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Virus Vector Relationship of Yellow Mosaic Virus and Whitefly, *Bemisia tabaci* (Gennadius) in Soybean

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ABSTRACT

Background: Whitefly is one of the most destructive sucking pest in the tropical and subtropical regions of the world and causing significant crop losses directly by sucking sap from the plants and indirectly through the transmission of viral diseases specifically caused by the genus *Begomovirus*. The *Begomovirus* species *viz*., *Mungbean yellow mosaic India virus* (MYMIV) and *Mungbean yellow mosaic virus* (MYMV) are causing yellow mosaic virus disease in soybean, which is transmitted by whiteflies. The disease accounts to 30-70 per cent yield loss and increases up to 80 - 100 per cent during severe incidence. Hence, there is a need for development of integrated pest management strategies against disease and whiteflies, for this the knowledge on virus-vector relationship is required. But, the studies on biological relationship of yellow mosaic virus disease and whitefly in soybean are scarce. At this juncture, considering the importance of disease in soybean, the present investigation was carried out to know the virus -vector relationship of the YMV and whitefly in soybean.

Methods: The experiment on virus-vector relationship of yellow mosaic virus and whitefly in soybean was conducted at Department of Entomology, College of Agriculture, G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand during 2016-17. The data on number of whiteflies per plant, acquisition and inoculation access feeding period and pre and post starvation period required for effective transmission of virus was recorded.

Result: A single viruliferous whitefly was able to transmit virus and ten viruliferous whiteflies per plant were required for cent per cent transmission of virus. The minimum acquisition access and inoculation access feeding periods required for virus transmission was 0.25h (15 min) each; while the 100 per cent virus transmission was recorded with acquisition and inoculation period of 12h, each. The per cent transmission was increased with the increase of acquisition and inoculation periods. The rate of transmission was positively correlated with pre-acquisition starvation period and negatively correlated with post- acquisition starvation period.

Key words: Acquisition access period, Inoculation access period, Vector, Whitefly, Yellow mosaic virus.

INTRODUCTION

Whitefly, *Bemisia tabaci* (Gennadius) is one of the most destructive insect pest in the tropical and subtropical regions of the world. It is highly polyphagous and feeding on several agricultural and horticultural crops. It is causing significant crop losses directly by sucking sap from the plants and indirectly by transmission of viral diseases specifically caused by the genus *Begomovirus* (Brown, 2010). The *Begomovirus* species *viz*., *Mungbean yellow mosaic India virus* (MYMIV) and *Mungbean yellow mosaic virus* (MYMV) are causing yellow mosaic virus disease (YMD) in soybean in north and south India, respectively (Usharani *et al*., 2004 and Girish and Usha, 2005) which is transmitted through whiteflies (Raghupathi, 1989). The YMD symptoms start with small yellow colour specs on the leaf lamina, which later turned to mosaic like irregular green and yellow patches. The yellow colour area on lamina increases and the entire leaf turns to yellow at maturity. The affected plants become unproductive and produce fewer flowers and pods (Malathi, 2007). The disease was first reported in India during 1960 (Nariani, 1960) which accounts to 30-70 per cent yield loss and increases up to 80-100 per cent during its severe incidence (Nene, 1972) and it is a major constraint to soybean production in Uttarakhand, Punjab, Madhya Pradesh, Delhi, Haryana, Uttar Pradesh, Rajasthan and Karnataka. Hence, there is a need for development of integrated pest management strategies for the management of disease and whiteflies, for this the knowledge on virus-vector relationship is required. But, the studies on biological relationship of yellow mosaic virus disease and whitefly in soybean are scarce. At this juncture, considering the importance of disease in soybean, the present investigation was carried out to know the virus -vector relationship of the YMV and whitefly in soybean.

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MATERIALS AND METHODS

The experiment on virus-vector relationship of yellow mosaic virus and whitefly in soybean was conducted at Department of Entomology, College of Agriculture, G. B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand during 2016-17.

Establishment and maintenance of whitefly pure culture

The whitefly population was collected from soybean fields at Pantnagar with the help of an aspirator and released on 20 days old brinjal plants for multiplication in insect rearing aluminium cages (45 cm × 45 cm × 30 cm) fitted with 40 mm mesh kept in the glasshouse. The old brinjal plants were replaced with healthy plants at regular interval for the maintenance of vigorous culture.

