CROP PROTECTION

Comparative Biology of the Whitefly *Trialeurodes vaporariorum* (West.) (Hemiptera - Homoptera: Aleyrodidae) on Soybean and Bean Cultivars

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Biologia Comparada de *Trialeurodes vaporariorum* (West.) (Hemiptera - Homoptera: Aleyrodidae) em Soja e Cinco Cultivares de Feijão

RESUMO - Com o desenvolvimento de culturas em casa de vegetação, a mosca branca *Trialeurodes vaporariorum* (West.) vem se transformando numa praga de grande importância. Foi estudada sua biologia sobre as cultivares de feijão IAC-Carioca Pyatã, IAPAR-57, Jalo Precoce, IAC-Bico de Ouro, IAC-Maravilha e sobre a cultivar Cristalina de soja, com o objetivo de verificar o efeito do hospedeiro no desenvolvimento dessa espécie. O experimento foi conduzido no Laboratório de Entomologia Agrícola - FCA - UNESP, a temperatura de 25 ± 3°C, umidade relativa de 80 ± 10% e fotofase de 14h. Os parâmetros biológicos avaliados foram: duração, viabilidade e número de instares do estágio ninfal; longevidade de machos e fêmeas, período de oviposição, número de ovos por fêmea e razão sexual; viabilidade de ovos e período de incubação; ciclo total. Com os dados obtidos, foram construídas tabelas de vida de fertilidade para a comparação do efeito das cultivares sobre o desenvolvimento biológico e conseqüente crescimento populacional da espécie. As cultivares de feijão IAC-Maravilha e Jalo Precoce influenciaram negativamente o desenvolvimento de *T. vaporariorum*, enquanto que as outras cultivares de feijão estudadas, assim como a cultivar Cristalina de soja, proporcionaram melhores condições ao desenvolvimento da praga.

PALAVRAS-CHAVE: Insecta, mosca branca, tabela de vida, relação inseto/planta

ABSTRACT - With the development of greenhouse grown crops, the whitefly *Trialeurodes vaporariorum* (West.) has become an important pest. Aiming at verifying the effect of host on the development of this species, the biology of the whitefly was studied on bean (*Phaseolus vulgaris* L.) cultivars IAC-Carioca Pyatã, IAPAR-57, Jalo Precoce, IAC-Bico de Ouro, IAC-Maravilha and on soybean (*Glycine max* L.) cultivar Cristalina. The study was conducted at the Laboratório de Entomologia Agrícola - FCA-UNESP, at 25 ± 3°C temperature, 80 ± 10% RH and 14h photophase. The biological parameters assessed were duration, viability and number of nymphal instars; male and female longevity, oviposition period, number of eggs per female and sex ratio; egg viability and incubation period and the life cycle duration. Based on data obtained, fertility life tables were constructed to allow a comparative analysis of the effect of cultivars on the biological development and consequent population growth of this species. The bean cultivars IAC-Maravilha and Jalo Precoce negatively influenced *T. vaporariorum* development, whereas, the other bean cultivars studied, as well as the soybean cultivar Cristalina, provided good conditions for development of this pest.

KEY WORDS: Insecta, whitefly, life table, insect/plant relationship

Bean (*Phaseolus vulgaris* L.) is the most important source of vegetal protein in the Brazilian diet (Oliveira *et al*. 1979). Bean production in Brazil is limited by several factors mainly climate, diseases and insect pests. According to Hohmann & Carvalho (1989), the whitefly becomes a serious problem at high temperatures as the length of the biological cycle of the pest is reduced and subsequently the number of pest generations per year increases.

Soybean is a very favorable whitefly host, where the whitefly population increases prior to its moving to adjacent bean fields (Almeida *et al*. 1984). The BGMV transmitted by the whitefly is responsible for bean production losses ranging from 40% to 100% (Faria *et al*. 1994).

In the State of São Paulo, Lourenção & Nagai (1994) observed the occurrence of high whitefly populations on tomato, broccoli, pumpkin, egg plant, bean and cotton. They also found it in ornamental and weed plants. Costa (1965) reported the first BGMV occurrence in Brazil in 1961, but considered it of little importance.

