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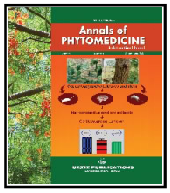

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A study on mosaic disease of bottle gourd (*Lagenaria siceraria* (Mol.) Standl.) in Ahmednagar district of Maharashtra, India

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Abstract

Bottle gourd (*Lagenaria siceraria* (Mol.) Standl.) mosaic disease has been reported to infect bottle gourd naturally causing enormous losses in respect of yield and quality of fruits in Ahmednagar district. Therefore, investigations were carried out with regard to symptomatology, particle morphology, host range and transmission of viral disease of bottle gourd with a view to identify the virus strain infecting the bottle gourd in growing areas of Ahmednagar. The virus infected samples were collected from All India Co-ordinated Research Project on Vegetable Crops, MPKV, Rahuri; Bottle gourd seed production plot, MPKV, Rahuri and also from farmer field of Kolhar, Sangamner, Akole, Nevasa and Rahuri tahasils of Ahmednagar district. The symptoms of naturally infected and artificially inoculated plants were dark green blistering (Bubbling), smaller and distorted leaves, mosaic mottling, stunted growth, puckering and vein clearing. Infected fruits were small, deformed and lesser fruits as compared to healthy ones and among all blistering was unique symptom. The virus particles of bottle gourd mosaic disease was flexuous rod shape measuring 701.58 nm in size. Host range of bottle gourd mosaic disease was confined to Cucurbitaceae family, does not infect host plant from other families such as Chenopodiaceae, Solanaceae, Leguminocae, Cruciferae, Malvaceae and Poaceae. Transmission studies indicated that the virus was transmitted successfully by mechanical sap inoculation and also transmitted in a non-persistent manner and effectively by *Myzus persicae* than Aphis gossypii. Aphid required appropriate acquisition feeding period of 15 min, infection feeding period of 30 min, pre-acquisition starvation period of 120 min and post-acquisition interval period of 0 min. According to studies undertaken bottle gourd mosaic virus was found closely related to PRSV-W (Watermelon mosaic virus-1) 'Potyvirus' belonging to family potyviridae causing bottle gourd mosaic disease.

1. Introduction

Bottle gourd (*Lagenaria siceraria* (Mol.) Standl.) is one of the oldest cultivated and major vegetable crop belonging to the family Cucurbitaceae, being used by humans for over 14,000 years. (Stephens, 2009). The bottle gourd is a warm season crop and grows best in a warm humid climate and is widely cultivated throughout the tropics, especially in India, Sri Lanka, Indonesia, Malaysia, Philippines, China, Tropical Africa and South America. Now, it is widely cultivated in almost all the parts of India (Upaganlawar and Balaraman, 2009). In Maharashtra, it is grown in Western districts, *viz.*, Pune, Nashik, Aurangabad, Dhule, Satara, Sangli, and Ahmednagar. In Konkan region it is grown commercially in Raigad district and also in certain pockets in Ratnagiri, Thane, and Sindhudurg districts where irrigation facilities are available. In India, bottle gourd is cultivated on more than 1,55,000 hectares with annual production of 25,73,000 MT and productivity of 16.6 MT/ha whereas, in Maharashtra, bottle gourd is cultivated on 2000 ha area with production of 35,870 MT/ha (Anon, 2017). In Maharashtra, commercially grown varieties of the bottle gourd are Samrat, Arka Bahar, Tasgaon-8-self, Pusa Navin, Malshiras 1, Akluj Local. Out of these, Samrat and Arka Bahar gives better fruit yield up to 35 to 40 tonnes per hectare within 55 to 65 days (Garande *et al*., 2017).

