Original Research Article

Integrated Management Strategies for Cucurbit Mosaic Disease in Cucumber (*Cucumis sativus*): A Field Study from Assam

ABSTRACT

Aims: The aim of the research is to evaluate various integrated management strategies for successful management of cucurbit mosaic disease in cucumbers (*Cucumis sativus*) in field conditions, as well as determine their impact on disease incidence and yield.

Study design:A field experiment with six treatments and one control was conducted using a Randomised Block Design (RBD) with three replications.

Place and Duration of Study: Experimental fields of Biswanath College of Agriculture, Biswanath Chariali, Assam, India, during 2021-2022.

Methodology:A local cucumber variety was used to test seven treatments, including insect-proof seedling raising, yellow sticky traps, straw mulch, foliar sprays with neem formulation (Azadirachtin 0.03%), mineral oil, biopesticides (*Beauveria bassiana* and *Bacillus thuringiensis*), and a chemical insecticide (Imidacloprid). Disease incidence and fruit yield were recorded at intervals of 15 days from 30 to 75 days after transplanting. Correlation analysis was performed between disease.

Results: Treatment with a neem formulation (Azadirachtin 0.03%) at 5 ml/L (T2) significantly reduced disease incidence (38.89%) and increased yield (32.83 q/ha), comparable to the insecticide treatment (Imidacloprid, T6), which had the lowest disease incidence (22.22%) and highest yield (38.55 q/ha).The disease incidence and aphid vector population were mild in treatment T2 and T6, while the control (T0) showed severe disease and high vector density. Correlation analysis revealed a strong negative relationship between disease incidence and yield (r = -0.969).

Conclusion: As an alternative to chemical pesticides, neem formulation has shown efficacy in controlling cucurbit mosaic disease with a reduced impact on the environment. Integrated management strategies that incorporate neem-based botanicals and biopesticides provide long-term alternatives for managing cucurbit mosaic disease and reducing cucumber yield losses. Regular field surveillance and vector control are essential for effective disease management.

Keywords: Cucurbit mosaic disease, integrated management, neem formulation, biopesticides, yield improvement.

1. INTRODUCTION

Cucurbit mosaic disease is one of the most serious virus diseases of cucurbits worldwide. It has been reported that different viruses are associated with the disease; *viz.,* cucumber mosaic virus (CMV), watermelon mosaic virus (WMV), zucchini yellow mosaic virus (ZYMV), Pumpkin yellow vein mosaic virus (PYVMV) as well as papaya ringspot virus-watermelon strain (PRSV-W) (Biswas and Ghosh 2018; Kumar *et al.* 2008). Aphid transmission is considered the primary mode of transmission of these viruses (Panno *et al.* 2021). Aphids acquire the Cucurbit mosaic virus (CMV) when they feed on infected plant tissue, and the virus can subsequently be transmitted to healthy plants during future feeding activities (Gilligan 2007; Roy *et al.* 2023). A prolonged feeding period is not necessary for the aphid to acquire or spread the virus because it is frequently spread in a non-persistent way (McKirdy and Jones 1994). The green peach aphid (*Myzuspersicae*), cotton aphid (*Aphis gossypii*), and cowpea aphid (*Aphis craccivora*) are the primary aphid species involved. They are all known to colonize cucurbit crops and weeds that can act as virus reservoirs (Shi *et al.* 2016). A comprehensive strategy that targets the virus and its aphid vectors is necessary for the effective management of Cucurbit mosaic disease.Cucumber beetles are also minor contributor of cucurbit virus infections. Cucurbit cultivation consists of about 5.6% of India's total vegetable production (Brar *et al.* 2021). Major cucurbit growing states of India are Orissa, Assam, Rajasthan and Punjab (Anon 2020). Common symptoms of Cucurbit mosaic disease has been reported as mosaic patterns of dark and light green to yellow, leaf distortion, yellow streaking/spots, and vein yellowing (Loebenstein and Lecoq 2012). Severely infected plants exhibit epinasty, reduced leaf size, and petiole/leaf surface bending (Zitter and Murphy 2009). Fruit symptoms include lumps, bumps, rings, and, if infected at pre-pollination stage; then the fruits show green/yellow blotches or stripes. Severe cases result in little to no fruit production, with deformities, discoloration, reduced size, yield, and potential fruit death (Anon 2021).

