MANAGEMENT OF *OKRA YELLOW MOSAIC VIRUS (OYMV)* THROUGH CONTROLLING INSECT VECTOR WITH IMIDACLOPRID AND LIGHT REFLECTING MULCH

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*This is to certify that thesis entitled, "***MANAGEMENT OF *OKRA YELLOW MOSAIC VIRUS (OYMV)* THROUGH CONTROLLING INSECT VECTOR WITH IMIDACLOPRID AND LIGHT REFLECTING MULCH***" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE IN PLANT PATHOLOGY, embodies the result of a piece of bona fide research work carried out by, Registration No. 12-04879 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma in any institute.*

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

……..

Dated: 20 October, 2019
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Dedicated
To
My Beloved Parents
and
Farmers Who Feed
The Nation

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MANAGEMENT OF *OKRA YELLOW MOSAIC VIRUS (OYMV)* THROUGH CONTROLLING INSECT VECTOR WITH IMIDACLOPRID AND LIGHT REFLECTING MULCH

ABSTRACT

A field experiment was conducted at the central farm of Sher-e- Bangla Agricultural University, Dhaka-1207, during March to July, 2017. The aim of the study was to investigate the varietal performance of two popular okra varieties namely BARI Dherosh-1 and Green finger against *Okra yellow mosaic virus* (*OYMV)* by controlling the insect vectors with Imidacloprid and light reflecting silver color mulch. Two experiments were carried out in two blocks layouted with RCBD and four treatments viz. T_0 (control/no spray), T_1 (only mulching), T_2 (1 spray+ mulching) and T_3 (3 times spray) with three replications. The mulch was used at 15 DAS and insecticide was sprayed at 30 DAS and continued with 15 days interval. At 95 DAS, the lowest disease incidence (%) was estimated in T_2 (one spray+ mulching) that were 34.72 % and 19.65 % in BARI Dherosh-1 and Green finger respectively. The highest disease incidence (%) was estimated in T_0 (untreated/control) that was 73.71 % in BARI Dherosh-1 and 51.11 % in Green finger. In case of morphological parameters; the highest number of leaves, flowers and fruits per plant was recorded in T_2 (one spray+ mulching) and that was 46.33, 9.33, 7.00 in BARI Dherosh-1 and 48.00, 12.33, 10.67 in Green finger respectively up to last harvesting. Yield and yield contributing characters were significantly varied among the treatments. The highest yield per plant and plot was obtained in T_2 (one spray+ mulching) treatment in case of both varieties (0.15 kg/plant, 2.86 kg/plot in BARI Dherosh-1 and 0.24 kg/plant, 4.37 kg/plot in Green finger). The highest plant height was also found in T_2 (one spray+ mulching) in both varieties (128.62 cm and 130.33 cm respectively). It was also observed that when percent disease incidence increased, the yield of okra was also decreased. However, considering the economic conditions/cost-benefit ratio T_2 (one spray+ mulching) gave the best results in terms of controlling the insect vector whitefly.

LIST OF CONTENTS

LIST OF CONTENTS (Contd.)

LIST OF CONTENTS (Contd.)

LIST OF CONTENTS (Contd.)

LIST OF TABLES

LIST OF TABLES (Contd.)

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ACRONYMS

AEZ	=	Agro-Ecological Zone
%	=	Percent
/plot	=	Per plot
BARI	=	Bangladesh Agriculture Research Institute
BBS	=	Bangladesh Bureau of Statistics
FAO	=	Food Agricultural Organization
cm	=	Centimeter
RCBD	=	Randomized Completely Block Design
CV%	=	Percentage of coefficient of variance
DAS	=	Days After Sowing
et al.	=	And others
ha^{-1}	=	Per hectare
kg	=	Kilogram
LSD	=	Least Significant Difference
MoP	=	Muriate of Potash
N	=	Nitrogen
no.	=	Number
NPK	=	Nitrogen, Phosphorus and Potassium
/plant	=	Per plant
SAU	=	Sher-e-Bangla Agricultural University
$t\ ha^{-1}$	=	Ton per hectare
t/ha	=	Ton per hectare
TSP	=	Triple Super Phosphate
Wt.	=	Weight

CHAPTER I

INTRODUCTION

INTRODUCTION

Okra (*Abelmoschus esculentus L.* Moench) belongs to the family Malvaceae. known as Lady's finger. It is commonly called "Dherosh" or "bhindi" in the different area of our country. It is originated from West Africa as an annual vegetable crop grown from seed in tropical and subtropical parts of the world (Thakur and Arora, 1986). The crop is very well distributed over the Indian subcontinent and East Asia (Rashid, 1999). Its tender green fruits are very popular as vegetables among all classes of people in Bangladesh and other countries. In Bangladesh, vegetable production is not same all over the year. Most of the vegetables are grown in the winter season and very low amount in the summer season; around 30% of the total vegetables are grown in the kharif season, while 70% grown in the Rabi season (Anon, 1993). Though it is popular vegetable, it is mainly grown during the summer season. It is also grown in winter season in Bangladesh with very poor land coverage. In Bangladesh, the annual okra production is 53.98 thousand metric tons from 11.34 thousand hectors of land (BBS, 2016). The production is quite lower in comparison to our neighbor country, in India it produces 8896.3 thousand metric tons from 1158.0 thousand hectors of lands (FAO, 2018). Its tender pods are eaten as vegetables, stewed with meat, used to make soup and also canned and dried for different purposes all over the world.

Okra is a very nutritious and delicious vegetable and rich in vitamins and minerals (Kushak *et al.,* 2003). Its 100gm edible portion of pod has moderate levels of vitamin A (0.01 mg) and vitamin C (18 gm), calcium (90 mg), phosphorus and potassium. The content of riboflavin (0.08 mg) , niacin (0.08 mg) and thiamine (0.07 mg) per 100 gm edible portion of pod is higher than any others vegetables (Rashid, 1999). It is a good source of gum, starch, spice etc. Okra is also useful against genito-urinary disorders, chronic dysentery and spermatorrhoea. It is effective in curing ulcers and relief from hemorrhoids (Adams, 1975). Okra contains special type of fiber that takes sugar levels in blood under control, providing sugar quantity, acceptable for the bowels. Mucilage remaining in okra is useful for washing away toxic substances and

harmful cholesterol, which causes different serious diseases in the liver. It ensures recovery the psychological and mental conditions like depression and general weakness. It is the most effective for pulmonary inflammations, bowel irritations, and sore throat. According to Indian researches it is known, okra is a complex replacement for human blood plasma. In order to remain the valuable substances safe, its practice to cook okra as shortly as possible, processing it either with steam, or on low heat (Purseglove *et al.*, 1999). The yield is also very low compared to that of other developing countries where the yield as high as 8-12 t/ha (Schippers, 2012). In Bangladesh the production of okra is very low due to lack of management and high disease incidence. The yield and quality of okra depend on several factors like diseases, insects, soil factors and climatic conditions. Among those factors responsible for the low yield and quality of okra, viral disease like okra yellow mosaic that caused by *Okra yellow mosaic virus (OYMV)* is the most important factor as reported by Sastry and Singh (1974). This virus may be reduced more than 90% yield (Akanda, 1991). The virus was systematically studied and characterized by different Indian scientists (Capoor and Verma, 1950; Kumar and Moorthy, 2000 and Verma, 1955). After study they proposed that *Okra Yellow mosaic virus* is a member of Geminivirus group which is semi-persistently transmitted by whitefly (*Bemesia tabaci*). This virus is also transmitted by mechanically or through seeds. They also observed that *Okra yellow mosaic virus* is the most important factor of yield reduction in india and some other okra growing regions of the sub-continent (Harender *et al.*, 1993, Nath *et al.*, 1993, Singh and Chakrabarti, 1997). The growth and development of a okra plant depends on its normal physiological and morphological processes. The pathogen may change the physiological and morphological system to the infected plants. There are some researches on biochemical changes of several crops other than okra due to virus infection (Haider and Hossain, 1994). But study on pigment content and physiological changes in virus infected okra is very rare. Considering above mentioned factors the research experiment was designed with the purpose of managing the *Okra yellow mosaic virus* by controlling the

insect vectors through one selected insecticide namely Imidacloprid and light reflecting plastic mulch with the following objectives:

The specific objectives of the study are given below-

- ✓ To evaluate the efficacy of imidacloprid and light reflecting mulch to control the insect vector whitefly
- ✓ To estimate the resistant/ tolerance level of selected okra varieties against *Okra yellow mosaic virus* (*OYMV*) under selected management practices

CHAPTER II

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Okra yellow mosaic virus (OYMV) is the most annihilating virus of okra in all okra growing regions. Kulkarni (1942) first identified that the occurrence of a virus which was responsible for huge yield reduction of okra in Bombay, India. Uppal *et al.,* (1940) observed the virus infecting okra and named it as *Okra yellow mosaic virus*. Okra yellow mosaic disease was first reported from Bombay (presently known as Mumbai) in India (Kulkarni, 1942). The causative virus, *Okra yellow mosaic virus (OYMV),* was shown to be a begomovirus based on its morphological and serological relationship with other begomoviruses, such as *African cassava mosaic virus* (Harrison *et al.,* 1991).

Capoor and Verma (1950) worked on *Okra mosaic virus* and concluded that the disease is a serious problem for okra cultivation in India and Bangladesh. The virus-vector relationship of *okra yellow mosaic virus* was also worked in India by Verma (1952). It was then established that the virus disperse by an insect vector (*Bemisia tabaci*) and also through bud grafting (Capoor and Verma, 1950; Verma 1952).

Sastry and Singh (1974) summerized that in the Indian subcontinent, the virus is however spread in the sub-tropical regions in the rainy season crop and in the tropical regions in the spring-summer crop. Later on, Handa (1993) conducted electron microscopy of virus while he was working in Indian Agricultural Research Institute (IARI) for his PhD degree and proposed that *okra yellow mosaic virus* is a member of graminivirus group. It , therefore seems that *Okra yellow mosaic virus* was researched in India extensively and introduced by the many scientists mainly to plant virus literature.

However, there are controversies in the nomenclature and abbreviation of the virus name infecting okra. In most, Indian literatures, the virus was proposed named as *Yellow vein mosaic virus (YVMV)* of bhindi, Bhindi/Bhendi *yellow*

vein mosaic virus (BYVMV), Okra yellow vein mosaic virus (OYVMV), etc. (Ali *et al.,* 2000; Bhagat, 2000; Borah and Nath, 1995; Handa and Gupta, 1993; Sharma *et al.,* 1987). In Bangladesh, a similar disease has been observed as *Lady's finger yellow vein mosaic virus, Okra mosaic virus* (Anonymous, 1993; Akanda, 1991; Miah, 1988).

In the very recent study, the name of the virus is used as *Okra yellow vein clearing mosaic virus (OYVCMV)* or simply *Okra yellow mosaic virus (OYMV)* of okra to accommodate all these synonyms and also differ the other viruses infecting okra. The works on o*kra yellow mosaic virus* conclusively proved that the disease obvious itself with the vein clearing symptoms, which later then transformers to vein mosaic, chlorosis, etc. as typical symptoms. The virus is transmissible mechanically and through seeds. It is also found to be semi-persistently by an insect vector (*Bemesia tabaci*) and through grafting. It was also observed that the virus is a member of geminivirus group (Handa and Gupta, 1993; Harrison *et al.,* 1991; Capoor and Verma, 1950). Another viruses so far infecting okra have been observed by Chakraborty *et al.,* (1997) and Givord *et al.,* (1972).

