



Research Article

Effect of Two Types of Plant Host on the Population Density of *Aphis fabae*, *Aphis gossypii* (Hemiptera: Aphididae) and their Parasitoids

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Abstract | This experiment was conducted to determine the population density of *Aphis gossypii* and *Aphis fabae* on Borage (*Borage officinalis*: Boraginaceae) and Flora (*Stachys macrosperma*: Marcrosperma) plants and to know their attractive and repellent effects on both aphid species and their parasitoids. The highest density of *A. gossypii* on a *B. officinalis* plant was 74.33 adults/ang², with a significant difference from *A. fabae*, which reached 22.53 adults/leave. However, the lowest density of the two aphid species was 29.66 and 1.33 adults/leave, respectively. The highest parasitism rate of *A. gossypii* on *B. officinalis* and *S. macrosperma* plants was recorded at 74 and 23.63%, respectively. The results showed that the highest rate of attraction on the *B. officinalis* was recorded at 66% for the alcoholic extract at a concentration of 25 mg/ml. In comparison, the highest rate of repellent for the cotton insect was 24% for the hot water extract. But, the highest rate of attraction to *S. macrosperma* plants was 22% for the hot water extract, and the highest rate of repulsion was 68% for the alcoholic extract at a concentration of 25 mg/ml on the two insects. The study also recorded three aphid parasitoids including *Praon volucre* (Haliday, 1833), *Trioxys pallidus* (Haliday, 1833), and *Diaeretiella rapae*.

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Keywords | *A. fabae*, *A. gossypii*, *B. officinalis*, *S. macrosperma*, Aphid, Water extract



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Introduction

Aphids are phytophagous, belonging to the Aphididae family, within the Hemiptera order (Rakhshani and Stay, 2021). Around 4,700 species have been identified in the world (Loxdale and Balog, 2018), of which 450 species are registered as plant pests. Approximately 100 species cause significant economic damage. In Iraq, Bandyani *et al.* (2021) has

recorded 59 species of aphids belonging to 24 genera on different plant families. Al-Hussainawy (2012) also recorded 18 species of aphids in Basra Province on different plant families.

The aphid life cycle is complex it needs two hosts to complete the life cycle. The main host is an herbaceous or perennial plant, and the second host is an herbaceous plant (Hayder *et al.*, 2012). Aphids

were found in colonies and are characterized by a dimorphic phenomenon. They have two different forms non-winged and winged forms. It helps them search for new hosts, establish new colonies, and continuously increase density through asexual virgin reproduction (Ganassi *et al.*, 2005). Aphids cause damage to plants by sucking nymphs and adults on the plant sap of roots, stems and leaves (Kieckhefer and Reidell, 1995). Also, some species of aphids contain enzymes in their saliva that affect the activity and inhibit the plant cell wall's functioning, causing the plant's yellowing and death (Riedell *et al.*, 2003).

The aphid responds to light waves reflected from the plant during flight. The insect can be attracted to the plant as a result of the insect's response to volatile plant materials and its recognition through the olfactory sensory centers located on the antennae (Visser *et al.*, 1996). The insect is affected by different types of data, it is affected by the color of the plant, and by various data that it is affected by while walking on the surface of the plant, such as the structure of the plant's wax layer and plant tissue (Powell *et al.*, 2006). It is also affected by the information received by the antennae, as well as its discrimination of the combination of attractive odors, volatile substances produced by the plant, and repulsive substances released by the plant (Powell *et al.*, 2000).

Insect parasitoids from the Aphidiidae family and Hymenoptera are among order the most important insect parasitoids on aphids. They are endoparasitoids and the parasitoid female lays eggs inside the different stages of aphids (nymphs-winged adults, Pterogota, and Apterogota) (Biondi *et al.*, 2013). On the other hand, there are plants that are considered a bank for aphid parasitoids and are characterized by attracting them as soon as they are infected with an aphid. One of these plants is the *Anchusa azurea* plant, which belongs to the Aceaceae family, and it is a medicinal plant that attracts insects of parasitoids on the aphids in Dhi Qar Province.

