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INTEGRATED MANAGEMENT OF CUCUMBER MOSAIC VIRUS DISEASE OF PUMPKIN IN ASSAM, INDIA

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ABSTRACT

Pumpkin (*Cucurbita moshcata*) is one of the important vegetable crops cultivated in India and abroad. The crop is suffered due to the effect of a wide range of biotic and abiotic causes resulting in different diseases limiting its production. Amongst the diseases affecting the crop, the cucumber mosaic virus disease caused by the Cucumber Mosaic Virus has become serious concern among the growers as drastically reduces the yield besides deteriorating the fruit quality. Considering the seriousness of the disease, an experiment was conducted to evaluate efficacy of eleven different integrated management strategies in managing the disease. The treatment comprising of two rows of maize as barrier crop + seed treatment with HCl (2% for 10min) + foliar spraying with imidacloprid 17.8 SL @ 2.0ml/10L at 30DAS + foliar spraying with bioagent (*Beauveria bassiana*) @ 1% at 45 DAS + foliar spraying with neem oil (3ml/l) at 60 DAS has resulted in the least disease incidence (16.67%), highest fruit yield of 83.89 q/ha with highest benefit-cost ratio of 2.53.

Key words : Pumpkin, Cucumber Mosaic Virus, Aphid, Disease incidence, Integrated management.

Introduction

Almost every region of India produces pumpkin, a significant vegetable crop, all year round because of its excellent nutritional content. It has high beta carotene concentration and is a prominent vegetable in Indian cuisine (Kumar *et al*., 2018). Pumpkin fruit is rich in vitamins and minerals and low in calories. Pumpkin is one of the rich sources of nutrients and they are the valuable source of functional components mainly carotenoids, zeaxanthin, vitamin E, ascorbic acids, phytosterols, selenium and linoleic acid, which acts as an antioxidant in human nutrition. Pumpkin has vast scope of diversification for its application in the production of commercial products such as jam, jelly, marmalades, puree, sauces, chutney, pickle and halwa, cookies and weaning mix, pies and beverages (Islam *et al*., 2014 and Dhiman *et al*., 2009). The skin color of the fruits can be from light to dark green, light to dark orange and the pulp can vary considerably from brown, to completely white, bright orange to greenish light (Ahmad *et al*., 2019). Pumpkin has a wide range of biological and medicinal qualities, such as anti-inflammatory, antioxidant, anti-cancer, anti-angiogenesis, and anti-diabetic effects. Each part of the pumpkin plant-seeds, fruits, stems offer a variety of health and nutritional advantages, such as high quantities of β-carotene, moderate carbohydrate content, vitamins and minerals (Rakcejeva *et al*., 2011). Numerous diseases and insect pests attack the pumpkin crop, severely reducing yields. One of the most dangerous disease affecting pumpkins in recent years has been identified as cucumber mosaic virus disease, which is caused by the cucumber mosaic virus (CMV). The single-stranded messenger sense RNAs known as genomic RNAs have three tRNA-like structures, a 52 cap and at least five open reading frames. The viral RNA is made up of two sub-genomic RNAs, RNA 4 and RNA 4A, and three genomic RNAs, RNA 1, RNA 2 and RNA 3.

All viral RNAs share the same 32 untranslated regions. Satellite, non-coding, short, linear RNA that is non-homologous to the helper CMV is frequently present with CMV (Mochizuki and Ohki, 2012).

The most significant disease found in pumpkins is the cucumber mosaic virus disease, which causes symptoms like fern leaf, mosaic, leaf curling, chlorosis, leaf distortion, and smaller leaflets of plants (Begum *et al*., 2016). As a result, there are significant losses in yield, both quantitatively and qualitatively. Numerous studies on various facets of the pumpkin disease caused by the CMV have been conducted worldwide, including in India. Nevertheless, there is not much of study, particularly in India's northeastern region, regarding the integrated control of the cucumber mosaic virus disease, which affects pumpkin. The current study was carried out to evaluate the efficacy of several integrated management approaches in managing the disease under field conditions, taking into account the relevance of the disease.

Materials and Methods

Location and preparation of the experimental field : The experiment was carried out in the PG Experimental Plot, Department of Plant Pathology, BNCA, Biswanath Chariali, Assam, India. Using a tractor-drawn disc plough, the field was prepared for planting. In order to get rid of the extra water, drainage ditches were also dug. Manures and fertilizers were applied in accordance with the package of practices for Assam, which are as follows: 20–25 t/ha FYM, 75 kg N, 80 kg P_2O_5, 80 kg K_2O and 30 kg CaO/ha for pumpkin. Plot size of 4.0m × 3.5m were created. Two rows of maize were planted as a barrier crop in the specific treatment 25 days prior to sowing of pumpkin seeds. Plants were spaced 1 meter apart, while rows of pumpkins were spaced 2.5 meters apart.

