



People's Democratic Republic of Algeria

Ministry of Higher Education and Scientific Research

ABBES LAGHROUR UNIVERSITY -KHENCHELA-

FACULTY OF NATURAL AND LIFE SCIENCES

DEPARTMENT OF AGRONOMIC SCIENCES

Dissertation

Submitted for the obtaining the Master's degree of Agricultural sciences

OPTION: Plant Production

Topic

Study of the Insecticidal Activity of Plant Extracts of

(Case of *Pistacia terebinthus*)

Presented by:

ACHI Hamza

BOARD OF EXAMINERS

Chairman	Toufik BENHIZIA	University of Khenchela
Supervisors	Salim LEBBAL	University of Khenchela
Examiner	Abdelghafour ABAIDIA	University of Khenchela

Academic year 2024 / 2025

Acknowledgements

First and foremost, we would like to express our sincere gratitude to our dissertation supervisor, **Lebbal Salim**, for their continuous support, guidance, and encouragement throughout the research and writing process of this dissertation. Their expertise and insightful feedback were invaluable in shaping the direction and quality of our work.

We are grateful to the staff of the **Natural & Life Sciences** faculty at **Abbes Laghrour University** for their support and for providing a stimulating academic environment. The resources and facilities available were essential for the completion of our research.

Our deepest appreciation goes to our family and friends for their unwavering support, patience, and encouragement. To our parents, your belief in us has been a constant source of motivation. To our friends, your understanding and companionship have been invaluable throughout this journey.

I would like to sincerely thank Profert Company for their warm welcome and the opportunity they offered me to carry out my training period within their organization. Their professionalism, availability, and the richness of the knowledge shared greatly contributed to the success of this experience.

Finally, we would like to thank everyone who has contributed, directly or indirectly, to the completion of this thesis. Your support, in various forms, has been greatly appreciated.

Thank you all.

ACHI Hamza

19/06/2025

Abbes Laghrour University

Dedication

Firstly, I thank the **Almighty God**, for the guidance, strength, power of mind, protection, and skills, and for granting me a healthy life.

This study is whole-heartedly dedicated to my **beloved parents**, who have been my source of inspiration and gave me strength whenever I felt like giving up, and who continually provided their moral, spiritual, emotional, and financial support.

To my **brothers, sister, nephews, nieces, relatives, mentors, friends, and classmates**, who shared their words of advice and encouragement throughout the journey of completing this study.

Title of the dissertation: Study of the Insecticidal Activity of Plant Extracts of *(Case of *Pistacia terebinthus*)*

Full name: Hamza Achi

Directed by: Salim Lebbal

Abstract

The intensive use of synthetic insecticides has led to environmental concerns and increased resistance in insect pests, highlighting the urgent need for eco-friendly alternatives. In this study, we evaluated the insecticidal and repellent effects of *Pistacia terebinthus* essential oil on three aphid species: *Aphis craccivora* & *fabae*, *Myzus persicae*, and *Dysaphis plantaginea*, under controlled laboratory conditions.

Toxicity tests revealed species-specific susceptibility to the essential oil. *D. plantaginea* exhibited the highest mortality rate, reaching 52.85% at 1000 ppm, followed by *M. persicae* with 42.83% at 1000 ppm, and *Aphis craccivora* & *fabae* with 20.5% at 10000 ppm after 24 hours. Regarding repellency, *D. plantaginea* showed the strongest response with 33.33%, while *A. craccivora* & *fabae* and *M. persicae* recorded 23.33% and 20%, respectively, at 10000 ppm after 24 hours.

These findings suggest that *P. terebinthus* essential oil possesses promising bioactivity against aphids and could serve as a potential botanical pesticide. However, further in vivo and field-based studies are recommended to confirm its effectiveness and broaden its application in integrated pest management programs.

Keywords: Essential oils, bio-pesticides, pests, toxicity, repellency, *A. craccivora* & *A. Fabae*, *P. Terebinthus*, *M. Persicae*, *D. Plantaginea* .

الملخص

أدى الاستخدام المكثف للمبيدات الحشرية الاصطناعية إلى إثارة مخاوف بيئية وزيادة مقاومة الآفات الحشرية، مما يبرز الحاجة الملحة إلى بدائل صديقة للبيئة. في هذا الإطار، قمنا بتقييم التأثير السمي والطارد لزيت *Pistacia terebinthus* العطري على ثلاث أنواع من حشرات المن: *Aphis craccivora* و *A. fabae* و *Myzus persicae* و *Dysaphis plantaginea*، في ظروف مخبرية مضبوطة.

أظهرت اختبارات السمية تفاوتاً في الاستجابة بين الأنواع. حيث سجلت *D. plantaginea* أعلى معدل وفيات بلغ 52.85% عند تركيز 1000 جزء في المليون، تليها *M. persicae* بنسبة 42.83% عند نفس التركيز، ثم *A. craccivora* و *A. fabae* بنسبة 20.5% عند 10000 جزء في المليون بعد 24 ساعة. أما في ما يخص الفعالية الطاردة، فقد سجلت *D. plantaginea* أعلى نسبة بلغت 33.33%، تليها *A. craccivora* و *A. fabae* بـ 23.33%، ثم *M. persicae* بـ 20% عند تركيز 100 جزء في المليون بعد 24 ساعة.

تشير هذه النتائج إلى أن زيت *P. terebinthus* العطري يتمتع بفعالية واعدة ضد حشرات المن، وقد يشكل بديلاً نباتياً محتملاً للمبيدات الكيميائية. ومع ذلك، يوصى بإجراء دراسات إضافية في الحقل وفي ظروف حية لتأكيد هذه النتائج وتوسيع نطاق تطبيقها في برامج مكافحة متكاملة للآفات.

الكلمات المفتاحية: زيوت عطرية، مبيدات حيوية، أعداء النبات، التأثير السمي، التأثير الطارد *A. craccivora* & *A.*

Fabae, *P. Terebinthus*, *M. Persicae*, *D. Plantaginea*.

Titre de mémoire: Étude de l'activité insecticide des extraits végétaux de *(cas de *Pistacia terebinthus*)*

Nom et prénom: Hamza ACHI

Encadreur: Salim LEBBAL

Résumé

L'utilisation intensive des insecticides de synthèse a suscité des préoccupations environnementales et favorisé le développement de résistances chez les insectes ravageurs, soulignant ainsi la nécessité urgente de solutions alternatives écologiques. Dans ce contexte, cette étude a évalué les effets toxiques et répulsifs de l'huile essentielle de *Pistacia terebinthus* sur trois espèces de pucerons : *Aphis craccivora* & *A. fabae*, *Myzus persicae* et *Dysaphis plantaginea*, dans des conditions de laboratoire contrôlées.

Les tests de toxicité ont révélé une sensibilité variable selon les espèces. *Dysaphis plantaginea* a présenté le taux de mortalité le plus élevé, atteignant 52,85 % à 1000 ppm, suivie de *Myzus persicae* avec 42,83 % à 1000 ppm, et *Aphis craccivora* & *Aphis fabae* avec 20,5 % à 10000 ppm après 24 heures. Concernant l'effet répulsif, *Dysaphis plantaginea* a montré la réponse la plus forte avec 33,33 %, suivie de *Aphis craccivora* & *Aphis fabae* (23,33 %) et de *Myzus persicae* (20 %) à 100 ppm après 24 heures.

Ces résultats suggèrent que l'huile essentielle de *Pistacia terebinthus* possède un potentiel prometteur en tant que pesticide botanique. Néanmoins, des études complémentaires *in vivo* et en conditions réelles sont nécessaires pour confirmer ces résultats et élargir leur application dans les programmes de lutte intégrée.

Mots clés: Huiles essentielles, bio-pesticides, ravageurs, toxicité, répulsive, *A. craccivora* & *A. Fabae*, *P. Terebinthus*, *M. Persicae*, *D. Plantaginea*.

Table of contents

Acknowledgements	I
Dedication	II
Abstract	III
الملخص	IV
Résumé	V
List of figures	IX
List of tables	X
Introduction	1
Part I: Material and Methods.....	5
1 Material.....	5
1.1 Plant material.....	5
1.2 Animal material	9
1.2.1 <i>Aphis craccivora</i>	9
1.2.2 <i>Dysaphis plantaginea</i>	10
1.2.3 <i>Myzus persicae</i> (Sulzer, 1776) (Figure 7).....	11
1.3 The laboratory equipment (Figure 8):.....	12
2 Methodology	14
2.1 Treatment preparation (Figure 9).....	14
2.2 Test of toxicity in vitro (Table 1, 2, 3 & figures 12, 13, 14).....	15
2.2.1 <i>Dysaphis plantaginea</i>	16
2.2.2 <i>Aphis spp</i>	16
2.2.3 <i>Myzus persicae</i>	17
2.3 Test of repellency in vitro (Figure 14).....	17
2.4 Statistical analysis.....	18
Part II: Results & discussion.....	19
3 Results	19
3.1 Evaluation of the effect of essential oils on the death of <i>Aphis (fabae & craccivora)</i>	19
3.2 Evaluation of the effect of essential oils on the mortality of <i>Dysaphis plantaginea</i>	19

3.3	Evaluation of the effect of essential oils on the mortality of <i>Myzus persicae</i>	20
3.4	Repellency test.....	21
3.5	Discussion	22
3.6	Toxicity effect	22
3.7	Repellency test.....	25
	<i>General conclusion</i>	28
	<i>References</i>	29

List of abbreviations

BCMV: *Bean common mosaic virus*

EOs: Essential Oils

LC50: Lethal Concentration

LD50: Lethal Dose

USDA GRIN: United States Department of Agriculture Germplasm Resources Information
Network

