EVALUATION OF DIFFERENT DOSES OF TWO SELECTED INSECTICIDES FOR CONTROLLING THE INSECT VECTOR (WHITE FLY) OF *OKRA YELLOW VEIN MOSAIC VIRUS (OYVMV)*

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CERTIFICATE

This is to certify that thesis entitled," **EVALUATION OF DIFFERENT DOSES OF TWO SELECTED INSECTICIDES FOR CONTROLLING THE INSECT VECTOR (WHITE FLY) OF *OKRA YELLOW VEIN MOSAIC VIRUS (OYVMV)"*** *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 Md. Hasibur Rahman* bearing *Registration No. 10-03932 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma in any institute.*

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

Dated: June, 2017
Dhaka, Bangladesh

Dr. Md. Belal Hossain
Supervisor


Dedicated To
My Beloved Parents

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ABSTRACT

A field experiment on okra was conducted at the Field Laboratory, Department of Plant Pathology, Sher-e- Bangla Agricultural University, Dhaka-1207, during March to July, 2016. The aim of the study was to evaluate the performance of two selected insecticides viz. Imitaf and ACmix in different spray schedules (1-6 sprays) against *Yellow vein mosaic virus* (*YVMV)* of okra for controlling the insect vectors. The treatments were T_0 (control/no spray), T_1 (1 spray), T_2 (2 spray), T_3 (3 spray), T_4 (4 spray), T_5 (5 spray) and T_6 (6 spray). The insecticides spraying started from 20 DAS (days after sowing) and continued with 5 days interval. The lowest percent disease incidence was recorded in T_6 (15.98%, 16.71%) at 95 DAS respectively for Imitaf and ACmix. The highest percent disease incidence was found in T_0 (88.21% and 89.27% respectively). In case of morphological features; number of leaves, flowers and fruits per plant was also recorded the highest in T_6 (50.00, 29.00, 28.33 for Imitaf and 50.33, 30.00, 30.00 for ACmix) up to last harvesting. In case of yield and yield contributing characters, significant variation was found among the treatments. The highest yield per plant and plot was recorded in T_6 (6 sprays) treatment in case of both the insecticides application (0.83kg/plant, 15.44 kg/plot for Imitaf and 0.82kg/plant, 15.04 kg/plot for ACmix). The highest plant height was recorded in T_6 in both experiment (129.92 cm and 127.51 cm respectively). In case of physiological features, the highest chlorophyll content was also measured the highest in T_6 (57.93 μ mol $m^{-2}s^{-1}$ and 56.55 μ mol m^{-2} s^{-1}, respectively). Plant height and yield showed the positive relationship with chlorophyll content and percent disease incidence showed negative relationship with chlorophyll content. The yield of okra was decreased with the increase of percent disease incidence. However, considering the fungicidal cost, T_4 (4 sprays) was the best in case of all measuring parameters.

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LIST OF ACRONYMS

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

INTRODUCTION

Okra (*Abelmoschus esculentus* L. Moench) is the member of Malvaceae family and known as Lady's finger. It is locally known as "dherosh" or "bhindi" in the different area of our country. It is an annual vegetable crop grown from seed in tropical and sub-tropical areas over the world. Okra may be originated in tropical Africa or in tropical Asia, and is now widely grown throughout the tropics. The crop is very well distributed over the Indian subcontinent and East Asia (Rashid, 1999). Its tender green fruits are popular as vegetables among all classes of people in Bangladesh and in abroad. In Bangladesh, vegetable production varies round the year. Most of the vegetables are grown in the winter season, but very low amount in the summer; around 30% of the total vegetables are grown in the kharif season, while 70% grown in the Rabi season (Anon, 1993). Okra production is mainly concentrated during the summer season. But it is also grown in winter season in Bangladesh. Its tender pods are eaten as vegetables, stewed with meat, used to make soup and also canned and dried for different purposes.

Okra is a very nutritious and delicious vegetable, also rich in vitamins and minerals (Kushak *et al.*, 2003).Per 100gm edible portion of pod has moderate levels of vitamin A (0.01 mg) and vitamin C (18 gm), calcium (90 mg), phosphorus and potassium. The content of niacin (0.08 mg), riboflavin (0.08 mg) and thiamine (0.07 mg) per 100 gm edible portion of pod is higher than any others vegetables (Rashid, 1999). It is the very good sources of gum, starch, spice etc. Okra is also useful against genito-urinary disorders, spermatorrhoea and chronic dysentery. It is effective in curing ulcers and relief from hemorrhoids (Adams, 1975). Okra contains special type of fiber which takes sugar levels in blood under control, providing sugar quantity, acceptable for the bowels. Mucilage remaining in okra is useful for washing away toxic substances and bad cholesterol, which causes different serious diseases in the liver. Okra ensures recovery of the psychological and mental conditions, like, depression and general weakness. Okra is the most effective for pulmonary inflammations, bowel irritations, and sore throat. According to Indian researches it is known as a complex replacement for human blood

plasma. In order to remain the valuable substances safe, it's practice to cook okra as shortly as possible, processing it either with steam, or on low heat (Purseglove *et al.*, 1999). In Bangladesh, The yearly okra production is 53.98 thousand metric tons from 11.34 thousand hectors of land (BBS, 2016). The production is quite lower in comparison to our neighbor country. India produced 8896.3 thousand metric tons from 1158.0 thousand hectors of lands (FAO, 2016). The yield of okra our country is very low compared to that of other developing countries where the yield is as high as 8-12 t/ha (Schippers, 2012) The low production of okra in our country is very low due to lack of management and disease incidence. The yield and quality of okra depend on several factors like diseases, insects, soil factors and climatic conditions. Among those factors responsible for the low yield and quality of okra, *Yellow vein mosaic virus (YVMV)* is the most important factor as reported by Sastry and Singh (1974). The virus may reduced more than 90% of okra yield (Akanda, 1991). The virus was systematically studied and characterized by different Indian scientists (Cooper and Verma, 1950; Kumar and Moorthy, 2000 and Verma, 1955). After the study, they proposed that *Yellow vein mosaic virus* is a member of Geminivirus group which is semi-persistently transmitted by whitefly (*Bemesia tabaci*). This virus is also transmitted through grafting, but not mechanically or through seeds.It is reported that *Yellow vein mosaic virus* is the most important factor of yield reduction in india and some other okra growing regions of the sub-continent (Farnendo and Udurawana, 1942; Harender *et al.*, 1993, Nath *et al.*, 1993, Sastry and Singh, 1975 and Sinha and Chakrabarti, 1978). Among the different biotic stresses, *Yellow vein mosaic virus (YVMV)* is the number one destructive disease of okra. *YVMV* is a semi persistent virus which is transmitted by white fly *(Bemesia tabaci)*. The growth and development of a okra plant depends on its normal physiological and morphological processes. The pathogen may change the physiological and morphological system to the infected plant.

Considering the facts above mentioned the research program was designed with the purpose to manage the *Yellow vein mosaic virus* of okra by controlling the insect vectors through two selected insecticides namely Imitaf and ACmix with the following objectives:

I. To evaluate the incidence level of *Okra Yellow vein mosaic virus (OYVMV)* in green finger variety.

II. To evaluate the performance of selected insecticides Imitaf and ACmix to control the insect vectors of O*YVMV*.

III. To find out the morphological and physiological changes of the infected okra plant in response to insecticides application in compared to the healthy plants.

REVIEW OF LITERATURE

Yellow vein clearing mosaic virus (YVCMV) is the most annihilating virus of okra in all okra growing countries.

Kulkarni (1942) first observed that the occurrence of a virus which was responsible for huge yield reduction of okra in Bombay, India.

Uppal *et al.,* (1940) observed the virus infecting okra and named it as *Yellow vein clearing mosaic virus*. Okra yellow vein mosaic disease was first reported from Bombay (presently known as Mumbai) in India (Kulkarni, 1942).

The causative virus, *Okra yellow vein mosaic virus (OYVMV),* was shown to be a begomovirus based on its morphological and serological relationship with other begomoviruses, such as *African cassava mosaic virus* (Harrison *et al.,* 1991).

Capoor and Verma (1950) worked on *Okra yellow vein 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 vein mosaic virus* was also worked in India by Verma (1952). It was then established that the virus spread by an insect vector (*Bemesia tabaci*) and also through bud grafting (Capoor and Verma, 1950; Verma 1952).

Sastry and Singh (1974) concluded 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 vein clearing mosaic virus* is a member of graminivirus group. It, therefore seems that *yellow vein clearing mosaic virus* of okra was researched in India extensively and introduced by the many scientists mainly to plant virus literature.

However, there are controversies in the nomenclature and abbreviation of the virus name infecting okra. In most, Indian literatures, the virus was proposed named as *Yellow vein mosaic virus (YVMV)* of bhindi, Bhindi/Bhendi *yellow vein mosaic virus (BYVMV), Okra yellow vein mosaic virus (OYVMV),* etc. (Ali *et al.,* 2000; Bhagat, 2000; Borah and Nath, 1995; Handa and Gupta, 1993; Sharma *et al.,* 1987). In Bangladesh, a similar disease has been found 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 *Yellow vein mosaic virus (YVMV)* of okra to accommodate all these synonyms and also differ the other viruses infecting okra. The works on 0kra *yellow vein 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 not non-transmissible mechanically and through seeds. The virus is also found to be semi-persistently by an insect vector (*Bemesia tabaci*) and through grafting. It was also observed that the virus is a member of geminivirus group (Handa and Gupta, 1993; Handa, 1993; Harrison *et al.,* 1991; Capoor and Verma, 1950). The other 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 *OYVMV* 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 *YVCMV*

2.1.1. Symptoms

The typical symptoms of okra *yellow vein mosaic virus (YVMV)* are vein clearing, vein chlorosis and yellowing having mosaic noted by the worked on the virus at the beginning (Handa 1991, Cooper and Verma 1950, Uppal *et al.*, 1940 and Kulkarni 1942). They also proposed dwarfing of the infected plants those produced deform small sized fruits as the showing of the symptoms of *YVMV*.

