



Selection of Resistant Varieties of Okra to Yellow Vein Clearing Mosaic Virus and Its Management

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Authors' contributions

This work was carried out in collaboration between all authors. Authors SAS, MKAS, MBH and MRI designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors SAS and MSAS performed the statistical analysis, managed the analyses of the study and literature searches. All authors read and approved the final manuscript.

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ABSTRACT

A two-factorial field experiment on okra was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka from April to August 2015. The aim of the study was to find out the resistance of okra varieties against the *Yellow vein clearing mosaic virus* (YVCMV) and its management. Four varieties viz. BARI dherosh-1, Green finger, Nuffield and Orca onamika were selected as the first factor and two insecticides (Imidacloprid and Sobicron) and one botanical nutrient namely Peak performance nutrients (PPN) were used as the second factor. The plants were grown and natural inoculum was relied upon for the infection of YVCMV. Growth parameters, yield attributes, and physiological features were significantly affected by okra varieties and two selected insecticides and PPN combinations. YVCMV incidence was significantly varied with these combinations. Among the varieties, the lowest disease incidence was found in BARI dherosh-1

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which showed high resistance. Green finger and Nuffield provided moderate resistance where Orca onamika was highly susceptible to the disease incidence. Application of Sobicron with PPN gave the lowest disease incidence while the control under the application of no insecticides and PPN gave the highest disease incidence. The availability of resistance sources against the virus is very limited among the cultivated okra varieties. Though BARI dherosh-1 provides resistance mechanism against the virus, Green finger and Nuffield which are moderate resistant can be developed as resistant cultivars through genetic regulation along with the molecular mechanism of resistance to YVCMV.

Keywords: Okra; variety; YVCMV; white fly; resistant; management.

1. INTRODUCTION

Okra (*Abelmoschus esculentus* L.) is an important vegetable crop belonging to the Malvaceae family. Okra is originated in West Africa which is widely cultivated in different parts of the world. It is well distributed in the Indian subcontinent and East Asia. It is known as 'dherosh' in Bangladesh which is also called 'bhindi' in India and Pakistan. In Bangladesh, the yield of okra is very low due to lack of proper management and higher diseases incidence [1]. The yield and quality of okra depend on several factors like diseases, insects, soils and climatic conditions. Among all the factors responsible for limiting the yield and quality of okra, *Yellow vein clearing mosaic virus* (YVCMV) is the most important one [2]. The virus may cause more than 90% yield loss [2]. *Yellow vein clearing mosaic virus* is a member of Geminivirus group which is transmitted semi-persistently by whitefly (*Bemisia tabaci*) [3-7]. 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 [8-11].

Yellow vein clearing mosaic virus was proved to be a severe problem in Bangladesh which can alone make the okra cultivation non-profitable. The systematic works on *Yellow vein clearing mosaic virus* have not yet been done in Bangladesh. Some sporadic works have been reported to find resistant variety or control measures [12-14,1]. Most of the research so far conducted in Bangladesh were disease survey type where the name of the disease observing field symptoms, the screen of cultivars against the disease under natural conditions was enlisted.

There is no effective control measure against the virus in the field if it is established once [15,16]. The most effective method of controlling the disease is the cultivation of resistant varieties,

but the availability of resistant varieties and sustainability of resistance in okra are rare [17,2]. The varieties so far cultivated in Bangladesh are highly susceptible to the virus. Control of its vector by spraying insecticides may be a suitable method of controlling this disease [18-20]. An appreciable amount of works have been done in India to find out the effective management package against the okra *Yellow vein clearing mosaic virus* [21].

The ultimate goal of the experiment was to evaluate the incidence level of *Yellow Vein Clearing Mosaic Virus* (YVCMV) against the tested okra varieties, to screen out the resistant okra varieties against the YVCMV under field condition and to manage the disease using Imidacloprid, Sobicron and Peak Performance Nutrients (PPN).