List of figures

Figure 1. Representative plant parts of <i>P. terebinthus</i> . From left to right: (a) Infructescence with mature red and black drupes; (b) Glossy pinnate leaves; (c) aphid-induced gall (likely <i>Baizongiapistaciae</i>) on the leaf rachis (Chaves Lobón et al., 2023).....	5
Figure 2. <i>Vicia faba</i> (original photo)	7
Figure 3. Leaves of Golden Delicious (original photo)	8
Figure 4. Leaves of Nectarine (original photo)	9
Figure 5. Faba bean aphids (original photo).....	10
Figure 6. <i>Dysaphisplantaginea</i> (original photo)	11
Figure 7. <i>Myzuspersicae</i> (original photo)	12
Figure 8. other used materials	14
Figure 9. Preparation of different solutions.....	15
Figure 10. Leaf disc	15
Figure 11. Random arrangement of Petri dishes containing <i>Dysaphisplantaginea</i>) and treated leaf discs (original photo)	16
Figure 12. Random arrangement of Petri dishes containing aphids (<i>Aphis</i> spp) and treated leaf discs (original photo)	17
Figure 13. Random arrangement of Petri dishes containing <i>Myzuspersicae</i> and treated leaf discs (original photo)	17
Figure 14. Arrangement of Petri dishes containing treated leaf discs and aphids (original photo)...	18
Figure 15. Corrected mortality percentages of <i>Aphis</i> (<i>fabae</i> & <i>craccivora</i>) on different essential oil treatments (Mean±Standard Error)	19
Figure 16. Corrected mortality percentages of aphids (<i>Dysaphisplantaginea</i>) on different treatments of <i>Pistacia terebinthus</i> EOs.....	20
Figure 17. Evolution of aphids (<i>Myzuspersicae</i>) mortality after 3, 6, 12 and 24 hours of exposure to the aqueous extract of <i>Pistacia terebinthus</i>	21
Figure 18. Repellency percentages of <i>Pistacia terebinthus</i> EOs against different aphid species.....	21

List of tables

Table 1. The experimental design for <i>Dysaphis plantaginea</i>	16
Table 2. The experimental design for aphids (<i>Aphis</i> spp)	16
Table 3. The experimental design for aphids (<i>Myzus persicae</i>).....	17

Introduction

One of the greatest challenges before mankind today is to ensure adequate food security for the ever-increasing world population, currently around seven billion people. The food situation is gloomy particularly in the over populated developing countries where not only the productivity is low but also insect pests and diseases destroy one-third of the food produced annually (Parmer and Walia 2001). Aphids are among the important harmful insects to agriculture, forestry, and horticulture, causing widespread, severe damage themselves, and spread several viruses as well. There are about 4700 species of *Aphididae* in the world (Remaudière and Remaudière, 1997). Of these, about 450 species have been recorded from crop plants (Blackman and Eastop, 2000), but only about 100 have successfully exploited the agricultural environment to the extent that they are of significant economic importance (Van Emden et Harrington, 2017).

Chemical control is the most common way to limit aphid infestations. In addition to its high cost, this method presents a potential danger to the environment (Bhatia et al., 2011). Some pesticides pollute surface and groundwater (Horrigan et al., 2002). On the other hand, Sullivan (2008) mentioned that non-selective pesticides can destroy auxiliaries. In addition, massive use of insecticides resulted in the development of resistant strains of aphids (Harmel et al., 2008) and other pest species (Brévault et al., 2003). Most pesticides have a limited effective life. Resistance has been reported in almost 500 species of insects and mites, 100 species of plant pathogens, 50 species of insects and rodents and 2 species of nematodes (Khatri and Meshram, 2014). Furthermore, consumers in more affluent countries are increasingly concerned about the safety of the foods that they eat and are applying more pressure on food producers to avoid insecticides that they perceive as imposing health risks; regulatory scrutiny of pesticides has increased worldwide, resulting in fewer products available to growers to mitigate pests.

As a result, scientists have begun to look for other ways to control these insects (Jordan, 2013). Many alternative methods were proposed such as:

- **Biological Control:**

Biocontrol is the use of natural enemies for control of vector population. Biological agents, such as parasites, pathogens and predators, can be used to target various life stages of the mosquito. These agents are inexpensive to implement, and safe for humans and non-target organisms. They therefore provide a potentially environmentally friendly option (Tyagi, 2016).

- **Cultural control:**

Involve manipulating planting, cultivation and other practices in ways that make the environment less favorable for the development and spread of pests. They are typically implemented early, sometimes even before planting your garden, because the best way to manage pests is to prevent them from occurring in the first place. Some other techniques can be included in this control type such as:

- Crop diversity: if a wide variety of plants are grown in a small location, it is more difficult for flying insects to find the right plant on which to feed. This can also slow the spread of diseases and provide a habitat for beneficial insects. For this reason, inter-cropping, or planting alternating varieties of crops, can help reduce pest problems more than if crops are planted in large blocks
- Crop rotation: involves the planting of non-related crops in a particular location in successive years to minimize the chances of plant-specific disease organisms and pests building up in the soil.
- Plant Selection: Carefully select the types of crops to be grown in your garden, discarding those that are likely to require pest control measures. (Kelly, 2010).

➤ Physical control:

Active methods involve the use of energy at the time of intervention, whether to destroy, injure or stress crop enemies, or even to remove from the middle.

Passive methods, for their part, proceed by modifying the environment and have a more durable character.

We can also classify the physical methods depending on the mode of energy use, i.e. the fight mechanical, thermal, electromagnetic or pneumatic. In this context, it is easy to imagine that other classes can be added as needed: acoustic struggle, thermodynamics and so on (Doe & Smith, 2022).

➤ Use of biopesticides:

There is a need to develop biopesticides for effective control that minimizes environmental hazards (Barzman et al., 2015). Biopesticides are the biological agents or plant-based products used to control the population of injurious organisms to the ecosystem. They are naturally occurring substances from living organisms (natural enemies) or their products (microbial products, phytochemicals) and their by-products (semiochemicals) that can control pests by non-toxic mechanisms (Salma and Jogen, 2011 cited by Rajamani and Negi, 2021). In comparison to pesticides, bio pesticide are an eco-friendly nontoxic natural type of pesticides, derived from natural substances like plants, bacteria & minerals which has the capacity to control pests without affecting the environment. It was reported in 2014 that about 430 bio pesticides and 1320 active products has been registered for use in agricultural land (Roychowdhury et al., 2014 cited by Preeti et al, 2017).

Based on the classification by Environmental Protection Agency on the type of ingredient used, biopesticides are categorized into three major classes (1) microbial,(2) biochemical and (3) plant-incorporated protectants (Olson 2015).

Contrary to the problems associated with the use of synthetic chemicals, botanicals are environmentally non-pollutive, renewable, inexhaustible, indigenously available, easily accessible, largely non-phytotoxic, readily biodegradable, and relatively cost effective. There are approximately 2000 plant species all over the world which have been found to exhibit biocidal activity (Grainge and Ahmed, 1988). Literature survey on the potential use of essential oils as bio-pesticides indicated that essential oils obtained from different plant families, including *Asteraceae* and *Lamiaceae* have insecticidal activity and they are active as a repellent, fumigant, larvicidal and adulticidal against insects (Mossa, 2016). Almost every plant shows some antifeedant repellent activity, repellency to pests, insect growth regulation, toxicity to other arthropods and invertebrate pests of agricultural importance and also antifungal, antiviral and antibacterial properties against pathogen (Prakash and Rao 1986; Prakash et al.1987, 1989, 1990; Schmutterer 1990, 1995; Dimetry and Schmidt 1991; Amer et al.1994, Koul, 1997; Remboldt 1989; El-Gengaihi et al. 1997; Mendki et al. 1999;Dimetry and Abd-El Salam 2005).

Essential oils are very complex natural mixtures and can contain about 20 to 60 compounds at different concentrations, characterized by two or three major components at fairly high concentrations compared to others components present in trace amounts. Generally, these major constituents determine the biological properties of the essential oils. Terpenes and terpenoids are the most representative molecules constituting 90% of the essential oils and allow a great variety of structures with diverse functions (Bakkali et al., 2008). Among components of essential oils, terpenes especially monoterpenoids have been shown to be toxic to a variety of insects (Couto et al., 2020).

There is a common notion that natural products with unique bioactive structures have been playing a vital role in developing new types of insecticides with glaring advantages of low residual, easy biodegradation and high security to non-target organisms, like the application of pyrethrin, rotenone, nicotine and neonicotine in the control of pests (Yan et al., 2018). Thus, there is a widespread effort to find new pesticides, and currently this effort is focused on natural compounds, such as flavonoids, terpenoids and phenolics from diverse botanical families from arid and semi-arid areas (Acheuk et al., 2017). Developing natural pesticides could relieve African farming and governments from the expensive importation of synthetic pesticides (Belmain et al., 2013). The plant extract formulations are different from traditional insecticides in their mode of action. They do not have knock down effect of conventional pesticides. Their effects are lower in time and need several days before reaching a balanced situation where the damage of the pest reached an acceptable level.

In this context, the aim of our work is to test essential oils of *Pistacia terebinthus* against different aphid species (*Myzus persicae*, *Aphis spp.*, *Dysaphis plantaginea*), under *in vitro* conditions.

Our manuscript is divided into two main chapters, the first one about material and methods used. Whereas, the second one is devoted to results and discussion.