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

Capoor and Verma (1950) are also studied symptomology and host range and described that the first appear symptom is small vein clearing due to *Yellow vein mosaic virus* infection which gradually extends to other veins and finally turns into vein chlorosis. The veins of the leaves of infected plants are thick, brittle, dark green and curl downward. The infected plants produce fruits that are pale colored, hard and fibrous. Mechanical inoculation test 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 is tested by using jassids (*Empoasca devastans* Distant, *Empoasca* sp.), Aphid (*Aphis gossypii* Glover) and Whitefly (*B. tabaci* Genn) was conducted by the same authors and the result revealed that among the species tested, among them only *B. tabaci* could be able to transmit the virus using dodder (*Cuscuts reflexa* Roxb).

Capoor and Verma (1950) also find out that the host range of *Yellow vein mosaic virus* of okra is also restricted to malvaceous plants although they could be able to transmit virus

in six different plant species out of 34 different plant species tested through vector inoculation. Handa and Gupta (1993) characterized the *Yellow vein mosaic virus* of okra (*Abelmoschus esculentus* L.) as a geminivirus having 18 × 30 nm in size.

2.1.2. Virus-vector relationship of YVMV and their transmission

Bhagabati and Goswami (1992) noticed that the incidence of *Yellow vein mosaic virus* of okra in relation to whitefly population and different sowing dates. They find that the highest whitefly population in the crop sown in May to June, while the incidence of *Yellow vein 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 population of whitefly.

Varma (1952) worked on the relationship of *YVMV* and its vector whitefly. Though a single insect was able 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 starts at various points near the leaf margins in about 15 – 25 days after inoculation of plants. Chemical control of the disease is difficult in affected plants. Removal of alternative hosts, control of white fly and other sucking insects and uprooting and burning of infected plants are some of the measures to reduce the vector population and also the diseased. Wild okra variety 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 virus prone areas. The results on the virus-vector relationship of *Okra yellow vein mosaic virus* worked by Capoor and Verma (1950) and Verma (1952) in India concluded that the virus is transmitted by whitefly (*Bemesia tabaci*). They had established the transmission of the virus through bud grafting.

Sastry and Singh (1975) investigated the effect of *Yellow vein mosaic virus* on growth and yield of okra by the infection of plants at different growth stages. The results

revealed 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 following germination. The yield reduction was measured as 83.63% and 49.63% in the plants infected within 50 and 60 days following germination, respectively. The incidence of *OYVCMV* was found to increase with the decreased temperature in September compared with August. There is a significant negative correlation co-efficient between temperature and virus incidence was detected. There was also evident that the varieties those were free of virus in August developed virus symptoms in September. They noticed that the temperature had influence on the resistance on *OYVMV.*

Tsering and patel (1990) conducted on the vector transmission of geminivirus using *Bemesia tabaci* and noted that *Bemesia tabaci* exposed to tobacco infected by *Tobacco leaf curl virus (TLCV)* and then to okra infected by *Okra yellow vein mosaic geminivirus (OYVMV)* in glass house condition, 8 of 15 tobacco plants become infected with *TLCV* and 5 of 15 okra plants with *OYVMV.* 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 *Bemesia tabaci.* About 100% infection of *yellow vein clearing mosaic virus (YVMV)* in the okra in Bangladesh causing as high as 90% yield loss as reported by Akanda (1991)

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Kandian and Naresh (1991) worked on the influence of weather factors on whitefly population and disease incidence of *Okra yellow vein mosaic virus (OYVMV).* The results of their study revealed that the weather factors mainly temperature and relative humidity have pronounced effect on the population build up of *Bemesia tabaci* in okra field. The spread of yellow vein mosaic disease of okra field is depended upon the number of whitefly present in okra. The results of their study reported that the temperature between 25 to 30℃ and relative humidity more than 40% were formed to be most congenial for *B.*

tabaci. There is significantly positive association between disease incidence and whitefly population, temperature, relative humidity and rainfall was recorded by Nath *et al.*, (1993). They also noticed 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 Yellow vein clearing mosaic virus* of bhindi (*Abelmoschus esculentus* L.) in relation to different dates of sowing. The minimum viral disease incidence (16.7%) was recorded on okra sown at the beginning of October and the maximum (100%) on the crop sown in May and June. The disease incidence was recorded 36.5% and 54.2% in February and March sown crop, respectively. A field experiment was conducted by Board *et al.*, (1993) to find out the relationship between *Bemesia tabaci* population density and the prevalence of *Yellow vein mosaic virus* of okra in 1988 and 1989 cropping seasons. In both the years the population of the vector reached a highest amount during first week of October. Symptoms of *YVMV* disease are appeared one week after infestation with *Bemesia tabaci*. The disease incidence was recorded to progressively increase with the corresponding increase of vector population.

Sarma *et al.* (1995) noticed that *Yellow vein 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 plants get infected by the virus. Total amount of sugar, reducing sugar, nitrogen, protein, phosphorus and potassium contents of the green fruits were decreased by virus infection.

Bhagabati *et al.* (1992) explained that the effect of *Yellow vein mosaic virus* of okra on some morphological parameters. They explained 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 rapidly reduced by virus infection. A moisture content of both diseased leaves and fruits was higher than healthy okra plants at all growth stage.

Hossain *et al*. (1998) reported the reaction of okra variety to *yellow vein mosaic virus (YVMV)* and biochemical changes in its infected leaf constituents. The infection rate of *Yellow vein mosaic virus (YVMV)* decreased as the age of the inoculated plants increased was recorded by Pun *et al.* (1999). It was concluded that 100% infection of *Yellow vein mosaic virus (YVMV)* 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 found that the incubation period of virus was increased with increased plant age.

2.3. Approaches to control *YVCMV*

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.*

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.

2.4. Studies on *YVCMV* in Bangladesh

In the ten years annual report published 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 viruses in respect of OYVM. The transmission works were also tried including the management through sowing date manipulation and insecticidal spray. Ahmed and Hossain (1985) conducted a survey on disease of crops with and view to establish a herbarium at Bangladesh Agricultural Research Institute (BARI), Joydevpur, Gazipur.

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

An experiment was carried out by Sayeed (1988) in Bangladesh Agricultural University Farm, Mymensingh with a Japanese okra variety, Pentagreen to find out the effects of date of planting and insecticidal spray on the control of *Yellow vein mosaic virus* of Lady's finger. There are three sowing dates are used viz. 17 April, 1 May and 17 May were used. The findings of the experiment were 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 okra was evaluated by Mian *et al.* (1990). They planted okra variety Pentagreen in three different dates viz. 17 April, 2 May and 17 May in 1986 and applied three insecticides namely Bidrin Ripcord and Sumithion in their experiment in Bangladesh Agricultural University Farm, Mymensingh. Among the three insecticides, Bidrin was found to be the most effective followed by Ripcord in controlling the yellow vein mosaic of okra disease incidence. The authors found a pronounced effect of planting dates on the disease

incidence as well as growth and yield of the crop. The lowest disease incidence was appeared in the first planting while it was the highest in the third planting.

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

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

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

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

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

MATERIALS AND METHODS

3.1. Experimental site

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

3.2. Experimental duration

The experiment was carried out during March to July, 2016 in Kharif-1.

3.3. Characteristics of soil

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

3.4. Climate

The weather condition of the experimental field was under the sub-tropical monsoon climate, which is characterized by heavy rainfall during kharif season (May- September) and scanty in the rabi season (October-March). There was no rainfall during December, January and February. The average maximum temperature of experimental site during the period of investigation was 35.10^0C and the average minimum temperature was 30.40^0C. Details of the meteorological data in respect of temperature, rainfall and relative humidity during the experimental site and period were collected from Bangladesh Meteorological Department, Agargaon, Dhaka and have been presented in Appendix II.

3.5. Planting materials used for experiment

Green finger okra variety was used in this study. The seed of okra collected from local market.

3.6. Insecticides collection

The selected insecticides namely Imitaf and ACmix were collected Green nursery, Agargoan, Dhaka-1207.

A B

Figure 1. Imitaf (A) and ACmix (B)

Table 1. Insecticides used in this study

Sl.No.	Trade name	Active ingredient	Application rate
01.	Imitaf	Imidacloroprid	2.5ml/10 litres
02.	ACmix	Chloropyriphos+cypermethrin	10ml/10 litres

3.7. Treatments for the experiment-1

Following treatments were used in experiment-1

T_0= control (no spray)

T_1= 1 spray with Imitaf at 20 DAS

T_2= 2 sprays with Imitaf at 20, 25 DAS

T_3=3 sprays with Imitaf at 20, 25, 30 DAS

T_4= 4 sprays with Imitaf at 20, 25, 30, 35 DAS

T_5= 5 sprays with Imitaf at 20, 25, 30, 35, 40 DAS

T_6=6 sprays with Imitaf at 20, 25, 30, 35, 40, 45 DAS

Following treatments were used in experiment-2

T_0= control (no spray)

T_1= 1 spray with ACmix at 20 DAS

T_2= 2 sprays with ACmix at 20, 25 DAS

T_3=3 sprays with ACmix at 20, 25, 30 DAS

T_4= 4 sprays with ACmix at 20, 25, 30, 35 DAS

T_5= 5 sprays with ACmix at 20, 25, 30, 35, 40 DAS

T_6=6 sprays with ACmix at 20, 25, 30, 35, 40, 45 DAS

3.8. Experimental design

The experiment was laid out in a randomized complete block design (RCBD) with three replications. In experiment-1, **Imitaf** was used and **ACmix** was used in experiment-2. There were seven treatments in each experiment, comprised 21 unit plot. Size of each unit plot was $3m^2$ and each of the plots contains 18 plants. The distance between unit plots was 0.70 m and block to 1m.

3.9. Land preparation

The selected land for the experiment was first opened on 13 March 2016 by disc plough. After opening the land, it was ploughed with a tractor 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 as per design.

3.10. Manure and fertilizer application

The following doses of manure and fertilizers were applied to the plots for okra cultivation (Anon., 1998).

Table 2. Doses of manure and fertilizers used in the study

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

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

3.11. Sowing of seeds

The okra seeds were sown after soaking in water for overnight and then wrapped with a piece of thin cloth. Then the soaked seeds were shade dried on brown paper for 2 hours to remove the surface water. Water soaking of seed was performed to help quick germination of seeds. The seeds were sown in rows of raised beds. Row to row and plant to plant spacing were maintained at 60 cm and 45cm, respectively and 2-3 seeds were placed in each pit. The seeds were covered with fine soil. After seed germination, only one healthy plant was kept in the pit.

