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# Alcoholic extracts of insecticidal plants in the management of *Bemisia tabaci* biotype B in tomato crops

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## ABSTRACT

This study aimed to evaluate the effectiveness of alcoholic extracts in managing *Bemisia tabaci* biotype B in tomato crops. The experiments were conducted at UEMS - Cassilândia, using a randomized block design with five treatments and four replications. Alcoholic extracts were obtained from *Ruta graveolens*, *Mentha pulegium*, *Tagetes erecta*, and *Allium sativum*. Both choice and no-choice tests were performed. The parameters evaluated included attractiveness, oviposition non-preference, and nymph mortality. The choice test observed adult repellency for *T. erecta* and *R. graveolens*. These same extracts also resulted in fewer eggs, indicating oviposition non-preference. *R. graveolens*, *T. erecta*, and *A. sativum* extracts exhibited the highest nymph mortality. In the no-choice test, *R. graveolens* and *T. erecta* continued to show the lowest oviposition preference. Again, the extracts of *R. graveolens*, *T. erecta*, and *A. sativum* increased nymph mortality. It was concluded that the extracts of *R. graveolens* and *T. erecta* negatively affected *B. tabaci* populations, particularly regarding repellency, inhibition of oviposition, and nymph mortality. These extracts demonstrated over 80% efficacy only in the choice test.

**Keywords:** Insect, Whitefly, Repellency, Nymph Mortality.

# Extratos alcoólicos de plantas inseticidas no manejo de *Bemisia tabaci* biótipo B em tomateiro

## RESUMO

O objetivo deste estudo foi avaliar a eficiência de extratos alcoólicos no manejo de *Bemisia tabaci* biótipo B na cultura do tomateiro. Os experimentos foram conduzidos na UEMS - Cassilândia, utilizando o delineamento em blocos casualizados com cinco tratamentos e quatro repetições. Os extratos alcoólicos utilizados foram de *Ruta graveolens*, *Mentha pulegium*, *Tagetes erecta* e *Allium sativum*. Foram realizados testes com e sem chance de escolha. Os parâmetros avaliados incluíram atratividade, não preferência à oviposição e mortalidade de ninfas. No teste com chance de escolha, observou-se repelência de adultos para *T. erecta* e *R. graveolens*. Esses mesmos extratos também resultaram em menor número de ovos, indicando não preferência à oviposição. Os extratos de *R. graveolens*, *T. erecta* e *A. sativum* apresentaram a maior mortalidade de ninfas. No teste sem chance de escolha, *R. graveolens* e *T. erecta* continuaram demonstrando a menor preferência à oviposição. Novamente, os extratos de *R. graveolens*, *T. erecta* e levaram ao aumento da mortalidade das ninfas. Concluiu-se que os extratos de *R. graveolens* e *T. erecta* tiveram efeitos negativos sobre as populações de *B. tabaci*, particularmente em termos de repelência, impedimento de oviposição e mortalidade das ninfas. Esses extratos apresentaram eficiência superior a 80% apenas no teste com chance escolha.

**Palavras-chave**: Inseto, Mosca branca, Repelência, Mortalidade de ninfas.

## 1. Introduction

Tomato (*Solanum lycopersicum*) originates from the Andean regions of the Americas. This species has a high capacity for adaptation to different regions and is one of the most widely consumed vegetables, being a source of lycopene and possessing preventive properties against degenerative diseases (Furquim and Nascimento, 2021).

China is the largest producer of tomatoes, while Brazil ranks seventh in production, producing 3.9 million tons in 2021, with the state of Goiás as the top producer (Zayat et al., 2022). However, due to its challenging management, tomato cultivation requires multiple pesticide applications throughout the growing season.

In recent years, the use of biological products has gained prominence in Brazilian agriculture. However, several factors must be considered regarding their use and application methods (Embrapa, 2020).

Given the growing demand for biological products and consumers' increasing concern for healthier food, several countries have promoted production focused on organic practices. In Brazil, multiple public policies have been established to regulate these products to achieve greater sustainability (Weber and Silva, 2020).

