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Effects of Temperature and Host-Plant Variability on *Bemisia Tabaci* (*Homoptera, Aleyrodidae*) Biology

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Abstract
This work aimed to evaluate *Bemisia tabaci* biological response to host- plants (C*ucumis melo L* (Cucurbitaceae), *Solanum melongum Miller* (Solanaceae), or *Helianthus annus L.* (Asteraceae)) variation under geothermal greenhouse. For this purpose, three serial experiments had been carried out: two *ex-situ* experiments (at laboratory conditions) that investigate the effects of temperature variation (22 and 32 °C) on *B. tabaci* biotic potential. The third, *in-situ* experiment (under geothermal greenhouse), it was used to determine the effects of host plants on *B. tabaci* biotic and reproductive responses. A total of 90 *B. tabaci* adult couples were used and equally randomized between all experiments. Our results showed *B. tabaci* (biotype B) biology is affected by both temperature and by the host plants used. Under greenhouse, hosting to *H. annus* unexpectedly decreased the females longevity (4,3±2.3 days) and the pre-oviposition (0.66±0.57 days), oviposition (3±2.64 days) and laying arrest (00±00 days) periods, when compared to *C. melo* (8.4±3.5, 0.80±0.83, 6±3.7 and 0.8±1.3; respectively) and *S. melongum* (8.8±5.4, 1.83±1.72, 6.16±4.35 and 0±0; respectively). It is concluded that geothermal greenhouse conditions influence the whitefly biology; which is a fact that should be considered in pest management programs.

Keywords: *Bemisia tabaci*, biology, reproduction, geothermal, greenhouse.

1. Introduction

Whiteflies constitute a diverse insect group. Among those, *Bemisia tabaci* whiteflies are considered as one of the most important ravaging pests [1]. *B. tabaci* (Hemiptera: Aleyrodidae) is a polyphagous insect attacking more than 600 different plants, including crops with higher economic values and ornamental plants. In addition to the feeding caused- damages, this insect constitutes a potential vector-transmitter for many viruses [2]; a fact that slumps down the agronomic value of the crop. In exception of Antarctica, *B. tabaci* is globally distributed [3, 4]. Its large scale distribution was attributed to the great tolerance of these insects to variant climatic factors, especially temperature and humidity [5] and their perquisite bulk of enzymatic systems (such as alkaline phosphatase which was expected to viaduct resistance to pesticides) that contributes to their "super bug" feeding [6]. As a result, it causes a global economic damage that overcomes billions of dollars each year [7, 8]. Instead of the huge plethora of scientific and agronomic reports scrutinizing *B. tabaci* biology and phylogeny, this phylum origin and characterization is still debated [3, 9]. *B. tabaci* pest management programs are usually found on insecticide application that remains restrained by their toxicity in humans and the great resistance that many wild insect types developed against [10-12]. The main cause of such resistance to chemical pesticides is in part due to *B. tabaci* higher reproductive potential. Since that, many trend to use its natural enemies to counteract its development are advanced, especially under greenhouse [13, 14]. To fulfill its biological cycle, *B. tabaci* goes throughout 5 different instars (egg, mobile larvae, 3 nymphal instars (static larvae), and a pre-imaginal pupae) to finish into adult fly [15]. The life-spans of each of these instars and that of the adult phenotypes are extremely varying simultaneously with both environmental conditions and the host-plant species; but no regular rules had been found in this context [7, 15, 16].

Greenhouse cultures are also affected by this pest. Because of the evidenced dependency of *B. tabaci* biologic potential specifically on temperature, it is hypothesized that it will be affected under geothermal greenhouse which has increased temperatures. Thus, this work was carried out to evaluate the biological response of *B. tabaci* (biotype B) on such conditions, using three different host-plants. In order to highlight the temperature effects, two serial ex-situ experiments were effectuated under 22 °C or 32 °C in laboratory terms. Such measures will inevitably enhance comprehensive strategies in *B. tabaci* controlling and geothermal greenhouses' culture, which is an increasing agriculture technique used in our country. So, we tested the effect of variable temperatures both in laboratory (22 and 32 °C) and under geothermal greenhouse on *B. tabaci* development