It is gaining importance due to its high yield potential, steady market price throughout the season. The fruits contain 0.2% protein, 2.9% carbohydrates, 0.5% fat and 11 mg of vitamin C per 100 g fresh weight (Maheshwari *et al*., 2015). In recent era, the demand for herbal medicines, various health products, pharmaceuticals, nutraceuticals, food supplements, are tremendously increased in the World market, (Amrutanand *et al.*, 2021) B12 is a vitamin necessary for hematopoiesis and promptly growing tissues. (Karuppiah *et al.*,2021). Production of bottle gourd has been reduced due to different causes where in susceptibility of the crop to various diseases is the major one. The fungal and virus diseases are of considerable economic importance. (Sarbhoy, 2006). Cucurbit viral diseases are a worldwide problem and induce major economic losses in commercial cucurbit production around the world (Lovisolo, 1980). Despite rapid technological advancements, only a fraction of plant species has been examined critically (Rekha, 2021). Several viruses have been reported to infect bottle gourd throughout the world causing enormous

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losses in respect of yield and quality ranging from 10 to 100 %. Specially, the vector transmitted viruses that may cause losses as high as 100% (Ullman *et al*. 1991).

Begmo virus infect a wide range of plant species and are emerging as one of the most detrimental pathogens. Recombination has led to the evolution and emergence of new species of begmovirus that are better adapted to new hosts (Abdul Samad, 2019). Important and prevalent viruses infecting bottle gourd are cucumber green mottle mosaic virus (CGMMV), cucumber mosaic virus (CMV), watermelon mosaic virus (WMV), papaya ring spot virus-watermelon strain (PRSV-W), tobacco mosaic virus (TMV), pumpkin yellow vein mosaic virus (PYVMV) and zucchini yellow mosaic virus (ZYMV). It was found that PRSV causes up to 100% losses in crop yield (Kunkalikar and Kulkarni, 2006). Mosaic disease of bottle gourd has not been studied in detail from Ahmednagar district. Considering the importance of the viral infections on bottle gourd and the losses caused by them, the systematic studies were therefore, undertaken with objectives like symptomatology, particle morphology, host range, mechanical and insect transmission, besides identification of the viruses present in the district. The result thus obtained during study are given here as under.

2. Materials and Methods

The experiment was conducted in 2018 at Pathology Lab, Department of Plant Pathology and Agricultural Microbiology, Mahatma Phule Krishi Vidyapeet, Rahuri, Ahmednagar, Maharastra.

2.1 Collection of bottle gourd mosaic diseased plant samples

The virus infected samples of bottle gourd mosaic disease were collected from farmers field of Kolhar, Sangamner, Akole, Newasa and Rahuri tahasils of Ahmednagar district and, AICRP on Vegetable Crops, MPKV, Rahuri.

2.2 Symptomatology

The symptoms of mosaic disease were studied by inoculating virus isolates to differential host plants of various families, *viz*., Cucurbitaceae, Chenopodiaceae, Solanaceae, Leguminoceae, Cruciferaceae, Malvaceae and Poaceae. A representative virus isolate was chosen for further study of particle morphology, host range and various methods of transmission in order to identify the causal virus.

2.3 Host range studies

Genetically pure and healthy seeds of bottle gourd, cucumber, watermelon, muskmelon, bitter gourd, sponge gourd, snake gourd, ridge gourd, pumpkin and okra, tomato, chilli, brinjal were collected from All India Co-ordinated Research Project on Vegetable Crops, MPKV, Rahuri. The seeds of other plant species, *viz*., groundnut, red gram, chick pea, cluster bean, soybean, french bean, cow pea and pea were obtained from Pulse Improvement Project, MPKV, Rahuri for further study. The virus samples exhibiting characteristics symptoms of mosaic were used for further studies such as particle morphology, host range and transmission.

Host of different plant species belonging to various families, *viz.*, Cucurbitaceae, Chenopodiaceae, Solanaceae, Leguminoceae, Cruciferae, Malvaceae and Poaceae were mechanically sap inoculated. Inoculated plants were kept in insect proof glasshouse and the test plants were recorded periodically upto 30-50 days for symptoms expression. The plants which did not show any symptoms were back indexed on test plants of bottle gourd cv. Samrat and also on local lesion host, *Chenopodium amaranticolor*.