BGMV is more severe during the dry season when the host is highly susceptible, whereas the infection ratio is lower during periods of low temperatures (Paiva & Goulart 1995). Usually, the low productivity of infected plants is due to the dropping of flowers and poor pod formation (Blair *et al*. 1995). Bedford *et al.* (1994) reported that different whitefly species, even from different genera, could act as BGMV vectors.

Soybean cultivar affects whitefly oviposition and young leaves are markedly preferred for feeding (Rossetto *et al.* 1977). Eichelkraut & Cardona (1989) reported that the preferred stage for oviposition on bean was on10- to 15-day old plants.

Several researchers studied the life cycle of the whitefly and all concluded that temperatures from 23°C to 30°C provided optimal conditions for development. They also concluded that at temperatures below 10°C and above 36°C, no development occurs (Verma *et al*. 1990).

Boiça Junior & Vendramim (1986) reported on the influence of different bean genotypes on the life cycle of *Bemisia tabaci* Gen. However, Lourenção (unpublished) found no effect of the soybean genotype on adult emergence and *B. tabaci* life cycle.

Most researchers have studied the whitefly nymph stages. However due to difficulties in observing longevity and oviposition parameters few papers have reported data on the adult stage.

The most studied whitefly species is *B. tabaci.* Salas & Mendoza (1995) reported periods of 7.3 ± 0.5 days for egg incubation, 4.0 ± 1.0 days for the first instar, 2.7 ± 1.1 days for the second instar, 2.5 ± 0.7 days for the third instar, and 5.8 ± 0.3 days for the pupal stage. Female longevity was 19.0 ± 3.3 days and male longevity was19.4 ± 5.8 days. The number of eggs per female was 194.9 with 86.5% of viability. The sex ratio was 1:2.7 male : female. In studies by Azab *et al*. (1971), the whitefly sex ratio varied according to the season, but the number of females was always higher than that of males. Eichelkraut & Cardona (1989) reported a sex ratio of 1:1.

The objectives of this study were to determine the biology of *T. vaporariorum* as affected by different bean cultivars and as compared to soybean, and to construct fertility life tables to verify the potential for population development on these hosts.

Material and Methods

The study was conducted at the Laboratório de Entomologia Agrícola - FCA - UNESP - Botucatu County, State of São Paulo, Brazil. The biology of *T. vaporariorum* was studied on plants of the following bean cultivars: IAC-Carioca Pyatã, IAPAR-57, Jalo Precoce, IAC-Bico de Ouro, IAC-Maravilha as well as on the soybean cultivar Cristalina, which was considered as the standard. Laboratory environmental conditions consisted of 25 ± 3°C temperature, 80 ± 10% RH, and 14h photophase.

Bean seeds were sown in pots containing three parts of soil, one part of sand and one part of organic matter. This substrate was sterilized at 120°C for one hour. One week after plant emergence, excess plants were eliminated, retaining only one plant per pot. The pots were then kept in a greenhouse until the appearance the first trifoliate pair. Afterward, the pots were moved to the laboratory.

To maintain a whitefly population with sufficient individuals to supply the laboratory necessities, tomato plants (*Lycopersicon esculentum*) cv 'Agrocica Botu 13' were grown in a greenhouse. To start the rearing program, whitefly adults collected from local bean field crops were introduced into the greenhouse where tomato plants were being grown. Adults were then collected from greenhouse plants and taken to the laboratory for biological studies on bean and soybean host cultivars.

Each cultivar was considered a treatment. For oviposition, a pair of whitefly adults collected from tomato plants was placed in a small cage, located on the lower side of a leaflet. After 24h, the cage and the adults were removed from the leaves. Excess eggs were removed from leaves, keeping only nine eggs per plant. Eighteen insects were observed by utilizing two plants of each cultivar. Each insect was considered a replication following a randomized experimental design.

The insects were observed daily to record the developmental changes. Nymphal growth was observed by taking measurements of body width and length with a graduated ocular lens under a stereomicroscope. When the nymphs reached the 4^{th} instar, the leaflet with the nymphs was removed from the plant and placed in another cage where it was kept until adult emergence.

After adult emergence, sex was determined by examining the body size and abdomen shape. Females are bigger and have a larger abdomen than the males. After death, the insects were observed under light microscope to confirm the sex.

