of *Alternaria* sp. was

prepared. In the culture the colonies of *Alternaria* are moderately slow growing and produce blackish culture on PDA medium within 10 days (Plate 3.E).

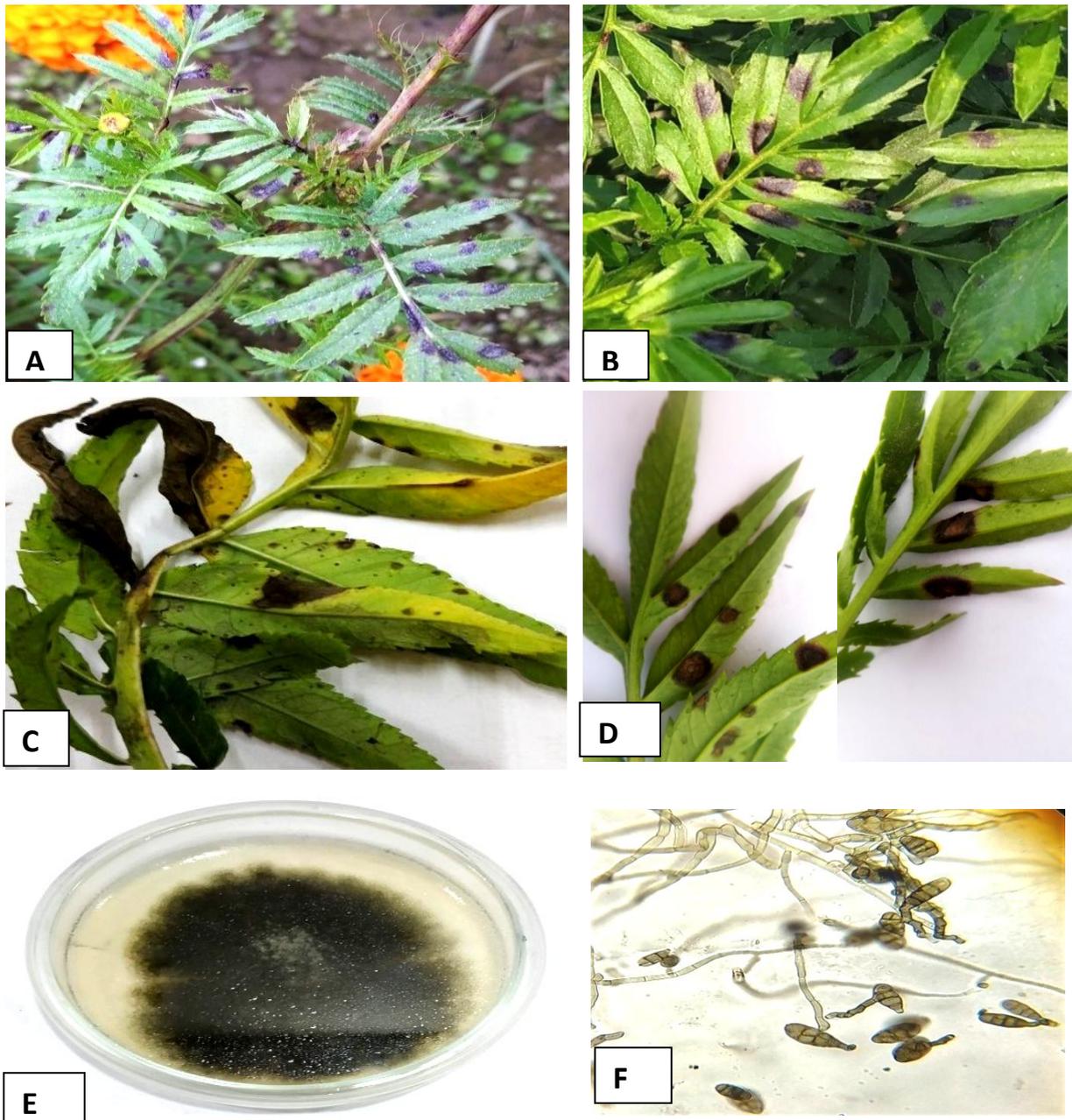


Plate 3. Symptoms and causal organism of leaf spot disease of marigold; (A & B) Field view of leaf spot disease; (C & D) Different stages of infection by leaf spot disease; (E) Pure culture of *Alternaria alternata*; (F) Conidia of *Alternaria alternata*.

C. Incidence and Severity of the Disease

Leaf spot disease was observed in all investigated locations. Incidence of disease varied significantly among the locations that ranged from 30% to 54.33% (Table 2). The highest disease incidence was recorded in Patuapara village (54.33%) and the lowest disease incidence was 30% in Hariya village of Jashore. In case of disease severity, similar trend were observed. Severity of Alternaria leaf spot also varied significantly among the location that ranged from 9.33 % to 18%. The highest disease severity was observed in Shiora and the lowest disease severity was observed in Gaburapur.

Table 2. Disease incidence and severity of leaf spot of marigold at Jhikargacha, Jashore in 2019

Locations	Disease Incidence (%)	Disease Severity (%)
Godkhali	31.33 g	14.00 ab
Patuapara	54.33 a	14.00 ab
Sadirali	38.33 c-g	13.00 ab
Belemath	38.33 c-g	10.33 b
Dhalipara	41.67 b-f	14.00 ab
Panisara	34.00 e-g	12.00 ab
Sayedpara	33.33 fg	11.33 ab
Nilkanthanagar	43.67 b-d	10.32 b
Kuliya	33.00 fg	14.00 ab
Gaburapur	35.00 d-g	9.33 b
Hariya	30.00 g	11.67 ab
Nimtola	47.67 a-c	12.67 ab
Chandpur	37.33 d-g	11.00 ab
Mathuapara	49.00 ab	12.33 ab
Nirbashkhola	34.33 d-g	12.67 ab
Shiora	43.44 b-e	18.00 a
LSD	9.48	6.84
CV (%)	14.60	32.79

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

4.1.2. Botrytis Blight Disease of Marigold

A. Symptomological Study

Botrytis blight is also called “gray mold” disease. The appearance of a gray, fuzzy mold on flowers and leaves is the sign of the fungal disease. Symptoms include leaf and flower spotting or blight, stem lesions, and dieback. Rotting of stems caused plants to collapse, flower buds failed to open and diseased flowers that open become decayed and dropped prematurely (Plate 4. A & B).

B. Identification of Causal Organism

The identified causal organism of Botrytis blight disease was *Botrytis cinerea*. In case of *Botrytis*, fuzzy gray mass of spores were observed. Threadlike branched hyphal structures were found with brown tree like conodiophore which are 2 mm long and smooth. Globose conidia were found in numerous numbers which were hyaline and non septate (Plate 4. D). Pure culture of *Botrytis* was made (Plate 4. C). The fungus was moderately fast growing. It produced whitish cottony colony on PDA culture medium within 8 days.

C. Incidence and Severity of the Disease

Botrytis blight disease was recorded in all investigated fields. Incidence of Botrytis blight varied significantly among the locations that ranged from 15.33% to 38.33% (Table 3). The highest disease incidence was recorded in Sayedpara village (38.33%) and the lowest disease incidence was 15.33% in Kuliya village of Jashore. In case of disease severity, similar trend were observed. Severity of Botrytis blight also varied significantly among the location that ranged from 6.67% to 21%. The highest disease severity was found in Godkhali and the lowest disease severity was observed in Kuliya which was 6.67%.

Table 3. Disease incidence and severity of Botrytis blight of marigold at Jhikargacha, Jashore in 2019

Locations	Disease Incidence (%)	Disease Severity (%)
Godkhali	34.00 a-d	21.00 a
Patuapara	37.67 a	15.00 a-c
Sadirali	33.33 a-d	12.67 b-d
Belemath	26.00 b-e	9.33 b-d
Dhalipara	29.00 a-e	8.67 cd
Panisara	29.67 a-e	13.67 a-d
Sayedpara	38.33 a	13.70 a-d
Nilkanthanagar	27.00 b-e	9.67 b-d
Kuliya	15.33 f	6.67 d
Gaburapur	24.67 c-e	9.67 b-d
Hariya	28.67 a-e	12.67 b-d
Nimtola	35.00 a-c	10.00 b-d
Chandpur	20.00 ef	6.70 d
Mathuapara	24.00 d-f	8.67 cd
Nirbashkhola	20.00 a-e	11.00 b-d
Shiorda	35.33 ab	17.00 ab
LSD	10.52	8.00
CV (%)	21.66	41.45

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

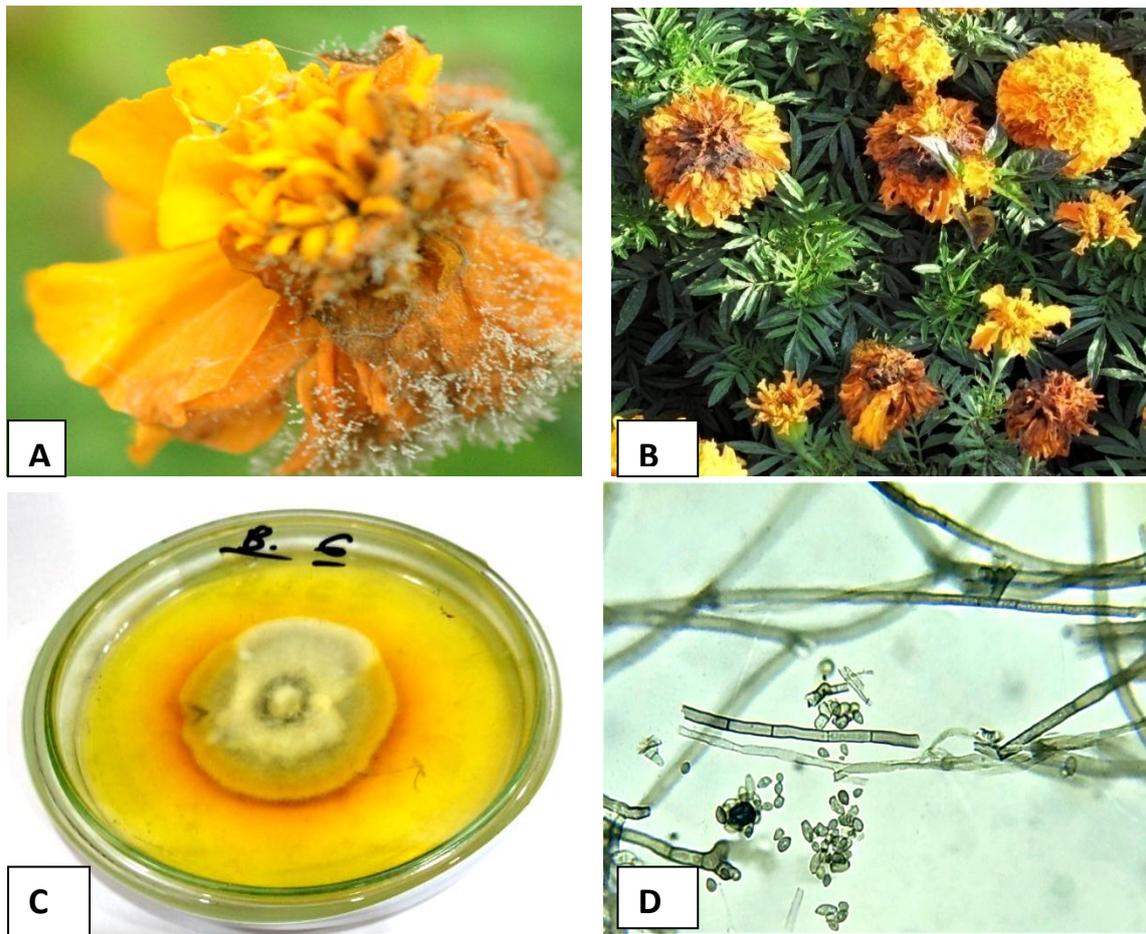


Plate 4. Symptoms and causal organism of *Botrytis* blight disease of marigold; (A & B) *Botrytis* blight disease in marigold flower; (C) Pure culture of *Botrytis cinerea*; (D) Conidia of *Botrytis cinerea* under compound microscope.