The virus observed by Givord *et al.,* (1972) was found to be mechanically transmitted and the other one observed by Chakraborty *et al.,* (1997) was identified as *Okra enation leaf curl virus,* which differed distinctly with *OYMV* in respect to symptom, severity and yield loss as reported by Capoor and Verma (1950), Harender *at el.,* (1993), Nariani and seth (1958), Nath and Saikia (1993) and Sastry and Singh (1975).

2.1. Characteristics of *OYMV*

2.1.1. Symptoms

The typical symptoms of *Okra yellow mosaic virus (OYMV)* are vein clearing, vein chlorosis and yellowing having mosaic noted by the worked on the virus at the beginning (Cooper and Verma 1950, Uppal *et al.,* 1940 and Kulkarni

1942). They also proposed dwarfing of the infected plants those produced deform small sized fruits as the showing of the symptoms of *OYMV*.

Fernando and Udurawana (1942) observed that the development of vein banding along with vein clearing, stunting and chlorosis due to attacking the virus disease of okra at Srilanka and they named the virus as *Okra yellow vein banding virus.* The severe stunting of *OYMV* infected plants was first reported by Sastry and Singh (1975). The infected plants produced little amount of leaves and fruits as they described.

Capoor and Verma (1950) also studied symptomology and host range and described that the first appear symptom is small vein clearing due to *Okra yellow mosaic virus* infection which gradually extends to other veins and finally turns into vein chlorosis. The leaves of the infected plants are thick, brittle, dark green and curl downward. The fruits of infected plants are pale colored, hard and fibrous. Mechanical inoculation test that was conducted by them was not found to be responsive. Seed transmission test using seeds from infected plants also proved to non-responsible. Graft transmission using buds of infected plants was proved as positive in their experiment. Insect transmission was tested by using jassids (*Empoasca devastans* Distant, *Empoasca* sp.), Aphid (*Aphis gossypii* Glover) and Whitefly (*B. tabaci* Genn) was conducted by the same authors and the result revealed that among the species tested, among them only *B. tabaci* could be able to transmit the virus using dodder (*Cuscuts reflexa* Roxb).

Capoor and Verma (1950) also find out that the host range of *Okra yellow mosaic virus* is also restricted to malvaceous plants although they could be able to transmit virus in six different plant species out of 34 different plant species tested through vector inoculation.Handa and Gupta (1993) characterized the *Okra yellow vein mosaic virus* (*Abelmoschus esculentus* L.) as a geminivirus having 18×30 nm in size.

2.1.2. Virus-vector relationship of OYMV and their transmission

Bhagabati and Goswami (1992) noticed the incidence of *Okra yellow mosaic virus* in relation to whitefly population and different sowing dates. They found that the highest whitefly population in the crop sown in May to June, while the incidence of *Yellow mosaic virus* of okra was the highest (100%) in crop sown in late October. They found a high positive correlation between the virus disease incidence and the population of whitefly.

Verma (1952) worked on the relationship of *OYMV* and its vector whitefly. Though a single insect was capable to transmit the virus, the minimum number of flies required to produce 100 percent infection was about ten. The first visual character is the clearing of small veins, which usually commences at various points near the leaf margins in about 15-25 days after inoculation of plants. Chemical control of the disease is very difficult in affected plants. Removal of alternative hosts, control of vector and other sucking insects and uprooting and burning of infected plants are some of the measures to reduce the white fly population and also the diseased. Some wild okra varieties such as *A. pungens, A. crinitus, H. vitifolius, H. panduracformis* are immune to this virus. During the last two decades several resistant varieties have been released which are giving sustainable high yields in different virus prone areas. The results on the virus-vector relationship of *Okra yellow mosaic virus* worked by Capoor and Verma (1950) and Verma (1952) in India concluded that the virus is transmitted by whitefly (*Bemesia tabaci*). They had established the transmission of this virus through bud grafting.

Sastry and Singh (1975) investigated the effect of *Okra yellow mosaic virus* on growth and yield of okra by the infection of plants at different growth stages. The results showed that the infected plants severely stunted in size and produced very few numbers of leaves and fruits when the infection occurred within 35 days after germination. The yield of okra reduction was estimated on an average as high as 93.80% when the plants were infected within 35 days after germination. The yield reduction was measured as 83.63% and 49.63% in

the plants those were infected within 50 and 60 days following germination, respectively. The incidence of *OYMV* was found to increase with the decreased temperature in September compared with August. There is a significant negative correlation co-efficient between temperature and virus incidence was detected. There was evident that the varieties those were free of virus in August also developed virus symptoms in September. They observed that the temperature had influence on the resistance on *OYMV*.

Tsering and patel (1990) conducted on the vector transmission of geminivirus using *Bemisia tabaci* and noted that *Bemisia tabaci* exposed to tobacco infected by *Tobacco leaf curl virus (TLCV)* and then to okra infected by *Okra yellow mosaic virus (OYMV)* in glass house condition, 8 of 15 tobacco plants become infected with *TLCV* and 5 of 15 okra plants with *OYMV*. The reversed initial exposure of the vectors gave same results. The results concluded that the both viruses were transmitted together and with equal efficiency by *Bemisia tabaci.* About 100% infection of *Okra yellow mosaic virus (OYMV)* in Bangladesh causing as high as 90% yield loss as reported by Akanda (1991)

.

Kadian and Naresh (1991) worked on the influence of weather factors on whitefly population and disease incidence of *Okra yellow mosaic virus (OYMV).* The results of their study disclosed that the weather factors mainly temperature and relative humidity have pronounced effect on the population build up of *Bemisia tabaci* in okra field. The spread of yellow mosaic disease of okra field is depended upon the number of whitefly present in okra. The results of their study revealed that the temperature between 25 to 30℃ and relative humidity more than 40% were formed to be most congenial for *B. tabaci.* There was significantly positive association between disease incidence and whitefly population, temperature, relative humidity and rainfall was recorded by Nath *et al.,* (1993). They also reported the negative correlation of fruit yield with disease incidence.

Goswami and Bhagbati (1992) conducted a field experiment in Jorhat, Assam India during 1991 to find out the natural incidence *of Okra yellow mosaic virus* (*Abelmoschus esculentus* L.) in relation to different dates of sowing. The minimum viral disease incidence (16.7%) was reported on okra sown at the beginning of October and the maximum (100%) on the crop sown in May and June. Besides, the disease incidence was recorded 36.5% and 54.2% in February and March sown crop, respectively. A field experiment was conducted by Board *et al.,* (1993) to find out the relationship between *Bemesia tabaci* population density and the prevalence of *Okra yellow mosaic virus* in 1988 and 1989 cropping seasons. In both the years the vector population reached a highest amount during first week of October. Symptoms of *OYMV* disease are appeared one week after infestation with *Bemesia tabaci*. The disease incidence was identified to progressively increase with the corresponding increase of vector population.

Sarma *et al.* (1995) noticed that *Okra yellow mosaic virus* of okra infection reduced chemical constituents of okra leaves, such as reducing chlorophyll, reducing sugar, phosphorus and potassium content, whereas total phenol, total sugar, non reducing sugar, nitrogen and protein contents increased. The increase or decrease of these constituents was found to be varied with the time of infection of okra by the virus i.e. on the growth stages of plant get infected by the virus. Total amount of sugar, reducing sugar, nitrogen, protein, potassium and phosphorus contents of the green fruits were decreased by virus infection.

Bhagabati *et al.* (1992) explained that the effect of *Okra yellow mosaic virus* on some morphological parameters. They explained that infection by *OYMV* retarded the growth and development of susceptible varieties of okra plants in India. The leaf area, fruit length, fruit weight and fruit volume were rapidly reduced by virus infection. A moisture percentage of both diseased leaves and fruits was higher than healthy okra plants at all growth stage.

Hossain *et al*. (1998) reported the reaction of okra variety to *Okra yellow mosaic virus (OYMV)* and biochemical changes in its infected leaf constituents. The infection rate of *Okra yellow mosaic virus (OYMV)* decreased as the age of the inoculated plants increased was recorded by Pun *et al.* (1999). It was concluded that 100% infection of *Okra yellow mosaic virus (OYMV)* occurred when 7-days old plants were inoculated whereas, the infection percentage dropped down to 31.70% when 49-days old okra plants were inoculated. They also noticed that the incubation period of virus was increased with increased plant age.

2.1.3. Approaches to control *OYMV*

Khan and Mukkopadhay (1985) suggested the practice of alternative cultural method to minimize the incidence of *yellow mosaic virus* of Lady's finger (*Abelmoschus esculentus* L. Monech). They observed that the use of yellow-colored polyethylene mulch significantly delayed the appearance of (*Hibiscus esculentus* L.) symptoms of *Yellow mosaic virus* in *Abelmoschus esculentus.*

As mentioned, reflective mulch increases the amount of light available to plants but it also increases air temperature, and photosynthesis, which means better growth. Reflective mulches utilize the entire light spectrum, thereby boosting the available amount of light and heat to plants resulting in higher yields and bigger fruit and vegetables. It also helps retard weeds and conserves moisture just as other forms of mulch in gardens.

Idris (1990) recorded that there are two types of disease symptoms, small vein thickening and main vein thickening, possibly reflecting the existence of two strains of the virus; the disease, transmitted by *Bemisia tabaci*, always disperse in the direction of the wind; the highest disease rate in the period of greatest plant growth and of highest vector population density; cotton intercropped with okra (*Abelmoschus esculentus)* exhibits higher disease incidence than cotton

cultivated as a pure crop; and that cv. Barakat has a high level of disease resistancy.

2.1.4. Studies on *OYMV* in Bangladesh

In the ten years annual report published by Anonymous (1993) by the Division of Plant Pathology of Bangladesh Agricultural Research Institute, Joydevpur, Gazipur included the works on survey, monitoring and screening of the viruses in respect of OYMV. The transmission works were also tried including the management through sowing date manipulation and insecticidal spray.

Ahmed and Hossain (1985) conducted a survey on disease of crops with a view to establishing a herbarium at Bangladesh Agricultural Research Institute (BARI), Joydevpur, Gazipur.

The survey was executed for three years in three cropping seasons 1982-83, 1983-84 and 1984-85. Disease incidence was worked out on 62 crops in nine districts of Bangladesh. In all 296 diseases were reported including okra yellow vein clearing disease as and commonly prevalent disease of okra.

An experiment was carried out by Sayeed (1988) in Bangladesh Agricultural University Farm, Mymensingh with a Japanese okra variety, Pentagreen to find out the effects of date of planting and insecticidal spray on the control of *Yellow mosaic virus* of Lady's finger. There are three sowing dates viz. 17 April, 1 May and 17 May were used. The findings of the experiment were the incidence of *Okra yellow mosaic virus* was 25%, 48% and 56% in the first, second and third planting, respectively.

The impact of insecticides and planting dates on *Yellow vein mosaic virus* of okra was evaluated by Mian *et al.* (1990). They planted okra variety Pentagreen in three different dates viz. 17 April, 2 May and 17 May in 1986 and applied three insecticides namely Bidrin, Ripcord and Sumithion in their experiment in Bangladesh Agricultural University Farm, Mymensingh. Among the three

insecticides, Bidrin was found to be the most effective followed by Ripcord in controling the incidence of yellow vein mosaic of okra disease. The authors observed a pronounced effect of planting dates on the disease incidence as well as growth and yield of the crop. The lowest disease incidence was appeared in the first planting while it was the highest in the third planting.

About 100% infection of *Okra yellow mosaic virus (OYMV)* in the okra in Bangladesh causing as high as 90% yield loss as reported by Akanda (1991). An experiment on the control of *Yellow mosaic virus* of okra conducted in the experimental field at Bangladesh Agricultural University, Mymensingh. The findings of the experiment showed that there is no an economic benefit successful enough to control the virus Anonymous (1993).

