

# Insecticidal activity of five extracts plant species against the black bean aphid *Aphis fabae* Scopoli, 1763 (Hemiptera: Aphididae)

Karima BENOUELLA-KITOUS <sup>1</sup>, Samia AIT AMAR-BERRAS <sup>1,2,3</sup>, Hocine FELLAG <sup>4</sup>

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**Insecticidal activity of five extracts plant species against the black bean aphid *Aphis fabae* Scopoli, 1763 (Hemiptera: Aphididae)**

**Abstract:** Biological control against aphids is very limited. Crop protection against these pests is still largely based on chemical methods, which highlights the need for alternative strategies that are economically viable, environmentally safe, and non-toxic. To contribute to the development of more sustainable control approaches, the potential of five plant species was evaluated against *Aphis fabae* Scopoli, 1763, a major pest of beans and several other cultivated crops. This study aimed to assess the efficacy of aqueous extracts of tooth lavender, oregano, peppermint, garlic, and noble laurel in controlling aphid populations. Aphid rearing and toxicity assays were conducted under laboratory conditions. Different concentrations of each extract were prepared by dilution and tested on *A. fabae*. The results showed that lavender and garlic leaf extracts exhibited strong aphicidal activity, causing 99.4 % and 97.9 % mortality, respectively, at the lowest concentration tested (10 %). In contrast, peppermint extract was the least effective, with an efficacy of 25.7 % at the same concentration.

**Key words:** biocidal effect, aqueous extract, *Aphis fabae*, tooth lavender, noble laurel, oregano, peppermint, garlic

**Insekticidno delovanje izvlečkov petih rastlinskih vrst proti črni listni uši fižola (*Aphis fabae* Scopoli, 1763 (Hemiptera: Aphididae))**

**Izvleček:** Biološki nadzor nad listnimi ušmi je zelo omejen. Zaščita pridelkov pred temi škodljivci še vedno v veliki meri temelji na kemičnih metodah, kar poudarja potrebo po alternativnih strategijah, ki so ekonomsko izvedljive, okolju varne in nestrupene. Da bi prispevali k razvoju bolj trajnostnih pristopov k nadzoru, je bil ocenjen potencial petih rastlinskih vrst proti vrsti *Aphis fabae* Scopoli, 1763, glavnemu škodljivcu fižola in več drugih gojenih poljščin. Namen te študije je bil oceniti učinkovitost vodnih izvlečkov nazobčane sivke, origana, poprove mete, česna in žlahtnega lovorja pri nadzoru populacij listnih uši. Testi gojenja in toksičnosti listnih uši so bili izvedeni v laboratorijskih razmerah. Različne koncentracije vsakega izvlečka so bile pripravljene z redčenjem in nanesene na uši. Rezultati so pokazali, da so izvlečki listov sivke in česna pokazali močno afidicidno delovanje, ki je pri najmanjši preiskuševani koncentraciji (10 %) povzročilo 99,4 % oziroma 97,9 % smrtnost. Nasprotno pa je bil izvleček poprove mete najmanj učinkovit, z učinkovitostjo 25,7 % pri isti koncentraciji.

**Ključne besede:** biocidni učinek; vodni izvleček; *Aphis fabae* (črna fižolova uš); nazobčana sivka; žlahtni lovor; origano; poprova meta; česen

<sup>1</sup> Laboratory for the Ecology, Biotechnology et health, Faculty of Biological Sciences and Agronomic Sciences, Mouloud Mammeri University, Tizi-Ouzou, Algeria.

<sup>2</sup> „Agronomy and Environment Research Laboratory. Institute of Life and Natural Sciences. Ahmed Ben Yahia El Wancharissi University of Tissemsilt, Algeria.

<sup>3</sup> Corresponding author: 3AIT AMAR-BERRAS Samia; E-mail: s.aitamer@univ-tissemsilt.dz

<sup>4</sup> Department of Mathematics, Mouloud Mammeri University of Tizi-Ouzou, Algeria.

## 1 INTRODUCTION

Damage caused by insects is very important. The black bean aphid, *Aphis fabae* Scopoli, 1763, is one of the most important species in bean crops. Indeed, it causes damage either through feeding punctures that weaken the plant, through the production of honeydew which stains leaves and pods, or by transmitting numerous plant viruses.