Maintenance of yellow mosaic virus culture

The virus infected soybean plants were collected from the field and maintained on JS 335 soybean plants in insect proof cages under glasshouse. The virus was inoculated to the healthy plants through viruliferous whiteflies.

Determination of number of whiteflies required for transmission of virus

The study was conducted to determine the number of viruliferous whiteflies required for the successful transmission of YMD in soybean. The acquisition access feeding period (AAFP) of 24 h was given to non viruliferous whiteflies on virus infected plants; later on they were transferred to 10-15 days old soybean seedlings at the rate of 1, 3, 5, 7, 10, 15 and 20 whiteflies per seedling. The whiteflies were killed by spraying of imidacloprid 17.8SL@0.4 ml/L on soybean plants after an inoculation access feeding period (IAFP) of 24 h and the plants were observed for the expression of symptoms. Thirty plants were inoculated in each treatment and per cent virus transmission was calculated in all the treatments with the following formula:

Per cent virus transmission =

$$\frac{\text{No. virus infected plants}}{\text{Total no. of inoculated plants}} \times 100$$

Determination of acquisition access feeding period required for transmission of virus

In order to find out the minimum AAFP required for the transmission of virus through whiteflies, the non viruliferous whiteflies were allowed for the AAFP of 0.08 h, 0.16 h, 0.25 h, 0.5 h, 1 h, 3 h, 6 h, 9 h, 12 h, 24 h and 48 h on virus infected plants, then they were transferred to 10-15 days old healthy soybean seedlings at the rate of ten viruliferous whiteflies per plant. They were killed by spraying of imidacloprid 17.8SL@ 0.4 ml/L on the inoculated plants after the inoculation access period of 24 h. Thirty plants were inoculated in each treatment and observed for the expression of symptoms. The per cent virus transmission and incubation period were recorded in all the treatments.

Determination of inoculation access feeding period required for transmission of virus

The AAFP of 24 h was given to non viruliferous whiteflies on virus infected plants after that they were transferred to 10-15 days old thirty soybean seedlings at the rate of ten viruliferous whiteflies per seedling for virus inoculation. Imidacloprid 17.8SL@ 0.4ml/L was sprayed on the inoculated plants for killing of whiteflies after the IAFP of 0.08 h, 0.16 h, 0.25 h 0.5 h, 1 h, 3 h, 6 h, 9 h, 12 h, 24 h and 48 h then the plants were observed for expression of symptoms. The per cent virus transmission and incubation period were noted in all the treatments.

Effect of pre-acquisition starvation period on transmission of virus

The non viruliferous whiteflies were starved for different periods *viz*., 0.5 h, 1 h, 1.5 h, 2 h, 2.5 h, 3 h and 3.5 h then the AAFP of 12 h was given to them on virus infected plants after that they were released on thirty 10-15 days old soybean seedlings at the rate of ten viruliferous whiteflies per seedling for virus inoculation. They were killed by spraying of imidacloprid 17.8SL@ 0.4 ml/L on plants after the inoculation feeding period of 12 h then the incubation period and per cent virus transmission were recorded in all the treatments after the symptom expression.

Effect of post-acquisition starvation period on transmission of virus

The effect of post-acquisition starvation period on the rate of transmission of virus through whiteflies was studied by allowing the feeding of non viruliferous whiteflies on diseased plants for 12 h to acquire the virus then, they were transferred to thirty 10-15 days old soybean seedlings at the rate of ten viruliferous whiteflies per seedling for virus inoculation after subjecting them to different post acquisition starvation periods *viz*., 0 h, 0.5 h, 1 h, 1.5 h, 2 h, 2.5 h, 3 h and 3.5 h. The insects were killed by spraying of imidacloprid 17.8 SL@ 0.4 ml/L after the IAFP of 12h. The plants were observed for expression of symptom in each treatment and observations on incubation period and per cent transmission were noted in each case.