Adult biology was determined by observing whiteflies on the leaves, through a transparent cage, which was attached to the leaf. Observations were made daily. The leaf was removed, and the eggs were counted. The assessed biological parameters were: nymphal stage (duration, survival, number of instars, and duration (also length) of each instar); adult stage (longevity of males and females, oviposition period, number of eggs per female, sex ratio); egg stage (duration, survival); total cycle (time extent from egg to adult emergence and survival).

Based on the biological data obtained on the various cultivars, fertility life tables were constructed according to Silveira Neto *et al.* (1976), considering: reproduction net rate (Ro = Σ mx.lx); mean of one generation development period (T = Σ mx.lx.x/Ro); ability to increase in number (rm = Ln.Ro/T); finite increase ratio (λ = erm).

Where: x = period (days) of sampling; mx = specific fertility: number of descendants in "x" stage per female that will give females; Lx = survival rate. All data were submitted to ANOVA and the means were compared by Tukey test at 5% of probability.

Results and Discussion

The whitefly *T. vaporariorum* presented four instars in all the hosts studied (Table 1). However, according to Deotale *et al*. (1994) and Salas & Mendoza (1995), the 4th instar of *B. tabaci* is considered as pupa. The duration of the nymphal phase was affected by the hosts. Significant differences in instar duration occurred from the 2nd instar on. The instar duration was differently affected by the various hosts during nymphal development, but this species was able to equalize these differences and the best nymphal development occurred on the following hosts: soybean 'Cristalina' with 15.5 days, bean 'IAC-'Bico de Ouro' with 15.0 days and bean 'IAC-Maravilha' with 15.5 days.

On Fig. 1 nymphal growth as based on the body area is shown. Nymph width was not significantly affected by the hosts, but the length of all instars was significantly affected. The greatest length was observed on bean cultivars 'IAC-Bico de Ouro' with 0.746 mm , 'IAC-Maravilha' with 0.744 mm and 'IAPAR 57' with 0.742 mm. Despite these differences, the mean growth ratio was 1.40 for both width and length, varying from 1.3 to 1.4.

There were no significant differences in nymphs survival on the various host plants (Fig. 2), but the hosts significantly affected the rate of nymphal development.

The longevity (Table 2) of both male and female adults was not significantly affected by the hosts, although the female longevity was greater than the male longevity. The sex ratio (Table 2) and the oviposition period were not significantly affected by the host plants. The number of eggs per female, however, was strongly affected by the hosts, showing great variation (Table 2). The bean 'Jalo Precoce' was the least oviposited host, with only 70.6 eggs per female, while the soybean 'Cristalina' was the most oviposited host

Table 1. Mean duration (days) of *T. vaporariorum* nymphal development on five cultivars of bean and one cultivar of soybean. Temperature: 23 ± 3°C; RH: 80 ± 10% and photophase: 14h

Host	Nymph I	Nymph II	Nymph III	Nymph IV	Nymphal stage I-IV
Soybean 'Cristalina'	3.2 ± 0.22 a	2.5 ± 0.29 ab	2.4 ± 0.23 b	7.3 ± 0.32 ab	15.5 ± 0.33 bc
Bean 'IAC - Carioca Pyatã'	3.4 ± 0.34 a	2.6 ± 0.22 a	2.9 ± 0.19 a	7.6 ± 0.43 ab	16.5 ± 0.59 a
Bean 'IAPAR - 57'	3.3 ± 0.30 a	2.2 ± 0.30 bc	3.0 ± 0.39 a	7.6 ± 0.33 ab	16.0 ± 0.91 ab
Bean 'Jalo Precoce'	3.4 ± 0.34 a	2.4 ± 0.23 ab	3.0 ± 0.22 a	7.6 ± 0.54 a	16.4 ± 0.48 a
Bean 'IAC - Bico de Ouro'	3.5 ± 0.58 a	1.9 ± 0.26 c	2.3 ± 0.22 b	7.2 ± 0.46 b	15.0 ± 0.85 c
Bean 'IAC - Maravilha'	3.2 ± 0.26 a	2.0 ± 0.50 c	2.7 ± 0.41 a	7.5 ± 0.41 ab	15.5 ± 1.16 bc
CV (%)	10.73	13.88	10.67	5.66	4.88
LSD (%)	0.35	0.30	0.28	0.41	0.75

Means in columns followed by same letter are not significantly different by Tukey test at 5% probability.