Among the North-Eastern states of India, Assam is one of the major states growing cucurbit vegetables (Anon 2020). It was reported that viral diseases such as cucumber mosaic virus (CMV) cause losses as high as 100% (Khan e*t al.*2015). From Assam, cucumber mosaic virus infection in pumpkin crop was documented by Gogoi *et al.* (2023) with disease incidence of 35.71% from Jorhat district and 52.38% from Golaghat district. This necessitates a need to document the presence of CMV in other cucurbit crops grown in Assam and experiment on integrated management strategies for the emerging cucurbit mosaic disease in this region of the country.

Therefore, an integrated approach for management of cucurbit mosaic disease of cucumber was carried out in the field experiment to determine the occurrence CMV.

2. MATERIAL AND METHODS

A field experiment comprised of seven treatments (including the control) with 3 replications was conducted to formulate an integrated management strategy for cucurbit mosaic disease in the experimental field of Biswanath College of Agriculture, Biswanath Chariali using a local cucumber variety having crop duration of 90-120 days and a potential yield of 50-60 q/ha. Nursery treatment (TA)= Cucumber seeds were germinated and seedlings were grown in polybags under insect-proof conditions. Seedlings were transplanted at 2-3 leaf stage in the main field.

The field experiment was comprised of the following treatment combinations:

1. T_0=Control
2. T_1= TA + Yellow sticky trap + Straw mulch
3. T_2= T_1 + Spraying of neem formulation (Azadirachtin 0.03%) @ 5 ml/L at 30, 45, 60 and 75 days after transplanting
4. T_3=T_1+ Application of mineral oil @ 5ml/L at 30,45, 60 and 75 days after transplanting
5. T_4= T_1 + Foliar spraying with Bio-sona (Bio formulation with *Beauveria bassiana*) @ 20 ml/L at 30,45, 60 and 75 days after planting
6. T_5 = T_1 + Spraying of Bio-Bt (Bio formulation with *Bacillus thuringiensis*) @ 20 ml/L at 30, 45, 60 and 75 days after transplanting
7. T_6 = T_1 + Foliar spraying with Imidacloprid @0.2ml/L at 30, 45, 60 and 75 days after planting

In the experiment, a commercial neem formulation, “Nimbecidine” with 0.03% Azadiractin was used. The bio pesticides *viz.;* Biosona and Bio- Bt standardized by Department of Plant Pathology, AAU, Jorhat were used for spraying. The commercial Imidacloprid insecticide “Dzire” containing 70% imidacloprid was used as chemical check.

Plants were examined on a routine basis for appearance of any symptoms of mosaic disease. The disease incidence was noted every 15 days between 30 and 75 days after planting. Data on fruit yield were also recorded for each treatment and further correlated with disease incidence.

3. RESULTS AND DISCUSSION

Characteristic symptoms of cucurbit mosaic disease were observed in the experimental plot (Fig 1). Early symptoms included light and dark green mosaic patterns on the leaves and upward curling of the leaf edges. There was reduction in size of the leaves of infected plants, resulting in small, crinkled, and abnormal leaves. The infected plants developed

chlorosis, deformed leaves, and unmarketable fruits as the disease progressed. Older leaves on infected plants showed vein banding and yellow spots. Vein clearing and leaf yellowing were also prominent in severely infected plants.

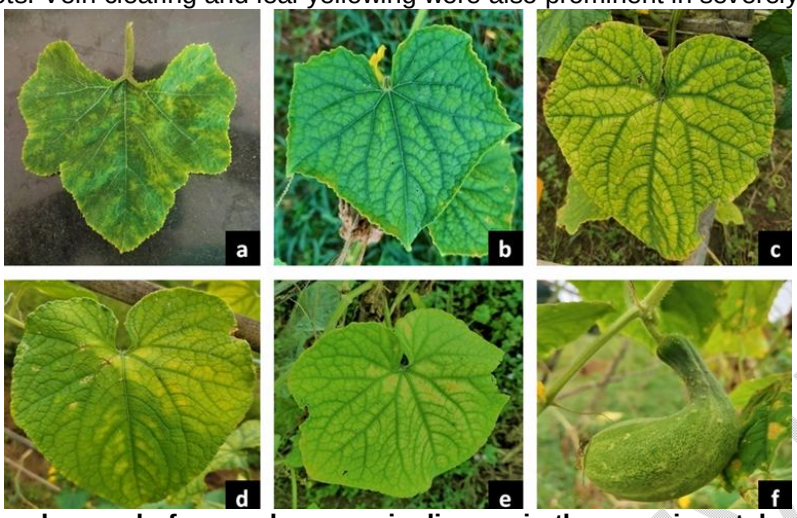

Fig 1.Different symptoms observed of cucumber mosaic disease in the experimental research plot. a= mosaic pattern on leaf. b= upward curling of leaf margins. c=vein banding. d= leaf chlorosis. e= deformed leaf. f= deformed fruit