3.12. Intercultural operations

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

3.12.1. Thinning and gap filling

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

3.12.2. Irrigation

The plot was irrigated as and when needed.

3.12.3. Weeding

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

3.12.4. Drainage

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

3.12.5. Spraying insecticides

The spray was started with Imitaf and ACmix from 20 DAS (days after sowing). The application of insecticide was done with 5 days interval with the recommended doses.

3.12.6. Harvesting

Green pods were harvested from field regularly when they attained edible stage. First harvesting was started from 30 days after seed sowing.

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

Based on the typical symptoms of *Yellow vein mosaic virus* of okra plant described by Capoor and Verma (1955), Begum (2002) and Hossain (1998) the data was recorded. The okra plants were observed every day until harvest and the symptom was recorded. 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 using the following formula:

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

Where,

X= Total number of plants inspected

X_1= Number of infected plants.

3.14. Parameters assessed

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

I. % Disease incidence
II. Number of leaves per plant
III. Number of infected leaves per plant
IV. Number of flowers per plant
V. Number of fruits per plant
VI. Plant height
VII. Chlorophyll content in leaves per plant
VIII. Root length
IX. Fruit weight
X. Yield.

3.15. Collection of data

The data on the selected parameters from the selected plants, were taken in the following ways-

3.16. Number of leaves per plant

Number of leaves of selected plants from each plot was recorded at 50, 65, 80 and 95 (DAS). Only the smallest young leaves at the growing point of the plant were excluded. Calculating the total number of leaves per plant, the average number was measured.

3.17. Number of infected leaves per plant

Number of infected leaves of selected plants from each pot was recorded at 50, 65, 80 and 95 DAS. Calculating the total number of infected leaves per plant and the average number was recorded.

3.18. 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. Number of fruits per plant

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

3.20. Fruit weight

From the first harvest, fruit weight was taken and calculated total fruit weight (kg)/plot.

3.21. Plant height

Average plant height of selected plants from each plot was recorded at 50, 65, 80 and 95 days after sowing (DAS). It was measured with the help of a meter scale from the soil level to the tip of the longest stem.

3.22. Yield

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

3.23. Root length

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

3.24. Chlorophyll content in leaves per plant

The average chlorophyll content in the leaves of the selected plants was measured with the help of "**S-PAD meter**" a modern technology to measure the chlorophyll content directly in plant leaf chlorophyll content was measured at 80 DAS.

3.25. Statistical analysis of data

The data were analyzed statistically by using the analysis of variance (ANOVA) and "**Statistic 10"** software for proper interpretation. The mean value was compared according to LSD at 5% level of significance. Graphs were used to interpret the data in some cases.

RESULTS

This chapter covers the experimental results. Seven (7) treatments with two insecticides viz. Imitaf and Acmix were assessed the performance against *Yellow vein mosaic virus* of Okra under field condition on Green Finger variety. Results were compiled based on disease incidence, morphological and physiological parameters at different days after sowing (DAS) in this chapter.

EXPERIMENT-1

4.1. Disease incidence (%) of *Yellow vein mosaic virus* in Imitaf treated plant at 50, 65, 80, and 95 DAS

After the application of Imitaf in experiment-1 up to six times spray, the percent disease incidence was calculated on the basis of typical symptoms (figure-2). There were no virus infected plant found in T_2, T_3, T_4, T_5, and T_6 at 50 DAS. But some virus infected plants were found in T_0 (control), T_1 (1 spray) where and disease incidence was estimated 7.14 % and 2.38% respectively.

At 65 DAS, no virus infected plant was found in T_4, T_5,T_6 at 65 DAS. But the virus infected plants were found in To, T_1, T_2 and T_3 treatments. Among these four treatments, the highest disease incidence was found in T_0 (50.44 %). The moderate disease incidence was found in the T_2 (16.30%) which is statistically similar with T_1 (27.95 %), T_2 (16.30) and T_3 (11.92 %).

At 80 DAS, virus infected plants were found in case of all treatments plots. The lowest disease incidence was found in T_6 (9.30 %) followed by T_5 (12.52 %), and these are statistically similar. The highest disease incidence was found in the T_0 (71.91%) preceed by T_1 (52.09 %), T_2 (37.21 %), T_3 (24.52 %) and T_4 (12.86 %). The moderate disease incidence was recorded in T_4 (12.86%).

At 95 DAS, the lowest disease incidence was also found in T_6 (15.98 %) followed by T_5 (24.64 %) and T_4 (26.93 %), which were statistically similar. The highest disease

incidence was found in the T_0 (88.21 %) preceed by T_1 (70.53 %), T_2 (63.47 %), and T_3 (45.69 %). The moderate disease incidence was recorded in T_4 (26.93 %). (Table 3)

A B

Figure 2. Infected plant (A) and Healthy plant (B)

Table 3. Effect of Imitaf on the incidence of *yellow vein mosaic* disease of okra at 50, 65, 80 and 95 DAS

Treatment	% of disease incidence 50 DAS	% of disease incidence 65 DAS	% of disease incidence 80 DAS	% of disease incidence 95 DAS
T_0	7.14 a	50.43 a	71.91 a	88.21 a
T_1	2.38 b	27.59 b	52.09 b	70.53 b
T_2	0.00 b	16.30 bc	37.21 c	63.47 b
T_3	0.00 b	11.91 cd	24.52 cd	45.79 c
T_4	0.00 b	0.00 d	12.86 de	26.93 d
T_5	0.00 b	0.00 d	12.52 de	24.64 d
T_6	0.00 b	0.00 d	9.33 e	15.98 d
$LSD_{(0.05)}$	2.77	13.62	13.38	12.84
CV (%)	114.53	50.47	23.89	15.06

T_0 (control/no spray), T_1 (1 spray), T_2 (2 spray), T_3 (3 spray), T_4 (4 spray), T_5 (5 spray), T_6 (6 spray).

4.2. The morphological features and disease incidence of okra against *Yellow vein mosaic virus (YVMV)* in response to application of Imitaf

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

At 50 DAS, the maximum number of leaves per plant was obtained in T_6 (19.67) followed by T_5 (18.67) and T_4 (17.66), which were statistically similar with each other. The minimum number of leaves per plant was obtained in the T_0 (12.67) followed by T_1 (14.33), T_2 (15.00), T_3 (16.67), respectively and these are statistically different with each other. The moderate number of leaves per plant was recorded in the variety T_4 (17.66).

At 65 DAS, the maximum number of leaves per plant was obtained in the T_6 (30.00) followed by T_5 (28.00) and which are statistically similar with each other. The lowest number of leaves per plant was obtained in T_0 (15.67) followed by T_1 (18.00), T_2 (21.67), T_3 (26.00), T_4 (28.33), respectively.T_5 (28.00) and T_4 (28.33) are statistically similar with each other. The moderate number of leaves per plant was recorded in the T_4 (28.33).

At 80 DAS, the maximum number of leaves per plant was obtained in the T_6 (43.67) followed by T_5 (37.00) and which are statistically different with each other. The minimum number of leaves per plant was obtained in the T_0 (17.00) followed by T_1 (21.33) which are statically similar with each other. T_2 (29.33), T_3 (35.00) are statistically different with each other. The moderate number of leaves per plant was recorded in the T_4 (38.33).

At 95 DAS, the maximum number of leaves per plant was obtained in the T_6 (50.00) followed by T_5 (48.367) which are statistically similar with each other. T_4 and T_5 are statically similar with each other. The minimum number of leaves per plant was obtained in the T_0 19.00) preceded by T_1 (24.67), T_2 (34.34), T_3 (43.00), T_4 (48.67) respectively and these are statistically different with each other. The moderate number of leaves per plant was recorded in the variety T_4 (48.67). (Table 4)

Table 4. Effect of Imitaf on the leaf number per plant at 50, 65, 80 and 95 DAS

Treatment	No. of Leaf at 50 DAS	No. of Leaf at 65 DAS	No. of Leaf at 80 DAS	No. of Leaf at 95 DAS
T_0	12.66 e	15.66 d	17.00 d	19.00 d
T_1	14.33 d	18.00 d	21.33 d	24.66 d
T_2	15.00 d	21.66 c	29.33 c	34.33 c
T_3	16.66 c	26.00 b	35.00 b	43.00 b
T_4	17.66 bc	28.33 ab	38.33 ab	48.66 ab
T_5	18.66 ab	28.00 ab	37.00 b	48.66 ab
T_6	19.66 a	30.00 a	43.66 a	50.00 a
$LSD_{(0.05)}$	1.59	3.24	5.53	6.20
CV	5.47	7.61	9.83	9.10

T_0 (control/no spray), T_1 (1 spray), T_2 (2 spray), T_3 (3 spray), T_4 (4 spray), T_5 (5 spray), T_6 (6 spray).

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

At 50 DAS, the maximum number of flowers per plant was recorded in the T_5 (10.00) which is statistically similar with T_4 (9.33) and T_6 (9.00). The minimum number of flowers per plant was found in the T_0 (3.00) followed by T_1 (4.33), T_2 (6.00) and T_3 (7.67). The moderate number flower was recorded in T_4 (9.33).

At 65 DAS, The maximum number of flowers per plant was recorded in the T_6 (16.33) followed by T_5 (15.33) and these are statistically similar from each other. The minimum number of flowers per plant was found in the T_0 (5.33) followed by T_1 (7.33), T_2 (10.00), T_3 (12.33) and T_4 (15.33) respectively and all they are statistically similar with each other. The moderate number flower was obtained from the T_4 (15.33).

At 80 DAS, The maximum number of flowers per plant was recorded in the T_6 (23.00) followed by T_5 (21.67) and these are statistically similar from each other. The minimum number of flowers per plant was found in the T_0 (7.33) followed by T_1 (9.33). T_2 (12.33) and T_3 (15.33) both are statistically different with each other. The moderate number flower was recorded from the T_4 (20.00).

