EFFECT OF TIME OF SOWING ON DISEASE INCIDENCE OF *OKRA YELLOW VEIN MOSAIC VIRUS* (OYVMV) AND ITS MANAGEMENT THROUGH SELECTED INSECTICIDES AND LIGHT REFLECTING COLORED MULCHES

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*This is to certify that thesis entitled, "***EFFECT OF TIME OF SOWING ON DISEASE INCIDENCE OF *OKRA YELLOW VEIN MOSAIC VIRUS* (OYVMV) AND ITS MANAGEMENT THROUGH SELECTED INSECTICIDES AND LIGHT REFLECTING COLORED MULCHES***" 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* ***SURAIYA JITU****, Registration No.* ***13-05315*** *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.

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DEDICATED

TO

MY BELOVED PARENTS,

MY SPOUSE

&

MY RESPECTED SUPERVISOR

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EFFECT OF TIME OF SOWING ON DISEASE INCIDENCE OF *OKRA YELLOW VEIN MOSAIC VIRUS* (OYVMV) AND ITS MANAGEMENT THROUGH SELECTED INSECTICIDES AND LIGHT REFLECTING COLORED MULCHES

ABSTRACT

A field experiment was conducted at the central farm of Sher-e-Bangla Agricultural University, Dhaka-1207, during March to August, 2018. The aim of the study was to investigate the time sowing effect on disease incidence of *Okra Yellow Vein Mosaic Virus* (OYVMV) in selected okra variety, and to evaluate the effect of light reflecting colored mulches and only one time spraying with selected insecticides to control the insect vector whitefly *(Bemisia tabaci)*. The experiment was carried out in three blocks layouted with RCBD comprising three different sowing times and eight treatments viz. T_0 (control/no spray), T_1 (1 time spray with imitaf), T_2 (1 time spray with protect), T_3 (1 time spray with tiddo plus), T_4 (1 time spray with terbine), T_5 (light reflecting silver color mulch),T_6 (light reflecting red color mulch) and T_7 (light reflecting black color mulch) with three replications. The mulches were used before sowing and insecticides were sprayed at 30 DAS. It was observed that among the sowing time, the lowest disease incidence (22.56 %) was found in first sowing (15th March) and the highest disease incidence (59.00%) was recorded in third sowing (15th April) at 80 DAS. Among the light reflecting colored mulches, the lowest disease incidence (11.48%) was recorded in the plots which mulched with red color mulch (T_6). Among the insecticides, the lowest disease incidence (30.17%) was recorded in plots that was sprayed with terbine (one time).Yield and yield contributing characters, morphological and physiological features of okra plant that changes due to disease infection which cause damages in okra production and reduce the fruit quality as well as market value was also the part of this study. Yield and yield contributing characters showed significant variance among the three different sowing times and selected treatments. The highest yield per plant (0.73 kg) and plot (3.88 kg) was obtained in first sowing. Among the light reflecting mulches, the highest yield per plant (0.92 kg) and plot (4.85 kg) was obtained in the plots that covered with red colored mulch (T_6). Among the selected insecticides, the highest yield per plant (0.82 kg) and plot (3.18 kg) was obtained in the plots that sprayed with terbine (one time). Among different light reflecting colored mulches and insecticides, the highest plant height (95.86 cm and 95.35 cm) was found in red color mulched plots (T_6) and in the plots that was sprayed with terbine (one time) respectively. In the relationship study, it was noticed that the yield and plant height was showed negative relationship with disease incidence. However, considering the all measuring parameters, maintaining sowing time with combining the treatments; spraying with terbine (one time) and used red color mulch may be recommended as good management approaches that will give higher okra production and lower disease incidence of *Okra Yellow Vein Mosaic Virus* (OYVMV).

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LIST OF ACRONYMS

AEZ	=	Agro-ecological zone
%	=	percent
/plot	=	Per plot
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
FAO	=	Food and 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
t/ha	=	Ton per hectare
TSP	=	Triple Super Phosphate
Wt	=	Weight
S^1	=	First sowing
S^2	=	Second sowing
S^3	=	Third sowing

CHAPTER 1

INTRODUCTION

INTRODUCTION

Okra commonly known as Lady's finger or Bhendi , Latin binomial names for okra are *Abelmoschus esculentus* and *Hibiscus esculentus*, belongs to the family *Malvaceae*. Both of the species, the most popularly grown species is *Abelmoschus esculentus* (Kumar *et al*., 2010). It is originated from West Africa as an annual vegetable that grown from seed in tropical and subtropical region of the world (Thakur and Arora, 1986). In Asian countries, it's grown throughout the year and has great commercial demand due to its high nutritional and medicinal values. It is a very common and 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 these countries including Bangladesh. 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 or kharif season. It is also grown in winter season in Bangladesh with very poor land coverage. In Bangladesh, the annual okra production is 54.901 thousand metric tons from 28.106 thousand hectares of land (BBS, 2017). The production is quite lower in comparison to our neighbor country, in India it produces 8896.3 thousand metric tons from 1158.0 thousand hectares of land (FAO, 2018).

Only the tender unripe fruit of okra is eaten as a vegetable. Okra may be prepared like asparagus, sauteed, or pickled, and it is also an ingredient in various stews and in the gumbos of the southern United States; the large amount of mucilage (gelatinous substance) it contains makes it useful as a thickener for broths and soups. The leaves and immature fruit long have been popular in the east for use in poultices to relieve pain (Melissa, 2019).Okra is a very nutritious and rich in vitamins and minerals (Kushak *et al.*, 2003). According to the U.S. Department of Agriculture (USDA) National Nutrient Database, one cup of raw okra, weighing 100 g contains 33 g calories, 1.9 g of protein, 0.2 g of fat, 7.5 g of carbohydrates, 3.2 g of fiber, 1.5 g of sugar, 31.3 mg of K , 299 mg of potassium,7 mg of sodium, 23 mg of vitamin C, 0.2 mg of thiamin, 57 mg of magnesium, 82 mg of calcium, 0.215 mg of vitamin B6, 60 µg of folate, 36 µg of vitamin A (https://www.medicalnewstoday. / com/articles 311977). Okra also provides some iron, phosphorus, and copper. Okra contains 0.08 mg niacin, 0.08 mg riboflavin (Rashid,1999). Okra is also a source of antioxidants derivatives, such as catechins and quercetin. These compounds have antimicrobial and anti-inflammatory properties. Okra contains lectin, which is a type of protein, researchers used lectin from okra in a lab test to treat human breast cancer cells. The treatment reduced cancer cell growth by 63% and killed 72% of the human cancer cells (*Dahm, et al.,2010*). A diet rich in fruits and vegetables can reduce a person's chances of developing a range of health conditions, including obesity, diabetes, and cardiovascular disease. The mucilage of okra may also help remove toxins from the body. Okra is a good source of folate. (Bailey, 2015). Higher dietary folate may have preventive effects against breast cancer risk. Fiber can reduce harmful cholesterol levels in the blood. (Chen *et al* ., 2014). The dry fruit shell and stem contain crude fibres which are used in manufacture of paper and cardboard. It is beneficial to people suffering from leucorrhoea and general weakness. The high iodine content in its fruits is considered useful to control goiter (Thamburaj and Singh, 2018).

It is effective in curing ulcers and relief from hemorrhoids (Adams, 1975). 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. 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 and quality of okra depend on several factors like disease, insects, soils and climatic conditions. Among the factors responsible for limiting the yield and quality of okra, *Yellow Vein Mosaic Virus* (YVMV) is the most important ones as reported by

Sastry and Singh (1974). A number of viruses infect okra (Kucharek, 2004) including: that causing Okra leaf curl disease (OLCD), is suspected of being associated with a whitefly-transmitted geminivirus (Genus *Begomovirus*), and *Okra* Y*ellow Vein Mosaic Virus* (OYVMV), transmitted by the whitefly (Ali *et al.*, 2000). Among several diseases, yellow vein mosaic disease is the most severe one affecting the quantity and quality of the fruits (Uppal *et al.,* 1940) and always been a serious problem in okra production and yield reductions of 20- 50% have occurred. This loss may increase up to 90% (Pullaiah *et al.*, 1998). The symptoms of *okra yellow vein mosaic disease* are characterized by a homogenous interwoven network of yellow mosaic pattern enclosing islands of green tissue in leaf blades. In extreme cases, infected leaves become yellowish or creamy color (Kucharek, 2004).

Okra Yellow Vein Mosaic Virus (OYVMV) was systemetically studied and characterized by different Indian scientists (Capoor and Verma, 1950; Kumar and Moorthy, 2000 and Verma, 1955). After study they proposed that *OYVMV* is member of Geminivirus group which is semi-persistently transmitted by whitefly (*Bemisia tabaci*). They also observed that OYVMV 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 Thakur,1979). The growth and development of 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). The virus seems to attack okra plants in any stage of plant growth, spreads quickly in the field and adversely affects the growth and yield contributing characters due to remarkable alternation in cellular components of the infected plants (Hossain *et al.* 1998, Sarma *et al.* 1995).

Yellow Vein Mosaic Virus proved to be a severe problem in Bangladesh which can alone makes the okra cultivation non-profitable as reported by Akanda (1991) and Ali (1999). The systematic works on *Yellow Vein Mosaic Virus* have not yet been done in

Bangladesh. Some sporadic works have been reported to find resistant variety or control measures (Ali 1999, Ali *et al.* 2000 and Rashid *et al.* 1999). Most of the research so far conducted in Bangladesh was disease survey type which listed the name of the disease observing the field symptoms, screening the varieties against the disease under natural conditions (Akanda 1991 and Akanda *et al.* 1991).

There is no effective control measure against the virus in the field once it is established. The most effective method of controlling the disease is cultivation of resistant varieties, but availability of resistant variety and sustainability of resistance in okra are rare. The varieties so far cultivated in our country are susceptible to the virus. Controlling its vector by spraying insecticide may be a method of controlling this disease or it may be used as a component of integrated control. The application of insecticides from date of seed sowing upto flowering might have meaningful effect to reduce the early population buildup of whitefly. This might be useful to avoid early and mid-stage infection of the virus resulting economically viable harvest of the crop. The variabilities of okra varieties in relation to the population build-up of whitefly under natural conditions have been reported by Begum (2002).

An appreciable amount of works have been done in India to find out effective management package against Okra *Yellow Vein Mosaic Virus* (Borah and Nath 1995, Dhal *et al.* 1992, Handa and Gupta 1993b, Nath and Saikia 1995 and Singh and Singh 1989). Among the chemicals Systox, Folidol, Aldicarb, Phorate, Monocrotophos, Ekatox, Rogor, Dimethioate, Methyl-parathion, Oxydemetomethyl, Thimet, Dimecron, Carbofuran, Malathion, Metasystox, Bidrin, Ripcord, Sumithion etc. were used by different workers to control whitefly. Some insecticides and plant extracts have also been evaluated against the whitefly transmitting the virus in okra field (Anon. 1993, Hossain 1998 and Miah 1988).