2.4 Transmission studies

2.4.1 Mechanical transmission

2.4.1.1 Preparation of inoculum

The inoculum was prepared from young infected leaves showing prominent virus symptoms of mosaic disease of bottle gourd. The leaves from each isolates were collected, washed thoroughly in running tap water to remove dirt, immediately wiped off excess water with the help of blotting paper. The inoculum was prepared by grinding young infected leaves in sterilised mortor and pestle in chilled 0.1 M phosphate buffer, pH 7.0. The buffer was added at the rate of 1 ml per gm of infected tissue 1:1(w/v) basis while macerating. The resulting pulp crude sap after maceration was obtained by squeezing through a double layered muslin cloth. This extract was used as "standard inoculum" for further studies.

2.4.1.2 Inoculation

The plants species from Chenopodiaceae and other families were inoculated at 5-6 leaf stage.

However, species of Cucurbitaceae families were inoculated on cotyledonous leaves. After inoculation, the inoculated leaves were washed immediately in the stream of tap water to remove excess inoculum. The inoculated seedlings were labelled properly and kept for observation in the glasshouse. The control plants were treated similarly using neutral phosphate buffer solution only. The inoculated plants were observed periodically and observations were recorded as and when the symptoms appeared.

2.4.2 Insect transmission

To study the role of insect vector in transmission of the virus, various studies were conducted on role of aphid vectors in transmission like number of aphides, acquisition feeding period, infection feeding period, pre-acquisition starvation and post-acquisition interval period on transmission of bottle gourd viruses. The virus transmission by aphids was carried out as per the method described by Capoor and Verma (1965).

2.5 Electron microscopy

Leaf dip preparations was used for detecting virus particles associated with virus infected leaves of bottle gourd isolates. A drop of sap was placed on carbon coated grids for 1 min., rinsed three times with sterile distilled water. Leaf dip preparations stained with 2% uranyl acetate (UA) or phosphotungustic acid (PTA) were examined under JEOL 100 C x II Transmission electron microscope (TEM) for the presence of virus particles at Advanced Centre for Plant Virology, IARI, New Delhi.

3. Results

3.1 Collection of bottle gourd mosaic disease samples

The naturally infected bottle gourd plants exhibiting symptoms like severe mottling, mosaic, dark green blistering, puckering, distortion of leaves, stunted growth, smaller leaves and short internodes under field condition were collected from various locations symptoms like severe mottling, mosaic, dark green blistering, puckering, distortion

of leaves, stunted growth, smaller leaves and short internodes under field condition. The incidence of bottle gourd mosaic disease ranged between 10-80 per cent in Ahmednagar district of Maharastra. The amount of disease incidence is given under the Table 1.

Table 1: Location wise disease samples of bottle gourd mosaic disease collected from different areas:

Sr. No.	Location	Variety	% Virus incidence	Symptoms
1.	Vegetable Blister Improvement Project, MPKV, Rahuri MPKV, Rahuri mottling, puckering	Samrat	20-25	Blistering, stunted growth, mosaic
2.	Bottle gourd seed production plot, Veg. Imp. Project, MPKV, Rahuri	Samrat	40-45	Leaf distortion, blistering, stunted growth, mosaic, mottling, puckering
3.	Kolhar	Samrat	10-15	Blistering, mosaic, mottling
4.	Sangamner	Samrat	35-38	Blistering, smaller leaves
5.	Akole	Local	60-70	Blistering, stunted growth, short internodes
6.	Newasa	Local	72-80	Vein yellowing, blistering, mosaic motling
7.	Rahuri	Samrat	20-23	Blistering, Stunted growth, puckering

3.2 Symptomatology

3.2.1 Under field and glasshouse conditions

Artificially inoculated bottle gourd plants showed symptoms like severe mottling, mosaic, dark green blistering, puckering, and distortion of leaves, stunted growth, smaller leaves and short internodes as well as fruit produced on diseased plants became mottle, small sized, irregular shaped and deformed as observed under field conditions (Figure 1). Mechanically inoculated seedlings of bottle gourd expressed symptoms under glasshouse condition after 9-12 days of inoculation were maintained for further studies.