4.1.3. Flower Bud Rot Disease of Marigold

A. Symptomological Study

During the disease young flower buds shrivel, turn deep brown in colour and dry up. Symptoms of the disease on mature buds are less prominent but these buds also fail to open due to the effect of pathogen. The pathogen also infects leaves of the plant causing blight and brown necrotic spots on margins and tips of older leaves (Plate 5. A). The pathogen also infects leaves causing blight. The infection is visible in the form of brown necrotic spots on margins and tips of older leaves.

B. Identification of Causal Organism

The identified causal organism of flower bud rot disease was *Alternaria dianthi*. In case of *Alternaria dianthi*, the mycelium was septated, branched, hyaline in tender age. Conidia were dark, with long beak (Plate 5. C), multicelled and muriform (both longitudinal and transverse septum was present), borne at the tip of conidiophores

singly or in short chains. The conidia contained 5-9 transverse septa and few longitudinal septa. The shape of conidia was elliptical to obclavate or ovoid which were pointed at distal end. Beak often slightly swollen at the tip. The pure culture of *Alternaria dianthi* was prepared. In the culture the colonies of *Alternaria* are moderately slow growing and produce brown to blackish culture on PDA medium within 10 days (Plate 5. B).

C. Incidence and Severity of the Disease

Flower bud rot disease was observed in all locations. Incidence of flower bud rot varied significantly among the locations ranged from 12% to 40.66 % (Table 4). The highest disease incidence was recorded in Mathuapara village and the lowest disease incidence was 12% in Hariya village of Jashore. In case of disease severity, similar trend were observed. Severity of flower bud rot also varied significantly among the location that ranged from 6.03% to 18 %. The highest disease severity was observed in Mathuapara which was 18%. Moreover, the lowest disease severity was observed in Sadirali which was 6.03%.

Table 4. Disease incidence and severity of flower bud rot disease of marigold at Jhikargacha, Jashore in 2019

Locations	Disease Incidence (%)	Disease Severity (%)
Godkhali	23.00 b-e	9.33 a-c
Patuapara	34.67 ab	16.00 a-c
Sadirali	22.33 b-e	6.03 bc
Belemath	27.67 a-e	17.33 ab
Dhalipara	26.67 a-e	13.33 a-c
Panisara	25.33 a-e	9.33 a-c
Sayedpara	15.00 de	9.67 a-c
Nilkanthanagar	16.00 de	11.33 a-c
Kuliya	30.67 a-d	14.67 bc
Gaburapur	27.00 a-e	11.33 a-c
Hariya	12.00 e	6.67 a-c
Nimtola	19.67 b-e	7.67 a-c
Chandpur	27.00 a-e	10.67 a-c
Mathuapara	40.66 a	18.00 a
Nirbashkhola	30.33 a-d	10.00 a-c
Shiorda	31.33 a-c	14.67 a-c
LSD	16.11	11.94
CV (%)	37.86	64.03

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

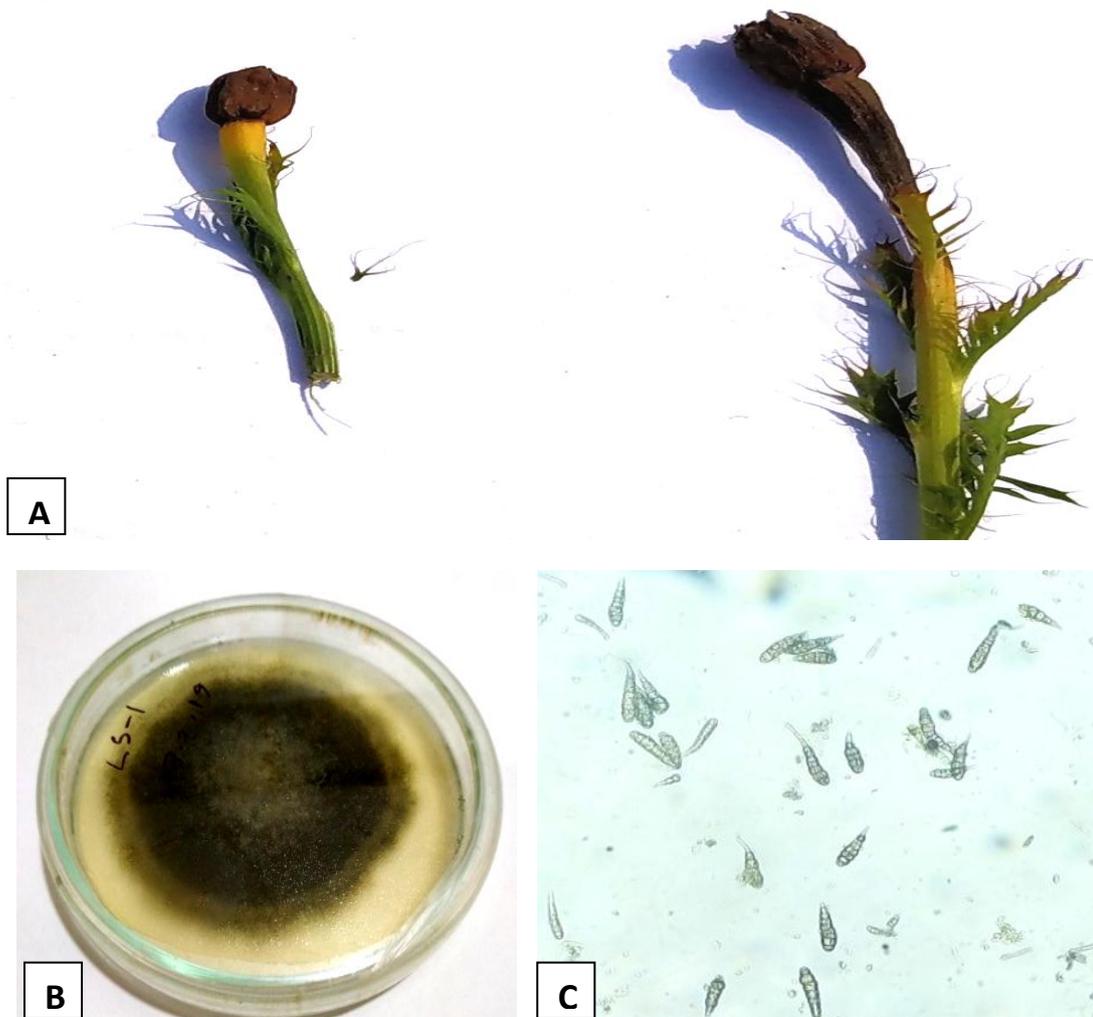


Plate 5. Symptoms and causal organism of flower bud rot disease of marigold; (A) Flower bud rot disease in marigold; (B) Pure culture of *Alternaria dianthi*; (C) Conidia of *Alternaria dianthi* under compound microscope.

4.1.4. Stem Rot disease of Marigold

A. Symptomological Study

At first brown spots appear on the stem and later necrosis start in the stem of marigold. Older leaves become yellow and gradually die. If infection cause after flowering, size, shape and color of flowers shows abnormality. In advance of the disease, the stem becomes breakdown due to necrosis (Plate 6. A & B). Flowers are not developed while stalks are curved in an S-shape. The symptoms are common as a firm, brownish to black stem rot, 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 marigold was *Fusarium oxysporum*. Small, oval shaped, bi-celled microconidia and hyaline, multicelled macroconidia with 3 septation were observed under microscope, which were sickle

shaped with notched base at one end (Plate 6. 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 6. C).

C. Incidence and Severity of the Disease

Stem rot disease were found in all investigated locations of Jashore district. Among the locations, incidence of stem rot ranged from 7% to 29% (Table 5). The highest disease incidence was recorded in Nirbaskhola village (29%) and the lowest disease incidence was observed in Shiorda (7%). Similarly, disease severity was ranged from 2.67% to 13%. The highest severity of stem rot disease was observed in Nirbaskhola (13%) and the lowest was in Sayedpara village that was 2.67%.

Table 5. Disease incidence and severity of stem rot of marigold at Jhikargacha, Jashore in 2019

Locations	Disease Incidence (%)	Disease severity (%)
Godkhali	26.00 a	10.33 ab
Patuapara	16.67 a-d	6.67 a-c
Sadirali	18.67 a-d	11.67 a
Belemath	21.67 a-c	8.67 a-c
Dhalipara	26.33 a	8.70 a-c
Panisara	20.00 a-d	10.00 ab
Sayedpara	10.67 b-d	2.67 c
Nilkanthanagar	9.33 cd	3.34 bc
Kuliya	15.67 a-d	7.00 a-c
Gaburapur	18.00 a-d	9.33 a-c
Hariya	23.67 ab	11.67 a
Nimtola	18.33 a-d	8.00 a-c
Chandpur	25.00 a	11.67 a
Mathuapara	22.67 a-c	6.67 a-c
Nirbaskhola	29.00 a	13.00 a
Shiorda	7.00 d	3.33 bc
LSD	13.60	7.17
CV (%)	42.40	51.96

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

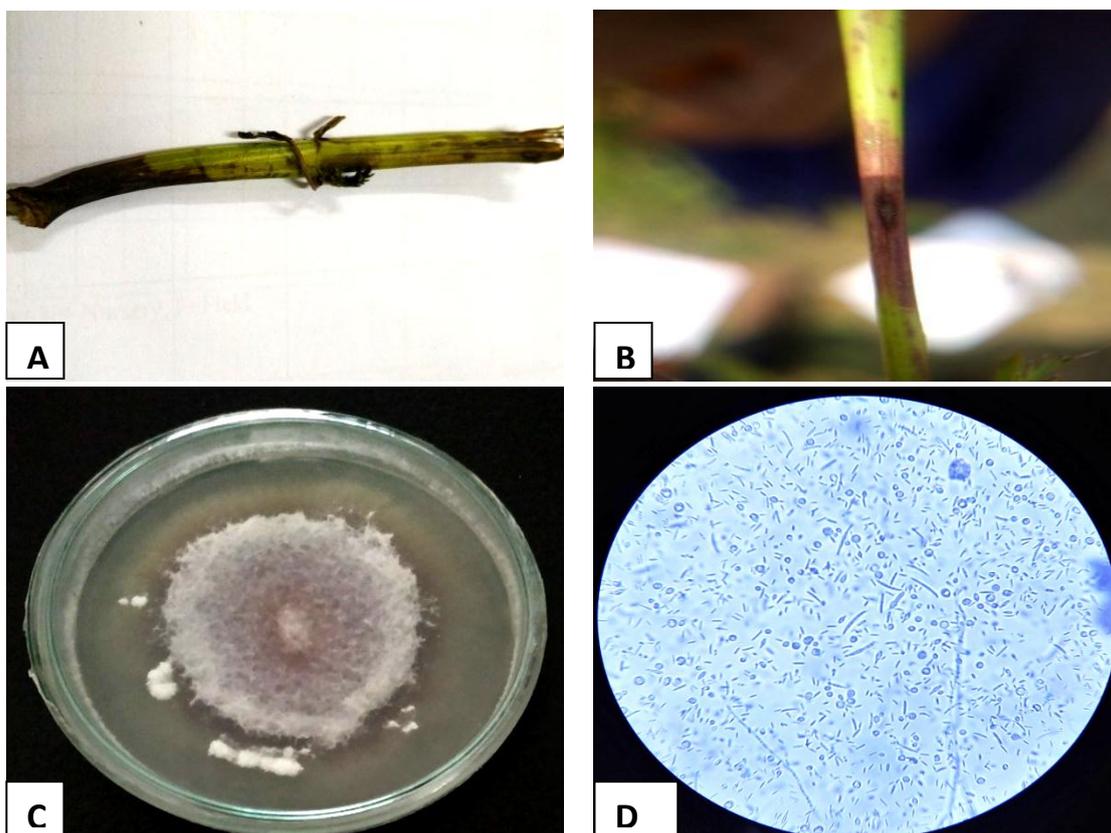


Plate 6. Symptoms and causal organism of stem rot disease of marigold; (A & B) Stem rot disease in marigold; (C) Pure culture of *Fusarium oxysporum*; (D) Micro and macro conidia of *Fusarium oxysporum*.