Early sowing can give maximum vegetative growth and fruit yield of okra (Ruchi, 2019). Minimum temperature and relative humidity had significant correlation with OYVMV disease severity and whitefly population. The disease incidence increased with the rise in minimum temperature and whitefly population decreased with increase in the relative humidity (Safdar *et. al*. 2005).

Many researches have been done to assess the impact of different mulch materials on the disease incidence of OYVMV. Mulching conserve soil moisture, controls weed and whitefly population through reflection of light. Plastic mulch induced the highest yield of okra plants and less disease incidence was observed. (Kareem, 2012).

Considering the above mentioned factors the research experiment was carried out to optimize the sowing time for estimation of disease incidence level of *Okra Yellow Vein Mosaic Virus* (OYVMV), and to use light reflecting plastic colored mulches and to spray selected insecticides only one time for management of OYVMV by controlling the insect vectors whitefly. The ultimate target of the proposed study was to minimize the insecticidal used in controlling the insect vectors whitefly.

Objectives:

The study was carried out to achieve the following specific objectives-

-To investigate the time of sowing effect on disease incidence of *Okra Yellow Vein Mosaic Virus* (OYVMV) in selected okra variety

-To evaluate the effect of light reflecting colored mulches and only one time spraying of Selected insecticides to control the insect vector whitefly

CHAPTER 2

REVIEW OF LITERATURE

REVIEW OF LITERATURE

***Okra Yellow Vein Mosaic Virus* (OYVMV)** is the most annihilating virus of okra in all okra growing regions. Kulkarni (1924) first identified that the occurrence of a virus which was responsible for huge yield reduction of okra in Bombay, India. Uppal *et al.*, (1942) established the viral rigin of the disease and coined the name *Okra yellow mosaic virus (YVMV)*. Okra yellow mosaic disease was first reported from Bombay (presently known as Mumbai) in India (Kulkarni, 1924). 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)

Literatures, the virus was proposed named as *Yellow Vein Mosaic Virus* (YVMV) of bhindi. 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) summarized 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 geminivirus 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, 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, 1993a; 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 from 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 (*Bemisia 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 OYVMV

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 1924). They also proposed dwarfing of the infected plants those produced deform and small sized fruits as the showing of the symptoms of *OYVMV*.

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, they named the virus as *Okra yellow vein banding virus.* The severe stunting of *OYVMV* 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 Varma (1950) described the symptoms of the disease include clearing of vein lets followed by chlorosis of veins, vein swelling, slight downward curling of the leaf margins, twisting of petioles, dwarfening and retardation of growth.

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) also.

Capoor and Verma (1950) also find out that the host range of *Okra yellow mosaic virus* is also restricted to malvaceous plants though 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. They performed ELISA test using polyclonal antiserum of *Indian cassava mosaic geminivirus (ICMV)* and found close relationship of *Yellow vein mosaic virus* of okra with *ICMV*. The result also demonstrated that *Bhindi Yellow Vein Mosaic Virus* was more closely related to *ICMV* than that of *African cassava mosaic begumo virus (ACMV).*

2.1.2. Virus-vector relationship of OYVMV and their transmission

Bhagabati and Goswami (1992) observed 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 vector 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* studied 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.

Verma (1955) observed that *Yellow vein mosaic virus* of the okra perpetuates on several wild plants and it is spread by whitefly (*B. tabaci*) under natural condition.

Sharma *et al.* (1987) assessed the effect of temperature on the incidence of *Hibiscus yellow vein mosaic virus (HYVMV)* on six varieties of okra over a period of 6 years. The incidence of *HYVMV* was found to increase with the decreased temperature in September compared with August. A significant negative correlation co-efficient between the temperature and virus incidence was detected. It was also evident that the varieties those were free of virus in August developed virus symptoms in September. They opined that the temperature had influence on the resistance on *HYVMV* and could, therefore, be under the control of a polygenic system.

Jeyarajan *et al*. (1988) reported that there was no outbreak of *Bemesia tabaci* in farmers fields in the Coimbatore district of Tamil Nadu, India in March 1986, which transmitted *tomato leaf curl virus*, *Tapioca mosaic virus, Urd bean yellow mosaic virus and Bhendi yellow vein mosaic viruses* at the rate of 80.0, 5.3, 67.4 and 84.0% respectively and all the viruses are the members of Gemini virus group.

Sastry and Singh (1975) investigated the effect of *Okra Yellow Mosaic Virus* on the 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 OYVMV was found to increase with in the decreased temperature in September compared with August. There is a significant negative correlation co-efficient between the 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 OYVMV.

Tsering and patel (1990) conducted on the vector transmission of gemini virus 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) studied on the influence of weather factors on whitefly population and disease incidence of *Okra Yellow Vein Mosaic Virus* (OYVMV). The results of their study disclosed that the weather factors mainly temperature and relative humidity have pronounced effect on the population buildup of *Bemisia tabaci* in okra field. The spread of yellow mosaic disease of okra field is depended on 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 the 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), he found 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 were 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.

Bhagat (2000) worked on the impact of *Yellow vein clearing mosaic virus (YVCMV)* on growth and yield of bhindi (*Abelmoschus esculentus* L.). Three okra varieties namely Parbhani Kranti, Vaishali Vadhu and Pusa Sawani were grown in the field to find out the effect of *YVCMV* infection on the growth and yield of okra. The plant height, number of leaves, fruits per plant, fruit length, fruit diameter, fruit weight/plant was found to be less affected due to virus infection in the resistant cultivar Parbhani Kranti in comparison to susceptible Vaishali Vadhu and Pusa Sawani.

Bhagat *et al.* (2001) conducted an experiment to find out the rate of dissemination of okra *Yellow vein clearing mosaic virus (YVCMV)* in okra cultivars named Pusa Sawani (highly susceptible), Vaishali Vadhu (susceptible), Parbhani Kranti (resistant). The maximum rate of disease development was between 35-45 days after sowing (DAS). The virus is mechanically non-transmitted, but transmitted by grafting and white fly (*B. tabaci*), which could be able to infect plants in any stage of plant growth as reported by Gupta (2000) and Parvin (2002).

2.1.3. Approaches to control OYVMV

Khan and Mukkopadhay (1985) suggested the practice of alternative cultural method to minimize the incidence of *Yellow vein 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 vein mosaic virus* in *Abelmoschus esculentus.* It was found that disease incidence in mulched crop was 24.3% compared to 58.6% in the control.

Singh and Singh (1989) observed that *Hibiscus yellow vein mosaic virus* was controlled by three sprays of phosphamidon (0.02%) or methyl demeton (demeton-S-methyl) (0.25%) a single soil application of Foratox (phorate) (15 kg/ha) or by early sowing (1 Mar.) or intercropping okra with cowpea (*Vigna unguiculata)* or mungbean *(V. radiata).* The insecticides reduced numbers of *Bemisia tabaci* per plant and increased yields more effectively than the other treatments.

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 spreads 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 resistance.

Atiri *et al.* (1991) observed the effects of three synthetic chemicals at recommended dosages on disease incidence, severity and total damage by the beetle transmitted *Okra mosaic tymovirus* (OMV) in okra (*Abelmoschus esculentus*) were compared with those of natural extracts from the seed of neem, *Azadirachta indica*. Only treatments with synthetic pyrethroid, lambacyhalothrin, at 15g a.i per ha and aqueous neem solution at 467 litres/ha significantly (P=0.05) reduced incidence, severity and total damage. Treatments with a cypermethrin + dimethoate mixture (3:25) at 280g a.i./ha apparently had the same effect on disease incidence and severity, but it had no effect on total damage relative to the untreated control. In all cases, the effects of neem oil at 60 litres/ha and carbaryl at 85g a.i./ha were not significantly different from the control. Metabolizing systems easily degrades Lambdacyhalothrin and aqueous neem solution.

Chowdhury, *et al.* (1992) evaluated the inhibition of *Bhendi (Okra) yellow vein mosaic virus* (BYVMV) by different plant extracts and found that alcohol extracts were superior to aqueous ones in preventing infection by *Okra (Bhendi) yellow vein mosaic geminivirus* and those from Callistemon, Datura, Agave and ginger (*Zingiber officinale)* gave a good degree of suppression of symptoms on okra sprayed in the field. A lower rate of disease dissemination was recorded in treated plants than in the controls sprayed with water only. Mortality of the vectors (*Bemisia tabaci)* was 20-80% when they were confined for 30 minute in cage with plants treated with the extracts.

An experiment was conducted by Dhal *et al.* (1992) to test the effect of planting and insecticides on the incidence and spread of *Yellow vein mosaic virus* of okra in Nepal. The results suggested that the systematic insecticides neither delayed nor reduced the incidence of *Okra yellow vein begomonivirus* in replicated field experiments. It was observed that the disease appeared after three weeks of sowing and the incidence reached to the comparable levels in both treated and untreated plots between 45 days to 60 days. The rate of disease increase was similar in both treated and untreated plots, but significantly different among various dates of observations. They suggested that the initial incidence of spatial development of the disease varied with the planting time. The disease incidence was found to be lower in May sowing in comparison to sowing in August.

Goswami and Bhagbati (1992) conducted a field trial in Jorhat, Assam India during 1991 to find out the natural incidence *of Yellow vein mosaic virus* of bhindi (*Abelmoschus esculentus* L.) in relation to different dates of sowing. The lowest viral disease incidence (16.7%) was recorded on okra sown at the beginning of October and the highest (100%) on the crop sown in May and June. The disease incidence was 36.5% and 54.2% in February and March sown crop respectively.

Significantly positive association between disease incidence and whitefly population, temperature, relative humidity and rainfall was recorded by Nath *et al.* (1992). They also observed the negative correlation of fruit yield with disease incidence.

Handa and Gupta (1993a) screened 14 cultivars in the field under natural infection by *Yellow vein mosaic virus* of okra. The results suggested that Parbhani Kranti was promising and tolerant variety against the virus and a selection from Ghana was found highly resistant. It was also observed that agronomic practices improved the yield to 65-67 q/ha in spring and 55-60 q/ha in the kharif season when plants were planted maintaining 60 × 30 cm space.

Handa and Gupta (1993b) applied Carbofuran 3G and Phorate 10G at the time of seed sowing and observed that two applications of both these insecticides were helpful for achieving a significant reduction in BYVMV disease incidence and consequent improvement in yield. However, they noted that Carbofuran 3G performed better over Phorate 10G in controlling whitefly.

Singh, *et al.* (1993) recorded *Okra yellow vein virus* infection for eight cultivars grown in the Tarai region of Uttar Pradesh during 1987-1988. Mean yield over the two years was highest for Prabhani Kranti (9.1 t/ha) followed by Punjab 7 and Punjab Padmini (9 and 8.8 t/ha respectively). The lowest levels of virus infection were recorded for Punjab 7 and Prabhani Kranti, of which 83.5 and 78.8% of the plants grown respectively, showed no viral infection.