Among the pests that can affect organic tomato crops, *Bemisia tabaci* biotype B (Hemiptera: Aleyrodidae) is considered one of the main pests in vegetable cultivation (Soares and Santos, 2021). This homopteran causes direct damage by sap-sucking and indirect damage by transmitting viruses, as well as releasing substances that aid in developing the fungus *Capnodium* sp. (Carvalho et al., 2015).

Although conventional producers commonly use chemical control, using insecticidal plant extracts for managing *B. tabaci* can be successful, as this species has shown resistance to several groups of insecticides, limiting their use (Baldin et al., 2020).

Therefore, botanical insecticides such as plant extracts can be a less harmful alternative to the environment due to their rapid degradation, lower toxicity, and the potential to spare natural enemies by being selective. In addition, they contain multiple active compounds, which makes it more difficult for pests to develop resistance (Embrapa, 2019).

Therefore, the objective of the present study was to evaluate the use of alcoholic extracts from insecticidal plants in the management of *Bemisia tabaci* in tomato crops.

## 2. Material and Methods

The experiment was conducted at Mato Grosso do Sul State University, Cassilândia Campus (19°05′S, 51°56′W; 470 m a.s.l.). *Bemisia tabaci* rearing and bioassays were conducted between February and July 2022.

Adults were collected using an aspirator from various host plants established in vegetable gardens in Cassilândia.

The insects were introduced into a cage lined with anti-aphid mesh and covered with plastic netting. To multiply the *B. tabaci* population, host plants such as soybean, cotton, kale, bell pepper, and poinsettia were used. These plants were irrigated and replaced as needed.

For the experiment, alcoholic extracts were prepared from the leaves of *Ruta graveolens* L., *Mentha pulegium* L., and *Tagetes erecta* L., as well as from the bulb of *Allium sativum*. Water was used as a control.

For the preparation of the extracts, plant materials of *R. graveolens*, *M. pulegium*, and *T. erecta* were commercially obtained and brought to the laboratory at the Mato Grosso do Sul State University, Cassilândia Campus. The materials were dried in a forced-air oven at 40 °C for 48 hours and ground in an electric knife mill (Baldin et al., 2020). The extracts were prepared using a shaker, with a concentration of 5 g of leaf powder per 100 mL of 70% ethanol, and were applied directly to the leaves until runoff.

The *A. sativum* bulb was blended for 1 minute with ethanol at the same concentration as the others. After this process, the mixtures were filtered through filter paper to obtain 5% alcoholic extracts, which were then bottled and stored in dark locations.

Tomato seedlings were initially grown in Styrofoam trays and subsequently transplanted into 5 L pots. At 30 days after emergence, the plants were transferred to cages made of PVC pipes and covered with voile fabric. Each cage contained five plants spaced approximately 50 cm apart.

The extracts were applied using a handheld sprayer with a capacity of 200 mL until runoff was achieved on both the adaxial and abaxial surfaces of the leaves. Subsequently, 500 unsexed *B. tabaci* adults were released into the center of each cage at a rate of 100 whiteflies per plant, totaling 2000 adults.

At 24 and 48 hours after infestation, the number of attracted insects was counted using a mirror on the abaxial surface. Three leaflets from each third of the plant (lower, middle, and upper) were selected and marked for counting. The attractiveness index was calculated as follows:

$$AI = \frac{2T}{(T + P)}$$

Where AI is the attractiveness index; T is the number of insects attracted to the evaluated extract; and P is the number of insects attracted to water.

AI values range from zero to two, with 1 indicating a similar attraction between water and the plants treated with extracts. Values less than 1 indicate greater repellency and values greater than 1 indicate greater attraction than water.

The experimental design used in the choice test was a randomized block design with five treatments and four replications, totaling 20 plants. For the assessment of oviposition preference, the same leaflets used for the attractiveness evaluation were observed under a stereomicroscope, and the number of eggs on the leaflets was counted after four days of infestation. The oviposition preference index was calculated using the following formula:

$$OPI = \left[\frac{T+P}{T+P}\right] \times 100$$

Where T is the number of eggs counted on the leaves treated with extracts, and P is the number of eggs counted on the leaves treated with water.