Treatments used for integrated management : A total of eleven treatments were used in the field experiment to examine how effectively integrated management strategies manage the aphid vector which caused by the cucumber mosaic virus. Table 1 shows the different management strategies that were applied.

The commercial neem formulation NEEMTA marketed by Maple Org Tech (India) Ltd was used in the experiment. The imidacloprid insecticide trade name RAMMIDA is marketed by Ramicide Crop Science Pvt. Ltd was used. The solid formulation of *Beauveria bassiana* marketed by Lucca Retail Pvt. Ltd with cfu counts 1×10^8 cfu/g was used as a foliar spray. For seed treatment of pumpkin, hydrochloric acid and Virkon-s containing potassium peroxymonosulfate was used.

Recording of data

Beginning ten days after the pumpkin seeds germinated, the plants were routinely checked every ten days to look for the aphid population build-up and the onset of disease symptoms. Aphid counts were made every ten days. The fruit production from several plots was taken into account to assess how effectively various treatments managed the disease.

Benefit: Cost ratio

The benefit: cost ratio for each treatment was determined by accounting in both the expense of the treatment and the revenue generated from it.

Table 1 : Evaluation of integrated management strategies against cucumber mosaic virus disease.

Treatments	Strategies integrated
T_1	Two rows of maize as barrier crop + seed treatment with potassium peroxymonosulfate (2%,10min)
T_2	Two rows of maize as barrier crop + seed treatment with HCl (2%, 10min)
T_3	T_1 + foliar spray with neem oil (3ml/l) at 30,45 and 60 DAS
T_4	T_2 + foliar spray with neem oil (3ml/l) at 30,45 and 60 DAS
T_5	T_1 + foliar spray with imidacloprid17.8 SL @ 2.0 ml/10 lit at 30,45 and 60 DAS
T_6	T_2 + foliar spray with imidacloprid 17.8 SL @ 2.0ml/10 lit at 30,45 and 60 DAS
T_7	T_1 + foliar spray with bioagent (*Beauveria bassiana*) @ 1% at 30,45 and 60 DAS
T_8	T_2 + foliar spray with bioagent (*Beauveria bassiana*) @ 1% at 30,45 and 60 DAS
T_9	T_1 + foliar spray with Imidacloprid 17.8 SL @ 2.0ml/10lit at 30 DAS + foliar spray with bioagent (*Beauveria bassiana*) @ 1% at 45 DAS + foliar spray with neem oil (3ml/l) at 60 DAS
T_{10}	T_2 + foliar spray with Imidacloprid 17.8SL @ 2.0ml/10lit at 30 DAS + foliar spray with bioagent (*Beauveria bassiana*) @ 1% at 45 DAS + foliar spray with neem oil (3ml/l) at 60 DAS
T_{11}	Control (no management strategy applied)

Results and Discussion

The period of time required for the disease symptom to initially emerge: The appearance of the first disease incidence under different treatments is presented in Table 2. From the table, it can be observed that in treatment 11, a smaller number of days were required for the first appearance of the disease whereas in the other treatment where the seeds were treated with hydrochloric acid and potassium peroxymonosulfate disease appeared lately compared to treatment T11. According to numerous past studies, HCl is highly effective in treating diseases caused by seed-borne viruses (Broadbent, 1965; Alexander, 1960; Mc Guire *et al*., 1979). According to Li *et al*. (2015), an infection with the tobacco mosaic virus can be prevented by using a potassium peroxymonosulfate (2%) solution.

Aphid population : The result presented in Table 3 and Fig. 1 clearly indicates that different management strategies exerted different affect in the development of the aphid population. The treatment T_{11} (control) had the highest mean aphid population of 22.03 numbers per 10 cm apical region of branch, whereas treatment T_{10} had the lowest mean aphid population, with 11.25 numbers per 10 cm apical region of branch. The lowest reduction of the aphid population (15.48%) over control was recorded in the treatment T_1 followed by T_2 with a 20.33 per cent reduction over control. Dey *et al*. (2005) conducted experiments to evaluate the effectiveness of several treatments in reducing the aphid population, and found that plants treated with imidacloprid 70 WS seed outperformed all other untreated plots. Kim *et al.* (2013) found that three days after germination, *Beauveria bassiana* caused 78 per cent mortality of green peach aphids. On the other hand, Zitter *et al*. (2009) reported that growing of effective border zones around fields or crops can aid in controlling CMV and its vectors as the natural predators are drawn to border crops, which may aid in aphid management. As such, the results obtained in the current investigation correspond with the earlier reports.

