Preference of Bemisia tabaci MEAM1 (Hemiptera: Aleyrodidae) for weed and cultivated species

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Abstract

Being capable of infesting a wide variety of plant species, the whitefly *Bemisia tabaci* MEAM1 (Hemiptera: Aleyrodidae) is responsible for severe losses in numerous agricultural crops. In order to increase knowledge regarding interactions involving *B. tabaci* MEAM1 and plants associated with agricultural landscapes, the present study sought to identify preferential hosts by comparing 15 different common weed species and five cultivated plants (tomato, bell pepper, soybean, maize and cotton) through free and no-choice tests. Additionally, a possible correlation between physical-morphological plant aspects and insect's colonization behavior was assessed. Positive correlations were verified between the oviposition index and trichome density, and between the number of adults and b* (yellow intensity) index. Negative correlations were observed between the number of adults and L* and a* (luminosity and green intensity, respectively) indexes. In the free choice test, the species *Solanum lycopersicum*, *Senna obtusifolia*, *Glycine max*, *Emilia sonchifolia* and *Euphorbia heterophylla* were the most infested during the mean of the evaluation periods, differing from *Spermacoce latifolia*, *Amaranthus viridis* and *Richardia brasiliensis*, which presented the lowest means of insect infestation. In this same test, *S. lycopersicum* and *E. sonchifolia* had the greatest oviposition, differing from most of the species. In the no-choice test, *E. heterophylla*, *Galinsoga parviflora* and *S. latifolia* had the highest means of eggs and nymphs per cm². Our results show evidence of the expressive potential of weed species frequently found in Brazilian agricultural fields, such as *E. sonchifolia*, *S. obtusifolia,* and *E. heterophylla*, as alternative hosts of *B. tabaci* MEAM1.

Introduction

Considered one of the most invasive pests in global terms, the whitefly *Bemisia tabaci* (Hemiptera: Aleyrodidae) includes a complex system of at least 44 morphologically identical cryptic species. Among these species is the Middle East-Asia Minor 1 (MEAM1 or B biotype), which stands out for its worldwide distribution and expressive economic impact in several crops (De Barro et al., 2011; Kanakala & Ghanim, 2019; Li et al., 2021).

Bemisia tabaci MEAM1 is highly polyphagous and can infest more than 1,000 plant species including fields crops, like soybeans and cotton, vegetables, such as tomato, brassica and cucurbit crops, and weed and ornamental species (Abd-Rabou & Simmons, 2010; De Barro et al., 2011; Shah et al., 2015). The whitefly can be found on most of the continents and is considered as a cosmopolitan insect (De Barro et al., 2005).

The damage caused by *B. tabaci* MEAM1 can be direct or indirect. Direct damage refers to sap sucking by nymphs and adults. This can lead to biochemical changes in the host plant, including loss of vigor and physiological disorders such as the irregular ripening in tomatoes and leaf silvering in cucurbits (Inbar & Gerling, 2008). Indirect damage involves sooty mold on leaves and fruits (Lourenção et al., 2015) and virus transmission (Fiallo-Olivé et al., 2020).

Among the types of damage caused by this pest, virus transmission poses the greatest threat regarding yield losses (Stansly & Natwick, 2009; Navas-Castillo et al., 2011). Several virus species are transmitted by *B. tabaci* MEAM1 to crops of economic importance throughout the world, such as *Tomato yellow leaf curl virus* (TYLCV), *Tomato chlorosis virus* (ToCV), *Cucurbit yellow stunting disorder virus* (CYSDV), *Cucumber vein yellowing virus* (CVYV), *Squash vein yellowing virus* (SqVYV), *Bean golden mosaic virus* (BGMV) and the complex of cotton begomoviruses (Jones, 2003; Gilbertson et al., 2015; Hasan et al., 2019).

Considering the challenges associated with *B. tabaci* MEAM1 management in the field, the broad range of host plants represents an issue of great importance related to the population dynamics of this pest in agricultural sites (Naranjo et al., 2010). Additionally, the high reproduction rates and the short developmental period of *B. tabaci* can lead to population outbreaks and difficult field management (Oliveira et al., 2001).

In this context, weed species can serve as alternative hosts for the whitefly, giving the opportunity to maintain the insect population throughout the year and making it possible to migrate this pest among plants and different crop systems (Chu et al., 1995; Gachoka et al., 2005). In addition, these plants can harbor plant pathogens (especially viruses) transmitted by the whitefly to cultivated plants (Barreto et al., 2013; Prajapat et al., 2014). The identification of alternative hosts, which can contribute to the presence of *B. tabaci* MEAM1 in agricultural fields, seems to be of great importance to avoid economic losses due to this pest. As demonstrated by previous studies (Sottoriva et al., 2014), *B. tabaci* MEAM1 presents variable patterns of preference and performance among different weed species, which can represent a greater or lesser risk to surrounding cultivated plants. Although the authors have verified different levels of susceptibility in six invasive evaluated species, this information requires further updating, since many of the species were not considered at that time and others became a significant part of crop systems, especially in agricultural crops. Additionally, the analysis of physical-morphological traits and their correlations with whitefly preference still need further investigation. These factors stimulate new studies aiming to deepen knowledge regarding interactions involving *B. tabaci* MEAM1 and cultivated and weed plant species.

