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Biology of whitefly, *Bemisia tabaci* on soybean cultivars

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Abstract
Madhya Pradesh is one of the main soybean producers in the country. But a considerable part of the production is lost due to *Bemisia tabaci* (Genn.) attacks. Resistant plants can be an important method for controlling this pest in an integrated pest management. Tests for evaluating some biological aspects of *B. tabaci* were carried out on three soybean cultivars, in controlled laboratory conditions (25± 2^0 C, 70±10% RH, 13 photophase). Trifoliate plants placed in plastic cages were infested with a pair of whitefly, for 72 hrs. The development was observed until adult emergence. The development period of insects grown on JS-20-98 cultivar (23.0±3.0 days) took 4-7 days longer when compared to the grown in JS-97-52 (19.0±3.0 days) and JS-335 (16.5±2.5 days). Adult emergence percentage highest on JS-335(92.30%), JS- 97-52 (85.19%) and JS-20-98(76.19%).The highest mortality rate of whitefly egg to whitefly occurred in JS-20-98(77.04%) and followed by JS-97-52 (38.48%) the lowest on JS-335 (24.89%, respectively). The length and width of the immature stages varied on JS-335, JS-97-52 and JS-20-98.

Keywords: *Bemisia tabaci*, biology, hatching, emergence, mortality

Introduction

Soybean (*Glycine max* L.) Merrill) is a globally important crop. It accounts approximately 50 percent of the total production of oilseed crops in the world with many possibilities of not only improving agriculture but also supporting industries. Among the legumes, the soybean is valued for its high protein and oil content (40 and 20%, respectively). It is a rich source of amino acids, vitamins and minerals. It also improves the soil fertility by fixing atmospheric nitrogen with the symbiosis of *Rhizobium japonica* microorganism. Hence, soybean has been designated as “Wonder crop” or “Golden bean” of the 20th century and “Miracle crop” of the 21st century [18].

In India, the area, production and productivity of soybean during 2015-2016 was 11.60 million (M) ha 7.13 million metric tonnes (MMT) and 0.61 Metric tonnes (MT)/ha, respectively (www.usda.com). In Madhya Pradesh, the area, production and productivity during 2015-16 was 5.9 M ha, 4.5 MMT, 0.76 MT/ha, respectively (www.seaofindia.com).

There is a gradual reduction in the soybean yield because of various problems in the field, such as interference from plant intruder organisms (pests and diseases). The pests on soybean attack the leaves, pods and stems. Whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) is one of the most serious, cosmopolitan sucking pest that causes severe yield losses in soybean. It can lead to damage either directly or indirectly [13]. Direct damage occurred when the stylet of whitefly pierces the leaves and suck the liquid that causes chlorosis in plants. While, the indirect damage occurs due to the accumulation of honeydew that catalyses the growth of sooty mold on the entire surface of the leaf and disrupts the process of photosynthesis [12]. In addition, whiteflies act as vectors of Yellow Mosaic Virus (YMV) resulting in 15-17% of yield loss (www.nmoop.gov.in).

In order to improve the ecological based management of the pest, the behaviour of the pest such as the host preference and oviposition should be known [15]. It prefers the leaves having thick trichomes for egg laying and it lays stalked eggs [2]. In resistant cultivars very few number of eggs hatch into nymphs [26] and the period of the developmental stages is also affected [10]. The number of adults developing from nymphs also decreases due to antibiosis [24]. Controlling insect pests in soybean by spraying insecticides is widely adopted by farmers [23]. Excessive insecticide application results in disturbance to the environment, pest resurgences, pest resistance and lethal effects on non-target organisms in the agro- ecosystems in addition to direct toxicity to users [7].

The control of whiteflies by spraying chemical insecticides has not given satisfactory results. This was due to biotypes of whiteflies easily formed with increased levels of resistance to pesticides [20].
In this study, focusing on alternative methods to chemicals *i.e* use of resistance cultivars. The use of resistant cultivar is an important tool for the integrated management of whitefly in soybean, reducing the population and cost of cultivation. Therefore, this research aimed to evaluate some biological aspects of *B. tabaci* on three soybean cultivars.