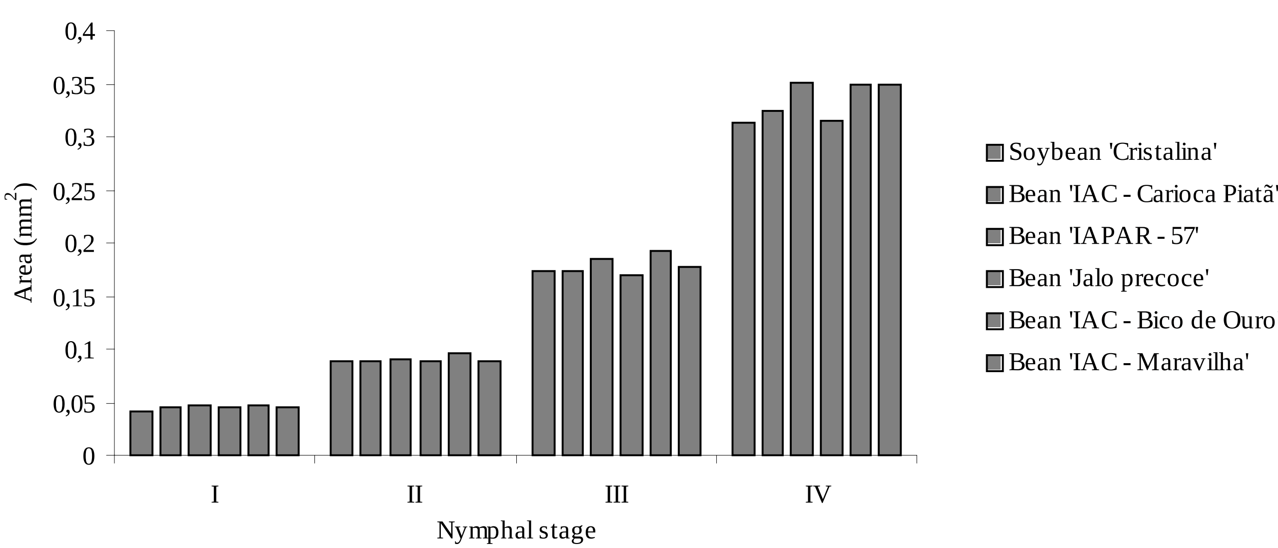

Figure 1. *T. vaporariorum* growth throughout the instars on five cultivars of bean and one cultivar of soybean. Temperature: 23 ± 3°C; RH: 80 ± 10% and photophase: 14h