The control of this aphid in Algeria is essentially based on the use of synthetic insecticides. However, this excessive reliance on chemical control poses serious environmental, health and economic problems (Devine & Furlong, 2007) and disrupts the activity of natural enemies. Sigrist *et al.* (1994) reported that synthetic aphicides have very high toxicity (50–75 %) on beneficial entomofauna. The development of new biocontrol methods that are less toxic and more environmentally friendly, while safeguarding auxiliary fauna and human health, represents a promising alternative.

Some plant extracts contain constituents with pesticidal properties that can be used against harmful insects. Indeed, plants constitute a source of natural substances with great potential for application against insects and other plant and animal parasites (Bonzi, 2007). According to Deguine and Vaissayre (2000), the use of biological insecticides (plant extracts, kairomones, growth regulators) against aphids represents a possible method within an integrated pest management framework.

Plant-origin substances have been the subject of numerous studies that have tested their insecticidal potential with a view to reducing losses caused by insect pests (Auger *et al.*, 2002; Ndomo *et al.*, 2009; Akantetou *et al.*, 2011; Benoufella-Kitous *et al.*, 2014; Mondedji *et al.*, 2014).

In this context, our research aims to contribute to the management of the black bean aphid by promoting cultivated and spontaneous flora. This involves evaluating the biocidal effect of five local aqueous extracts of plant species collected from the local flora in Algeria (garlic *Allium sativum* L., 1753; toothed lavender *Lavandula dentata* L., 1753; oregano *Origanum glandulosum* L., 1753; noble laurel *Laurus nobilis* L., 1753; and peppermint *Mentha x piperita* L., 1753) on aphid populations in order to exploit their potential phytosanitary properties.

## 2 MATERIAL AND METHODS

### 2.1 ANIMAL MATERIAL

Adult Aphids were used for all bioassays. The insects were collected from a single host plant, faba bean

(*Vicia faba* L.), variety Histal, to ensure uniformity in the experimental conditions. collected from naturally infested faba bean plants in a private plot during April 2014. After collection, the aphids were transported to the laboratory and maintained on fresh bean plants, for 24 hours prior to initiating the bioassays.

To ensure a sufficient population for the bioassays, collected aphids were mass-reared on bean plants of the Histal variety, a widely cultivated and naturally occurring variety in Algeria, grown under laboratory conditions ( $25 \pm 2$  °C,  $60 \pm 5$  % relative humidity, and a 16:8 h light:dark photoperiod). Leaves infested with aphids were regularly transferred to fresh bean plants to maintain healthy colonies. The rearing was initiated using a population of 30 adult aphids to establish homogeneous colonies for the experiments.

### 2.2 PLANT MATERIAL

Leaves of five plant species were harvested at the beginning of April 2014 from private gardens in the Tizi-Ouzou region. Oregano (*Origanum glandulosum* L.) was collected in Ain El Hammam (36°34' N, 4°18' E, 1000 m a.s.l.), noble laurel (*Laurus nobilis* L.) in Boghni (36°32' N, 3°57' E, 300 m a.s.l.), peppermint (*Mentha x piperita* L.) in Ouacif (36°32' N, 4°13' E, 600 m a.s.l.), garlic (*Allium sativum* L. Local white ecotype) in Ouadhias (36°33' N, 4°05' E, 400 m a.s.l.), and tooth lavender (*Lavandula dentata* L.) near the Institute of Biological and Agronomic Sciences, University of Mouloud Mammeri, Tizi-Ouzou (36°43' N, 4°03' E).

Fresh leaves (100 g per plant) were ground in a mortar to form a paste, which was then filtered through a fine cloth to remove debris. The filtrates were considered stock solutions, which were subsequently diluted with distilled water to prepare the desired concentrations for the bioassays.

### 2.3 EXPERIMENTAL DESIGN

Experiments were conducted under controlled laboratory conditions ( $25 \pm 2$  °C,  $60 \pm 5$  % relative humidity, and a 16:8 h light:dark photoperiod) using a completely randomized design. Aphids were assigned to six groups: five treated groups corresponding to different extract concentrations and one control group treated with distilled water. For each extract, concentrations of 10 %, 20 %, 30 %, 40 %, and 50 % were tested. Each experimental unit consisted of a bean plant infested with 30 aphids at various developmental stages.