Part I: Material and Methods

1 Material

1.1 Plant material

Pistacia terebinthus L., commonly referred to as the terebinth or turpentine tree, is a wild-growing deciduous shrub native to Mediterranean ecosystems (Chaves et al., 2023). Known for its distinctive aroma, bioactive richness, and historical importance, various parts of the tree—including fruits, seeds, resin, leaves, and galls (Figure 1)—have long been used in traditional food, medicine, and natural preservation practices (Chaves et al., 2023). Despite its rich ethnobotanical heritage and demonstrated functional properties, *P. terebinthus* remains underrepresented in modern food research and industrial applications. Previous reviews have primarily focused on its traditional use, general phytochemical composition, and pharmacological activities (Fidan et al., 2023).

In our case, the plant material was collected from (...), then identified and extracted using hydrodistillation (for Essential Oils ‘EO’) by Dr. FERCHA Azzeddine and Dr. REHAL Khaled (university of Khenchela).

Then, we prepared five concentrations (100, 500, 1000, 5000 and 10000 ppm).

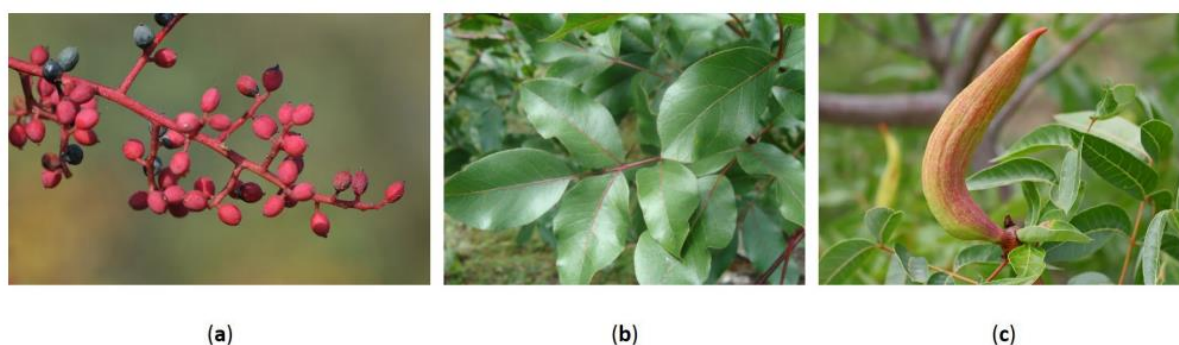


Figure 1. Representative plant parts of *P. terebinthus*. From left to right: (a) Infructescence with mature red and black drupes; (b) Glossy pinnate leaves; (c) aphid-induced gall (likely *Baizongiapistaciae*) on the leaf rachis (Chaves Lobón et al., 2023)

According to Quezel and Santa (1963) and Dupont and Guignard (2007), *Pistacia terebinthus* belongs to the following taxonomic hierarchy:

- **Kingdom:** *Plantae*
- **Clade:** *Tracheophytes* (vascular plants)
- **Branch:** *Phanerogams* (Spermaphytes)
- **Sub-branch:** *Angiosperms*
- **Class:** *Eudicots*
- **Order:** *Sapindales* (syn. *Rutales*)
- **Family:** *Anacardiaceae* (Cashew or Turpentine family)
- **Genus:** *Pistacia*
- **Species:** *Pistaciaterebinthus* L.
- **Common names:** Terebinth, Turpentinetree, Pistachier térébinthe, بطم (Butm)

In addition, we used faba bean (Figure 2) leaflets in our bioassay. The material used in this experiment was obtained from uninfected broad bean planted by ourselves.

Faba bean *Vicia faba* L is an annual herbaceous plant with a single stem, upright, unbranched hollow and of quadrangular cross-section, more than a meter high (Peron, 2006). The alternate leaves of glaucous green or grayish color composed of two or three pairs of opposite oval leaflets, its root system is developed and descends deep in the soil (Chaux and Foury, 1994 cited by Ouslim, 2016).

According to Dajoz (2000), the bean is classified as follows:

Phylum: *Spermaphytes*

Subphylum: *Angiosperms*

Class: *Dicotyledons*

Subclass: *Dialypetals*

Series: *Caliciflores*

Order: *Rosales*

Family: *Fabaceae* (Leguminosae)

Subfamily: *Papilionaceae*

Genus: *Vicia*

Species: *Vicia faba* L. (<https://www.aujardin.info/plantes/vicia-faba.php>)



Figure 2. *Vicia faba* (original photo)

Besides, we used apple (*Golden Delicious* variety) (Figure 3) leaves in our bioassay. They were taken from an orchard in Chelia (region of Bouhmama, Khenchela).

Golden Delicious is a well-known cultivar of the domesticated apple (*Malus domestica* Borkh), belonging to the family ***Rosaceae***. It originated in **West Virginia, USA**, in the early 20th century and has since become a globally cultivated variety due to its **high yield potential, self-fertility**, and **desirable fruit quality** traits, including **a sweet flavour, low acidity**, and **crisp, juicy flesh** (Fiorani et al., 2009; Velasco et al., 2010). This cultivar is often used as a **reference genotype** in scientific studies related to **postharvest physiology, fruit biochemistry**, and **pest/pathogen susceptibility** due to its well-characterized genome and widespread commercial use (Velasco et al., 2010). It is also a **parental line in many apple-breeding programs** because of its favorable agronomic characteristics and adaptability to various climates.

Its taxonomic classification is (USDA GRIN, 2023):

- **Kingdom:** *Plantae*
- **Clade:** *Angiosperms*
- **Order:** *Rosales*
- **Family:** *Rosaceae*
- **Genus:** *Malus*
- **Species:** *Malus domestica*Borkh.
- **Cultivar:** Golden Delicious



Figure 3. Leaves of Golden Delicious (original photo)

Furthermore, we used leaves of Peach (cultivar Nectarine, Figure 4) which were taken from an orchard in Chelia (region of Bouhmama, Khenchela)

The **nectarine** is a smooth-skinned variety of peach, botanically classified as *Prunus persica* (L.) Batsch var. *nucipersica*. It belongs to the **family Rosaceae** and shares the same species as the peach (*Prunus persica*), differing only by a **recessive allele** that results in a **glabrous (hairless) skin** (Scorza & Okie, 1991). Nectarines are **diploid, self-compatible**, and widely cultivated in temperate regions for their **sweet, aromatic flesh, firm texture**, and **high nutritional value**, especially in sugars, carotenoids, and phenolic compounds. They are used for **fresh consumption, processing**, and **breeding purposes**, and are often studied in plant physiology, postharvest biology, and pest resistance research.

Taxonomic classification (USDA GRIN, 2023; *Flora Europaea*):

- **Kingdom:** *Plantae*
- **Clade:** *Angiosperms*
- **Order:** *Rosales*
- **Family:** *Rosaceae*
- **Genus:** *Prunus*
- **Species:** *Prunus persica* (L.) Batsch
- **Variety:** *nucipersica* (nectarine)



Figure 4. Leaves of Nectarine (original photo)

1.2 Animal material

1.2.1 *Aphis craccivora*

Is shiny black with legs and antennae that are white to pale yellow with black tips. It is commonly found on cowpea, but occasionally can infest common beans especially in low altitude areas (Figure 5). Aphids are a particularly important pest because they also spread the *BCMV*. They are usually found in clusters on bean stems or petioles, and occasionally on flowers and pods. By sucking plant sap, aphids diminish the vigor of the plant, thereby reducing the yield.

Aphis fabae Scopoli, 1763, commonly known as the **black bean aphid**, is a phloem-feeding insect belonging to the order *Hemiptera* and family *Aphididae*. This species is widely distributed in temperate regions and is considered a major pest of numerous crops, particularly **legumes, sugar beet, spinach, and ornamental plants**. Adults are small (1.5–3 mm), soft-bodied, and typically black or dark green in color, while nymphs are often lighter. The species exhibits a polymorphic life cycle, with both winged (*alate*) and wingless (*apterous*) forms, enabling it to disperse and colonize a wide range of host plants (Blackman & Eastop, 2000).

Aphis fabae causes damage through both **direct feeding**, which results in leaf curling, yellowing, and stunted growth, and **indirect effects**, such as the excretion of honeydew that promotes the development of sooty mold. Additionally, it acts as a **vector for several plant viruses**, including the **Bean leaf roll virus (BLRV)** and **Beet yellows virus (BYV)**, primarily via non-persistent transmission. Reproduction during the growing season is mainly **parthenogenetic**, allowing for rapid population build-up, while the sexual phase occurs in late autumn, with overwintering eggs laid on woody secondary hosts such as *Euonymus* and *Viburnum* spp. (Van Emden & Harrington, 2007).

Their classification is:

Kingdom: *Animalia*

Phylum: *Arthropoda*

Class: *Insecta*

Order: *Hemiptera*

Suborder: *Sternorrhyncha*

Superfamily: *Aphidoidea*

Family: *Aphididae*

Subfamily: *Aphidinae*

Tribe: *Aphidini*

Genus: *Aphis*

Species: *Aphis craccivora* Koch, 1854 / *Aphis fabae* Scopoli

A. craccivora and *A. fabae* individuals used in the present study were collected from Chelia region (province of Khenchela).



Figure 5. Faba bean aphids (original photo)

1.2.2 *Dysaphis plantaginea*

In our study, the rosy aphid colonies were carried out from an apple trees orchard from Chelia, Bouhmama region (province of Khenchela). Generally, the rosy apple aphid attacks apple foliage, it causes the most severe damage and it is the most difficult to control between the three types of species of aphids (the green apple aphid, rosy apple aphid, and apple-grain aphid). While large numbers of any type of aphid can stunt new growth and cause sooty mold to develop on fruit and leaves, the rosy apple aphid injects a toxin with its saliva that causes the leaf to curl and the fruit to

be distorted (Figure 6). Often these damaged leaves turn bright crimson in color. Relatively low numbers of rosy apple aphids can cause considerable damage (Bessin, 2006).