At 95 DAS, The maximum number of flowers per plant was recorded in the T_6 (29.00) followed by T_5 (28.67), T_4 (27.00) and these are statistically similar from each other. The minimum number of flowers per plant was found in the T_0 (8.66) followed by T_1 (12.33). T_2 (12.3) and T_3 (16.67), they are statistically similar with each other. The moderate number flower was obtained from the T_4 (27.00).The results are presented in Table 5.

Table 5. Effect of Imitaf on flowers number per plant at 50, 65, 80, 95 DAS

Treatment	No. of flower at 50 DAS	No. of flower at 65 DAS	No. of flower at 80 DAS	No. of flower at 95 DAS
T_0	3.00 e	5.33 e	7.33 e	8.67 d
T_1	4.33 de	7.33 de	9.33 e	12.33
T_2	6.00 cd	10.00 cd	12.33 d	14.00 bc
T_3	7.67 bc	12.33 bc	15.33 c	16.67 b
T_4	9.33 ab	15.00 ab	20.00 b	27.00 a
T_5	10.00 a	15.33 a	21.67 ab	28.67 a
T_6	9.00 ab	16.33 a	23.00 a	29.00 a
$LSD_{0.05}$	1.72	2.763	2.96	3.46
CV	13.79	13.31	10.70	9.99

T_0 (control/no spray), T_1 (1 spray), T_2(2 spray), T_3 (3 spray), T_4(4 spray) , T_5 (5 spray), T_6(6 spray).

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

At 50 DAS, the highest numbers of fruits per plant were recorded in the T_6 (6.00) followed by T_5 (5.33) and both are statistically similar from each other. The lowest numbers of fruits per plant were recorded from the T_0 (2.00) followed by T_1 (3.00) these are statistically identical with each other. T_1 (3.00), T_2 (4.67), T_3 (4.00) and T_4 (4.33)

these are statistically similar with each other. The moderate number of fruits per plant was obtained from the T_4 (5.33).

At 65 DAS, The highest numbers of fruits per plant were recorded in the T_6 (14.00) followed by T_5 (12.33) and both are statistically similar from each other. The lowest numbers of fruits per plant were recorded from the T_0 (3.67) proceeded by T_1 (6.00) both are statistically identical with each other, T_2 (8.00) and T_3 (8.00) both are statistically similar with each other.T_3 (8.00) and T_4 (10.00) are statically identical with each other. The moderate number of fruits per plant was obtained from the T_4 (10.00).

At 80 DAS, the highest numbers of fruits per plant were recorded in the T_6 (20.67) followed by T_5 (17.67) and both are statistically similar from each other. The lowest numbers of fruits per plant were recorded from the T_0 (4.67) followed by T_1 (7.67) which are statistically similar from each other. T_1 (7.66) and T_2 (11.00), these are statistically identical with each other, T_2 (11.00) and T_3 (12.33) are statically similar with each. The moderate number of fruits per plant was obtained from the T_4 (15.67).

At 95 DAS, the highest numbers of fruits per plant were recorded in the T_6 (28.33) followed by T_5 (28.33), T_4 (26.33) and both are statistically similar from each other. The lowest numbers of fruits per plant were recorded from the T_0 (7.67) followed by T_1 (10.33) both are statistically similar from each other. T_2 (13.00), T_3 (15.67) respectively both are statistically identical with each other. The moderate number of fruits per plant was obtained from the T_4 (26.33). (Table 6).

Table 6. Effect of Imitaf on fruits number per plant at 50, 65, 80 and 95 DAS

Treatment	No. of Fruit at 50 DAS	No. of Fruit at 65 DAS	No. of Fruit at 80 DAS	No. of Fruit at 95 DAS
T_0	2.00 b	3.66 c	4.66 e	7.66 d
T_1	3.00 ab	6.00 bc	7.66 de	10.33 cd
T_2	4.66 ab	8.00 b	11.00 cd	13.00 bc
T_3	4.00 ab	8.00 b	12.33 cd	15.66 b
T_4	4.33 ab	10.00 ab	15.66 bc	26.33 a
T_5	5.33 a	12.33 a	17.66 ab	28.33 a
T_6	6.00 a	14.00 a	20.66 a	28.33 a
$LSD_{0.05}$	3.13	4.32	4.74	4.59
CV	42.09	27.42	20.82	13.96

T_0 (control/no spray), T_1 (1 spray), T_2 (2 spray), T_3 (3 spray), T_4 (4 spray), T_5 (5 spray), T_6 (6 spray).

4.2.4. Yield (kg)/plot

The highest yield per plot was recorded in the T_6 (15.45 kg) followed by T_5 (15.17 kg) and T_4 (15.49 kg) these are statistically similar from each other. The lowest yield per plant was recorded from the T_0 (10.67kg) proceeded by T_1 (11.65 kg), T_2 (12.27 kg), T_3 (13.23 kg), T_4 (14.49 kg), respectively these are statistically different with each other. The moderate yield per plant was obtained from the T_4 (14.49 kg). (Table 7).

Table 7. Effect of Imitaf on yield (kg).

Treatment	Yield per plant (kg)	Yield per plot (kg)
T_0	0.60 e	10.67 f
T_1	0.66 d	11.65 e
T_2	0.68 cd	12.27 d
T_3	0.71 c	13.23 c
T_4	0.77 b	15.49 a
T_5	0.82 a	15.17 a
T_6	0.83a	15.44 a
$LSD_{0.05}$	0.0409	0.47
CV	3.18	2.01

T_0 (control/no spray), T_1 (1 spray), T_2 (2 spray), T_3 (3 spray), T_4 (4 spray) , T_5 (5 spray), T_6 (6 spray).

4.2.5. Plant height (cm)

The maximum plant height was recorded in the T_6 (129.92 cm) followed by T_5 (126.92 cm) and both are statistically different with each other. The minimum plant height was recorded in the T_0 (116.63 cm) proceeded by T_1 (119.73 cm) and both are statistically different with each other, T_1 (119.73 cm), T_2 (120.91 cm), T_3 (122.57) they are statistically similar from each other. The moderate plant height was recorded in T_4 (125.70 cm). (Table 8).

Table 8. Effect of Imitaf on plant height (cm).

Treatment	Plant height
T_0	116.63 d
T_1	119.73 c
T_2	120.91 c
T_3	122.57 c
T_4	125.70 c
T_5	126.70 c
T_6	129.92 a
$LSD_{0.05}$	3.0102
CV	1.37

T_0 (control/no spray), T_1 (1 spray), T_2 (2 spray), T_3 (3 spray), T_4 (4 spray) , T_5 (5 spray), T_6 (6 spray).

4.2.6. Root length (cm)

The maximum root length was recorded in the T_6 (28.00 cm) followed by T_5 (26.67 cm) and both are statistically identical with each other. The minimum root length was recorded in the T_0 (20.00 cm) proceeded by T_1 (21.00 cm) both are statically identical with each other. T_2 (22.33) and T_3 (23.67cm) and both are statically identical with each other. T_3 (23.66) and T_4 (26.00 cm) both are statistically different with each other. The moderate plant height was recorded in T_4 (26.00 cm). (Table 9).

Table 9. Effect of Imitaf on root length

Treatment	Root length/plant
T_0	20.00 e
T_1	21.00 de
T_2	22.33 cd
T_3	23.66 c
T_4	26.00 b
T_5	26.66 ab
T_6	28.00 a
LSD0.05	1.68
CV	3.95

T_0 (control/no spray), T_1 (1 spray), T_2 (2 spray), T_3 (3 spray), T_4 (4 spray) , T_5 (5 spray), T_6 (6 spray).

4.3. The physiological features which are identical, in-relation to disease incidence in okra against *Yellow vein mosaic virus*

4.3.1. Net chlorophyll content per plant (µ mol m^{-2} s^{-1})

The net chlorophyll content in the leaves of the infected and non-infected plant was measured by the "S-Pad" meter. The highest net chlorophyll content per plant was recorded in the T_6 (57.93) and followed by T_5 (57.01) both are statistically similar from each other. The lowest net chlorophyll content per plant was obtained in the T_0 (48.65) proceeded by T_1 (50.88) both are statically similar with each other. T_2 (53.53) and T_3 (55.14) and both are statically simlar with each other.T_3 (55.14) and T_4 (56.07) both are statistically similar from each other. The moderate net chlorophyll content/plant (µ mol m^{-2} s^{-1}) was recorded in T_4 (56.07 cm). (Table 8).

Table 10. Effect of Imitaf on net chlorophyll content/plant (µ mol m^{-2} s^{-1})

Treatment	Net chlorophyll content/plant (µ mol m^{-2} s^{-1})
T_0	48.65 d
T_1	50.88 cd
T_2	53.53 bc
T_3	55.14 ab
T_4	56.07 ab
T_5	57.01 a
T_6	57.93 a
$LSD_{0.05}$	2.87
CV	2.98

T_0 (control/no spray), T_1 (1 spray), T_2 (2 spray), T_3 (3 spray), T_4 (4 spray), T_5 (5 spray), T_6 (6 spray).

4.4. Relationship between chlorophyll content with disease incidence, plant height and yield

4.4. 1. Relation between chlorophyll content and disease incidence

Relation study was done to establish the relationship between disease incidence and chlorophyll content of okra plants. From the figure-3 it is clear that relation between disease incidence and chlorophyll content showed inverse relationship**.** It was revealed that higher percentage of disease incidence of plant reduces the total amount of

chlorophyll content.

