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S Onkara Naik
Division of Entomology and Nematology, ICAR- - Indian Institute of Horticultural Research, Bengaluru, Karnataka, India

GS Kannan
School of Agriculture and Animal Science, Gandhigram Rural Institute- Deemed University, Gandhigram, Dindigul, Tamil Nadu, India

V Venkataravanappa
Division of Entomology and Nematology, ICAR- - Indian Institute of Horticultural Research, Bengaluru, Karnataka, India

AK Chakravarthy
Division of Entomology and Nematology, ICAR- - Indian Institute of Horticultural Research, Bengaluru, Karnataka, India

Correspondence
S Onkara Naik
Division of Entomology and Nematology, ICAR- - Indian Institute of Horticultural Research, Bengaluru, Karnataka, India

Relationship of whitefly, *Bemisia tabaci* Genn. as a vector and bitter gourd yellow mosaic virus disease

S Onkara Naik, GS Kannan, V Venkataravanappa and AK Chakravarthy

Abstract
Whitefly is one of the most intractable, highly polyphagous and serious pest on economically important food and fibre crops. It does direct damage to plants by feeding on the sap. Besides it serves as a potent means of virus transmission from plant- to -plant. The whitefly transmitted begomoviruses (YMV) are emerging as a serious threat causing leaf curl and yellow mosaic virus diseases on cucurbit and bitter gourd. The number of whiteflies required for YMV transmission experiment results indicated that, single whitefly transmitted the virus to an extent of 19.5 per cent and with an incubation period of 13.75 days. Fifteen whiteflies transmitted 100 % virus within 6.15 days of incubation. The whiteflies needed a minimum AAFP of 16 min to become viruliferous resulting in 15.65 per cent transmission. An IAFP of 30 min made the whiteflies viruliferous to cause 47.25 per cent transmission; an IAFP of 3h or more resulted in 100 per cent disease transmission. As IAFP increased, the incubation period decreased. The pre-acquisition starvation of whiteflies lasted for 3h or more was resulting in 100 per cent transmission and post-acquisition starvation period of whiteflies did not have any effect in increasing YMV transmission.

Keywords: Whiteflies, bitter gourd, YMV, vector, virus AAP, IAP

1. Introduction
The plant viruses are transmitted by vectors namely aphids, whiteflies, thrips, leafhoppers and mites on crops. The vector feeds on virus infected plants, carries the virus and spreads the virus from one plant to another and one host to another. The virus transmissions by vectors are characterized by specificity. The vectors are involved in virus transmission specificity. The plant viruses can cause severe yield losses to the cereal, vegetable, fruit, and floral industries, and substantially lessen the quality of crop products. Over 35 viruses have been reported on cucurbits Brown *et al*.[1], of which Tomato Leaf Curl New Delhi Virus (ToLCNDV), Squash Leaf Curl China Virus (SLCCNV), Cucumber Mosaic Virus (CMV), Cucumber Green Mottle Mosaic Virus (CGMMV), Squash Mosaic Virus (SqMV), Papaya Ring Spot Virus (PRSV), Watermelon Mosaic Virus (WMV) and Zucchini Yellow Mosaic Virus (ZYMV) cause serious losses. However, whitefly transmitted begomoviruses are emerging as a serious threat causing leaf curl and yellow mosaic virus diseases on cucurbits Sandhu and Kang[2]. Whitefly, *B. tabaci* is one of the most intractable, highly polyphagous and serious pest on economically important food and fibre crops. It does direct damage to plants by feeding on the sap. Besides it is a potent means of virus transmission from plant- to -plant. The vector excretes honeydew and transmits over 100 plant viruses, especially of genus begomovirus. Whitefly transmits plant viruses of seven distinct groups, *viz*., geminiviruses, closteroviruses, carlaviruses, potyviruses, nepoviruses, luteoviruses and a DNA-containing rod shaped virus. The economically important are the geminiviruses (Family Geminiviridae: Genus Begomovirus) and the closteroviruses (Family Closteroviridae: Genus Crinivirus). Cassava, beans, cowpea, soybean, cotton, tobacco, tomatoes, peppers, okra, squash, melon, watermelon, lettuce and papaya have been affected by one or more whitefly transmitted viral diseases causing yield losses to crops between 20 and 100%. The vector – virus relationship studies on whiteflies (*B. tabaci*) and bitter gourd YMV has not been studied so far. The present study was carried out to investigate the relationship between whitefly and bitter gourd YMV.