4.1.5. Foliage Blight Disease of Marigold

A. Symptomological Study

Flowers, leaves of marigold were affected by foliage blight disease. The outer petals of the flowers started blighting first. In some cases blighting was started from the center of the flowers. The blighted petals were black in color and became shriveled (Plate 7. A & B). In some cases, the upper portion of the petal became greenish and had numerous black spots. The sepals were also affected. Blighting occurred due to using flower caps which sometimes injured the petals and started to blight. The blighted area had no margins. Sometimes very small, brown colored spots appear on only one side of the leaf. All leaves are blighted in severe condition (Plate 7. C & D).

B. Identification of Causal Organisms

The identified causal organisms of foliage blight (flower & leaf blight) disease of marigold were *Alternaria* sp. and *Curvularia lunata* and *Aspergillus fumigatus*. In case of *Curvularia lunata*, colonies display rapid growth with olivaceous to grayish colour. Conidiophores are darkly pigmented and geniculated 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 (Plate 7. F). *Curvularia lunata* produces large, upright stroma readily visible in culture with the

naked eye (Plate 7. F). The conidia of *C. lunata* typically have three septa and four cells. Their shape were obclavate to elliptical or ovoid which were pointed at distal end In the pure culture the colonies of *Curvularia* are moderately fast growing and produce dark white to blackish culture on PDA medium within 7days (Plate 7. E). In case of *Aspergillus fumigatus*, colonies of the fungus on PDA plates were grey-green, cottony and reverse side was off white (Plate 7. G). Conidiophores are aseptate, smooth, greenish. Vesicles flask shaped typically fertile over the upper half. Sterigmata in one series are crowded. Conidia are grey-green, one celled, globose, echinulate and catenate (Plate 7. H).

In case of *Alternaria sp*, the mycelium was septated, branched, hyaline in tender age. The conidiophore was simple, septated, short, colored and beard conidia at the top. Conidia were dark, beakless, short and long beaked, multicelled and muriform (both longitudinal and transverse septum was present), borne at the tip of conidiophores singly or in short chains. The conidia contained 4-8 transverse septa and few longitudinal septa (Plate 7. J). The shape of conidia was elliptical to obclavate or ovoid which were pointed at distal end The pure culture of *Alternaria sp*. was prepared (Plate 7. I). In the culture the colonies of *Alternaria* are moderately slow growing and produce blackish culture on PDA medium within 10 days (Plate 7. I).



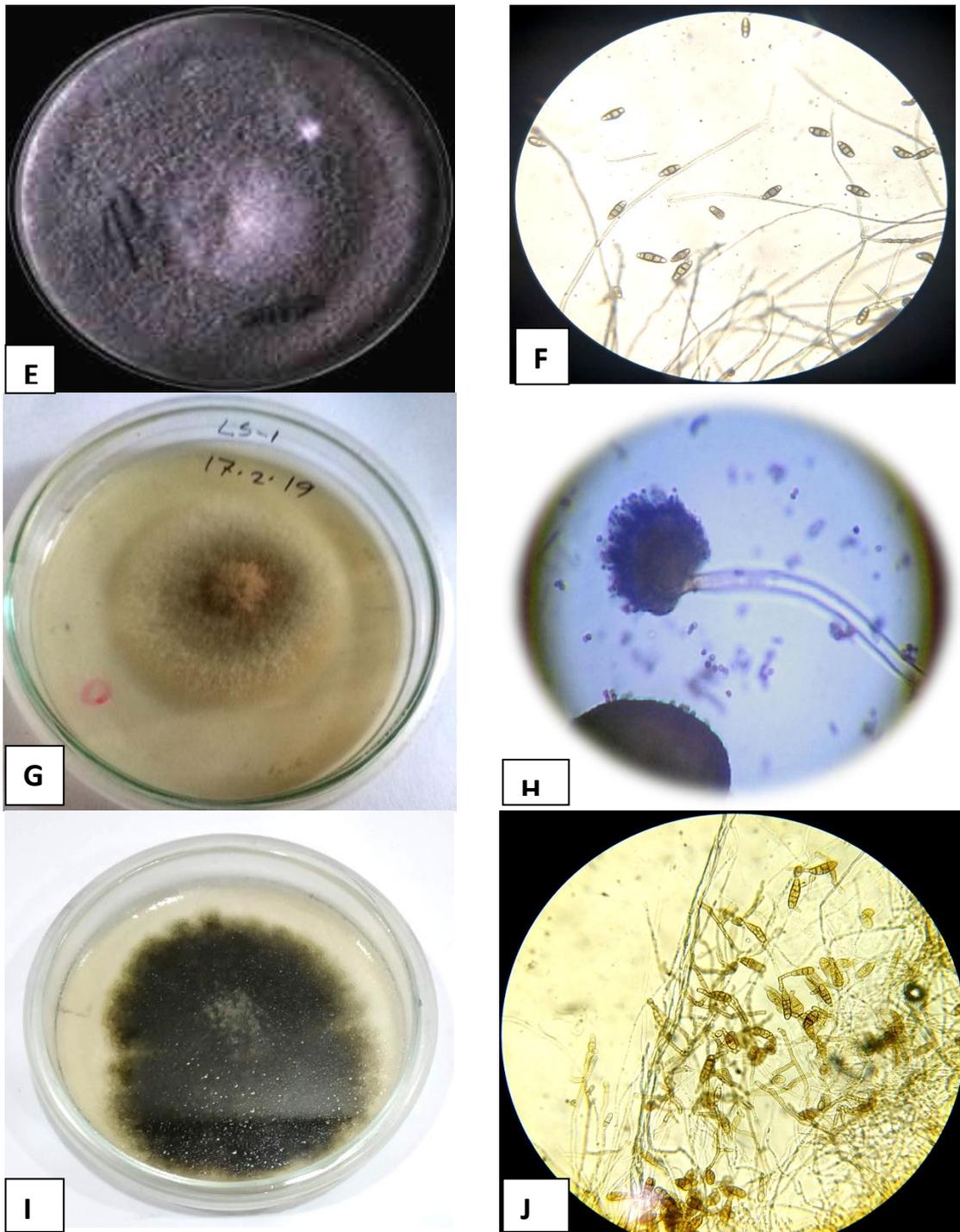


Plate 7. Symptoms and causal organism of foliage blight (flower & leaf blight) disease of marigold; (A & B) Flower blight disease in marigold; (C) Leaf blight disease of marigold; (D) Foliage blight in marigold plant; (E) Pure culture of *Curvularia lunata*; (F) Conidia of *Curvularia lunata*; (G) Pure culture of *Aspergillus fumigatus*; (H) Compound microscopic view of *Aspergillus fumigatus*; (I) Pure culture of *Alternaria* sp.; (J) Conidia of *Alternaria* sp.

C. Incidence and Severity of the Disease

Foliage blight disease of marigold was also found all fields under investigation. Among the locations, incidence of foliage blight ranged from 5.67% to 42%. The highest disease incidence was recorded in Godkhali village (42%) and the lowest disease incidence was observed as 5.67% in Gaburapur. Similarly, disease severity ranged from 1 to 18%. The highest severity of foliage blight was observed in Nirbashkhola that was 18% and the lowest was in Gaburapur village that was only 1%.

Table 6. Disease incidence and severity of foliage blight of marigold at Jhikargacha, Jashore in 2019

Locations	Disease Incidence (%)	Disease Severity (%)
Godkhali	42.00 a	17.00 a
Patuapara	41.00 a	16.00 a
Sadirali	41.67 a	17.33 a
Belemath	30.00 ab	12.00 ab
Dhalipara	19.67 bc	8.33 ab
Panisara	32.33 ab	14.00 a
Sayedpara	24.67 a-c	8.67 ab
Nilkanthanagar	34.33 ab	9.33 ab
Kuliya	32.33 ab	15.00 a
Gaburapur	5.67 c	1.00 b
Hariya	24.00 a-c	7.67 ab
Nimtola	29.67 ab	11.33 ab
Chandpur	29.70 ab	12.00 ab
Mathuapara	23.33 a-c	7.70 ab
Nirbashkhola	35.67 ab	18.00 a
Shiorda	30.00 ab	11.00 ab
LSD	19.21	12.10
CV (%)	38.41	62.45

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

4.1.6. Foot and Root Rot Disease of Marigold

A. Symptomological Study

Plants were observed failed to grow adequately and remained stunted due to foot and root rot disease of marigold. The foliage developed an off color. The fungus grow over the plant surface and the leaves, flowers, and stems eventually become covered with white colonies. Leaf symptoms include chlorosis and darkened midrib and veins followed by loss of turgor and desiccation. Symptomatic plants will usually have significant root and crown discoloration and deterioration. Infection appears more common after flowering. The disease was initiated as dark brown water soaked lesion on the stem and later spread through collar portion extending up to root hairs.

Foliar yellowing and defoliation were the general aerial symptoms noticed in the affected plants (Plate 8. A & B). As the disease progresses the entire plant become wilts and dies.

B. Identification of Causal Organism

Causal organism was not identified from this disease.

C. Incidence and Severity of the Disease

Foot and root disease of marigold were found all investigated locations of Jashore districts. Disease incidence of foot and root rot ranged from 5% to 29.67% among the locations (Table 7). The highest disease incidence was recorded in Chandpur village (29.67%) and the lowest disease incidence (5%) was observed in Sayedpara. Similarly severity of foot and root rot disease was observed highest in Chandpur that was 13% and the lowest in Sayedpara that was 1.67%.