Singh, *et al.* (1994) conducted an experiment to find out the effects of sowing time on the incidence of *Yellow vein mosaic virus* of okra and the seed yield of okra. They used two variety of okra cv. Pusa Sawani were sown at weekly intervals during June and July in 1989 and 1990 in Uttar Pradesh. In general, plants from seeds sown later in the year exhibited a higher percentage of *Yellow vein mosaic virus* infection and a lower yield of seeds compared with plants from seeds sown earlier in the year.

Borah and Nath (1995) conducted field experiments at Diphu, Assam, India, during 1993-1994 to investigate the efficacy of different spread schedules of carbofuran, dimethoate and malathion in the control of *B. tabaci* on okra and also therefore, for control of the virus for which it is a vector, *Yellow vein mosaic virus* (*Bhendi yellow vein mosaic geminivirus*) (BYVMV). Dimethoate 0.03% at 15 and 30 days after germination gave the best control of the insect pest and this treatment also had the least incidence of BYVMV and the greatest increase in yield over the untreated control.

Nath and Saikia (1995) studied the influence of 15 different sowing dates from February to March on *Bhendi yellow vein mosaic geminivirus* (BYVMV) disease of okra was studied during 1989-1990. The incidence of BYVMV on okra cv. Pusa sawani varied from 75 to 91% in plots sown between early April and the end of June. Infection in plots sown during February to the end of March was progressively less. The lowest yield of okra was obtained from the plots sown in May and Jun. A strong positive correlation was obtained between percent of disease incidence and whitefly (*Bemisia tabaci*) population (r=0.085) whereas a strong negative correlation was obtained from disease incidence and fruit yield (r=-0.84).

Bhagabati *et al.* (1998) explained the effect of *Yellow vein mosaic virus* of okra on some morphological parameters. They noted that infection by *YVMV* retarded the growth and development of susceptible varieties of okra plants in India. The leaf area fruit length, fruit weight and volume were drastically reduced by virus infection. Moisture content of both diseased leaves and fruits was higher than that of the of healthy okra plants at all growth stage.

Singh *et al.* (1999) reported that the spraying of asafoetida plant extract to an okra crop in the rainy season was tested for the control of the viral vectors *Empoasca devastans (Amrasca biguttula biguttula)*. The asafoetida formulation at 1-3% conc. in vitro and in field trials in Allahabad, Uttar Pradesh, India, showed strong insect repellent activity against *A. biguttula biguttula*, leading to reduced yellow vein mosaic viral infection levels.

Alegbejo (2001) reported that the effect of sowing date (30 June, 15 July and 30 July) on the incidence of *Okra mosaic virus* (OKMV) was investigated during 1997 and 1998 at Samaru, Nigeria. Two okra cultivars were used in the study, the resistant ABK 102 and the highly susceptible JOKOSO. The average number of virus vectors caught per plot decreased with delay in sowing. These vectors were identified as *Podagrica spp*, *Syagrus calcaratus and Nisotra dilecta.* The percentage of OMV infected plants increased with delay in sowing, while fruit yield decreased.

Rhizobacteria controls the viruses through systemic defense mechanism by activating the encoding chitinase, beta-1,3 glucans, peroxidase, PALase, and other enzymes. It reduces the incidence of YVMV to the maximum extent (up to 86.6%) through induced systemic resistance by triggering defense molecules. Greater fruit yield of okra, and reduction in disease incidence and whitefly population were obtained with application of Crozophera oil at 1.0 ml/litre, followed by Palmrosa oil at 1.0 ml/litre. (Biswas, *et.al.* 2008).

Fajinmi, *et. al.* (2010) concluded that the easiest method of reducing YVMV disease is planting of resistant varieties against this disease.

Patil, *et. al.* (2011) suggested that the biological product like Azadirachtin spray at an interval of 15 days reduces the white fly population up to the 79.2%. Plant growth promoting rhizobacteria (PGPR) has been promoted as an alternative approach for disease management which is eco-friendly and safe.

Ansar, *et al.* (2014) suggested seed treatment with Imidacloprid and sowing of two rows of maize border with spraying of Imidacloprid + Neem oil spray until fruit formation showed least incidence (15.47%) of disease.

Chaudhary, *et. al.* (2017) used four plants extracts i.e. *Azadirachta indica* (neem), *Allium sativum* (garlic), *Zingiber officinale* (ginger) *Allium cepa* L (onion) to manage OYVMV and its vector. For this purpose four Okra varieties Sabz pari, Pahuja, Pusa sawani and Lush green was sown under RCBD design. Data obtained from vector population and disease incidence was analyzed through ANOVA. Sabz pari was found moderately resistant. Pahuja showed tolerant behavior while Lush green and Pusa sawani showed moderately susceptible and susceptible response respectively. Among four plants extract *Azadirachta indica* (Neem) at 5% concentration was effective as compared to control and other extracts in reducing the whitefly and OYVMV disease incidence under field condition.

2.1.4. Studies on OYVMV in Bangladesh

In the ten years, annual report published individually by Anonymous (1980-1990) by the Division of Plant Pathology of Bangladesh Agricultural Research Institute, Joydevpur, Gazipur, included the works on survey, monitoring and screening of the viruse in respect to OYVMV. The transmission studies were also tried including the management through sowing date manipulation and insecticidal spray. However, the researchers so far concluded seem to be discontinuous and inconclusive.

Ahmed and Hossain (1985) made a survey on disease of crops with and view to establish a herbarium at Bangladesh Agricultural Research Institute (BARI), Joydevpur, Gazipur. The survey was conducted for three cropping seasons 1982-1983. 1983-1984 and 1984-85. Disease severity was worked out on 62 crops in nine districts of Bangladesh. In all cases, 296 diseases were recorded including okra yellow vein clearing disease as and commonly prevalent disease of okra.

An experiment was conducted by Sayeed (1988) in Bangladesh Agricultural University Farm, Mymensingh, with a Japanese okra cultivar, Pentagreen to find out the effects of date of planting and insecticidal spray on the control of *Yellow vein mosaic virus* of Lady‟s finger. Three sowing dates viz. 17 April, 1 May and 17 May were used. The results suggested that the incidence of *Yellow vein mosaic virus* was 25%, 48% and 56% in the first, second and third planting, respectively.

The effect of insecticides and planting dates on *Yellow vein mosaic virus* of Lady's finger were evaluated by Mian *et al.* (1990). They planted okra variety Penta green (Japanese variety) 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 insecticides, Bidrin was found to be the most effective followed by Ripcord in controlling the yellow vein mosaic of Lady's finger disease incidence. Sumithion used in their experiment was found ineffective. The authors recorded a pronounced effect of planting dates on the disease incidence as well as growth and yield of the crop. The lowest disease incidence was obtained in the first planting while it was the highest in the third sowing.

About 100% infection of Okra *Yellow Vein Mosaic Virus (YVMV)* in the okra in Bangladesh causing as high as 90% yield loss as reported by Akanda (1991). He performed ultra-structural studies of infected tissues and serology using antisera of 20 different viruses including *Mungbean yellow mosaic virus* and concluded that might be a member of Gemini virus group.

A study on the control of yellow vein mosaic of Lady"s finger in the experimental field Bangladesh Agricultural University, Mymensingh. The findings of the study showed an economic benefit though it was not successful enough to control the virus, Anonymous (1993).
Hossain *et al*. (1998) investigated the reaction of okra variety to *yellow vein mosaic virus (YVMV)* and biochemical changes in its infected leaf constituents. Okra cultivars BARI-1, Comilla, Pusa Shawny and local were evaluated for their reaction to *YVMV* reaction, particularly biochemical changes in leaf constituents in response to *YVMV*. BARI-1 had the lowest percentage leaf infection among the cultivars, while the highest disease incidence was observed in Pusa Shawny.

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

Rashid *et al.* (1999) reported the development of okra variety resistant to *Yellow vein clearing mosaic virus (YVCMV)* at Bangladesh Agricultural Research Institute, Joydevpur, Gazipur and released the variety named as BARI dherosh-1.

The name of the virus infecting okra plants producing scientific type of symptoms is recognized as *Okra Yellow Vein mosaic virus (OYVMV)* to accommodate all synonyms used for the virus as reported by Begum (2002).

Moniruzzaman, *et al*. (2007) conducted a research in 1997-1998 and found that the highest seed yield (2.97 t/ha) was recorded from 15 April sowing closely followed by 15 March sowing (2.77 t/ha) whereas the best quality seed was obtained from 16 February (88.7% germination and 29.75 seed vigour index) and 15 March (83.7% germination and 28.80 seed vigour index) sowing. Plant spacing of 60 × 40 cm produced the highest seed yield of okra (2.86 t/ha) followed by 60 × 30 cm spacing (2.80 t/ha). The germination percentage and seed vigour index were unaffected due to different plant spacings. 15 April sowing accompanied with 60 × 30 cm spacing.

CHAPTER 3

MATERIALS AND METHODS

MATERIALS AND METHODS

In this chapter, a short description of location of the experimental plot, climatic conditions of the area where the plot was situated, materials used for the experiment, treatments, design of the experiment and method of cultivation, data collection and statistical analysis have been presented.

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 with elevation of 9 meters above the sea level and have been presented in appendix-I.

3.2. Experimental duration

The experiment was carried out in Kharif-1 season during March to August, 2018.

3.3. Characteristics of soil

The soil of the experimental land was carried out in a 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 Tejgao soil series with a p^H -6.7 (Appendix Ⅲ).

3.4. Climate

The weather condition of the experimental field was under the sub-tropical monsoon climate, which is 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 33.7^0 C and the average minumum temperature was 20.4^0 C.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, Agargao, Dhaka and have been presented in (Appendix II)

3.5. Planting materials used for experiment

Okra variety namely Green Finger was used as planting material in the study. The seeds of okra was collected from local marcket (Figure 1).Picture of the planting material is given below:

Figure 1 : Green Finger used as planting material

3.6. Insecticides and mulch collection

There were four types of insecticides and three types of mulches were used in the experiment. The selected four insecticides viz. Imitaf, Protect, Tiddo Plus, Tebrine (Figure 2) and light reflecting color mulches (Figure 3) were collected from local market.