2. Materials and Methods

For conducting studies under laboratory conditions, thirty bitter gourd plants *cv*. Arka harit were grown in earthen pots (15 x 25 cm) filled with mixture of soil and compost in 2:1 ratio and pots kept inside the insect proof cages (2ft x 2ft x 2ft) covered with 40-mesh size nylon net at one side, other three sides covered with transparent glasses and bottom covered with wooden plate. Brinjal (*Solanum melongena* L.) *cv*. Dhruva plants were grown for maintenance of whitefly colonies under caged conditions (Plate 1).

2.1 Whitefly culture

The indigenous *B. tabaci* colony used in this study was originally collected on brinjal and maintained on brinjal plants itself in wooden cages (2ft x 2ft x 2ft). These cages were kept under glasshouse. The aspirator (20 x 0.5 x 30 cm) was made by a glass tube and a 40 cm rubber tube, by which the whiteflies were sucked through rubber tube and collected into glass tube. The colonized leaves turned slightly upwards with healthy whiteflies were sucked in to the glass tube and gently blown in to the plastic vials. Such disease-free whiteflies were collected and used further investigations.

2.2 Whiteflies required for transmission

To standardise the number of whiteflies required to transmit the yellow mosaic disease of bitter gourd, whiteflies were given an 24 h of AAP on virus infected plants. The viruliferous whiteflies were released on six days old bitter gourd plants at 0, 1, 2, 4, 6, 8, 10, 12, 14 and 20 insects per plant and in each treatment 10 plants were inoculated. After 24 h of IAP, the Imidacloprid 17.8 SC (0.05 %) was sprayed to kill the whiteflies. The plants were kept under insect proof cage for development of disease symptoms; the per cent transmission was recorded based on symptom expressed by the plants.

2.3 Acquisition and inoculation access feeding period

The rate of transmission effect of AAP on the of yellow mosaic disease of bitter gourd was tested by feeding the whitefly biotype at the rate of 0, 5, 10, 15, 20, 30 min and 1, 4, 8, 6, 12, 16 and 24 h on YMV infected bitter gourd plants. After AAP, the whiteflies were released on to seven days old healthy bitter gourd plants at the rate of 10 whiteflies per plant. Ten bitter gourd plants were inoculated under each treatment. After 24 h of IAP, the whiteflies were killed by spraying Imidacloprid and the inoculated plants were kept under insect proof cage for development of disease symptoms.

2.4 Pre and post -acquisition starvation period

To define the effect of pre-acquisition starvation period on transmission rate of YMV, the whiteflies were allowed to starve for *viz*., 30 min, 1h, 2h, 3h and 4h. The insects were then given an AAFP and IAFP of 12h each. The influence of post-acquisition starvation period on transmission rate of bitter gourd YMV was determined by allowing the whiteflies to acquire the virus for 12h. subsequently the insects were starved for periods *viz*., 30 min, 1, 2, 3 and 4h. The IAFP of 24h was given for the whiteflies to feed on the test plants. The plants were then observed for symptom expression and observations on transmission and incubation period were recorded.

3. Results and Discussion

The number of whiteflies required for YMV transmission revealed that, a whitefly can transmit the virus to an extent of 19.5 per cent with incubation period of 13.75 days. Fifteen whiteflies transmitted 100 % virus within 6.15 days of incubation (Table 1).

3.1 Acquisition access feeding period (AAFP)

The whiteflies needed a minimum AAFP of 16 min to become viruliferous resulting in 15.65 per cent transmission (Table 2). The acquisition feeding period of 6h or more required for 100 per cent transmission. As AAFP increased, the whiteflies became viruliferous percentage increased, as could be observed from the higher percentage of infected plants, and the days required for symptom expression became less.

3.2 Inoculation Access Feeding Period (IAFP)

The results from inoculation threshold study revealed that an IAFP of 30 min made the whiteflies viruliferous to cause 47.25 per cent transmission (Table 3). With an increase in IAFP, there was a gradual increase in the percentage of infected plants. An IAFP of 3h or more resulted in 100 per cent disease transmission. As IAFP increased, the incubation period decreased. Capoor and Ahmad [3], Jayashree [4] and Reddy and Yaraguntaiah [5] reported that even 30 seconds was sufficient for single whitefly to become viruliferous in the pumpkin plants inoculated with PYVMV. They also found that allowing the insects to feed on disease source for periods longer than 5 min partially inactivated the virus.

However, the present study revealed that as AAFP increased, the per cent transmission also increased. Capoor and Ahmad [3] also reported that an IAFP of 2h and 30 min resulted in 90 per cent infection. Further, Reddy and Yaraguntaiah [5] found that an AAFP of 6h and IAFP of 24h were required to cause maximum percentage of transmission of yellow mosaic virus in *Lablab niger*. Subramanian [6] reported that both AAFP and IAFP required for transmitting TLCV to healthy tomato plants for 30 min. Salalrajan [7] found that 2h was the AAFP and IAFP required for transmitting yellow mosaic virus to urdbean plants. Ragupathy [8] found that an IAFP of 12h resulted in 50 per cent transmission of soybean yellow mosaic virus whereas an IAFP of 12h resulted only in 40 per cent transmission. Pun [9] reported that in okra, 100 per cent transmission of OYVMV was obtained after AAFP and IAFP of 6h each.