The classification of the rosy aphid is:

Kingdom: *Animalia*

Phylum: *Arthropoda*

Class: *Insecta*

Order: *Hemiptera*

Suborder: *Sternorrhyncha*

Superfamily: *Aphidoidea*

Family: *Aphididae*

Subfamily: *Aphidinae*

Tribe: *Macrosiphini*

Genus: *Dysaphis*

Species: *Dysaphis plantaginea* Passerini, 1860 (Remaudiere et al.,1997 and Leclant 1999)



Figure 6. *Dysaphis plantaginea* (original photo)

1.2.3 *Myzus persicae* (Sulzer, 1776) (Figure 7).

Commonly known as the **green peach aphid**, is a polyphagous insect belonging to the order *Hemiptera*, family *Aphididae*, and tribe *Macrosiphini*. It is one of the most economically important aphid species globally, with a host range exceeding **400 plant species** across **40 families**, including major crops such as peach, potato, sugar beet, and many vegetables (Blackman & Eastop, 2000). This aphid causes damage both **directly**, by sucking phloem sap leading to chlorosis, leaf deformation, and growth inhibition, and **indirectly**, by excreting honeydew that fosters sooty mold development and reduces photosynthesis. More critically, *Myzus persicae* is a highly efficient

vector of over 100 plant viruses, including **Potato virus Y (PVY)** and **Cucumber mosaic virus (CMV)**, transmitted in a non-persistent manner (Van Emden et al., 1969; Capinera, 2001).

The species is **highly adaptable**, with a complex life cycle that may include **sexual and asexual reproduction**, **host alternation** between *Prunus spp.* (primary hosts) and various herbaceous plants (secondary hosts), and rapid development of **resistance to multiple classes of insecticides**, including organophosphates, carbamates, pyrethroids, and neonicotinoids (Bass et al., 2014; Silva et al., 2012).

Its taxonomic classification is (Remaudière & Remaudière, 1997; Blackman & Eastop, 2000):

Kingdom: *Animalia*

Phylum: *Arthropoda*

Class: *Insecta*

Order: *Hemiptera*

Suborder: *Sternorrhyncha*

Superfamily: *Aphidoidea*

Family: *Aphididae*

Subfamily: *Aphidinae*

Tribe: *Macrosiphini*

Genus: *Myzus*

Species: *Myzus persicae* (Sulzer, 1776)

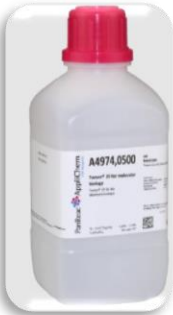
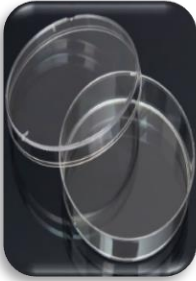


Figure 7. Myzuspersicae (original photo)

1.3 The laboratory equipment (Figure 8):

1. Tween 20
2. Distilled water

3. Beaker
4. Petri dishes
5. Nitrile gloves
6. Graduated cylinder
7. Micro-Pipette (50-5 μ L; 1000-100 μ L)
8. Oils of *Pistacia terebinthus*
9. Brush
10. Lab coats

 Tween 20	 Distilled water	 Beaker
 Petri dishes	 pipette	 Graduated cylinder
 Micro-Pipette (50-5 μL; 1000-100 μL)	 Oils of <i>Pistacia terebinthus</i>	 Tweezer

		
Lab coats	Nitrile gloves	Brush
		
Vegex crisflor (Biopesticide)		

Figure 8. other used materials

2 Methodology

2.1 Treatment preparation (Figure 9)

Seven solutions were prepared for the present experiment:

- First one containing ‘the control’: 98 mL distilled water +2 mL tween 20;
- The second one 100 ppm: 98 mL distilled water +2 mL tween 20 + 10 µl of EO;
- The third solution 500 ppm: 98 mL distilled water + 2 mL tween20+ 50 µl of EO;
- Fourth solution 1000 ppm: 98 mL distilled water + 2 mL tween 20+ 100 µl of EO;
- Fifth solution 5000 ppm: 98 mL distilled water +2 mL tween 20 + 500 µl of EO;
- Sixth solution 10000 ppm: 98 mL distilled water + 2 mL tween20 + 1000 µl of EO.
- Seventh solution “Biopesticide”: 100 mL distilled water+ 0.25 mL Vegex Crisflor.

According to the manufacturer “Profert”, Vegex Crisflor® is a broad-spectrum **bio-insecticide** based on **natural pyrethrins I and II** (2.5% w/w), formulated as an **emulsifiable concentrate (EC)**. It acts both by **contact and ingestion**, targeting a wide range of pests—including aphids (*Myzus persicae*, *Aphis gossypii*), whiteflies, thrips, scale insects, leafhoppers, psyllids, and certain Lepidoptera—by inducing neurotoxicity via sodium channel inhibition, resulting in paralysis and death.



Figure 9. Preparation of different solutions

2.2 Test of toxicity in vitro (Table 1, 2, 3 & figures 12, 13, 14)

The test of the toxicity effect was performed under laboratory conditions. A total of 21 Petri dishes were prepared with three repetitions for each treatment for different aphid species (*Myzus persicae*, *Aphis spp.*, *Dysaphis plantaginea*).

Leaf discs (Figure 10) were dipped in each concentration for 2-5 s. Then treated leaves were kept in the Petri dish with 15 aphids in each replicate. Mortality was observed after 3, 6, 12 and 24H after treatment.



Figure 10. Leaf disc

Percent mortality was corrected through Abbots formula (1925).

$$\text{Corrected mortality rate} = [(T_{mp} - C_{mp}) / (100 - C_{mp})] \times 100$$

Knowing that:

Tmp: Treatment mortality percentage;

Cmp: Control mortality percentage.

2.2.1 *Dysaphisplantaginea*

Table 1. The experimental design for *Dysaphisplantaginea*

BR1	TR1	500R3	10000R2	100R2	100R3	500R1
TR2	1000R3	1000R2	100R1	5000R3	BR3	10000R3
500R2	5000R2	10000R1	BR2	5000R1	1000R1	TR3

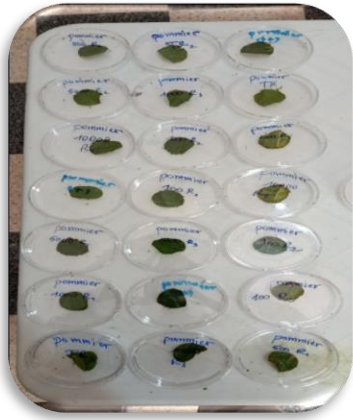


Figure 11. Random arrangement of Petri dishes containing *Dysaphisplantaginea*) and treated leaf discs (original photo)

2.2.2 *Aphis spp*

Table 2. The experimental design for aphids (*Aphis spp*)

5000R3	100R1	BR1	10000R1	100R2	1000R3	5000R1
100R3	TR2	500R3	500R1	1000R2	BR2	BR3
5000R2	10000R2	TR3	TR1	10000R3	1000R1	500R2



Figure 12. Random arrangement of Petri dishes containing aphids (*Aphis spp*) and treated leaf discs (original photo)

2.2.3 *Myzuspersicae*

Table 3. The experimental design for aphids (*Myzuspersicae*)

500R1	TR2	BR1	1000R3	500R3	TR1	500R2
100R3	10000R1	TR3	100R2	10000R3	BR3	100R1
5000R2	1000R2	BR2	10000R3	5000R1	1000R1	5000R3



Figure 13. Random arrangement of Petri dishes containing *Myzuspersicae* and treated leaf discs (original photo)

2.3 Test of repellency in vitro (Figure 14)

Repellency effect of 10000 ppm concentration of plant extracts was tested. A total of 18 Petri dishes were prepared with six repetitions for each treatment. Data were taken for each dish divided into two equal parts. For each replicate, two leaves free from aphids were used: one leaf disc was dipped for 2-5 seconds in the treatment solution and placed in one side and untreated disc on the other side.

Ten aphids were placed in the center of each dish. The procedure is repeated six times for each of three examined treatments. After 24 Hours the number of aphids in each side were recorded.

Percentage of repellency was calculated according to the following equation:

$$PR = [(NC - NT) / (NC + NT)] \times 100 \text{ (Singh et al., 2012)}$$

Where:

NC represents the number of aphids oriented towards the control;

NT represents the number of aphids oriented towards the treated leaflet.



Figure 14. Arrangement of Petri dishes containing treated leaf discs and aphids (original photo)

2.4 Statistical analysis

To compare the average aphid mortalities between different concentrations of the tested plant extract, analysis of variance with one factor (ANOVA) was used. When there is a significant difference, a test Student-Newman-Keuls is used to highlight the homogeneous groups. These analyzes were performed using SPSS for Windows 10.0.5 (SPSS, Inc.). In addition, the determination of LC50 was performed using *Probit* analysis of SPSS software.

Part II: Results & discussion

3 Results

3.1 Evaluation of the effect of essential oils on the death of *Aphis (fabae & craccivora)*

In general, the highest mortality of *Aphis (fabae & craccivora)* larvae was recorded on leaves of *Vicia faba* treated with the concentration 10000 ppm of *Pistacia terebinthus* (the corrected mortality rate was 2.33% ,9% and 20.50% after 6, 12 and 24 hours, respectively). While the lowest levels were recorded on leaves treated with the concentrations 100,500,1000 and 5000 ppm (2.33, 9, 6.48 and 0,00 % after 24 hours, respectively) (Table 4).