Table 7. Disease incidence and severity of foot and root rot of marigold at Jhikargacha, Jashore in 2019

Locations	Disease Incidence (%)	Disease Severity (%)
Godkhali	18.67 a-c	7.33 a-c
Patuapara	7.67 bc	3.00 bc
Sadirali	25.67 a-c	9.00 a-c
Belemath	20.67 a-c	6.00 a-c
Dhalipara	15.00 a-c	3.33 bc
Panisara	24.67 a-c	7.00 a-c
Sayedpara	5.00 c	1.67 c
Nilkanthanagar	12.67 a-c	4.67 a-c
Kuliya	21.00 a-c	7.10 a-c
Gaburapur	14.00 a-c	6.10 a-c
Hariya	6.33 bc	2.33 bc
Nimtola	27.67 ab	7.33 a-c
Chandpur	29.67 a	13.00 a
Mathuapara	6.67 a	3.00 bc
Nirbashkhola	17.33 a-c	7.33 a-c
Shiorda	17.67 a-c	11.00 ab
LSD	21.74	9.26
CV (%)	77.35	90.01

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



Plate 8. Symptoms and causal organism of foot and root rot disease of marigold; (A) Above ground symptoms of foot rot disease of marigold; (B) Root rot symptoms of marigold.

4.1.7. White Mold Disease of Marigold

A. Symptomological Study

Symptoms began from petals and subsequently expanded to the whole flower and the lower part of the plant. Dark brown lesions with necrotic tissues appeared on the infected leaves and petals (Plate 9. A & B). Seriously infected plants showed flower dropping and branch wilting. Some infected plant parts died prematurely and became bleached. The disease was observed in successive years with a significant lower yield. Under favorable conditions of cool and wet weather for an extended period, pathogen invades host plants and sclerotia found with the infected areas.

B. Identification of Causal Organism

The identified causal organism of white mold disease of marigold was *Sclerotinia sclerotiorum*. Dark sclerotia produced in the pure culture in PDA medium (Plate 9. C). Fragments of dead plants developed white mycelia and sclerotia typical of *S. sclerotiorum* when they were kept in a moist chamber. The fungus will produce a survival structure called a sclerotium either on or inside the tissues of a host plant (Plate 9. C). *S. sclerotiorum* is capable of invading nearly all tissue types including stems, foliage, flowers.

C. Incidence and Severity of the Disease

White mold disease of marigold were found only in different locations of Jhikargacha upazilla of Jashore districts. Among the locations, incidence of white mold ranged from 0% to 26.67% (Table 8). The highest disease incidence was recorded in Shiorda village (26.67%) followed by Godkhali and Panisara. Similarly severity of white mold was observed highest in Shiorda that was 10.67% followed by Godkhali (8.33%). No disease was found in Patuapara village.

Table 8. Disease incidence and severity of white mold disease of marigold at Jhikargacha, Jashore in 2019

Locations	Disease Incidence (%)	Disease Severity (%)
Godkhali	22.67 ab	8.33 ab
Patuapara	0.00 c	0.00 d
Sadirali	4.33 bc	1.33 cd
Belemath	11.67 a-c	1.67 cd
Dhalipara	12.33 a-c	3.00 b-d
Panisara	18.67 a-c	6.33 a-c
Sayedpara	18.33 a-c	4.67 a-d
Nilkanthanagar	9.00 a-c	2.33 b-d
Kuliya	17.67 a-c	5.00 a-d
Gaburapur	18.67 a-c	5.33 a-d
Hariya	4.00 bc	0.67 cd
Nimtola	8.33 a-c	3.33 b-d
Chandpur	5.33 bc	1.67 cd
Mathuapara	8.33 a-c	3.10 b-d
Nirbashkhola	16.00 a-c	6.00 a-d
Shiorda	26.67 a	10.67 a
LSD	20.52	6.11
CV (%)	92.75	97.71

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

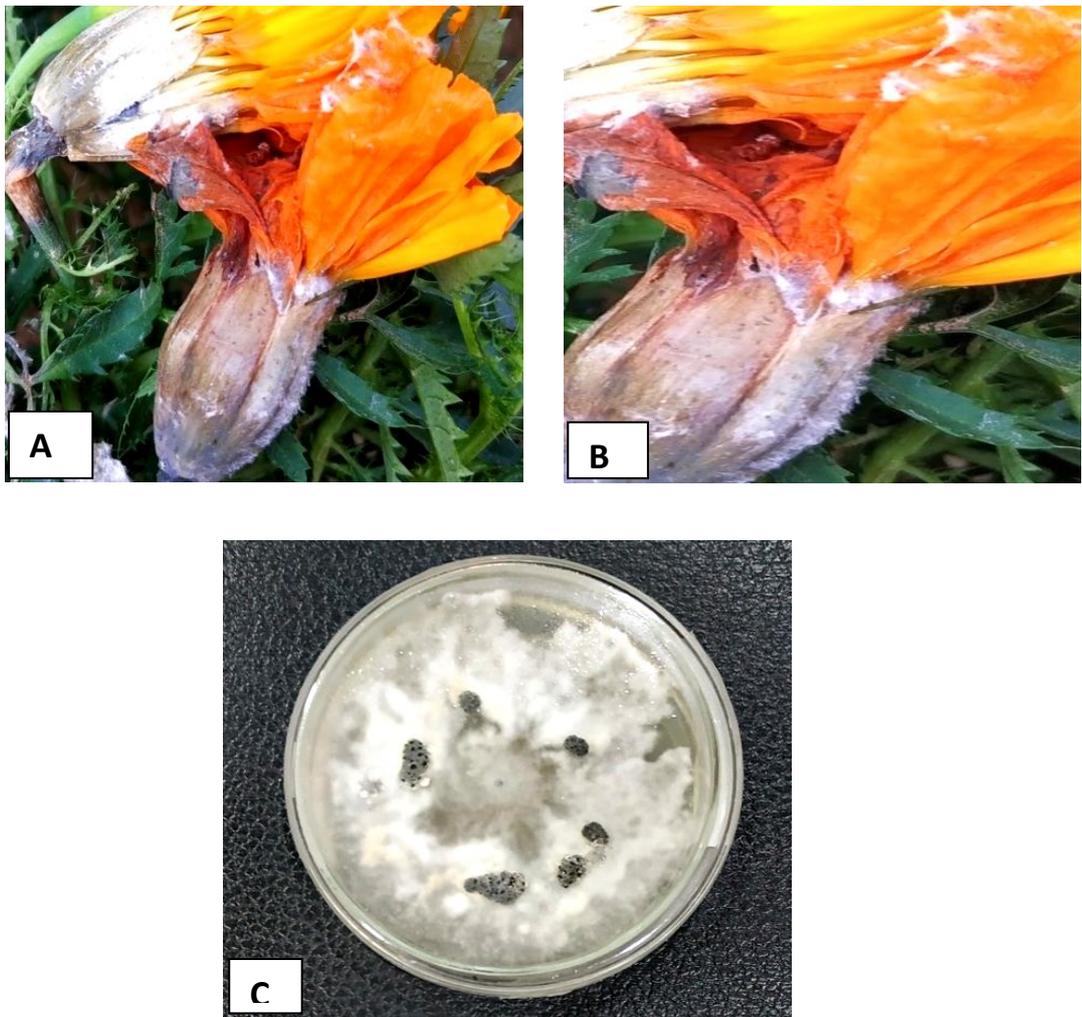


Plate 9. Symptoms and causal organism of white mold disease of marigold; (A&B) Infected flower and sepal of marigold by white mold disease; (C) Pure culture of *Sclerotinia sclerotiorum* showing black sclerotia.

In total, seven diseases were identified in the fields of marigold during investigation. All the diseases are caused by fungal pathogen and three of them are soil borne diseases. The identified diseases of marigold were leaf spot, botrytis blight, flower bud rot, stem rot, foliage blight, white mold and foot and root rot. The major microflora associated with these diseases were *Alternaria alternata*, *Botrytis cinerea*, *Alternaria dianthi*, *Fusarium oxysporum*, *Curvularia lunata* and *Sclerotinia sclerotiorum*. Considering the disease incidence and severity, four diseases viz. leaf spot, botrytis blight, foliage blight (flower & leaf blight) and flower bud rot were found major diseases of marigold in Bangladesh. However, another three diseases viz. stem rot, foot and root rot and white mold were minor diseases of marigold. These diseases were also reported by many scientists, researchers and plant pathologists in the world.

Shamsi and Aktar (2017) reported that *Alternaria* leaf spot disease in marigold is caused by *Alternaria* spp. Out of these leaf spot and flower blight incited by

Alternaria tagetica is the most serious disease in Bangladesh along with over the country. Tomioka *et al.* (2000) reported leaf spot or leaf blight of marigold which was new to Japan. Leaf spot and blight are two common diseases of *Tagetes erecta* and *T. patula*. The disease initiates as circular to oblong brownish spot, later turned dark brown to blackish, enlarged and coalesce to cover almost the entire leaf and made the plant burnt. From India Mukerji and Bhasin (1986) reported that leaf spot is caused by *Alternaria alternata*. Shamsi and Aktar (2017) isolated a total of 20 species of fungi from *Tagetes erecta* and *Tagetes patula*, out of which *Aspergillus fumigatus*, *Alternaria alternata* and *Curvularia lunata* were found to cause foliage leaf blight to *Tagetes erecta* and *T. patula*. Cotty and Mishaghi (1985) reported that leaf spot disease caused a loss of flower yield upto 55-60% in northern Madhya Pradesh. Sultana and Shamsi (2011) reported that gray mold of *T. erecta* is caused by *Botrytis cinerea*. A covering of gray fuzzy fungal growth and spores appears on infected plant tissue of marigold. It is a serious disease in Bangladesh. It causes 70% losses in crops. Kumar (2012) reported that flower bud rot was caused by *Alternaria dianthi*. The infection is visible in the form of brown necrotic spots on margins and tips of older leaves. Singh *et al.* (2012) found that spraying of 0.2% Mancozeb and 0.2% Dithane M-45 effectively controls the infection of flower bud rot.

Kumar (2012) reported that stem rot disease of marigold is caused by the fungus *Fusarium oxysporum* which infect the collar portions of the plants. During wet weather, root system are rotted. White mold disease caused by *Sclerotinia sclerotiorum* on marigold also reported by Rahman *et al.* (2015). In this case sclerotia and fungi recovered from the affected tissue was confirmed as *S. sclerotiorum*. Under favorable conditions of cool and wet weather for an extended period, *S. sclerotiorum* invades host plants causing rot on plant parts. Marigold plant is susceptible to many diseases caused by fungi, bacteria and nematodes. Sultana *et al.* (2014) revealed that the virus disease-like symptoms manifested in marigold plants had mixed infection of CMV (*Cucumber mosaic virus*) and PRSV (*Papaya ring spot virus*). Shane and Baumer (1984) reported bacterial leaf spot of marigold, caused by *Pseudomonas syringae* pv. *tagetis*, was found in greenhouses in North Carolina in 1983 and again in 1984.

Experiment 2. Determination of Seed health status of Marigold by Blotter Method

4.2. Seed Health Study

Seeds of marigold from two varieties were collected from Dhaka and Jashore districts of Bangladesh. Blotter method was used to determine the health status of seed of marigold. All together five fungi viz. *Fusarium oxysporum*, *Aspergillus flavus*, *Aspergillus niger*, *Alternaria alternata* and *Rhizopus stolonifer* were isolated and identified from seeds of marigold. Moreover, bacterial ooze was observed on the seeds (Plate 10).

4.2.1. Incidence of Pathogen in Seeds of Marigold

Incidence of pathogens in seeds of marigold was identified by blotter method and presented in Table 8 and 9. Seed collected from Dhaka showed 52% germination and 67.5% seeds were infected by different pathogens. Similarly, seed collected from Jashore showed that, 77.5% seeds were germinated and 55% seeds were infected by different pathogens.