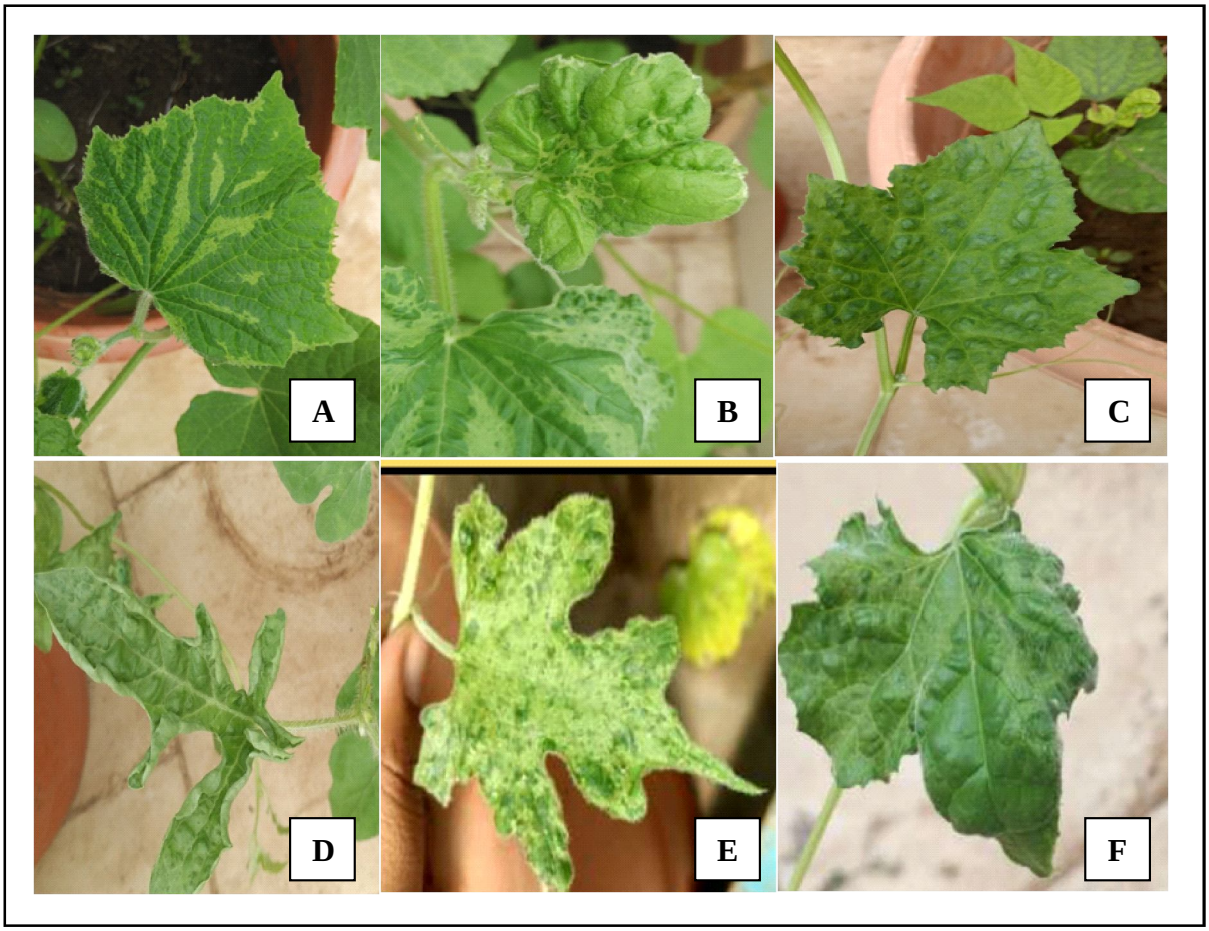

Figure 1: Host range of bottle gourd mosaic virus (A-Cucumber, B-Musk melon, C-Sponge gourd, D-Water melon, E-bottle gourd, F-Snake gourd).