Material and Methods

Life history of whitefly from egg to adult stage on three soybean cultivars *viz.* JS-335, JS-97-52 and JS-20-98 were studied under laboratory conditions at 25±2 ^{0}C temperature, 70±10% relative humidity and with photophase period of 13 hours.
The culture of *Bemisia tabaci* was multiplied and maintained on the potted plants of soybean variety JS-335. The plants were grown in the screen house in disposable plastic pots having diameter and height of 10 and 20cm, respectively. The pots were filled with vermicompost, soil and sand in the ratio of 2:1:1. Watering was done manually once in every two days. Initially whitefly adults were collected from the field using aspirator and were released on the soybean plants which were kept inside the screen house. The whiteflies were allowed to develop and multiply on those plants. Second generations of the non-virulent *B.tabaci* adults were used for the study of their biology. Different immature stages and adults of whitefly were obtained from the culture for the experiment. The following materials were used to conduct the studies on biology; aspirator, nylon cages, stereo zoom binocular microscope, camel hair brush, marking tags, petri dishes, ocular micrometer 20 mega pixel camera, walk-in BOD chamber and soybean cultivars of different susceptibility groups against whitefly JS-335, JS-97-52, JS 20-98.
Soybean cultivars were raised in small pots (50x40 cm) under caged condition (80 mesh) in walk-in BOD chamber. Each variety was maintained with 3 plants / cage and a total of 3 sets were maintained. The males and females of *B. tabaci* were identified on the basis of the abdominal tips and size, the females are bigger in size and have blunt abdominal tips, while the males are smaller in size and have pointed abdominal tips. Moreover, fore and hind wings and antennae of females were larger than those of males [6] [4]. After 72 hours of release, the adults were removed from the cages. However, the number of eggs laid on the seedlings of each cage were examined after 24, 48 and 72 hours of release. To study the incubation period of the eggs which were laid on the leaves of the seedlings were marked with marker for easy recognition. Daily observations were made to note the changes in the eggs. The length and breadth of the eggs were measured by using ocular micro meter. The incubation period, hatching (%) and survival from egg to adult, duration and measurement of various immature stages and adult emergence were recorded. Length of the immature stages was recorded by placing the ocular meter on the body in vertical position and breadth was recorded by placing it on the widest portion of the body.

Statistical Analysis

The whitefly *Bemisia tabaci*, biology, mortality, length and breadth were studied by using mean and standard deviation.

Results and Discussion

The *B*emisia *tabaci* females laid eggs singly on the lower surface of the leaves. The eggs are very small with a tube like structure called stalk or pedicel, which helps the eggs to get attached with the leaf surface and transports the water from the tissues to the eggs.
Whitefly oviposition was influenced by soybean cultivars JS-335 showed the highest numbers of eggs (31eggs) differing from other two cultivars JS-97-52(27 eggs) and JS-20-98 (21 eggs) (Table 1). The mean incubation period on the three soybean cultivars varied and it was lowest on JS-335 (5.5±0.5 days) followed by JS-97-52 (7.0±1.0 days) and highest on JS-20-98 (8.0±1.0 days). Hatching percentage was affected by cultivars the highest percentage was recorded on JS-335 (93.55%) followed by JS-97-52 (85.19%) and least hatching percentage was recorded on JS- 20-98(76.19%) (Table 1). The soybean cultivars also affecting the immatures duration, length and breadth, survivorship and mortality.

Table 1: Impact of soybean cultivars on oviposition and egg development of *Bemisia tabaci*

Soybean cultivars	Mean No. of eggs			Incubation period(days)
	Laid	Hatched	Hatching (%)	
JS-335	31	29	93.55	5.5±0.5
JS-97-52	27	23	85.19	7.0±1.0
JS-20-98	21	16	76.19	8.0±1.0

Highest egg laying was observed on soybean cultivar JS-335 followed by JS-97-52 and lowest on JS-20-98.The preference and variation in the oviposition might be attributed to the presence of trichomes on the leaves. The present findings are in accordance with the findings of Mansaray and Sundufu [17], Khan *et al*.,[15], Baldin *et al*. [5]; Hasanuzzaman *et al*.,[11] and Sulistyo and Inayati,[24] they also reported that the presence of dense trichomes on soybean rendered it vulnerable for egg laying. The trichomes favoured the attachment of the eggs to the epidermis during heavy wind Lima and Lara,[16]. The present findings corroborates the findings of Fekrat and Shishehbor [9], as they also reported that average eggs laid per day by adult female whitefly was 5.8±1.3, 4.2±1.6 and 5.13± 0.97. The mean incubation period on the three cultivars *viz*., JS-335, JS -97-52 and JS-20-98 varied and it was 5.5±0.5, 7.0±1.0 and 8.0±1.0 days, respectively. The present findings are in accordance with the findings of Salas and Mendoza [21]; Auslane and Smith [3]; Fancelli and Vendramim [8]. They also reported that incubation period of *B.tabaci* was 7.3 ± 0.5 days, 6-7 days, 11.1±0.1 and 11.5 ± 0.1 days on tomato. The hatching percentage was maximum (93.55%) on susceptible cultivar followed by 85.19% on tolerant cultivar and minimum on the resistant cultivar. The present findings confirms the findings of Musa and Ren [19]; Takahashi *et al*., [25] and Ahmad *et al*.,[1] they also reported that the egg hatching percentage on soybean was 95.97±3.58,91.36±3.39 and 88.85±2.28%, respectively.