The present study's objective was to assess *B. tabaci* MEAM1's preferences for feeding and oviposition on 15 weed species and five cultivated species of economic importance in Brazilian agricultural fields. The plant species were assessed for trichome presence (density and typification) and colorimetric parameters in order to identify possible correlations with the colonization behavior of the insect.

Materials And Methods

Selected weed species

To carry out the tests, 15 species of common weeds in crops of economic importance in Brazil were selected (Table 1). Five cultivated species were also evaluated, including tomato (*Solanum lycopersicum* L. – cv. Santa Clara), soybean (*Glycine max* L. – cv. TMG 7062 IPRO), cotton (*Gossypium hirsutum* L. –

cv. FMT 707), corn (*Zea mays* L. – cv. 30F53 VYHR), and bell pepper (*Capsicum annuum* L. – cv. Cascadura Ikeda).

Stock colony of *Bemisia tabaci* MEAM1

The insects used in the tests were provided from a previously established colony identified according to De Barro et al. (2003). The colony was kept in a greenhouse (2.5 × 2.5 × 2.0 m), with the sides and roof partially closed with glass and covered with an anti-aphid screen. Soybean and kale (*Brassica oleracea* var. *acephala* L.) plants were offered to maintain the insects and were kept in 2.5 L plastic pots. The deteriorated plants were replaced by healthy ones as needed.

Adult attractiveness and oviposition test

The preference for infestation and oviposition by adults of *B. tabaci* MEAM1 in the described plant species was evaluated through free-choice assays, as described in previous studies (Domingos et al., 2018; Santos et al., 2021). For that, one plant of each plant species was sowed and cultivated in pots (1 L) containing Carolina Soil® substrate and kept in a greenhouse free from insect infestation.

Plants of each species presenting four to six fully-developed leaves were randomly arranged in a circle inside a metallic cage (3.0 × 3.0 × 2.5 m) with the sides covered in anti-aphid mesh and the ceiling formed by plastic film and shade. Subsequently, a proportion of 50 couples of *B. tabaci* MEAM1 per plant species were released close to the center and equidistantly between the vessels (total of 2,000 insects per cage).

The number of adults present in each plant species was quantified 24, 48 and 72 hours after infestation with the aid of a mirror positioned close to the abaxial face of the leaves. After the last quantification (72 h), all the leaves were collected from the plants for evaluation in the laboratory, where the eggs were counted for each whole plant. Then, the leaf areas of the plants were measured using the LI 3000A meter (LI-COR® Inc., Lincoln, NE, USA), in order to determine the number of eggs per cm^2 (Baldin et al., 2005). The design used was randomized blocks, with 20 treatments (plant species) and 10 replications. Each cage, containing 20 pots with one plant of each species, constituted a repetition.

Colorimetric analysis

After replanting the selected plant species, two leaves were collected from the middle portion of each plant at a phenological stage similar to that used in the test described above. Three distinct regions of the adaxial face of each leaf were evaluated using the CIELAB color space (Colorimeter Minolta Color Reader), determining the parameters L* luminosity (0 indicates black and 100 indicates white) and the chromatic coordinates a* and b* (+a indicates red and -a indicates green; +b indicates yellow and -b indicates blue) (Minolta, 1998).

Four plants per species (n= 8 leaves/species) were evaluated in a completely randomized design, with a total of 20 treatments (species) and eight replications.

Trichome analysis

The existing trichomes in the structures of the plant species were evaluated along the abaxial face of 8 leaves/leaflets of the middle third of each plant from each species. For that, the trichomes present in an area of 25 mm² beside the midrib were quantified and also classified as glandular or non-glandular and as to type (Channarayappa et al., 1992), with the aid of a stereoscopic microscope. A completely randomized design was adopted, with 20 treatments and 8 replications (8 leaves/leaflets per species) (Valle & Lourenção, 2002).

Oviposition and colonization no-choice test

For this test, metallic cages (35 cm in diameter and 70 cm in height) covered with voile fabric were used to individualize each of the plant pots. When the plants had four-to-six fully expanded leaves, 50 adult couples of *B. tabaci* MEAM1 were released inside each cage. Fifteen days after release, eggs and nymphs were counted on all leaves of each plant of the plant species. As with the free-choice test, the leaf areas of the evaluated plants were measured in order to determine the number of eggs and nymphs per cm^2. Each plot was represented by a pot containing the evaluated plant species and the adults of the insect, following a completely randomized design, with 10 replications.

Statistical analysis

The data obtained were submitted for analysis of variance using the F test. Normality was verified using the Shapiro-Wilk test and homogeneity using the Levene test. Then, the Fisher LS-Means test, adjusted for Tukey ($P \leq 0.05$) was used to compare the means. The statistical package PROC MIXED-SAS 9.2 (Sas Institute, 2001) was used for the analyses.

Spearman's correlation coefficients were calculated between the density of trichomes and the density of eggs in the plant species at the end of the free-choice test; and between the number of adults (after 24 h of infestation of the free-choice assay) and the colorimetric parameters (L*, a* and b*). The coefficients were obtained using the PROC Corr-SAS package (Sas Institute, 2001).