2. MATERIALS AND METHODS

2.1 Geographical Location

The field experiment was designed to achieve the objectives of the study and executed following standard procedures and methods. The experiment was carried out at the Horticultural farm of Sher-e-Bangla Agricultural University (SAU), Dhaka from April to August 2015. The location of the experimental site was at 23°46' N latitude and 90°24' E longitude with the elevation of 9 m above the sea level. The experimental site was under the sub-tropical monsoon climatic condition, which is characterized by heavy rainfall during kharif season (May-September) and scanty in the rabi season (October-March). There was very low or no rainfall during the month of December, January, and February. The maximum temperature during the period of investigation was found 35.10°C while the minimum temperature was found 26.60°C. The soil of the experiment site is a medium high land belonging to the modhupur tract under the Agro-Ecological Zone (AEZ) 28. The soil texture was silty loam, non-calcareous and dark grey soil of

Tejgaon soil series with a p^H 6.7. The experimental area was flat having available irrigation and drainage system.

2.2 Planting Materials

Four okra varieties namely BARI dherosh-1, Green finger, Nuffield and Orca onamika were used in the experiment. BARI dherosh-1 was used as a resistant variety to the *Yellow vein clearing mosaic virus (YVCMV)*, that was collected from Bangladesh Agricultural Research Institute (BARI), Joydevpur, Gazipur. The other three varieties were collected from the local market and used as the test cultivars. The selected insecticides namely Imidacloprid and Sobicron were collected from the local market and PPN was collected from China through representative country dealers.

2.3 Design and Layout of the Experiment

The experiment was laid out in a randomized complete block design (RCBD) with three replications where blocks were representing the replication. Each block comprised 18 unit plot and a total number of plots were 72 (18 X 4=72). Size of each unit plot was 5 m². The distance between plot to the plot was 0.70 m and block to block was 1 m.

2.4 Intercultural Operations and Fertilizer Application

Preparation of land was done as per treatment. After the establishment of seedlings, various intercultural operations were accomplished for better growth and development of the okra. Proper intercultural operation facilities e.g .thinning and gap filling, weeding and mulching, irrigation and drainage were provided at the right time. Cow dung, TSP, MP, and Urea were applied at the rate of 14 ton/ha, 150 kg/ha, 150 kg/ha and 150 kg/ha respectively. The entire amount of cow dung, TSP, and MP @ 100 kg/ha were applied at the time of final land preparation. The remaining TSP and MP were applied after 30 days of sowing seed. Urea was applied in three equal installments at 30, 45 and 60 (DAS).

2.5 Identification and Disease Incidence of Okra Yellow Vein Clearing Mosaic Virus (YVCMV)

Disease incidence of YVCMV was observed on the basis of the study of typical symptoms. The

okra plants were inspected every day until the harvest and the symptoms appeared in the okra plants were noted. The growth stage of the plants was categorized as follows-

- 1) Early stage- 6 weeks after sowing seed
- 2) Mid-stage- 3 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 a stage as well as total i.e., an average of three stages. The percent disease incidence was calculated using the following formula Begum (2002).

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

Where,

X= Total number of plants

X₁= Number of infected plants

2.6 Disease Rating Scale

On the basis of disease incidence (%) of okra disease rating scale of YVCMV is as follows [3,12].

Table 1. Disease rating scale of YVCMV of Okra

Rating scale	Incidence range (%)
0 Immune	0
1 Highly resistant	1-10
2 Moderate resistant	11-25
3 Tolerant	26-50
4 Moderate susceptibility	51-60
5 Susceptibility	61-70
6 High susceptibility	71-100

2.7 Collection and Statistical Analysis of Data

A number of plants and number of infected plants from each plot at 40, 60 and 80 days after sowing (DAS) were recorded. The data were analyzed statistically by using the analysis of variance (ANOVA) and MSTAT-C software for proper interpretation. The mean value was compared according to Duncan's Multiple Range Test (DMRT) at 1% level of significance. Correlation and regression study was also done to check the relationship among varieties, insecticides, disease incidence and disease reaction. Tables and bar diagrams were used to interpret the data when required.