RESULTS AND DISCUSSION

Determination of number of viruliferous whiteflies required for YMD transmission

The per cent transmission of YMD (23.33% to 100%) and incubation period (7 to 18 days) varied with number of viruliferous whiteflies inoculated per plant in soybean (Fig 1). A single viruliferous whitefly per plant was able to transmit virus in 23.33 per cent inoculated plants in 16 days and the per cent transmission was increased with increase in number of viruliferous whiteflies per plant. However, the minimum number of whiteflies required for cent per cent transmission was 10 and the incubation period was 8.5 days. The incubation period decreases with increase in number of whiteflies released per plant. The results were in conformity with findings of Jyothi (2012) who reported that a single

viruliferous whitefly transmitted virus in 40 per cent of the inoculated plants and 10 viruliferous whiteflies were required for 100 per cent transmission of YMV in pole bean. Similarly, 15-20 viruliferous whiteflies per plant were required for 100 per cent transmission of *Pumpkin yellow vein mosaic virus* (PYVMV) in pumpkin (Jayasree *et al*. 1999) and YMV in soybean (Raghupathi, 1989) and urdbean (Salalrajan, 1988).

Influence of acquisition access feeding period on YMD transmission in soybean

The whiteflies required a minimum AAFP of 0.25h (15 min) for acquisition of virus from YMV infected soybean plants whereas, the 100 per cent transmission of virus through whiteflies was recorded with the acquisition period of 12h (Fig 2). The per cent transmission of virus was directly proportional to AAFP and inversely proportional to incubation period as the whiteflies. The AAFP of 0.25 h, 0.5 h, 1 h, 3 h and 6 h was required for 13.33, 26.67, 40.00, 63.33 and 90.00 per cent transmission of virus, respectively and the incubation period varied from 7 to 16 days. Similarly, the whiteflies required the minimum AAFP of 10 min for transmission of mesta leaf curl disease (Ambuja *et al*., 2018), MYMV in mungbean (Chenulu *et al*., 1979) and *Indian cassava mosaic virus* in cassava (Mathew, 1988). The AAFP 30 min is required for transmission of YMV in croton (Mandal, 1989) and PYVMV in pumpkin (Babitha, 1996). However, the vector has required 12h AAFP for 50 per cent transmission of YMD in soybean (Raghupathi, 1989) and 6 h AAFP for 100 per cent transmission of OYVMV (*Okra yellow vein mosaic virus*) in okra (Pun, 1995).

Influence of inoculation access period on YMD transmission in soybean

The transmission percentage and incubation period required for expression of symptoms of YMD varied with IAFP. The whiteflies required minimum IAFP of 0.25 h for transmission (20.00%) of virus and the symptom was expressed in 17-20 days after inoculation; whereas, 12 h IAFP recorded cent per cent transmission of virus (Fig 3). The rate of YMD transmission was increased from 20 to 100 per cent; whereas the incubation period was reduced from 20 to 8 days with the increase in IAFP from 0.25 to 48 h. The per cent transmission of virus through whiteflies in soybean was directly proportional to IAFP. The minimum and maximum IAFP required for transmission of YMV in soybean was 0.25h and 12 h, respectively. Dastogeer *et al*. (2012) noticed that the minimum IAFP of 15 min was required for transmission of JLMV (*Jute leaf mosaic virus*) through whiteflies whereas; the IAFP of 5 h had recorded 100 per cent transmission of virus in jute. The IAFP of 30 min and 3h were required for 48.33 and 100 per cent transmission of PYVMV in pumpkin, respectively (Jayashree *et al*., 1999). Salalrajan (1988) found that whiteflies required 2 h of AAFP for the transmission of YMV to urdbean plants. According to Raghupathi (1989),

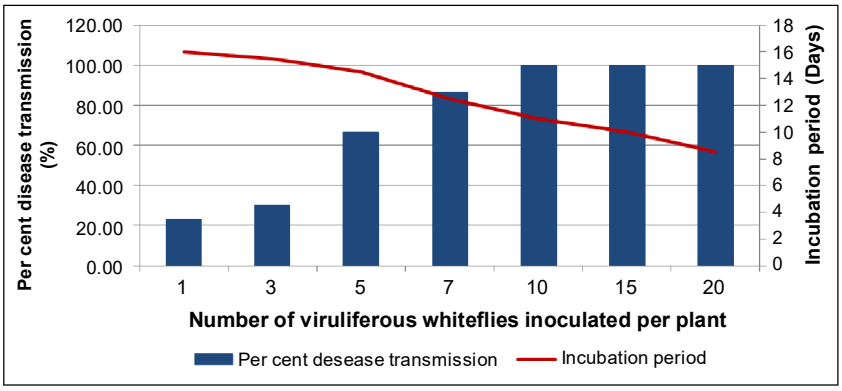

Fig 1: Influence of number of whiteflies on transmission of yellow mosaic disease in soybean.