3.3 Pre and Post acquisition starvation period

The pre-acquisition starvation of whiteflies lasted for 3h or more was resulting in 100 per cent transmission (Table 4). The results are in confirmation with Bushra [10], Jayashree [4] and Capoor [11] who stated that in order to fix the whiteflies in their feeding position, it was necessary to starve them for at least 3h before releasing plants and this might be the reason for increased disease transmission.

Cent per cent transmission of bitter gourd YMV was obtained when whiteflies were not starved after acquisition (Table 5). The study pointed that post-acquisition starvation period of whiteflies did not have any effect in increasing YMV transmission. The increased post-acquisition starvation period, resulted in the decreased YMV transmission efficiency gradually. This had a negative correlation between post-acquisition starvation period and YMV transmission. Capoor and Ahmad [3], Jayashree [4] and Capoor [11] reported that 2h starvation of whiteflies before acquisition gave

maximum infection while starvation after acquisition led to reduction in transmission efficiency in PWMV inoculated pumpkin plants. This reduction was directly proportional to an increase in the length of post-acquisition starvation period. However, post-acquisition starvation period was effective up to 4h in OYVMV Verma [12].

Table 1: Number of whiteflies required for transmission of bitter gourd YMV

No. of whiteflies/plant	Transmission (%)	Incubation period (days)
1	19.50	13.75
3	24.10	10.15
5	54.20	9.85
7	60.40	7.25
9	79.75	6.95
11	88.80	6.65
15	100.00	6.15
20	100.00	5.90
CD (P=0.05)	3.34	0.19

Table 2: Influence of acquisition feeding period on transmission of bitter gourd YMV

Acquisition access feeding (hrs)	Transmission (%)	Incubation period (days)
0.16	15.65	11.85
0.25	24.95	13.85
0.5	37.85	12.95
1	60.15	11.35
3	79.15	11.85
4	89.85	10.45
6	100.00	9.95
8	100.00	9.15
12	100.00	8.85
CD (P=0.05)	3.16	0.17

Table 3: Influence of Inoculation feeding period on transmission of bitter gourd YMV

Inoculation access feeding period (hrs)	Transmission (%)	Incubation period (days)
0.5	47.25	16.05
1	60.85	13.95
2	80.25	13.60
3	90.45	11.75
5	100.00	11.65
7	100.00	10.60
9	100.00	10.35
12	100.00	10.05
16	100.00	9.95
CD (P=0.05)	4.34	0.27

Table 4: Influence of pre - access feeding period on transmission of bitter gourd YMV

Pre-acquisition starvation feeding period (hrs)	Transmission (%)	Incubation period (days)
0.25	12.35	13.75
0.5	28.20	11.75
1	66.55	11.15
2	80.40	10.15
3	100.00	9.85
4	100.00	8.85
6	100.00	8.25
CD (P=0.05)	3.71	0.25

Table 5: Influence of Post-acquisition starvation feeding period on transmission of bitter gourd YMV

Inoculation access feeding period (hrs)	Transmission (%)	Incubation period (days)
0	100.00	12.15
5	95.40	11.45
1	64.95	11.15
2	54.40	11.05
3	52.45	10.65
4	48.45	10.45
6	43.85	10.05
CD (P=0.05)	3.41	0.12