3. RESULTS

Four (4) cultivars viz. BARI dherosh 1, Green finger, Nuffield and Orca onamika were assessed against *Yellow vein clearing mosaic virus* of Okra and to manage this disease through Peak Performance Nutrients (PPN), Imidacloprid and Sobicron under field condition.

3.1 Effect of Varieties on Disease Incidence (%) of Yellow Vein Clearing Mosaic for Per Plot and Per Plant at 40, 60 and 80 Days after Sowing (DAS) Respectively

In case of per plot, Orca onamika (18.03, 42.10 and 45.92%) showed highest disease incidence followed by Nuffield (14.79, 18.58 and 25.82%) which are statistically different. The lowest disease incidence was found in the BARI dherosh-1 (8.44, 9.78 and 7.22%) and Green finger (10.16, 10.03 and 10.53%), where they were statistically similar to each other.

The highest disease incidence per plant was observed in Orca onamika (55.87, 75.34 and 88.79%) followed by Nuffield (52.65, 72.07 and 87.51%) which are statistically different. BARI dherosh-1 (43.39, 67.51 and 54.27%) and Green finger (44.66, 69.4 and 67.46%) provided lowest

disease incidence and they are also statistically different to each other. The results are presented in Fig. 1.

From the Fig. 1, it can be revealed that disease incidence per plot and per plant were highest in Orca onamika variety and lowest in the variety of BARI Dherosh-1 at 40, 60 and 80 days after sowing (DAS).

3.2 Effect of Insecticides and Peak Performance Nutrients (PPN) on Disease Incidence (%) of Yellow Vein Clearing Mosaic for Per Plot and Per Plant at 40, 60, 80 Days after Sowing (DAS) Respectively

In case of per plot, the highest disease incidence was observed when no insecticides and PPN (17.92, 27.73 and 32.32%) were used which are statistically different. The moderate disease incidence was found in PPN (14.18, 23.62 and 28.53%), Imidacloprid with PPN (12.38, 17.01 and 17.17%), Imidacloprid (10.65, 21.42 and 19.79%), Sobicron (12.36, 16.84 and 25.69%) which are statistically different to each other. Application of Sobicron with PPN (9.63, 14.12 and 10.78%) showed the lowest disease incidence which is statistically different from the others.

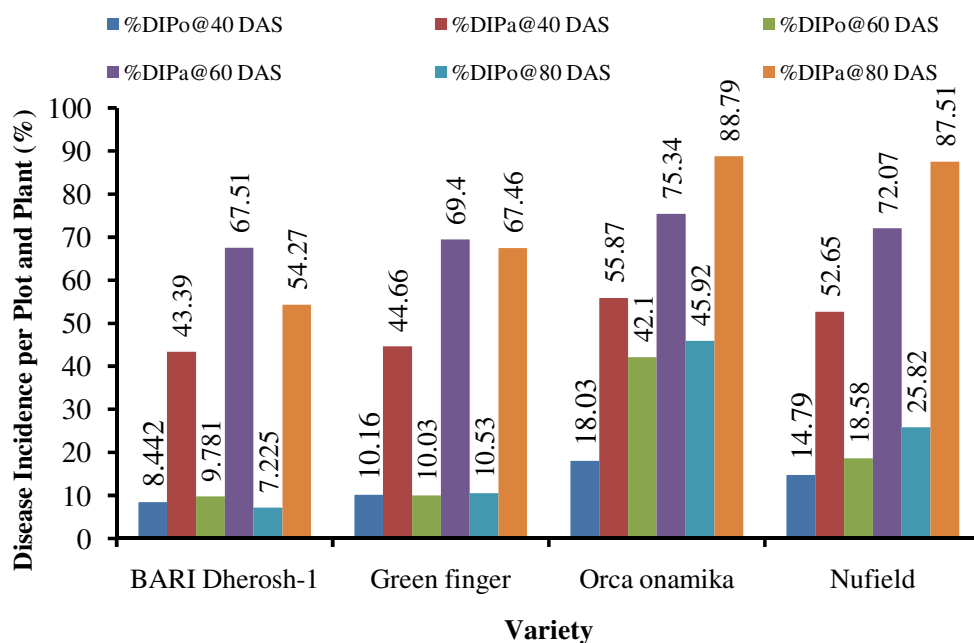


Fig. 1. Disease incidence (%) of YVCMV due to varietal effect at different days after sowing (DAS)