## 2.4 BIOASSAYS

Prepared solutions were evenly applied to aphid-infested plants. Each concentration and the control were replicated five times. Mortality was assessed every three days using a hand-held magnifying glass. For peppermint, garlic, and tooth lavender-based extracts, two observations were conducted, whereas three observations were performed for oregano- and noble laurel-treated groups, due to differences in the speed of action of the tested extracts; the first three extracts showed a rapid insecticidal effect, while oregano and noble laurel exhibited a slower mortality response, requiring an additional observation to properly monitor mortality progression over time

## 2.5 MORTALITY ASSESSMENT

Aphid mortality was recorded at 3, 6, and 9 days post-treatment. Corrected mortality percentages were calculated according to Abbott's formula (1925):

$$MC\% = ((M2 - M1) / (100 - M1)) \times 100$$

Where:

- MC%: Corrected mortality percentage
- M1: Mortality in the control group
- M2: Mortality in the treated group

## 2.6 DATA ANALYSIS

Measured variables included mortality, concentration, and exposure time. As the mortality data did not follow a normal distribution, the Kruskal-Wallis non-parametric test was applied. Observations were ranked in ascending order to evaluate the efficacy of each extract across concentrations and over time, allowing a detailed analysis of mortality trends in relation to both concentration and duration of exposure. All statistical analyses and data processing were performed using the R statistical software.

## 3 RESULTS

### 3.1 EFFECT OF DOSE ON THE EFFICACY OF EXTRACTS ON *APHIS FABAE* POPULATIONS

Mortality rates recorded in *A. fabae* populations were markedly higher on plants treated with the different aqueous extracts than on the control plants. The water-treated control showed very low mortality, reaching 1.53 % mortality after 6 days in the assays with garlic, peppermint, and toothed lavender (Fig. 1–3), and 1.69 % after 9 days in the assays with noble laurel and oregano (Fig. 4–5).

Aphid mortality induced by the five plant extracts varied according to the concentrations applied (Tab. 1).

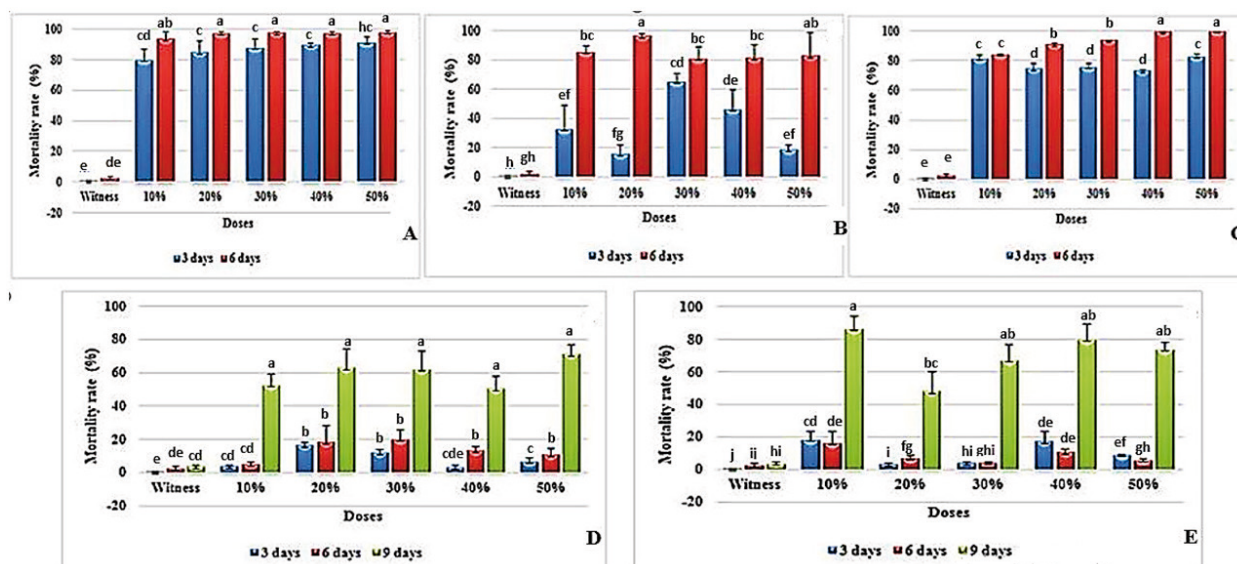


**Figure 1:** Mortality rate. A: Mortality of *Aphis fabae* populations treated with garlic extract 3 and 6 days after treatment. B: Mortality of *Aphis fabae* populations treated with peppermint extract 3 and 6 days after treatment. C: Mortality of *Aphis fabae* populations treated with tooth lavender extract 3 and 6 days after treatment. D: Mortality of *Aphis fabae* populations treated with noble laurel extract 3, 6 and 9 days after treatment. E: Mortality of *Aphis fabae* populations treated with oregano extract 3, 6 and 9 days after treatment.