Hossain *et al*. (1998) investigated the reaction of okra to *yellow mosaic virus (YMV)* and biochemical changes in its infected leaf constituents.

Ali (1999) developed a variety which was resistant against *Okra yellow mosaic virus,* which was released in the name of IPSA Derosh-1.

Rashid *et al.* (1999) reported the development of okra variety resistant to *Okra yellow mosaic virus (OYMV)* at Bangladesh Agricultural Research Institute, Joydevpur, Gazipur and which was released the variety named as BARI Dherosh-1.

The name of the virus infecting okra producing of symptoms is recognized as *Okra yellow mosaic virus (OYMV)* to accommodate all synonyms used for the virus as reported by Begum (2002).

CHAPTER III

MATERIALS AND METHODS

MATERIALS AND METHODS

3.1. Experimental site

The experiment was conducted in the central research field, Department of Plant Pathology, Sher-e-Bangla Agricultural University (SAU), Dhaka-1207. The experimental site was at $23^0 46^/$ N latitude and $90^0 24^/$ E longitude with elevation of 9 meters above the sea level and have been presented in Appendix 1.

3.2. Experimental duration

The experiment was carried out in Kharif-1 season during March to July, 2017.

3.3. Characteristics of soil

The soil of the experimental land was carried out in a medium high land belonging to the modhupur tract under the agro ecological zone (AEZ) 28. The field's soil texture was silty loam, non-calcareous, dark grey soil of Tejgaon soil series with a p^H -6.7(Appendix II).

3.4. Climate

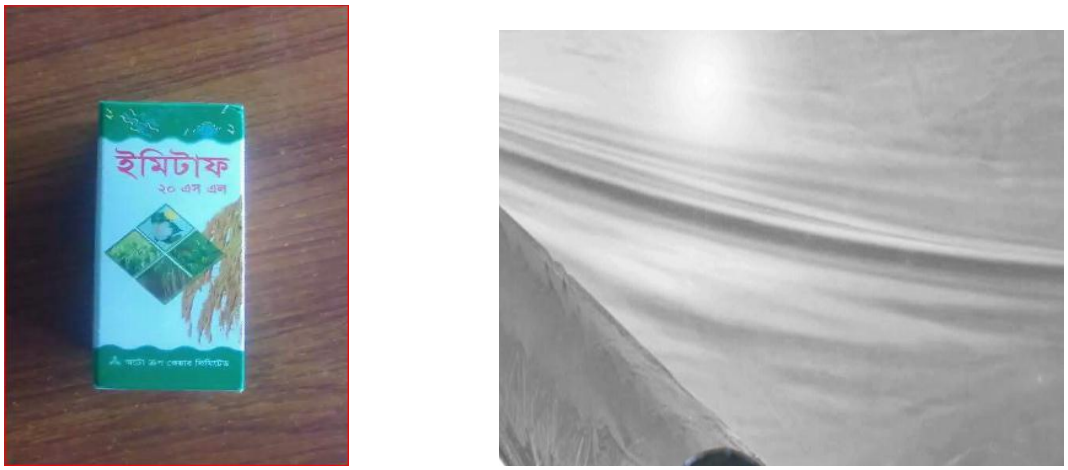
The weather condition of the experimental field was under the sub-tropical monsoon climate, which is characterized by heavy rainfall during kharif season (May- September) and scanty in the rabi season (October-March). There was no rainfall during December, January and February. The average maximum temperature of experimental site during the period of investigation was 35.11^0C and the average minimum temperature was 30.40^0C. Details of the meteorological data in respect of temperature, rainfall and relative humidity during the experimental site and period were collected from Bangladesh Meteorological Department, Agargaon, Dhaka and have been presented in Appendix II.

3.5. Planting materials used for experiment

Two okra varieties namely Green finger and BARI Dherosh-1 were used as planting material in this study. The seeds of okra collected from local market.

3.6. Insecticide and mulch collection:

The selected insecticide namely Imidacloprid and light reflecting silver color mulch were collected from Green nursery, Agargoan, Dhaka-1207.



A B

Figure1. Imidacloprid (A) and Light reflecting silver color mulch (B)

3.7. Treatments of the experiment

Treatments were considered as following-

T_0 = control (no spray, no mulch)

T_1 = Light reflecting silver color mulch

T_2 = 1 spray of Imidacloprid with Light reflecting silver color mulch

T_3 =3 times sprays of Imidacloprid

3.8. Experimental design

The experiment was laid out in a randomized complete block design (RCBD) in two blocks with three replications. In experiment-1, **BARI Dherosh-1** and in experiment-2 **Green Finger** was used. There were four treatments combination in each block, comprised 12 unit plot and total number of plots were 24 (12 X 2=24). Size of each unit plot was 4.5 m^2 and each plot contained 18 plants. The distance between unit plots was 0.70 m and block to 1m.

3.9. Land preparation

The selected land for the experiment was first opened on 23 March 2017 by disc plough. After opening the land with a tractor it was ploughed and cross-ploughed four times with a power tiller and each ploughing was followed by laddering to break the clods to obtain good tilth and to level the land. All weeds, stubbles and dead roots were removed from the land. After land preparation, the experimental plot was laid out.

3.10. Manure and fertilizer management

The following doses of manure and fertilizers were applied to the land for okra cultivation (Anonymous, 1993).

Table 1. Doses of manure and fertilizers used in the study

Manures/Fertilizer	Doses
Cow dung	14 ton/ha
TSP	150 kg/ha
MP	150kg/ha
Urea	150 kg/ha

The whole amount of cow dung, TSP and MP and one third urea were applied at the time of final land preparation. The rest amount of urea was applied in two equal installments at 30, 45 and 60 (DAS).

3.11. Seed sowing

The okra seeds were sown after soaking in water for overnight and then wrapped with a piece of thin cloth. Then the soaked seeds were dried on polythene sheets for 3 hours to dry out the surface water. This treatment was done to help quick germination of seeds. Seeds were sown in rows of raised beds. Row to row and plant to plant spacing were maintained at 50 cm and 45cm. respectively and 2-3 seeds were placed in each pit. The seeds were

covered with fine soil. After seed germination, only one healthy seedling was kept in the pit.

3.12. Intercultural operations

The seedlings were always kept under very careful observation. Proper intercultural operations were done through the cropping season for proper growth and development of tested plants.

3.12.1. Thinning, gap filling and irrigation

The seedlings were thinned out from the pit at 10 DAS keeping only one healthy seedling per pit. On the contrary, gap filling was also done where needed with healthy seedling by collecting seedlings from other pits. The plot was irrigated as and when needed.

3.12.2. Weeding

During plant growth period four times hand weeding were done, First weeding was done at 30 DAS followed by second, third and forth weeding at 40,50 and 60 DAS.

3.12.3. Drainage

Stagnant water was effectively drained out at the time of heavy rains from the field.

3.12.4. Mulching with light reflecting silver color mulch

The light reflecting silver color plastic mulch was used in selected plots at 15 DAS.

3.12.5. . Spraying insecticides

The spray was started with Imidacloprid at the 30 DAS. The application was done at 15 days interval with the recommended dose 2.5 ml/ 10 liters water.

3.12.6 Harvesting

Green pods were harvested from field regularly when they attained edible stage. Harvesting was started from 40 DAS.

3.13. Identification of disease symptoms and estimation of disease incidence (%) of *Okra yellow mosaic virus (OYMV)*

Based on studying of typical symptoms of *okra yellow mosaic virus* tested of okra plant were described by Capoor and Verma (1955), Begum (2002) and Hossain (1998). The okra plants were observed regularly until harvest. And the symptom was recorded found in the okra plants. The growth stage of the okra plants were categorized as follows-

1) Early stage - 5 weeks after seed sowing

2) Mid stage - 5 weeks after early stage, and

3) Late stage - after mid stage up to harvest.

4) The disease incidence was expressed in percentage on the basis of crop growth stages as well as average of three stages. The percent of disease incidence was calculated by using the following formula:

$$\text{Disease incidence (\%)} = \frac{X_1}{X} \times 100$$

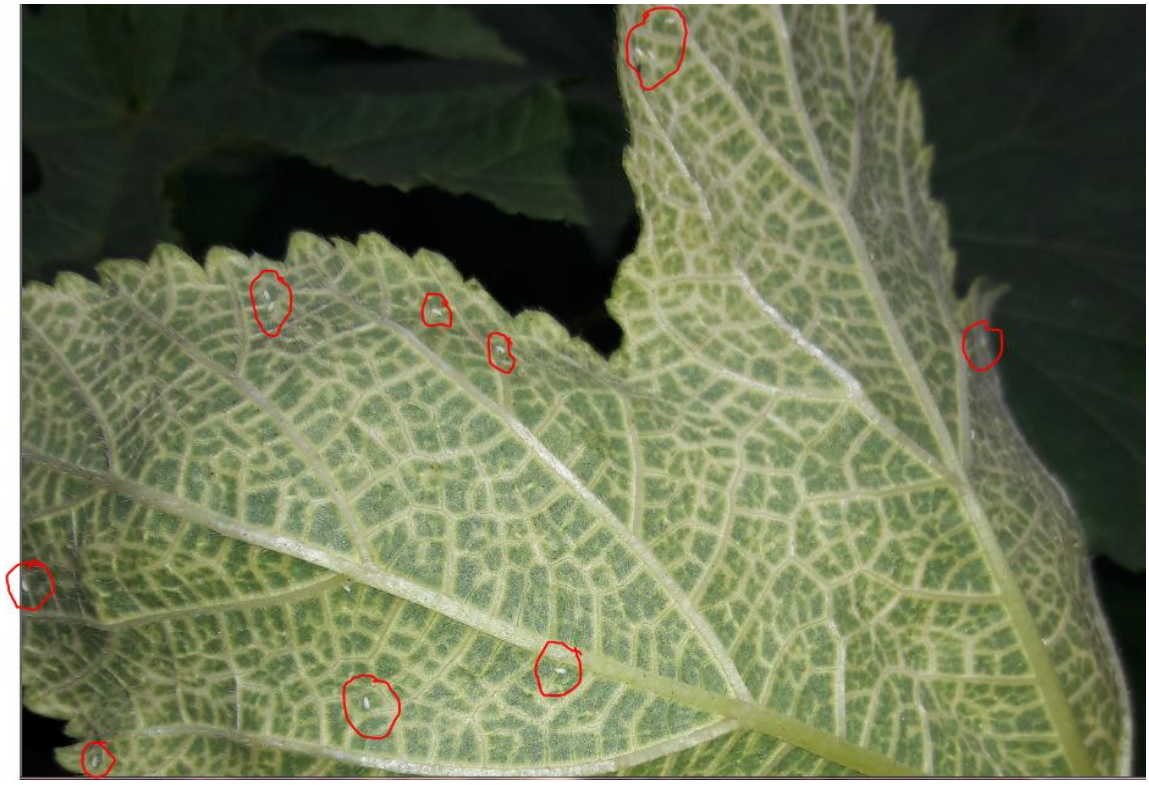
Where,

X= Total number of plants

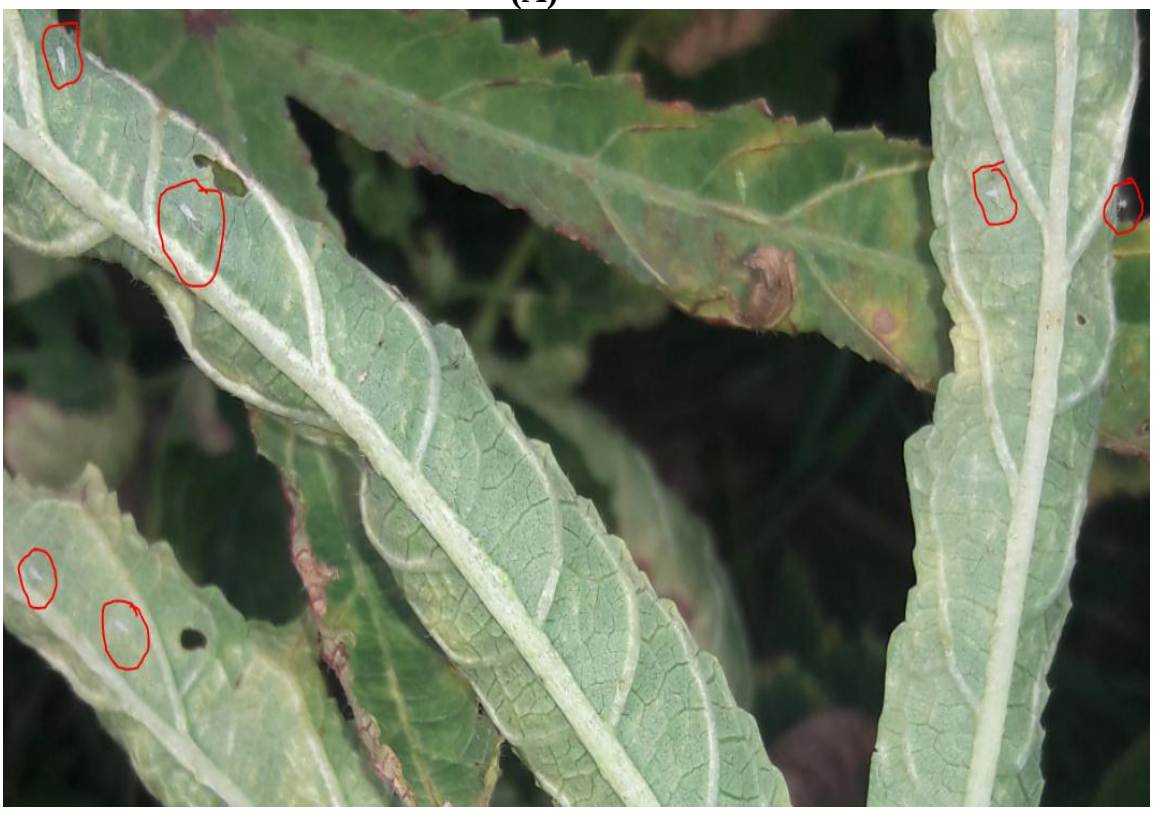
X_1= Number of infected plants.

3.14. Study of insect vectors whitefly association (whitefly/leaf)

The whitefly association study was done by direct visual method. For that purpose in total five leaves were investigated from each of the plant at early in the morning. The whitefly was counted and number was recorded as per leaf so that whitefly association with each treatment could be measured. The sampling on the infestation of whitefly was taken three times after flowering at an interval 10 days. Whitefly association was investigated at adult stage of whitfly (Gupta, 2016)



(A)



(B)

Figure 2: Whitefly at underside of okra leaves in BARI Dherosh-1 (A) and Green finger (B)

3.15. Parameters assessed

In each plot five plants were selected randomly 18 plants and harvested carefully from the total experimental site and mean data on the following parameters were recorded –

I. Disease incidence (%)
II. Number of leaves per plant
III. Number of infected leaves per plant
IV. Number of flowers per plant
V. Number of fruits per plant
VI. Plant height (cm)
VII. Root length (cm)
VIII. Fruit weight (Kg)
IX. Yield (Kg)

3.16. Collection of data

The data were collected on different morphological and physiological parameters from the selected plants, different kind of measures were taken. Data over the parameters were taken in the following ways-

3.17. Number of leaves per plant

Number of leaves of selected plants from each plot was recorded at 50, 60, 75 and 95 (DAS). Only the smallest young leaves at the growing point of the plant were excluded. Calculating the total number of leaves per plant and the average number was recorded.

3.18. Number of infected leaves per plant

Number of infected leaves of selected plants from each plot was recorded at 50, 60, 75 and 95 DAS. Calculating the total number of infected leaves per plant and the average number was recorded.

3.19. Number of flowers per plant

Only the healthy flowers from the selected plants were counted at 50, 60, 75 and 95 DAS. The average number of flowers from each plant was recorded.

3.20. Number of fruits per plant

Mean number of healthy fruits of selected plants from each plot as per treatment was recorded.

3.21. Fruit weight

From the first harvest period fruit weight was taken of every tested plant and also calculated total plot fruit weight (kg).

3.22. Plant height

Average plant height of selected plants from each plot was recorded at 50, 60, 75 and 95 days after sowing (DAS). It was measured with the help of a meter scale from the soil level to the tip of the longest stem in centimeter (cm).

3.23. Yield

Yield of green fruit was calculated by converting the mean healthy fruit weight (kg/plot) of each plot as per treatment combination.

3.24. Root length

Roots were collected from selected plants of each plot and length was measured with the meter scale.

3.25. Statistical analysis of data

The data were analyzed by using computer based software **Statistix 10** and performed the analysis of variance (ANOVA) for proper interpretation. The mean value was compared according to CV value and LSD at 5% level of significance. The analyzed data are presented in tabular and graphical form.

CHAPTER IV

RESULTS AND DISCUSSION

RESULTS

This chapter covers the experimental results. Four (4) treatments with one insecticide namely Imidacloropid and light reflecting silver color mulch were assessed the performance to control the insect vectors of *Okra yellow mosaic virus* under field condition. Two popular varieties of okra namely BARI Dherosh-1 and Green Finger were used as planting material. Results were compiled based on disease incidence (%), insect vectors association and morphological parameters at different days after sowing (DAS).

EXPERIMENT-1 (BARI Dherosh-1)

4.1. Disease incidence of *Okra Yellow mosaic virus* in BARI dheros-1 at 50, 65, 80, and 95 DAS

After providing light reflecting silver color mulch and three time application of imidacloprid, the percent disease incidence was estimated on the basis of typical symptoms of *OYMV* in young leaves of okra plants (Figure-3). There was no virus infected plant in T_1 (only mulching), T_2 (one spray+ mulching), T_3 (3 times spray) treatments at 50 DAS. But some virus infected plants were found in T_0 (control) where disease incidence was estimated 10.46%.

At 65 DAS, virus infected plants were found in all treatments plots including control treatment. The lowest disease incidence (9.02 %) was found in T_2 (one spray+ mulching) and the highest disease incidence (34.18%) was found in the T_0 (control). In T_1 (only mulching) and T_3 (3times spray) disease incidence was estimated 19.41 % and 15.55 % respectively.

At 80 DAS, the lowest disease incidence (20.83 %) was also estimated in T_2 (one spray+ mulching) and the highest disease incidence (52.56 %) was found in the T_0 (control) followed by T_1 (only mulching) where disease incidence was estimated 41.39 %. The moderate disease incidence (28.88 %) was recorded in T_3 (3 times spray) treatment.

In this experiment it was observed that up to 95 DAS the disease incidence results showed similar trend. The lowest disease incidence (34.72 %) was found in T_2 (one spray+ mulching). The highest disease incidence (73.71 %) was found in the T_0 (control) followed by T_1 (only mulching) where disease incidence was estimated (56.04 %). The moderate disease incidence (44.44 %) was recorded in T_3 (3 times spray).These results are presented in Table 2.

A B

Figure 3. Typical symptoms of *OYMV* in young leaves, Infected leaves (A) and Healthy leaves (B)

Table 2. Efficacy of imidacloprid and light reflecting silver color mulch on the incidence of *Okra yellow mosaic virus* at 50, 65, 80 and 95 DAS

Treatment	Disease incidence (%) at			
	50 DAS	65 DAS	80 DAS	95 DAS
T_0 (control)	10.46 a	34.18 a	52.56 a	73.71 a
T_1 (only mulching)	0.00 b	19.41 b	41.39 b	56.04 b
T_2 (one spray+ mulching)	0.00 b	9.02 c	20.83 d	34.72 d
T_3(3 times spray)	0.00 b	15.55 b	28.88 c	44.44 c
CV (%)	4.26	4.10	5.88	6.45
$LSD_{(0.05)}$	1.74	1.67	2.40	2.63

4.2. Association of whitefly per leaf

The maximum number of whitefly association (11.00) per leaf was counted in T_0 (control) followed by T_1 (only mulching) where the number of whitefly was (8.33). The minimum number of whitefly (4.33) per leaf was recorded in T_2 (one spray+ mulching) followed by T_3 (3times spray). All are statistically

different with each other. Results of white fly association are presented in table 3.

Table 3. Efficacy of imidacloprid and light reflecting silver color mulch on association of whitefly per leaf

Treatment	Whitefly per leaf
T_0 (control)	11.00 a
T_1 (only mulching)	8.33 b
T_2 (one spray+ mulching)	4.33 d
T_3 (3 times spray)	6.00 c
CV (%)	2.33
$LSD_{(0.05)}$	0.95

4.3. The morphological features which are identical, inrelation to disease incidence against *Okra Yellow mosaic virus (OYMV)* after application of Imidacloprid and mulch material.

4.3.1. Number of leaves per plant at 50, 65, 80 and 95 DAS

At 50 DAS, The maximum number of leaves (20.00) per plant was counted in the T_2 (one spray+ mulching). The minimum number of leaves (15.67) per plant was counted in the T_0 (control) preceded by T_1 (only mulching) where number of leaves was (16.33). The moderate number of leaves (18.00) per plant was recorded in the T_3 (3 times spray) treatment.

At 65 DAS, The maximum number of leaves (34.00) per plant was counted in the T_2 (one spray+ mulching). The minimum number of leaves (26.67) per plant was counted in the T_0 (control) preceded by T_1 (only mulching) where number of leaves was (27.33). The moderate number of leaves (29.33) per plant was recorded in T_3 (3 times spray) treatment.

At 80 DAS, The maximum number of leaves (43.67) per plant was counted in the T_2 (one spray+ mulching). The minimum number of leaves (34.67) per plant was counted in the T_0 (control) preceded by T_1 (only mulching) where

number of leaves was (36.67). The moderate number of leaves (39.67) per plant was recorded in T_3 (3 times spray) treatment.

At 95 DAS, The maximum number of leaves (46.33) per plant was counted in the T_2 (one spray+ mulching). The minimum number of leaves (38.00) per plant was counted in the T_0 (control) preceded by T_1 (only mulching) where number of leaves was (39.67). The moderate number of leaves (43.00) per plant was recorded in T_3 (3 times spray) treatment. The results are presented in Table 4.

Table 4. Efficacy of imidacloprid and light reflecting silver color mulch on the leaf number per plant at 50, 65, 80 and 95 DAS

Treatment	No. of Leaf at			
	50 DAS	65 DAS	80 DAS	95 DAS
T_0 (control)	15.67 c	26.67 c	34.67 b	38.00 c
T_1 (only mulching)	16.33 bc	27.33 bc	36.67 b	39.67 bc
T_2 (one spray+ mulching)	20.00 a	34.00 a	43.67 a	46.33 a
T_3 (3 times spray)	18.00 b	29.33 b	39.67 ab	43.00 ab
CV (%)	1.88	2.20	5.31	4.60
$LSD_{(0.05)}$	0.76	0.90	2.17	1.88

4.3.2. Number of flowers per plant at 50, 65, 80 and 95 DAS.

At 50 DAS, The maximum number of flowers (12.67) per plant was counted in the T_2 (one spray+ mulching). The minimum number of flowers (8.00) per plant was counted in the T_0 (control) preceded by T_1 (only mulching) where number of flowers was (9.00). The moderate number of flowers (10.67) per plant was recorded in the T_3 (3 times spray) treatment.