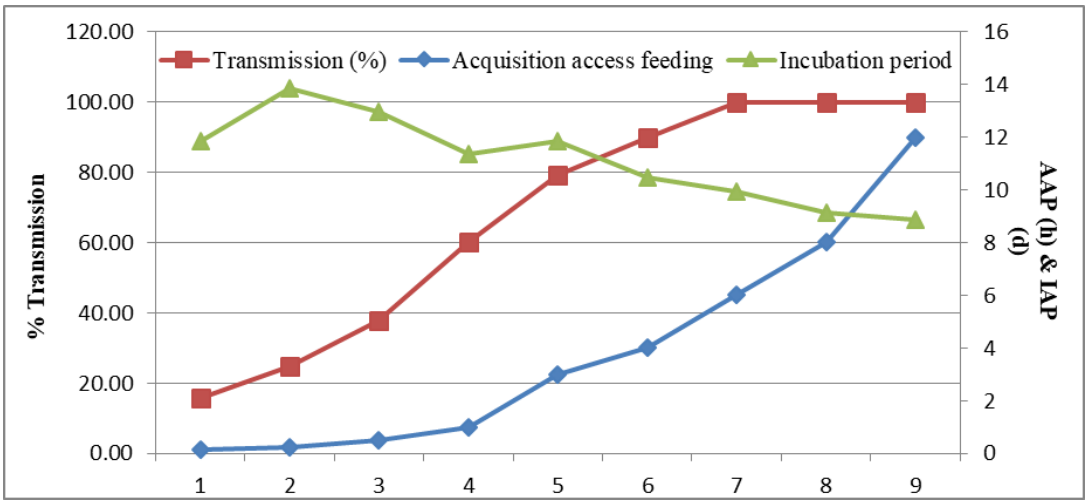

Fig 1: Number of whiteflies, incubation and transmission of bitter gourd YMV

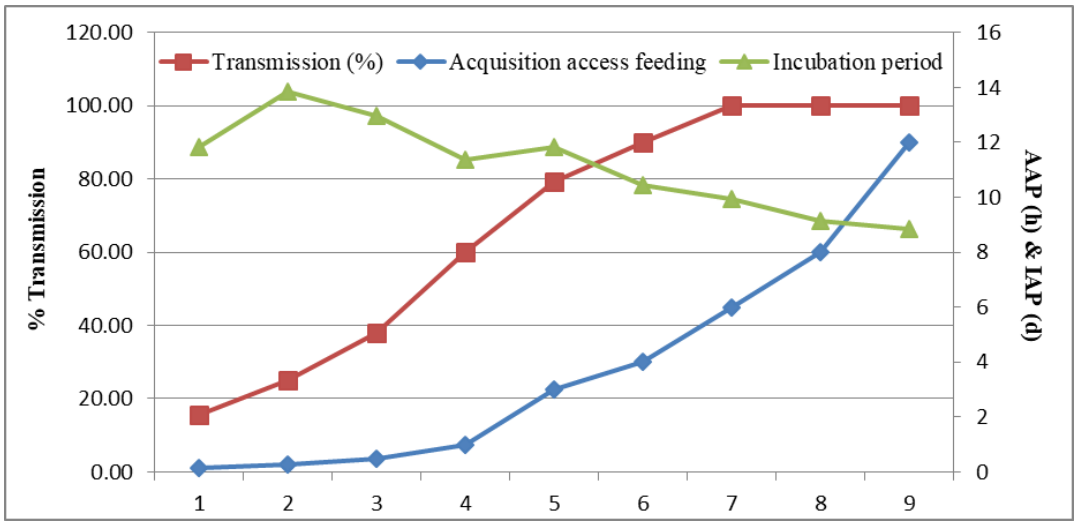

Fig 2: Acquisition feeding period on transmission of bitter gourd YMV

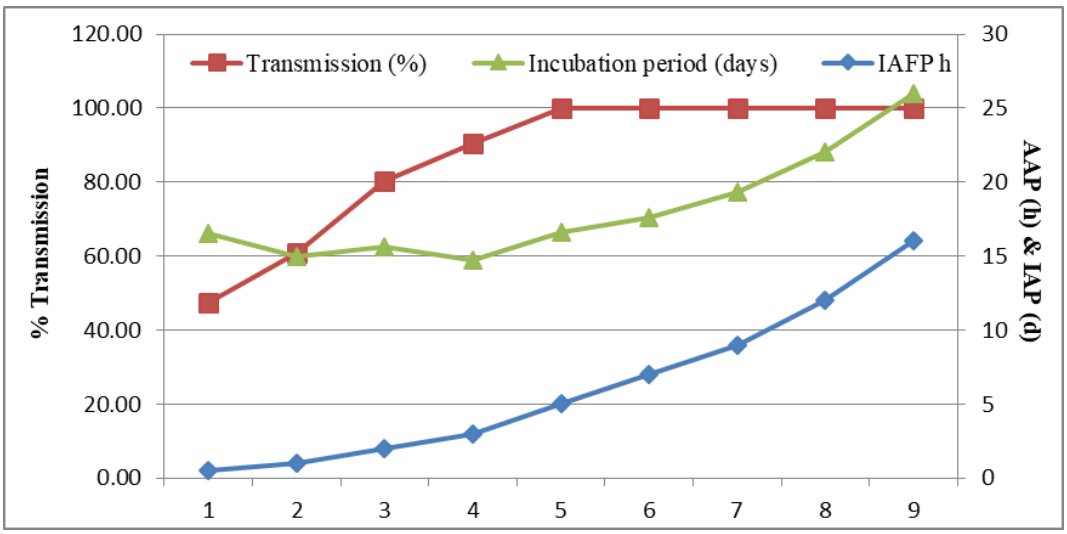

Fig 3: Inoculation feeding period on transmission of bitter gourd YMV

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