This index ranges from +100, indicating a highly stimulating effect, to -100, indicating complete deterrence, with 0 representing neutrality. For the no-choice test, another 20 plants were used, following the same design as the choice test and of the same age, arranged in rows. This time, the plants were individually covered with voile fabric sleeves, supported by two bamboo stakes to form a cage, ensuring insect confinement and preventing the entry of others. One hundred unsexed *B. tabaci* adults were released per plant, and three leaflets were marked on each plant. The number of eggs was counted using the same methodology as in the choice test.

The number of nymphs (preview count) was recorded on the abaxial side of the same marked leaflets from the previous test, followed by a second spraying of the extracts. Subsequently, using a stereomicroscope at 4x magnification, nymph mortality on these leaflets was recorded at 3, 7, and 15 days after spraying (DAS) in both tests (choice and no-choice). Nymph mortality was calculated based on the preview count as follows:

$$M(\%) = \frac{(P-T) \times 100}{P}$$

Where P is the number of nymphs at the preview count, and T is the number of nymphs in the treatments.

The efficacy of the extracts was calculated using the following equation, Abbott (1925):

$$\mathrm{E.E}(\%) = \frac{(T-Tr) \times 100}{T}$$

Where T is the number of live insects in the water treatment, and Tr is the number of live insects in the extract treatments. Henderson and Tilton (1952):

$$E.E(\%) = [1 - \frac{(Ta \times Cb)}{(Tb \times Ca)}] \times 100$$

Where Ta and Ca are the numbers of insects after the application of the extracts; Tb and Cb are the numbers of insects before the application of the extracts. The data were subjected to analysis of variance, and the means were grouped using the Scott-Knott test (1974) at a 5% significance level. For statistical analysis, the data were transformed using the square root transformation $(x+1)^{0.5}$.

## 3. Results and Discussion

It was observed that the average number of *B. tabaci* adults at 24 and 48 hours after the alcoholic extract applications (Table 1) differed significantly in the choice test. Plants treated with *R. graveolens* and *T. erecta* extracts showed lower numbers than others, indicating repellency for these extracts. According to Quintela and Pinheiro (2009), *B. tabaci* repellency by extracts may reduce virus transmission to plants, as the insects move away from the plants before probing, thereby preventing their action as vectors.

The extracts of *M. pulegium* and *A. sativum* did not differ significantly from water after adult infestation. This indicates that these extracts are attractive, suggesting that the adults may still be opposing. The attractiveness indices (Figure 1) for the infestation showed that the extracts of *R. graveolens* and *T. erecta* were classified as repellent, whereas *M. pulegium* and *A. sativum* had indices higher than or close to water, making them attractive. It is noted that the *R. graveolens* extract showed better results 48 hours after application, given the higher repellency observed during this period.

Baldin et al. (2015) conducted studies using aqueous extracts of *R. graveolens* and reported adult mortality in tomato plants ranging from 37.5% to 42.5% at 24 and 48 hours, respectively. The *R. graveolens* extract increased repellency within the evaluated intervals in the present study.

According to Malo et al. (2017), plant extracts, in addition to causing repellency, can activate the defense mechanisms of tomato plants, thereby reducing the need for chemical products. Moroni et al. (2014), when exposing *Pediculus capitis* to an ethanolic extract of *R. graveolens* at a concentration of 500 mg/L, observed 87.7% repellency after two hours. *T. erecta* exhibited greater adult repellency at 24 hours compared to 48 hours, with a reduction in repellency observed; however, it remained below the standard value, indicating low attractiveness compared to the other extracts and water (Figure 1).