At 65 DAS, The maximum number of flowers (11.00) per plant was counted in the T_2 (one spray+ mulching). The minimum number of flowers (7.00) per plant was counted in the T_0 (control) preceded by T_1 (only mulching) where number of flowers was (8.33). The moderate number of flowers (9.67) per plant was recorded in T_3 (3 times spray) treatment.

At 80 DAS, The maximum number of flowers (11.67) per plant was counted in the T_2 (one spray+ mulching). The minimum number of flowers (7.00) per plant was counted in the T_0 (control) preceded by T_1 (only mulching) where number of flowers was (8.33). The moderate number of flowers (10.00) per plant was recorded in T_3 (3 times spray) treatment.

At 95 DAS, The maximum number of flowers (9.33) per plant was counted in the T_2 (one spray+ mulching). The minimum number of flowers (5.67) per plant was counted in the T_0 (control) preceded by T_1 (only mulching) where number of flowers was (6.67). The moderate number of flowers (8.00) per plant was recorded in T_3 (3 times spray) treatment. The results are presented in Table 5.

Table 5. Efficacy of imidacloprid and light reflecting silver color mulch on the flower number per plant at 50, 65, 80 and 95 DAS

Treatment	No. Of flower at			
	50 DAS	65 DAS	80 DAS	95 DAS
T_0 (control)	8.00 c	7.00 d	7.00 c	5.67 d
T_1 (only mulching)	9.00 c	8.33 c	8.33 bc	6.67 c
T_2 (one spray+ mulching)	12.67 a	11.00 a	11.67 a	9.33 a
T_3 (3 times spray)	10.67 b	9.67 b	10.00 ab	8.00 b
CV (%)	1.66	1.10	2.42	0.76
$LSD_{(0.05)}$	0.68	0.45	0.99	0.33

4.3.3. Number of fruits per plant at 50, 65, 80 and 95 DAS

At 50 DAS, The maximum number of fruits (7.00) per plant was counted in the T_2 (one spray+ mulching). The minimum number of fruits (3.00) per plant was counted in the T_0 (control) preceded by T_1 (only mulching) where number of fruits was (4.67). The moderate number of fruits (6.00) per plant was recorded in the T_3 (3 times spray) treatment.

At 65 DAS, The maximum number of fruits (7.67) per plant was counted in the T_2 (one spray+ mulching). The minimum number of fruits (3.67) per plant was counted in the T_0 (control) preceded by T_1 (only mulching) where number of fruits was (5.67). The moderate number of fruits (6.33) per plant was recorded in T_3 (3 times spray) treatment.

At 80 DAS, The maximum number of f fruits (9.00) per plant was counted in the T_2 (one spray+ mulching). The minimum number of fruits (3.33) per plant was counted in the T_0 (control) preceded by T_1 (only mulching) where number of fruits was (4.33). The moderate number of fruits (7.33) per plant was recorded in T_3 (3times spray) treatment.

At 95 DAS, The maximum number of fruits (7.00) per plant was counted in the T_2 (one spray+ mulching). The minimum number of fruits (3.00) per plant was counted in the T_0 (control) preceded by T_1 (only mulching) where number of fruits was (4.33). The moderate number of fruits (6.00) per plant was recorded in T_3 (3times spray) treatment. The results are presented in Table 6.

Table 6. Efficacy of imidacloprid and light reflecting silver color mulch on fruits number per plant at 50, 65, 80 and 95 DAS

Treatment	No. Of fruit at			
	50 DAS	65 DAS	80 DAS	95 DAS
T_0 (control)	3.00 c	3.67 c	3.33 b	3.00 c
T_1 (only mulching)	4.67 b	5.67 b	4.33 b	4.33 b
T_2 (spray+ mulching one)	7.00 a	7.67 a	9.00 a	7.00 a
T_3 (3 times spray)	6.00 a	6.33 b	7.33 a	6.00 a
CV (%)	1.28	0.99	0.84	1.28
$LSD_{(0.05)}$	0.52	0.40	2.07	0.52

4.3.4. Yield (kg/plot)

The highest yield (2.86 kg) per plot was recorded in the T_2 (one spray+ mulching). The lowest yield (1.49kg) per plot was recorded in the T_0 (control) preceded by T_1 (only mulching) where the yield per plot was (2.30 kg). The moderate yield per plot was obtained in T_3 (only mulching) and it was 2.60 kg per plot. The results are presented in Table 7.

Table 7. Efficacy of imidacloprid and light reflecting silver color mulch on yield.

Treatment	Yield/Plant (KG)	Yield/ Plot (KG)
T_0(control)	0.08 c	1.49 c
T_1(only mulching)	0.12 b	2.30 b
T_2(one spray+ mulching)	0.15 a	2.86 a
T_3(3 times spray)	0.14 ab	2.60 ab
$LSD_{(.05)}$	9.18	0.16
CV (%)	0.02	0.40

4.3.5. Plant height (cm)

The maximum plant height (128.62 cm) was measured in T_2 (one spray+ mulching) followed by T_3 (3 times spray) where the plant height was 125.70 cm and both are statistically different with each other. The minimum plant height (118.08 cm) was measured in T_0 (control) preceded by T_1 (only mulching) where the plant height was 121.33 cm and both are statistically different with each other. The results are presented in Table 9.

4.3.6. Root length (cm)

The maximum root length (29.00 cm) was recorded in the T_2 (one spray+ mulching) followed by T_3 (3 times spray) where the root length was (25.67 cm) and both are statistically different with each other. The minimum root length (20.00 cm) was recorded in T_0 (control) proceeded by T_1 (only mulching) where the root length was (22.83 cm) and both are statically different with each other. The results are presented in Table 8.

Table 8. Efficacy of imidacloprid and light reflecting silver color mulch on plant height and root length.

Treatment	Plant height	Root length/plant (cm)
T_0(control)	118.08 d	20.00 d
T_1(only mulching)	121.33 c	22.83 c
T_2(one spray+ mulching)	128.62 a	29.00 a
T_3(3 times spray)	125.70 b	25.67 b
$LSD_{(.05)}$	1.6846	1.14
CV (%)	0.6885	0.46

4.4. Relationship between disease incidence and yield

The relationship between disease incidence and yield performance of okra plants was also studied. From the study it was revealed that there are inverse relation between disease incidence and yield**.** From the liner graph presentation (Figure 4) it was revealed that the yield of okra decreased with the increases of disease incidence.

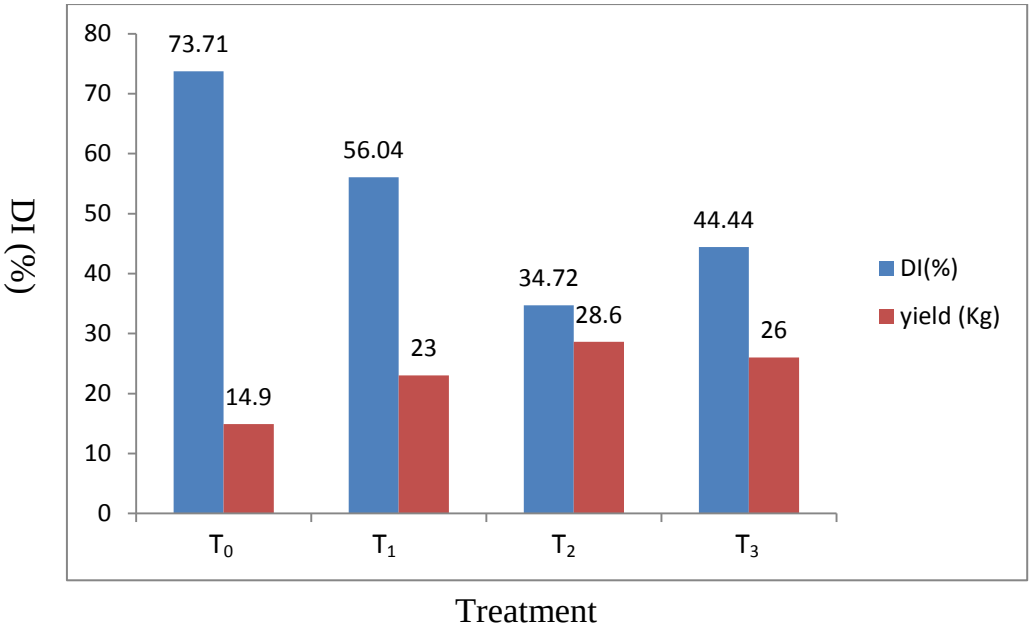


Figure 4. Relationship between yield and disease incidence (%).

EXPERIMENT-2

4.5. Disease incidence of *Okra Yellow mosaic virus* in Green Finger at 50, 65, 80, and 95 DAS

After providing light reflecting silver color mulch and three time application of imidacloprid, the disease incidence was estimated on the basis of typical symptoms of *OYMV* in young leaves of okra plants (Figure-5). There was no virus infected plant found at 50 DAS.

At 65 DAS, virus infected plants were found in all treatments plots except T_2 (one spray+mulching). Among other three treatments the lowest disease incidence (2.83 %) was found in T_3 (one spray+mulching) and the highest disease incidence (10.83%) was found in the T_0 (control). The moderate disease incidence (4.30 %) was recorded in T_1 (only mulching) treatment.

At 80 DAS, the lowest disease incidence (7.85%) was also estimated in T_2 (one spray+ mulching) and the highest disease incidence (28.19 %) was found in the T_0 (control) followed by T_1 (only mulching) where disease incidence was

estimated 21.06 %. The moderate disease incidence (14.61 %) was recorded in T_3 (3 times spray) treatment.

In this experiment it was observed that up to 95 DAS the disease incidence results were showed in same trend. The lowest disease incidence (19.65 %) was found in T_2 (one spray+mulching). The highest disease incidence (51.11 %) was found in the T_0 (control) followed by T_1 (only mulching) where disease incidence was estimated (37.59 %). The moderate disease incidence (24.92 %) was recorded in T_3 (3 times spray).These results are presented in Table 9.

A B

Figure5. Typical symptoms of *OYMV* in Infected leaves (A) and Healthy leaves (B)

Table 9. Efficacy of imidacloprid and light reflecting silver color mulch on the incidence of *Okra yellow mosaic virus* at 50, 65, 80 and 95 DAS

Treatment	Disease incidence (%) at			
	50 DAS	65 DAS	80 DAS	95 DAS
T_0 (control)	0	10.83 a	28.19 a	51.11 a
T_1 (only mulching)	0	4.30 b	21.06 b	37.59 b
T_2 (one spray+ mulching)	0	0.00 b	7.85 d	19.65 c
T_3 (3 times spray)	0	2.08 b	14.61 c	24.92 c
CV (%)	0	4.77	2.09	6.55
$LSD_{(0.05)}$	0	1.95	0.85	2.68

4.6. Association of whitefly per leaf

The maximum number of whitefly (9.00) per leaf was counted in T_0 (control) followed by T_1 (only mulching) where the number of whitefly was (7.33). The minimum number of whitefly (3.33) per leaf was recorded in T_2 (one spray+ mulching) followed by T_3 (3times spray) where the number of whitefly was

(5.33). All are statistically different with each other. Results of white fly association are presented in table 10.