Results

Adult attractiveness and oviposition test

There was a significant difference in all evaluation periods (24, 48 and 72 h) regarding the number of insects present under the plants (Table 2). After 24 hours of infestation, tomato stood out with the highest number of adults of *B. tabaci* MEAM1 (225.10), followed by soybean and three weed species *S. obtusifolia*, *E. heterophylla* and *E. sonchifolia*, which presented averages between 192.70 and 150.30 insects per plant. The less attractive species to adults of *B. tabaci* in the first evaluation period were *S. latifolia*, *A. viridis*, *R. brasiliensis*, *D. insularis*, *C. benghalensis*, corn, *R. raphanistrum*, *G. parviflora* and *C.*

canadensis, which differed from those mentioned above, with averages varying between 3.20 and 23.30 adults.

Tomato (300.20 insects), *S. obtusifolia* (206.30), soybean (199.00) and *E. sonchifolia* (188.10) remained as the most attractive species to insects after 48 hours of release, differing of most other plant species (3.00 - 55.60) (Table 2). In the last evaluation (72 hours), the highest averages of whitefly adults were again observed in tomato (320.90 insects), *S. obtusifolia* (189.80), *E. sonchifolia* (178.60), soybean (173 .90) and *E. heterophylla* (134.30), which differed from most of the other plant species evaluated.

Considering the average of the three evaluation periods, the tomato plant differed from the other species, attracting the largest number of adults of *B. tabaci* (282.06). In addition to tomato, *S. obtusifolia*, soybean, *E. sonchifolia* and *E. heterophylla* showed high levels of infestation, with averages varying between 189.43 and 151.57 insects per plant. Among the least infested, the species *S. latifolia* (2.93), *A. viridis* (3.13) and *R. brasiliensis* (3.20) stood out, with the lowest averages of insects on the plants.

Regarding the oviposition in the plants after 72 hours of infestation, tomato and *E. sonchifolia* showed the highest oviposition rates (22.52 and 20.27 eggs/cm², respectively), differing from most other species, especially *R. brasiliensis,* corn and *A. viridis*, which presented averages lower than 1.00 egg/cm².

Colorimetric analysis

Plant species differed significantly in all colorimetric parameters analyzed (Table 3). Regarding luminosity (L^*), the species *G. parviflora* stood out with the highest average (44.35), followed by *C. benghalensis* and *C. canadensis*, which presented averages of 43.89 and 43.85 for this parameter, respectively. These species differed from soybean, *S. obtusifolia*, *I. grandifolia*, *S. rhombifolia*, *A. viridis*, cotton and *E. heterophylla*, which presented the lowest luminosity averages (35.71-40.80).

Considering the a^* parameter (green-red), *E. sonchifolia*, tomato, *G. parviflora* and soybean showed the most negative indices (higher intensity of green), differing from most species. The highest values of a^* (tending to red) were observed in cotton, *S. rhombifolia* and *E. heterophylla* (-10.89; -11.43 and -11.96, respectively). The highest values for the b^* parameter were found in *G. parviflora* (27.42) and tomato (27.23), followed by the species *M. aegyptia* and *E. sonchifolia*, with 27.25 and 26.90, respectively. The lowest rates for this parameter were found in *S. rhombifolia*, cotton and *A. viridis* (15.35 to 18.48).

There was a significant correlation between the number of adults after 24 hours of infestation and all colorimetric parameters evaluated. Correlations were negative for L^* ($r = -0.23$) and a^* ($r = -0.19$), and positive for b^* ($r = 0.20$) (Table 4).

Trichome analysis

A significant difference was found among the plant species evaluated in terms of trichome density. Among the evaluated species, there was no presence of trichomes on the leaf blade of the abaxial face of

the *I. grandifolia*, *M. aegyptia*, *D. insularis*, corn, cotton, sweet pepper and *S. obtusifolia*.

Regarding the species with trichomes, tomato (134.50), soybean (100.88), *S. latifolia* (85.00) and *C. canadensis* (73.63) had the highest densities/25 mm^2, differing from the other plant species (Table 5). The species with the lowest densities of trichomes were *A. viridis*, *R. raphanistrum*, *B. pilosa*, *E. sonchifolia* and *R. brasiliensis*, with averages varying between 1.13 and 9.63.

In addition, a positive correlation was observed between the density of eggs and the density of trichomes/25 mm^2 in the free-choice test (r = 0.17) (Table 4).

Oviposition and colonization no-choice test

There was a significant difference between the plant species in terms of the number of eggs and nymphs/cm² present on the plants (Table 6). The species *E. heterophylla* stood out with the highest oviposition rate (42.35 eggs), followed by *G. parviflora* (29.20) and *S. latifolia* (27.05). The least oviposited plants in the trial were *A. viridis*, *D. insularis*, soybean, sweet pepper and corn, which presented averages ranging from 0.24 to 3.55 eggs/cm².