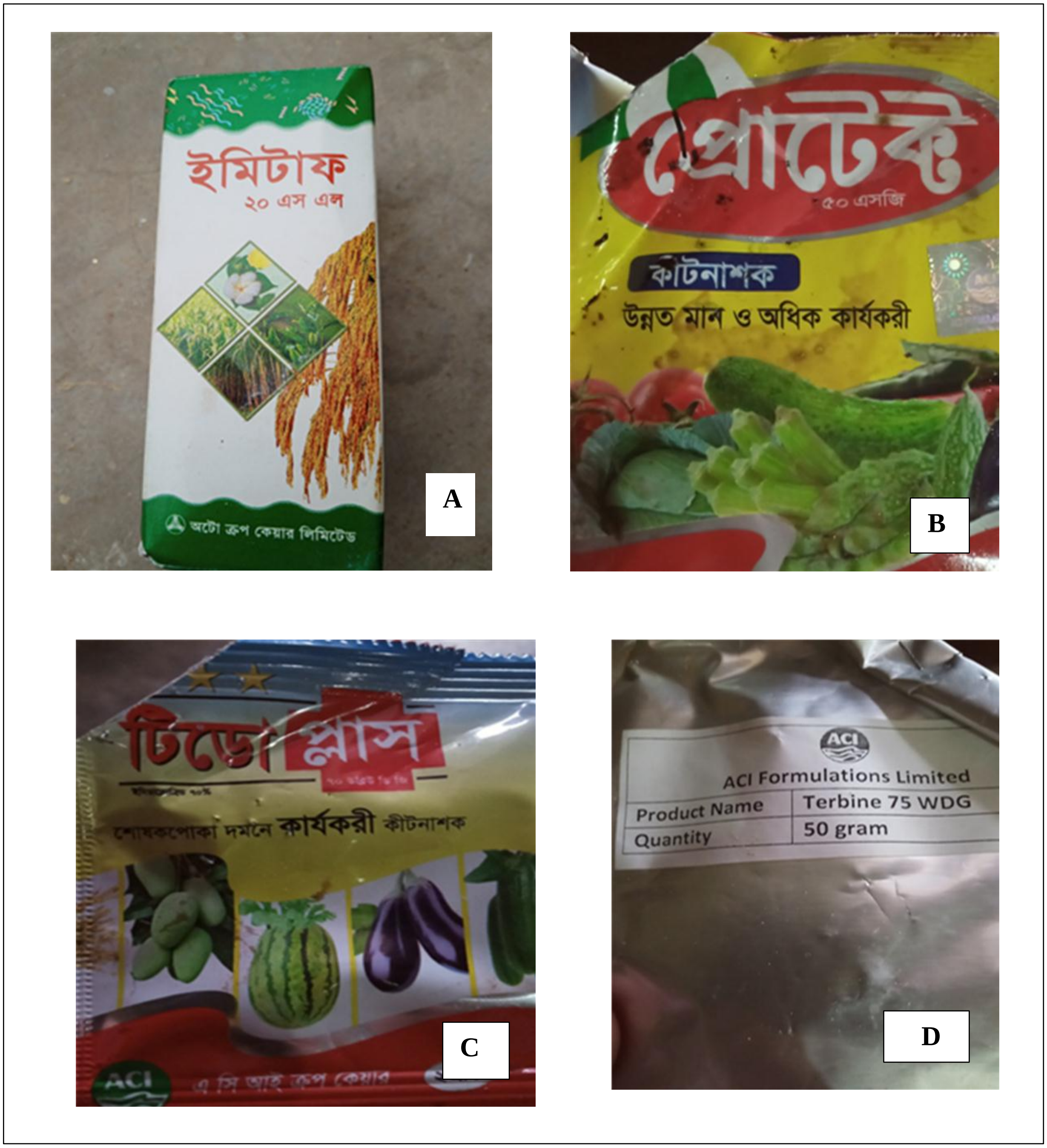


Figure 2: The selected four insecticides viz. Imitaf (A) and Protect (B), Tiddo Plus (C) and Terbine (D)

Figure 3: Light reflecting color mulches; silver colored mulch (A), red colored mulch (B) and black colored mulch (C)

3.7. Treatments of the experiment

Treatments were considered as following-

T_0 = control (no spray, no mulch)

T_1 =1 spray of Imitaf 20 SL @2.5ml/10L water

T_2 = 1 spray of Protect 50 SG @2.5ml/L water

T_3 =1 Spray of Tiddo Plus70 WDG @ 0.2g/L water

T_4 =1 Spray of Terbine 75 WDG @ 0.2 g/L Water

T_5 = Light reflecting silver color mulches

T_6 = Light reflecting red color mulches

T_7 = Light reflecting black color mulches

3.8. Experimental design

The experiment was laid out in a randomized complete block design (RCBD) in three blocks with three replications. There were eight treatments combination in each block, comprised 8 unit plot and total number of plots were 24 (8 X 3=24). Size of each unit plot was 6 m^2 and each plot contained 22 plants. The distance between unit plots was 0.70 m and block to 1 m.

3.9. Land preparation

The selected land for the experiment was first opened on 15 March 2018 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 Application

The following doses of manure and fertilizers were applied to the land for okra cultivation with the doses mentioned in table 1 (Anonymous, 1993). The whole amount of cow dung , TSP, MP and one third of urea were applied at the time of final land preparation .The rest amount of urea was applied as top dressing in two equal installments.

Table1. Doses of manures and fertilizers applied to the land for okra cultivation

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

3.11. Seed sowing

In this study, seeds were sown in three times, the first sowing was on 15th March, the second on 30th March and the third on 15th April, respectively. 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 and covered with fine soil. Before sowing, the okra seeds were soaked in water for overnight and then wrapped with a piece of thin cloth. Then the soaked seeds were dried on blotter paper for 3 hours to dry out the surface water. This treatment was done to help quick germination of seeds.

3.12. Intercultural operation

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.

3.13. Thinning, gap filling and irrigation

After seed germination, only one healthy seedling was kept in the pit through thinning out at 10 DAS. 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.

3.14. Weeding

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

3.15. Drainage

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

3.16. Mulching with light reflecting color mulches

The selected plots were covered with light reflecting color plastic mulch viz. white colored, red colored and black colored at 15 DAS. Mulches were used in this experiment in selected plot in three times sowing.

3.17. Spraying insecticides

Spraying was done with selected insecticides at 30 DAS. Water was also applied at the 30 DAS. The insecticides doses were given below:

Table 2: Doses of selected insecticides used for management of *Okra Yellow Vein Mosaic Virus* (OYVMV)

Insecticides	**Doses**
Imitaf 20 SL	2.5 ml/10 liters water
Protect 50 SG	2.5ml/L water
Tiddo Plus70 WDG	0.2g/L water
Terbine 75 WDG	0.2 g/L Water

3.18. Parameters assessed

In this study different kind of measures were taken. The following parameters were documented-

I. Disease incidence (%)

II. Number of leaves per plant

III. Number of infected leaves per plant

IV. Study of insect vectors association (vectors/leaf)

V. Number of flowers per plant

VI. Number of fruits per plant

VII. Fruit weight (Kg)

VIII. Yield (Kg)

IX. Plant height (cm)

X. Root length (cm)

3.19. Data Collection

The data were collected on different morphological parameters from the selected plants. Data over the parameters were taken in the following ways-

3.19.1. Identification of disease symptoms and estimation of disease incidence (%) of *Okra Yellow Vein Mosaic Virus* (OYVMV)

Based on studying of typical symptoms of *okra yellow vein 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.

Disease incidence (%) = $\frac{X1}{X}$ ×100

Where**,**
X= Total number of plants
X1= Number of infected plants

3.19.2. Number of leaves per plant

Calculating the total number of leaves per plant and the average number was recorded. For counting the leaves per plant, five (5) plants were selected randomly from each plot. Number of leaves in selected plants were recorded at 50, 65, 80 and 95 DAS. The smallest young leaves at the growing point of the plant were excluded.

3.19.3. Number of infected leaves per plant

Calculating the total number of infected leaves per plant and the average number was recorded. For counting the infected leaves per plant, five (5) plants were selected randomly from each plot. Number of infected leaves in selected plants were recorded at 50, 65, 80 and 95 DAS.

3.19.4. 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 selected 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 whitefly (Gupta, 2016)

3.19.5. Number of flowers per plant

Only the healthy flowers from the selected plants were counted at 50, 65, 80 and 95 DAS. The average number of flowers from each plant was recorded.

3.19.6. Number of fruit per plant

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

3.19.7. Fruit weight

Green pods were harvested from field regularly when they attained edible stage. Harvesting was started from 40 DAS, from the first harvest period fruit weight was taken of every tested plant and also calculated total plot fruit weight (kg).

3.19.8. Yield

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

3.19.9. Plant height

Average plant height of selected plants from each plot was recorded at 90 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).

3.19.10. Root length

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

3.20. Statistical analysis

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 4

RESULTS AND DISCUSSION

RESULTS

This chapter covers the experimental results. Eight (8) treatments with four insecticides viz. Imitaf, protect, tiddo plus, terbine and three types of light reflecting colored mulches such as silver, red, black color were assessed the performance to control the insect vectors of *Okra Yellow Vein Mosaic Virus* (OYVMV) under field condition. Results were compiled based on disease incidence (%), insect vectors association and morphological parameters at different days after sowing (DAS). One popular okra variety namely Green Finger was used as planting material.

4.1. Effect of sowing time and selected treatments on disease incidence of *Okra Yellow Vein Mosaic Virus* (OYVMV)

4.1.1. Effect of three different sowing time and selected treatment on disease incidence (%) of Okra *Yellow Vein Mosaic Virus* (OYVMV) at 40, 60 and 80 DAS

Seeds were sown in three times, the first sowing was done on 15th March, the second sowing on 30th March and the third sowing on 15th April, 2018 respectively. From the study it was observed that among the three different sowing dates, the highest disease incidence (7.50%) was recorded in 3rd sowing followed by 1st sowing (3.21%) and 2nd sowing (2.09%) at 40 DAS respectively. At 60 DAS, the highest disease incidence (22.15%) was recorded in 3rd sowing followed by 1st sowing (10.65%) and 2nd sowing (9.59%) respectively. It was noted that the disease incidence in 1st and 2nd sowing was statistically similar at 60 DAS. It was also observed that among the three different sowing dates, the highest disease incidence (59.00%) was recorded in 3rd sowing followed by 2nd sowing (23.59%) and 1st sowing (22.56%) at 80 DAS respectively. It was also noted that the disease incidence in 1st and 2nd sowing was statistically similar at 80 DAS. From above mentioned results, it was revealed that the highest disease incidence was recorded in 3rd sowing (on 15th April) in each of the observation. These results are presented in figure 5.

After providing the light reflecting colored mulches and one time application of selected insecticides viz. Imitaf 20 SL, protect 50 SG, Tiddo plus70 WDG and Terbine 75 WDG at 30 DAS, the disease incidence was estimated on the basis of typical symptoms of okra *Yellow Vein Mosaic Virus* **(**OYVMV) in young leaves of okra plants (Figure 4).

In the experiment it was observed that up to 40 DAS, there was no diseased plants plants were found in treatment plots which covered with light reflecting color mulches; silver color mulching (T_5), red color mulching (T_6) and black color mulching (T_7), and plots sprayed with insecticide Imitaf (T_1) one time. The experiment plots sprayed with Tiddo plus (T_3) and Protect (T_2) one time was showed the moderate disease incidence (2.38 % and 3.80 % respectively). The highest disease incidence (9.73 % and 6.18 %) was recorded in the control plots (T_0) and plots sprayed with terbine (T_4) one time respectively.

At 60 DAS, virus infected plants were found in all treatment plots. Among the treatments, the lowest disease incidence (3.62 %, 4.89 % and 7.02 %) was recorded in the plots which covered with light reflecting color mulches; silver color mulching (T_5), red color mulching (T_6) and black color mulching (T_7) respectively. Moderate disease incidence (14.81%, 15.01 %, 17.92 %, 18.55 %) was found in the plots which sprayed with selected insecticides viz. Protect (T_2), Imitaf (T_1), Terbine (T_4), Tiddo plus (T_3) one time, respectively. The highest disease incidence (31.22 %) was recorded in control plots (T_0).