**Table 1:** Corrected mortality average of *Aphis fabae* populations by doses after treatment with the 5 aqueous extracts.

| Dose (%) | Corrected mortality average (%) |            |                |              |         |
|----------|---------------------------------|------------|----------------|--------------|---------|
|          | Garlic                          | Peppermint | Tooth lavender | Noble laurel | Oregano |
| 10       | 97.70                           | 93.01      | 83.58          | 48.25        | 82.45   |
| 20       | 97.55                           | 98.71      | 90.71          | 54.28        | 37.5    |
| 30       | 97.21                           | 94.97      | 93.43          | 55.14        | 62.38   |
| 40       | 97.20                           | 92.53      | 99.22          | 46.06        | 76.49   |
| 50       | 97.94                           | 94.51      | 99.39          | 67.47        | 71.71   |

For toothed lavender, mortality increased steadily with concentration, and this trend was statistically supported by the Kruskal–Wallis test ( $p = 0.006$ ). In contrast, garlic leaf extract produced similar mortality levels across all concentrations, indicating a limited dose effect.

For oregano, the 10 % concentration resulted in the highest mortality, whereas for peppermint, the 20 % concentration proved to be the most effective. Noble laurel extract showed its greatest toxicity at 50 % concentration.

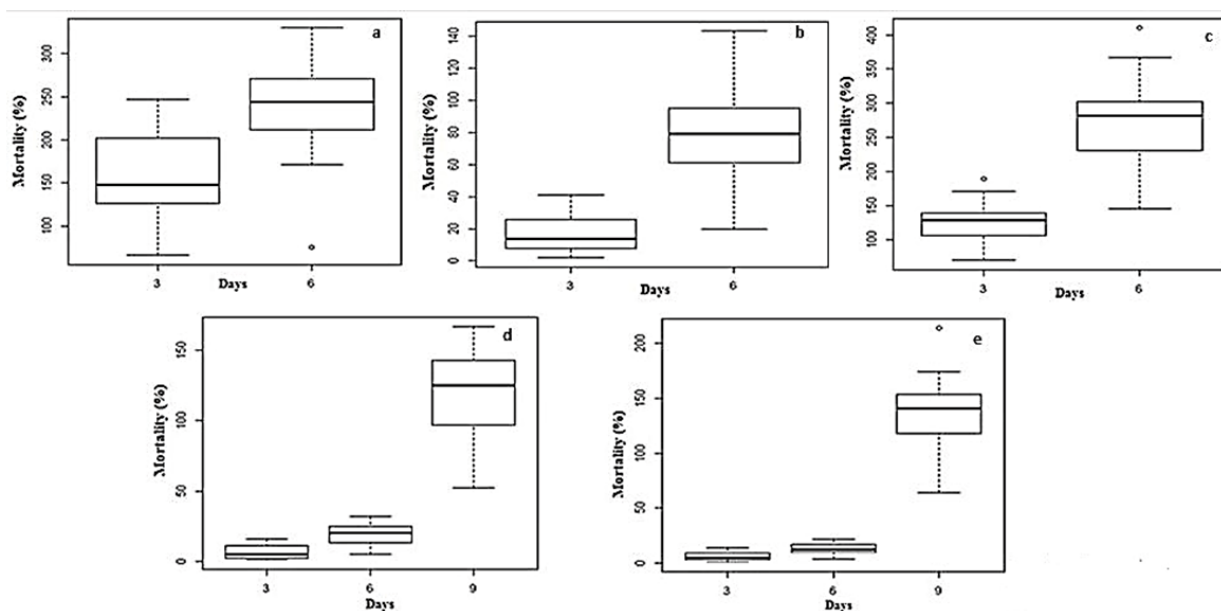
For these four extracts, mortality did not follow a clear dose-dependent pattern, a conclusion supported by Kruskal–Wallis test results:  $p = 0.537$  for garlic, 0.759 for oregano, 0.580 for peppermint, and 0.095 for noble laurel.

### 3.2 EFFECT OF TIME ON THE EFFICACY OF EX-

### TRACTS ON *APHIS FABAE* POPULATIONS

Mortality rates of aphids exposed to different concentrations of the five tested extracts increased progressively over the observation periods (3, 6, and 9 days) on treated plants. Under the present experimental conditions, the strongest insecticidal effect was recorded 6 days after treatment for the garlic, toothed lavender, and peppermint extracts, and 9 days after treatment for the bay laurel and oregano extracts.