**Table 1**. Mean number (± SE) of *Bemisia tabaci* adults recorded in the choice test 24 and 48 hours after infestation.

| Extracts | 24 hours | 48 hours |
|---|---|---|
| *T. erecta* | 1.25 ± 0.48 a[1] | 1.75 ± 0.85 a |
| *R. graveolens* | 2.00 ± 1.08 a | 0.50 ± 0.29 a |
| *A. sativum* | 12.50 ± 4.35 b | 11.00 ± 1.83 b |
| *M. pulegium* | 16.50 ± 11.21 b | 14.75 ± 9.51 b |
| Water | 17.25 ± 4.27 b | 12.50 ± 1.85 b |
| F(trat.) | 4.82** | 6.90** |
| C.V (%) | 39.29 | 33.45 |

Means followed by the same letter within a column do not differ significantly according to the Scott-Knott test at the 5% significance level. [1]Original data; for analysis, the data were transformed to $(x+1)^{0.5}$.

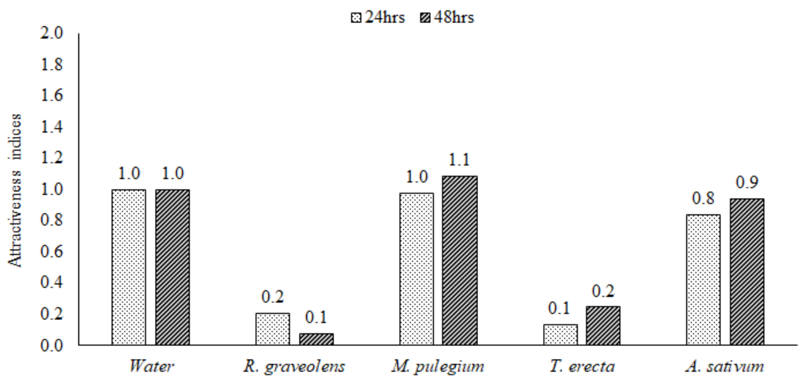


**Figure 1**. Attractiveness indices of *Bemisia tabaci* in response to alcoholic extracts at 24 and 48 hours after infestation.

According to Noviyanti et al. (2022), this species contains flavonoids with repellent properties against insects. Niu et al. (2022), when using *T. erecta*, observed that volatile compounds such as thymol anisole, thymol, and camphor contribute to leafhopper repellency.

In the oviposition preference test (Table 2), the mean number of eggs on plants treated with *R. graveolens* and *T. erecta* extracts was the lowest, significantly differing from the others. According to the oviposition preference index, these extracts were described as deterrents, with *R. graveolens* (-89.42) and *T. erecta* (-77.23) indicating non-preference for oviposition. In agreement with the results of the present study, Baldin et al. (2020) described that insecticidal plant extracts from the Asteraceae family can be used as alternative agents for controlling the oviposition of *B. tabaci*.

Moreira and Ferreira (2015) also observed a high potential for repellency with *T. erecta* when its shoots were incorporated into the soil for nematode control in tomato cultivation. This species has high potential due to its compounds that disrupt sodium and potassium ion transport across cell membranes (Rodrigues et al., 2017).

Extracts of *M. pulegium* and *A. sativum* did not differ significantly from water, classifying them as neutral. Lara (1991) described that substances with deterrent properties prevent adults from continuing to oviposit in areas where volatile compounds are present.

Regarding nymph mortality, all extracts differed significantly from water at three and seven days after spraying (DAS), except at 15 DAS. This highlights insecticidal activity from the extracts (Table 3).

**Table 2.** Mean number (± SE) of *Bemisia tabaci* eggs and oviposition preference index (OPI) in the choice test.

| Extracts | No. of eggs | Oviposition Preference Index | |
|---|---|---|---|
| | | OPI (± SE)[1] | Classification |
| *R. graveolens* | 2.50 ± 2.50 a[2] | -89.42 ± 23.92 | Deterrent |
| *T. erecta* | 5.75 ± 1.70 a | -77.23 ± 23.92 | Deterrent |
| Water | 44.75 ± 2.17 b | 0.00 ± 23.92 | Standard |
| *A. sativum* | 45.00 ± 19.19 b | 0.28 ± 23.92 | Neutral |
| *M. pulegium* | 54.50 ± 33.92 b | 9.82 ± 23.92 | Neutral |
| F(trat.) | 3.79* | --- | --- |
| C.V (%) | 53.41 | --- | --- |

Means followed by the same letter within a column do not differ significantly according to the Scott-Knott test at the 5% significance level. [1]OPI = [(T–P)/(T+P)] x 100. OPI ranges from +100 (highly stimulating) to –100 (complete deterrence), with 0 indicating neutrality. [2]Original data; for analysis, the data were transformed to $(x+1)^{0.5}$.