In the experiment it was also observed that up to 80 DAS, the disease incidence results were showed in same trend as recorded at 40 and 60 DAS. The plots which covered with light reflecting color mulches; red color mulching (T_6), silver color mulching (T_5) and black color mulching (T_7) showed lowest disease incidence (11.48%, 12.72%, 16.83%) respectively. The moderate disease incidence (30.17 %, 30.72 %, 32.21 % and 34.45 %) was recorded in the plots which sprayed with selected insecticides viz. Terbine (T_4), Protect (T_2), Imitaf (T_1), Tiddo plus (T_3) one time, respectively. The highest disease incidence (58.50 %) was recorded in control plots (T_0).

These results are presented in Table 3.

Figure 4: Typical symptoms of OYVMV in infected leaves of okra plant

Disease incidence (%) was observed in three different sowing time in figure 5.

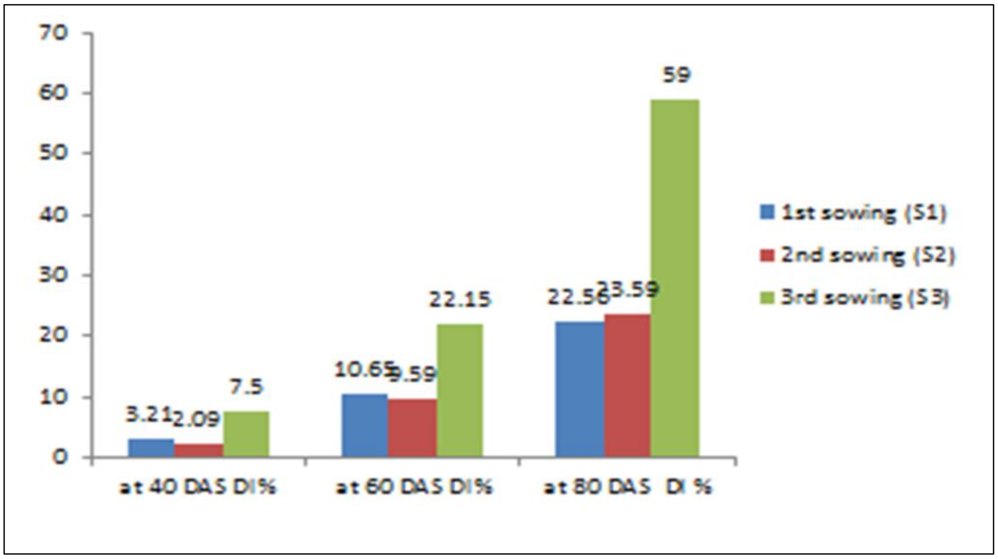


Figure 5: Effect of three different sowing time on the disease incidence of *Okra Yellow Vein Mosaic Virus* (OYVMV) at 40, 60 and 80 DAS

Table 3. Efficacy of selected insecticides and light reflecting colored mulches on the disease incidence of *Okra Yellow Vein Mosaic Virus* (OYVMV) at 40, 60 and 80 DAS

Treatment	Disease incidence (%)		
	at 40 DAS	at 60 DAS	at 80 DAS
T_0 = control (no spray, no mulch)	9.73 a	31.22 a	58.50 a
T_1 =1 spray of Imitaf	0.0 d	15.01 c	32.21 b
T_2 = 1 spray of Protect	3.80 b	14.81 c	30.72 c
T_3 =1 Spray of Tiddo Plus	2.38 b	18.55 b	34.45 b
T_4 =1 Spray of Terbine	6.18 c	17.92 b	30.17 c
T_5 = Silver color mulch	0 d	3.62 d	12.72 d
T_6 = Red color mulches	0 d	4.89 d	11.48 d
T_7 = Black color mulches	0 d	7.02 e	16.83 e
CV%	5.38	30.74	23.28
LSD(0.05)	3.37	2.28	5.39

4.1.2. Effect of three different sowing time and selected treatment on whitefly association per leaf of okra plant

The maximum number (12.00) of whitefly association per leaf was counted in third sowing (S_3) and minimum number (4.00) of whitefly association per leaf was counted in first sowing (S_1). In second sowing (S_2), whitefly association per leaf counted that was higher than 1st sowing (6.00) and less than 3rd sowing ($4 \geq 6 \leq 12$). Results of white fly association are presented in figure 5.

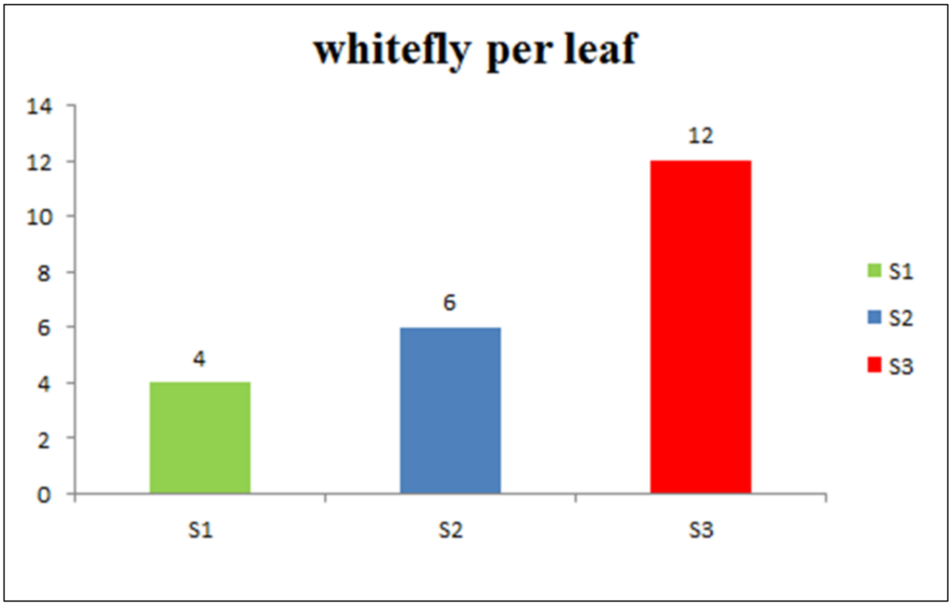


Figure 6: Whitefly association per leaf at different sowing time

The minimum number of whitefly (4.00, 4.33, 5.00) per leaf was recorded in the plants from the plots which covered with light reflecting colored mulches; red color mulch (T_6), silver color mulch (T_5) and black color mulch (T_7) respectively, and one time sprayed with Terbine (T_4). The moderate number whitefly association per leaf (6.33, 6.35 and 7.35) was recorded from the plants of plots which sprayed with selected insecticides Imitaf (T_1), Tiddo plus (T_3), Protect (T_2) one time (Table 5). The maximum number (12.00) of whitefly association per leaf was counted in plants of control plots (T_0). Results of white fly association are presented in table 4.

Table. 4: Efficacy of selected insecticides and light reflecting colored mulches on whitefly association per leaf

Treatment	**Whitefly association/leaf**
T_0 = control (no spray, no mulch)	12.00 a
T_1 =1 spray of Imitaf	6.33 c
T_2 = 1 spray of Protect	7.35 b
T_3 =1 Spray of Tiddo	6.35 c
T_4 =1 Spray of Tebrine	5.00 d
T_5 = Silver color mulch	4.33 d
T_6 = Red color mulches	4.00 d
T_7 = Black color mulches	5.00 d
CV%	2.35
LSD(0.05)	0.96

4.2. Effect of different sowing time and selected treatments on morphological features of okra plant against *Okra Yellow Vein Mosaic Virus* (OYVMV)

4.2.1. Number of leaves per plant

The maximum number (22.63) of leaves per plant was counted in first sowing (S_1) and minimum number (14.09) of leaves per plant was counted in third sowing (S_3). In second sowing (S_2), moderate number (15.40) of leaves per plant observed that was lower than 1^{st} sowing (22.63) but higher than 3^{rd} sowing (14.09). These results are presented in Table 5.

Among the treatments, the maximum number of leaves (20.56, 19.96, 19.60, 19.16, 19.15) per plant was recorded in the plants from the plots which covered with light reflecting colored mulches; red color mulch (T_6), black color mulch (T_7) and silver color mulch (T_5) respectively and one time sprayed with Terbine (T_4) and Tiddo Plus (T_3) was (21.15, 19.15).The moderate number of leaves (15.10, 12.24) per plant was recorded from the plants of plots which sprayed with selected insecticides protect (T_2), Imitaf (T_1) The minimum number of leaves (10.24) per plant was counted in the T_0 (control) condition. These results are presented in Table 6.

4.2.2. Number of flower per plant

The maximum number (26.89) of flowers per plant was counted in first sowing (S_1) and minimum number (11.89) of flowers per plant was counted in third sowing (S_3). In second sowing (S_2), moderate number (16.96) of flowers per plant observed that was lower than 1^{st} sowing (26.89) but higher than 3^{rd} sowing (16.96). These results are presented in Table 5.

Among the treatments, the maximum number (22.98, 20.64, 19.00) of flowers per plant was recorded in the plants from the plots which one time sprayed with selected insecticides Terbine (T_4), Tiddo Plus (T_3) and Protect (T_2). The moderate number (18.18, 17.84, 17.51, 17.00) of flowers per plant was recorded in the plants from the plot covered with light reflecting colored mulches; red color mulch (T_6), one time spray of Imitaf (T_1), black color mulch (T_7) and silver color mulch (T_5) respectively. The minimum number of flowers (15.51) per plant was counted in the control condition (T_0) These results are presented in Table 6.

4.2.3. Number of fruit per plant

The maximum number (22.73) of fruits per plant was counted in first sowing (S_1) and minimum number (9.27) of fruits per plant was counted in third sowing (S_3). In second sowing (S_2), moderate number (13.50) of fruits per plant observed that was lower than 1^{st} sowing (22.63) but higher than 3^{rd} sowing (9.27). These results are presented in Table 5.

Among the treatments, the maximum number of fruit (20.00) per plant was counted in Terbine (T_4). The minimum number of fruit (12.18) per plant was counted in the T_0 (control) condition. The moderate number of fruits (17.67, 15.49, 15.23, 14.79, 14.49, 14.18) per plant was recorded in the Tiddo Plus (T_3), red color mulch (T_6), Protect (T_2), silver color mulch (T_5), black color mulch (T_7) and Imitaf (T_1). The results are presented in table 6.