Regarding the infestation of nymphs/cm², the highest averages were found in the species *E. heterophylla* and *S. latifolia* (22.70 and 16.65 nymphs, respectively). The lowest rates were observed in corn, soybean, *A. viridis*, *M. aegyptia*, bell pepper and *I. grandifolia* (0.27 to 3.25 nymphs/cm²).

Discussion

The assessments carried out in this study revealed significant differences in the attractiveness and oviposition of *B. tabaci* MEAM1 in different weed and cultivated species, as well as variable colonization rates under no-choice conditions.

In the free-choice test (Table 2), tomato showed to be a highly attractive plant species to *B. tabaci* MEAM1, differing from all other species in the 2nd, 3rd and mean of the evaluations. *Emilia sonchifolia*, *S. obtusifolia*, soybean and *E. heterophylla* were also highlighted as attractive species. With respect to *E. heterophylla*, Sottoriva et al. (2014) found significantly higher infestation in this species compared to six other weed species and one cultivated plant (soybean). Their study found that over three evaluation periods, similar to those of the present study, *E. heterophylla* surpassed the soybean infestation in addition to presenting the highest number of eggs/cm². In the present study, *E. heterophylla* also presented a higher number of adults of *B. tabaci*, being among the most infested in the average of the evaluation periods in a free-choice test, similar to that verified with tomato. This species stood out even more in the no-choice test (Table 6), where it presented the highest averages of eggs and nymphs/cm² among all the evaluated species.

Other authors observed a higher incidence of eggs and nymphs of *B. tabaci* MEAM1 in *E. heterophylla* among the weed species found in cotton fields in the Midwest region of Brazil (Rodrigues & Silva, 2018).

Among the evaluated species, *C. benghalensis*, *Conyza* spp., *E. heterophylla*, *Ipomoea* spp., *R. brasiliensis* and *S. latifolia* were considered alternative hosts for the insect. Of these species, *E. heterophylla* was the most prominent in the free-choice and no-choice assays of the present study, followed by *S. latifolia*, which also showed high densities of eggs and nymphs in the no-choice assay.

Evaluating the density of eggs and nymphs of *B. tabaci* MEAM1 on weeds present in Florida, Smith et al. (2014) observed higher rates in *S. obtusifolia* and in plants of the genus *Emilia*. In the free-choice test performed in the present study, *S. obtusifolia* and *E. sonchifolia* stood out as the most infested and with the highest number of eggs after tomato, corroborating the results of those authors.

In another study evaluating weeds as alternative hosts for *B. tabaci*, Barman et al. (2022) included *Ipomoea quamoclit*, *Ipomoea cordatotriloba*, *Sida spinosa* and *E. heterophylla* as suitable hosts for the insect. Among the whitefly's unfavorable hosts, the species *R. raphanistrum*, *Amaranthus palmeri* and *Richardia scabra* stood out in Barman's study. This corroborated the present study, where *R. raphanistrum,* and species of the *Amaranthus* and *Richardia* genus also emerged as unattractive hosts to *B. tabaci* MEAM1.

Given the variations in insect preference for different plant species, it should be noted that the process of identification and selection of a host plant by the insect involves a series of external stimuli, including visual, morphological, olfactory and gustatory aspects (Smith, 2005). In this sense, the color of the plant tissue, as well as the presence of secondary compounds and the density of trichomes can play an important role in the host selection behavior of the insect.

In the case of the whitefly, there is a strong dependence on visual stimuli for the orientation and movement of the insect (Mound, 1962; Isaacs et al., 1999). Color is considered one of the most important factors involved in host selection, according to Van Lenteren and Noldus (1990). Considering the sessile habit during most of the nymphal period of *B. tabaci*, the choice of a suitable host for oviposition is fundamental for successful insect colonization (Novaes et al., 2020). In the present study, significant correlations were found between the number of adults in the free-choice test (24 h) and the three colorimetric parameters evaluated in the materials (L*, a* and b*).

The correlation between the number of insects and luminosity was negative in this study, indicating a greater preference of adults of *B. tabaci* MEAM1 for plants with darker leaves (lower L* values). The species *E. heterophylla*, which presented the lowest light index, was among the most infested plants in the free-choice evaluations, and stood out with the highest averages of eggs and nymphs/cm² in the no-choice test. However, tomato and the species *S. obtusifolia* and *E. sonchifolia*, which were the most infested in the free-choice trial, showed intermediate values of L*. In a study evaluating cucumber genotypes, Novaes et al. (2020) found no significant correlation between this parameter and the presence of adults of *B. tabaci* MEAM1. Similarly, in a preference study with different genotypes of cabbage and the same whitefly species, no significant influence of luminosity on the insect selection behavior was found (Domingos et al., 2018). It is likely, therefore, that in studies in which genotypes of the same plant

species are evaluated, smaller variations in the luminosity of the plant tissue should be observed in relation to studies involving different plant species, as is the present case.

Regarding the chromatic coordinates evaluated in this study, there was a negative correlation between the number of adults and the a^* index, indicating a preference of *B. tabaci* MEAM1 for plant species with greater intensity of green. Among the evaluated species, tomato and *E. sonchifolia* showed the highest green intensities, standing above the most infested species. This same trend (intensity of green) was observed by Prado et al. (2015) who, in an evaluation of the active cotton germplasm bank of the Instituto Agronômico (IAC) for resistance to *B. tabaci* MEAM1, found that the IAC PV 010-175 strain, the most attractive host plant, presented the highest intensity of green.