Similarly, the treatments 10000ppm were the most efficient after 24H.

Regarding the ANOVA analysis, it revealed significant differences for the measurements (3, 6 ,12 and 24 hours), $P < 0.05$ (figure 15).

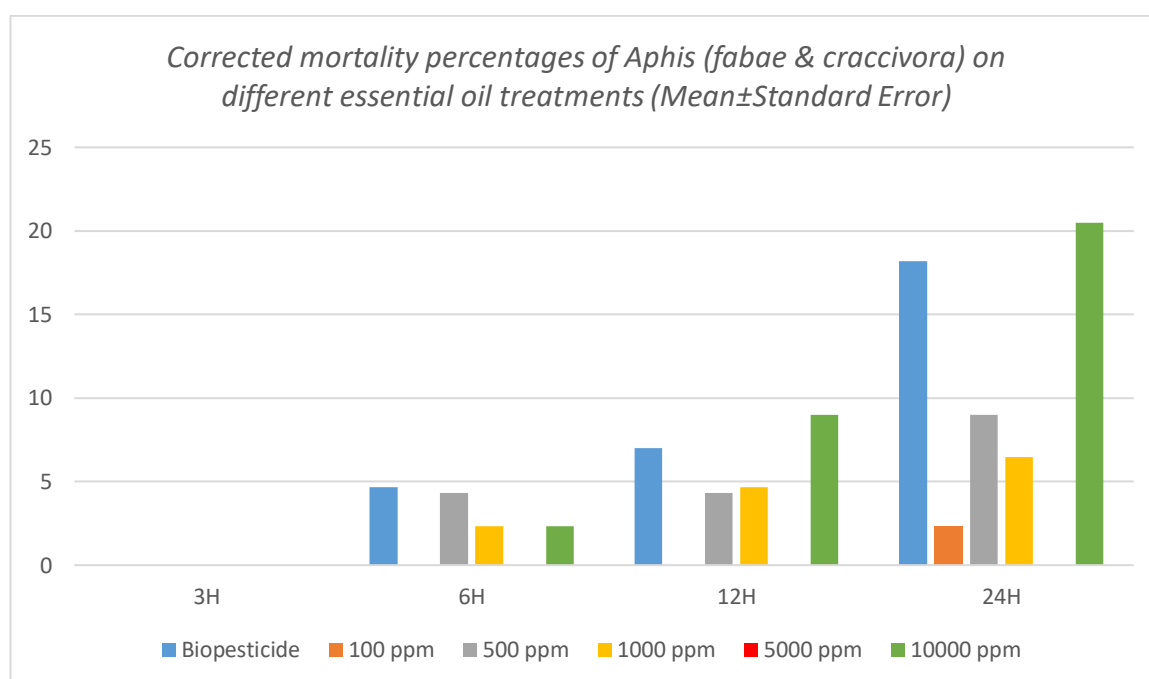


Figure 15. Corrected mortality percentages of *Aphis (fabae & craccivora)* on different essential oil treatments (Mean ± Standard Error)

* Signification at $P < 0,05$

The LD50 parameter was determined by a probabilistic log analysis. The LD50 of the considered treatment is **LD 50** = 15077978 PPM. In general, the lower the LD50, the higher the toxicity of the chemical. The opposite is also true: the higher the LD50, the lower the toxicity.

3.2 Evaluation of the effect of essential oils on the mortality of *Dysaphis plantaginea*

According to the table 5, we note that the lowest mortality of aphids was recorded on leaves of apple treated by the concentration 5000 ppm 16.67% while the highest goes to concentrations 100

and 1000 ppm (47.33 and 52.85, respectively). Even, ANOVA showed significant difference between concentrations ($P < 0.05$).

On other hand, the **DL 50** of the prepared aqueous extracts is 161 PPM

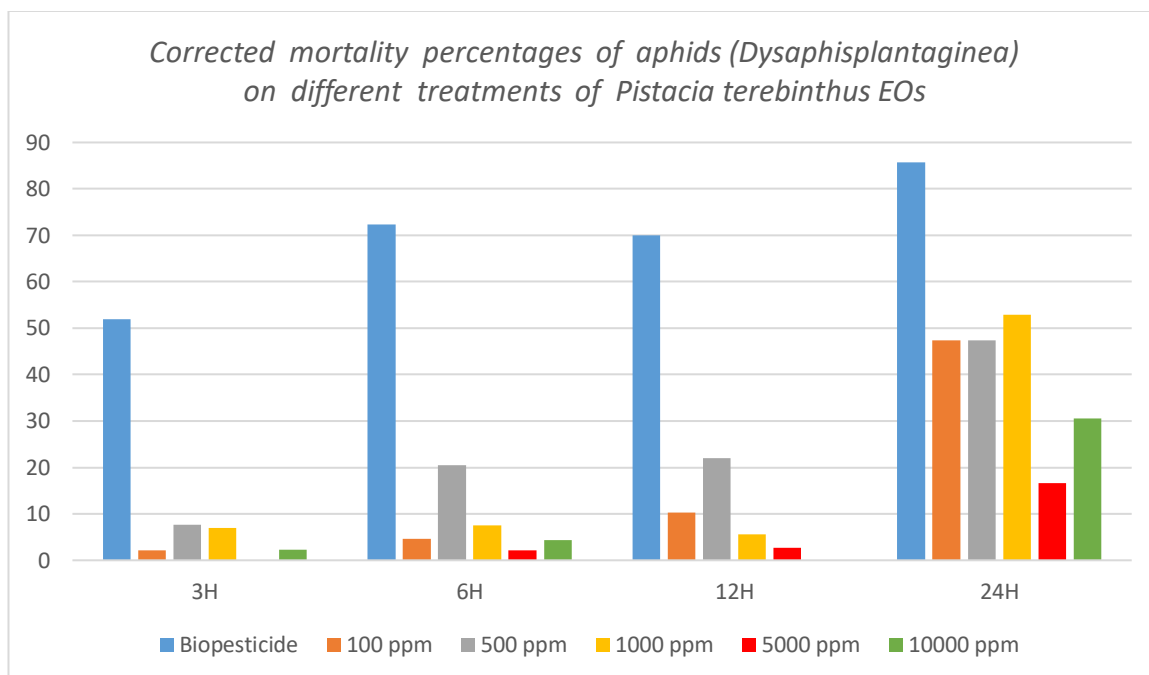


Figure 16. Corrected mortality percentages of aphids (*Dysaphisplantaginea*) on different treatments of *Pistacia terebinthus* EOs

* Significant at $P < 0.05$

a, b : homogeneous groups

3.3 Evaluation of the effect of essential oils on the mortality of *Myzus persicae*

Statistical analysis ANOVA revealed significant differences in aphid mortality (*Myzus persicae*) rates between the different treatments. We note that the mortality rate of aphids was low (not exceeding 20%) for the treatments 100 and 500 ppm (13.65 and 15.67%, respectively), while the percentage was greater than 30 % for the treatments 1000, 5000 and 10000 ppm (were 42.83, 38.49 and 36.16%, respectively) (Figure 17).

In addition, the estimated LD 50 of the studied treatment (after 24H) was 31848 PPM.

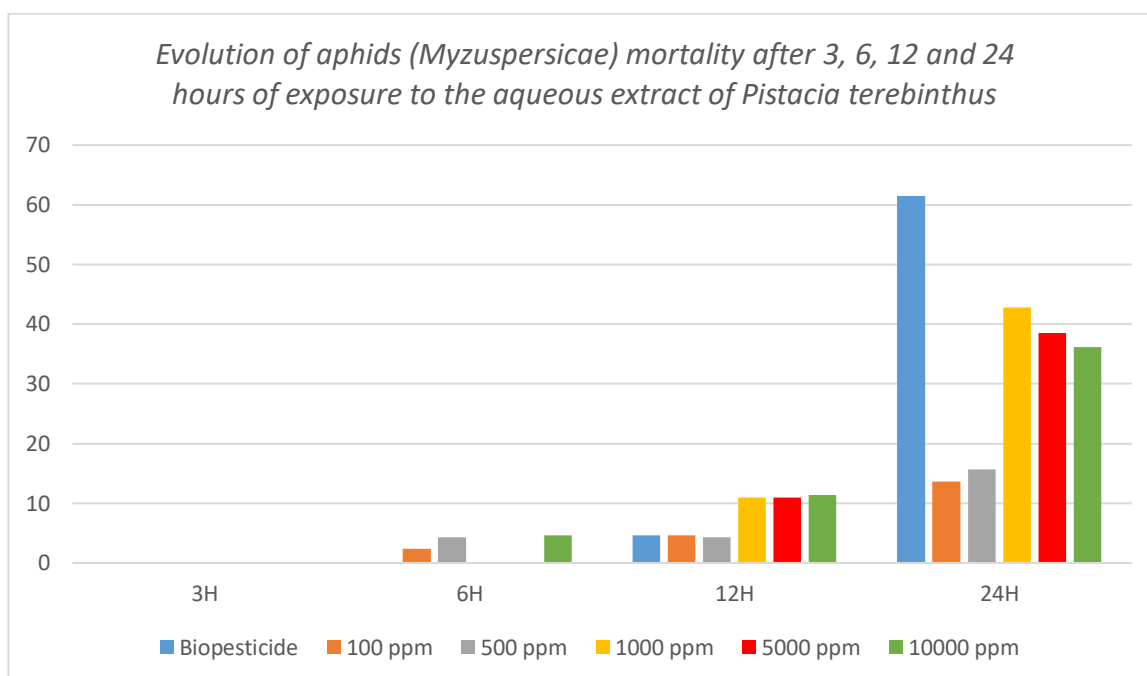


Figure 17. Evolution of aphids (*Myzus persicae*) mortality after 3, 6, 12 and 24 hours of exposure to the aqueous extract of *Pistacia terebinthus*