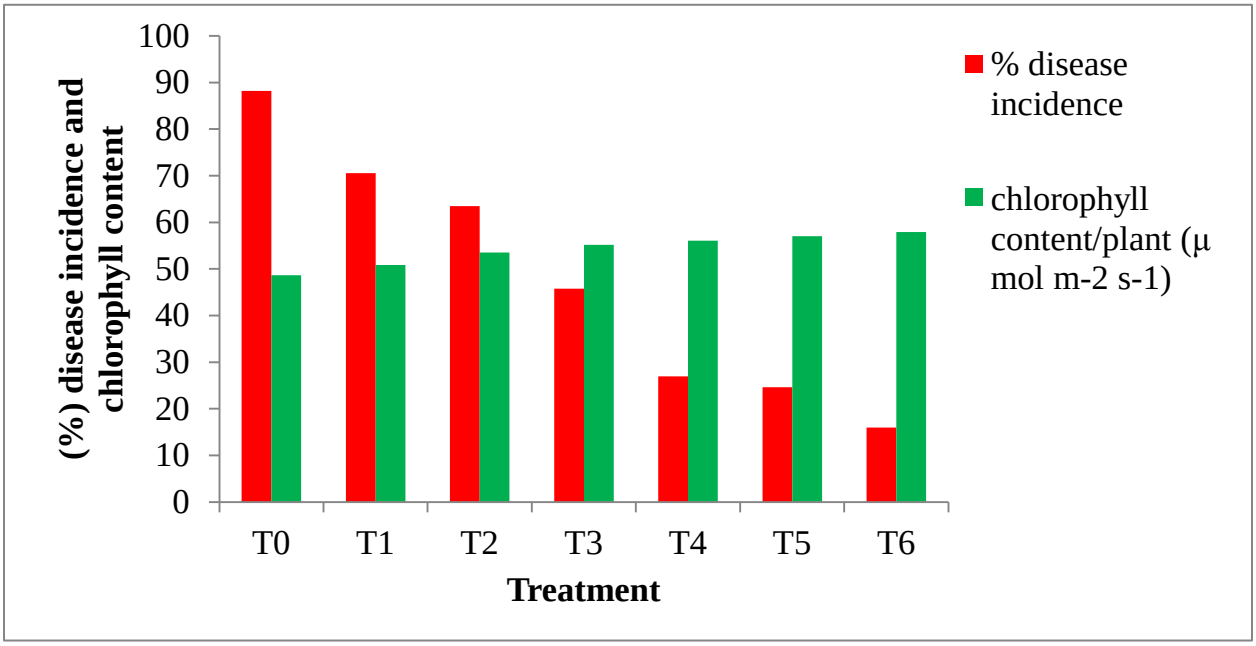

Figure 3. Relation between chlorophyll content and disease incidence.

4.4.2. Relation between yield and disease incidence

The relationship between disease incidence and yield performance of okra plants was also studied. From the study it was revealed that there is inverse relation disease incidence and yield**.** When disease incidence is increased, the yield of okra is also decreased. It was evident from the Figure 11.

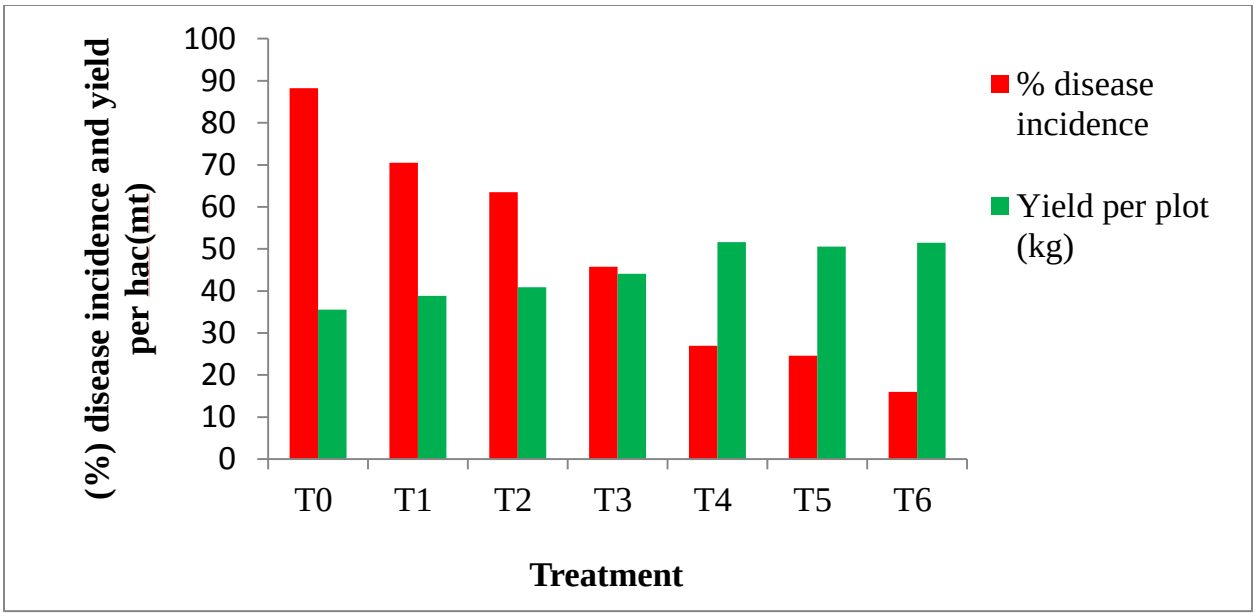

Figure 4. Relation between yield and % disease incidence.

EXPERIMENT-2

4.5. Disease incidence (%) of *Yellow vein mosaic virus* in ACmix treated plots at 50, 65, 80, and 95 DAS

After the application of ACmix in experiment-2 upto six times spray, the percent disease incidence was recorded on the basis of typical symptoms (figure-2). At 50 DAS, There were no disease infected plant found in $T_{2,\ E}T_3$, T_4, T_5, T_6 at 50 DAS. But some virus infected plants were found in T_0, T_1 were disease incidence was (7.14 %) and T_1 (2.38) respectively.

At 65 DAS, There was no disease infected plant found in T_4, T_5, T_6, it means disease incidence zero in the mentioned treatments. The highest disease incidence was found in T_0 (50.65 %). T_1 (27.95 %) and T_2 (28.89 %) are statistically identical from each other. T_2 (28.89 %) and T_3 (12.27%) are statistically identical from each other.

At 80 DAS, virus infected plants were found in all treatment plots including control treatment. The lowest disease incidence was found in T_6 (9.33 %) followed by T_5 (12.79 %) and these are statistically identical. The highest disease incidence was found in the T_0 (73.53 %) followed by T_1 (52.65 %), T_2 (40.14 %), T_3 (26.56 %) and T_4 (13.56 %) respectively. The moderate disease incidence was recorded in T_4 (13.56%).

At 95 DAS, The lowest disease incidence was found in T_6 (16.56 %) followed by T_5 (26.19 %) and these are statistically identical with each other. The highest disease incidence was found in the T_0 (89.27 %) followed by T_1 (74.92 %), T_2 (65.25 %) and T_3 (65.25 %) respectively. The moderate disease incidence was found in T_4 (30.87 %). These results are presented in Table-11.

A B

Figure 5. Infected plant (A) and Healthy plant (B)

Table 11. Effect of ACmix on the incidence of *yellow vein mosaic* of okra at 50, 65, 80 and 95 DAS

Treatment	% of disease incidence 50 DAS	% of disease incidence 65 DAS	% of disease incidence 80 DAS	% of disease incidence 95 DAS
T_0	7.14 a	50.65 a	73.53 a	89.27 a
T_1	2.38 b	28.89 b	52.65 b	74.92 b
T_2	0.00 b	16.64 bc	40.14 bc	65.25 b
T_3	0.00 b	12.27 cd	26.56 cd	47.21 c
T_4	0.00 b	0.00 d	13.56 de	30.87 d
T_5	0.00 b	0.00 d	12.79 de	26.19 de
T_6	0.00 b	0.00 d	9.33 e	16.71 e
$LSD_{0.05}$	27.71	13.90	15.82	12.93
CV	114.53	50.45	27.24	14.52

T_0 (control/no spray), T_1 (1 spray), T_2 (2 spray), T_3 (3 spray), T_4 (4 spray), T_5 (5 spray), T_6 (6 spray).

4.6. The morphological features which are identical, in-relation to disease incidence in okra against *Yellow vein mosaic virus (YVMV)* after application of ACmix

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

At 50 DAS, The maximum number of leaves per plant was obtained in the T_6 (19.67) followed by T_5 (18.67), T_4 (18.00) which are statistically identical with each other. The minimum number of leaves per plant was obtained in the T_0 (13.00) proceeded by T_1 (14.00) and they are statically identical with each other. T_2 (14.67), T_3 (16.33), T_4 (18.00) respectively and these are statistically different with each other. The moderate number of leaves per plant was recorded in the variety T_4 (18.00).

At 65 DAS, The maximum number of leaves per plant was obtained in the T_6 (30.00) followed by T_5 (28.00) and which are statistically similar with each other. The minimum number of leaves per plant was obtained in the T_0 (15.67) preceded by T_1 (19.00) and

they are statically identical with each other.T_2 (21.67) and T_3 (23.00) are statistically similar with each other.T_3 (23.00) and T_4 (29.33) are statically different with each other. The moderate number of leaves per plant was recorded in the variety T_4 (29.33).

At 80 DAS, The maximum number of leaves per plant was obtained in the T_6 (41.00) followed by T_5 (37.67), T_4 (39.33) and which are statistically similar with each other. The minimum number of leaves per plant was obtained in the T_0 (16.67) proceeded by T_1 (21.67) are statistically similar with each other.T_1 (21.66), T_2 (30.00), T_3 (36.00) are statically different with each other. The moderate number of leaves per plant was recorded in the T_4 (39.33).

At 95 DAS, The maximum number of leaves per plant was obtained in the T_6 (50.33) followed by T_5 (49.33) and which are statistically identical with each other.T_4 (48.00) and T_5 (49.33) are statically similar with each other. The minimum number of leaves per plant was obtained in the T_0 (18.67) proceeded by T_1 (24.67) are statically similar with each other. T_2 (35.00), T_3 (44.00), T_4 (48.33), respectively and these are statistically different with each other. The moderate number of leaves per plant was recorded in the T_4 (48.33). The results are presented in Table 12.

Table 12.Effect of ACmix on leaf number

Treatment	No. of Leaf 50 DAS	No. of Leaf 65 DAS	No. of Leaf 80 DAS	No. of Leaf 95 DAS
T_0	13.00 e	15.66 c	16.66 c	18.66 d
T_1	14.00 de	19.00 bc	21.66 c	24.66 d
T_2	14.66 d	21.66 b	30.00 b	35.00 c
T_3	16.33 c	23.00 b	36.00 a	44.00 b
T_4	18.00 b	29.33 a	39.33 a	48.33 ab
T_5	18.66 ab	28.00 a	37.66 a	49.33 ab
T_6	19.66 a	30.00 a	41.00 a	50.33 a
$LSD_{0.05}$	1.4525	4.15	5.12	6.05
CV	5.00	9.80	9.06	8.81

T_0 (control/no spray), T_1 (1 spray), T_2 (2 spray), T_3 (3 spray), T_4 (4 spray), T_5 (5 spray), T_6 (6 spray).