Material and methods

The research was conducted at the Institute of Arid Regions of Kebili (southern Tunisia), using *B. tabaci* (Gennadius) wild B-biotype collected from *Lantana camara* which constitutes a long-living host-plant for this insect. The study was set from February to March (2013). It consisted of three serial experiments had been carried out to determine parameters of female's biotic potential: two ex-situ laboratory experiments within temperature of 22 or 32 °C in constant conditions, and in-situ experimentation (under geothermal greenhouse). Under laboratory conditions, the photoperiod and humidity were kept respectively constant at 16 hours of light and 60%. During the experimental period, the minimal temperature under geothermal greenhouse was of 11.73±4.32 °C and the maximal one of 44.23±4.65 °C; and the relative air humidity of about 40±15%. The embryo-larval development of *B. tabaci* was also evaluated under geothermal greenhouse.

The collected pupae were allowed to transform at constant conditions of 60% of air humidity at 25 °C, in an incubation room. Thereafter, flies sexual determination was undertaken, in order to permit a controlled copulation during experiments. To determine the biological response of *B. tabaci* to the host-plant strain, couples had been reared on either Pencha variety of *Cucumis melo L* (Cucurbitaceae), *Solanum melongum Miller* (Solanaceae), or *Helianthus annus L*. (Asteraceae), at the designated conditions. Plants were grown under geothermal greenhouse. For the ex-situ experiment, plants were transferred into conditioned room. To randomize the condition, hosting was performed at the stage of 4-leaves plants. Experiments were carried out using 90 isolated *B. tabaci* couples that were equally distributed as shown in table 1.

Table 1: distribution of *B. tabaci* adult- couples during experimentation

Conditions		**Host- plants**		
		H. annus	*S. melongum*	*C. melo*
Ex-situ	22 °C	10	10	10
	32 °C	10	10	10
In-situ	Greenhouse	10	10	10

Each adult couple was appropriately fixed upon a plant leaf using a modified clip-cage, in order to allow the scoring of its biotic potential. In order to follow the pupae apparition and avoid new -flies escaping, the performed clip-cage was surrounded by traps permitting the collection and scoring of all individuals at each day of experimentation. Throughout the experiment, adult flies' longevity, daily and total fecundity, pre-, post- and oviposition, and laying arrest periods were recorded. Embryo-larval development was estimated by measuring the duration of each instar, only for experiments under greenhouse which is the subject of this study.

The obtained results were analyzed by ANOVA followed by post-hoc tests, using SPSS program for windows. All, results are presented as mean ± SD.

Results and discussion

Ravaging- insects constitute an important limiting factor for vegetal production and quality amelioration, especially for green-housed plants. Understanding these biological pest processes is an obligatory starting-point to restrain their propagation and growth, in order to avoid the crops' production-destroying effects they did induce. Since insects' biological cycles are largely dependent on environment conditions and feeding-plants availability [8, 10, 18], we tried to determine some biological and developmental responses of *B. tabaci* to temperature and host-plants variations. So, the chosen experimental temperatures may enable us to predict the insect response to conditions in geothermal green-house which is a widespread used agriculture technique in Tunisia.

Our results showed significant variability of *B. tabaci* biotic potential parameters between the used plant species and thermal conditions (Table 2).

Under laboratory conditions, the adult flies (male and females) life-span was greatly increased in 22 °C on hosted *C. melo* (10.00±7.00 and 7.66±7.37 days, respectively), more than in other thermal conditions and used host plants. The shortest life-span of flies was observed in 22 °C on *H. annus* (3.5±2.08 and 2.25±1.25 days, respectively) plants (Fig 1 a and b).

Table 2: Comparison of *B. tabaci* biotic potential parameters using multivariate ANOVA test.