Table 2: Impact of soybean cultivars on total developmental period of *Bemisia tabaci*

Stages(days)	Soybean cultivars		
	JS-335	JS-97-52	JS-20-98
Egg period	5.5±0.5	7.0±1.0	8.0±1.0
Instars			
Crawler	2.5±0.5	3.5±0.5	3.5±0.5
II instar	2.5±0.5	2.5±0.5	3.5±0.5
III instar	2.5±0.5	2.5±0.5	3.5±0.5
IV instar	3.5±0.5	3.5±0.5	4.5±0.5
Total larval period	11.0±2.0	12.0±2.0	15±2.0
Total period	16.5±2.5	19.0±3.0	23.0±3.0
Mean adult emergence (%)	92.30	90.00	81.80

Newly emerged first instar nymphs are known as crawlers. Mean developmental period of the first instar nymphs or crawlers on the three soybean cultivars varied, and it was highest (3.5±0.5 days) on the resistant cultivars and lowest on the susceptible cultivars (2.5±0.5 days) as shown in (Table 2). Salas and Mendoza [21]; Kedar *et al.*,[14] and Silva *et al.*, [22] they also reported that mean developmental period of the first instar nymphs was 4.01±1.0 days on tomato and 3-5 days on cotton. Freshly moulted second instar nymphs were whitish yellow in colour, oval, flat and became yellowish and dome shaped after feeding. The mean developmental period of the second and third instar nymphs on the three soybean cultivars varied, and it was highest (3.5±0.5 days) on cultivar JS-20-98, followed by cultivars JS-97-52 and JS-335(2.5±0.5 days) respectively, (Table 2).The present findings are in conformity with the findings of Salas and Mendoza[21] and Silva *et al.*, [22]. They also reported that on tomato the duration of the second instar nymphs were 2.70±1.10 and 2.5± 0.7 days, 3.26±0.35 and 2.10±0.10 days, respectively.

The mean developmental period of the fourth instar nymphs on the three soybean cultivars and it was highest (4.5±0.5 days) on the JS-20-98 and lowest on the (3.5±0.5 days). The mean total development period (from egg to adult) on three soybean cultivars varied, and it was highest (23.0±3 days) on resistant cultivars (JS-20-98) followed by tolerant cultivars (JS-97-52) 19.0±3.0 days and lowest (16.5±2.5 days) on susceptible cultivars (JS-335) (Table 2). The present findings contradiction with Musa and Ren [19]; Fekrat and Shishehbor [9] and Fekri *et al.*, [10]. They also reported on different host crops soybean, aubergine, tomato, and potato the developmental period was 18.2, 14.9, 20.0 to 26.66 and 14.2 days, respectively. Highest emergence of adults (92.30%) was recorded on cultivar JS- 335 followed by JS-97-52 (90.00%) and lowest on JS-20-98 (81.80%).

The average length and breadth of crawlers were 0.231±0.047mm and 0.224±0.049mm on susceptible cultivar (JS-335), 0.235±0.049mm and 0.297±0.003mm on tolerant cultivar (JS-97-52) and 0.238±0.050mm and 0.213±0.034mm on resistant (JS-20-98), respectively (Table 3). The results indicates that the breadth of the crawlers was maximum which developed on susceptible cultivar followed by tolerant and resistant cultivars, respectively.The present findings are in accordance with the findings of Auslane and Smith [3], as they also reported that the length and width of crawlers were 0.27mm and 0.14mm, respectively.

The average length and breadth of second instar nymphs which developed on susceptible cultivar (JS-335) were 0.332±0.048 mm and 0.246±0.051 mm, while it was 0.323±0.043 mm and 0.218±0.039 mm on tolerant cultivar (JS-97-52) and 0.321±0.043mm and 0.229±0.048mm on resistant cultivar (JS-20-98), respectively (Table 3). No reports are available in the literature on the size of second instar nymphs.