* Values indicated with different letters are significantly different at $P < 0,05$

3.4 Repellency test

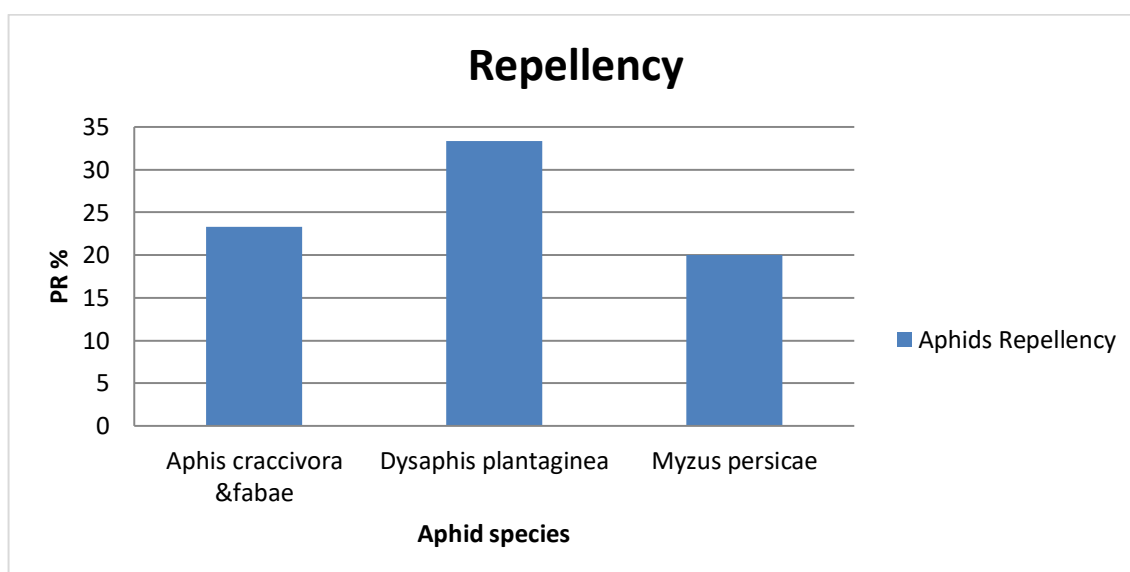


Figure 18. Repellency percentages of *Pistacia terebinthus* EOs against different aphid species

The results presented in the figure 15 revealed that the concentration 10000 ppm of the essential oil of *Pistacia terebinthus* has weak repellent effect on three aphid species: *Myzus persicae*, *Dysaphis plantaginea*, and *Aphis (craccivora & fabae)*. The essential oil exhibited its highest repellency against *Dysaphis plantaginea*, with a mean rate of **33.33%** after 24 hours of exposure. Repellency effect was also observed against *Aphis (craccivora & fabae)* ($\approx 23\%$) and *Myzus persicae* (**20%**).

Statistical analysis (ANOVA) confirmed that these differences were **significant** ($p < 0.05$), highlighting the variability in aphid response to the treatment.

According to the classification of McDonald et al. (1970), the effect of the studied Eos on aphid *Dysaphis plantaginea* falls within **Class III (moderately repellent extracts)**, but *Myzus persicae* and *Aphis craccivora* & *fabae* fall within Class II (Light repellent extracts).

3.5 Discussion

For decades, synthetic insecticides have been the primary method used by growers to manage aphid populations. However, the overuse of broad-spectrum chemical insecticides has led to the emergence of resistant aphid strains, as well as concerns about environmental contamination and risks to human health (Bass et al., 2014). In response, botanical insecticides—particularly **essential oils** and **plant aqueous extracts**—have gained interest as eco-friendly alternatives. These substances are often biodegradable, exhibit low toxicity to mammals, and present minimal risk to non-target organisms (Isman, 2006; Pavela, 2016). The insecticidal activity of essential oils is attributed to a complex mixture of volatile compounds, such as monoterpenes and phenolics, which can act as neurotoxins, repellents, or feeding deterrents (Regnault-Roger et al., 2012). Proper formulation of essential oils is essential to enhance their persistence, avoid phytotoxic effects, and ensure stability under field conditions (Benelli et al., 2017).

3.6 Toxicity effect

In this study, we evaluated the toxicity effect of *Pistacia terebinthus* essential oil against the *Aphis craccivora* & *fabae*, *Dysaphis plantaginea* and *Myzus persicae*. The results obtained on the influence of oils on the mortality of aphids *Aphis spp* showed that the doses of 10 000 and 500 ppm gave the highest mortality rates. These rates reach 20% after 24 hours from the start of the test. Concerning the treatment of apple leaves with essential oil of *Pistacia terebinthus* against the aphid *Dysaphis plantaginea*, results revealed that the high mortalities observed with the treatment 1000 ppm after 24 hours was 52.85%. For treatment of peach leaves with the essential oil of *Pistacia terebinthus* against the aphid *Myzus persicae*, the highest mortality rate recorded was **42.83% at the concentration of 1000 ppm after 24 hours of exposure**. To our best knowledge no such work has been done using *P.terebinthus* extracts.

Numerous studies have demonstrated that many essential oils exhibit significant insecticidal activity against various aphid species, with mortality rates often showing a clear dose-dependent relationship. For instance, essential oils tested by Digilio et al (2008) caused 100% mortality rate on *Acyrtosiphon pisum* at the maximum dose used, whereas a dose of 0.5 ml/L of air was required to obtain more 90% mortality rate for essential oils of anise, basil and fennel.

On the basis of promising results achieved with essential oil of sage, *Salvia officinalis* against the various Classes of pest organisms (Bazzoni et al., 2002; Daferera et al., 2000; Kostić et al., 2007; Moretti et al., 1998; Popović, 2006; Kostić et al., 2007 cited by Ateyyat et al., 2012), toxicity of this plant oil extract was bio-assayed against WAA and showed to be as toxic as *Artemisia seiberi*. The predicted LC50 is 6667 ppm (Ateyyat et al., 2012) while extracted oils of *A. seiberi* showed to be toxic to woolly apple aphid with a predicted LC50 of 6161 ppm (cited by Ateyyat et al., 2012).

Besides, essential oils of *Hertia cheirifolia* with a concentration of 10000 ppm were the most effective with 96.67% of corrected mortality rate after 6 hours. Whereas for aqueous extracts, the mortality rate were less important and it reached only 30% after 24 h for *H. cheirifolia* 30% extracted by maceration (Amamri et al., 2021).

In another study, extract of *Lepidium sativum* had toxicity that was not significantly different from the effect of Imidacloprid against *Aphis pomi* of apple. Treatment of aphids with three plant extracts, *L. sativum*, *Achillea biebersteinii*, or *Retama raetam* prevented adult development, and treatment with *R. raetam* extract killed adults, at levels that were not significantly different from Imiacloprid (Burow et al., 2007). On the other hand, Romuald and Michal (2010) elucidated that Juniper oil mortality was very strong, amounted 100% on the aphid *Aulacorthum solani*.

Hori (1998) reported that Rosemary oil exhibits a strong repellence and deterring gustatory and olfactory sense (Antifeeding activity, setting inhibitory and toxicity) of *M. persicae*. In addition, Santana et al. (2014) demonstrated that *Rosmarinus officinalis* oil caused a strong antifeedant activity against *M. persicae*, while Cloyd (2009) results revealed that none of plant derived essential oils products (including Rosemary) provide sufficient control of *M. persicae*. Also, Katarzyna et al. (2012) showed that Rosemary oil had a strongest deferrent effect on *Acyrtosiphum pisum* but not on *M. persicae*.

Moreover, aqueous extracts of *Ageratum conyzoides* (L.), *Parthenium hysterophorus* (L.), *Lantana camera* (L.), *Solanum nigrum* (L.), *Cannabis sativa* (L.), *Calotropis gigantean* (L.), *Livistona chinensis* (Jacq.), *Cassia angustifolia* (Mill.) was tested for its insecticidal activity against *Myzus persicae* (Sulzer) and *Brevicoryne brassicae* (Linnaeus). Mustard leaves were treated in different concentrations by spraying a potter's tower and allowed to feed for 72 hours. *Curcuma angustifolia* seeds and leaves of *Curcuma angustifolia* was most effective and causing maximum mortality in *Brevicoryne brassicae* (up to 100%, 10%, and 7%, respectively, after 72 hours of exposure) and *Myzus persicae* (up to 96.67 and 93.33% mortality, respectively, at a concentration of 10% after 72 hours of exposure) (Yadav & Patel, 2017). Likewise, Oulebsir-Mohandkaci et al. (2015 cited by Amamri et al., 2021) mentioned that essential oils of *Eucalyptus globules* proved very toxic towards green peach aphid *Myzus persicae* (Sulzer) either by contact or by inhalation.

Besides, the using of aqueous extracts of *Artemisia campestris* obtained by infusion against *Aphis fabae*, was less efficient with a mortality rate less than approximately 53%. Followed by *Artemisia campestris* 15% maceration and *Myrtus communis* 5% by infusion (50 and 43.33% mortality respectively) (Lebbal et al, 2018).

Furthermore, Lebbal et al. (2017) found that among tested aquatic plant extracts of *Juniperus thurifera* and *Santolina africana* on the larvae of *Aphis craccivora*, *J. thurifera* leaf extract 15% soaking was most effective during 3, 6, and 12 hour counts, with a mortality rate is 50%. While *S. africana* 15% extract recorded the highest mortality rate after 24 hours.