Tomato and *E. sonchifolia* also showed higher levels of b^*, confirming that *B. tabaci* MEAM1 also shows attraction to yellowish substrates, as documented by Berlinger (1980). Similar to the results obtained in the present study, Domingos et al. (2018) found a preference of *B. tabaci* MEAM1 for kale genotypes that had leaves with higher intensities of green and yellow, also corroborating previous work on the subject (Van Lenteren & Noldus, 1990).

In addition to the colorimetric factors, the trichomes present on the leaves can exert a strong influence on the colonization of *B. tabaci*. In this work, a positive correlation was found between the density of trichomes on the leaves of plant species and the density of eggs of *B. tabaci* MEAM1. Tomato plants showed the highest rates of preference for adults and oviposition in the free-choice test, and also stood out with the highest density of trichomes followed by soybean. The species *S. latifolia*, with a high density of trichomes, was among the least selected by adults of *B. tabaci* MEAM1 in the free-choice test, although it presented high averages of eggs and nymphs per cm^2 in the no-choice test. Biochemical studies indicate the occurrence of several secondary compounds in the Rubiaceae plant family, such as phenolic compounds, flavonoids, tannins, triterpenes and alkaloids (Cosmoski et al., 2015; Martins & Nunez, 2015), which may be related to changes in colonization behavior and the lower preference of adults of *B. tabaci* MEAM1 for *S. latifolia* (a member of the Rubiaceae plant family) in a free-choice test.

There are several hypotheses regarding the role of trichomes in the process of host plant selection and colonization by whiteflies. In one of them, it is suggested that the insect's preference for ovipositing at the base of the trichomes is associated with an adaptive advantage over the attack of natural enemies, as well as a possible favorable microclimate in leaves with high densities of non-glandular trichomes (Butter & Vir, 1989; Chu et al., 1995; Heinz & Zalom, 1995; Torres et al., 2012; Miyazaki et al., 2013). In this sense, the positive correlation between plant susceptibility and the presence of trichomes was found in studies with different crops such as soybean, cotton, tomato and eggplant (Heinz & Zalom, 1995; Silva et al., 2012; Hasanuzzaman et al., 2016; Oliveira et al., 2021). On the other hand, several reports in the literature point to negative correlations between the total density of trichomes and the oviposition of *B. tabaci* (Oriani & Vendramim, 2010; Taggar & Gill, 2012), indicating that the isolated analysis of this morphological factor may be questionable for the classification of susceptibility and/or resistance of plants to the whitefly (Muigai et al., 2003).

Adding to the quantification of these structures, other factors related to trichomes seem to influence the colonization of *B. tabaci*, such as angle, length and type (Lambert et al., 1995; Lakshminarayan et al., 2008; Valle et al., 2012). Glandular trichomes are capable of releasing allelochemicals involved in non-preference for oviposition, and may also keep the insect attached to the leaf surface through released exudates (Fancelli et al., 2005; Oriani & Vendramim, 2010). In this study, *A. viridis* showed greater variability of glandular trichomes (types IV, VI and VII) and also low averages of adults and eggs in free-choice assessments, confirming the negative role of this type of structure in whitefly colonization.

In general, the results obtained in this study reveal the expressive potential of some weed species, frequently present in crops in Brazil, to act as alternative hosts of *B. tabaci* MEAM1. Invasive species such as *E. sonchifolia*, *S. obtusifolia* and *E. heterophylla* proved to be highly attractive to the insect, showing infestation levels close to those observed with cultivated insect host species, such as tomato and soybean.

Although some species did not attract significant numbers of *B. tabaci* under free-choice conditions, they showed high rates of insect colonization under confined conditions (no choice), as verified with *G. parviflora* and *S. latifolia*. In this mandatory condition, *E. heterophylla* also stood out as the species with the highest density of eggs and nymphs. In this sense, it is important to emphasize that in agricultural scenarios where preferential hosts are not present, as well as in off-season periods, weeds can assist in maintaining pest populations in the cultivation area, thereby contributing to the continuity of the insect cycle.

In regions with high population densities of whitefly year around, it is important to focus on the presence of the weed species highlighted above. In addition to acting as attractive hosts for the whitefly, some invasive species play an important role in the dissemination of viruses transmitted by the insect, making it appropriate to adopt strategies aimed at eradicating and eliminating such plants (Gilbertson et al., 2011). Monitoring and control of these species can be recommended in order to reduce favorable conditions for the insect and possible sources of inoculum, thus contributing to the management of *B. tabaci* MEAM1 populations and its associated diseases in the field.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data and material

Not applicable.

Competing interests

M. G. Sacilotto, F. S. F. Souza, E. L. L. Baldin, C. A. Carbonari, A. L. Lourenção and R. D. Faria declare that they have no competing interests.