The mortality–time boxplots indicate greater variability in mortality, with higher mortality levels observed at 6 and 9 days compared to 3 days. This trend is strongly supported by the Kruskal–Wallis test, which yielded  $p$ -values approaching zero ( $2.414 \times 10^{-6}$  for garlic,  $2.724 \times 10^{-9}$  for lavender,  $3.43 \times 10^{-9}$  for mint,  $5.893 \times 10^{-7}$  for noble laurel, and  $1.583 \times 10^{-5}$  for oregano), indicating a

**Figure 2:** Boxplot mortality–time. a: for garlic extract. b: for peppermint extract. c: for tooth lavender extract. d: for noble laurel extract. e: for oregano extract.

highly significant effect of time on aphid mortality (Fig. 6–10).

### 3.3 EFFECT OF EXTRACT NATURE ON *APHIS FABAE* POPULATIONS

Results of the corrected mortality calculations obtained with the different extracts show that the most toxic treatments were the toothed lavender extract, with an efficacy of 99.39 % at the 50 % dose, and the garlic extract, which reached 97.94 % at the same concentration. The least effective extract was that of noble laurel, with a maximum efficacy of 67.47 % at the highest tested dose. These results suggest that insecticidal activity strongly depends on the plant species used.

This interpretation is supported by the Kruskal–Wallis test comparing mortality across extract types, which yielded a chi-square value of 262.15 and a  $p$ -value of less than  $2.2 \times 10^{-16}$ , indicating that mortality is highly dependent on extract nature.

## 4 DISCUSSION

Results obtained from the biological tests performed with the five biopesticides clearly demonstrate their bioactivity against the black bean aphid, an economically important pest in Algeria. The toxicity observed varied depending on the applied dose applied, exposure time, and the plant species, highlighting the importance of these factors in determining the effectiveness of plant-based treatments.

Many authors have reported the effectiveness of plant extracts against aphid species. Ondet (2007) showed that 10 % infusions of peppermint and mugwort significantly reduced aphid populations of green aphids on apple trees. Similarly, the study by Laznik et al. (2011) demonstrated that glycolic extracts of comfrey (*Symphytum officinale* L., 1753) and marigold (*Calendula officinalis* L., 1753) were capable of controlling outbreaks of the apple aphid *Aphis pomi* De Geer, 1773 at the highest concentration tested (5 %), with a stronger effect observed three days after treatment compared with earlier observation times.

Extracts of mugwort wormwood and common mugwort have also shown toxicity toward *Myzus persicae* Sulzer, 1876 and *Nasonovia ribisnigri* Mosley, 1841, respectively, seven days after treatment (Prisca et al., 2013). Benoufella-Kitous et al. (2014) reported the biocidal activity of aqueous extracts of nettle (*Urtica dioica* L., 1753) and fern (*Dryopteris filix-mas* (L.) Schott, 1834) on the black bean aphid, with mortality increasing with both dose and exposure duration.

Work by Biniaś et al. (2017) demonstrated that aqueous extracts of *Mentha piperita* (peppermint) induce mortality of *A. fabae*, with higher extract concentrations resulting in higher mortality rates. Likewise, the study by Benoufella-Kitous et al. (2020) revealed that sage (*Salvia officinalis* L., 1753) exhibits strong insecticidal activity on aphid populations, achieving a high mortality rate of 98.54 % at a 40 % concentration, with maximum effects observed nine days after treatment.

The insecticidal properties of neem (*Azadirachta indica* A. Juss., 1830) have been widely reported against aphids. This plant has been shown to significantly reduce of the cabbage aphid *Brevicoryne brassicae* Linnaeus, 1758 and on *Myzus persicae* in different cropping system (Agboyi, 2009; Ochieng and Nderitu, 2011; Abdelmaksoud et al., 2023), confirming its potential as a botanical alternative to synthetic insecticides.

Similarly, Bouabida et al. (2022) observed that spraying extracts prepared from four Lamiaceae species on *A. fabae* populations led to an increase in mortality, with both dose and exposure time, with total mortality achieved at the highest concentrations after prolonged exposure. According to the authors, species belonging to the Lamiaceae family are rich in secondary metabolites with strong toxic effects against insect pests.

Other studies have shown that several essential-oil-based biopesticides are equally effective. Akantetou et al. (2011) reported that the toxicity of essential oil extracted from whitish basil (*Ocimum canum* Sims, 1824) against aphids decreases with dilution. Amirat et al. (2011) showed that mortality in *Aphis pomi* increased proportionally with doses of lavender and oregano essential oils.