Table 9. Seed health report of marigold by blotter paper method

Location/ Seed source	No of Inspected Seed	% Seed Germination	No of Infected Seed	% Infection on Seed
Dhaka	200	52.0	135.0	67.5
Jashore	200	77.5	110.0	55.0

Table 10. Pathogen incidence in seed of marigold by blotter paper method

Seed source	% Pathogen Incidence					
	<i>Fusarium oxysporum</i>	<i>Aspergillus flavus</i>	<i>Aspergillus niger</i>	<i>Rhizopus stolonifer</i>	<i>Alternaria alternata</i>	Bacterial Ooze
Dhaka	25.5	39.5	15.0	19.0	10.5	2.2
Jashore	20.5	13.5	25.5	11.0	7.5	1.0

In case of collected seeds from Dhaka, 39.5% seeds were affected by *Aspergillus flavus* followed by *Fusarium* spp. (25.5%), *Rhizopus stolonifer* (19%), *Aspergillus niger* (15%) and *Alternaria alternata* (10.5%). Moreover, bacterial ooze was observed in 2.2% seeds by blotter method. Similarly, for seeds collected from Jashore, 25.5% seeds were infected by *Aspergillus niger* followed by *Fusarium* spp. (20.5%), *Aspergillus flavus* (13.5%), *Rhizopus stolonifer* (11%) and *Alternaria alternata* (7.5%). Bacterial ooze was observed in one percent seeds.

4.2.2. Description of Identified Pathogens

A. *Fusarium oxysporum*

This fungus showed as cottony mycelium in the pure culture. The fungus produces sparse to abundant growth, covering part or whole seed. Colony grows rapidly with cottony white aerial mycelium and often become tan to orange in color. 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 may be 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 produced intercalary or terminal on short lateral branches (Plate 10. A & B).

B. *Aspergillus niger*

This fungus showed as coffee or blackish color. Conidial heads are brown to black, globose in shape with long, erect, hyaline conidiophores which are characteristic of the fungus. Conidiophore bearing the heads are clearly visible in the light. Conidiophores solitary or in small groups. They cover parts of seed or whole seed. Conidia are more or less globose, dark brown often rough or echinulate (Plate 10. E & F).

C. *Aspergillus flavus*

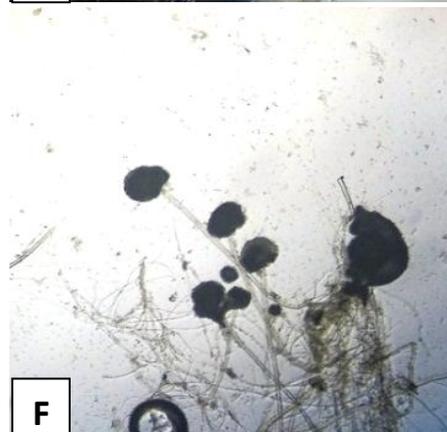
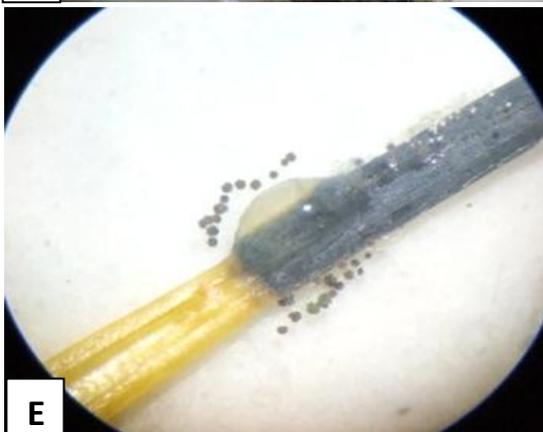
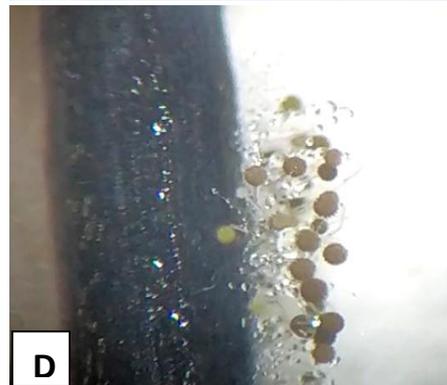
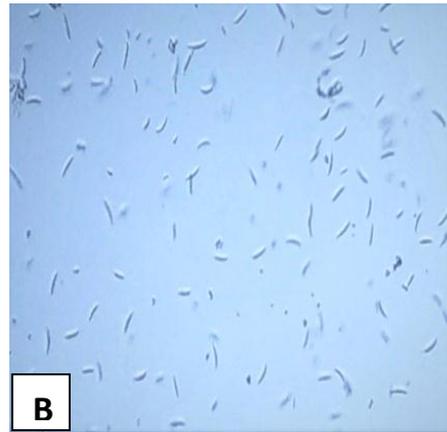
The fungus showed whitish to yellowish to greenish color in pure culture. The growth of the fungus on seed is characterized by immature, while heads and mature heads in shades ranging from yellowish cream to green. Conidiophores bear the heads which were clearly seen when the growth was started. They have long hyaline conidiophores which terminate with bulbous heads. Conidia are globose to subglobose, usually rough (echinulate) and yellowish-green (Plate 10. C & D).

D. *Rhizopus stolonifer*

Often the growth of the fungus covers the whole seeds and extends to blotter paper. This is because of the fast spreading nature of the fungus. Even from one infected seed the dense mycelium can cover the whole petri dish. Colony are fluffy and gray, browning with time. The reverse is white or light colored. Sporangioophores are often branched and rudimentary. The brown sporangioophores are long, solitary or arise. The rhizoids at the base of sporangioophores 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 10. I & J).

E. Alternaria alternata

The growth of this fungus have seen on the whole seed. Chain of conidia was observed under compound microscope. Colonies of *A. alternata* were black velvety. Hyphae were pale to mid brown, smooth septate. Conidiophore was solitary, flexous, septate, pale to mid brown, long, but usually much shorter. Conidia were straight, muriform (both vertical and horizontal septation present), oblong, rounded at the base, pale to mid brown, septate and thick (Plate 10. G & H).



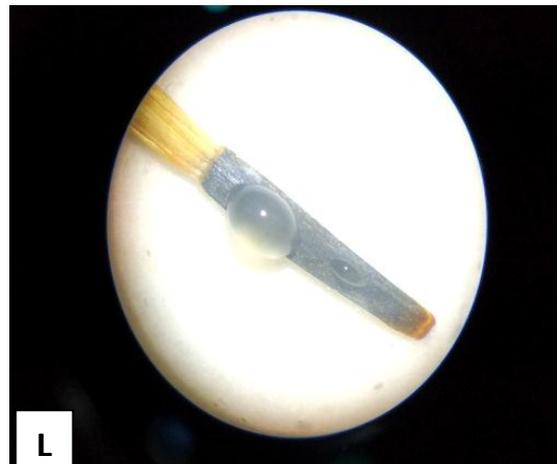
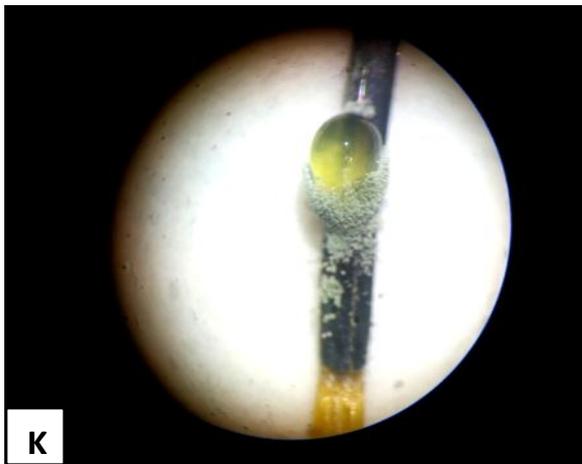
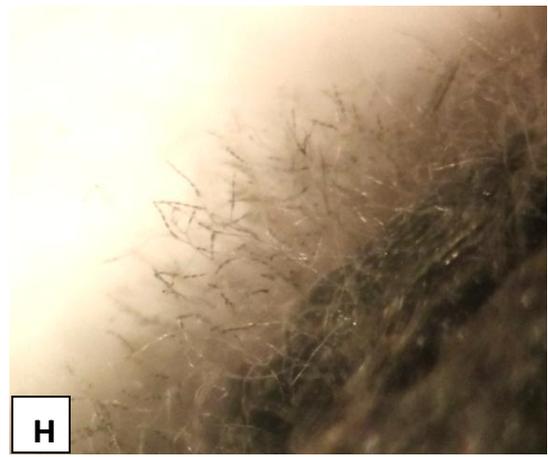
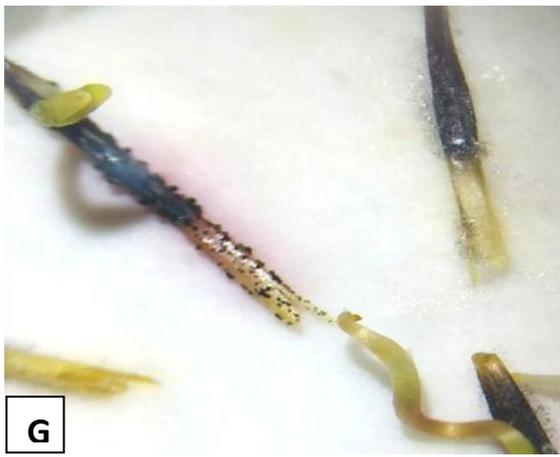


Plate 10. Seed borne pathogens of marigold identified by blotter method; (A) Infected seed by *Fusarium*; (B) *Fusarium oxysporum* under compound microscope; (C) Infected seed by *Aspergillus flavus*; (D) *Aspergillus flavus* under stereo microscope; (E) Infected seed by *Aspergillus niger*; (F) *Aspergillus niger* under stereo microscope; (G) Infected seed with *Alternaria alternata*; (H) *Alternaria alternata* under stereo microscope; (I) Infected seed with *Rhizopus stolonifer*; (J) *Rhizopus stolonifer* under stereo microscope; (K & L) Bacterial ooze showed on marigold seed under stereo microscope.

Similar results was also found by Wu *et al.*, 2006; Chou and Wu, 1995; Wu *et al.* 2001 and Wu and Wu, 2003. Wu *et al.* (2006) identified *Cladosporium sphaerospermum*, *Drechslera halodes*, *Ulocladium botrytis*, *Alternaria cosmosa*, *C. sphaerospermum*, *Curvularia eragrostidis*, *C. penniseti*, *C. ovoidea*, *Drechslera maydis*, *A. alternate*, *A. alternaria*, *D. australiensis*, *Colletotrichum dematium* and *Stachybotrys* spp. from seeds of 15 different ornamental flower plants. Moreover, *A. patula*, *Stemphylium vesicarium* and *Ulocladium atrum* was found in the seeds of French marigold. Chou and Wu (1995) detected twenty-four fungi from 22 seed samples of 13 species of flower crops. Among these fungi, *Curvularia lunata* and *Drechslera rostrata* isolated from French marigold. Wu and Wu (2005) identified a new species of *Alternaria* named *Alternaria patula* from seeds of French marigold. According to Wu and Wu (2019), *Alternaria patula*, the cause of French marigold leaf black spot and flower blight, was first isolated from seeds of French marigold cv. Queen Sophia. Wu *et al.* (2001) were isolated *Stemphylium vesicarium* and *Alternaria tagetica* for the first time from seeds of diseased pot marigold (*Calendula officinalis*) and marigold (*Tagetes erecta*), respectively, in Taiwan.