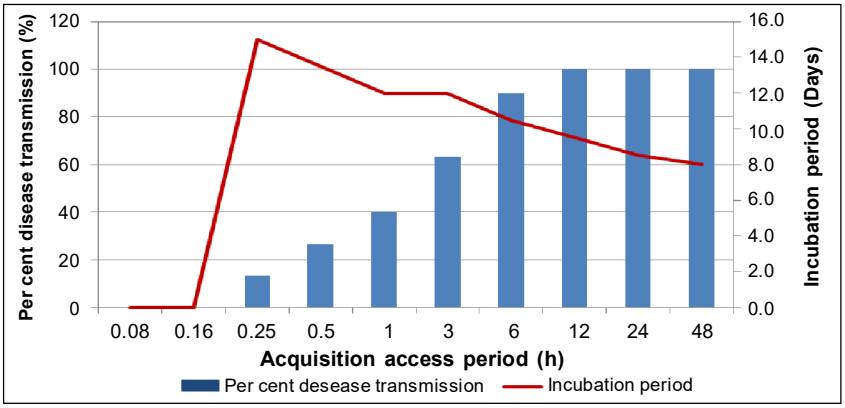

Fig 2: Influence of acquisition access period on transmission of yellow mosaic disease in soybean.

the viruliferous whiteflies required 12 h IAFP for 40 per cent transmission of YMV in soybean.

Effect of pre-acquisition starvation period on transmission of virus

The results presented in the Fig 4 revealed that the minimum pre-acquisition starvation period of 0.5 h was required for successful transmission of the virus through whiteflies and the percentage of transmission was increased with the increase in pre-acquisition starvation period. The cent percent transmission of YMD in soybean was recorded when pre-acquisition starvation period of 3.5 h was given to whiteflies. The results were similar to the findings of Dastogeer *et al*. (2012), who observed that the minimum pre-acquisition starvation period of 30 min was required for transmission of JLMV in jute. The pre-acquisition starvation period of 3.5 h ensured hundred per cent transmission of *Bittergourd yellow mosaic virus* (BGYMV) through whiteflies in bittergourd (Rajinimala *et al*., 2005). It was necessary to starve the whiteflies for 2 h (Capoor and Ahmad, 1975) and 3 h (Jayashree *et al*., 1999) to get cent per cent transmission of PYVMV in pumpkin.

Effect of post-acquisition starvation period on transmission of virus

The per cent transmission of virus through whiteflies was decreased and the incubation period was increased with the increase in post-acquisition starvation period (Fig 5). The 100 per cent transmission was ensured when whiteflies were not exposed to the post-acquisition starvation period. The per cent transmission was decreased from 100 to 23.33 when the post-acquisition starvation period was increased from 0.5 to 3 h. The negative correlation was observed between the post-acquisition starvation period of whiteflies and per cent transmission of virus. The rate of transmission efficiency reduction was directly proportional to the increase in the length of post-acquisition starvation period. The similar results were observed by Capoor and Ahmad (1975) and Jayashree *et al*. (1999) in the transmission of PYVMV through whiteflies. However, Varma (1952) and Dastogeer *et al*. (2012) reported that the post-acquisition starvation period was effective up to 4 h in the transmission of OYVMV in okra and JLMV in jute through whiteflies.