Parameters	**Female longevity**	**Male longevity**	**Daily fecundity**	**Total fecundity**
F	7,20	1,32	4,14	3,89
Df	2	2	2	2
P	0,002	0,28	0,024	0,03
Parameters	**Pre-oviposition**	**Oviposition**	**Post-oviposition**	**Laying arrest**
F	2,22	7,49	0,21	3,51
Df	2	2	2	2
P	0,12	0,002	0,81	0,04

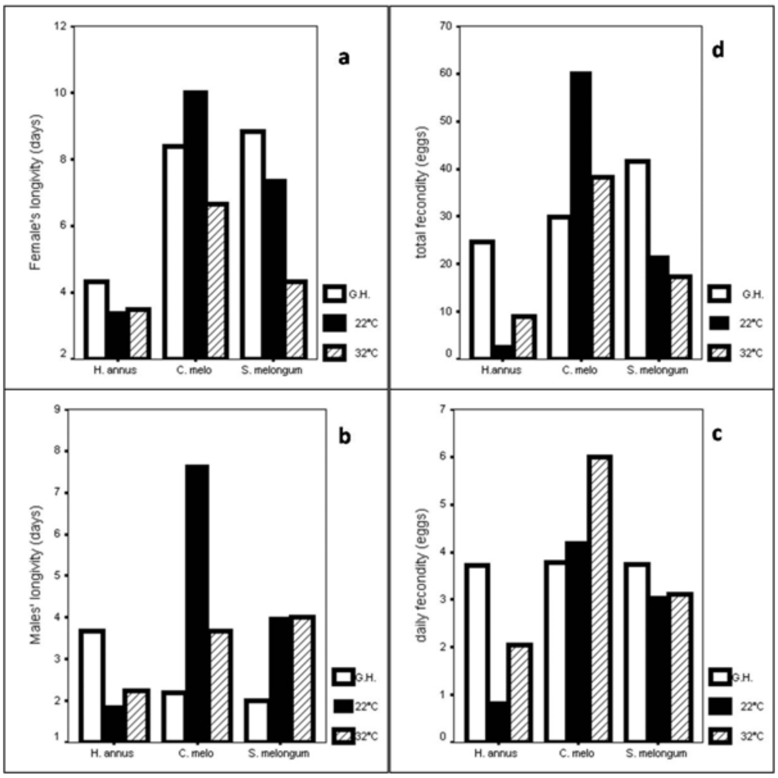

Fig 1: Adult female's (a) and male's (b) longevity; and daily (c) and total fecundity (d). Bars represent the mean results of 10 experimental replicates in laboratory conditions (Temperature of 22 or 32 °C) or under geothermal greenhouse. Insects had been grown on *H. annus*, *C. melo* or *S. melongum* plants.

Similarly, the greatest total fecundity was observed on *C. melo* (60.33±83.81) leaves at 22 °C, while the daily one significantly increased on the same host-plant at 32 °C (38.33±5.66) (Fig1 C and D). Under geothermal greenhouse, in exception of females' longevity which was diminished on *H. annus* leaves, other biotic potential parameters were not affected by the Host-plant variability. The oviposition related parameters (pre-, post-, oviposition; and laying arrest periods) significantly changed dependently on thermal conditions and the hosted plant species (Fig2).