Table 5: Effect of three different sowing time on the leaf number, flower and fruit per plant

Sowing time	No. of leaf / plant	No. of flower /plant	No. of fruit / plant
1st sowing (S^1)	22.63 a	26.89 a	23.73 a
2nd sowing (S^2)	14.39 b	16.96 b	13.50 b
3rd sowing (S^3)	15.09 b	11.89 c	9.27 c
CV%	10.18	10.18	12.85
LSD(0.05)	2.02	2.16	3.54

Table 6: Efficacy of selected treatments and light reflecting colored mulches on the leaf number, flower and fruit per plant

Treatment	No. of leaf/plant	No. of flower/plant	No. of fruit/plant
T_0 = control (no spray, no mulch)	10.24 d	15.51 b	12.179d
T_1 = 1spray of Imitaf	12.24 cd	17.84 ab	14.18 c
T_2 =1spray of Protect	15.10 bc	19.00 ab	15.23 b
T_3 = 1spray of Tiddo Plus	19.16 abc	20.64 ab	17.67 b
T_4 = 1 spray of Terbine	21.15 a	22.98 a	20.00 a
T_5 = Silver color mulch	19.60 abc	17.00 b	14.78 c
T_6 = Red color mulches	20.56 ab	18.18 b	15.49 c
T_7 = Black color mulches	19.94 abc	17.51 ab	14.49 c
CV%	10.18	10.18	12.85
LSD(0.05)	3.14	3.36	3.54

4.2.4. Yield (kg/ plant)

In first sowing (S_1), maximum yield (0.73 kg) per plant was observed. In second sowing (S_2), yield (0.72 kg) per plant was recorded. In third sowing (S_3), minimum yield (0.67 kg) per plant was observed. Among the three different sowing time, comparatively in third sowing (S_3) yield per plant (kg) was less. Because of different sowing time, yield per plant was (kg) varied respectively. The results are presented in table 7.

Among the treatments, the highest yield (0.92 kg , 0.87 kg, 0.82 kg , 0.81 kg , 0.72 kg) per plant was recorded in the T_6 (red color mulching),T_7 (black color mulching), Terbine (T_4), silver color mulching (T_5) and T_3 (Tiddo plus). The lowest yield (0.40 kg) per plant was recorded in the control condition (T_0). The moderate yield (0.66 kg, 0.61 kg) per plant was recorded from the plants which sprayed with Imitaf (T_1) and Protect (T_2) .The results are presented in table 8.

4.2.5. Yield (kg/plot)

Maximum yield (3.88 kg, 3.86 kg) per plot was recorded in first sowing (S_1) and second sowing (S_2). In third sowing (S_3), minimum yield (2.19 kg) per plot (kg) was observed. Among the three different sowing time, comparatively in 3rd sowing (S_3) yield per plot (kg) was less than the 1st sowing and 2nd sowing. Because of different sowing time, yield (kg) per plot was varied respectively. The results are presented in table 7.

The highest yield (4.85 kg, 4.71 kg, 4.08 kg) per plot was recorded from the plots which covered with light reflecting color mulches; red color mulching (T_6), black color mulching (T_7) and silver color mulching (T_5). The lowest yield (1.23 kg) per plot was recorded in the control condition (T_0). The moderate yield (3.18 kg , 3.09kg, 2.83 kg, 2.54 kg) per plot was obtained from the plots which sprayed with selected insecticides; Terbine (T_4), Tiddo plus (T_3), Protect (T_2) and Imitaf (T_1) .The results are presented in table 8.

Table 7: Effect of three different sowing time on yield

Sowing time	Yield per plant (kg)	Yield per Plot(kg)
1st sowing (S^1)	0.73 a	3.88 a
2nd sowing (S^2)	0.72 a	3.86 a
3rd sowing (S^3)	0.67 b	2.19 b
CV%	18.28	23.35
LSD(0.05)	0.02	0.88

Table 8: Efficacy of selected treatments and light reflecting colored mulches on yield

Treatment	Yield per plant (kg)	Yield per plot (kg)
T_0 = control (no spray, no mulch)	0.40 d	1.23 d
T_1 = 1 spray of Imitaf	0.66 c	2.54 c
T_2 = 1spray of Protect	0.61 c	2.83 c
T_3 = 1spray of Tiddo Plus	0.72 b	3.09 b
T_4 = 1spray of Terbine	0.82 b	3.18 b
T_5 = silver color mulch	0.81 a	4.08 a
T_6 = red color mulches	0.92 a	4.85 a
T_7 = black color mulches	0.87 a	4.71 a
CV%	18.28	23.35
LSD(0.05)	0.023	1.37

4.2.6. Plant height (cm)

In first sowing (S_1), maximum plant height (105.84) was observed. In second sowing (S_2), plant height (85.92) was recorded. In third sowing (S_3), minimum (74.18) was observed. Among the three different sowing, comparatively in third sowing (S_3) plant height per plant was less than the 1st sowing and 2nd sowing. Because of different sowing time, plant height per plant was varied respectively. The results are presented in table 9.

For treatments, the maximum plant height (95.86 cm, 95.35 cm, 94.36 cm, 92.78 cm) was measured in red color mulching (T_6), terbine (T_4), tiddo plus (T_3) and black color mulch

(T_7). The minimum plant height (74.13 cm) was measured in control condition (T_0). The moderate plant height (89.65 cm, 89.08 cm , 77.97cm) was observed in silver color mulching (T_5), Imitaf (T_1) and Protect (T_2). This data were statistically different with each other. The results are presented in table 10.

Table 9: Effect of three different sowing time on plant height (cm) and root length (cm)

Sowing time	Plant height (cm)	Root length (cm)
1st sowing (S^1)	105.84 a	30.71 a
2nd sowing (S^2)	85.92 b	20.73 b
3rd sowing (S^3)	74.18 c	14.40 c
CV%	10.89	12.23
LSD(0.05)	11.07	3.07

Table 10: Efficacy of selected insecticides and light reflecting colored mulches on plant height (cm) and root length (cm)

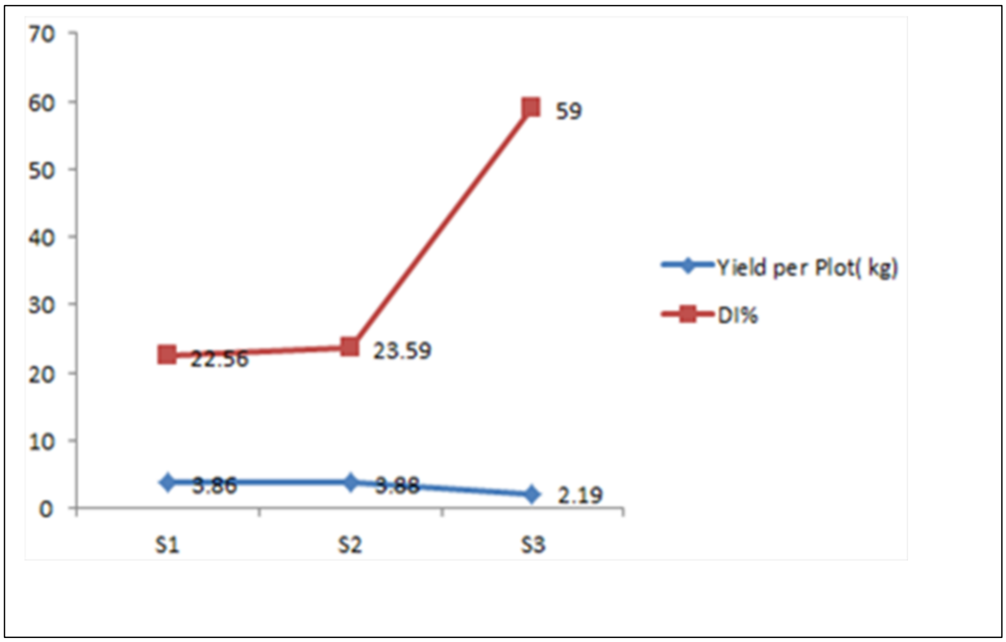
Treatment	Plant height (cm)	Root length (cm)
T_0 = control (no spray, no mulch)	74.13 c	18.56d
T_1 = 1 spray of Imitaf	89.08 b	19.73c
T_2 = 1spray of Protect	77.97 c	19.51c
T_3 = 1spray of Tiddo Plus	94.36 a	22.00b
T_4 = 1spray of Terbine	95.35 a	23.93b
T_5 = silver color mulch	89.65 b	24.13a
T_6 = red color mulches	95.86 a	24.11a
T_7 = black color mulches	92.78 a	23.62b
CV%	10.89	12.23
LSD(0.05)	7.88	4.77

4.3. Effect of sowing time in relationship between disease incidence (%) and yield/plot (kg)

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 between disease incidence and yield**.** When disease incidence is increased, the yield of okra is also decreased. It was evident from the Figure 7.

DI

(%)



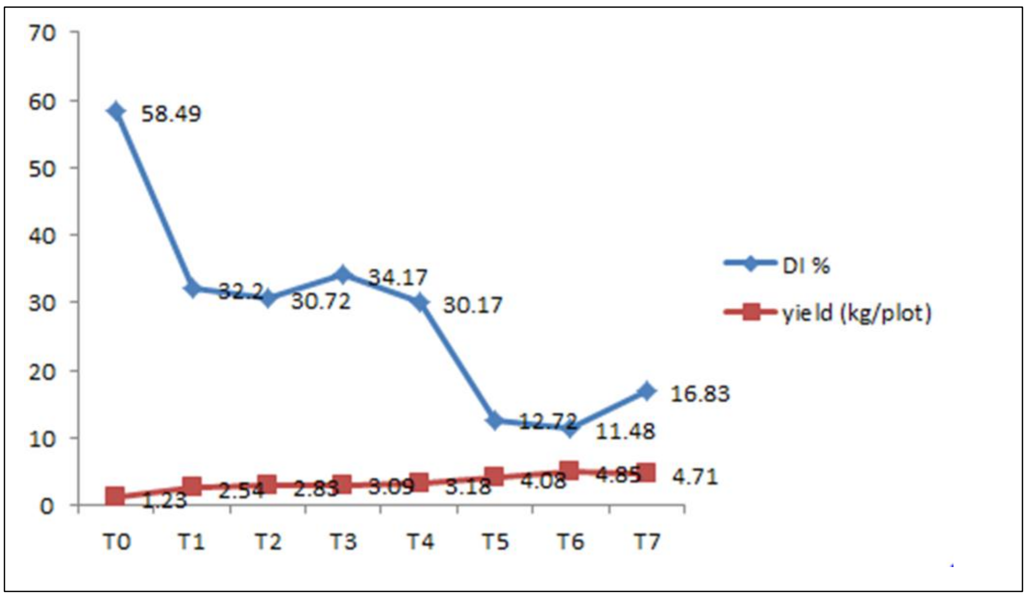
Sowing time

Figure 7: Relationship between disease incidence (%), yield and sowing time

4.4. Effect of different treatments in relationship between disease incidence (%) and yield/plot (kg)

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 between disease incidence and yield**.** When disease incidence is increased, the yield of okra is also decreased. It was evident from the Figure 8.