%DIPo= Disease Incidence(%) per Plot and %DIPa= Disease Incidence(%) per Plant

The highest disease incidence per plant was found with the application of no insecticides and PPN (58.30, 84.58 and 85.07%). Moderate disease incidence was observed in PPN (53.40, 81.60 and 77.22%), Imidacloprid with PPN (47.61, 65.25 and 68.07%), Imidacloprid (45.89, 70.45 and 77.13%), Sobicron (48.90, 65.35 and 72.02%). The lowest disease incidence was observed with the application of Sobicron with PPN (40.74, 59.26 and 67.52%) and all of them are statistically different with each other. The results are presented in Fig. 2.

From the Fig. 2, it can be revealed that disease incidence for per plot and per plant were high when no insecticides and PPN (Control) were used followed by only PPN. The lowest disease incidence for per plot and per plant were found when Sobicron with PPN was used followed by Imidacloprid with PPN, only Sobicron, and only Imidacloprid at 40, 60 and 80 days after sowing (DAS).

3.3 Reaction of Tested Okra Varieties against YVCMV in Case of Disease Incidence (%) per Plot at 40, 60 and 80 Days after Sowing (DAS) Respectively

The highest disease incidence per plot was found in Orca onamika (18.03, 42.10 and

45.92%) while Nuffield showed moderate disease incidence (14.79, 18.58 and 25.82%). The lowest disease incidence was observed in the BARI dherosh-1 (8.44, 9.78 and 7.22%) and Green finger (10.16, 10.02 and 10.53%) respectively. It revealed that Orca onamika showed moderate resistance at 40 DAS and tolerance at 60 and 80 DAS where BARI dherosh-1 showed high resistance in all observations at 40, 60 and 80 DAS. The results are presented in Table 2.

3.4 Reaction of Tested Okra Varieties against YVCMV in Case of Disease Incidence (%) Per Plant at 40, 60 and 80 Days after Sowing (DAS) Respectively

The highest disease incidence per plant was found in Orca onamika (55.87, 75.34 and 88.79%) followed by Nuffield (52.65, 72.07 and 87.51%) respectively. The lowest disease incidence was observed in the BARI dherosh-1 (43.39, 67.51 and 54.27%) and Green finger (44.66, 69.40 and 67.46%) respectively. So it can be concluded that Orca onamika showed moderate susceptibility at 40 DAS and high susceptibility at 60 and 80 DAS. The tolerance, susceptibility and moderate susceptibility showed