Table 10. Efficacy of imidacloprid and light reflecting silver color mulch on association of whitefly per leaf

Treatment	Whitefly per leaf
T_0(control)	9.00 a
T_1(only mulching)	7.33 b
T_2(one spray+ mulching)	3.33 d
T_3(3 times spray)	5.33 c
CV	0.57
$LSD_{(0.05)}$	0.23

4.7. The morphological features which are identical, in-relation to disease incidence against *Okra Yellow mosaic virus (OYMV)* after application of Imidacloprid and mulch material

4.7.1. Number of leaves per plant at 50, 65, 80 and 95 DAS

At 50 DAS, the maximum number of leaves (22.00) per plant was counted in the T_2 (one spray+ mulching). The minimum number of leaves (16.67) per plant was counted in the T_0 (control) preceded by T_1 (only mulching) where number of leaves was (18.00). The moderate number of leaves (19.33) per plant was recorded in the T_3 (3 times spray) treatment.

At 65 DAS, the maximum number of leaves (33.67) per plant was counted in the T_2 (one spray+ mulching). The minimum number of leaves (25.67) per plant was counted in the T_0 (control) preceded by T_1 (only mulching) where number of leaves was (27.00). The moderate number of leaves (30.33) per plant was recorded in T_3 (3 times spray) treatment.

At 80 DAS, the maximum number of leaves (45.67) per plant was counted in the T_2 (one spray+ mulching). The minimum number of leaves (39.67) per plant was counted in the T_0 (control) preceded by T_1 (only mulching) where

number of leaves was (41.67). The moderate number of leaves (43.00) per plant was recorded in T_3 (3times spray) treatment.

At 95 DAS, the maximum number of leaves (48.00) per plant was counted in the T_2 (one spray+ mulching). The minimum number of leaves (41.33) per plant was counted in the T_0 (control) preceded by T_1 (only mulching) where number of leaves was (43.00). The moderate number of leaves (45.33) per plant was recorded in T_3 (3 times spray) treatment. The results are presented in Table 11.

Table 11. Efficacy of imidacloprid and light reflecting silver color mulch on the leaf number per plant at 50, 65, 80 and 95 DAS

Treatment	No. of Leaf at			
	50 DAS	**65 DAS**	**80 DAS**	**95 DAS**
T_0 (control)	16.67 d	25.67 c	39.67 d	41.33 d
T_1 (only mulching)	18.00 c	27.00 c	41.67 c	43.00 c
T_2 (one spray+ mulching)	22.00 a	33.67 a	45.67 a	48.00 a
T_3 (3 times spray)	19.33 b	30.33 b	43.00 b	45.33 b
CV (%)	0.74	1.79	1.28	0.66
$LSD_{(0.05)}$	0.30	0.73	0.52	0.27

4.7.2. Number of flowers per plant at 50, 65, 80 and 95 DAS.

At 50 DAS, The maximum number of flowers (13.33) per plant was counted in the T_2 (one spray+ mulching). The minimum number of flowers (8.33) per plant was counted in the T_0 (control) preceded by T_1 (only mulching) where number of flowers was (9.33). The moderate number of flowers (11.33) per plant was recorded in the T_3 (3 times spray) treatment.

At 65 DAS, The maximum number of flowers (17.00) per plant was counted in the T_2 (one spray+ mulching). The minimum number of flowers (12.33) per plant was counted in the T_0 (control) preceded by T_1 (only mulching) where number of flowers was (13.67). The moderate number of flowers (15.00) per plant was recorded in T_3 (3 times spray) treatment.

At 80 DAS, The maximum number of flowers (17.67) per plant was counted in the T_2 (one spray+ mulching). The minimum number of flowers (12.67) per plant was counted in the T_0 (control) preceded by T_1 (only mulching) where number of flowers was (14.33). The moderate number of flowers (15.33) per plant was recorded in T_3 (3 times spray) treatment.

At 95 DAS, The maximum number of flowers (16.33) per plant was counted in the T_2 (one spray+ mulching). The minimum number of flowers (12.00) per plant was counted in the T_0 (control) preceded by T_1 (only mulching) where number of flowers was (13.00). The moderate number of flowers (15.00) per plant was recorded in T_3 (3 times spray) treatment. The results are presented in Table 12.

Table 12. Efficacy of imidacloprid and light reflecting silver color mulch on the flower number per plant at 50, 65, 80 and 95 DAS

Treatment	No. Of flower at			
	50 DAS	**65 DAS**	**80 DAS**	**95 DAS**
T_0 (control)	8.33 d	12.33 d	12.67 c	12.00 d
T_1 (only mulching)	9.33 c	13.67 c	14.33 bc	13.00 c
T_2 (one spray+ mulching)	13.33 a	17.00 a	17.67 a	16.33 a
T_3 (3 times spray)	11.33 b	15.00 b	15.33 b	15.00 b
CV (%)	0.57	1.10	2.025	0.99
$LSD_{(0.05)}$	0.23	0.45	0.82	0.40

4.7.3. Number of fruits per plant at 50, 65, 80 and 95 DAS

At 50 DAS, The maximum number of fruits (10.00) per plant was counted in the T_2 (one spray+ mulching). The minimum number of fruits (5.33) per plant was counted in the T_0 (control) preceded by T_1 (only mulching) where number of fruits was (7.33). The moderate number of fruits (8.33) per plant was recorded in the T_3 (3 times spray) treatment.

At 65 DAS, The maximum number of fruits (13.33) per plant was counted in the T_2 (one spray+ mulching). The minimum number of fruits (7.33) per plant was counted in the T_0 (control) preceded by T_1 (only mulching) where number of fruits was (8.33). The moderate number of fruits (11.33) per plant was recorded in T_3 (3 times spray) treatment.

At 80 DAS, The maximum number of f fruits (14.67) per plant was counted in the T_2 (one spray+ mulching). The minimum number of fruits (8.67) per plant was counted in the T_0 (control) preceded by T_1 (only mulching) where number of fruits was (9.33). The moderate number of fruits (13.33) per plant was recorded in T_3 (3times spray) treatment.

At 95 DAS, The maximum number of fruits (13.67) per plant was counted in the T_2 (one spray+ mulching). The minimum number of fruits (7.67) per plant was counted in the T_0 (control) preceded by T_1 (only mulching) where number of fruits was (8.67). The moderate number of fruits (11.67) per plant was recorded in T_3 (3times spray) treatment. The results are presented in Table 13.

Table 13. Efficacy of imidacloprid and light reflecting silver color mulch on fruits number per plant at 50, 65, 80 and 95 DAS

Treatment	No. Of fruit at			
	50 DAS	65 DAS	80 DAS	95 DAS
T_0 (control)	5.33 c	7.33 c	8.67 b	7.67 c
T_1 (only mulching)	7.33 b	8.33 c	9.33 b	8.67 c
T_2 (one spray+ mulching)	10.00 a	13.33 a	14.67 a	13.67 a
T_3 (3 times spray)	8.33 ab	11.33 b	13.33 a	11.67 b
CV (%)	1.73	1.28	1.85	1.28
$LSD_{(0.05)}$	0.70	0.52	0.75	0.52

4.7.4. Yield (kg/plot)

The highest yield (4.37 kg) per plot was recorded in the T_2 (one spray+ mulching). The lowest yield (2.48 kg) per plot was recorded from the T_0 (control) preceded by T_1 (only mulching) where the yield per plot was (3.10 kg). The moderate yield per plot was obtained from the T_3 (only mulching) and it was (3.30 kg). The results are presented in Table 14.

Table 14. Efficacy of imidacloprid and light reflecting silver color mulch on yield.

Treatment	**Yield/Plant (KG)**	**Yield/ Plot (KG)**
T_0 (control)	0.13c	2.48c
T_1 (only mulching)	0.16bc	3.01bc
T_2 (one spray+ mulching)	0.24a	4.37a
T_3 (3 times spray)	0.18b	3.30b
$LSD_{(.05)}$	0.01	0.28
CV (%)	0.03	0.69

4.7.5. Plant height (cm)

The maximum plant height (130.33 cm) was recorded in the T_2 (one spray+ mulching) followed by T_3(3 times spray) where the plant height was (127.42 cm) and both are statistically different with each other. The minimum plant height (121.75 cm) was recorded in the T_0 (control) preceded by T_1 (only mulching) where the plant height was (123.58 cm) and both are statistically different with each other. The results are presented in Table 16.

4.7.6. Root length (cm)

The maximum root length (30.33 cm) was recorded in the T_2 (one spray+ mulching) followed by T_3 where the root length was (28.50 cm) and both are statistically different with each other. The minimum root length (21.08 cm) was recorded in T_0 (control) proceeded by T_1 (only mulching) where the root length was (23.67 cm) and both are statically different with each other. The results are presented in Table 15.

Table 15. Efficacy of imidacloprid and light reflecting silver color mulch on plant height and root length.

Treatment	Plant height	Root length/plant (cm)
T_0 (control)	121.75d	21.08a
T_1 (only mulching)	123.58c	23.67a
T_2 (one spray+ mulching)	130.33a	30.33a
T_3 (3 times spray)	127.42b	28.50a
$LSD_{(.05)}$	1.15	57.85
CV (%)	0.47	23.64

4.8. Relation between % disease incidence and yield

The relationship between disease incidence and yield performance of okra plants was also studied. From the study it was revealed that there is inverse relation disease incidence and yield**.** When disease incidence is increased, the yield of okra is also decreased. It was evident from the Figure 6.

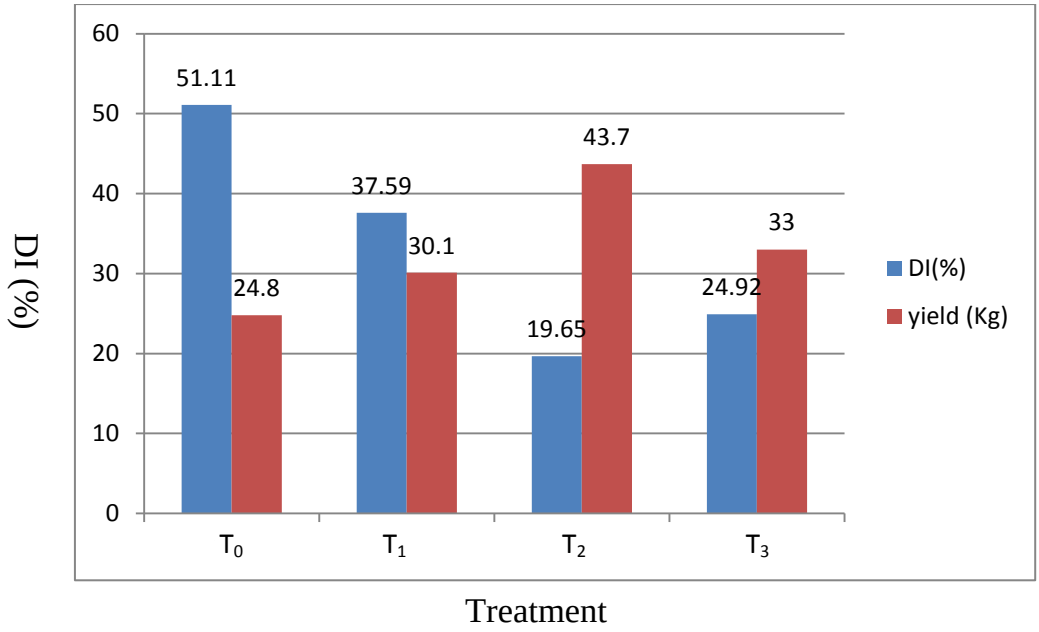


Figure 6. Relationship between yield and % disease incidence.

DISCUSSION

In Bangladesh the production of okra is quite lower in comparison to our neighbor country like, in India it produces 8896.3 thousand metric tons from 1158.0 thousand hectors of lands (FAO, 2016) whereas the yearly production of okra in Bangladesh is 53.98 thousand metric tons from 11.34 thousand hectors of lands (BBS, 2016).In this study two popular okra varieties namely Green finger and BARI Dherosh-1 was used. The major target of this study was to minimize the insecticide used to control the insect vector of OYMV.