Disease incidence : The perusal of results presents in Table 3 clearly indicate that, the treatments evaluated have distinct effect in the disease incidence which varied from 16.67 and 100% in different treatments. The treatment comprising of "two rows of maize as a barrier crop + seed treatment with HCl (2%) for 10min + foliar spray with imidacloprid 17.8 SL @ 2.0ml/10lit at 30DAS + foliar spray with bioagent (*Beauveria bassiana*) @ 1% at 45 DAS + foliar spray with neem oil (3ml/l) at 60 DAS" resulted in the lowest disease incidence (16.67%) and the plants in the control plots had the highest disease incidence (100%). In confirmity to the results obtained in the present investigations, earlier investigations, Kalita and Dhawan (2010) reported that use of bajra as a barrier

Table 2 : Effect of different management strategies for first appearance of symptoms.

Treatment number	Treatments	Time required for first appearance of symptoms (No of days)
T_1	Two rows of maize as barrier crop + seed treatment with potassium peroxymonosulfate (2%, 10 min)	7
T_2	Two rows of maize as barrier crop + seed treatment with HCl (2%, 10min)	8
T_3	T_1 + foliar spray with neem oil (3ml/l) at 30,45 and 60 DAS	7
T_4	T_2 + foliar spray with neem oil (3ml/l) at 30,45 and 60 DAS	9
T_5	T_1 + foliar spray with imidacloprid17.8 SL @ 2.0 ml/10 lit at 30,45 and 60 DAS	7
T_6	T_2 + foliar spray of imidacloprid 17.8 SL @ 2.0ml/10 lit at 30,45 and 60 DAS	8
T_7	T_1 + foliar spray with bioagent (*Beauveria bassiana*) @ 1% at 30,45 and 60 DAS	8
T_8	T_2 + foliar spray with bioagent (*Beauveria bassiana*) @ 1% at 30,45 and 60 DAS	9
T_9	T_1 + foliar spray of imidacloprid 17.8 SL @2.0ml/10lit at 30 DAS + foliar spray with bioagent (*Beauveria bassiana*) @ 1% at 45 DAS+ foliar spray with neem oil (3ml/l) at 60 DAS	7
T_{10}	T_2 + foliar spray of imidacloprid 17.8SL @ 2.0ml/10lit at 30DAS + foliar spray with bioagent (*Beauveria bassiana*) @ 1% at 45 DAS + foliar spray with neem oil (3ml/l) at 60 DAS	9
T_{11}	Control (no management strategy applied)	6

Table 3 : Effect of different management practices on aphid population, disease incidence and fruit yield of pumpkin.

Treatments	Aphid population (nos./10 cm apical portion of branches)	Disease incidence(%)	Yield (q/ha)	Increase over control (%)	B:C ratio
T_1	18.62	66.67(54.72)	33.11	17.60	1.33
T_2	17.55	61.11(51.40)	34.03	19.83	1.38
T_3	15.42	44.44(41.79)	54.75	50.17	1.44
T_4	14.59	38.89(38.57)	55.96	51.25	1.49
T_5	13.84	33.33(35.25)	56.28	51.52	1.88
T_6	12.40	27.78(31.79)	57.42	52.49	1.94
T_7	15.98	55.55(48.17)	40.13	32.02	1.39
T_8	15.50	50.00(44.98)	40.36	32.40	1.42
T_9	12.87	22.22(28.11)	75.73	63.97	2.27
T_{10}	11.25	16.67(24.09)	83.89	67.48	2.53
T_{11}	22.03	100.00(78.22)	27.28	-	0.95

Figures in the parenthesis represent angular transformed values.

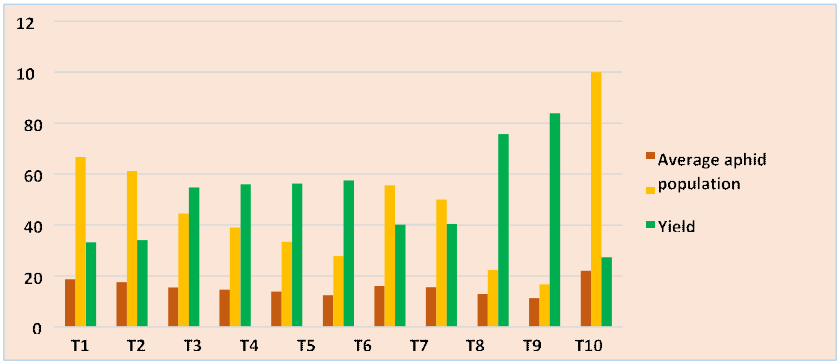

Fig. 1 : Overall effects of treatments on aphid population build up, disease incidence and yield.