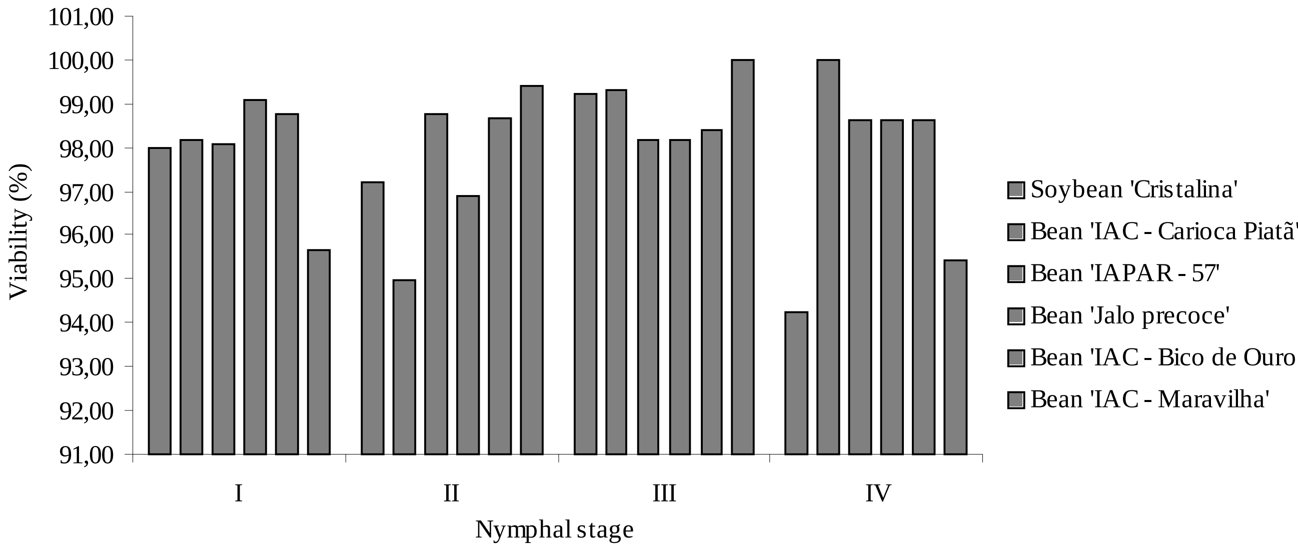

Figure 2. Survival (%) of *T. vaporariorum* instars on five cultivars of bean and one cultivar of soybean. Temperature: 23 ± 3°C; RH: 80 ± 10% and photophase: 14h

Table 2. Biological parameters of *T. vaporariorum* adults on five cultivars of bean and one cultivar of soybean. Temperature: 23 ± 3°C; RH: 80 ± 10% and photophase: 14h

Host	Longevity (days)		Sex ratio	Oviposition period (days)	Eggs per female
	Male	Female			
Soybean 'Cristalina'	25.6 ± 6.67 a	29.6 ± 5.28 a	0.3 ± 0.08 a	25.6 ± 5.28 a	337.0 ± 81.52 a
Bean 'IAC - Carioca Pyatã'	15.5 ± 12.64 a	30.0 ± 11.87 a	0.6 ± 0.26 a	26.6 ± 11.06 a	102.2 ± 51.87 b
Bean 'IAPAR - 57'	17.9 ± 13.00 a	27.1 ± 9.02 a	0.5 ± 0.05 a	23.3 ± 8.62 a	172.4 ± 113.77 ab
Bean 'Jalo Precoce'	17.3 ± 10.53 a	18.0 ± 6.00 a	0.3 ± 0.23 a	15.0 ± 5.07 a	70.6 ± 28.86 b
Bean 'IAC - Bico de Ouro	24.9 ± 11.96 a	25.3 ± 8.49 a	0.6 ± 0.09 a	21.3 ± 8.49 a	199.4 ± 57.3 ab
Bean 'IAC - Maravilha'	22.8 ± 14.41 a	30.0 ± 14.14 a	0.3 ± 0.00 a	26.0 ± 14.14 a	238.0 ± 0.00 ab
CV (%)	52.74	32.43	37.22	36.04	41.18

Means followed by the same letter are not significantly different by Tukey test at 5% probability.

with 337 eggs per female. Despite this great difference, the bean cultivars 'IAC-Maravilha', 'IAC-Bico de Ouro' and 'IAPAR-57' were not statistically different from soybean 'Cristalina' and bean 'Jalo Precoce'. These data are similar to those reported for *B. tabaci* on cotton by Azab *et al.* (1971), where the number of eggs per female varied from 48 to 394.

The incubation period (Table 3) of eggs laid by insects reared on beans 'IAC-Carioca Pyatã' and 'Bico de Ouro' were longer than those from insects reared on bean 'IAC-Maravilha', while the eggs from other host plants did not show any significant difference. Egg hatch was significantly affected by the host on which the females were reared (Table 3), with egg hatch varying from 69.8% to 90.1%. The highest percent hatch occurred with eggs laid by insects reared on beans 'Jalo Precoce' and 'Bico de ouro' and on soybean 'Cristalina'. The lowest percent hatch was obtained with eggs laid by insects reared on beans 'IAPAR-57'and 'IAC-Maravilha'. On the other hand, the eggs laid by insects from the rearing on tomato

Table 3. Effects of five bean cultivars and one cultivar of soybean, on biological parameters of *T. vaporariorum* eggs. 23 ± 3°C temperature; 80 ± 10%RH, and photophase: 14h