3.3 Host range study

Host range studies were conducted on different plant species belonging to various families, *viz.*, Cucurbitaceae, Leguminoceae, Solanaceae, Chenopodiaceae, Cruciferae, Malvaceae and Poaceae by mechanically sap inoculation of bottle gourd mosaic virus by conventional leaf rub method. The information given in Table 2 revealed that the host species belonging to only Cucurbitaceae family mainly includes plants like *Langenaria siceraria*, *Cucumis sativus.*, *Citrullus lanatus*, *Cucumis melon*, *Memordica charantia*, *Luffa cylindrica*, *Trichosanthes anguina*, *Luffa acutangula*, and *Cucurbita moschata*. produced common symptoms like severe mottling, mosaic, dark green blistering, puckering, distortion of leaves, stunted growth, and small leaves, shortening of internodes, irregular chlorotic mottling, mosaic and vein clearing (interveinal chlorosis) under glasshouse condition, whereas blistering was unique symptom in all host plants.

Table 2: Information of host plants exhibited typical symptoms of bottle gourd mosaic virus disease

Sr. No.	Host range/common name	No. of inoculated plants	No. of infected plants	Incubation period	Symptoms developed	% of infection
1	*Lagenaria siceraria* (Bhopala)	10	9	9-12	LD, S, B, MM, SL, SI	90
2	*Cucumis sativus* L. (Cucumber)	10	8	10-11	LD, S, B, MM, SL, SI	80
3	*Citrullus lanatus* (Watermelon)	10	7	10-12	LC, SL, B, S, SI	70
4	*Cucumis melo* L. (Muskmelon)	10	7	10-12	MM, VC, LD, B	70
5	*Momodica charantia* L. (Bitter gourd)	10	4	11-12	LD, S, MM	40
6	*Luffa cylindrica* Roem. (Sponge gourd)	10	6	9-10	B	60
7	*Trichosanthes anguina*	10	4	10-12	MM	40
8	*Luffa acutangula* (L.) Roxb. (Ridge gourd)	10	5	10-12	B, MM, SL	50
9	*Cucurbita maxima* Duch. (Pumpkin)	10	7	10-11	MM	70

LD = Leaf distortion, S = Plant stunting, VC = Veinclearing, B = Blistering, MM = Mosaic mottling, LC = Leaf clearing, SL = Small leaves, SI = Shortening of internode

Where as inoculation done on other family host did no show any characteristic symptoms. The host plant species without symptoms (Non-host plant) belonging to various families were back indexed mechanically on bottle gourd. The back index host included Chenopodiaceae (*Chenopodium amaranticolor*.), Solanaceae (*Capsicum annuum* L., *Datura stramonium* L. *Lycopersicon esculentum* Mill. *Nicotiana glutinosa* L., *N. rustica*, *N. rependa*, *N. tabacum* L. *var. white burley*, *Solanum melongena* L.), Leguminoceae (*Arachis hypogea* L., *Cajanus cajan* L., *Cicer arietinum* L., *Cyamopsis tetragonoloba* L., *Glycine max* L., *Phaseolus vulgaris* L., *Vigna sinensis* L., *Pisum sativum* L.), Cruciferae (*Brassica compestris* L.,), Malvaceae (*Abelmoschus esculentus* L.), Poaceae (*Zea mays* L.). None of these host plants showed any symptom reaction to the bottle gourd mosaic virus isolate. The thirty days after inoculation indexed, plant did not indicate recovery of the inoculated virus from watermelon mosaic virus-1.

3.4 Mode of transmission

3.4.1 Transmission by mechanical sap inoculation

The results on mechanical transmission indicated that (Table 3), the virus causing mosaic in bottle gourd was transmitted by mechanical means using 0.1 M potassium phosphate buffer from bottle gourd-to-bottle gourd and other host plants, *viz.*, cucumber, watermelon, muskmelon, bitter gourd, sponge gourd, snake gourd, ridge gourd and pumpkin. Further, it was noticed that in general transmission percentage are ranging from 40% to 90%, it means virus responsible for mosaic disease in bottle gourd can be successfully transmitted by mechanical means of transmission. Bottle gourd mosaic virus isolate No. 1, 2, and 5 were more virulent and has high transmission ability.

3.4.2 Insect transmission

3.4.2.1 Aphid transmission

Symptoms produced on bottle gourd plants on aphid inoculation were identical with those which were produced on bottle gourd under natural infection in field.