The study aims to evaluate the effect of the host plant on the severity of aphid infestation by diagnosing and calculating the density of aphid species on two types of medicinal plants (*Borage officinalis* and *Stachys macrosperma*) that found in the Iraq. As well as, record the types of parasitoids and the rate of parasitism on aphids in the field. In addition, test the behavior of attraction and repulsion of hot, cold and alcoholic

aqueous extracts of *B. officinalis* and *S. macrosperma* plants on aphids under laboratory conditions.

Materials and Methods

Plant materials

Borage (*Borage officinalis*: *Boraginaceae*) seeds obtained from local agricultural offices were planted and placed in the wooden bed belonging to the Department of Horticulture Engineering at the College of Agriculture, Al-Qadisiyah University, Al-Qadisiyah, Iraq.

The seed of the *Stachys macrosperma* plant were obtained from one of the local nurseries at one age, and after 40 days of germinating the seeds of the borage plant. They were transferred to plastic pots with a size of 10 kg containing the organic fertilizer and a mixture of soil at a ratio of (1:1) and planted in lines at a distance of 50 cm. The plants were left to natural infestation with insects without applying the control process (Figure 1).

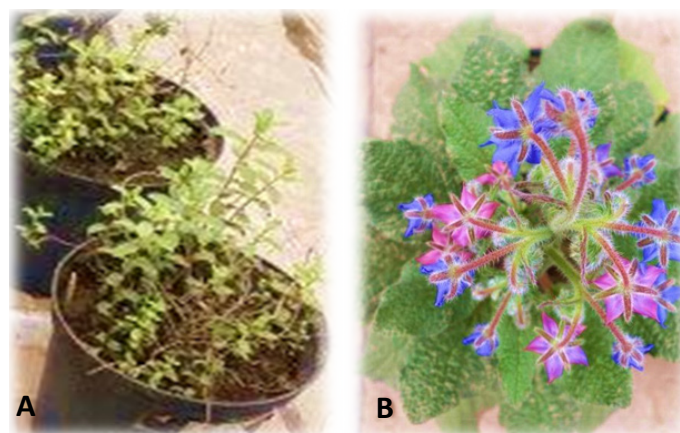


Figure 1: *Stachys macrosperma* plant (A) and *Borage officinalis* plant (B).

Insect identification

The experiments included identifying the types of aphids that were found on both plants using taxonomic keys. The types of parasitoids present in the aphid types were also classify within the experiment.

Calculating the density of aphid species and parasitism rates

Three replicates for each plant have been used. The density was calculated by taking 10 leaves from each replicate randomly from the top, middle, and bottom of both plants. Then, the leaves were placed in polyethylene bags. It was brought to the laboratory and placed in the refrigerator for 20 mins for the

purpose of killing insects. The numbers of aphids was calculated by removing the insects on both surfaces of the leaf using a soft brush on a white board. Their density and nutritional preference were determined, and the percentage of parasitism was recorded (Figure 2).

$$\text{Attraction ratio} = \frac{\text{The number of insects that were tested and were 25 cm}}{\text{The total number of insects}} \times 100$$

$$\text{Repellent ratio} = \frac{\text{The number of insects opposite of tested was 25 cm from the center}}{\text{The total number of insects}} \times 100$$