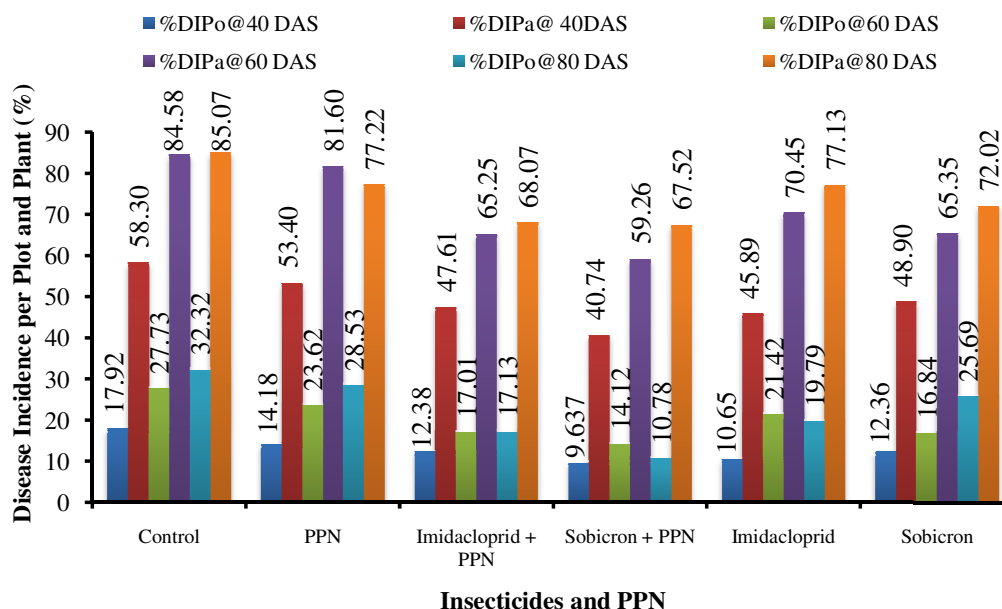


Fig. 2. Disease incidence (%) of YVCMV due to insecticidal and PPN effect at different days after sowing (DAS)

%DIPo= Disease Incidence(%) per Plot, %DIPa= Disease Incidence(%) per Plant and Control= No insecticides and PPN

Table 2. Reaction of tested okra varieties against YVCMV in case of disease incidence (%) per plot

Variety	Disease Incidence (%) per Plot			Disease Reaction		
	40 DAS	60 DAS	80 DAS	40 DAS	60 DAS	80 DAS
BARI Dherosh-1	8.44	9.78	7.22	HR	HR	HR
Green finger	10.16	10.03	10.53	MR	MR	MR
Nuffield	14.79	18.58	25.82	MR	MR	T
Orca onamika	18.03	42.10	45.92	MR	T	T
LSD _{0.01}	4.621	5.307	0.2194			
CV%	16.38	12.02	0.10			

HR= Highly Resistant, MR= Moderate Resistant, T= Tolerant

by BARI dherosh-1 at 40, 60 and 80 DAS respectively. The results are presented in Table 3.

3.5 Reaction of Selected Insecticides and PPN against YVCMV in Case of Disease Incidence (%) Per Plot at 40, 60 and 80 Days after Sowing (DAS) Respectively

The highest disease incidence per plot was found with the application of no insecticides and PPN (17.92, 27.73 and 32.32%). The moderate disease incidence was observed in PPN (14.18, 23.62 and 28.53%), Imidacloprid with PPN (12.38, 17.01 and 17.13%), Imidacloprid (12.36, 21.42 and 19.79%), Sobicron (10.56, 16.84 and 25.69%) were applied. The lowest disease incidence was found with the application of Sobicron with PPN (9.63, 14.12 and 10.78%). It implied that moderate resistance at 40 DAS and tolerance at 60 and 80 DAS were observed when no insecticides and PPN were used. The high resistance at 40 DAS and moderate resistance at 60 and 80 DAS appeared when Sobicron with

PPN was applied. The results are presented in Table 4.

3.6 Reaction of Selected Insecticides and PPN against YVCMV in Case of Disease Incidence (%) Per Plant at 40, 60 and 80 Days after Sowing (DAS) Respectively

The highest disease incidence per plant was found when no insecticides and PPN (58.30, 84.58 and 85.07%) were applied. Moderate disease incidence was observed in PPN (53.40, 81.60 and 77.22%), Imidacloprid with PPN (47.61, 65.25 and 68.07%), Imidacloprid (45.89, 70.45 and 77.13%), Sobicron (48.90, 65.35 and 72.02%). Application of Sobicron with PPN (40.74, 59.26 and 67.52%) showed lowest disease incidence. It implied that moderate susceptibility at 40 DAS and high susceptibility at 60 and 80 DAS were observed when no insecticides and PPN were used. The tolerance, moderate susceptibility and susceptibility at 40, 60 and 80 DAS respectively, were appeared when Sobicron with PPN was used. The results are presented in Table 5.