There was comparatively low disease incidence (38.89%) in the treatment no.3 (T_2= T_1 + Foliar spraying with Azadirachtin 0.03% at 30, 45, 60 and 75 days after planting) than the other treatments and this was effective in reducing disease incidence similarly as that of the insecticide check; *i.e.,*the treatment no.7 (T_6= T1 + Foliar spraying with Imidacloprid @0.2 ml/L at 30, 45, 60 and 75 days after planting) which showed the lowest disease incidence of 22.22% throughout the cropping period. In case of treatments; the treatment no.3 (T_2= T_1 + Spraying of neem formulation (Azadirachtin 0.03%@ 5 ml/L at 30, 45, 60 and 75 days after transplanting) was followed by the treatment no.5 (T_4=T1 + Foliar spraying with Bio-sona (*Beauveria bassiana*at 30, 45, 60 and 75 days after planting) with 55.56% disease incidence (Table I). Highest yield of 38.55 q/ha (8 no. of fruits per bed) was obtained from the treatment no.7 (T_6) (insecticide check). Amongst various treatments, higher yield was obtained from the treatment no.3 (32.83q/ha**).** Table II shows effects of different treatments on cucumber yield (75 days after planting).

Table I Effect of different treatments on cucurbit mosaic disease incidence

Treatment No.	Treatments	Disease incidence through visual observation at different intervals after planting (%)			
		30 DAP	45 DAP	60 DAP	75 DAP
1	T_0	12.57 (19.20)	45.36 (42.29)	83.60656 (12.88)	88.89 (13.34)
2	T_1	7.10 (13.28)	34.43 (35.93)	72.6776 (12.00)	83.33 (12.88)
3	T_2	1.64 (7.36)	1.64 (7.36)	23.49727 (6.54)	38.89 (8.75)
4	T_3	12.57 (19.20)	23.50 (28.73)	56.28415 (10.50)	66.67 (11.48)
5	T_4	1.64 (7.36)	7.10 (13.28)	34.42623 (8.13)	55.56 (10.50)
6	T_5	1.64 (7.36)	18.03 (25.13)	50.81967 (9.88)	61.11 (11.02)
7	T_6	1.64 (7.36)	1.64 (7.36)	18.03279 (5.74)	22.22 (6.54)
SEd		5.781349	3.625833	5.12	7.44
CD(P=0.05)		NS	7.90	1.28	1.45
CV		61.11	19.42	7.65	7.64

*There was no disease development up to 30 days after planting.

Data are sum of three replications. Data within parentheses are angular transformed values

Table II Effect of different treatments on yield

Treatment No.	Treatments	No. of cucumber per plant	Weight of cucumbers (g) per plant	Yield (q/ha)
1	T_0	1	170	3.09
2	T_1	3	182	9.93
3	T_2	7	258	32.83
4	T_3	4	190	13.82
5	T_4	6	247	26.95
6	T_5	5	220	20.00
7	T_6	8	265	38.55
SEd				0.60
CD (P=0.05)				1.317
CV				15.236

Severe symptoms and highest vector population were observed in treatment no.1 (Control, T_0) and treatment no. 2 (T_1= TA + Yellow sticky trap + Straw mulch). Mild symptoms with lowest vector population were observed in treatment no.3 (T_2= T_1 + Spraying of neem formulation (Azadirachtin 0.03%) @ 5 ml/L at 30, 45, 60 and 75 days after transplanting) along with treatment no.7 (T_6 = T_1 + Foliar spraying with Imidacloprid @0.2ml/L at 30, 45, 60 and 75 days after planting.)

Table III Severity of cucurbit mosaic symptoms and vector population count in different treatment combinations

Treatment No.	Treatment	Symptoms observed in the field	Vectors
1	T_0	+++	***
2	T_1	+++	***
3	T_2	+	*
4	T_3	++	**
5	T_4	++	**
6	T_5	++	**
7	T_6	+	*

(+) = Mild (less than 50%), (++) = Moderate (50-75%), (+++) = Severe (75% and more)
(*) = Low (Less than 50%), (**) = Medium (50-75%), (***) = High (75% and more)

The correlation analysis showed that the yield of cucumber was negatively correlated with cucurbit mosaic disease incidence with coefficients of correlation for disease incidence and yield was -0.969 (**Significance at 1 per cent probability level). Hence, it was evident that with increase in cucurbit mosaic disease incidence there was reduction in yield of cucumber (Fig 2).

