https://doi.org/10.29321/MAJ.10.A03210

Madras agric. J. 64 (7) : 437—441. July, 1977

Transmission of Greengram Yellow Mosaic Virus by the White fly, *Bemisia tabaci* (Genn.)

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Transmission studies revealed that a single viruliferous *Bemisia tabaci* (Genn.) was able to transmit the virus successfully and maximum percentage of infection was obtained when 10 white flies were used per test plant. Maximum percentage of infection resulted when the vector was given a pre-acquisition starvation starvation of 3 hr. and acquisition feeding period of 24 hr. The incubation period was 8 hr. High percentage of infection resulted when the transmission feeding period of the vector was 24 hr The virus was retained by the vector for a maximum period of 4 days. There was no trans-ovum transmission, and the first instar nymphs of the vector were not capable of acquiring and transmitting the virus.

Occurrence of the *mung* yellow mosaic and its transmission by the white fly vector, *Bemisia tabaci* (Genn) was first reported by Nariani (1960). Nene (1972) studied the virus vector relationship. Further studies on the transmission of the disease were carried out and the results are presented in this paper.

MATERIALS AND METHODS

Bemisia tabaci cultured on *Solanum nigrum* Linn. in the glass house under caged condition was used in the transmission studies. Ten to twelve days old plants of CO. 2 green gram raised in pots were used as test plants in various transmission studies. The virus inoculum was maintained on CO.2 plants through vector transmission. Newly emerged white flies were starved for the required period and confined on virus infected plant. After sufficient acquisition feeding, the white flies were transferred to healthy plants in glass cages. The inoculated plants were protected with insecticide in cages and observed for symptoms upto 40 days. Unless and otherwise mentioned, 15 white flies were used for inoculation per test plant.

To study the minimum number of viruliferous white flies required for successful transmission of virus, white flies with 24 hr acquisition feeding on diseased source, were transferred to healthy plants in groups of 1, 2, 3, 5, 10 and 15 for transmission feeding for 24 hr. To determine the minimum acquisition feeding period, the non-viruliferous white flies, starved for 3 hr, were allowed to feed on diseased source for different periods ranging from 5 minutes to 24 hr and transferred to test plants for 24 hr transmission feeding. To find out the influence of different preacqui-

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sition starvation periods on the transmission of the virus, non-viruliferous white fly adults were starved for various intervals of time *viz.*, 15 min, 30 min, 1 hr, 2 hr and 3 hr and transferred to diseased source for acquisition of the virus. After 3 hr acquisition feeding, they were transferred to test plants for 24 hr transmission feeding.

To find out the incubation period of the yellow mosaic virus in its vector, non-viruliferous white flies, were given an acquisition feeding of 3 hr on diseased source and immediately transferred to the test plants and given transmission feeding ranging from 1 hr to 10 hr. To investigate the minimum transmission feeding period, white flies after 15 hr acquisition feeding on diseased source were starved for 3 hr, transferred to healthy plants and were given transmission feeding for different periods ranging from 5 min to 24 hr. The effect of pre-inoculation starvation periods on the transmission of the virus was determined by starving the viruliferous white flies after a sufficient acquisition feeding on diseased source and releasing them on the test plants for one hour transmission feeding. The retention of infectivity by the vector was determined by releasing the white flies on the test plants and retransferring them daily after transmission feeding period of 24 hr on a series of green gram test plants.

To ascertain whether the green gram yellow mosaic virus passes on to the progeny of viruliferous white flies, the viruliferous vectors were released on the immune *S. nigrum* (immune to yellow mosaic) for one week, after which the white flies were removed from *S. nigrum*. Eggs laid within this period developed into adults and this new generation of white fly adults were transferred to test plants. To test the transmission by nymphs, the white fly adults were released on young leaves of yellow mosaic infected green gram plants for egg laying. The first instar nymphs, 2 or 3 days after the emergence from the egg were transferred to healthy test plants by means of soft camel hair brush. After the emergence of adults, the plants were sprayed with an insecticide.

RESULTS AND DISCUSSION

The results of the experiments on transmission of green gram yellow mosaic virus are presented in Table I. A single white fly was able to transmit the virus and the percentage of infection was 37.5. However, the percentage of transmission increased to 62.5 when 10 or more white flies were used. It is reasonable to assume in this context that feeding by increased number of vectors would have resulted in inoculation of more virus titre, which might have resulted in increased infection of test plants. Similar results were reported by Nene (1972) in the case of *mung* yellow mosaic and in other white fly transmitted viruses like leaf curl of *Zinnia elegans* (Mathur, 1933) bhendi yellow vein mosaic (Varma, 1952, Sangappa, 1966), cassava mosaic (Chant, 1958), and tomato yellow leaf curl (Cohen and Nitzany, 1966).