Table 3. Reaction of tested okra varieties against YVCMV in case of disease incidence (%) per plant

Variety	Disease incidence (%) per plant			Disease reaction		
	40 DAS	60DAS	80 DAS	40 DAS	60DAS	80 DAS
BARI Dherosh-1	43.39	67.51	54.27	T	S	MS
Green finger	44.66	69.40	67.46	T	S	S
Nuffield	52.65	72.07	87.51	MS	HS	HS
Orca onamika	55.87	75.34	88.79	MS	HS	HS
LSD _{0.01}	2.103	4.565	0.5284			
CV%	1.95	2.93	0.32			

HR= Highly Resistant, MR= Moderate Resistant, T= Tolerant

Table 4. Reaction of selected insecticides and PPN against YVCMV in case of disease incidence (%) per plot

Insecticides and PPN	Disease incidence (%) per plot			Disease reaction		
	40 DAS	60 DAS	80 DAS	40 DAS	60 DAS	80 DAS
Control	17.92	27.73	32.32	MR	T	T
PPN	14.18	23.62	28.53	MR	MR	T
Imidacloprid + PPN	12.38	17.01	17.13	MR	MR	MR
Sobicon + PPN	9.63	14.12	10.78	HR	MR	MR
Imidacloprid	12.36	21.42	19.79	MR	MR	MR
Sobicon	10.56	16.84	25.69	MR	MR	T
LSD _{0.01}	4.621	5.307	0.2194			
CV%	16.38	12.02	0.10			

HR= Highly Resistant, MR= Moderate Resistant, T= Tolerant

Table 5. Reaction of selected insecticides and PPN against YVCMV in case of disease incidence (%) per plant

Insecticides and PPN	Disease incidence (%) per plant			Disease reaction		
	40 DAS	60 DAS	80 DAS	40 DAS	60 DAS	80 DAS
Control	58.30	84.58	85.07	MS	HS	HS
PPN	53.40	81.60	77.22	MS	HS	HS
Imidacloprid + PPN	47.61	65.25	68.07	T	S	S
Sobicon + PPN	40.74	59.26	67.52	T	MS	S
Imidacloprid	45.89	70.45	77.13	T	S	HS
Sobicon	48.90	65.35	72.02	T	S	HS
LSD _{0.01}	2.103	4.565	0.5284			
CV%	1.95	2.93	0.32			

T= Tolerant, MS=Moderate Susceptible, S= Susceptible, HS= Highly Susceptible.

4. DISCUSSION

4.1 Disease Incidence

Orca onamica application with no insecticides and PPN combination showed the quick response to the virus. Moderate disease incidence was observed in Green finger and Nuffield when applied with any one of PPN, Imidacloprid with PPN, Imidacloprid, and Sobicon. BARI dherosh-1 with the application of Sobicon and PPN combination showed the best performance against the virus.

4.2 Disease Reaction

BARI dherosh-1 with the application of sobicon and PPN combination has been proved as a highly resistant cultivar. Green finger and Nuffield showed moderate resistance when applied with any one of PPN, Imidacloprid with PPN, Imidacloprid, and Sobicon. Orca onamia was observed as highly susceptible when applied with no insecticides and PPN.

BARI dherosh-1 showed moderate resistance at early growth stages and resistance capacity was increased with the increase of seedlings ages

where both Green finger and Nuffield showed tolerance at an early stage and moderate resistance with the increase of seedlings ages. Orca onamica is highly susceptible to all growth stages. BARI dherosh-1 with the application of Sobicon and PPN combination provided the best performance rather than other cultivars and individual application of insecticides.

5. CONCLUSION

The study was conducted to evaluate the effects of different varieties of okra and two selected insecticides and Peak Performance Nutrients (PPN) on disease incidence of YVCMV. BARI dherosh-1 showed more resistance than Green finger and Nuffield but prior to Orca onamica. Sobicon with PPN combination induced more resistant than other insecticides. Considering the effects of varieties, insecticides, and PPN, it can be concluded that, BARI dherosh-1 with the application of Sobicon with PPN showed better resistance than Green finger and Nuffield against YVCMV with of application Sobicon and PPN combination yet over on Orca onamica with the application of no insecticides and PPN combination.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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