**Table 3**. Mean number (± SE) of *Bemisia tabaci* nymphs at the preview count and 3, 7, and 15 days after extract application in the choice test.

| Extracts | Preview | 3 DAS | 7 DAS | 15 DAS |
|---|---|---|---|---|
| *R. graveolens* | 0.75 ± 0.75 a[1] | 0.25 ± 0.25 a | 0.00 ± 0.00 a | 0.00 ± 0.00 a |
| *T. erecta* | 3.50 ± 1.89 a | 0.50 ± 0.50 a | 0.50 ± 0.50 a | 0.50 ± 0.50 a |
| Water | 35.50 ± 6.22 a | 26.00 ± 5.43 b | 15.25 ± 5.92 b | 11.25 ± 7.56 a |
| *A. sativum* | 29.50 ± 25.89 a | 5.75 ± 3.28 a | 4.75 ± 2.50 a | 4.00 ± 2.04 a |
| *M. pulegium* | 42.50 ± 19.19 a | 5.00 ± 3.14 a | 4.25 ± 2.53 a | 3.25 ± 1.89 a |
| F(trat.) | 2.38$^{ns}$ | 8.30** | 5.33** | 1.97$^{ns}$ |
| C.V (%) | 68.99 | 47.48 | 47.94 | 61.48 |

Means followed by the same letter in the column do not differ significantly by the Scott-Knott test at a 5% significance level.
[1]Original data; for analysis, the data were transformed to $(x+1)^{0.5}$.

Extracts of *M. pulegium* and *A. sativum* did not differ significantly from water, classifying them as neutral. Lara (1991) described that substances with deterrent properties prevent adults from continuing to oviposit in areas where volatile compounds are present.

Regarding nymph mortality, all extracts differed significantly from water at three and seven days after spraying (DAS), except at 15 DAS. This highlights insecticidal activity from the extracts (Table 3).

Nymph mortality after extract spraying is shown in Figure 2. It was observed that the *R. graveolens* extract resulted in total nymph mortality at 7 and 15 DAS, corroborating the finding that this extract showed the lowest attractiveness and oviposition indices. This behavior indicates that the extract is effective against both the adult and immature (nymph) stages of *Bemisia tabaci*, maintaining the population at near-zero levels throughout the evaluation period.

On the other hand, extracts of *A. sativum*, *M. pulegium*, and *T. erecta* showed nymph mortality only. Since they did not demonstrate efficacy in repelling the insects, the adults had the opportunity to oviposit on the treated leaves, resulting in a higher number of nymphs at 3 DAS and, consequently, higher mortality values than the *R. graveolens* extract during this initial period.

Ayil-Gutiérrez et al. (2015) observed that *R. graveolens* contains metabolites such as 2-undecanone and psoralen, which are highly toxic to insect species, possibly producing the same effects on *B. tabaci* adults. This may have prevented the low proliferation of the species on the plant and thus resulted in a lower nymph mortality rate compared to the other extracts.