3.4.2.1.1 Effect number of aphids required to transmit the bottle gourd mosaic disease virus by *M. Persicae* and *A. gossypii*

The results presented in Table 4 indicated that even a single viruliferous adult of *M. persicae* was able to acquire and transmit the virus up to 40 per cent, while *A. gossypii* transmit up to 20 %. Further, it was noticed that virus transmission increased up to 100% with increase in aphid number up to 10-15 aphids per test plant and per cent transmission reduced as the aphid population is increased after certain number, *i.e.*, 15 aphids per plant. *M. persicae* acquire and transmit the virus most effectively than *A. gossypii*.

3.4.2.1.2 Effect of acquisition feeding period on transmission of bottle gourd mosaic disease virus by *M. persicae* and *A. gossypii*

The results presented in Table 5 indicate that no virus transmission observed at 0 min acquisition feeding period and it required at least 1 min acquisition feeding period to get settled down on infected bottle gourd leaves and to acquire virus for both *M. persicae* and *A. gossypii* to transfer virus infection in bottle gourd. The acquisition feeding period of 15 min was found most efficient in both species to transmit the virus to its maximum capacity and to express maximum virus transmission up to 90%. Thereafter, increase in acquisition feeding period did not increase percent transmission on the contrary transmission was observed to reduce after 15 min.

Table 3: Mechanical transmission studies of bottle gourd mosaic virus

Sr. No.	Bottle gourd mosaic virus isolate	No. of inoculated plant	No of infected plant	Symptoms	%Transmission
1	BGMVI-1 Vegetable Improvemnet Project, MPKV, Rahuri	10	9	B, SG, MM	90
2	BGMVI-2 bottle gourd seed production plot, Vegetable Imp. Project, MPKV, Rahuri	10	8	B, SG	80
3	BGMVI-3 Kolhar	10	4	B, SL, M	40
4	BGMVI-4 Sangamner	10	6	B, VC, P	60
5	BGMVI-5 Akole	10	8	B, MM, P, SL	80
6	BGMVI-6 Newasa	10	7	MM, B, SG	70
7	BGMVI-7 Rahuri	10	5	B, SG, LC	50

Table 4: Effect of number of *M. persicae* and *A. gossypii* on transmission of bottle gourd mosaic virus

Sr. No.	No. of aphids	Bottle gourd mosaic virus				
		No. of plant inoculated by each aphid	No. plant infected out of 10 by		Per cent transmission by	
			M. persicae	*A. gossypii*	*M. persicae*	*A. gossypii*
1	1	10	4	2	40	20
2	4	10	5	3	50	30
3	7	10	8	5	80	50
4	10	10	10	8	100	80
5	13	10	10	7	100	70
6	15	10	10	5	100	50
7	20	10	9	4	90	40
8	25	10	7	2	70	20

Table 5: Effect of acquisition feeding period on per cent transmission of bottle gourd mosaic virus by *M. persicae* and *A. gossypii*

Sr. No.	No. of aphids	Bottle gourd mosaic virus				
		No. of plant inoculated by each aphid	No. plant infected out of 10 by		Per cent transmission by	
			M. persicae	*A. gossypii*	*M. persicae*	*A. gossypii*
1	1	10	4	2	40	20
2	4	10	5	3	50	30
3	7	10	8	5	80	50
4	10	10	10	8	100	80
5	13	10	10	7	100	70
6	15	10	10	5	100	50
7	20	10	9	4	90	40
8	25	10	7	2	70	20

Figure 2: Acquisition feeding period of aphids.

3.4.2.1.3.Effect of infection (inoculating) feeding period on transmission of bottle gourd mosaic disease virus by *M. persicae and A. gossypii*

The results presented in Table 6 revealed that infection feeding period of 1min was sufficient to transmit the virus, whereas it increases with increase in feeding period up to 30 min. Maximum percentage of virus transmission, *i.e.*, 70- 80% observed in 30 min infection feeding whereas increased feeding, period beyond 30 min decreased transmission percentage of bottle gourd mosaic virus in both species.