Observations on measurement of third instar nymphs revealed that the average length and breadth of the nymphs which developed on susceptible cultivar (JS-335) was 0.430±0.047 mm and 0.333±0.048 mm, while it was 0.424±0.049 mm and 0.333±0.048 mm on tolerant cultivar (JS-97-52) and 0.415±0.038 mm and 0.324±0.044 mm on resistant cultivar (JS-20-98), respectively (Table 3). The results indicate that the breadth of the third instar nymphs was maximum, which developed on susceptible cultivar followed by tolerant and resistant cultivars, respectively. No reports are available in the literature on the size of the third instar nymphs.

Observations on measurement of fourth instar nymphs revealed that the average length and breadth the nymphs which developed on cultivar JS-335 were 0.531±0.047 mm and 0.450±0.051 mm, while it was 0.530±0.047 mm and 0.435±0.049 mm on JS-97-52 and 0.527±0.047 mm and 0.427±0.040 mm on JS-20-98, respectively (Table 3).The present findings are in accordance with the findings on tomato cultivars the fourth instar nymphs average length was 0.622mm reported by Auslane and Smith [3].The results indicates that bigger size fourth instar nymphs were found to be more abundant on the susceptible cultivar followed by tolerant and resistant cultivar, respectively.

Table 3: Impact of soybean cultivars on size of *Bemisia tabaci* instars

Stages	JS-335 (Mean±SD)		JS-97-52 (Mean±SD)		JS-20-98 (Mean±SD)	
	Length (mm)	Breadth(mm)	Length(mm)	Breadth(mm)	Length(mm)	Breadth(mm)
Egg	0.129± 0.046	0.113±0.022	0.126 ± 0.045	0.113±0.022	0.124±0.044	0.112±0.022
Crawler	0.231 ± 0.047	0.224 ± 0.044	0.235 ± 0.049	0.217 ± 0.003	0.238 ± 0.050	0.213 ± 0.034
II instar	0.332 ± 0.048	0.246 ± 0.051	0.323 ± 0.043	0.218 ± 0.039	0.321 ± 0.043	0.229 ± 0.048
III instar	0.430 ± 0.047	0.333 ± 0.048	0.424 ± 0.049	0.333 ± 0.048	0.415 ± 0.038	0.324 ± 0.044
IV instar	0.531 ± 0.047	0.450 ± 0.051	0.530 ± 0.047	0.435 ± 0.049	0.527 ± 0.047	0.427 ± 0.040

The survival percentage of various immature stages on the soybean cultivars varied. It was maximum in susceptible cultivar, JS-335(93.55% crawler, 96.55% second instar nymph, 96.42% third instar nymph and 96.29% pseudo pupa, respectively) followed by tolerant cultivar, JS-97-52(85.19% crawler, 95.65% second instar nymphs, 95.45% third instar nymphs and 95.23% pseudo pupa, respectively) and minimum in resistant cultivar, JS-20-98 (76.19% crawler, 87.5% second instar nymphs, 92.85% third instar nymphs and 84.61% pseudo pupa, respectively) (Table 4).

The present findings are in conformity with the findings of Fancelli and Vendramim [8], they reported that the total survival percentage of immature stages was 86.9%±2.1% and 42.3±9.7% on *Lycopersicon* spp.cv. LA1739 and LA1609, respectively. Similarly Musa and Ren [19] reported that the survival percentage was 77.4% and 64.08% on soybean and gardenbean, respectively.

Table 4: Impact of soybean cultivars on egg hatching, emergence and mortality of different immature stages and adults of *Bemisia tabaci.*

Stages	Soybean cultivars					
	JS-335		JS-97-52		JS-20-98	
	E	M	E	M	E	M
Egg to adult	93.55	6.45	85.19	14.81	76.19	23.81
Crawler to II instar	96.55	3.45	95.65	4.35	87.50	12.50

II instar to III instar	96.42	3.58	95.45	4.55	92.85	7.15
III instar to IV instar	96.29	3.71	95.23	4.77	84.61	15.39
IV instar to adult	92.30	7.70	90.00	10.00	81.80	18.19
Cummulative mortality (Egg to adult)	-	24.89	-	38.48	-	77.04

E: Emergence, **M:** Mortality

Conclusion
The adult whitefly, *B.tabaci* females laid eggs singly on the lower surface of the leaves which were whitish yellow in colour, transparent and spindle shaped. Among the three soybean cultivars, JS-335 was found to be highly susceptible to whitefly and is evident by maximum oviposition and hatching coupled with a short developmental period of the various immature stages, least mortality and high survival percentage. However, cultivars JS-97-52 and JS-20-98 were found to have a detrimental effect on the biology of the whitefly *i.e.* less oviposition and hatching, with a prolonged developmental period, high mortality coupled with less survival percentage.

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