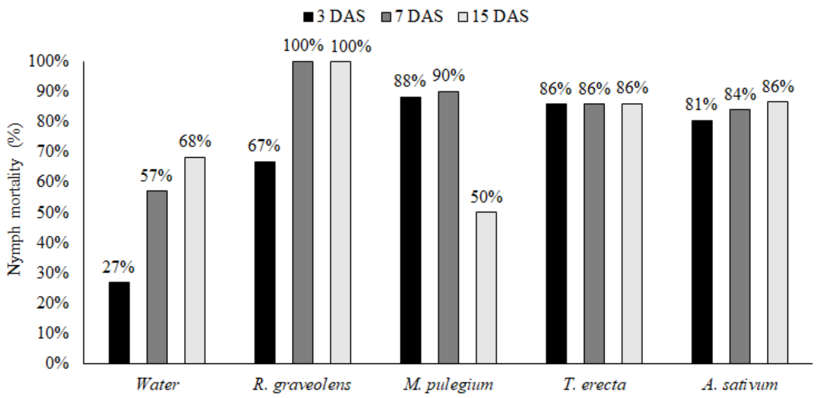


**Figure 2.** Mortality of *Bemisia tabaci* nymphs after extract application in the choice test.

The *M. pulegium* extract showed 88% and 90% nymph mortality at 3 and 7 DAS, respectively, dropping to 50% at 15 DAS, indicating near-total nymph control at 7 DAS. For the *T. erecta* alcoholic extract, nymph mortality was 86% at 3, 7, and 15 DAS. The *A. sativum*-based extract resulted in nymph mortality ranging from 81% to 86%, demonstrating promising results in reducing the nymph population on the leaflets.

The *A. sativum* extract is widely used as an agricultural pesticide by many producers; however, several plants benefit from this extract as it contains a high sulfur content, which aids in pathogen control (Conceição et al., 2024).

The efficacy of the extracts (Figure 3) shows that the *R. graveolens* extract achieved 99% and 100% efficacy at 3, 7, and 15 DAS, while *T. erecta* demonstrated 98%, 97%, and 96% efficacy, respectively, highlighting their promising potential for use in the management of *B. tabaci*.

At 3 DAS, the *M. pulegium* and *A. sativum* extracts exhibited 81% and 78% efficacy, respectively, but were less effective at 7 and 15 DAS. Some extracts, such as *A. sativum* bulb extract, contain toxic substances for various species and have systemic action on the plant, leading to mortality (Silva et al., 2018).

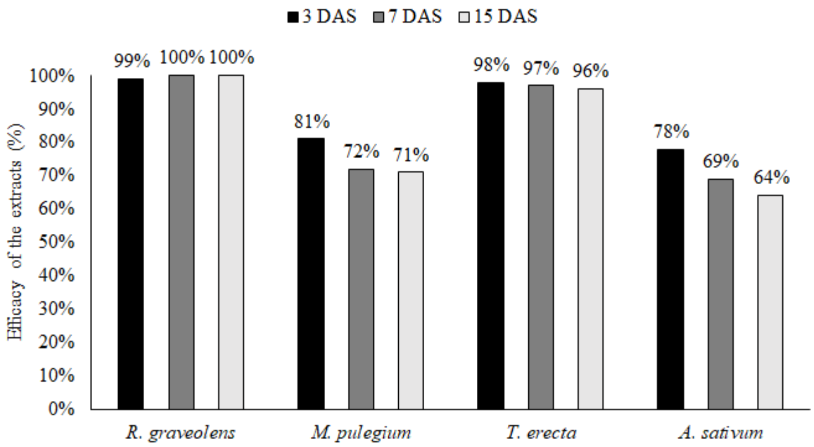


**Figure 3.** Efficacy of the extracts in the choice test.

The mean number of eggs (Table 4) did not differ significantly among the extracts in the no-choice test, but the OPI for the *R. graveolens* and *T. erecta* extracts were similar to those observed in the choice test (Table 2).

It was observed that in this test, all extracts resulted in a slightly higher number of eggs compared to the choice test. This is likely because the insects had no other option for oviposition to ensure the survival of the species.

Since biotype B has a high capacity for resistance when treated with insecticides or substances such as extracts in small or frequent doses, a phenomenon called hormoligosis may occur, where these stressful substances can have a beneficial effect (Crowder et al., 2010; Dumra et al., 2024).