3.4.2.1.4.Effect of pre-acquisition starvation period on transmission efficiency of bottle gourd mosaic disease virus by *M. persicae* and *A. gossypii*

Results given in Table 7 showed that *M .persicae and A. gossypii* could transmit virus up to 30 % without starvation. Further, studies indicated that maximum transmission of 80-90% was obtained when they were starved for 120 min before acquisition feeding and after 120 min of starvation period, they tend to lose their transmissivity.

Table 6: Effect of infection (inoculating) feeding period on per cent transmission of bottle gourd mosaic virus by *M. persicae* and *A. gossypii*

Sr. No.	Infection feeding period (min)	Bottle gourd mosaic virus transmission as affected by infection feeding period				
		No. of plant inoculated by each aphid	Infected plant by		Per cent transmission by	
			M. persicae	*A. gossypii*	*M. persicae*	*A. gossypii*
1	1	10	2	1	20	10
2	5	10	3	2	30	20
3	10	10	4	4	40	40
4	15	10	7	5	70	50
5	30	10	8	7	80	70
6	60	10	4	6	40	60
7	120	10	3	3	30	30
8	180	10	1	2	10	20

Table 7: Effect of pre-acquisition starvation period on per cent transmission of bottle gourd mosaic virus by *M. persicae* and *A. gossypii*

Sr. No.	Pre-acquisition starvation period (min)	Bottle gourd mosaic virus as affected by pre-acquisition starvation period				
		No. of plant inoculated by each aphid	Infected plant		Per cent transmission	
			M. persicae	*A. gossypii*	*M. persicae*	*A. gossypii*
1	0	10	3	2	30	20
2	30	10	5	4	50	40
3	60	10	6	5	60	50
4	90	10	8	6	80	60
5	120	10	9	8	90	80
6	150	10	4	4	40	40
7	180	10	0	0	00	00

3.4.2.1.5 Effect of post-acquisition interval period (between acquisition feeding and infection feeding) on transmission efficiency of bottle gourd mosaic disease virus by *M. persicae* and *A. gossypii*

The results effect of post-acquisition interval period (between acquisition feeding and infection feeding) on transmission efficiency of bottle gourd mosaic disease virus by *M. persicae* and *A. gossypii* given in Table 8, showed that maximum transmission of 70-90% was obtained when *M. persicae* and *A. gossypii* were transfer immediately to healthy plant after acquisition feeding, *i.e.,* Zero min. post-acquisition interval period. Further, results indicated that virus infection percentage reduced when longer interval period between acquisition feeding and infection feeding period occurs.

Table 8: Effect of post-acquisition interval period (between acquisition feeding and infection feeding) on per cent transmission of bottle gourd mosaic virus by *M. persicae*

Sr. No.	Post-acquisition interval period (min)	Bottle gourd mosaic virus transmission as affected by post-acquisition interval period				
		No. of plant inoculated by each aphid	Infected plant		Per cent transmission	
			M. persicae	*A. gossypii*	*M. persicae*	*A. gossypii*
1	0	10	9	7	90	70
2	30	10	7	6	70	60
3	60	10	5	4	50	40
4	90	10	4	3	40	30
5	120	10	3	1	30	10
6	150	10	0	0	00	00
7	180	10	0	0	00	00

The results on aphid transmission of virus causing mosaic in bottle gourd showed that the aphid species *M. persicae* and *A. gossypii* were found to transmit the virus in nonpersistent manner. The aphid *M. persicae* used for virus transmission proved to be most efficient vector in transmitting the virus. The aphid *M. persicae* and *A. gossypii* required at least 1 min of acquisition feeding period to transmit the virus particle.

3.5 Particle morphology and identification of virus

The glasshouse infected leaves of bottle gourd were examined under transmission electron microscope by leaf dip method at Advanced Centre for Plant Virology, IARI, New Delhi, which revealed the presence of flexuous rods measuring 701.58 nm. This clearly indicates that the virus belongs to potyvirus group family Potyviridae.