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

At the 50 DAS, the maximum number of flowers per plant was recorded in the T_5 (10.00) followed by T_4 (9.33) and which are statistically similar from each other. The minimum number of flowers per plant was found in the T_0 (2.67) proceeded by T_1 (4.33), T_2 (6.00), T_3 (7.67) and T_6 (9.00) respectively and all they are statistically different with each other. The moderate number flower was obtained from the T_4 (9.33).

At the 65 DAS, the maximum number of flowers per plant was recorded in the T_6 (16.67) followed by T_5 (15.67), T_4 (15.33) respectively and these are statistically similar from each other. The minimum number of flowers per plant was found in the T_0 (4.67) proceeded by T_1 (7.00), T_2 (10.00) and these are statically different from each other. T_2 (10.00) and T_3 (12.00) are statistically similar with each other. The moderate number flower was recorded in T_4 (15.33).

At the 80 DAS, the maximum number of flowers per plant was recorded in the T_6 (23.67) followed by T_5 (22.33), T_4 (21.33) and these are statistically similar from each other. The minimum number of flowers per plant was found in the T_0 (6.67) proceeded by T_1 (9.00), T_2 (13.33) and these are statically different from each other. T_2 (13.33) and T_3 (17.00), are statistically similar with each other. The moderate number flower was present in T_4 (21.33).

At the 95 DAS, the maximum number of flowers per plant was recorded in the T_6 (30.00) followed by T_5 (29.00), T_4 (27.00), and these are statistically similar from each other. The minimum number of flowers per plant was found in the T_0 (6.67) proceeded by T_1 (11.33) .T_2 (15.33) and T_3 (19.67), they are statistically identical with each other. The moderate number flower was obtained from the T_4 (27.00). The results are presented in Table 13.

Table 13. Effect of ACmix on flower number at 50, 65, 80 and 95 DAS

Treatment	No. of flower at 50 DAS	No. of flower at 65 DAS	No. of flower at 80 DAS	No. of flower at 95 DAS
T_0	2.67 e	4.67 d	6.67 c	7.67 d
T_1	4.33 d	7.00 c	9.00 c	11.33 cd
T_2	6.00 c	10.00 b	13.33 b	15.33 bc
T_3	7.67 b	12.00 b	17.00 b	19.67 b
T_4	9.33 a	15.33 a	21.33 a	27.00 a
T_5	10.00 a	15.67 a	22.33 a	29.00 a
T_6	9.00 ab	16.67 a	23.67 a	30.00 a
$LSD_{0.05}$	1.63	2.29	4.05	4.96
CV%	13.10	11.11	14.08	13.96

T_0 (control/no spray), T_1 (1 spray), T_2 (2 spray), T_3 (3 spray), T_4 (4 spray), T_5 (5 spray), T_6 (6 spray).

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

At 50 DAS, the highest numbers of fruits per plant were recorded in the T_6 (7.00) followed by T_5 (6.67) and both are statistically identical from each other. The lowest numbers of fruits per plant were recorded from the T_0 (1.67) proceeded by T_1 (3.00) both are statistically identical with each other. T_2 (4.67) and T_3 (4.67) are statistically similar with each other. T_4 (6.33) and T_5 (6.67) are statistically similar with each other. The moderate number of fruits per plant was obtained from the T_4 (6.33).

At 65 DAS, the highest numbers of fruits per plant were recorded in the T_6 (14.33) followed by T_5 (13.33), T_4 (13.33) and these are statistically similar from each other. The lowest numbers of fruits per plant were recorded from the T_0 (3.67) proceeded by T_1 (6.33) and both are statistically different with each other.T_2 (8.67) and T_3 (10.00) are statically identical with each other. The moderate number of fruits per plant was obtained from the T_4 (13.33).

At 80 DAS, the highest numbers of fruits per were recorded in the T_6 (21.00) followed by T_5 (20.00) and they are not statistically different from each other. The lowest number of

fruits per plant were recorded from the T_0 (4.67) proceeded by T_1 (7.67) and both are statistically similar with each other. The moderate number of fruits per plant was obtained from the T_4 (18.33).

At 95 DAS, the highest numbers of fruits per plant were recorded in the T_6 (30.00) followed by T_5 (29.00), T_4 (27.00) and these are statistically similar from each other. The lowest numbers of fruits per plant were recorded from the T_0 (7.67) proceeded by T_1 (11.33), and both are statistically identical with each other. The moderate number of fruits per plant was obtained from the T_4 (27.00). (Table 14).

Table 14. Effect of ACmix on fruit number at 50, 65, 80 and 95 DAS

Treatment	No. of fruit at 50 DAS	No. of fruit at 65 DAS	No. of fruit at 80 DAS	No. of fruit at 95 DAS
T_0	1.67 d	3.67 d	4.67 d	7.67 d
T_1	3.00 cd	6.33 c	7.67 d	11.33 cd
T_2	4.67 bc	8.67 bc	12.00 c	15.33 bc
T_3	4.67 bc	10.00 b	15.33 bc	19.67 b
T_4	6.33 ab	13.33 a	18.33 ab	27.00 a
T_5	6.67 ab	13.33 a	20.00 a	29.00 a
T_6	7.00 a	14.33 a	21.00 a	30.00 a
$LSD_{0.05}$	2.13	2.51	3.37	4.97
CV%	24.74	14.18	13.42	13.98

T_0 (control/no spray), T_1 (1 spray), T_2 (2 spray), T_3 (3 spray), T_4 (4 spray), T_5 (5 spray), T_6 (6 spray).

4.6.4. Yield kg/plot

The highest yield per plot was recorded in the T_6 (15.04 kg) followed by T_5 (14.87 kg) and these are statistically similar from each other. The lowest yield per plot was recorded from the T_0 (10.75 gm) proceeded by T_1 (11.69 kg) and these are statically different with each other. T_1 (11.69) and T_2 (12.34 kg), T_2 (12.34 kg) and T_3 (12.82 kg) are statically identical with each other. The moderate yield per plant was obtained from the T_4 (13.97 gm). (Table 15).

Table 15. Effect of ACmix on fruit weight (kg) per plot.

Treatment	Yield per plant (kg)	Yield per plot (kg)
T_0	0.60 e	10.75 e
T_1	0.66 d	11.69 d
T_2	0.68 cd	12.34 cd
T_3	0.71 c	12.82 c
T_4	0.77 b	13.97 b
T_5	0.82 a	14.87 a
T_6	0.83a	15.04 a
$LSD_{0.05}$	0.0409	0.6835
CV	3.18	2.94

T_0 (control/no spray), T_1 (1 spray), T_2 (2 spray), T_3 (3 spray), T_4 (4 spray), T_5 (5 spray), T_6 (6 spray).

4.6.5. Plant height (cm)

The maximum plant height was recorded in the T_6 (127.51 cm) followed by T_5 (125.47 cm) and both are statistically different with each other. The minimum plant height was recorded in the T_0 (116.67 cm) proceeded by T_1 (118.45 cm), both are statistically different with each other, T_1 (118.45 cm) and T_2 (119.67 cm) are statistically similar from each other. T_3 (122.13 cm) and T_4 (124.33) are not statistically identical from each other. The moderate plant height was recorded from the T_4 (124.33 cm). (Table 16).

Table 16. Effect of ACmix on stem length per plant.

Treatment	Plant height
T_0	116.67 e
T_1	118.45 d
T_2	119.67 d
T_3	122.13 c
T_4	124.33 b
T_5	125.47 b
T_6	127.51 a
$LSD_{0.05}$	1.43
CV%	0.66

T_0 (control/no spray), T_1 (1 spray), T_2 (2 spray), T_3 (3 spray), T_4 (4 spray), T_5 (5 spray), T_6 (6 spray).

4.6.6. Root length (cm)

The maximum root length was recorded in the T_6 (28.00 cm) followed by T_5 (26.33 cm) and both are statistically identical with each other. The minimum root length was recorded in the T_0 (19.67 cm) proceeded by T_1 (21.67 cm) and both are statistically different with each other. T_2 (22.67 cm) and T_3 (24.00 cm) both are statistically identical with each other. The moderate plant height was recorded in T_4 (25.33 cm). The results are presented in Table 17.

Table 17. Effect of ACmix on root length.

Treatment	Root length
T_0	19.67 f
T_1	21.67 e
T_2	22.67 de
T_3	24.00 cd
T_4	25.33 bc
T_5	26.33 ab
T_6	28.00 a
$LSD_{0.05}$	1.88
CV%	4.43

T_0 (control/no spray), T_1 (1 spray), T_2 (2 spray), T_3 (3 spray), T_4 (4 spray) , T_5 (5 spray), T_6 (6 spray).

4.7. The physiological features which are identical, in-relation to yield in okra against *Yellow clearing vein mosaic virus:*

4.7.1. Net chlorophyll content per plant (µ mol m^{-2} s^{-1})

The net chlorophyll content in the leaves of the infected and non-infected plant was measured by the “S-Pad” meter. The highest net chlorophyll content per plant was

recorded in the T_6 (56.55) and T_5 (55.68) both are statistically similar from each other. The lowest net chlorophyll content per plant was obtained in the T_0 (49.25) proceeded by T_1 (51.22) and both are statically different with each other, T_2 (52.34) and T_3 (53.62), both are statistically identical from each other. The moderate net chlorophyll content was recorded in T_4 (54.95 cm). These results are presented in Table 18.

Table 18. Effect of ACmix on net chlorophyll content per plant (μ mol m^{-2} s^{-1})

Treatment	Net chlorophyll content/plant (μ mol m^{-2} s^{-1})
T_0	49.25 e
T_1	51.22 d
T_2	52.34 cd
T_3	53.62 bc
T_4	54.95 ab
T_5	55.68 a
T_6	56.55 a
$LSD_{0.05}$	1.75
CV	1.85

T_0 (control/no spray), T_1 (1 spray), T_2 (2 spray), T_3 (3 spray), T_4 (4 spray) , T_5 (5 spray), T_6 (6 spray).