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Authors' contributions

Matheus Gerage Sacilotto and Edson Luiz Lopes Baldin conceived the study. Matheus Gerage Sacilotto, Felipe Savieto Furquim de Souza and Rodrigo Donizeti Faria conducted the experiments. Caio Antonio Carbonari contributed the material. Matheus Gerage Sacilotto analyzed the data and conducted the statistical analyses. Matheus Gerage Sacilotto, Edson Luiz Lopes Baldin and André Luiz Lourenção wrote the manuscript. All authors reviewed and approved the manuscript.

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Tables

Table 1. Description of the weed species evaluated in the trials with *Bemisia tabaci*.

Plant species	Family name	Common name	Plant description
Amaranthus viridis[*]	Amaranthaceae	Pigweed	Annual plant, erect, little branched, may or may not have purple pigmentation on the stem and petiole. Paniculate inflorescence of greenish color. Height between 40 and 100 cm.
Bidens pilosa[*]	Asteraceae	Beggarticks	Annual plant, herbaceous, erect, aromatic, little branched, leaves membranous, entire or tri- or penta-lobed. Height between 40 and 120 cm.
Conyza canadensis[*]	Asteraceae	Horseweed	Annual, herbaceous, pubescent plant. Foliose stem with few branches. Height between 60 and 120 cm.
Emilia sonchifolia[***]	Asteraceae	Red tasselflower	Annual plant, herbaceous, erect, little branched, leaves pubescent. Height between 30 and 60 cm.
Galinsoga parviflora[*]	Asteraceae	Small-flower galinsoga	Annual, herbaceous, erect, much branched plant. Leaves slightly pubescent and membranous. Height between 20 and 40 cm.
Raphanus raphanistrum[*]	Brassicaceae	Wild radish	Annual plant for winter and spring, herbaceous, erect. Leaves with rigid trichomes. Height between 50 and 100 cm.
Commelina benghalensis[*]	Commelinaceae	Benghal dayflower	Perennial plant, tender, branched with roots at the nodes, leaves with an oval shape and slightly pubescent. Height between 30 and 60 cm.
Ipomoea grandifolia[***]	Convolvulaceae	Morning glory	Annual, herbaceous, pubescent, vine with extensive branches.
Merremia aegyptia[**]	Convolvulaceae	Hairy woodrose	Annual, herbaceous, climbing plant with pubescent stem. Length between 200 and 400 cm.
Euphorbia heterophylla[*]	Euphorbiaceae	Spurge	Annual, lactescent, erect, little branched plant. Leaves slightly pubescent. Height between 30 and 80 cm.
Senna obtusifolia[*]	Fabaceae	Sicklepod	Perennial, subshrub, woody, erect and branched plant. Height between 70 and 160 cm.
Sida rhombifolia[*]	Malvaceae	Arrowleaf sida	Annual or perennial plant, erect, leaves stipulated and pubescent. Height between 30 and 80 cm.
Digitaria insularis[*]	Poeaceae	Sourgrass	Perennial, herbaceous plant with slightly rough leaves. Form clumps. Height between 50 and 100 cm.
Spermacoce latifolia[*]	Rubiaceae	Oval-leaf false-buttonweed	Annual, herbaceous, prostrate and branched plant. Tetragonal stem. Height between 20 and 50 cm.
Richardia	Rubiaceae	Brazil	Annual plant, herbaceous and prostrate, with

brasiliensis[*]	pusley	branched stem and pubescent leaves on both sides. Length between 20 and 50 cm.

[*]Description obtained from Lorenzi (2014). [**]Description obtained from Lorenzi (2008). [***]Description from Kissmann and Groth (1999).

Table 2. Means (± EP) of adults and eggs/cm² of *Bemisia tabaci* MEAM1 in 15 weed species and five cultivated species, in a free-choice test in a greenhouse.