$$\text{Balance ratio} = \text{attraction ratio} - \text{Repellent ratio}$$

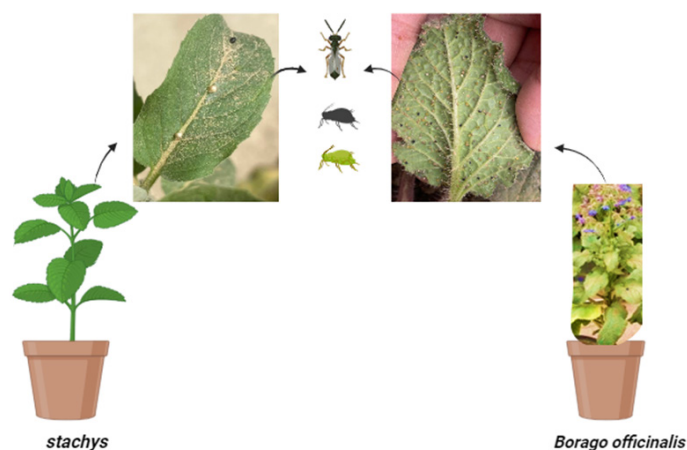


Figure 2: Calculating the density of the types of aphids and parasitoids on *B. officinalis* and *S. macrosperma*.

Statistical analysis

The data were analyzed by using SPSS program. The Randomized Complete Block Design (RCBD) design was used in these experiments with three replicates. The differences of means have been measured by using least significant differences (LSD) with the level of 0.05%.

Results and Discussion

The results of the phenotypic classification of the aphid species showed the found of both the cotton aphid *Aphis gossypii* and the bean aphid *Aphis fabae* on both plants. Three types of parasitoids wasps on aphid was also recorded: *Praon volucre* (Haliday, 1833) and *Trioxys pallidus* (Haliday, 1833) and *Diaeretiella rapae* (M'Intosh, 1885) based on classification keys.

The results of calculating the taxonomic density of aphid species on plants showed that the highest infestation rate of cotton aphids was recorded on both plants were 74.33 and 22.53, respectively. In contrast, the lowest infestation rate of bean aphids was recorded were 29.66 and 1.33, respectively, (Figure 3).

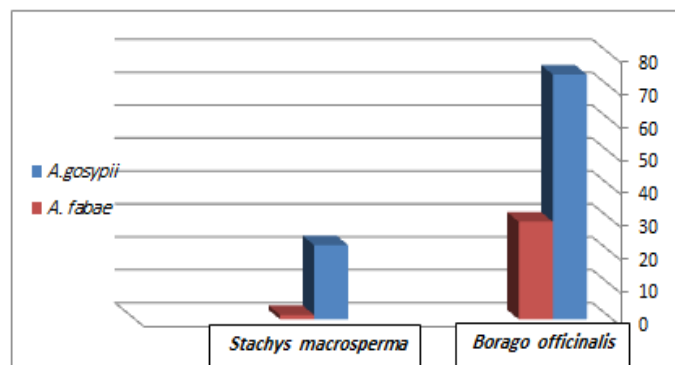


Figure 3: Number density of *A. fabae* and *A. gossypii* on *B. officinalis* and *S. macrosperma*.

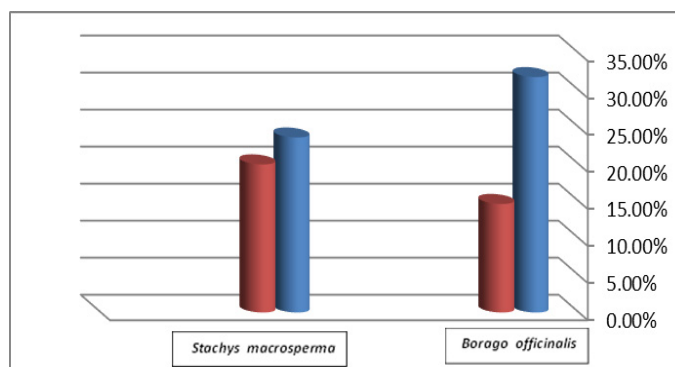


Figure 4: Parasitism rates on *A. fabae* and *A. gossypii*.

The rates of parasitism on aphids on both plants were recorded by counting the number of mummies present on the collected leaves. The highest rate of parasitism was recorded on individuals of cotton found on *B. officinalis* and *S. macrosperma* plants, which were 31.74 and 23.63%, respectively, while the rate of parasitism on aphids reached 14.66. and 20%, respectively, Figure 4.