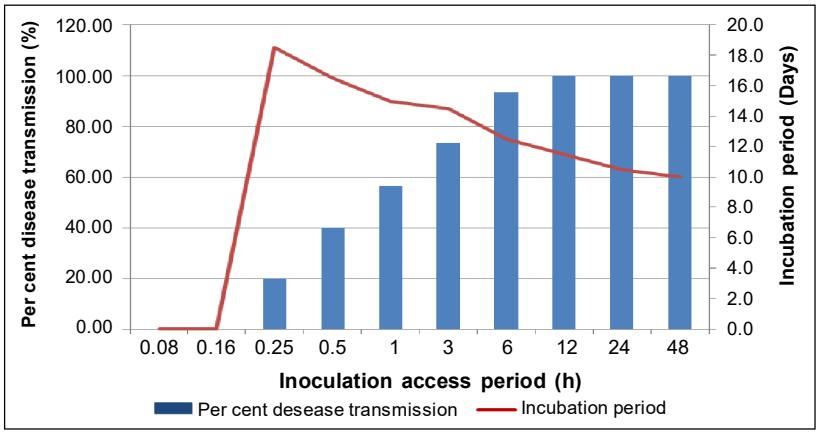

Fig 3: Influence of inoculation access period on transmission of yellow mosaic disease in soybean.

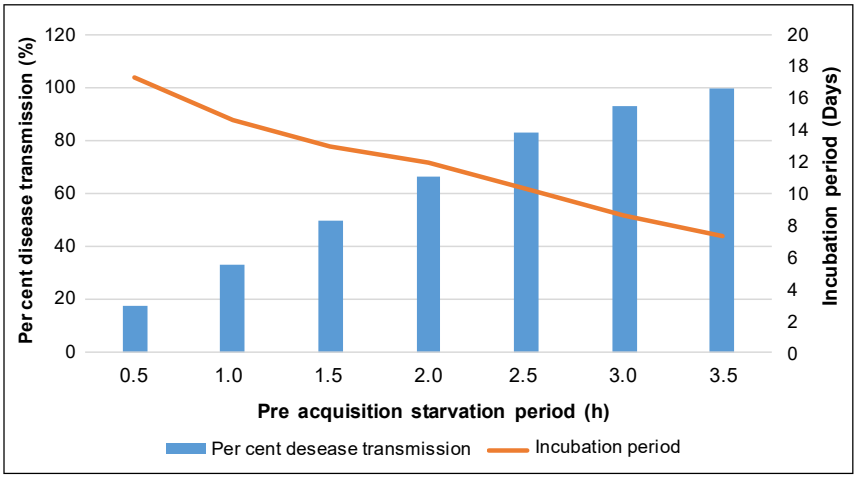

Fig 4: Influence of pre-acquisition starvation period on transmission of yellow mosaic disease in soybean.

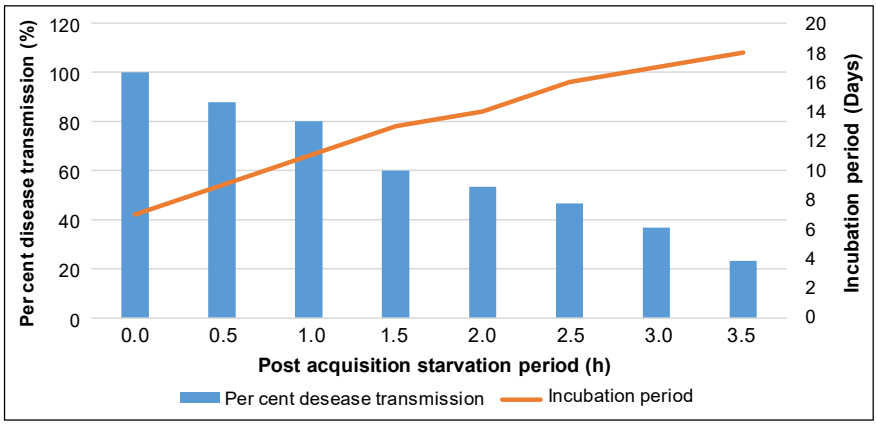

Fig 5: Influence of post-acquisition starvation period on transmission of yellow mosaic disease in soybean.

CONCLUSION

The efficiency of YMD transmission through whiteflies in soybean was determined by number of whiteflies inoculated per plant, acquisition and inoculation access feeding periods and pre and post acquisition starvation periods. The rate of transmission was directly proportional to number of whiteflies, AAFP, IAFP and pre acquisition starvation period and inversely proportional to the post acquisition starvation period. The incubation period was negatively correlated with the number of whiteflies per plant, AAFP, IFAP and pre acquisition starvation period and positively correlated with post acquisition starvation period.

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