**Table 4.** Mean number (± SE) of *Bemisia tabaci* eggs and oviposition preference index (OPI) in the no-choice test.

| Extracts | No. of eggs | Oviposition Preference Index | |
|---|---|---|---|
| | | OPI (± SE)[1] | Classification |
| *R. graveolens* | 9.25 ± 2.95 a[2] | -73.09 ± 15.07 | Deterrent |
| *T. erecta* | 22.75 ± 14.73 a | -44.68 ± 15.07 | Deterrent |
| Water | 59.50 ± 9.02 a | 0.00 ± 15.07 | Standard |
| *A. sativum* | 48.50 ± 41.90 a | -10.19 ± 15.07 | Neutral |
| *M. pulegium* | 45.75 ± 21.05 a | -13.06 ± 15.07 | Neutral |
| F(trat.) | 1.68ns | --- | --- |
| C.V (%) | 52.94 | --- | --- |

Means followed by the same letter within a column do not differ significantly according to the Scott-Knott test at the 5% significance level.
[1]OPI = [(T–P)/(T+P)] x 100. OPI ranges from +100 (highly stimulating) to –100 (complete deterrence), with 0 indicating neutrality.
[2]Original data; for analysis, the data were transformed to $(x+1)^{0.5}$.

It was observed that the mean number of nymphs at 3, 7, and 15 DAS was lower in the *R. graveolens*, *T. erecta*, and *A. sativum* extracts, significantly differing from water and *M. pulegium* (Table 5).

According to the results observed in the choice test (Table 3), *R. graveolens* and *T. erecta* inhibited egg hatching.

Baldin et al. (2015) observed the same result with *R. graveolens* and reported an 80% inhibition of *B. tabaci* egg hatching when this extract was applied.

The *T. erecta* extract caused 80% mortality at 3, 7, and 15 DAS (Figure 4), compared to 86% observed in the choice test at 3 DAS (Figure 2), indicating similarity in these results regardless of the test.

**Table 5**. Mean number (± SE) of *Bemisia tabaci* nymphs at the preview count and 3, 7, and 15 days after extract application in the no-choice test.

| Extracts | Preview | 3 DAS | 7 DAS | 15 DAS |
|---|---|---|---|---|
| *R. graveolens* | 2.75 ± 2.14 a[1] | 1.00 ± 0.58 a | 0.50 ± 0.50 a | 0.50 ± 0.50 a |
| *T. erecta* | 1.25 ± 0.95 a | 0.25 ± 0.25 a | 0.25 ± 0.25 a | 0.25 ± 0.25 a |
| Water | 23.75 ± 10.66 b | 22.00 ± 9.03 b | 19.50 ± 6.79 b | 12.25 ± 2.72 b |
| *A. sativum* | 6.25 ± 4.73 a | 3.50 ± 2.18 a | 3.50 ± 2.18 a | 2.25 ± 2.25 a |
| *M. pulegium* | 23.25 ± 12.93 b | 21.00 ± 13.92 b | 17.00 ± 10.28 b | 11.50 ± 6.65 b |
| F(trat.) | 2.49* | 2.85** | 3.55** | 3.67** |
| C.V (%) | 66.57 | 71.44 | 63.84 | 56.50 |

Means followed by the same letter within a column do not differ significantly according to the Scott-Knott test at the 5% significance level. [1]Original data; for analysis, the data were transformed to $(x+1)^{0.5}$.

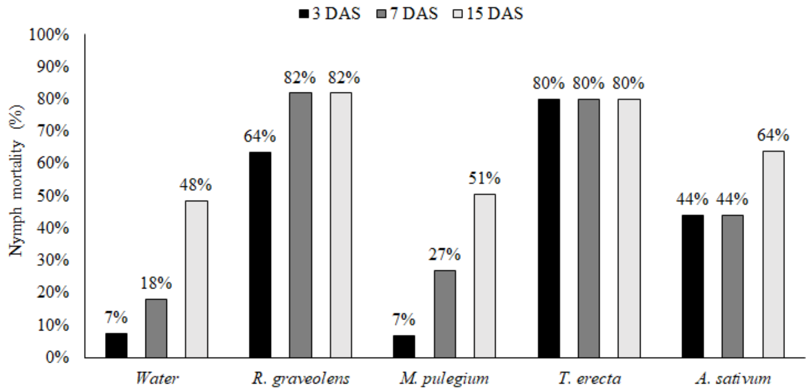


**Figure 4.** Mortality of *Bemisia tabaci* nymphs after extract application in the no-choice test.

Guerra et al. (2020) described that phytochemical compounds such as 1,8-cineole, D-limonene, beta-sitosterol, p-coumaric acid, and kaempferol are responsible for the insecticidal effect on *B. tabaci*. Although the mortality observed with the *Ruta graveolens* extract was lower than the other treatment, this extract still demonstrated high efficacy in controlling *Bemisia tabaci*.

