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# MANAGEMENT OF CUCUMBER MOSAIC VIRUS (CMV) INFECTING CUCUMBER IN BANGLADESH

M. S. RAHMAN[1], A. U. AHMED[2], K. JAHAN[3], F. KHATUN[4]

## Abstract

*Cucumber mosaic virus* (CMV) is the most important and widespread virus. It attacks cucumber **(***Cucumis sativus***)** causingsevere yield loss. A research project was undertaken with a view to developing appropriate management option against CMVof cucumber in Bangladesh.Six integrated disease management packages were tested under field condition. A non-treated control was included for comparison with the packages. The experiment was conducted in the research field of Bangladesh Agricultural Research Institute, Gazipur during *rabi* season of 2018. All the treatment packages appreciably reduced CMV incidence of cucumber over control. Disease incidence was reduced to 35.71 to 76.97% over control and yield was increased to 0.37 to 6.40 t/h due to all treatment combinations compared to control. Two treatment packages $T_2$- Netting seedling, sticky yellow trap, polythene mulch and 4 sprays of Imidacloprid 0.1 % at 15 days interval and $T_1$- $T_2$+Bio-neem0.2 % instead of Imidacloprid were considered as the most effective management options on the basis of minimum disease incidence (9.67; 10.5), higher yield (13.04 t/ha; 12.96 t/ha) and Marginal benefit cost ratio (1:3.17&1:2.93), respectively. Marginal cost benefit analysis indicated that the two management packages $T_1$and $T_2$may be economically viable and cost effective.These management packages may be recommended for management of CMV infecting cucumber.

Keywords: CMV; Cucumber; management; sticky yellow trap.

## Introduction

Cucumber **(***Cucumis sativus***)** is a year round important commercial vegetable crop having export potential, throughout the world (Zitter and Murphy, 2009; Rahman *et al*., 2016). In Bangladesh, the crop is cultivated in an area of about 9,593 ha with a total production of 65,499 metric tons. and the average yield is only 6.83 $tha^{-1}$ (Annon, 2018) which is very low as compared to other cucumber growing countries where average yield is more than 30 t $ha^{-1}$. CMV was first found in cucumbers showing mosaic symptoms in 1934 hence the name *Cucumber MosaicVirus* (Price, 1934). It is the type member of the genus *Cucumovirus* in the family Bromoviridaeand has the broadest host range known for any plant virus with approximately 1200 plant species in over 100 plant families (Fauquet *et al.*, 2005; Zitter and Murphy, 2009). Disease, particularly those caused by viruses are considered the major constraints to economic

[1-4]Bangladesh Agricultural Research Institute, Plant Pathology Division, Gazipur-1701, Bangladesh.

production of cucumber and yield losses ranging from 60-100 % in case of early infection (Akbar *et al.*, 2015; Singh and Cheema, 1989). There are essentially two approaches to manage virus diseases. The first approach is to decrease the sources of infection (reservoirs) and secondly to minimize the rate of spread by vector control.

Spraying of insecticides is the only option available to the farmers for managing CMV through vectors control. Only insecticides may not successfully control aphid-transmitted Non-persistent viruses (Hooks *et al.*, 2007)). As the CMV is anaphid-transmitted Non-persistent virus, only insecticidal spray may not control the disease effectively. Moreover, dependence on a single method is highly vulnerable to failure (Lepidot *et al.*, 2001). However, when integrated with more than one management strategies may repress disease significantly more than any single tactic alone (Irwin *et al*., 2000). Therefore, if available an integrated approach is preferred. Many reports are available on the successful application of integrated management tactics for CMV (Anandam and Doraiswamy, 2002; Jones, 2001, Alegbejo and Abo, 2002). Cohen and Marco (1973) reduced the spread of CMV of peppers by using sticky yellow polyethylene along the edges of the field or surrounding the plots. However, such approach has not been tried yet for the management of CMV in Bangladesh. Considering the above facts, the present piece of research was undertaken to evaluate some integratedmanagement approaches against CMV of cucumber.

**Materials and methods**

CMV is an aphid transmitted virus. So, attempts were to control the insects as indirect method to manage the Cucumber mosaic disease of Cucumber. The control tactics tested in the experiment in integrated approaches were as follows:

i) Growing seedling of cucumber under insect proof net.

ii) Use of sticky yellow trap to catch, count and kill the aphids in the experimental plot.

iii) Use of dark color polythene mulch to enhance soil temperature, conserve soil moisture and suppress weeds in the plot.

iv) Four spray with Bio-neem at 15 days interval

v) Spraying with Imidacloprid (0.1%) at 15 or 20 days interval for 4 or 2 times.