Experiment-1(BARI Dherosh-1)

4.9. Disease Incidence

In this study, one selected insecticide and light reflecting silver color mulch was used to manage the *Okra yellow mosaic virus* through controlling the insect vectors white fly. The disease incidence (%) was estimated at 50, 65, 80 and 95 DAS. It was noticed that the disease incidence (%) due to *Okra yellow mosaic virus* was found in all treatments plots at 80 DAS.

The highest disease incidence (%) was estimated in T_0 (untreated/control) followed by T_1 (only mulching), T_3 (3times spray) and T_2 (one spray+

mulching) respectively. Among the treatments, the lowest disease incidence (%) was recorded in T_2 (one spray with imidacloprid+ mulching). The result of the present study is in accordance with the results of Sayed *et al.,* (2018) when they used imidacloprid as single spray. In the present study imidacloprid was sprayed with light reflecting silver color mulch and resulted lower incidence of *Okra yellow mosaic virus*. This is due to presence of lower number of insect vector white fly (*Bemisia tabaci*. So considering the economic condition/cost-benefit ratio T_2 (one spray+ mulching) was gave the best result among the selected treatments.

4.10. Infestation of whitefly per leaf

The minimum number of whitefly per leaf in was recorded in T_2 (one spray+ mulching) preceded by T_3 (3times spray) whereas the maximum number of whitefly per leaf was recorded in T_0 (untreated/control) followed by T_1 (only mulching).

Early infection of (*OYMV)* causes drastic reduction of all the growth contributing character of all the okra varieties. The extent of damage in different growth contributing characters was largely dependent upon the stage of infection of (*OYMV),* condition of growing seedlings and okra varieties. Almost same phenomenon with the (*OYMV)* infection was noted by Gupta, (2016).

4.11. Morphological features

4.11.1. Number of leaves, flowers and fruits per plant

The yield of individual treatment depends on the number of leaves, flowers and fruits per plant. The highest number of leaves, flower and fruits per plant were recorded in T_2 (one spray+ mulching) followed by T_3 (3times spray with imidacloprid) and T_1 (only mulching). The lowest number of leaves, flowers and fruits per plant were recorded in the T_0 (control treatment). These same results were agreed with the recent study that was conducted by Sayed *et al.,* (2018) and Gupta, (2016). They also observed that Imidacloprid is better than mulch.

4.12. Yield and yield contributing characters

The highest yield per plant and plot was recorded in T_2 (one spray+ mulching) followed by the treatment T_3 (3times spray with imidacloprid) and T_1 (only mulching). Considering the economic condition/cost-benefit ratio T_2 (one spray+ mulching) gave the best result regarding in yield and yield contributing characters.Where the lowest yield per plant/plot was recorded in T_0 (control treatment). Almost same results were found in recent study that was conducted by Sayed *et.al,* (2018) and Gupta, (2016). There is no more previous report over yield of okra against *OYMV* in our country.

Experiment-2 (Green Finger)

4.13. Disease Incidence

In this study, one selected insecticide and light reflecting silver color mulch was used to manage the *Okra yellow mosaic virus* through controlling the insect vectors white fly. The disease incidence (%) was estimated at 50, 65, 80 and 95 DAS. It was noticed that the disease incidence (%) due to *Okra yellow mosaic virus* was found in all treatments plots at 80 DAS. The highest disease incidence (%) was estimated in T_0 (untreated/control) followed by T_1 (only mulching), T_3 (3times spray) and T_2 (one spray+ mulching) respectively. Among the treatments, the lowest disease incidence (%) was recorded in T_2 (one spray with imidacloprid+ mulching). The result of the present study is in accordance with the results of Sayed *et al.,* (2018) when they used imidacloprid as single spray. In the present study imidacloprid was sprayed with light reflecting silver color mulch and resulted lower incidence of *Okra yellow mosaic virus*. This is due to presence of lower number of insect vector white fly (*Bemesia tabaci*. So considering the economic condition/cost-benefit ratio T_2 (one spray+ mulching) gave the best result among the selected treatments.

4.14. Infestation of whitefly per leaf

The minimum number of whitefly per leaf in was recorded in T_2 (one spray+ mulching) preceded by T_3 (3times spray) whereas the maximum number of whitefly per leaf was recorded in T_0 (control) followed by T_1 (only mulching).

Early infection of (*OYMV)* causes drastic reduction of all the growth contributing character of all the okra varieties. The extent of damage in different growth contributing characters was largely dependent upon the stage of infection of (*OYMV),* condition of growing seedlings and okra varieties. Almost same phenomenon with the (*OYMV)* infection was noted by Gupta, (2016).

4.15. Number of leaves, flowers and fruits per plant

The yield of individual treatment depends on the number of leaves, flowers and fruits per plant. The highest number of leaves, flower and fruits per plant were recorded in T_2 (one spray+ mulching) followed by T_3 (3times spray with imidacloprid) and T_1 (only mulching). The lowest number of leaves, flowers and fruits per plant were recorded in the T_0 (control treatment). These same results were agreed with the recent study that was conducted by Sayed *et al.,* (2018) and Gupta, (2016). They also observed that Imidacloprid is better than mulch.

4.16. Yield and yield contributing characters

The highest yield per plant and plot was recorded in T_2 (one spray+ mulching) followed by the treatment T_3 (3times spray with imidacloprid) and T_1(only mulching). Considering the economic condition/cost-benefit ratio T_2 (one spray+ mulching) gave the best result regarding in yield and yield contributing characters. Where the lowest yield per plant/plot was recorded in T_0 (control treatment) . Almost same results were found in recent study that was conducted by Sayed *et.al,* (2018) and Gupta, (2016). There is no more previous report over yield of okra against *OYMV* in our country.

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SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

The study on okra was carried out at the central farm of Sher-e- Bangla Agricultural University, Dhaka-1207, during March to July, 2017 with normal agronomic practices. Yield and yield contributing characters and morphological features of okra plant that changes due to disease infection which cause damages of okra production and reduce the market value was also part of this study. The study was to evaluate the performance of one selected insecticide and light reflecting silver color mulch against *Okra yellow mosaic virus* (O*YMV)* through control the insect vectors. Two popular okra varieties namely Green finger and BARI Dherosh-1 were used as selected cultivar and one insecticide viz. Imidacloropid was sprayed up to three times to control the insect vectors. The experiment was carried out in Randomized Complete Block Design (RCBD).The insecticides were sprayed at 30 DAS and continued with 15 days interval. In experiment-1 BARI Dherosh-1 and in experiment-2 Green finger was cultivated. The lowest disease incidence (%) was calculated in T_2 (one spray+ mulching) that was 34.72 % in experiment -1 and 19.65 % in experiment-2 at 95 DAS. The highest disease incidence (%) was recorded in T_0(untreated/control) that was 73.71 % in experiment-1 and 51.11 % in experiment-2. Considering the economic conditions/cost-benefit ratio T_2(one spray+ mulching) was the best. In case of morphological parameters; the highest number of leaves, flowers and fruits per plant was recorded in T_2(one spray+ mulching) and that was 46.33, 9.33, 7.00 in experiment-1 and 48.00, 12.33, 10.67 in experiment-2 respectively up to last harvesting. Yield and yield contributing characters showed significant variance among the treatments. The highest yield per plant and plot was obtained in T_2 (one spray+mulching) treatment in case of both varieties (0.15 kg/plant, 2.86 kg/plot in experiment-1 and 0.24 kg/plant, 4.37 kg/plot in experiment-2). The highest plant height was found in T_2 (one spray+ mulching) in both experiment (128.62 cm and 130.33 cm respectively). In the relationship study, it was noticed that disease incidence and yield have negative relation. When disease incidence is high, yield is low. In case of all the treatments T_2 (one spray+ mulching) and T_3 (3times spray) showed better performance. However, considering the economic conditions/cost-benefit ratio T_2 (one spray+ mulching) was the best in case of all measuring parameters.

REFERENCES

REFERENCES

Adams, C. F. (1975). Nutritive value of American foods in common units, U.S.Department of Agriculture, Agric Handbook. 425, pp 29.

Ahmed, H. U. and Hossain, M. M. (1985). Crop disease survey and establishment of a herbarium at BARI. Plant Pathology Division, Bangladesh Agricultural Research Institute, Joydevpur, Gazipur. pp107.

Akanda, A. M. (1991). Studies on the virus and mycoplasma disease of crops in Bangladesh. Ph.D. Thesis. Department of Plant Pathology, Kyushu University, Japan. 191p.

Akanda, A. M., Tsuno, K. and Wakimoto, S. (1991). Serodiagnosis of viruses infecting some crops of Bangladesh. *Journal of the Faculty of Agriculture*, Kyushu University, japan. **35** (3-4): 121-129.

Ali, M. (1999). IPSA Okra-1 and IPSA Drum stick-1: Two improved variety of vegetable. Outreach Program, BSMRAU, Salna, Gazipur. pp. 1-5.

Ali, M., Hossain, M. Z. and Saker, N. C. (2000). Inheritance of *Okra* y*ellow mosaic virus* (OYMV) tolerance in a cultivar of okra *(Abelmoschus esculentus* L. Moench). *Euphytica*. **11** (3): 205-209.

Anonymous, (1993). Control of y*ellow mosaic virus* of Lady's finger. MS Thesis. Department of Plant Pathology. Bangladesh Agricultural University, Mymensingh.

BBS. 2016. Year Book of Agricultural Statistics of Bangladesh, 2015-2016, Statistics Division, Ministry of Planning, Dhaka.

Begum, M. A. (2002). Prevalence and spread of *Okra* y*ellow mosaic virus* in the field and its impact on growth and yield of okra. MS Thesis. Department of Plant Pathology. BSMRAU, Gazipur. pp. 135.

Bhagabati, K. N. and Goswami, B. K. (1992). Incidence of *Okra* y*ellow mosaic virus* disease of okra *(Abelmoschus esculentus* L. Moench.) in relation to whitefly *(Bemisia tabaci* Genn.) population under different sowing dates. *Indian Journal of Virology*. **8** (1): 37-39.

Bhagat, A. P. (2000). Effect of *Bhindi yellow mosaic virus,* on growth and yield of bhindi. *Journal of Mycology and Plant Pathology*. **30** (1): 110-111.

Borad, V. K., Puri, S. N., Brown, J. K. and Butler, G. D. (1993). Relationship of *Bemisia tabaci* population density and yellow vein mosaic disease incidence in okra. *Pest Management and Economic Zoology*. **1**(1): 14-19.

Borah, R. K. and Nath, P. D. (1995). Evaluation of an insecticide schedule on the incidence of whitefly, *Bemisia tabaci* (Genn.) and yellow vein mosaic in okra. *Indian Journal of Virology*. **11**(2): 65-67.

Capoor, S. P. and Verma, P. M. (1950). Yellow vein mosaic of *Hibiscus esculentus* L. *Indian Journal of Agricultural Science*. **20**: 217-230.

Chakrabarty, S., Pandey, P. K. and Singh, B. (1997). Okra enation leaf curl disease - a threat to cultivation of okra *(Abelmoschus esculentus* L. Moench*). Vegetable-Science.* **24** (1): 52-54.

FAOSTAT, 2018. (http://fao.org).

Fernando, M. and Udurawana, S. B. (1942). The nature of the mosaic disease of Bandakka *(Hibiscus esculentus* L.). *Tropical Agriculture (Ceylon).* **98**: 16-24.

Givord, M. D., Meah, M. B. and Rahman, G. M. M. (1972). Reaction of okra variety to *Yellow mosaic virus* and biochemical changes in its infected leaf constituents. *Bangladesh Journal of Plant Pathology*. **14** (1-2): 29-32.