Experiment 3: 4.3. Survey on Socio-Economic Status, Cultivation Practices, Diseases and Other Problems Related to Marigold Cultivation at Jashore District

The study was done through a pre-tested questionnaires and interviews. Physical field visits were also conducted to know the real situation of the diseases of marigold. The data collected from the fields were analyzed statistically. The results obtained from study are presented below sequentially under three items and then discussed as to extract the findings systematically in line with the objective of the research work.

A. Survey on Socio-Economic Status of Marigold Farmers

4.3.1. Gender of the Farmers

In the survey program 48 marigold farmers were interviewed from Jhikargacha upazila in Jashore. Among them, most (91.67%) of the farmers were male and 8.33% were female (Table 11).

Table 11. Gender of the marigold flower farmers

District	Gender	No. of the respondent	Response (%)
Jashore	Male	44	91.67
	Female	4	8.33
Total		48	100.0

4.3.2. Age of the Farmers

Majority of the marigold farmers (45.83%) were between 30 to 40 years old (Table 12). 12.5% farmers were below 20 years old and 14.58% farmers were above 50 years old. However, 27.1% farmers were between 40 to 50 years old.

Table 12. Age of the farmers engaged in marigold flower cultivation

Ages (years)	No. of respondent [N=48]	% Response
<30	6	12.50
30-40	22	45.83
40-50	13	27.10
>50	7	14.58
Total	48	100.0

4.3.3. Education of the Farmers

Education level of marigold growers up to HSC was 18.75%. Among the education level of farmers, Class IV to SSC was ranked first (37.5%) followed by Class 1-5 (20.83%). About 10.42% farmers were illiterate (Table 13). Among the respondent, 8.33% completed Degree and 4.17% completed Masters. From this finding it was revealed that the training on flower cultivation is required for marigold farmers.

Table 13 . Education level and their percentage of the marigold flower farmers

Education level	No. of respondent	% Response
Illiterate	5	10.42
Class 1-5	10	20.83
Class 6- SSC	18	37.50
HSC	9	18.75
Degree	4	8.33
Masters	2	4.17
Total	48	100.0

4.3.4. Land Utilization under Marigold Cultivation

Land utilization by farmers under marigold cultivation ranges from 2 to 5 bigha was 43.75% (Table 14). 20.83% farmers cultivate marigold in between 6-10 bigha lands. Moreover, 25% farmers cultivate marigold in below 2 bigha lands. Around 10.42% farmers cultivate marigold in more than 10 bigha lands.

Table 14. Land utilization under marigold cultivation in Jashore district

Land utilization (Bigha)	No. of respondent	% Response
<2	12	25.0
2-5	21	43.75
6-10	10	20.83
10<	5	10.42
Total	48	100

4.3.5. Farmers' Opinion on the Land Utilization Pattern for Marigold Cultivation [N=48]

According to the farmers opinion, on an average total land area owned of 48 farmers was 0.89 ha, of which cultivable land under total land owned was 0.75 ha. The land under Marigold flower cultivation was 0.35 ha. From these findings it was revealed that a large portion of the cultivable lands of the farmers was engaged under marigold flower cultivation (Table 15).

Table 15. Farmers' opinion on the land utilization pattern for marigold cultivation

Land utilization pattern	Land size (Trimmed Mean)	
	Bigha	Hectare
Total land area owned	6.68	0.89
Cultivable land under total land owned	5.63	0.75
Land area under Marigold flower cultivation	2.63	0.35

*1 hectare = 7.5 bigha

4.3.6. Duration (year) engaged in Marigold flower cultivation

The farmers were engaged in marigold cultivation more than 15 years. Out of 48 farmers, 8.33% of the total farmers are cultivating marigold more than 15 years. However, 29.17% farmers are cultivating marigold in last five year and 41.67% farmers are cultivating marigold between 6 to 10 years. Moreover, 20.83% farmers was growing marigold from 11 to 15 years (Table 16).

Table 16. Duration (year) engaged in marigold flower cultivation

Duration (year)	No. of respondent	% Response
<5	14	29.17
6-10	20	41.67
11-15	10	20.83
>15	4	8.33
Total	48	100

B. Survey on Production Technology Used by Marigold Farmers at Jashore

4.3.7. Source of Planting Materials Used by Marigold Farmers for Cultivation

Farmers were collecting planting materials (seed and seedlings) of marigold from very limited sources. Out of 48 farmers, most of them (41.67%) were collecting planting materials (seed and seedlings) of marigold from nursery. The importers and seed dealers import seeds of marigold of different hybrid varieties mostly from India. Quality hybrid marigold varieties were found less in numbers. 29.17% farmers collected marigold seed from importers. However, 10.42 % farmers have started to preserve plantlets personally as it is more reasonable considering production cost. Few farmers (6.25%) collect planting materials from local market.

Table 17. Farmers' opinion on the source of planting materials (seed and seedlings) used for marigold cultivation at Jashore

Source of Rose planting materials	Response of farmers	
	No. of respondent [N=48]	% Response
1. Nursery	20	41.67
2. Directly from importer	14	29.17
3. Personal preservation	5	10.42
4. Local market	3	6.25
5. Dealer	2	4.17
6. Others	4	8.33
Total	48	100

4.3.8. Fertilizer Application in Marigold Fields at Jashore

Application of organic manure is very importance for flower cultivation. Total amount of farm yard manure was applied once during land preparation @ 2500 kg/ha with Urea, TSP, MOP, Zinc, Zypsum @ 240 kg/ha, 200 kg/ha, 150kg/ha, 7 kg/ha and 11 kg/ha, respectively (Table 18).

Table 18. Fertilizer application in marigold fields

Manure/Fertilizer	Dose per/ha (kg)
Farm Yard Manure	2500
Urea	20.50
TSP	25.30
MOP	21.50
Zinc	7.00
Zypsum	11.00

4.3.9. Cost Involved in Pest Management of Marigold Cultivation at Jashore

According to the farmers opinion total cost involved for pest management of marigold is around 3700 taka per year per bigha. Out of this, 1100 taka is for disease management and the rest is for insects and weeds management. Insect and weed management needs 1300 taka and 800 taka per year per bigha, respectively. (Table 19).

Table 19. Cost involved in pest management of marigold cultivation at Jashore

Cost/Bigha/Year (Tk.)			Other pest control cost Tk/Bigha/Year
Disease	Insects	Weeds	
1100	1300	800	500
Total= 3700 Tk/Bigha/year			

4.3.10. Buyer of Marigold from Farmers

Among the 48 farmers, 56.25% reported that they sell the flowers through middle man. Different Companies buy flowers from some of the farmers (6.25%). However, 31.25% farmers sell their flowers directly in the market (Table 20).

Table 20. Buyer of marigold from farmers

Buyer	No. of respondent [N=48]	% Response
Directly	15	31.25
Middle man	27	56.25
Company	3	6.25
others	2	4.17
Total	48	100.0

4.3.11. Cost Involved and Benefit Cost Analysis for Marigold Cultivation /bigha at Jashore

Cost of production of marigold was more or less same for all farmers. Farmers cultivated marigold as open cultivation in field. Due to open cultivation, farmers have to face problems of insect and disease infestation. Total BDT 20,400 required for marigold cultivation per bigha. Major cost involved for planting materials (Tk. 12,000) followed by other intercultural operations.

Table 21. Cost involvement in marigold cultivation (Bigha/year) in Jashore district

Cost involvement	Taka/Bigha
Land preparation	2000
Planting materials	12000
Weeding	800
Irrigation	1200
Pesticide	2900
Picking flowers	1000
Other cost	500
Total cost	20,400

4.3.12. Benefit Cost Ratio of Marigold Cultivation (Bigha/year)

Benefit cost ratio is the tool for appraising the worthiness of investment and it helps to ascertain the profitability of an enterprise. Cost of production and benefit cost ratio varied from flower to flower year to year. The production of flower was varied and it depended upon different factors. The flower production was lower initially and gradually increased with time. Around 30,000 flower produce in one bigha land/year. In the peak season farmers got around 500 Tk/100 flowers but in off peak they got only 50 Tk/100 flowers. On some special days and occasions such as International Mother Language Day, Victory Day, Valentines Day the demand of flowers was

high and farmers get more price of flowers. On average the net profit of marigold cultivation was about 55,000 Tk/bigha/year (Table 22).

Table 22. Benefit cost analysis of marigold (Bigha/year)

Production /year or season /bigha	Price (TK)	Total cost (Tk)/Bigha/year or season	Total income (Tk)/bigha/year or season	Net profit (Tk/bigha/season)
30,000	Pick-500/100 flowers Off pick-50/100 flowers	20,000	75,000	55,000

4.3.13. Incidence of Disease Infections in the Marigold Field

Considering the opinion expressed by the farmers, the diseases of marigolds in field were leaf spot, Botrytis blight, flower bud rot, stem rot, foliage blight, foot and root rot and white mold (Table 23). Among these diseases, leaf blight, Botrytis blight foliage blight and flower bud rot were considered as major disease. As per farmer's opinion, the minor diseases were stem rot, foot and root rot and white mold. The infestation intensity of the diseases was low to medium to high expressed by most of the farmers.

Table 23. Farmers' response on the incidence of disease in the marigold field

Name of disease	No. of respondent N=48]	% Response	Infection intensity			
			High	Medium	Low	Total
1. Leaf spot	15	31.25	65.75	24.36	9.89	100
2. Botrytis blight	10	20.83	62.25	21.20	13.55	100
3. Flower bud rot	6	12.5	25.36	13.60	61.04	100
4. Stem rot	4	8.33	23.25	13.52	63.23	100
5. Foliage blight	8	16.67	41.26	18.63	40.11	100
6. Foot and root rot	3	6.25	8.26	4.56	87.18	100
7. White mold	2	4.17	0.00	26.35	73.65	100

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

At Jashore, most of the farmers (85.42%) expressed their opinion that there were positive relationship among insect pest, disease and weed infestation in the field, whereas only 14.58% farmers expressed their negative opinion (Table 24).

Table 24. Farmers' opinion on the relationship among insect pests, diseases and weed infestation in the marigold field

Types of response	Response on the relationship	
	No. of respondents	% Response
Yes	41	85.42
No	7	14.58
Total	48	100

4.3.15. Degree of Relationship among Insect Pests, Diseases and Weed Infestation in the Marigold 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 in the marigold field (Table 25). This result indicates insect infestation and disease infection become high when weed infestation become high expressed by the 54.16% and 50 % farmers, respectively. Insect infestation and disease infection increased with the increase of the weed infestation. Similarly, disease infection become high when insect populations become high expressed by the 35.42% farmers, i.e., disease infection was increased with the increase of the vector population. From this finding it was revealed that weed infestation enhanced the insect pest population and disease incidence in marigold fields. Mites and thrips act as vectors of virus caused disease in marigold. Some other insect pests were Mealy bug, Aphid, Caterpillars (dhora poka) are also damage marigold plants.