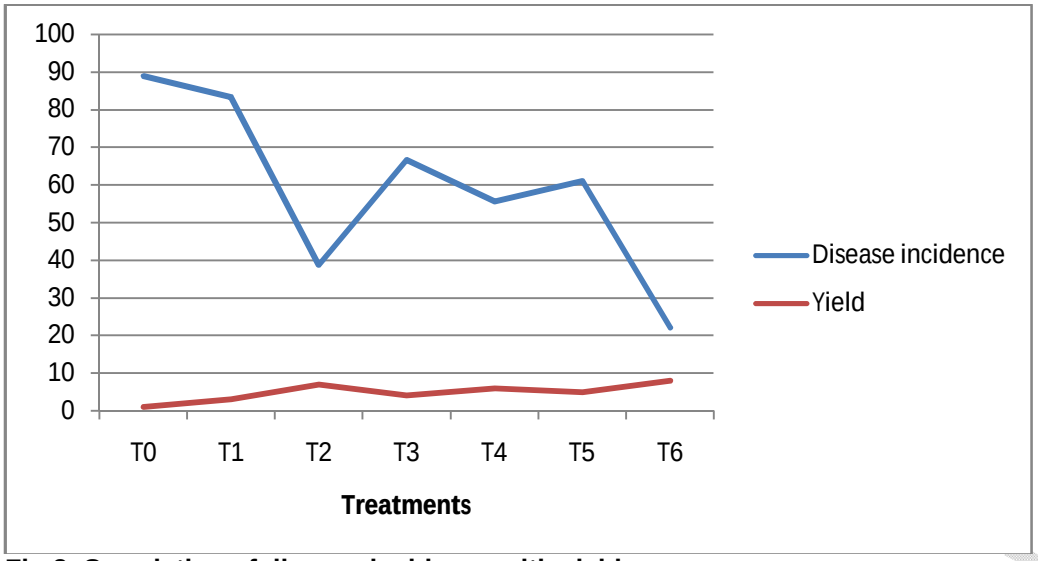

Fig 2. Correlation of disease incidence with yield

Discussion: The integrated management module showed some effective strategies for management of cucurbit mosaic disease. The neem formulation, could give effective results with low disease incidence with low vector populationand it is having minimum environmental residual effect, making it a safer option than chemical pesticides. Early detection and routine field inspection are therefore crucial for effective disease management. The use of botanicals like neem formulations as well as entomopathogenic biopesticides, showed good results in management of the cucurbit mosaic disease; hence could be suggested as effective strategies for the same.

The complex interactions between the virus, vector, and host plants frequently make it difficult to design efficient management strategies. Identification of the causal agent and application of different control measures under integrated approach has been one of the important components of viral disease management. Under field conditions, monitoring and trapping of insect vectors can help to reduce the spread of the disease. The use of a systemic insecticide may also aid in aphid population reduction (Jam *et al.* 2014; Daunde*et al.* 2020). However, chemical insecticides are not considered as a long-term strategy for controlling CMV, as these can harm beneficial insects in addition to the targeted pest (Wang and Uchida 2014).

Insecticide use on a regular basis can also result in the development of insecticide-resistant vectors. Furthermore, insecticides are expensive and contribute to environmental imbalance. Neem based formulations have been shown to be highly effective in controlling aphid populations in cucurbits (Sharma *et al.* 2017). Biopesticides can also be used as an alternative management strategy of chemical treatments.

4. CONCLUSION

Among all the treatments, T6 (foliar spraying with imidacloprid) was the most successful treatment; it showed the highest yield (38.55 q/ha) and the lowest illness incidence (22.22%). Promising results were also demonstrated by T2 (spraying of neem formulation), which was an environmentally safer alternative with a higher yield (32.83 q/ha) and a lower disease incidence (38.89%). The study emphasizes the potential of biopesticides and neem-based formulations as long-term and successful approaches to managing cucurbit mosaic disease, lowering disease incidence and vector populations. By combining these techniques with regular monitoring, cucurbit farming can become more environmentally friendly and sustainable over the long run by reducing the requirement for chemical pesticides.