4.8. Relationship between chlorophyll content with disease incidence, plant height and yield

4.8. 1. Relation between chlorophyll content incidence and disease

Relation study was done to establish the relationship between disease incidence and chlorophyll content of okra plants. From the figure 6 it is cleared that relation between disease incidence and chlorophyll content showed inverse relationship**.** It was revealed that higher percentage of disease incidence of plant reduces the total amount of chlorophyll content.

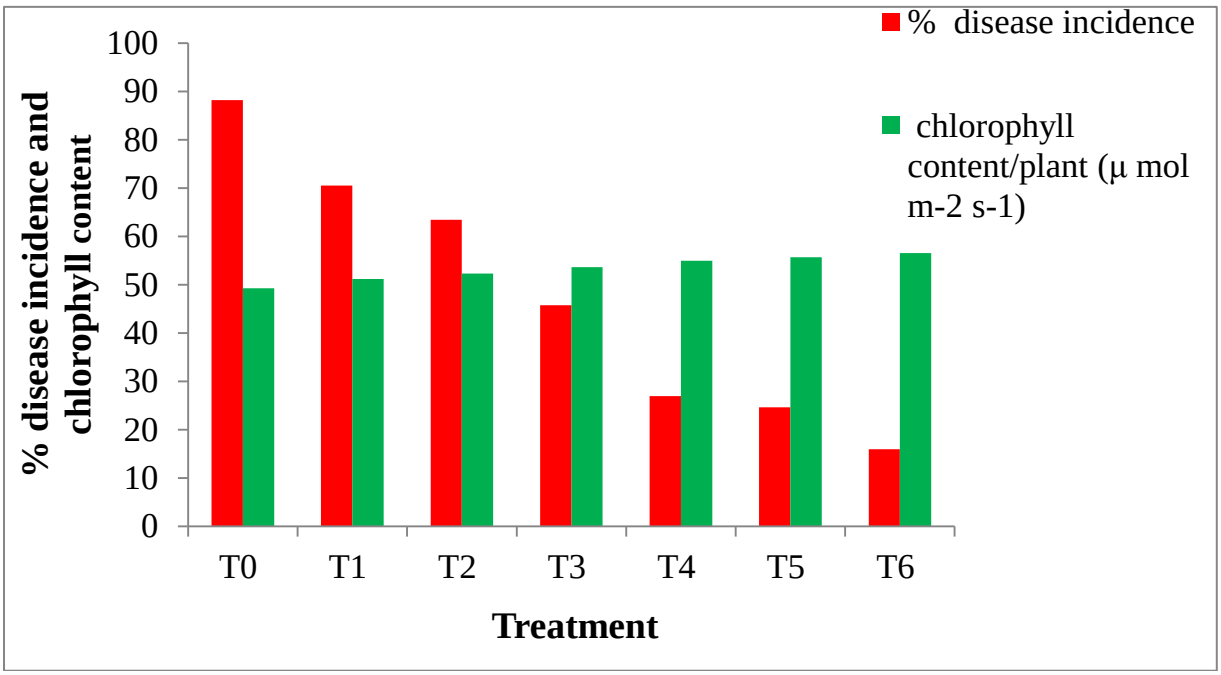

Figure 6. Relation between chlorophyll content and disease incidence.

4.8.4. Relation between % disease incidence and yield

The relationship between disease incidence and yield performance of okra plants was also studied. From the study it was revealed that there is inverse relation disease incidence and yield**.** When disease incidence is increased, the yield of okra is also decreased. It was evident from the Figure 7.

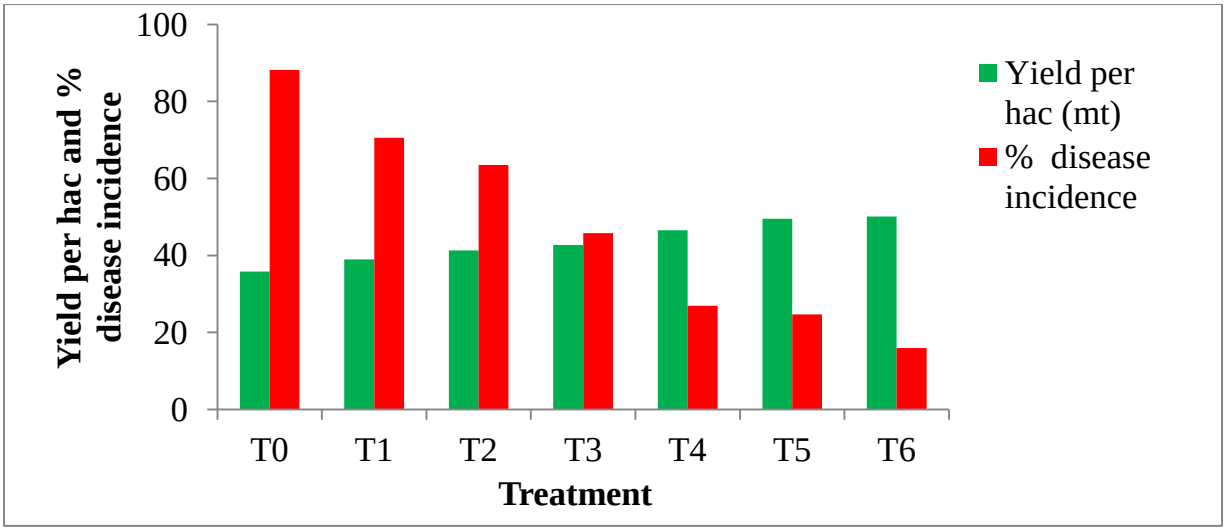

Figure 7. Relation between yield and % disease incidence

DISCUSSION

The yearly okra production is 53.98 thousand metric tons from 11.34 thousand hectors of land in Bangladesh (BBS, 2016). The production is quite lower in comparison to our neighbour country like, in India it produces 8896.3 thousand metric tons from 1158.0 thousand hectors of lands (FAO, 2016). *Yellow vein mosaic virus* is considered one of the major constrain for the lower yield of okra in our country. The main objective of this study was to assessment the performance Imitaf and Acmix to manage of *Yellow vein mosaic virus* through controlling the insects of this virus. The experiment was conducted in the field condition of during March to July, 2016. Green finger variety was used in the experiment.

Experiment-1(Imitaf)

4.9. Disease Incidence

In this study, two selected insecticide was used to manage the okra *yellow vein mosaic virus* through controlling the insect vectors aphid. It was noticed that the disease incidence (%) due to *yellow vein mosaic virus* was found in almost all the plots at 80 DAS. The highest percentage disease incidence was recorded in the T_0 (control treatment) followed by T_1, T_2, T_3, T_4, T_5 and T_6 respectively. Among all the treatment, the lowest disease incidence (%) was found in T_6 (6 sprays). The findings are near to similar with the some previous study. The result of the present study is in accordance with the results of Sayed *et al.,* (2018).They found that single spray of Imitaf. The result was comparatively higher incidence of *Yellow vein mosaic virus* in compare to Sobicron. But in the present study imitaf was sprayed six times start from 20 DAS resulted lower incidence of Yellow vein mosaic virus. This is due to presence of lower number of white fly (*Bemesia tabaci*) in the plot where Imitaf sprayed six times. But considering the economic condition/cost-benefit ratio T_4 (4 sprays) was the best in both types of insecticides applications.

4.10. Morphological features

4.10.1. Number of leaves, flowers and fruits per plant

The yield of individual treatment depends on the number of leaves flowers and fruits per plant. The highest number of leaves, flower and fruits per plant were recorded in followed by T_3 (3 sprays), T_2 (2 sprays), and T_1 (1 spray). But considering the economic condition/cost-benefit ratio T_4 (4 sprays) was the best in both block, because there was no significant different among T_4, T_5, T_6, regarding these mentioned parameters. The lowest number of leaves, flowers and fruits per plant were recorded in the T_0 (control treatment). The same results were found in the previous study that was conducted by Sayed *et al.,* (2018). The finding of the previous work was Imitaf better than Sobicron.

4.11. Yield and yield contributing characters

The highest yield per plant and plot was recorded in T_6 (6 sprays) followed by the treatment T_5, T_4, T_3, T_2 and T_1. But considering the economic condition/cost-benefit ratio T_4 was the best in both study, because there was no significant different among T_4, T_5, T_6, regarding yield per plant and plot. Where the lowest yield per plant/plot was founded in T_0 (control treatment). The same results were found in the previous study that was conducted by Sayed *et.al,* (2018). There is no more previous report over yield of okra against *YVMV* in our country.

4.12. Physiological features

The infected okra plant shows different physiological responses against different physiological features. From the findings of this study, it was revealed that among the seven treatments, three treatments; T_4 (4 sprays), T_5 (5 sprays) and T_6 (6 sprays) showed better morphological and physiological performance as compared to other treatments against *Yellow vein mosaic virus (YVMV)*. These results are in agreement with the findings of Shil (2005) and the published research report of Sayed *et al.*, (2018).

4.13. Relationship between Chlorophyll content with disease incidence, Plant height and Yield

In both types of insecticides application in experiment 1 & 2, the lowest chlorophyll content per plant was recorded in T_0 (control treatment) followed by T_1 (1 spray). The highest chlorophyll content per plant was recorded in T_4 (4 sprays), T_5 (5 sprays) and T_6 (6 sprays). There is a strong and positive relation showed when to establish the relationship between chlorophyll content with plant height and yield. There is negative relationship between chlorophyll content and percentage of disease incidence. It was observed that plant reduces the amount of chlorophyll content in leaves when percentage disease incidence was higher. It was also noticed that when percent disease incidence increased, the yield of okra was also decreased proportionally. The results of the present study are in resemblance with the findings of the previous studies that conducted by Sarker *et al.*, (2018).