Although the mortality observed with the *Ruta graveolens* extract was lower than the other treatment, this extract still demonstrated high efficacy in controlling *Bemisia tabaci*.

The *A. sativum* extract showed 44% mortality at 3 and 7 DAS and 64% at 15 DAS in this test (Figure 4), whereas in the choice test, the highest mortality rate was 86% (Figure 2). However, a similar effect to that observed in the no-choice test was reported by Silva et al. (2018), who found that hydroalcoholic extracts of *Allium sativum* bulbs at a 5% concentration caused 60.71% mortality in *Brevicoryne brassicae* nymphs. *T. erecta* extracts showed 79%, 76%, and 62% efficacy at 3, 7, and 15 DAS (Figure 5), respectively, lower than in the choice test (Figure 3).

Meanwhile, *R. graveolens* extracts demonstrated 61%, 78%, and 65% efficacy at 3, 7, and 15 DAS, also lower than the choice test. Additionally, *M. pulegium* and *A. sativum* extracts exhibited low efficacy compared to the choice test.

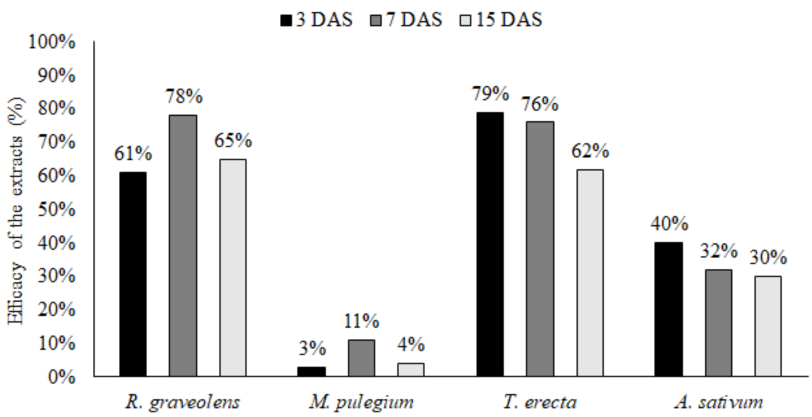


**Figure 5.** Efficacy of the extracts in the no-choice test.

It is speculated that this difference compared to the choice test may be explained by uncontrollable experimental factors, such as temperature fluctuations, since the extracts contain different secondary compounds that may be more sensitive to such exposures.

Additionally, the alcohol-based formulation may have contributed to increased volatilization. High temperatures can cause rapid evaporation of solutions, resulting in significant loss of active ingredients before they even reach the plant surfaces (Khort et al., 2022).

## 4. Conclusions

It was concluded that the extracts of *R. graveolens* and *T. erecta* negatively affected *B. tabaci* populations, particularly regarding repellency, oviposition inhibition, and nymph mortality. These extracts demonstrated over 80% efficacy only in the choice test.

## Authors' Contribution

Conceptualization and methodology: Diego Miguel Blanco Bertolo, Luciana Cláudia Toscano; data collection and curation: Diego Miguel Blanco Bertolo, Italo Ferreira Vetruve, Gustavo Davanzo Ballera, José Augusto dos Santos Rodrigues; formal analysis: Diego Miguel Blanco Bertolo, Luciana Cláudia Toscano; data interpretation: Diego Miguel Blanco Bertolo, Italo Ferreira Vetruve, José Augusto dos Santos Rodrigues; project administration: Luciana Cláudia Toscano, Diego Miguel Blanco Bertolo; supervision: Luciana Cláudia Toscano; original draft preparation: Diego Miguel Blanco Bertolo, Gustavo Davanzo Ballera, José Augusto dos Santos Rodrigues; writing - review and editing: Diego Miguel Blanco Bertolo, Luciana Cláudia Toscano, Italo Ferreira Vetruve. All authors read and approved the final version of the manuscript.

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