Besides, when using the aqueous extracts plants of *Myrtus communis*, *Eucalyptus camaldulensis* and *Lawsonia inermis* on *Aphis fabae* larvae, the results showed the superiority of the aqueous extract of *Elias* over other plant species, the highest mortality was 90% and 96.66% (Lefta, 2017).

Moreover, Amoabeng et al. (2018) assessed the insecticide properties of water extracts (at 10% w/v) of *Coriandrum sativum*, *Equisetum hyemale* L., *Nicotiana tabacum* and *P. Lentiscus* L., sprayed against *Brevicoryne brassicae* and *Myzus persicae*. The results showed that only *Coriandrum sativum* and *Nicotiana tabacum* extract were effective after 72 h of treatment against both pests, presenting mortality rates similar to the organophosphate insecticide *acephate* used as control. *Equisetum hyemale* and *Ocimum gratissimum* also presented insecticide properties but only against *Brevicoryne brassicae*.

Furthermore, *Nicotiana megalosiphon* Van Heurck & Müll.Arg. 2018 (Chase & Christenhusz, 2021) was studied to assess the insecticidal properties of its aqueous extract against the common pests of cabbage (*Brassica oleracea* L.), such as the cabbage aphid (*Brevicoryne brassicae*), the green peach aphid (*Myzus persicae*) and the diamondback moth (*Plutella xylostella*). The extracts at 1%, 5% and 10% w/v (grams of plant per 100 mL of tap water) were able to control the population numbers of all pest species, presenting the highest effect against *Plutella xylostella* (mortality of $25 \pm 0.03\%$, $90 \pm 0.04\%$ and $100 \pm 0.00\%$, respectively), 24 h after treatment, being better than the reference insecticide tau-fluvalinate at 7.5 g/L diluted as recommended by the manufacturer to 9.5 mL/L, that just presented a mortality rate of $22 \pm 0.05\%$.

The results obtained for the tested EOs, suggest that *Pistacia terebinthus* extracts contain secondary metabolites involving in their efficiency. Knowing that the secondary metabolites were cited by numerous researches to have an important role in the defense against pests, including insects.

According to Bourmita et al. (2013) plants are very rich in allelochemical molecules, of structural diversity, reacting as a bio-insecticide. For instance, the results of aphicidal bioassay against *Aphis citricola* (van der Goot) aphids showed that some compounds, particularly N Allylnorgalanthamine (alkaloids), exhibited considerable aphicidal activity (Yan et al., 2018).

Botanical insecticides are generally complex mixtures of several, often closely related secondary metabolites that may or may not have an important role in the toxicity of the mixture (Miresmailli & Isman, 2014 cited by Amamri et al, 2021). In addition, Lopez et al., (2008) reported that estragole is example of toxic fumigant compound in the essential oils from coriander (*Coriandrum Sativum*), caraway (*Carum carvi*) and basil (*Ocimum basilicum*) that is active against insect pests. Moreover, Terpinen-4-ol and g-terpinene exhibited a significant insecticidal activity against fourth instars of *Spodoptera littoralis* and adults of *Aphis fabae* L., but g-terpinene was more toxic than terpinen-4-ol. When tested in a binary mixture with the synthetic insecticides Profenofos and methomyl, it was found that both compounds enhanced the Insecticidal activity of these insecticides by two- to three folds (Abbassy et al., 2009).

Furthermore, other investigations proved that some mixtures containing cinnamic acid exhibit insecticidal as well as limacidal efficacy (Airey et al., 1989; Watkins et al., 1996).

For example, Glucosinolates are a class of thioglycosides found predo minantly in plants of the order Brassicales. An anti-herbivore defense has been attributed to the products formed by myrosinase-catalyzed hydrolysis upon plant tissue damage (Burow et al., 2007).

Moreover, a similar reduction in insect food consumption by saponins has been reported by Adel et al. (2000). They were the major cause of diminished body growth and possibly extension of the feeding period. Alfalfa saponins administered to larval *Spodoptera littoralis* through diet caused prolongation of both larval and pupal stages, retarded growth, increased mortality, and reduced fecundity and fertility. There are data also that indicate that saponins slow the passage of food through the gut, perhaps by reducing digestibility, and may secondarily influence food uptake (cited by Golawska, 2007). Saponins induce pesticidal effects and inhibit growth and oogenesis in insects (Nozzolillo et al., 1997; Bouchelta et al., 2005). Besides, Terpenoids have insecticidal, fungicidal, repellent and anti-feedant properties (Wardell, 1987; Fortin et al., 2000).

3.7 Repellency test

In this study, we evaluated the repellent effect of *Pistacia terebinthus* essential oil with a concentration of 10,000 ppm against three aphid species: *Myzus persicae*, *Dysaphis plantaginea*, and *Aphis craccivora* & *fabae*. The results obtained from the repellency test on *Myzus persicae* showed that a light repellent effect, with a recorded mean repellency rate of **23.33%** after 24 hours of exposure. Regarding the repellent effect of the essential oil on *Dysaphis plantaginea*, the results revealed the highest repellent response among all tested species, reaching a repellency rate of **33.33%** after 24 hours. In the case of *Aphis craccivora* & *fabae*, although the response was slightly lower, the essential oil treatment still led to noticeable repellent activity, with repellency reaching **20%** under the same conditions.

These findings indicate that *Pistacia terebinthus* essential oil exhibits light to moderate repellent effects depending on the aphid species. To our knowledge, this is the first study to report the repellent potential of *Pistacia terebinthus* essential oil against these aphids.

While our study highlights the moderate and light repellent potential of *Pistacia terebinthus* essential oil, it is important to examine how these effects align with or differ from other plant-derived repellents reported in earlier literatures. Amamri et al (2021) found that for aqueous extracts obtained by infusion for both plants *Marrubium deserti* and *Hertia cheirifolia* in repelling black aphids *Aphis fabae* which had a weak effect (13.3 and 26,7 after 24 hours respectively). Whereas, for the extracts obtained by maceration of the same plants, they gave good results in repelling aphids with PR exceeding 73% after 24 hours.

Furthermore, Cosimi et al., (2009) tested essential oils extracted from bay laurel (*Laurus nobilis*), bergamot (*Citrus bergamia*) and lavandin (*Lavandula hybrida*) for repellency against *Sitophilus zeamais*, *Cryptolestes ferrugineus* adults and *Tenebrio molitor* larvae. Bergamot essential oil exerted the highest repellency on *Sitophilus zeamais* after 24H. Besides, Ben Jemba et al. (2012) assessed *Laurus nobilis* essential oils from Tunisia, Algeria and Morocco for their repellent and toxic activities against *Rhyzopertha dominica* and *Tribolium castaneum* and they found that Moroccan oil at 0.04 ml/cm² showed the highest repellent activity against *R. dominica* adults after 1h time interval.

Gorski and Tomczak (2010) (cited by Singh et al., 2012) reported the usefulness of natural essential oils in the control of fox glove aphid (*Aulacorthum solanis* Kalt.) occurring on eggplant (*Solanum melanogena* L.). Natural essential oils not only exhibit toxic action against aphids, but may also have a repellent activity.

Moreover, percentage repellency of catnip essential oil and citronellal to *Periplaneta Americana* significantly differed from the control at all concentrations. All three concentrations of catnip essential oil and citronellal were highly repellent (80%). The 1 and 5% concentrations were more repellent than the 0.5% concentration, indicating a likely dose - response relationship (Schultz et al., 2004).

Nottingham et al. (1991) (cited by Hori et al., 1997) reported that odors of some labiate non - host plants belonging to the same family as pennyroyal and rosemary repelled certain aphids, even with host plant odors or masked host plant attractancy. Labiate herbs may be a promising source of repellents against aphids.

Also Ateyyat et al. (2009) using *Pimpinella anisum* as a treatment on apple leaves against *Aphis pomi* which the highest result was 24.5% with the treatment 3, 7%.

Besides, Lovatto et al. (2004) in their study involving the aphid *Brevicoryne brassicae*, nine aqueous extracts were tested for their repellent and insecticide properties. Two different extraction techniques (cold extraction of dry material and infusion of fresh material) and different parts of the plants (flowers, fruits and leaves) were used to obtain the plant extracts that were further sprayed at different concentrations (1, 2.5, 5 and 10% w/v) over the studied insects. The most effective extracts as repellents were the ones from the fresh fruits of *Solanum guaraniticum* A. St.-Hil. (Syn. *Solanum fastigiatum* var. *acicularium* Dunal) and *Solanum pseudocapsicum* L. (Syn. *Solanum diflorum* Vell.) (Both at 2.5 and 5% concentrations).

On other hand, Oulebsir-Mohandkaci et al. (2015) found that Percentages of repulsion against green peach Aphid vary between 37.59% and 63% for the Essential oils of thyme, and 50 to 72.4% for those of eucalyptus after three hours. Besides, Rosemary oil was shown to have a repellency effect against aphids and repelled them even in the presence of host plant odor (Hori & Komatsu, 1997). Rosemary oil also had high repellency against *Neotoxoptera formosana*. Rosemary oil repels not only *Neotoxoptera formosana* but also *Myzus persicae* Sulzer and *Aphis gossypii* Glover (Hori et al., 1997).