The test trial comprised of six treatment packages along with an untreated control was conducted in the research field of Plant Pathology Division, Bangladesh Agricultural Research Institute, Gazipur during *rabi* season of 2018. A year round cucumber variety (Lal teer) susceptible to CMV was used in the experiment. The management packages tested were as follows:

**Table 1. Treatments of the experiment**

| Treatments | Description |
|---|---|
| $T_1$ | Netting Seedling + sticky yellow trap + Polythene mulch + 4 sprays of Bio-neem at 15 days' interval |
| $T_2$ | $T_1$+ spray with Imidacloprid 0.1% |
| $T_3$ | Netting Seedling + sticky yellow trap + Polythene mulch + 2 sprays of Imidacloprid 0.1% at 20 days' interval |
| $T_4$ | Netting Seedling + 4 sprays of Imidacloprid 0.1% at 15 days' interval |
| $T_5$ | Polythene mulch + 4 sprays of Imidacloprid 0.1% at 15 days' interval |
| $T_6$ | Netting Seedling + Maize as barrier crop (Maize were sown in line at 10 cm spacing around the plot at 20 days before transplanting of seedling.) + sticky yellow trap + straw mulch + 2 spray of Imidacloprid |
| $T_7$ | Untreated control |

The efficacy of the treatment packages was evaluated based on disease incidence and severity as described as below (Monma and Sakata, 1997)

Diseases incidence was calculated using the the following formula:

$$\text{Diseases incidence (\%)} = \frac{\text{No. of infected plants}}{\text{Total plants in the plot}} \times 100$$

Disease incidence were confirmed by DAS-ELISA and RT-PCR.

**Disease severity**

Severity of CMV was determined according to Monma and Sakata (1997) with some modification. The disease severity was index based on a 0-4 scale, where,

0= No Symptom, 1= Mild Mosaic, 2= Mosaic, 3= Mosaic and deformed leaf 4= mosaic and stunted plants

$$\text{Severity Index} = \frac{\sum(\text{Symptom index} \times \text{Number of plants with each symptom indeed})}{\text{Total number of plants}}$$

Number of aphidwas counted from randomly selected 10 leaves/plot.Average populations of the insects/leaf was computed. Yield data were recorded in Kg/plot and converted into ton/ha

Economic analysis was performed by partial budget technique as described by Rahman *et al*. (2011) to find out the economically suitable package. Following points were considered for economic analysis:

Variable Cost = Cost (Taka) that vary in different packages

Gross Return (TR) = Yield in terms of money

Gross margin = Gross Return – Variable cost

Marginal benefit = Gross margin (Packages) – Gross margin (control)

Marginal benefit cost ratio (MBCR) was calculated by the following formula:

$$\text{MBCR (over control)} = \frac{\text{Marginal benefit}}{\text{Var. Cost}}$$

**Design of experiment and data analysis**

Randomised complete block design with 3 replications was used for field experiments. Data were analyzed statistically for analysis of variance (ANOVA) using open source R software and means were compared according to Duncan's Multiple Range Test (Gomez and Gomez, 1984). Data were transformed as and when necessary using Arcsine transformation method.

**Results and Discussion**

**Aphid population**

The effect of different management options on aphid population per leaf is shown in Fig. 1. The highest number of aphid per leaf (14.50) was recorded from the plants under control. Every management packages caused significant reduction in number of aphid population per plant over untreated control. Significantly lower number of aphids was recorded from plant treated with management packages $T_2$ and $T_1$ compared to other packages. However, efficacy of two packages was statistically similar and very few aphid was observed in treatment plot of $T_2$ and $T_1$. It might be due to effectively control of aphids in the treatment i.e. Sticky yellow trap act as continuous barrier against the aphid and again spray with insecticide reduce the colonization of aphid vector on leaf in the treated plot. Therefore, the disease incidence was less in treated plot as compared to control.