CONSENT (WHEREEVER APPLICABLE)

Consent from all the authors were taken before submitting this manuscript.

ETHICAL APPROVAL (WHEREEVER APPLICABLE)

This manuscript is ethically approved by all the authors.

REFERENCES

Biswas, M.K., Ghosh, T. (2018) Natural incidence of mosaic disease of pumpkin (Cucurbita moschata) and its management through avoidance. Bionature, 38 (2), 96-104.

Kumar, Y., Hallan, V., Zaidi, A. A. (2008) Molecular characterization of distinct Begomovirus species infecting tomato in India. Virus Genes, 37, 425- 431.

Panno, S., Davino, S., Caruso, A., Bertacca, S., Crnogorac, A., Mandić, A. et al. (2021). A Review of the Most Common and Economically Important Diseases That Undermine the Cultivation of Tomato Crop in the Mediterranean Basin. Multidisciplinary Digital Publishing Institute, 11(11), 2188-2188. https://doi.org/10.3390/agronomy11112188

Gilligan, C. A. (2007). Sustainable agriculture and plant diseases: an epidemiological perspective. Royal Society, 363(1492),741-759. https://doi.org/10.1098/rstb.2007.2181

Roy, B., Venu, E., Kumar, S., Dubey, S., Lakshman, D.K., Mandal, B. et al. (2023). Leaf Curl Epidemic Risk in Chilli as a Consequence of Vector Migration Rate and Contact Rate Dynamics: A Critical Guide to Management. Multidisciplinary Digital Publishing Institute, 15(4), 854-854. https://doi.org/10.3390/v15040854

McKirdy, S., Jones, R. A. C. (1994). Infection of alternative hosts associated with narrow-leafed lupin (Lupinus angustifolius) and subterranean clover (Trifolium subterraneum) by cucumber mosaic virus and its persistence between growing seasons. CSIRO Publishing, 45(5),1035-1035. https://doi.org/10.1071/ar9941035

Shi, X., Gao, Y., Yan, S., Tang, X., Zhou, X., Zhang, D. et al. (2016). Aphid performance changes with plant defense mediated by Cucumber mosaic virus titer. BioMed Central, 13(1). https://doi.org/10.1186/s12985-016-0524-4

Brar, A., Deswal, S., Singh, D. (2021)Cultivation technology of Cucurbits.Indian Farmer, 8, 259-267.

Anonymous. (2020). Pumpkin Cultivation. Horticulture Guruji.https://www.horticultureguruji.in/pumpkin-cultivation/#:~:text=The%20pumpkin%20crop%20will%20reach,from%20the%20vine%20or%20dried.

Loebenstein, G., Lecoq, H. (2012). Viruses and virus diseases of vegetables in the Mediterranean basin, 84. (In press)

Zitter, T. A., Murphy, J. F. (2009). Cucumber mosaic. Plant Health Instructor,https://apsjournals.apsnet.org/doi/10.1094/PDIS-08-14-0844-PDN

Anonymous. (2021). Zucchini yellow mosaic virus.https://en.wikipedia.org/wiki/Zucchini_yellow_mosaic_virus.

Khan, A. A., Ahmad, Z., Begum, F. (2015). Varietal reaction of cucumber against cucumber mosaic virus. American Journal of Plant Sciences , 6(7), 833-838.

Gogoi, K., Borah, M., Nath, P. D., Mishra, R. (2023) Incidence and molecular characterization of cucumber mosaic virus in Pumpkin crop from Assam.The Pharma Innovation, 12(10), 1531-1535.

Jam, N. A., Kocheyli, F., Mossadegh, M. S., Rasekh, A., Saber, M. (2014). Lethal and sublethal effects of imidacloprid and pirimicarb on the melon aphid, *Aphis gossypii* Glover (Hemipter: Aphididae) under laboratory conditions. Journal of Crop Protection, 3 (1), 89- 98.

Daunde, A. T., Baghele, R. D., Khandare, V. S. (2020).Management of prevalent diseases of cucumber (Cucumis sativus) through integrated approach. International Journal of Current Microbiology and Applied Sciences, 9 (7), 3022-3028

Wang, K. H., Uchida, J. (2014). Plant Disease Prevention and Management in Sustainable Agricultural Systems. Sustainable Horticultural Systems, 353-384.

Sharma, N. K., Shyam, S., Awasthi, L. P. (2017). Prevention and control of viral diseases in watermelon through botanical biopesticides. Virology: Research & Reviews, 1 (3), 1-8.