Table 25. Farmers' response on the degree of relationship among insect pest, disease and weed infestation in the marigold field

Relationship	Degree of relationship	No. of respondents [N=48]	% Response
Insect infestation high when weed infestation	High	26	54.16
	Medium	13	27.08
	Low	5	10.42
	Don't Know	4	8.33
	Total	48	100
Disease infestation high when weed infestation	High	24	50.00
	Medium	15	31.25
	Low	5	10.42
	Don't Know	4	8.33
	Total	48	100
Disease infestation high when vector insect	High	17	35.42
	Medium	13	27.10
	Low	8	16.67
	Don't Know	10	20.83
	Total	48	100

4.3.16. Probable Sources of Pests and Diseases of Marigold

The probable sources of diseases were from seedlings (cuttings), imported seed, soil, local planting materials, use of imbalanced fertilizer, through irrigation water (Table 26). Among these local planting materials was ranked first which played role as source of pest and disease infestation on marigold expressed by the maximum farmers (25%) participated in the program. Second most important source was the soil borne expressed by the 20.83% farmers.

Table 26. Farmers response on the probable sources of marigold disease

Probable sources	Response	
	No. of respondents [N=48]	% Response
1. Seedlings	9	18.75
2. Imported seed	8	16.67
3. Soil borne	10	20.83
4. Local planting materials	12	25
5. Use of imbalanced fertilizer	3	6.25
6. Through irrigation water	2	4.17
7. Other sources (if any)	4	8.33

4.3.17. Probable Ways of Spreading of Marigold Disease

Farmer's response on the probable ways of dissemination of marigold diseases is presented in Table 27. Around 43.75% farmers believe that diseases are spreading by infected seed and seedlings. Another ways of spreading disease of marigold were weeds (12.5%), imported seeds (8.33%), crops debris and manure (6.25%), Irrigation water, insects, wind, rain splash, intercultural works were also played role as probable ways in spreading marigold pests and disease.

Table 27. Farmer's response on the probable ways of spread of disease

Probable ways of spread of disease	No. of respondents [N=48]	% Response
1. Infected seed and seedlings	21	43.75
2. Imported seed	4	8.33
3. Weeds	6	12.5
4. Insect	4	8.33
5. Wind	2	4.16
6. Irrigation water	1	2.08
7. Crop debris and Manure	3	6.25
8. Rain splashing	1	2.08
9. Spreads through human being	2	4.16
10. Spreads through intercultural works	4	8.33

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

At Jashore, among 48 farmers, majority (70.83%) of them said that they took measures to control diseases and pest of marigold in the field. Moreover, 20.83% farmers do not take any measures against pest. However, 8.33% farmers did not respond on this question (Table 28).

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

Types of response	Response on the measures taken to control pests	
	No. of respondents	% Response
Yes	34	70.83
No	10	20.83
Not replied	4	8.33
Total	48	100

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

Among 48 farmers at Jashore, majority (41.66%) had taken both preventive and curative measures to control diseases of marigold in field. However 33.33% farmers took preventive measures and 25% farmers took curative measures for the control marigold diseases in the field (Table 29).

Table 29. Farmers' response on the types of measures taken to control disease of marigold in the field

Types of measures	Response (%) on the types of measures taken	
	No. of respondent [N=48]	% Response [100%]
1. Preventive	16	33.33
2. Curative	12	25.00
3. Both	20	41.66

4.3.20. Farmer's Response on Management of Diseases of Marigold

At Jashore, different methods applied for the management of marigold diseases and pests. Most of the farmers (33.33%) applied pesticides to control insect pests and diseases (Table 30). They consider it the better management practices for disease and pest control. Considering the farmers' opinion, the better management practices for controlling disease of marigold were the spraying of fungicides such as Dithane M-45, Tilt, Mancozeb, Acrobat MZ, Tilt, Mancozeb etc. The concentration of Mancozeb they used @ 3gm/L water as spray.

Table 30. Farmers' response on the methods of disease control in marigold field

Methods of disease control	Response on the methods applied	
	Diseases	
	Nos. [N=48]	% Response
1. Use of pesticides	16	33.33
2. Use of disease resistant variety	10	20.83
3. Treatment of planting materials	12	25.00
3. Cultural practices & control measures	7	14.58
4. IPM method	1	2.08
5. Others (if any)	2	4.17

4.3.21. Farmer's Response on receiving assistance and service for controlling diseases of marigold

Respondent farmers were received assistance and other services for controlling disease of marigold from different sources. Farmers were mostly helped by the visit of extension officers (37.50%) in their field and meeting with field level officers of DAE which was 27.03% (Table 31). Farmers also got services from experts, field day and field demonstration.

Table 31. Farmers response on receiving assistance and service for controlling diseases of marigold

Assistance and service	No. of respondent [N=48]	% Response
1. Visit of Extension Officers	18	37.50
2. Experts suggestion	5	10.42
3. Field day	6	12.5
4. Field demonstration	4	8.33
5. Meeting with the field level officers	13	27.03
6. No opinion	2	4.67
Total	48	100.0

4.3.22. Major Problems of Marigold Cultivation

There are 48 farmers, who attend in this survey in Jashore. Maximum farmers (25%) were considered disease as major problem for marigold cultivation (Table 32). Rest of the problems were faced by the farmers are transportation problem, pest and insect attack, high price of planting materials, natural hazard, low price of flower, unrecognized market etc.

Table 32. Farmer's response on different problems in marigold cultivation

Problems	No. of respondent [N=48]	% Response
High price of planting materials	5	10.42
Insect pest	10	25
Diseases	12	20.83
Transportation	9	18.75
Natural hazards	3	6.25
Low price of the products	2	4.17
Unorganized market	12	20.83

4.3.23. Farmer's suggestions for better management of diseases of Marigold

Some operations should be involved for better management of disease of marigold. Use of healthy planting materials, effective use of pesticides, proper inter-culture operation, regular field visit and more researches are required for better management of marigold. Most of the farmers (31.25%) responded on the use of healthy planting materials and 16.67% farmers suggested about use of effective pesticides and least 6.25% farmers emphasized on more researches for pest management of marigold.

Table 33. Farmer's suggestions for better management of diseases of marigold

Suggestions	No. of respondent [N=48]	% Response
1. Use of healthy planting materials	15	31.25
2. Effective use of pesticides	8	16.67
3. Proper inter-culture operation	7	14.58
4. Regular field visit	11	22.91
5. More research on disease management	3	6.25
6. Use of disease resistant variety	4	8.33

Similar findings were also reported by Hossain *et al.*, 2016; Haque *et al.*, 2012 ; Jagoroni Chokkro Foundation , 2012 ; Sultana, 1995 and Hossain and Rahman, 1994. Hossain *et al.* (2016) conducted a socio economic study on marigold cultivation in Bangladesh at the flower market in Agargaon, Shahbag and other retail shops at Dhaka during June 2015 to May 2016 and investigated the present scenario of market demand and price of marigold flowers in Bangladesh with the help of different wholesalers, retailers and farmers. The results indicated that the market demand, supply and price of different types of marigold flowers was varied in different days of the week, different month of the year and different special days of

the year. The highest demand starts to increase from the month of November and superseded demand in the month of February and March. The highest price was of marigold flower was observed in August and September (Tk.100 per hundred pieces) and the lowest price was observed in March (Tk.40 per hundred pieces). Average price of marigold was 70.83 tk. per hundred pieces in different month of the year. Average price of marigold was 80.00 tk. per hundred pieces in the days of the week. The highest price was observed in Valentine's Day and Bengali New Year's Day , English New Year , National Victory Day and International Mothers' Language Day. Haque *et al.* (2012) conducted another socio economic study on marigold cultivation in Bangladesh at Jashore and Jhenaidah district during February and identified agronomic practices, analyze relative profitability, and input-output relationship. The per hectare costs of marigold cultivation were Tk. 1,47,234 and Tk. 1,02,858 on full cost and variable cost, respectively. The major share of full cost was for human labour (34%), land use (18%), fertilizer (15%), and irrigation (10%). The yield of marigold was 2,650,447 flowers per hectare. The gross margin and net return were Tk.1, 62,186 and Tk.1, 17,812 per hectare, respectively. The net return was 81% higher than lentil, 85% higher than mustard, and 6% lower than potato cultivation. The benefit cost ratios were 2.57 and 1.80 on variable cost and full cost basis, respectively and revealed that human labour, land preparation, seedling, urea, TSP, MoP, and irrigation had positive effect on marigold cultivation. The lack of technical knowledge, non- availability of high yielding variety, and infestation of insects and diseases were major problems for marigold cultivation.

Jagoroni Chokkro Foundation (2012) also conducted a report on flower cultivation at Jashore district in Bangladesh. 9,000 hectares of land covers flower cultivation taking the lead by Jashore district. The cultivation duration of Marigold is less than one year. Marigold makes profit ranging from about Tk. 45,000 to Tk.70,000 in a year. During the peak season, per piece price of marigold is at 500-300Tk. per hundred. On the other hand, in off-peak season, the price of marigold is sold at 50-100 Tk. per hundred. Sultana (1995) identified some problems of marigold flower marketing which are - unavailability of sufficient 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 modem storage facilities, improvement of cultivation practices of flower for the whole year and arrangement of contract marketing. Hossain and Rahman (1994) revealed that the capital investment in flower business, the total number of shop has been increasing and merchandizing patterns have been diversified, the scale of flower made products is rising. The positive attitude of respondents toward flowers, multipurpose uses of flowers, increasing uses of flower made products and an unsatisfied demand of some flowers are all positive indicators of the business boom.

CHAPTER V

SUMMARY AND CONCLUSION

Flower demand is increasing day by day and simultaneously the land under flower cultivation and the total yield of flower is also increasing. The cultivation of marigold flower is highly profitable because of its higher demand compared to its production. Even though, insect and diseases infestation is most important constraints for quality marigold production. The marigold farmers face various problems during production and marketing of their produces. The major problems are transportation facility, insects and diseases infestation and lack of technical knowledge etc. Among the diseases of marigold, leaf spot, botrytis blight, foliage blight, flower bud rot mostly occur in Jashore districts of Bangladesh. However, very few research works were conducted on the diseases of marigold in Bangladesh.

Three experiments were conducted to investigate diseases of marigold in Jashore district of Bangladesh during February 2019 to May 2019. The first experiment was detection, identification and measurement of diseases of marigold at Jashore in Bangladesh. Second experiment was detection of seed health status of marigold and the third experiment was to survey on socio economic status of Marigold farmers, production technologies and disease and other problems related to Marigold cultivation in Bangladesh. In case of field investigation, 16 villages under 4 Unions of Jhikargacha Upazila of Jashore 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. Seed Health study of marigold was done by blotter method following ISTA rules. The seed samples were collected from Jashore and Dhaka. The pathogens were observed in stereo and compound microscope and transferred into pure culture. The diseases were identified based on the symptomological study and identified causal organisms. The causal organisms of the disease were detected and identified as CMI (Commonwealth Mycological Institute) description and other reference materials. Moreover, repeated isolation and observation was carried out to confirm the pathogen. But pathogenicity test following by Kotch's postulates were not done because of limitation of time and materials. The data of disease incidence and severity was analyzed by using STATISTIX-10 and the mean difference was judged by Least Significant Difference (LSD). Analysis of variance (ANOVA) was used to find out the variation of result from experimental treatments. Moreover, a survey was conducted on socio economic status of marigold farmers, production technologies, diseases and problems related to tuberose cultivation in Bangladesh.