**Incidence and severity of CMV:** Disease incidence and severity of CMV under different treatments are presented in Fig. 2. Incidence of CMV under all the management packages ($T_1$-$T_6$) ranged 9.67-25.10 %, which was lower compared to control. The highest disease incidence (42.00%) was recorded from $T_7$ (control). The lowest incidence (9.67%) was observed under $T_2$ which was statistically similar to $T_1$ (10.5%). The incidence of CMV in $T_4$, $T_5$ and $T_6$, was statistically similar but significantly higher compared to $T_1$, $T_2$ and $T_3$. Similarly, the highest disease severity index was found in $T_7$ (control) and each of the management packages ($T_1$-$T_6$) reduced severity of CMV significantly over control. The lowest severity was found under $T_2$, which was statistically similar to $T_1$. Among the treatments $T_2$ and $T_1$ was found very much effective in reducing both disease incidence and severity. However, treatments involving sticky yellow trap, polythene mulch with 4 spray of Bio-neem or imidacloprid

($T_2$ and $T_1$) was better than other management packages. It might be due to better control of CMV vectors (aphids) in the treated plot. CMV is an aphid transmitted non- persistent virus, so only insecticides spray is not enough to control the vector as it required only few seconds to transmit virus from infected to healthy plant. So use of disease free seedling, sticky yellow trap, polythene mulch and then spray insecticide effectively controlled the vectors and reduced the disease incidence and severity in the management packages.

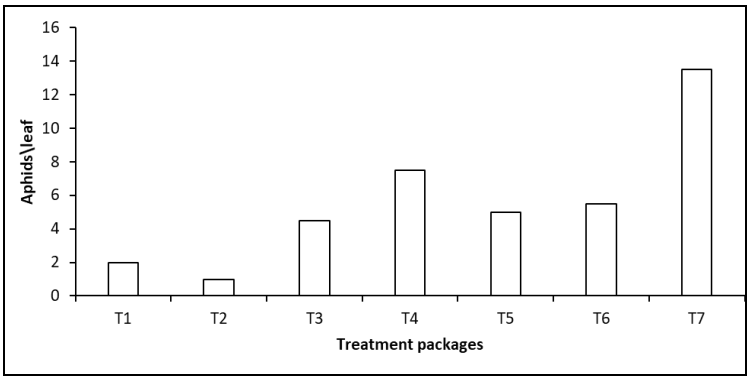


**Fig. 1. Effect of different management packages on number of aphids/leaf.($T_1$: Netting Seedling + sticky yellow trap +Polythene mulch + 4 sprays of Bio-neem at 15 days' interval; $T_2$: $T_1$ + spray with Imidacloprid 0.1%; $T_3$: Netting Seedling + sticky yellow trap + Polythene mulch + 2 sprays of Imidacloprid 0.1% at 20 days' interval; $T_4$: Netting Seedling + 4 sprays of Imidacloprid 0.1% at 15 days' interval; $T_5$: Polythene mulch + 4 sprays of Imidacloprid 0.1% at 15 days' interval; $T_6$: Netting Seedling + Maize as barrier crop + sticky yellow trap + straw mulch + 2 spray of Imidacloprid; $T_7$: Control).**

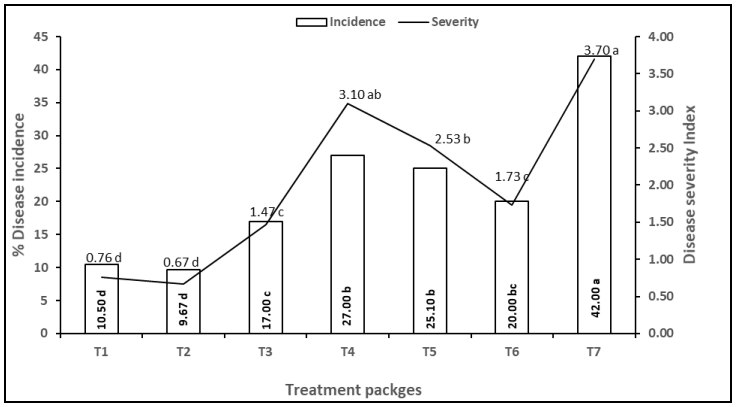


**Fig. 2. Effect of different management packages on the incidence and severity index of CMV in Cucumber. ($T_1$: Netting Seedling + sticky yellow trap +Polythene mulch + 4 sprays of Bio-neem at 15 days' interval; $T_2$: $T_1$ + spray with Imidacloprid 0.1%; $T_3$: Netting Seedling + sticky yellow trap + Polythene mulch + 2 sprays of Imidacloprid 0.1% at 20 days' interval; $T_4$: Netting**