Host	Incubation period (days)	Hatch (%)
Soybean 'Cristalina'	6.7 ± 0.61ab	84.0 ± 5.68
Bean 'IAC - Carioca Pyatã'	7.0 ± 1.06 a	82.1 ± 5.57
Bean 'IAPAR - 57'	6.8 ± 0.81 ab	69.9 ± 11.41
Bean 'Jalo precoce'	6.6 ± 0,51 ab	88.3 ± 2.62
Bean 'IAC - Bico de ouro	7.1 ± 0.34 a	90.1 ± 3.59
Bean 'IAC - Maravilha'	6.2 ± 0.38 b	69.8 ± 11.31
CV (%)	9.96	9.35
LSD (%)	0.65	7.31

Means in columns followed by same letter are not significantly different by Tukey test at 5% probability.

plants in the green house, showed a varying hatch from 91.9% to 99.4%, independently of the host on which they were laid.

The egg-adult cycle was significantly affected by the host (Table 4). The shortest period of egg-adult was obtained with insects reared on bean 'IAC-Maravilha'. On the other hand, survival to the adult stage was the lowest on this host (Table 4). The egg-adult survival was the greatest for insects reared on bean 'Jalo Precoce' and 'IAC-Bico de Ouro'. Insects reared on 'Jalo Precoce' also had a long life cycle. These biological parameters equalized one another providing an equilibrium to the cycle on different hosts. However, the best combinations of life cycle length (short) and survival (high) for maximum population growth occurred on bean 'IAC-Bico de Ouro'.

Table 4. Effects of five cultivars of bean and one cultivar of soybean on the length of the life cycle, and survival from egg to adult, of *T. vaporariorum*. Temperature: 23 ± 3°C; RH: 80 ±10% and photopohase: 14h

Host	Cycle length (days)	Survival (%)
Soybean 'Cristalina'	22.2 ± 0.78 bcd	72.6 ± 17.20 abc
Bean 'IAC - Carioca Pyatã'	23.5 ± 1.20 a	74.5 ± 11.51 ab
Bean 'IAPAR - 57'	22.8 ± 0.93 abc	63.5 ± 14.16 bc
Bean 'Jalo Precoce'	23.0 ± 0.78 ab	81.0 ± 9.04 a
Bean 'IAC - Bico de Ouro	22.0 ± 0.72 cd	84.6 ± 8.36 a
Bean 'IAC - Maravilha'	21.6 ± 1.03 d	60.3 ± 17.01 c
CV (%)	4.10	18.36
LSD (%)	0.89	12.94

Means in columns followed by same letter are not significantly different by Tukey test at the 5% level of probability.

Analyzing the life table data (Table 5), it is evident that the bean cultivar 'IAC-Maravilha', followed by 'Jalo Precoce', were the poorest hosts for *T. vaporariorum* development, while the soybean 'Cristalina' was the best. The best bean cultivars, 'IAPAR-57' and 'IAC-Bico de O uro', were both poorer than the soybean cultivar 'Cristalina' for population development of the whitefly.

Based on these data, bean cultivars are less favorable hosts than soybean for biological development of *T. vaporariorum*, as also observed by Costa *et al.* (1973) for *B. tabaci*.

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Table 5. Effects of host plants on *T. vaporariorum* life table data. Temperature: 23 ± 3° C; RH: 80 ± 10% and photophase: 14h

Host	Couple number	Sex ratio	Ro	T (days)	rm	λ	λ^{t*}
Soybean 'Cristalina'	11	0.32	630.26	38.83	0.166	1.181	627.11
Bean 'IAC - Carioca Pyatã'	9	0.56	267.72	40.00	0.140	1.150	226.40
Bean 'IAPAR - 57'	12	0.50	259.16	35.18	0.158	1.171	458.84
Bean 'Jalo Precoce'	7	0.27	66.35	34.47	0.122	1.129	112.33
Bean 'IAC - Bico de Ouro	10	0.58	492.17	39.33	0.158	1.171	453.04
Bean 'IAC - Maravilha'	2	0.25	71.10	37.10	0.115	1.122	86.40

t* = 38.8 days; mean time spent from egg to adult development of whitefly on 'Cristalina' soybean
Ro = Reproduction net rate; T = One generation development period; Rm = Ability to increase; λ = Finite increase ratio

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