TABLE I. Transmission of greengram mosaic virus

No. of white flies required for transmission		Pre-acquisition starvation period		Acquisition threshold		Incubation period		Transmission feeding period		Pre-inoculation starvation period	
Number of white flies used	Percentage of infection	Starvation period	Percentage of infection	Acquition feeding period	Percentage of infection	Feeding period on test plant (hr)	Percentage of infection	Feeding period on healthy plant	Percentage of infection	Pre-inoculation starvation period allowed	Percentage of infection
1	37.5	15 min	12.5	5 min	0.0	1	0.0	5 min	0.0	0	12.5
2	25.0	30 min	12.5	15 min	0.0	2	0.0	10 min	0.0	15 min	12.5
3	25.0	1 hr	25.0	30 min	25.0	3	25.0	15 min	0.0	30 min	12.5
5	37.5	2 hr	37.2	1 hr	25.0	4	25.0	30 min	12.5	1 hr	25.0
10	62.5	3 hr	50.0	2 hr	37.5	6	25.0	60 min	25.0	2 hr	25.0
15	62.5			24 hr	62.5	8	37.5	24 hr	37.5	3 hr	25.0
						10	25.0				

Starvation of the vector for 15 and 30 min before acquisition resulted only in 12.5 per cent transmission. However, the percentage of infection increased steadily from 1 hr starvation period on wards. White flies were able to acquire the virus in a minimum feeding period of 30 min from the disease source. A perusal of literature show that the minimum acquisition feeding period in most of the white fly transmitted viruses ranged from 15-30 min. Costa and Bennett (1950) and Varma (1952) reported a minimum of 30 min. acquisition feeding period in the case of *Euphorbia* mosaic and bhendi yellow vein mosaic respectively. The reports of Rao and Varma (1964, and Cohen and Nitzany (1966) on yellow vein masaic of *Malvastrum coromandelianum* and leaf curl of tomato respectively were also in accordance with this finding.

Viruliferous white flies could not transmit the virus to the test plants upto 2 hr after acquisition feeding. The findings suggested that minimum incubation period of the virus in *B. tabaci* was 3 hr and investigation by Nene (1972) also revealed it, to be 3-4 hours. Earlier studies by Varma (1963) also suggested that all the white fly transmitted viruses had a few hours of incubation period in the vector. Transmission threshold studies indicated that feeding upto 15 min by the viruliferous vector did not bring about infection. With 30 min inoculation feeding, 12.5 per cent of the plants were infected, while 24 hr feeding resulted in 37.5 per cent infection. Pre-inoculation starvation upto 30 min had no difference in influencing the infection percentage. When the vectors were starved for 1 hr, there was 25 per cent infection. Further in-

crease in starvation did not bring about any change in the percentage of infection. While increased pre-acquisition starvation period resulted in a steady increase in infection percentage, increased pre-inoculation starvation did not bring about similar results. It was found that the effect of starvation was more pronounced before acquisition rather than before inoculation. Similar association between the white fly vector on one hand and the pre-acquisition and pre-inoculation starvation period on the other was reported by Varma (1952) in bhendi yellow vein mosaic virus and Nene (1972) in *mung* yellow mosaic virus.

Viruliferous white fly adults retained the green gram yellow mosaic virus for a maximum period of 4 days (Table II) and similar short retention

TABLE II. Retention of infectivity by the Vector

S. No. (Insect groups)	Transmission (Days after acquistion) 1	2	3	4	5	6	7
1	+	—	+	D	—	—	—
2	+	+	—	+	—	—	D
3	+	+	—	—	D	—	—
4	—	+	—	D	—	—	—
5	—	+	D	—	—	—	—
6	+	—	+	D	—	—	—

(+) = Positive transmission
(—) = Negative transmission
(D) = Death of Vector

periods were reported by Bird (1957, 1958) in *Jatropha gossypifolia* mosaic virus and infectious chlorosis virus of *Sida carpinifolia*. Transovarial and nymphal transmission of the disease by the vector was not successful. Similar negative results of transovarial transmission were reported by Kirkpatrick (1931), Costa and Bennett (1950) Capoor and Varma (1950), Bird (1957) and Cohen and Nitzany (1966). The first instar nymphs of *B. tabaci* were neither able to acquire nor transmit the virus. Kirkpatrick (1931), Costa and Bennett (1950) and Cohen and Nitzany (1960) were able to infect the healthy plants with the virus using adults emerging from the infected plants and concluded that the immature forms were able to acquire the virus. Since there was very high percentage of mortality of the nymphs if they were detached after they settled in the host, the efficiency of the second and third nymphal instars in the transmission of the virus was not tested in the present study.

In general it has been reported time and again, that the percentage of infection of the circulative virus increased in proportion with the increased inoculation feeding period of the vector. Incubation period of the virus in the vector and persistence of the virus in the vector for more than 24 hours are also characteristics of circulative type of virus. It is not surprising that a similar trend existed in the present instance also, since the yellow mosaic of green gram possessed several characters for grouping it under the circulative type.

The senior author is thankful to the Tamil Nadu Agricultural University, Coimbatore for according permission to publish this research finding, which formed part of her M.Sc.(Ag.) dissertation.

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