Goswami, B. K. and Bhagabati, K. N. (1992). Natural incidence of *Yellow vein mosaic virus* disease of bhendi *(Abelmoschus esculentus* L. Moench) in relation to different dates of sowing. *Journal of Assam Science Society*. **34** (2): 19-24.

Gupta, N. D. (2016). Occurrence of *Okra yellow mosaic virus* (OYMV) and its effect on growth and yield of okra. An MS thesis submitted to the Department of Plant Pathology, BSMRAU, Salna, Gazipur, Bangladesh. pp77.

Haider, J. and Hossain, T. (1994). Metabolic changes in okra caused by *Okra* y*ellow mosaic virus. Bangladesh journal of Botany*. **23** (2): 217-223.

Harender, A. and Gupta, M. D. 1993a. Characterization of *Yellow mosaic-virus* of bhindi *(Abelmoschus esculentus* L. Moench.) *International Journal Tropical Plant Disease*. **11** (1): 117-123.

Handa, A. and Gupta, M. D. (1993). Management of *Bhindi yellow mosaic-virus* disease. *Indian Phytopathology*. **46** (2): 123-130.

Harrison, B. D., Muniyappa, V., Swanson, M. M., Roberts, I. M. and Robinson, D. J. (1991). Recognition and differentiation of seven whitefly-transmitted geminivirus from India, and their relationships to *African cassava mosaic* and *Thailand mungbean yellow mosaic viruses. Annals of Applied Biology*. **118** (2): 299-308.

Hossain, A. B. M. S. (1998). Effect of intercropping on incidence of okra mosaic disease. MS thesis. Depariment of Plant Pathology, Bangladesh Agricultural University, Mymensingh.

Hossain, M. D., Meah, M. B. and Rahman, G. M. M. (1989). Reaction of okra variety to *Yellow mosaic virus* and biochemical changes in its infected leaf constituents. *Bangladesh Journal of Plant Pathology*. **14** (1-2): 29-32.

Handa, A. and Gupta, M. D. (1993a). Charterization of Yellow vein mosaic virus of bhindi (*Abelmoschus esculentus* L. Monech.) *International Journal of Tropical Plant Disease*. **11**(1): 117-123.

Kadian O. P. and Naresh K. (1991). Influence of weather factors on whitefly population and disease of yellow vein mosaic of okra. *Indian phytopathology*. Vol **45**: P. 83.

Khan, M. A. and Mukhopadhyay, S. (1985). Studies on the effect of some alternative cultural methods on the incidence of *yellow mosaic virus* (YMV) disease of okra (*Abelmoschus esculentus* (L) Monech). *Indian Journal of Virology*. **1**(1): 69-72.

Kulkarni, G. S. (1942). Mosaic and other related diseases of crops in the Bombay presidency. *Proceedings of the 11th Indian Science Congress*, b.**42**: 3.

Kumar, N. K. K. and Moorthy, P. N. K. (2000). Transmission of *Yellow mosaic Geminivirus* to Imidacioprid treated okra by the whitefly, *Bemisia tabaci* Gennadious. *Insect Environment*. **6** (1): 46-47.

Khushk, A.M., Usman, S.M., Memon, M.A (2003). The cultivation of okra in Sindh and its economic view, PARC Technology transfer institute, Tandojam. Published in Sindh Zarat. **136**: 17-18.

Miah, M. A. S. (1988). Effect of Date of planting and insecticidal spray on the control of yellow vein mosaic disease of Lady's finger *(Hibiscus esculentus* L.). Abstracts of Thesis (1966-1990). Department of Plant Pathology, Bangladesh Agricultural University, Mymensingh-2202, March, 1991. 79p.

Mian, S. A., Momon, A., Hossain, M. and Khan, A. A. (1990). Effect of insecticide and date of planting on Yellow vein mosaic of Lady‟s finger. *Bangladesh Horticulture*. **18**(1&2): 65-68.

Nariani and seth (1958). Influence of sowing time on the incidence of yellow vein mosaic and whitefly *(Bernisia tabaci)* population on okra. *Indian Journal of Virology*. **8** (1): 45-48.

Nath, Gupta, M. K and Saikia (1993). Altered metabolic of okra plants infected with okra yellow mosaic virus. *Physiol. Plant pathol*. **24**:1-7.

Pun, K. B., Doraiswamy, S. and Jeyarajan, R. (1999). Immunological detection of *Okra yellow mosaic vims*. *Indian Journal Virology*. **15** (2): 93-96.

Purseglove, J. W. (1999). Tropical crops. Dicotyledons. 1st Edition, Longmans, Green & Co. LTD.

Rashid, M. M. (1999). Shabji Biggan (in Bengal). Bangla Academy, Dhaka. 466p.

Sharma, B. R , Sharma, O. P. and Bansal, R. D. (1987). Influence of temperature on incidence of *Yellow mosaic virus* in okra. *Vegetable Science*. **14** (1): 65-69.

Sastry, K. S. M. and Singh, S. J. (1974). Effect of *Yellow mosaic virus* infection on growth and yield of okra crop. *Indian Phytopathology*. **27**: 294-297.

Sastry, K. S. M. and Singh, S. J. (1975). Yellow mosaic of Bhindi. Curr. Sci. **9**: 227-228.

Sayed, S.M, Hossain, M. and Khan, A. A. (2018). Effect of insecticide and mulching on Yellow vein mosaic of Lady‟s finger. *Bangladesh Horticulture*. **18**(1&2): 65-68.

Sayeed, A. (1988). Effect of the date of planting and insecticidal spray on the control of yellow vein mosaic of Lady‟s finger. M. Sc. Thesis, Department of Plant Pathology, B. A. U. Mymensingh.

Thakur and Arora, (1986). Influence of temperature on incidence of *Yellow mosaic virus* in okra. *Vegetable Science*. **14** (1): 65-69.

Tsering, K. and Patel, B. N. (1990). Simultaneous transmission of *Tobacco leaf curl virus* and *Yellow vein mosaic virus* of *Abelmoschus esculentus* L. Moench. By *Bemisia tabaci* Genn. *Tobacco Research*. **16** (2): 127-128..

Uppal, B. N., Verma, P. M. and Capoor, S. P. (1940). Yellow mosaic of bhendi. *Curr. Sci.* **9**: 227-228.

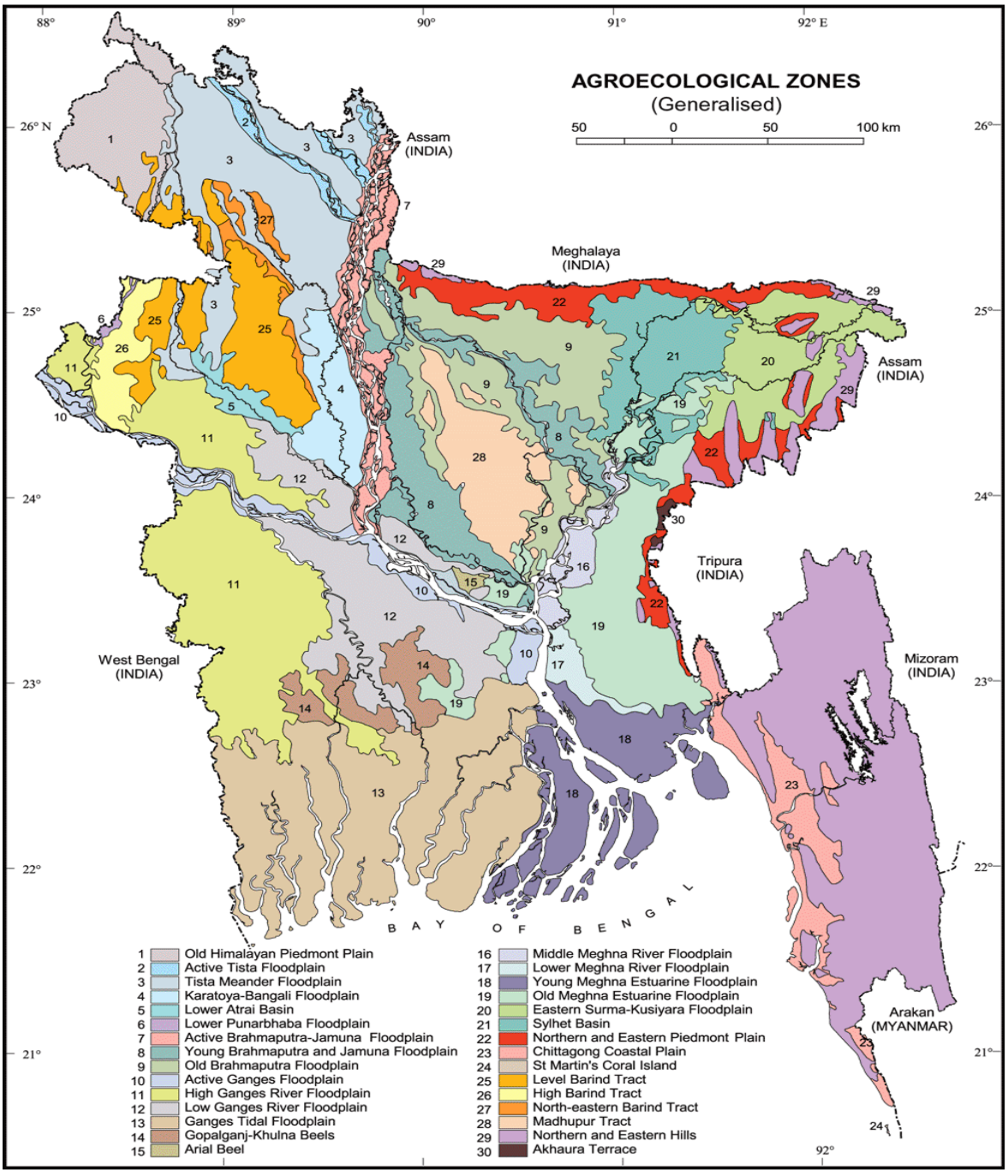
Verma, P. M. (1952). Studies on the relationship of the *Bhindi yellow mosaic virus* and its vector, the whitefly, *Bemisia tabaci* Gen. *Indian Journal of Agricultural Science*. **22**: 75-92.

Verma, P. M. (1955). Persistence of *Yellow vein mosaic virus of Abelmoschus esculentus* (L.) Monech, in its vector, *Bemisia tabaci* Gen. *Indian Journal of Agricultural Science*. **25**: 293-302.

APPENDIX

APPENDICES

Appendix I. Map showing the field laboratory under study.



Appendix II. Monthly average relative humidity, maximum and minimum temperature, rainfall and sunshine hours during the experimental period (March 2015 to July 2017)

Month	Average RH (%)	**Average Temperature** (ºC)		**Total Rainfall (mm)**	**Average sunshine Hours**
		Minimum	**Maximum**		
March	66	23.7	34.2	166.8	4.8
April	80	24.6	33.5	324.3	4.6
May	82	25.2	35.5	415.4	4.9
June	83	26.8	34.7	501.6	4.9
July	83	27.87	33.2	495.4	4.5

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

Appendix III. Physiochemical properties of soil of field laboratory

Characteristics	**Value**
Partical size analysis	25.68
% Sand	53.85
% Silt	20.47
% Clay	Silty loam
Textural class	5.8-7.1
pH	0.31
Organic carbon (%)	0.54
Organic matter (%)	0.027
Total N (%)	23.66
Phosphorus(µg/g soil)	0.60
Exchangeable K (me/100 g soil)	28.43
Sulphur (µg/g soil)	0.05
Boron (µg/g soil)	2.31
Zinc (µg/g soil)	

Source: Soil Resources Development Institute (SRDI), Dhaka-1207