Recent studies have confirmed the strong insecticidal potential of essential oils against aphids, including *A. fabae*. For instance, several essential oils such as *Lavandula angustifolia* Mill., 1768, *Tagetes minuta* L. 1753, and *Juniperus virginiana* L. 1753 have shown significant toxicity against *A. fabae*, with enhanced efficacy depending on formulation and concentration (Abdelmaksoud et al., 2023).

Similarly, laboratory studies have demonstrated that essential oils can induce high mortality rates in *A. fabae* depending on dose and exposure time, confirming their potential as botanical insecticides (Sadek et al., 2025).

Earlier work also demonstrated that essential oil vapours exhibit strong toxicity against aphid species, with efficacy depending on chemical composition and exposure conditions (Kimbaris et al., 2010).

Habou et al. (2011) demonstrated the biocidal activity of *Jatropha curcas* L., 1753 oil against *Aphis craccivora* Koch, 1854, with mortality rising as oil concentration increased. Concentrations of 5 % and 7.5 % reduced aphid infestation levels by 10 % and 50 %, respectively, compared with the control. According to these authors, the

biocidal effect of jatropha oil intensifies over time, reaching its maximum after four days. In a later study, the same authors (2013) confirmed the toxic activity of this oil on *Aphis gossypii* Glover, 1877, showing it to be more effective than deltamethrin.

Several studies have demonstrated the potential of plant-derived products against aphids, including *A. fabae*. In particular essential oils of *Thymus* species have shown strong biocidal activity against aphid populations. For example, the essential oil of *Thymus pallescens* Noé, 1849 significantly reduce the survival of *A. fabae* survival, with corrected mortality reaching 84.89 % at 12  $\mu\text{l ml}^{-1}$  after 24 hours (Saifi and Belhamra, 2018).

Results of the present study indicate that the efficacy of the tested extracts varied according to the plant species. This variability is likely linked to the chemical composition of the extracts. According to Khalfi-Habes *et al.* (2011, 2012), the insecticidal activity of plant-based treatments is largely attributed to secondary metabolites such as terpenoids, phenolics, and alkaloids. Ondet and Salva (2005) also reported that the therapeutic action of plant extracts on piercing-sucking insects differs depending on the chemical nature of the extract. Plants naturally produce chemical mediators that ensure inter-species communication and play crucial roles in defense. More than 2,000 plant species with insecticidal properties have been identified (Ngamo and Hance, 2007), and numerous studies have sought to isolate or characterize the secondary metabolites responsible for anti-insect activity (Ndomo *et al.*, 2009).

Various secondary compounds can inhibit insect development, disrupt feeding (anti-feedant effect), or act as repellents or confusion agents (Laznik *et al.*, 2011). For example, odors emitted by *Ocimum basilicum* L., 1753 are known to be strong repellents (Aouinty *et al.*, 2006). Species of the genus *Allium* possess recognized insecticidal and fungicidal properties; they are commonly used in intercropping systems, where their sulfur-based allelochemicals exert repellent and anti-appetent effects (Auger *et al.*, 2002). Chromenes isolated from *Callistemon viminalis* G. Don, 1830 extracts have also demonstrated insecticidal activity against *A. fabae* (Ndomo *et al.*, 2009). Gueye *et al.* (2011) highlighted that active compounds vary not only between plant families but even between species within the same family, and that insect susceptibility differs across developmental stages. Natural plant extracts therefore represent promising tools for managing insecticide resistance in pest populations (Attia *et al.*, 2011).

Overall, plant-derived substances represent promising tools for the development of environmentally friendly pest management strategies, offering sustainable alter-

natives to synthetic insecticides and contributing to the management of resistance in aphid populations.

## 5 CONCLUSION

In light of the results obtained, the five tested plant extracts demonstrated notable biocidal activity against *A. fabae*. The calculated efficacy degrees indicate that two extracts, namely toothed lavender leaves and garlic, showed particularly high toxicity compared to the others.

These two extracts merit further evaluation under market-garden field conditions to confirm their aphicidal potential. Their successful use could offer a valuable alternative to the excessive application of synthetic insecticides within integrated pest management strategies, thereby reducing the harmful environmental and health impacts associated with chemical pesticides.

The findings of this study open promising perspectives for the development of plant-based biopesticides. Future research should aim to identify the active insecticidal compounds contained in these extracts, optimize formulation and application methods, and assess potential residue-related risks for human health.

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