The results showed that the effect of boiled and cold extract and alcoholic extract of *B. officinalis* leaves on inducing the behavior of attraction and repulsion of individuals of the aphid indicate their tendency to attract aphids. The highest rate of attraction was 66% and 64% for cotton aphids and black bean aphids, respectively. They were exposed to the alcoholic extract at a concentration of 25 mg/ml after an hour of treatment. At the same time, the highest rate of expulsion was recorded at 28% when exposing black bean aphid insects to the boiling water extract. However, the highest rate of repelling insects from cotton was 24% for the boiling water extract. The results also showed that the highest rate for the alcoholic extract on cotton was 54%, while the highest neutralization rate for the alcoholic extract on black bean sprouts was 38% (Table 1).

Table 1: Effectiveness of boiled, cold and alcoholic extract of *B. officinalis* leaves in attracting and repelling *A. fabae* and *A. gossypii*.

<i>B. officinalis</i> extract	<i>A. fabae</i>			<i>A. gossypii</i>		
	Attracting %	Repelling %	Balance %	Attracting %	Repelling %	Balance %
Cold water	58	22	36	65	16	49
Boiled water	54	28	26	52	24	24
Alcoholic	64	26	38	66	12	54

LSD (0.05) for the attraction ratio = 4.454; LSD (0.05) for expulsion ratio = 3.616

Table 2: Effectiveness of boiled, cold and alcoholic extract of *S. macrosperma* leaves in attracting and repelling *A. fabae* and *A. gossypii*.

<i>S. macrosperma</i> extract	<i>A. fabae</i>			<i>A. gossypii</i>		
	Attracting %	Repelling %	Balance %	Attracting %	Repelling %	Balance %
Cold water	24	48	-24	32	60	-28
Boiled water	22	42	-20	36	60	24-
Alcoholic	28	68	-40	32	64	-32

LSD (0.05) for the attraction ratio = 3.517; LSD (0.05) for expulsion ratio = 4.638

Table 2 also shows that the boiled and cold aqueous extract and 96% ethyl alcohol of the *S. macrosperma* plant tended to repel aphids. The highest expulsion rate was 68% and 64% for black beans and cotton, respectively, when exposed to the alcoholic extract at a concentration of 25 mg/ after an hour of treatment. However, the highest rate of attraction was 22% when exposing black bean insects to the boiling water extract. In comparison, the highest rate of attraction to cotton insects was 36% to the boiling water extract. Table 2 also showed that the highest balance percentage for the alcoholic extract on black bean was -40%, while the highest balance percentage for the alcoholic extract on cotton seeds was -32%.

Aphids have a wide family range and have the ability to adapt in the absence of the main host to migrate to secondary hosts. The rate of aphid infestation on plants may vary depending on the difference in the preference of aphids for those families. It is linked to several phenotypic factors such as the thickness and area of the plant leaf, the density and length of the hairs, and the color of the plant. In addition, to the chemical factors represented by the secondary compounds produced by the plant, which include flavonoids, the chemical factors represented by the secondary compounds produced by the plant, include flavonoids, phenols, terpenes, and tannins. All of them play a role in the difference in the aphid's preference for the host and thus the rates of insect infection (Dai et al., 2018).

The *B. officinalis* plant belongs to the Aceaceae family, is considered an insect-attracting plant (Dogimont et al., 2010). This may explain the preference of aphid species compared to the low numerical density of aphid species on the tangerine plant, which is characterized by containing compounds that are unpalatable or repellent to aphids.

This was indicated by Davis et al. (2017), who studied the effective components of the oil extract of the leaves of the *Stachys rieder* plant. It tested its effect on the adults of both the corn weevil *Sitophilus zeamais* and the booklice *Liposcelis bostrychophila*. They found that there are 40 components in the essential oil, representing 96.01% of oil components, five of which have a killing effect on insects namely acetanisol, anisol, 1, 8-cineole, eugenol, and geraniol, indicating their effectiveness in causing killing through fumigation and contact.