crop and imidacloprid spray on bajra four times at fifteen-day intervals beginning from fifteen days after okra germination proved to be very effective in reducing Okra Yellow Vein Mosaic Virus. Shabbir *et al.* (2020) reported neem extract as the most effective treatment for reducing cucumber mosaic virus disease (CMV) in cucumbers, with 15.49 per cent disease incidence, followed by urea (18.65%), milk (28.12%), eucalyptus (18.13%), salicylic acid (19.46%), and urea (18.65%). Bharadwaj (2022) reported that "two rows of maize as a barrier crop + seed treatment with Thiomethoxam 30% FS @ 10ml/Kg seed + sticky trap (1 no/plot of 20m^2) + foliar spray with Imidacloprid 17.8 SL @ 2.0ml/10L at 30 and 45 DAS" has resulted in the lowest disease incidence (11.6%) of yellow mosaic virus disease of green gram. It is well known that azadirachtin, the active ingredient in neem, acts as an insect repellent and feeding inhibitor, protecting crop plants (Vasanthi *et al.*, 2017) and the systemic effect of imidacloprid on the aphid vector and the reduced probability of infective aphids landing and probing on pumpkin due to interception by the barrier crop might be the cause of the disease incidence reduction in the current investigation.

Effect on yield : The effects of the disease on yield, benefit cost ratio, and the percentage increase in yield are shown in Table 3 and Fig. 1.

Treatment T_{10} *i.e.*; two rows of maize as a barrier crop + seed treatment with HCl (2%) for 10min+ foliar spray with imidacloprid 17.8 SL @ 2.0ml/10lit at 30DAS + foliar spray with bioagent (*Beauveria bassiana*) @ 1% at 45 DAS + foliar spray with neem oil (3ml/l) at 60 DAS" resulted in the highest fruit yield of 83.89 q/ha with highest benefit-cost ratio of 2.53 among all the eleven treatments tested for managing the disease, whereas, treatment T_{11} had the lowest fruit yield of 27.28 q/ha with highest benefit-cost ratio of 0.95. Since the pumpkin plots treated with T_{10} had the lowest aphid population and disease incidence when compared to the other treatments, there were more healthy plants, which eventually led to the maximum pumpkin fruit production. In control plots, disease incidence in the early crop growth stages resulted in severe disease and the lowest fruit production. Similar results were also reported by Rahman *et al.* (2020), who reported that all treatment combinations enhanced yield from 0.37 to 6.40 t/ha when compared to control, and the incidence of cucumber mosaic virus disease in cucumber plants decreased from 76.97 percent to 35.71 percent. Again adoption of two rows of maize as a barrier crop + seed treatment with thiomethoxam 30% FS @ 10ml/ kg seed + sticky trap (1 no./plot of 20 m2) foliar spray with imidacloprid17.8 SL @ 2.0 ml/10L at 30 and 45 DAS

produced the highest yield (7.9 q/ha) of the nine treatments evaluated for management of yellow mosaic virus disease of green gram (Bharadwaj, 2022). In order to control the incidence of cucumber mosaic virus disease, Rahman *et al*. (2020) reported that treatment comprising of netting of seedlings, sticky yellow trap, polythene mulch and four sprays of imidacloprid 0.1% at 15-day intervals (T_2) and T_2 + Bio-neem 0.2% in place of imidacloprid resulted in a marginal benefit-cost ratio of 3.17 and 2.93, respectively.

Conclusion

In the present investigation, the management strategy comprising of two rows of maize as a barrier crop, treating the seeds with HCl (2% for 10 minutes), spraying of imidacloprid 17.8 SL @ 2.0 ml/10 lit at 30 DAS, spraying of bio-agent (*Beauveria bassiana*) at 1% at 45 DAS, and spraying of neem oil (3 ml/l) at 60 DAS, had the lowest disease incidence and aphid population, highest yield and benefit-cost ratio among the IDM practices evaluated for management of the cucumber mosaic virus disease in pumpkin. In addition, the treatment combination comprising of two rows of maize as a barrier crop, treating the seeds with potassium peroxymonosulfate (2% for 10 minutes), foliar spraying with imidacloprid 17.8 SL @ 2.0 ml/10 lit at 30 DAS, foliar spraying a bio-agent (*Beauveria bassiana*) at 1% at 45 DAS, and applying neem oil (3 ml/l) at 60 DAS was also very effective in controlling the disease, yielding a benefit:cost ratio of 2.27 which is comparable to the best treatment and significantly better than that of control plants. As per the results obtained in the present investigation, the management strategy comprising of two rows of maize as a barrier crop, treating the seeds with HCl (2% for 10 minutes), foliar spraying of imidacloprid 17.8 SL @ 2.0 ml/10 lit at 30 DAS, foliar spraying of bio-agent (*Beauveria bassiana*) at 1% at 45 DAS, and foliar spraying of neem oil (3 ml/l) at 60 DAS can be recommended to the farmers to manage the cucumber mosaic virus disease in pumpkin.

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