**Seedling + 4 sprays of Imidacloprid 0.1% at 15 days' interval; $T_5$: Polythene mulch + 4 sprays of Imidacloprid 0.1% at 15 days' interval; $T_6$: Netting Seedling + Maize as barrier crop + sticky yellow trap + straw mulch + 2 spray of Imidacloprid; $T_7$: Control).**

## Relationship between aphid population and incidence of CMV

In the field trial it was found that the number of CMV infected plants were higher with the increase of aphid number per plant. The relationship was linear, positive and significant ($R^2$ = 0.7553, r=86.901*) and could be expressed by the regression equation Y= 3.6484x + 4.8546, where Y= incidence of CMV (%) and x =number of aphids per plant (Fig. 3). The $R^2$ value indicates that the spread of CMV in the field might be attributed by aphid population by 75.53 %.

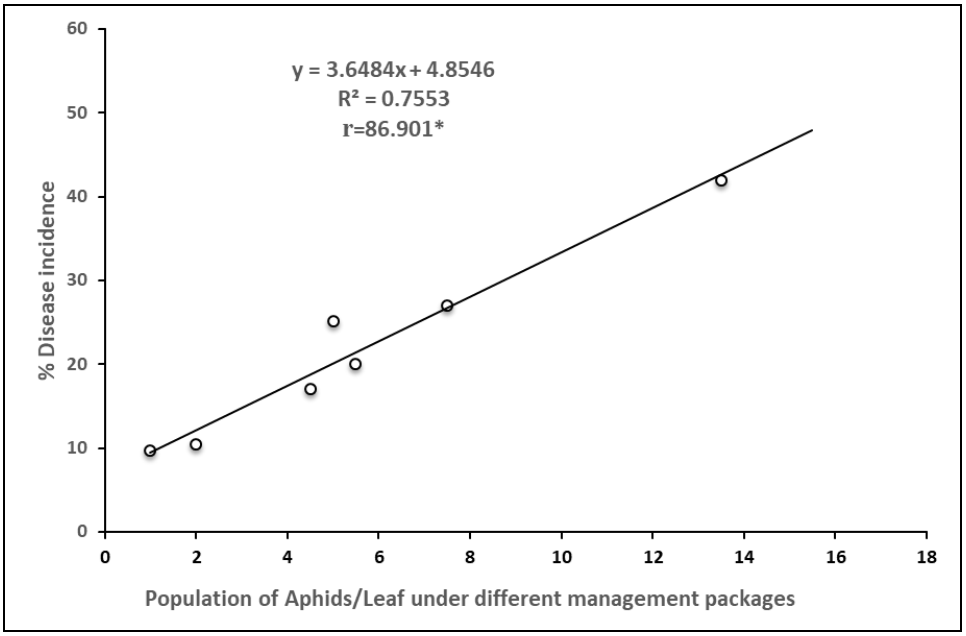


**Fig. 3. Relationship between aphid population and percent disease incidence in different management options.**

## Effect of management packages on yield

All the management options reduced disease incidence and gave higher yield as compared to control (Table 2). The highest yield was found 13.07 ton/ha in treatment packages $T_2$ (Netting Seedling + sticky yellow trap +Polythene mulch + 4 sprays of imidacloprid 0.1% at 15 days' interval) which was statistically similar to $T_1$ (Netting Seedling + sticky yellow trap +Polythene mulch + 4 sprays of Bio-neem at 15 days' interval) but significantly higher from other management options. The lowest yield (6.67 t/ha) was found in $T_7$ (untreated

control). The yield of other treatments ranged from 7.04 to 10.15 t/ha. The highest reduction of disease incidence was found 76.97% in treatment $T_2$ which was statistically similar to $T_1$ (75 %). Other treatment packages also reduced disease incidence at a considerable level (35.71-59.52 %). However, among the treatment packages, performance of packages $T_2$ and $T_1$ was the best.