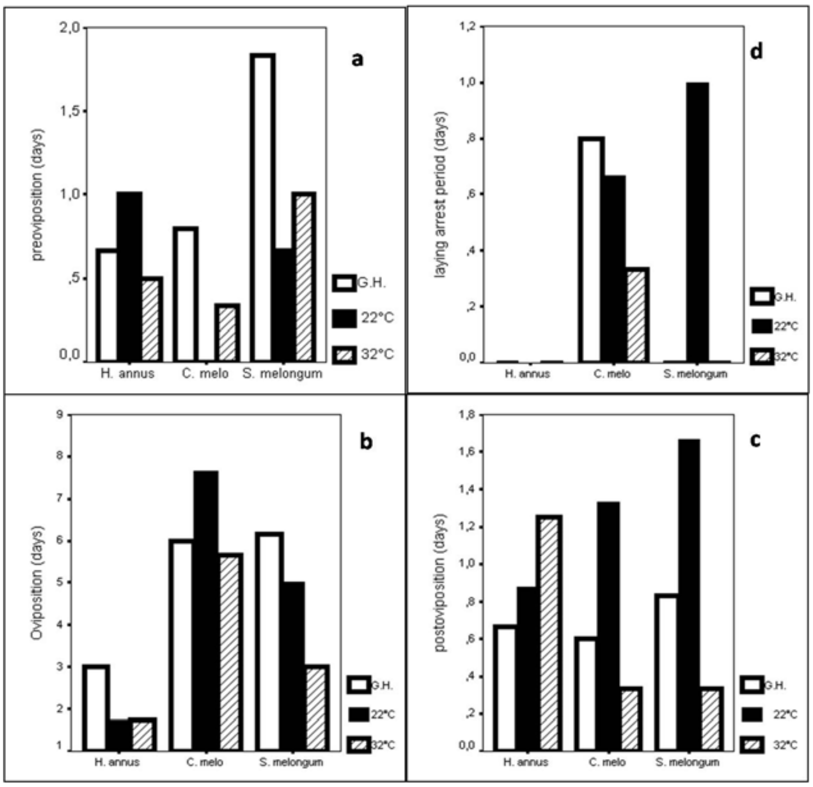

Fig 2: preoviposition (a), oviposition (b), postoviposion (c) and laying arrest (d) periods. Bars represent the mean results of 10 experimental replicates in laboratory conditions (Temperature of 22 or 32 °C) or under geothermal greenhouse. Insects had been grown on *H. annus, C. melo* or *S. melongum* plants.

Under geothermal greenhouse conditions, pre-oviposition, oviposition and laying arrest's extents are mildly to greatly increased; whereas the post-oviposition period was shortened, when compared to laboratory conditions. Under greenhouse, hosting to *H. annus*, unexpectedly decreased the pre-oviposition, oviposition and laying arrest periods, when compared to *C. melo* and *S. melongum*. In the same condition, *B. tabaci* females give up laying when hosting *H. annus* and *S. melongum*; while it still intermittent on *C. melo*. This period shortage is also true for ex-situ experiments on *H. annus*: and at 32 °C on *S. melongum* plants. Briefly, these findings mitigate those reported in the literature postulating for the important influence of environmental conditions and host variability on *B. tabaci* biology and reproduction [5, 15, 17]. The meaning of dependent host-plant variations had been attributed to host-plant organs' digestibility and toxicity [8, 18]. The temperature effects on *B. tabaci* biotic potential were evidence, however their still confusing [5]. In our experiment, geothermal greenhouse conditions enhanced females' longevity on C. melo and S. melongum; but without real effects on fecundity.

The data shown in table 3 represent the main values of embryo-larvae instars durations, under geothermal greenhouse conditions. Hosting to *H. annus* and *S. melongum* significantly enlarged the second and fourth larvae periods, when compared to *C. melo*. However, *S. melongum* specifically enhances the eggs, the first (mobile), and third instars periods prolongation, in comparison to other plants. *B. tabaci* pupae used the longest time to clash when fixed to *H. annus* leaves, in comparison to C. melo and *S. melongum*.

Table 3: Comparison of *B. tabaci* developmental stages' durations between different host plants under geothermal greenhouse.

Developmental stages		Host plant		
		H. annus	*C. melo*	*S. melongum*
Egg		8.83±0.37	9.50±1.45 (c)	8.22±0.3 (b)
Larvea	L1	2.97±1.08 (c)	3.45±0.52 (c)	7.00±3.86 (ab)
	L2	4.14±1.19 (b)	2.00±0.00 (ac)	4.77±1.98 (b)
	L3	3.25±1.29 (c)	2.50±0.70 (c)	5.00±1.00 (ab)
	L4	4.52±0.73 (b)	2.00±0.00 (ac)	4.00±1.73 (b)
Pupae		4.66±1.65 (b)	2.00±0,00 (a)	3.66±0.57

Group assigned with different letters are significantly different at $p \leq 0.05$.

Thereby, using geothermal water in green-housed crop irrigation disparately favorizes eggs, nymphal and pupae development. This effect is extremely sensitive to the grown host-crop strain. It could be hypothesized that the great temperature variation under geothermal greenhouse (between 11 and 44 °C) could be an important regulator factor for such biological responses.

It is concluded that *B. tabaci* biotic and reproductive potentials are deeply modified by host-plants strains which are grown under geothermal greenhouse. Such biological responses should be considered in programs of pest management.

No conflict of interest

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