Plant species	(Eggs/cm²)[1]	Number of adults[1]			Mean[2]
		24 h	48 h	72 h	
Solanum lycopersicum	22.52 ± 3.07 a	225.10 ± 39.76 a	300.20 ± 24.19 a	320.90 ± 23.70 a	282.06 ± 29.10 a
Emilia sonchifolia	20.27 ± 9.26 ab	150.30 ± 34.61 abcd	188.10 ± 40.90 b	178.60 ± 34.52 b	172.33 ± 11.35 b
Senna obtusifolia	16.58 ± 4.06 abc	172.20 ± 36.53 abc	206.30 ± 39.99 ab	189.80 ± 38.94 b	189.43 ± 9.85 b
Sida rhombifolia	11.59 ± 4.35 abcd	87.50 ± 33.32 bcde	55.60 ± 22.53 d	68.50 ± 28.79 cd	70.53 ± 9.26 cd
Merremia aegyptia	10.88 ± 4.46 abcd	101.90 ± 35.06 bcde	75.40 ± 27.30 cd	90.50 ± 34.70 bcd	89.27 ± 7.67 c
Euphorbia heterophylla	10.54 ± 2.23 abcd	152.20 ± 32.02 abcd	168.10 ± 32.54 bc	134.30 ± 26.52 bc	151.57 ± 9.73 b
Glycine max	10.14 ± 1.85 abcd	192.70 ± 35.95 ab	199.00 ± 33.79 ab	173.90 ± 29.65 b	188.53 ± 7.54 b
Ipomoea grandifolia	9.29 ± 2.63 abcd	70.10 ± 21.34 cde	46.80 ± 14.40 d	55.50 ± 22.35 cd	57.47 ± 6.80 cdef
Capsicum annuum	7.96 ± 2.82 abcd	91.30 ± 36.45 bcde	49.60 ± 20.60 d	44.90 ± 17.24 cd	61.93 ± 14.74 cde
Commelina benghalensis	6.72 ± 2.48 bcd	19.40 ± 5.77 e	20.40 ± 6.85 d	19.30 ± 9.38 d	19.70 ± 0.35 efg
Gossypium hirsutum	3.71 ± 1.28 cd	46.80 ± 15.44 de	28.10 ± 7.75 d	35.90 ± 11.58 cd	36.93 ± 5.42 defg
Galinsoga parviflora	3.69 ± 1.35 cd	21.40 ± 5.28 e	15.10 ± 3.15 d	17.90 ± 6.93 d	18.13 ± 1.82 efg
Raphanus raphanistrum	3.29 ± 1.34 cd	20.70 ± 6.25 e	14.10 ± 5.91 d	15.10 ± 5.25 d	16.63 ± 2.05 efg
Conyza canadensis	3.08 ± 1.13 cd	23.30 ± 5.94 e	20.00 ± 6.29 d	21.90 ± 6.60 d	21.73 ± 0.96 defg
Bidens pilosa	2.41 ± 0.93 cd	38.50 ± 13.80 de	47.50 ± 22.15 d	35.10 ± 17.18 cd	40.37 ± 3.70 cdefg
Spermacoce latifolia	2.01 ± 1.46 cd	3.20 ± 0.83 e	3.70 ± 1.90 d	1.90 ± 0.67 d	2.93 ± 0.54 g
Digitaria insularis	1.66 ± 0.78 cd	10.60 ± 5.53 e	8.10 ± 3.51 d	7.40 ± 3.49 d	8.70 ± 0.97 fg
Amaranthus viridis	0.84 ± 0.31 d	4.00 ± 1.02 e	3.60 ± 1.05 d	1.80 ± 0.59 d	3.13 ± 0.55 g

Zea mays	0.21 ± 0.14 d	20.00 ± 9.02 e	13.50 ± 4.03 d	5.60 ± 1.47 d	13.03 ± 4.16 efg
Richardia brasiliensis	0.21 ± 0.08 d	4.40 ± 2.11 e	3.00 ± 0.98 d	2.20 ± 0.66 d	3.20 ± 0.64 g
P	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

[1] Means followed by the same letters in the column do not differ by the Fisher LS-Means test, adjusted for Tukey ($P \leq 0.05$).

[2] Average number of insects considering the three evaluation periods (24, 48, 72 h).

Table 3. Means (± EP) of the parameters of the colorimetric analysis performed on the adaxial face of the leaves of 15 weed species and five cultivated species

Plant species	Colorimetric parameters[1]		
	L	a*	b*
Galinsoga parviflora	44.35 ± 0.51 a	-16.80 ± 0.13 jk	27.42 ± 0.20 a
Commelina benghalensis	43.89 ± 0.40 ab	-16.20 ± 0.44 hijk	23.78 ± 0.90 abcde
Conyza canadensis	43.85 ± 0.68 ab	-14.22 ± 0.59 cdefgh	21.16 ± 1.15 defg
Merremia aegyptia	43.36 ± 0.61 abc	-15.75 ± 0.38 ghijk	27.25 ± 1.17 ab
Emilia sonchifolia	43.03 ± 0.67 abc	-17.44 ± 0.43 k	26.90 ± 0.91 abc
Raphanus raphanistrum	43.29 ± 0.36 abc	-14.70 ± 0.45 efghij	23.16 ± 0.99 abcdef
Richardia brasiliensis	42.80 ± 0.61 abc	-13.80 ± 0.42 cdefg	20.69 ± 0.90 efg
Capsicum annuum	41.86 ± 0.57 abcd	-14.27 ± 0.41 defgh	20.17 ± 0.93 efgh
Spermacoce latifolia	41.63 ± 0.68 abcde	-12.06 ± 0.66 abcd	22.08 ± 0.89 cdef
Zea mays	41.56 ± 0.52 abcde	-14.48 ± 0.33 efghi	19.94 ± 0.76 efgh
Bidens pilosa	41.36 ± 0.26 bcde	-13.42 ± 0.20 bcdef	24.50 ± 0.23 abcde
Solanum lycopersicum	41.31 ± 0.31 bcde	-16.99 ± 0.22 jk	27.23 ± 0.68 a
Digitaria insularis	41.03 ± 1.07 bcdef	-14.22 ± 0.63 cdefgh	24.53 ± 1.83 abcde
Glycine max	40.80 ± 0.52 cdef	-16.74 ± 0.42 ijk	25.68 ± 0.92 abcd
Senna obtusifolia	39.78 ± 0.26 def	-15.34 ± 0.25 fghijk	22.68 ± 0.53 abcdef
Ipomoea grandifolia	39.42 ± 0.52 def	-13.79 ± 0.81 cdefg	25.75 ± 1.62 abcd
Sida rhombifolia	38.97 ± 0.63 ef	-11.43 ± 0.28 ab	15.35 ± 0.54 h
Amaranthus viridis	38.96 ± 0.64 ef	-12.94 ± 0.48 abcde	18.48 ± 0.90 fgh
Gossypium hirsutum	38.23 ± 0.25 fg	-10.89 ± 0.43 a	16.41 ± 0.88 gh
Euphorbia heterophylla	35.71 ± 0.45 g	-11.96 ± 0.38 abc	22.32 ± 0.99 bcdef
P	<0.0001	<0.0001	<0.0001

[1] Means followed by the same letters in the column do not differ by the Fisher LS-Means test, adjusted for Tukey ($P \leq 0.05$).