Seven diseases were identified from marigold from this investigation. The diseases were leaf spot, Botrytis blight, flower bud rot, stem rot, foliage blight, foot and root rot and white mold. The identified causal organism of these diseases were *Alternaria alternata*, *Botrytis cinerea*, *Alternaria dianthi*, *Fusarium oxysporum*, *Curvularia lunata* and *Sclerotinia sclerotiorum*. Leaf spot, Botrytis blight, foliage blight and flower bud rot disease were mostly occurred in the fields of marigold. Other diseases were also observed in minor quantity in different location of Jashore district.

Farmer's saved seeds of Marigold were collected from Dhaka and Jashore districts of Bangladesh. Seeds from two varieties of Marigold (African marigold and French Marigold) were collected from each district. Blotter paper method was used to determine health status of marigold seeds. All together five fungi viz. *Fusarium oxysporum*, *Aspergillus flavus*, *Aspergillus niger*, *Rhizopus stolonifer* and *Alternaria alternata* were isolated and identified from seeds of marigold.

In most cases disease incidence and severity were varied significantly among different locations. According to the opinion of farmers, 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. No powdery mildew was observed in the field as it frequently occurs in the summer season and the field investigation was carried out in the winter season. In case of flower abnormality, the older plants are mostly affected. The nematode and bacterial disease was very rare in marigold.

For survey, 48 farmers from 16 villages of Jhikargacha upazila were interviewed with a pre-tested questionnaire. From the socio-economic point of view, gender, age, education level and the land utilization pattern of the farmers were studied. Again, on the basis of production technology, various information related to it such as planting materials, fertilizer application, pest management, benefit cost ratio etc. were collected and analyzed. Farmers' opinion on different disease related parameters were also taken in consideration along with their suggestions for better management of the diseases. For example, according to the farmers' opinion, the leaf spot and botrytis blight are the most common diseases in marigold. Sometimes the older plants got yellowing and blighted because of diseases.

Farmers expressed their positive opinion on relationship among insect pest, disease and weed infestation in marigold 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% marigold farmers think that, seed are the main source of pest and diseases. Around 43.75 % farmers believe,

diseases are spreading by infected planting materials . 70.83% farmers took measures to control diseases and pest of Marigold in the field. Thus, 33% of the interviewed farmers were preferred to treat seeds with fungicides as preventive method of disease management. However, 14.58% farmers give importance on cultural practices to control diseases. Respondent farmers were received assistance and other services for controlling disease of marigold from different sources. Maximum farmers (25%) were considered disease as major problem for marigold cultivation. There are some important suggestions gave the farmers for better managements diseases of marigold. Maximum suggestions (31.25%) were related to use of healthy planting materials. Rest of the suggestions given by the farmers were effective use of insecticides & pesticides, regular field visit ,proper inter-culture operation, more research on disease management, assistance from DAE, loan for flower cultivation, use of resistant variety etc.

Marigold is a commercially grown flower in Bangladesh. It is a profitable flower in floral industry. But research on diseases of marigold is very few in Bangladesh. Moreover, marigold cultivation is a great source of employment. The finding of this research work will give a baseline for further researches on marigold diseases. Still, further research should need to be performed to get a clear image about the marigold diseases, production technology, cultivation and socio economic status of marigold growers in Bangladesh.

CHAPTER VI

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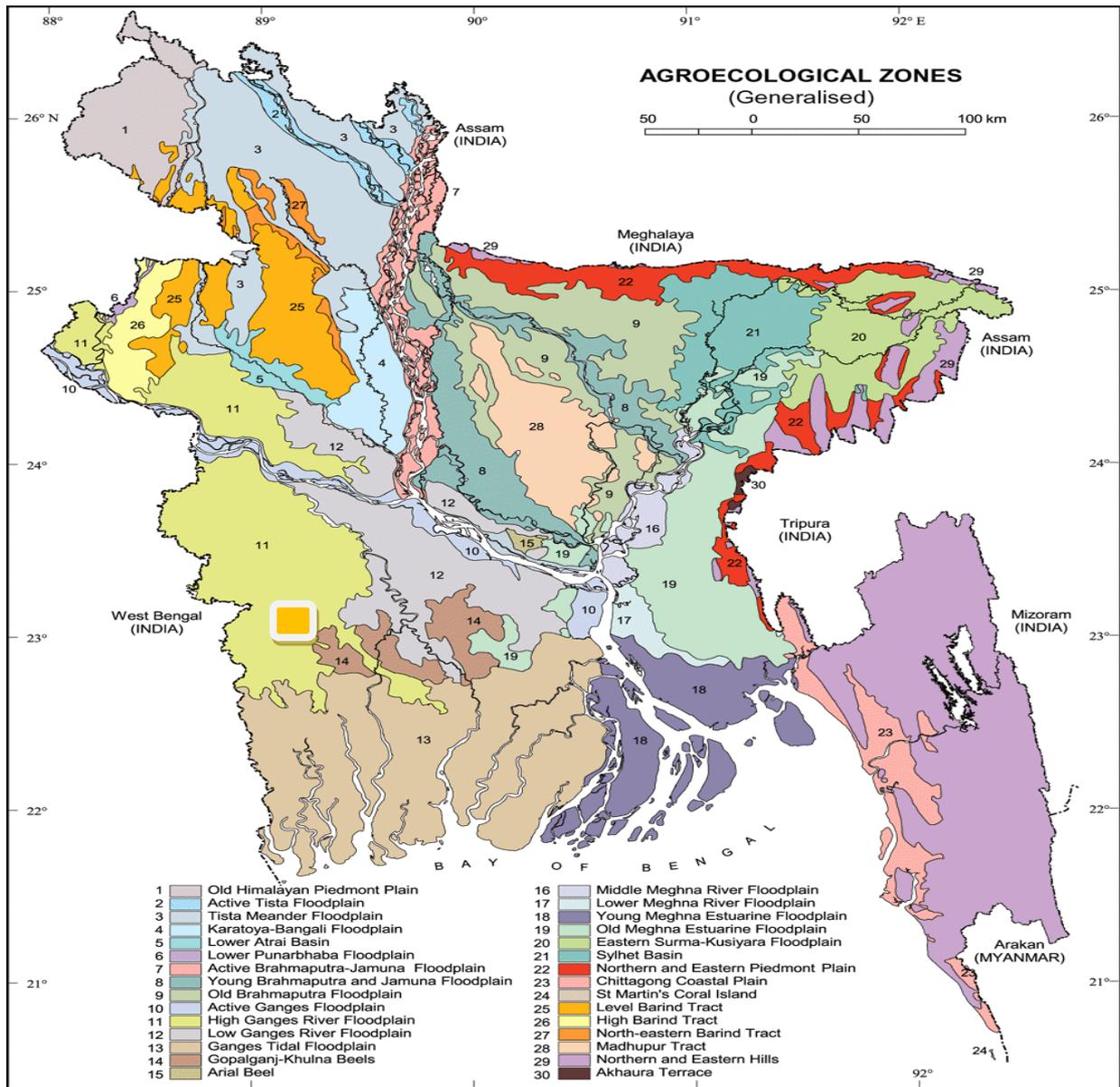
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APPENDICES

Appendix I. Experimental Site under Investigation and Survey



 **Experimental site (Jashore, Bangladesh)**

Appendix II. Plant Diseases Survey Sheet for Marigold

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



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						
Botrytis blight/ gray mold														
Leaf spot														
Stem rot														
Flower bud rot														
Foliage blight														
Foot and root rot														
White mold														

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						
Powdery Mildew														
Mosaic														
Leaf Curl														
Leaf Rust														

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

Symptomological Study

Symptoms	Botrytis blight/ gray mold	Leaf spot	Stem rot	Flower bud rot	Foliage blight	Foot and root rot	White mold	Powdery mildew	Mosaic	Leaf curl	Leaf rust
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 III. Questionnaire for Survey on Diseases of Marigold
Department of Plant Pathology
Sher-e-Bangla Agricultural University, Dhaka



Questionnaire for Survey on Diseases of Marigold in Bangladesh
Field / Nursery / Post Harvest

Serial				
--------	--	--	--	--

Cell Phone												
------------	--	--	--	--	--	--	--	--	--	--	--	--

Name of Respondent:..... Village:.....

Union: Upazila..... District:

Education: Age..... Sex..... Profession.....

1. Land Information

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

2. Cultivation of Marigold

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

3. Sources of purchasing planting materials of Marigold

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

(নিজের / প্রতিবেশী/ কোম্পানীর/ স্থানীয়/ ব্যবসায়ী/ এনজিও/ আমদানী/ গবেষণা প্রতিষ্ঠান)

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

Cultivation Duration (month/year)	Production/ 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)
6-7 Months		Pick- Off pick-			

5. Cost involved for pest management of Marigold

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

6. Fertilizer application in Marigold field

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

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

Name of Insects pest	Stage of infestation			Incidence/severity		
	Seedling	Vegetative	Flowering	High	Moderate	Low
1. পাতা সুড়ঙ্গকারী 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. লেদা পোকা						
11. পাতাথেকো পোকা						
12. Leaf minor						
13. White fly/ সাদা মাছি						
14. Mites/ মাকড় বা লাল মাকড়						
15. মাছি পোকা						
16.						
17.						
18.						

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

Name of Diseases	Stage of infection			Incidence/ severity			Infected Parts of Plant							Distribution		Status		Seasons			
	S	V	F	H	M	L	L	S	T	B	F	FP	Others	EF	R	New	Old	S	R	W	
1. Botrytis blight/ Gray mold																					
2. Leaf spot পাতায় দাগ																					
3. Stem rot কান্ড পঁচা																					
4. Flower bud rot																					
5. Foliage blight																					
6. Foot and root rot গোড়া পচা																					
7. White mold																					
8. Powdery mildew																					
9. Mosaic																					
10. Leaf curl পাতা কুকড়ে রোগ																					
11. Leaf Rust মরিচা রোগ																					
12.																					
13.																					
14.																					

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 Marigold in field/ Nursery (please put ✓)

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

(দুর্বা, মুখা, চাপড়া, বখুয়া, ভাদাইল, শ্যামা, ধুতুরা, তিতবেগুন, বনবেগুন, ফোস্কাবেগুন, হেলেছা, বনকফি, চেচরা, শুশনি, বনশরিষা, নাকফুল, শাকনটে, কাটানটে, বিষকাটালী, আংগুলাীগাস, হাতিশুড়, স্বর্ণলতা, পার্থেনিয়াম)

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

[Yes = ✓, No=X]

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

[Yes = ✓, No=X]

9.1 Insect population high when weed incidence is high:

9.2 Disease incidence high when weed incidence is high:

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

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

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

13. Pests infestation in Marigold after harvest/ in stored condition (please put ✓)

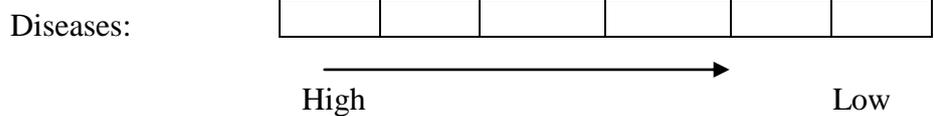
Insect pests/ Diseases	Extent of Damage		
	High	Medium	Low
A. Insect pests			
1.			
2.			
3.			
4.			
B. Diseases			
5.			
6.			

7.			
8.			
Others			
9.			
10.			

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

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

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



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

16. Who purchase Marigold from farmer/grower? (please put ✓)

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

17. Mention major problems on cultivation of Marigold 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 Marigold.

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

Name and Signature of Surveyor
 Date: / /2019

Name and Signature of Supervisor
 Date: / /2019