Experiment-2 (ACmix)

4.14. Disease Incidence

In this study, two selected insecticide was used to manage the okra *yellow vein mosaic virus* through controlling the insect vectors aphid. It was noticed that the disease incidence (%) due to *yellow vein mosaic virus* was found in almost all the plots at 80 DAS. The highest percentage disease incidence was recorded in the T_0 (control treatment) followed by T_1, T_2, T_3, T_4, T_5 and T_6 respectively. Among all the treatment, the lowest disease incidence (%) was found in T_6 (6 sprays). The findings are near to similar with the some previous study. The result of the present study is in accordance with the results of Sayed *et al.,* (2018).They found that single spray of Imitaf. The result was comparatively higher incidence of *Yellow vein mosaic virus* in compare to Sobicron. But in the present study imitaf was sprayed six times start from 20 DAS resulted lower incidence of Yellow vein mosaic virus. This is due to presence of lower number of white

fly (*Bemesia tabaci*) in the plot where Imitaf sprayed six times. But considering the economic condition/cost-benefit ratio T_4 (4 sprays) was the best in both types of insecticides applications.

4.15. Number of leaves, flowers and fruits per plant

The yield of individual treatment depends on the number of leaves flowers and fruits per plant. The highest number of leaves, flower and fruits per plant were recorded in followed by T_3 (3 sprays), T_2 (2 sprays), and T_1 (1 spray). But considering the economic condition/cost-benefit ratio T_4 (4 sprays) was the best in both block, because there was no significant different among $T_{4,}$ T_5, $T_{6,}$ regarding these mentioned parameters. The lowest number of leaves, flowers and fruits per plant were recorded in the T_0 (control treatment). The same results were found in the previous study that was conducted Sayed *et al.*, (2018). The finding of the previous work was Imitaf better than Sobicron.

4.16. Yield and yield contributing characters

The highest yield per plant and plot was recorded in T_6 (6 sprays) followed by the treatment $T_{5,}$ T_4, T_3, T_2 and T_1. But considering the economic condition/cost-benefit ratio T_4 was the best in both study, because there was no significant different among $T_{4,}$ T_5, $T_{6,}$ regarding yield per plant and plot. Where the lowest yield per plant/plot was founded in T_0 (control treatment). The same results were found in the previous study that was conducted by Sayed *et.al,* (2018). There is no more previous report over yield of okra against *YVMV* in our country.

4.17. Physiological features

The infected okra plant shows different physiological responses against different physiological features. From the findings of this study, it was revealed that among the seven treatments, three treatments; T_4 (4 sprays), T_5 (5 sprays) and T_6 (6 sprays) showed better morphological and physiological performance as compared to other treatments

against *Yellow vein mosaic virus (YVMV)*. These results are in agreement with the findings of Shil (2005) and the published research report of Sayed *et al.*, (2018).

4.18. Relationship between Chlorophyll content with disease incidence, Plant height and Yield

In both types of insecticides application in experiment 1 & 2, the lowest chlorophyll content per plant was recorded in T_0 (control treatment) followed by T_1 (1 spray). The highest chlorophyll content per plant was recorded in T_4 (4 sprays), T_5 (5 sprays) and T_6 (6 sprays). There is a strong and positive relation showed when to establish the relationship between chlorophyll content with plant height and yield. There is negative relationship between chlorophyll content and percentage of disease incidence. It was observed that plant reduces the amount of chlorophyll content in leaves when percentage disease incidence was higher. It was also noticed that when percent disease incidence increased, the yield of okra was also decreased proportionally. The results of the present study are in resemblance with the findings of the previous studies that conducted by Sarker *et al.*, (2018).

SUMMARY AND CONCLUSION

The study on okra was carried out at the central Farm of Sher-e- Bangla Agricultural University, Dhaka-1207, during March to July, 2016 with normal agronomic practices. Yield and yield contributing characters, morphological and physiological features of okra plant that changes due to disease infection which cause damages okra production and reduce the market value was also part of this study. The study was to evaluate the performance of selected two insecticides against *Yellow vein mosaic virus* (*YVMV)* through control the insect vectors. A hybrid okra variety namely green finger was used as a selected cultivar and two insecticides viz. Imitaf and Acmix were sprayed up to six times to control the insect vectors. The experiment was carried out in Randomized Complete Block Design (RCBD).The insecticides were sprayed at 20 DAS and continued with 5 days interval. In experiment -1 Imitaf was sprayed @ 2.5ml/10 liters and in experiment-2 ACmix was sprayed @ 10ml/10 liters. The lowest percent disease incidence was calculated in T_6 (15.98 % in block-A, 16.71 % in experiment-2) at 95 DAS. The highest percent disease incidence was recorded in T_0 (88.21 % and 89.27 % respectively). Considering the economic conditions/cost-benefit ratio T_4 was the best. Because T_4 (26.93 %and 30.87 % respectively), T_5 (24.64 % and 26.19 % respectively) and T_6 (15.98 % and 16.71 % respectively) were showed almost same performance but T_5 (24.64 % and 26.19 % respectively) and T_6 (15.98 % and 16.71 % respectively) were more expensive than T_4 (26.93 %and 30.87 % respectively). In case of morphological parameters; number of leaves, flowers and fruits per plant was recorded in T_6 (50.00, 29.00, 28.33 in experiment-1 and 50.33, 30.00, 30.00 in experiment-2) up to last harvesting. Yield and yield contributing characters significant variance was found among the treatments. The highest yield per plant and plot was obtained in T_6 treatment in case of both insecticides application (0.83kg/plant, 15.44 kg/plot in experiment and 0.82kg/plant, 15.04 kg/plot in experiment-2). The highest plant height was found in T_6 in both experiment (129.92 cm and 127.51 cm respectively). In case of physiological features the maximum chlorophyll content was measured in T_6 (57.93 μ mol m^{-2} s^{-1}

and56.55 μ mol m^{-2} s^{-1} respectively) for both insecticides. In the relationship study, it was noticed that disease incidence and yield have negative relation. When disease incidence is high, yield is low. On the other hand yield showed the positive relationship with chlorophyll content. Higher amount of chlorophyll content of plant increase the yield. Plant height and yield was also showed a strong and positive relationship with chlorophyll content. In case of higher chlorophyll content of plant was also gained higher plant height and yield. It was also observed that when percent disease incidence increased, the chlorophyll content of okra plant was decreased ultimately plant height and yield was also decreased. In case of all the treatments T_4, T_5, T_6 showed better performance. However, considering the economic conditions/cost-benefit ratio T_4 was the best in case of all measuring parameters, because there was no too much significant difference between T_4 and T_6 results.

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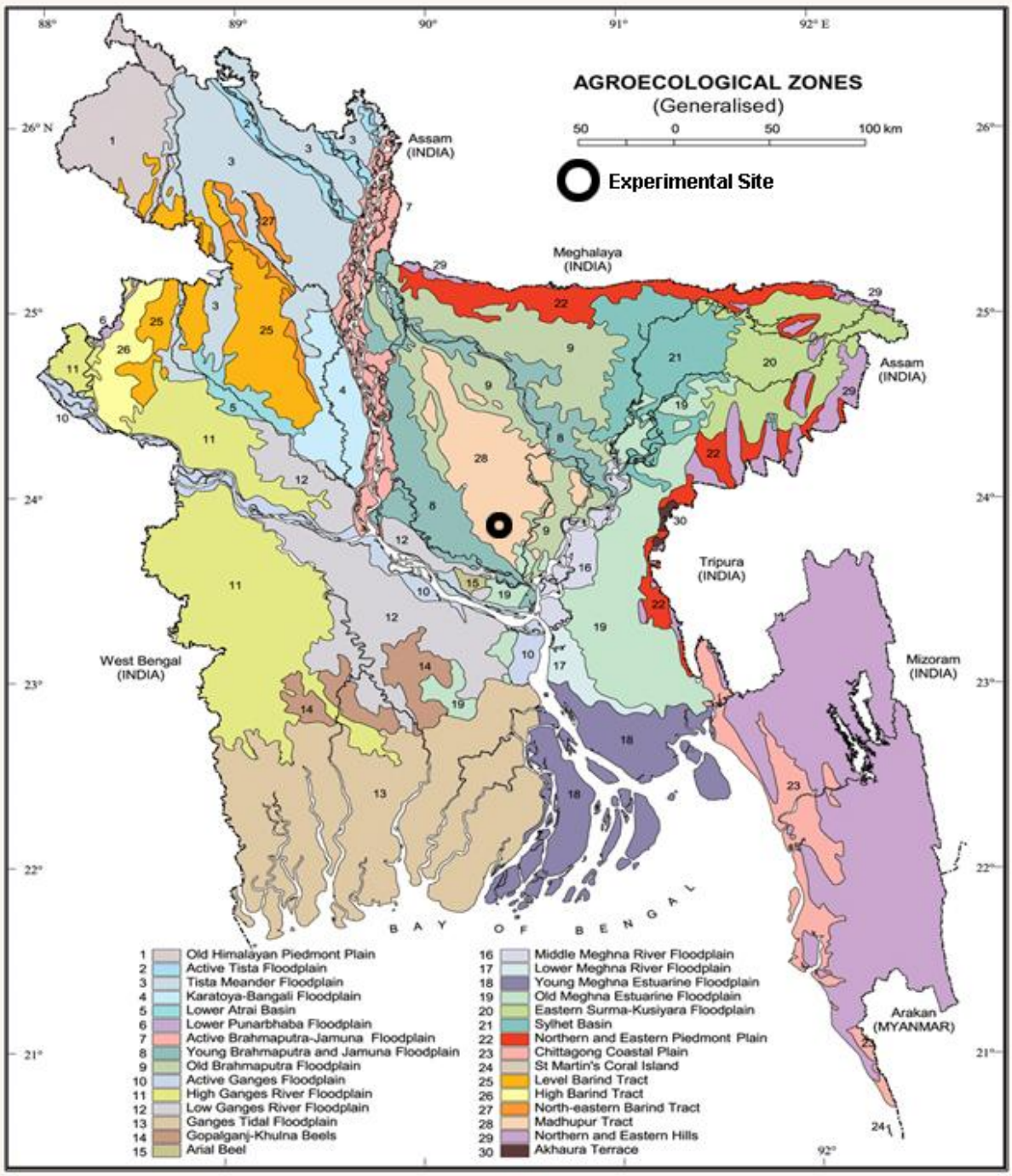
APPENDICES

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 2014 to July 2016)

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

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

Appendix III. Physiochemical properties of soil of field laboratory

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

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