Table 4. Spearman correlation coefficients obtained between the number of eggs/cm² of *Bemisia tabaci* MEAM1 after 72 hours and the number of trichomes/25 mm²; and number of adults after 24 hours and colorimetric indices of 15 weed species and five cultivated from free-choice assay.

Variable	Correlation coefficient[1]
Number of adults × L^* index	-0.23*
Number of adults × a^* index	-0.19*
Number of adults × b^* index	0.20*
Density of eggs × density of trichomes	0.17*

[1] Significant at 5% probability. L^*= luminosity index; a^*= green to red color variation index; b^*= blue to yellow color variation index.

Table 5. Means (± EP) of trichomes of selected plant species and respective classifications.

Plant species	(Number of trichomes/25 mm²)[1]	Trichomes classification[2]
Solanum lycopersicum	134.50 ± 11.19 a	I, II, III, V, VI
Glycine max	100.88 ± 4.13 b	V
Spermacoce latifolia	85.00 ± 15.81 bc	V
Conyza canadensis	73.63 ± 7.80 c	II, III, IV, VI
Euphorbia heterophylla	37.88 ± 6.61 d	III, V, VIII
Sida rhombifolia	17.88 ± 1.42 de	VIII
Commelina benghalensis	12.50 ± 1.31 de	I, II, V, VIII
Galinsoga parviflora	12.50 ± 1.21 de	I, II, III, V, VI
Amaranthus viridis	9.63 ± 1.84 e	I, II, III, IV, V, VI, VII
Raphanus raphanistrum	6.50 ± 1.10 e	II, V
Bidens pilosa	6.50 ± 1.00 e	II, III, V
Emilia sonchifolia	3.38 ± 1.21 e	I, II, III, VIII
Richardia brasiliensis	1.13 ± 0.48 e	V
P	< 0,0001	-

[1] Means followed by the same letters in the column show no significant difference by the Fisher LS-Means test, adjusted for Tukey ($P \leq 0.05$). [2] Classification of trichomes: glandular (types I, IV, VI and VII) and non-glandular (types II, III, V and VIII).

Table 6. Means (± EP) of eggs and nymphs/cm² of *Bemisia tabaci* MEAM1 in 15 weed species and five cultivated species, in a no-choice test in a greenhouse.

Plant species	(Eggs/cm²)[1]	(Nymphs/cm²)[1]
Euphorbia heterophylla	42.35 ± 14.93 a	22.70 ± 8.45 a
Galinsoga parviflora	29.20 ± 7.22 ab	11.57 ± 2.41 abc
Spermacoce latifolia	27.05 ± 6.78 abc	16.65 ± 5.15 ab
Raphanus raphanistrum	22.59 ± 6.05 abcd	7.37 ± 1.49 bc
Sida rhombifolia	13.70 ± 3.00 bcd	5.74 ± 1.87 bc
Gossypium hirsutum	12.28 ± 3.62 bcd	7.00 ± 2.23 bc
Senna obtusifolia	9.80 ± 2.20 bcd	4.98 ± 1.33 bc
Richardia brasiliensis	9.62 ± 3.12 bcd	7.61 ± 2.81 bc
Bidens pilosa	9.50 ± 2.22 bcd	6.30 ± 1.64 bc
Ipomoea grandifolia	7.71 ± 1.82 bcd	3.25 ± 0.62 c
Commelina benghalensis	7.37 ± 1.53 bcd	6.84 ± 1.48 bc
Conyza canadensis	7.22 ± 1.78 bcd	3.57 ± 0.66 bc
Merremia aegyptia	6.40 ± 0.84 bcd	2.67 ± 0.50 c
Emilia sonchifolia	5.88 ± 1.30 cd	3.55 ± 0.76 bc
Solanum lycopersicum	5.10 ± 1.34 cd	5.03 ± 1.31 bc
Amaranthus viridis	3.55 ± 0.72 d	2.49 ± 0.61 c
Digitaria insularis	3.53 ± 1.40 d	4.22 ± 1.49 bc
Glycine max	1.78 ± 0.46 d	1.55 ± 0.26 c
Capsicum annuum	1.35 ± 0.50 d	2.89 ± 0.69 c
Zea mays	0.24 ± 0.05 d	0.27 ± 0.04 c
P	< 0.0001	< 0.0001

[1] Means followed by the same letters in the column show no significant difference by the Fisher LS-Means test, adjusted for Tukey ($P \leq 0,05$).