**Table 2. Effect of management packages on disease reduction and yield of cucumber**

| Treatments | Disease Incidence (%) | Reduction in disease incidence (%) | Yield (t/ha) | Yield increase (t/ha) |
|---|---|---|---|---|
| $T_1$=Netting Seedling + sticky yellow trap +Polythene mulch + 4 sprays of Bio-neem at 15 days' interval; | 10.50 d (18.88) | 75.00 | 12.96 a | 6.29 |
| $T_2$=T1 + spray with Imidacloprid 0.1%; | 9.67 d (18.05) | 76.97 | 13.07 a | 6.40 |
| $T_3$=Netting Seedling + sticky yellow trap + Polythene mulch + 2 sprays of Imidacloprid 0.1% at 20 days' interval | 17.00 c (24.31) | 59.52 | 10.15 b | 3.48 |
| $T_4$=Netting Seedling + 4 sprays of Imidacloprid 0.1% at 15 days' interval | 27.00 b (31.29) | 35.71 | 7.04 d | 0.37 |
| $T_5$=Polythene mulch + 4 sprays of Imidacloprid 0.1% at 15 days' interval | 25.10 b (30.06) | 40.23 | 9.30 b | 2.63 |
| $T_6$=Netting Seedling + Maize as barrier crop + sticky yellow trap + straw mulch + 2 spray of Imidacloprid | 20.00 bc (26.51) | 52.38 | 8.52 c | 1.85 |
| $T_7$=Control | 42.00 a (40.36) | - | 6.67 d | - |
| LSD | 4.76 | | 0.87 | |
| CV % | 9.91 | | 14.50 | |

* Means followed by same letter are not significantly different at 5% level by DMRT. Value within parenthesis are arcsine transformed value.

## Economic analysis

Results obtained from economic analysis of various treatments are presented in Table 3 and 4. All treatments more or less increased the gross return over

control. However, gross return was highest in $T_2$ followed by $T_1$, $T_3$, $T_5$, $T_6$ and $T_4$. The lowest was obtained from Control. Marginal analysis has pointed out that all the management packages increased marginal benefit as well as marginal benefit cost ratio (MBCR) over control (Table 4). The highest MBCR was obtained from $T_2$ and the lowest from $T_4$. The results showed that additional investment of Taka 1 in $T_2$ over control had additional income of Taka 3.17 and similarly Tk. 2.93 in $T_1$, Tk. 1.61 in $T_3$, Tk. 1.47 in $T_5$, Tk. 1.31 in $T_6$, respectively. Considering cost and return and MBCR from the economic analysis indicated that all the management packages except $T_4$ (MBCR 1:0.85) were economically viable and maximum gain could be obtained from $T_2$ (integration with netting seedlings, sticky yellow trap, polythene mulch and 4 spray with imidacloprid 0.1%).

**Table 3. Cost and return in different management packages**

| Packages | *Var. Cost (Tk $ha^{-1}$) | Yield (t $ha^{-1}$) | **Gross return (Tk $ha^{-1}$) |
|---|---|---|---|
| $T_1$=Netting Seedling + sticky yellow trap +Polythene mulch + 4 sprays of Bio-neem at 15 days' interval; | 24000.00 | 12.96 | 194400.00 |
| $T_2$=T1 + spray with Imidacloprid 0.1%; | 23000.00 | 13.07 | 196050.00 |
| $T_3$=Netting Seedling + sticky yellow trap + Polythene mulch + 2 sprays of Imidacloprid 0.1% at 20 days' interval | 22000.00 | 10.15 | 152250.00 |
| $T_4$=Netting Seedling + 4 sprays of Imidacloprid 0.1% at 15 days' interval | 5000.00 | 7.04 | 105600.00 |
| $T_5$=Polythene mulch + 4 sprays of Imidacloprid 0.1% at 15 days' interval | 19000.00 | 9.30 | 139500.00 |
| $T_6$=Netting Seedling + Maize as barrier crop + sticky yellow trap + straw mulch + 2 spray of Imidacloprid | 12000.00 | 8.52 | 127800.00 |
| $T_7$=Control | - | 6.67 | 100050.00 |