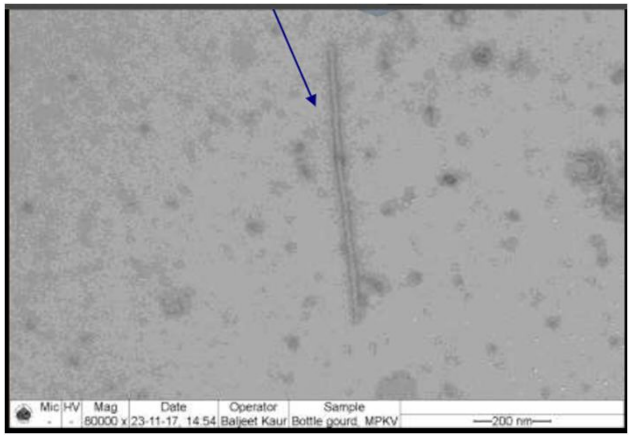

Figure 3: Particle morphology of bottle gourd mosaic virus.

4. Discussion

The mosaic of bottle gourd which is one of the important disease causing severe losses. The results from the study indicate that the disease symptoms observed under field conditions are in conformity with those reported by the Luis-Arteaga, (1998) and Mantri *et al.* (2004). Kim *et al* (2010) reported that potexvirus was detected from bottle gourd (*L. siceraria*), showing mosaic and mottle symptom.

Pathogenicity of sap isolated from the each samples were proved on the test plant and similar host range has been reported in case of watermelon mosaic caused by watermelon mosaic virus-1 (WMV-1) by Chakraborty *et al.* (1997) and Ali *et al.* (2014). Lecoq and Desbiez (2008) reported that watermelon mosaic virus causing mosaic in cucumber has wide host range. Potyviruses belonging to family Potyviridae are the most numerously mechanically sap and aphid transmitted viruse and has caused crop yield losses between 10-100 % (Mantri *et al.*, 2004).

The virus transmission studies indicate that the virus is both mechanically and insect transmitted and causing highest disease severity. These results are in agreement with those reported by Mantri *et al.* (2004). Shoeibi *et al* (2009), WMV is considered among the most important aphid-borne viruses infecting cucurbits worldwide, especially in temperate and Mediterranean climates. Mumo *et al.* (2022) reported that watermelon mosaic virus was pathogenic on zucchini, watermelon and cucumber but not on papaya. Ilhe, *et al.* (2014) reported that with increase in number of viruliferous vectors the disease severity has increased in the cucumber. The results on aphid transmission of virus causing mosaic in bottle gourd showed that the aphid species *M. persicae*, and *A. gossypii* were found to transmit the virus in non-persistent manner and these findings are in

agreement with those reported by Anderson (1954), Mantri *et al*. (2004) and Ilhe *et al*. (2014). MWMV infects several cucurbit species and has a wide distribution in Africa and the Mediterranean region (Kidanemariam *et al*., 2019).

The aphid *M. persicae*, used for virus transmission proved to be most efficient vector in transmitting the virus and these results are in conformity with those reported by the scietists, Makkouk and Lesemann (1980); Ilhe *et al*. (2014) for transmission of Watermelon mosaic virus-1. The aphid *M. persicae*, and *A. gossypii* required at least 1 min of acquisition feeding period to transmit the virus particle and these findings are in conformity with those reported by Lastra (1968).

In present investigation based on symptomatology, particle morphology (size and shape), host range, mechanical sap inoculation and insect transmission of bottle gourd virus isolate was found closely related to PRSV-W 'potyvirus'. The virus particle of bottle gourd mosaic virus isolate is similar in morphological characters with those reported earlier for watermelon mosaic virus-1 (WMV-1) by Chakraborty *et al.* (1997) and Mantri *et al*. (2004). Mumo *et al*. (2022) reported that watermelon mosaic virus naturally infects and severely threatens production of cucurbits and papaya.

5. Conclusion

Several viruses have been reported to infect bottle gourd naturally throughout the world causing enormous losses in respect of yield and quality of fruits. Based on symptomatology, particle morphology, host range and transmission by mechanical sap and aphid transmission, all these results indicated that virus causing mosaic disease in bottle gourd was found closely related to PRSV-W potyvirus causing Watermelon mosaic virus-1 (WMV-1). The results help on further controlling the vectors effectively preventing the spread of disease.

Conflict of interest

The authors declare no conflicts of interest relevant to this article

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