DI (%)



Treatment

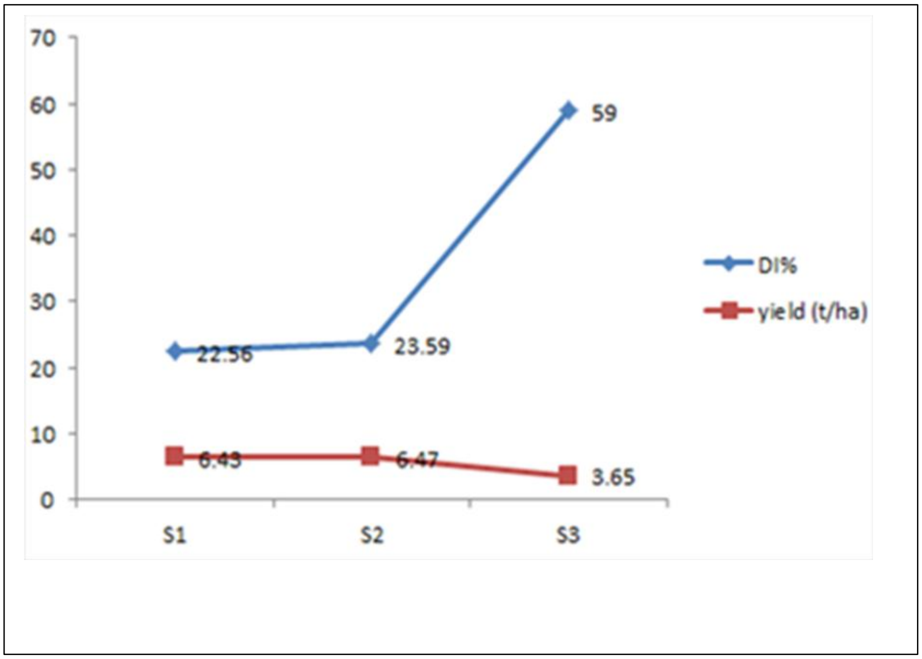
Figure 8: Relationship between disease incidence (%), different treatments and yield

4.5. Effect of sowing time in relationship between disease incidence (%) and yield (t/ha)

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 between disease incidence and yield**.** When disease incidence is increased, the yield of okra is also decreased. It was evident from the Figure 9.

DI

(%)



Sowing time

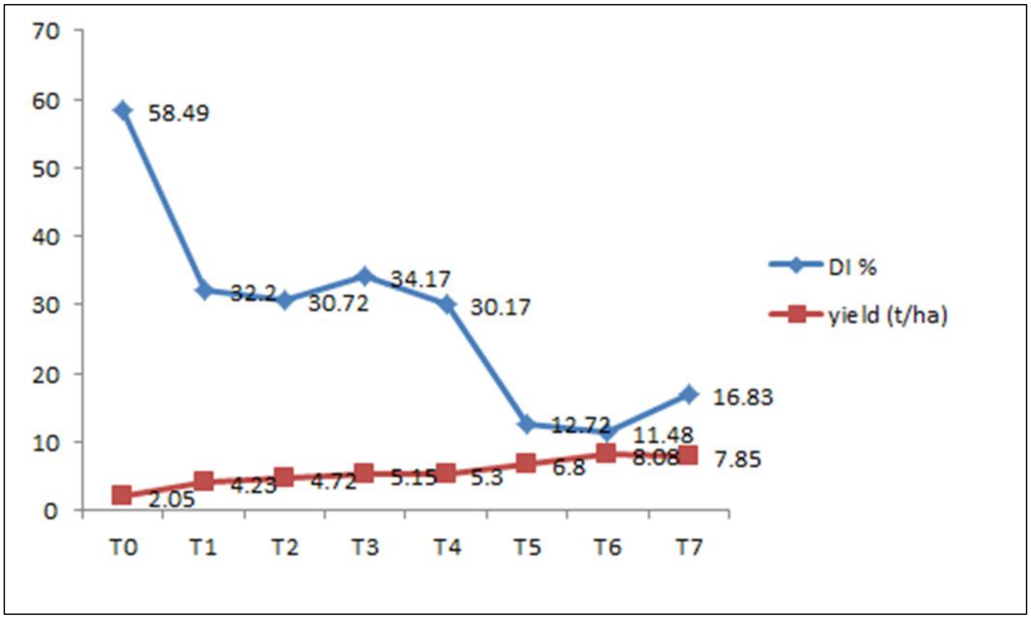
Figure 9: Relationship between disease incidence (%), different sowing time and yield (t/ha)

4.6. Effect of different treatments in relationship between disease incidence (%) and yield (t/ha)

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 between disease incidence and yield**.** When disease incidence is increased, the yield of okra is also decreased. It was evident from the Figure 10.

DI

(%)



Treatment

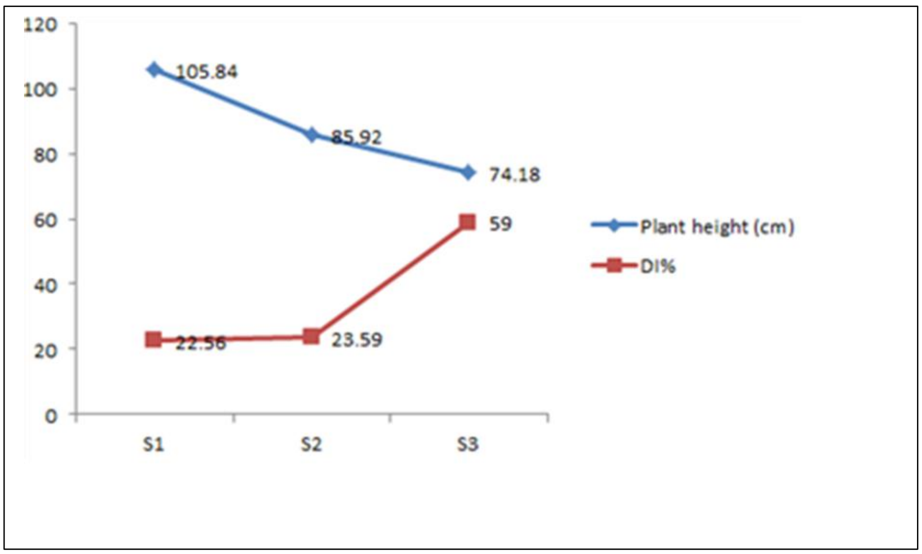
Figure 10: Relationship between disease incidence (%), different treatments and yield (t/ha)

4.7. Effect of sowing time in relationship between disease incidence (%) and plant height (cm)

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 between disease incidence and yield. When disease incidence is increased, the plant height of okra plant is also decreased. It was evident from the Figure 11.

DI

(%)



Sowing time

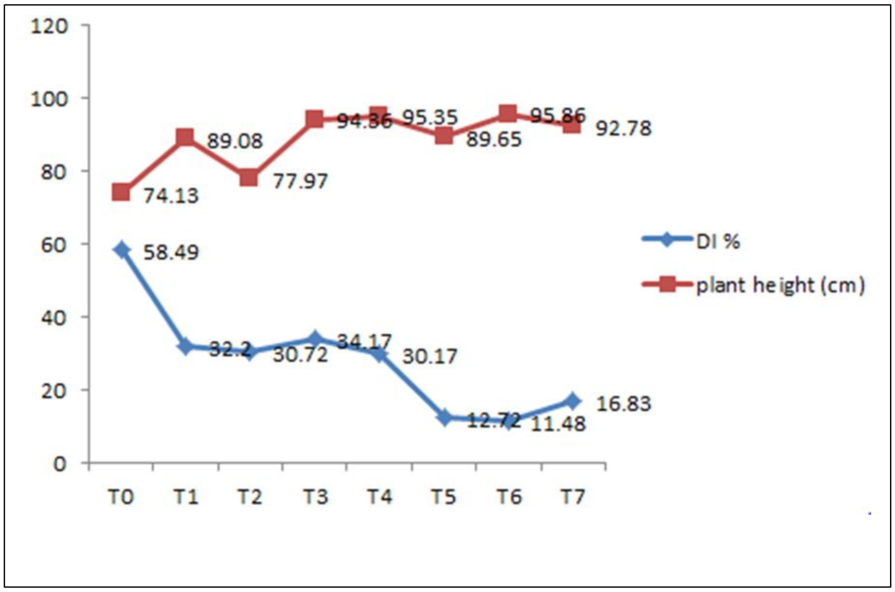
Figure 11: Relationship between disease incidence (%), different sowing time and plant height (cm)

4.8. Effect of different treatments in relationship between disease incidence (%) and plant height (cm)

The relationship between disease incidence and plant height of okra plants was also studied. From the study it was revealed that there is inverse relation between disease incidence and plant height**.** When disease incidence is increased, the plant height of okra is also decreased. It was evident from the Figure 12.

DI

(%)



Treatment

Figure 12: Relationship between disease incidence (%), different treatments and plant height (cm)

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 54.901 thousand metric tons from 28.106 thousand hectares of lands (BBS, 2017).In this study one popular okra variety namely Green finger was used. The main target of this study was to minimize the insecticide used to control the insect vector of OYVMV.

4.9. Effect of sowing time on disease incidence (%) of *Okra Yellow Vein Mosaic Virus* (OYVMV)

In this study, effect of time sowing was applied to manage the *Okra Yellow Vein Mosaic Virus* by controlling the insect vectors white fly of this viral disease. The disease incidence (%) was estimated at 40, 60 and 80 DAS. It was noticed that the disease incidence (%) was varied in all investigation of three different sowing time. The highest disease incidence (%) was estimated in 3rd sowing (on 15 April) but the disease incidence was (%) less in 1st sowing (on 15 March) and 2nd sowing (on 30 March). The result of the present study is in accordance with the results of Sujat,(2006) okra seeds were sown late gave lower yield than planting early.

4.10. Effect of insecticides and colored mulches on disease incidence (%) of *Okra Yellow Vein Mosaic Virus* (OYVMV)

In this study, four selected insecticides and three light reflecting colored mulches were used to manage the *Okra yellow vein mosaic virus* via controlling the insect vectors white fly. The disease incidence (%) was estimated at 40, 60 and 80 DAS. It was noticed that the disease incidence (%) due to *Okra Yellow Vein Mosaic Virus* was varied in all treatments plots in each of observation. Among the treatments, the lowest disease incidence (%) was recorded in the plots which covered with red color mulch. This treatment was combined with sowing time, it gave the best result in controlling the insect vectors white fly. It was also noticed that among the selected insecticides, Imitaf and Terbine also showed the best performance with combination of sowing time in controlling the insect vectors whitefly. The highest disease incidence (%) was estimated in control plots in case of all sowing time. The result of the present study is in accordance with the results of Sayed *et al.,* (2018) when they used imidacloprid as single spray combined with mulch gave best result. This is due to presence of lower number of insect vectors white fly. So considering the economic condition/cost-benefit ratio, red color mulch gave the best result among the selected treatments. The present study is also accordance with the result of Kareem, (2012), they found that Plastic mulch produced the highest yield and the mulches especially plastic are effective in controlling okra mosaic virus (OMV).

4.11. Effect of sowing time and selected treatments on whitefly association per leaf

The minimum number of whitefly per leaf was recorded in first sowing (S^1) and second sowing (S^2).The maximum number of whitefly per leaf was recorded in third sowing (S^3). The minimum number of whitefly per leaf was recorded in the plots which covered with light reflecting silver color mulching (T_5).The maximum number of whitefly per leaf was recorded in control plants. So, light reflecting silver color mulching combined with early sowing was unfavorable for whitefly infestation. Early infection of insect vectors whitefly 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 (OYVMV) via insect vectors, condition of growing seedlings and okra varieties. Ojiako , (2018) concluded that okra cultivated with plastic mulch reduced insect pests and produced healthier plants.