For the presence of parasitoids and the difference in parasitism rates, the highest parasitism rate was recorded on the types of aphids found on the *B. officinalis* plant, which is due to the fact that the plant is known to be attractive to aphid parasitoids (Fujinuma et al., 2010). The parasitism exploits volatile compounds from the plant infected with aphids as a guide to determine the location of the infestation. It is known as herbivore induced plant volatiles (HIPVs).

Fujinuma et al. (2010) have investigated whether the *B. officinalis* plant is an attractive plant for aphid

parasitoids by testing the susceptibility of females of the parasitoid *Aphidius colemani* to being attracted to the odors emanating from plants (Borage, Japanese radish, and barley infested with aphids, *Myzus persicae*, and *Rhopalosiphum padi*) and mechanically damaged by 4-arm olfactometer device. It has recorded the highest rate of attraction for parasitic adults to the *B. officinalis* plant. The variation in the percentage of attraction and repulsion may be due to variation in the chemical components of these plants (Asadi *et al.*, 2018).

Therefore, these extracts may affect the behavioral reactions of the insect of feeding, including orientation. Thus, they are effective stimulants or inhibitors to feeding. Sometimes the insect is attracted to a substance that is not desirable to it because the influential substances within the components of the food may not be perceived by the insect because the concentration of its vapor may not be sufficient. It affects the olfactory response (Jankowska, 2010). The repulsive feature is useful in keeping insects away from the places where they are protected from infection. The attracting feature is useful in attracting insects and catching them to where the toxic substance is located, killing them (Suleiman *et al.*, 2012).

The difference in the ability to attract and repel the extract of *B. officinalis* and *S. macrosperma* plants for aphid species may be due to the chemicals, minerals and nutrients present in both plants and even the odors emanating from them. Griffiths-Lee *et al.* (2020) have indicated the effectiveness of the *B. officinalis* plant in attracting many insects when grown in greenhouses with strawberry plants. It was observed that pollinating insects such as bees, bumblebees, butterflies, beetles, and many insects are attracted.

Asnaashari *et al.* (2010) showed the effectiveness of the methylated extract of the plant *Stachys byzantina* at concentrations of 5, 10, and 20 mg/ml as an insecticide to kill adults of *Oryzaephilus mercator* insect. It recorded a kill rate of 13.3, 26.6, and 33.3, respectively, after 48 hrs of treatment, indicating that the plant contains anti-insect compounds, which identified as three types of phenylethanoids, namely 2'-O-arabinosyl verbascoside, verbascoside, and aescynanthoside C, and three flavinoid compounds, which are 7-O-glucoside, 7-O-(6-p-coumaroyl)-glucoside, and apigenin.

Conclusions and Recommendations

The study concludes that the population density of *A. gossypii* is higher than the density of *A. fabae* on borage plants. The *B. officinalis* extract has an attractive effect on aphids, while the *S. macrosperma* plant has a repellent effect. The study has recorded three parasitoids *Praon volucre* (Haliday, 1833), *Trioxys pallidus* (Haliday, 1833), and *Diaeretiella rapae* on *A. gossypii* and *A. fabae*.

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Novelty Statement

The study is first of its kind to evaluate the effect of the host plant on the severity of aphid infestation by diagnosing and calculating the density of aphid species on two types of medicinal plants (*Borage officinalis* and *Stachys macrosperma*) that are found in the Iraq.

Author's Contribution

Dalal Tareq Al-Ameri: Conceptualization

Hasan Al-Khshemawee: Methodology and writing-original draft preparation

Khalid J. Al-Hussainawy: Software, data curation investigation, writing-review and editing, and supervision

Conflict of interest

The authors have declared no conflict of interest.

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