* Var. Cost: Cost that vary in different packages

** Whole Sell rate of cucumber @ TK 15.00/Kg

**Table 4. Marginal analysis of different treatment packages**

| Packages | Gross return (Tk $ha^{-1}$) | Var.Cost (Tk $ha^{-1}$) | Gross margin (Tk $ha^{-1}$) | Marginal benefit (Tk $ha^{-1}$) | MBCR |
|---|---|---|---|---|---|
| $T_1$=Netting Seedling + sticky yellow trap +Polythene mulch + 4 sprays of Bio-neem at 15 days' interval; | 194400.00 | 24000.00 | 170400.00 | 70350.00 | 1: 2.93 |
| $T_2$=T1 + spray with Imidacloprid 0.1%; | 196050.00 | 23000.00 | 173050.00 | 73000.00 | 1: 3.17 |
| $T_3$=Netting Seedling + sticky yellow trap + Polythene mulch + 2 sprays of Imidacloprid 0.1% at 20 days' interval | 152250.00 | 20000.00 | 132250.00 | 32200.00 | 1: 1.61 |
| $T_4$=Netting Seedling + 4 sprays of Imidacloprid 0.1% at 15 days' interval | 105600.00 | 3000.00 | 100600.00 | 550.00 | 1: 0.85 |
| $T_5$=Polythene mulch + 4 sprays of Imidacloprid 0.1% at 15 days' interval | 139500.00 | 16000.00 | 123500.00 | 23450.00 | 1: 1.47 |
| $T_6$=Netting Seedling + Maize as barrier crop + sticky yellow trap + straw mulch + 2 spray of Imidacloprid | 127800.00 | 12000.00 | 115800.00 | 15750.00 | 1: 1.31 |
| $T_7$=Control | 100050.00 | - | 100050.00 | - | - |

(MBCR: Marginal benefit cost ratio)

Different management packages caused 35.71-76.97% reduction in disease incidence and increased yield 0.37-6.40 ton/ha (Table 2). In the present investigation, treatment packages comprising with Netting Seedling, sticky yellow trap, Polythene mulch and 4 sprays of Imidacloprid 0.1% /Bio-neem at 15 days interval ($T_2$& $T_1$) were found better than any other packages in terms of disease suppression and yield improvement (Table 2). Successful application of integrated management for CMV has also been postulated in the review by Hooks and Fereres (2006). Among the treatment packages, $T_4$ was found less effective. This is obvious, because the non-persistent manner of virus transmission like CMV. Only use of insecticides is not always effective as the aphids become irritated and therefore jump from leaf to leaf or plant to plant in an attempt to avoid the insecticides, subsequently infecting healthy plants because the acquisition and inoculation time is very short. For this, aphids are

capable to inoculate healthy plants within few seconds. That is why disease incidence and severity was high as compared to other packages and ultimately reduced the yield (Table 2). Because of the very short time needed to transmit a virus, aphids are capable of transmitting NPVs (Non-persistent viruses) prior to being killed by an insecticide. This observation is an agreement with the findings of Hooks *et al*. (2007).

Again treatment $T_2$ gave higher yield than $T_1$but their difference was not significant. It might be due to less suppression of aphids by Bio-neem as compared to Imidacloprid 0.1 %. However, in case of diseases incidence and yield both the packages more or less similar. The better result was achieved with the treatment packages $T_2$ and $T_1$,it might be due to sticky yellow trap acted as continuous "spread breakers" by attracting aphids and preventing the colonization on the cucumber leaves and insecticidal sprays further suppressed disease spread. The finding is also in conformity of the previous findings of Anandam and Doraiswamy (2002)in case of non-persistent virus like CMV.

Economic analysis revealed that profit varies depending on the management packages. Results of the present investigation indicate that $T_2$ is the best treatment in terms of economic gain. It has got chemical back up in addition to sticky yellow trap. So that successful control was achieved against aphid vector which reduced incidence and severity of CMV. Furthermore, polythene mulch increases the soil temperature that enhance the growth and development of cucumber as well as suppress weeds in the field. Therefore, higher yield was achieved from that treatment. From the environmental point of view $T_1$ may be used. Because it has got botanical insecticide (Bio-neem) instead of chemical which is environmentally safe although marginal benefit cost ratio (MBCR) was little lower than $T_2$. Although the variable cost of $T_2$and $T_1$ (Tk 24000 and 23000) is higher but the treatments are cost effective considering return for additional cost.

Effect of CMV on yield depends on a number of factors, including plant age and growth stage when infected, viruliferous vector population, environmental conditions etc. (Agrios, 1988 Rahman, 2008). Results of the present investigation demonstrate that CMV of cucumber may be effectively managed through integration of netting seedlings, use of sticky yellow trap, polythene mulch (winter season) and four spray of imidacloprid 0.1% or Bio-neem 0.2 % at 15 days interval. This is the first report of an integrated management of *Cucumber mosaic virus* (CMV) of cucumber in Bangladesh.

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