4.12. Effect of different sowing time and selected treatments on morphological features of okra plant

The yield of individual sowing depends on the number of leaves, flowers and fruits per plant. The highest number of leaves, flowers and fruits per plant was recorded in first sowing (S^1) and second sowing (S^2).The lowest number of leaves, flowers and fruits per plant was recorded in the third sowing(S^3). Time sowing effect can increase the leaves, flowers and fruits per plant. The maximum number of leaves, flowers, fruits per plant was recorded in the plots which covered with light reflecting silver color mulching (T_5) and red color mulching (T_6) and the plots sprayed with Terbine (T_4). The minimum number of leaves, flowers, fruits per plant was recorded in control condition (T_0). So, light reflecting silver color mulching and red color mulching combined with early sowing was favorable for okra production. Khan, (2000) studied that late sowing gave less plant population and gave less leaf, flower and fruits.

4.13. Effect of different sowing time and treatments on yield and yield contributing characters of okra plant

The highest yield per plant and plot was recorded in first sowing (S^1) and second sowing (S^2). Considering the economic condition/cost-benefit ratio only early sowing gave the best result regarding in yield and yield contributing characters. Where the lowest yield per plant and per plot was recorded in third sowing (S^3). The research was conducted by Moniruzzaman, *et. al.*, (2007), Seeds sown in either 15 February or 15 March produced the best quality seed (88.7% and 83.7% germination, 29.75 and 28.80 vigour index, respectively), whereas 15 April and 15 May sowings produced inferior seed (70% and 72.9% germination 18.75 and 23.75 vigour index, respectively). The highest germination percentage and seed vigour index was obtained from 15 February and 15 March. The present findings are same to Moniruzzaman and Uddin (2007) who recommended that the highest germination percentage and seed vigour index was obtained from 15 February and 15 March sowing because the fruits faced lower amount of rainfall during their harvesting period compared to others. This same results were agreed with the recent study. The highest yield per plant and plot was recorded in the plots which covered with light reflecting silver color mulching (T_5) and red color mulching (T_6). The highest yield per plant and plot was also recorded in the plots which covered with light reflecting black color mulching (T_7). Considering the economic condition/cost-benefit ratio maintaining sowing time along with three different types of mulch gave the best result regarding in yield and yield contributing characters. Among the insecticides, Terbine (T_4) also gave highest yield. Where the lowest yield per plant and plot was recorded in control condition (T_0). Almost same results were found in recent study that was conducted by Sayed, (2018). There is no more previous report over yield of okra against OYVMV in our country.

4.14. Effect of different sowing time and treatments on plant height and root length of okra plant

The maximum plant height and root length was recorded in first sowing (S^1) and second sowing (S^2). The minimum plant height and root length was recorded in third sowing (S^3). The maximum plant height and root length was recorded in the plots which covered with light reflecting silver color mulching (T_5), red color mulching (T_6) and black color mulching (T_7). The maximum Plant height and root length was also recorded in the plots which sprayed with insecticides Terbine (T_4), Tiddo plus (T_3) and Imitaf (T_1). The minimum plant height and root length was recorded in control condition (T_0). So, light reflecting silver, red, black color mulching combined with early sowing was favorable for maximum plant height. The result is accordance with Khan, (2000) and he studied that late sowing gave minimum plant height.

CHAPTER 5

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

A study on okra was carried out at the central farm of Sher-e- Bangla Agricultural University, Dhaka-1207, during March to August, 2018 with normal agronomic practices. The study was to investigate the time sowing effect on disease incidence of *Okra Yellow Vein Mosaic Virus* (OYVMV) in selected okra variety, and to evaluate the effect of selected treatments; only one time spraying with selected insecticides and cover with light reflecting colored mulches to control the insect vector whitefly. Yield and yield contributing characters, morphological and physiological features of okra plant that changes due to disease infection which cause damages in okra production and reduce the fruit quality as well as market value was also the part of this study. A widely cultivated hybrid okra variety namely green finger was used as a planting material. Four selected insecticides viz. Imitaf, Protect, Tiddo plus and Terbine were sprayed one time in selected plots. Three (3) light reflecting colored mulches viz. silver color mulch, red color mulch and black mulch, were used to cover the selected plots. Seeds were sown in three different sowing time at an interval 15 days such as 1st sowing on 15 March (S^1), 2nd sowing on 30 March (S^2) and 3rd sowing on 15 April (S^3).The experiment was carried out in Randomized Complete Block Design (RCBD). The insecticides were sprayed only one time at 30 DAS. It was observed that among the three different sowing time, the lowest disease incidence (22.56%) was found in 1st sowing (on 15 March) and the highest disease incidence (59.00%) was found in 3rd sowing (on 15 April) at 80 DAS. In 2nd sowing (on 30 March), the disease incidence (23.59%) was found moderate. It was also investigated that among the selected treatments, the lowest disease incidence was estimated from the plots that covered with red colored mulch and one time sprayed with insecticide, Terbine that was 11.48% and 30.17% respectively, at 80 DAS. The highest disease incidence (58.50%) was recorded in control condition.

In case of morphological parameters; the highest number of leaves, flowers and fruits per plant was recorded in first sowing (on 15 March) that was 22.63, 26.89 and 23.731 per plant respectively. Among the light reflecting colored mulches, the highest number of leaves, flowers and fruits per plant was recorded in the plots that covered with red color mulch (T_6) that was 20.56, 18.18 and 15.49 respectively, up to last harvesting. Among the different selected insecticides, the highest number of leaves flowers and fruits per plant was recorded in the plots that sprayed one time with Terbine (T_4) that was 21.15, 22.98 and 20.00 respectively.

Yield and yield contributing characters showed significant variation among the three different sowing times and selected treatments. The highest yield per plant (0.73 kg) and plot (3.88 kg) was obtained in first sowing. Among the light reflecting color mulches, the highest yield per plant (0.92 kg) and plot (4.85 kg) was obtained in the plots that covered with red colored mulch (T_6) and among the selected insecticides, the highest yield per plant (0.82 kg) and plot (3.18 kg) was obtained in the plots that sprayed one time with Terbine (T_4).The highest plant height was found in first sowing (S^1) and second sowing (S^2) that was 105.84 cm and 85.92 cm respectively. Among different light reflecting colored mulches, the highest plant height (95.86 cm) was found in red color mulched plots (T_6) and among different insecticides, the highest plant height (95.35 cm) was found in plots that was sprayed with Terbine (T_4) one time. In the relationship study, it was noticed that the yield and plant height showed negative relationship with disease incidence. The yield and plant height decreased with the increased of percent disease. From the study, it may conclude that the month March is suitable for okra seeds sowing to avoid the insect vectors and to get the best okra production. Among the treatments, the red color mulch and one time spray with Terbine gave the better performance in controlling the insect vectors whitefly. However, considering the all measuring parameters, for cultivation of okra in Kharif-1 season early sowing, one time spray with Terbine and used red color mulch may be recommended as management approaches of *Okra Yellow Vein Mosaic Virus* (OYVMV).

CHAPTER 6
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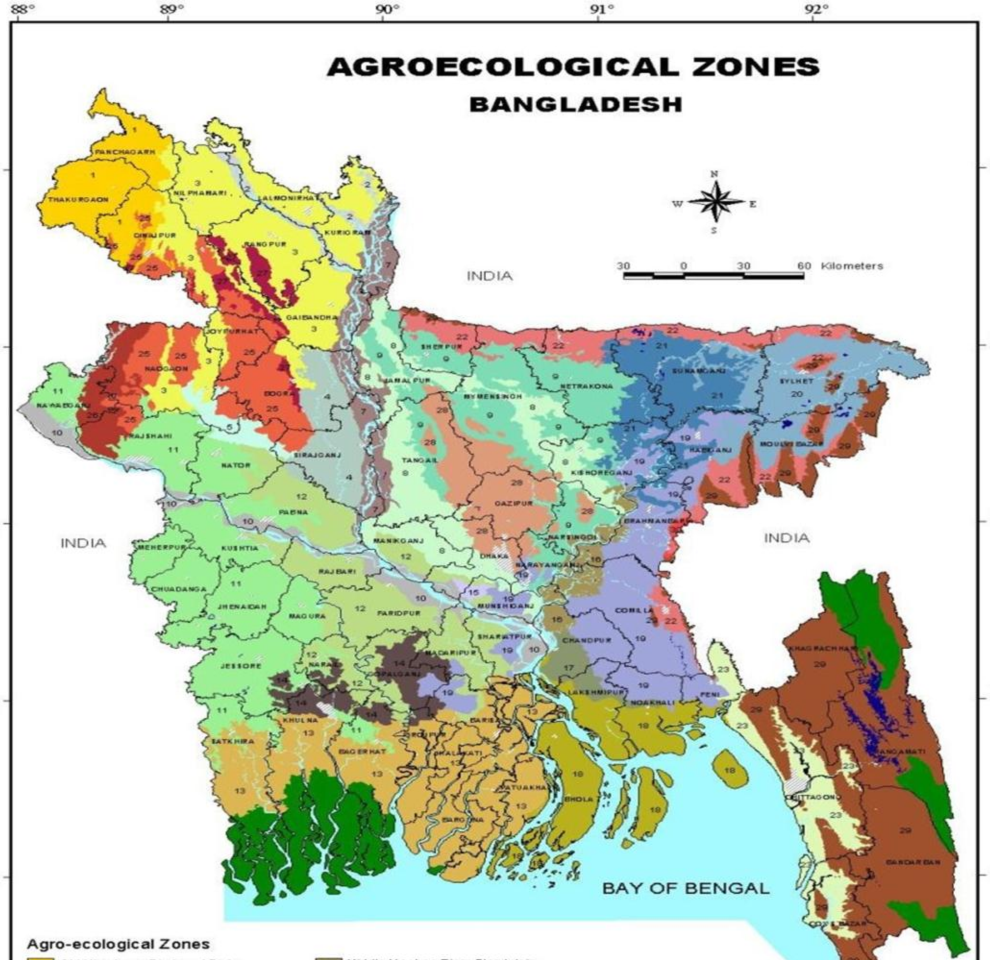
APPENDIX

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 2018)

Month	Average RH (%)	Average Temperature (^0C)		Total Rainfall (mm)	Average sunshine Hours
		minimun	maximum		
March	38	20.4	32.5	65.8	12
April	42	23.6	33.7	156.3	12.7
May	59	24.5	32.9	339.4	13.3
June	72	26.1	32.1	340.4	13.6
July	72	26.2	31.4	373.1	13.4
August	74	26.3	31.6	316.5	12.9

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	28.43
(me/100 g soil)	0.05
Sulphur (μg/g soil)	2.31
Boron (μg/g soil)	
Zinc (μg/g soil)	

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

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Author	SURAIYA JITU
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