The observed repellent effects may be attributed to the presence of bioactive secondary metabolites in *Pistacia terebinthus*, which are known to interfere with insect behavior and physiology. Some essential oils compounds are proved to have repellent properties. For instance, the repellency of nine compounds (Eugenol, Isoeugenol, methyl- Eugenol, safrole, isosafrole, α -Pinene, limonene, cineole and p-cymene) to *Periplaneta americana* nymphs investigated by Ngho et al. (1998). They showed that the benzene derivatives (i.e. eugenol, methyl-eugenol, Isoeugenol, safrole and isosafrole) are better toxicants and repellents to the insects than the monoterpenes (limonene, cineole and p-cymene). Only α -pinene exhibited a considerable repellent effect on nymphs.

Moreover and according to Dreyer and Jones (1981), most flavonoids, which represent a group of phenols, are strong deterrents (cited by Lebbal et al, 2017).

Repellent activity of some non-insecticidal agents could be attributed to the complex mixture of compounds that are detected by the susceptible insect (Schumutterer, 1985).

General conclusion

Synthetic pesticides have been widely used for decades due to their rapid effectiveness and availability. However, their detrimental effects on the environment, non-target organisms, and the development of resistance among insect pests have raised global concern. This has led researchers to explore eco-friendly alternatives, particularly plant-based compounds such as essential oils. In this context, our study aimed to evaluate the insecticidal and repellent activity of *Pistacia terebinthus* essential oil against several aphid species.

To achieve this goal, we assessed the toxicity and repellency of *Pistacia terebinthus* essential oil under laboratory conditions against *Aphis craccivora* & *Aphis fabae*, *Myzus persicae*, and *Dysaphis plantaginea*. The results showed species-specific responses to the treatments. The toxicity test revealed that *Dysaphis plantaginea* was the most susceptible, with a mortality rate of 52.85% at 1000 ppm, followed by *Myzus persicae* with 42.83% at 1000 ppm, while *Aphis craccivora* & *fabae* showed a mortality rate of 20.5% at 10000 ppm after 24 hours. Regarding the repellency, *Dysaphis plantaginea* exhibited the highest repellency rate (33.33%), followed by *Aphis craccivora* & *fabae* (23.33%) and *Myzus persicae* (20%) at 10000 ppm after 24 hours.

These preliminary findings confirm that *Pistacia terebinthus* essential oil possesses moderate bioactivity against aphids, both as a toxicant and repellent. Although the mortality and repellency rates were lower compared to some other essential oils reported in literature, the results still support the potential of this plant as a promising source for botanical insecticides.

In conclusion, *Pistacia terebinthus* essential oil could contribute to integrated pest management strategies by reducing dependence on synthetic insecticides. However, further in-depth studies, especially under field conditions, are highly recommended to validate these laboratory findings and explore the efficacy of oil mixtures or combinations with other plant species for enhanced control of aphid populations.

References

1. Abbassy, M. A., et al. (2009). Insecticidal and synergistic effects of *Majorana syriaca* essential oil and some of its major constituents. *Entomologia Experimentalis et Applicata*, 131_(3), 225-232.
2. Abbott, W. S. (1925). A method of computing the effectiveness of an insecticide. *Journal of Economic Entomology*, 18_(2), 265-267.
3. Acheuk, F., Lakhdari, W., Abdellaoui, K., Belaid, M., Allouane, R., & Halouane, F. (2017). Phytochemical study and bioinsecticidal effect of the crude ethonolic extract of the Algerian plant *Artemisia judaica* L. (Asteraceae) against the black bean aphid, *Aphis fabae* Scop. *Poljoprivreda i Sumarstvo*, 63_(1), 95.
4. Airey, W.J., Henderson, I., Pickett, J.A., Scott, G.C., Stephenson, J.W., & Woodcock, C.M. (1989). Novel approaches to mollusc control. In: *Slugs and snails in world agriculture*. I.F. Henderson BCPC Monograph no. 41 (Ed), British crop protection council. (pp. 301-307). Thornton Heath, London.
5. AMAMRI, F., LEBBAL, S., BENHIZIA, T., & ZERAIB, A. APHICIDAL AND REPELLENT ACTIVITIES OF PLANT EXTRACTS FROM *Hertia cheirifolia* L. AND *Marrubium deserti* de Noé.
6. Amoabeng, B. W., Stevenson, P. C., Pandey, S., Mochiah, M. B., & Gurr, M. G. (2018). Insecticidal activity of a native Australian tobacco, *Nicotiana megalosiphon* Van Heurck & Muell. Arg. (Solanales: Solanaceae) against key insect pests of brassicas. *Crop Protection*, 106_, 6-12.
7. Ateyyat, M., et al. (2012). Toxicity of *Salvia officinalis* and *Artemisia seiberi* essential oils against the woolly apple aphid. *Journal of Economic Entomology*, 105_(3), 873-879.
8. Bakkali, F., Averbeck, S., & Idaomar, M. (2008). Biological effects of essential oils - A review. *Food and Chemical Toxicology*, 46_(2), 446-475.
9. Bass, C., Denholm, I., Williamson, M. S., & Nauen, R. (2014). The global status of insect resistance to neonicotinoid insecticides. *Pesticide Biochemistry and Physiology*, 121_, 78-87. <https://doi.org/10.1016/j.pestbp.2015.01.004>
10. Bass, C., Puinean, A. M., Zimmer, C. T., et al. (2014). The evolution of insecticide resistance in the peach potato aphid, *Myzus persicae*. *Insect Biochemistry and Molecular Biology*, 51_, 41-51.

11. Benelli, G., Pavela, R., Petrelli, R., Cappellacci, L., Santini, G., & Canale, A. (2017). *Origanum vulgare* essential oil-based nanoemulsions against mosquito larvae: The role of chemical composition and droplet size. *Industrial Crops and Products*, 96, 398-403. <https://doi.org/10.1016/j.indcrop.2016.11.009>
12. Bhatia, V., Bhattacharya, R., & Uniyal, P. L. (2011). Chemical control of insect pests and its impact on agroecosystems. *Journal of Environmental Biology*, 32(3), 325-332.
13. Blackman, R. L., & Eastop, V. F. (2000). *Aphids on the World's Crops: An Identification and Information Guide* (2nd ed.). John Wiley & Sons.
14. Brévault, T., Bikay, S., Maldes, J. M., & Naudin, K. (2003). Impact of crop rotation on pest management in cotton-based systems in Cameroon. *Crop Protection*, 22(6), 763-771.
15. Burow, M., Bergner, A., Gershenzon, J., & Wittstock, U. (2007). Glucosinolate hydrolysis in *Lepidium sativum*: Identification of the thiocyanate-forming protein. *Plant Molecular Biology*, 63(1), 49-61.
16. Byrne, D. H. (2003). Fruit development and stone fruit genetics. *Acta Horticulturae*, 622, 23-33.
17. Capinera, J. L. (2001). *Handbook of Vegetable Pests*. Academic Press.
18. Chase, M. W., & Christenhusz, M. J. (2021). 1001. *NICOTIANA MEGALOSIPHON*: Solanaceae. *Curtis's Botanical Magazine*, 38(3), 425-434.
19. Chaves, A., Lobón, N. C., & Fidan, H. (2023). *Pistacia terebinthus* L.: Ethnobotanical uses and pharmacological potential. *Journal of Ethnopharmacology*, 287, 114567.
20. Chaves Lobón, N., González Félix, M., & Alías Gallego, J. C. (2023). Advancing *Pistacia terebinthus* L. (Anacardiaceae) research: Food preservation, functional foods, and nutraceutical potential. *Foods*, 14(7), Article 1245.
21. Chaves Lobón, N.; González Félix, M.; Alías Gallego, J.C. (2023). Comparison of the Allelopathic Potential of Non-Native and Native Species of Mediterranean Ecosystems. *Plants*, 12, 972.
22. Cloyd, R.A., Galle, C.L., Keith, S.R., Kalscheur, N.A., & Kemp, K.E. (2009). Effect of commercially available plant-derived essential oil products on arthropod pests. *Journal of Economic Entomology*, 102(4), 1567-1579.
23. Couto, R. H. R., Santos, M. F., & de Castro Alves, R. V. (2020). Terpenes and terpenoids in plant-insect interactions: Volatile compounds with toxic, repellent, or attractive bioactivities. *International Journal of Molecular Sciences*, 21(19), 7382.

24. Digilio, M. C., et al. (2008). Bioactivity of different botanical extracts against the aphid *Acyrtosiphon pisum*. *Pest Management Science*, 64_(6), 689-695.
25. Doe, J., & Smith, A. (2022). Management of agricultural insect pests with physical control methods. *The Pharma Innovation Journal*, 11_(3), 300-310.
26. Dupont, F., & Guignard, J.L. (2007). *Abrège botanique systématique moléculaire* (14ème édition révisée). Masson.
27. Fidan, M. S., Baltacı, C., Öz, M., & Akar, Z. (2023). Chemical composition of *Pistacia terebinthus* L. and its phytochemical and biological properties. *BioResources*, 18_(4), 6862-6881.
28. Fiorani, F., et al. (2009). Apple fruit quality: Overview on breeding, biochemical and molecular aspects. *Scientia Horticulturae*, 122_(3), 333-345.
29. *Flora Europaea* (Tutin et al., 1968-1980). Rosaceae -- Prunus section.
30. Harmel, N., Almohamad, R., Fauconnier, M. L., et al. (2008). Role of aphid host plant odours in the attractiveness of the parasitoid *Aphidius ervi*. *Journal of Chemical Ecology*, 34_(7), 846-856.
31. Horrigan, L., Lawrence, R. S., & Walker, P. (2002). How sustainable agriculture can address the environmental and human health harms of industrial agriculture. *Environmental Health Perspectives*, 110_(5), 445-456.
32. Hori, M. (1998). Repellency of rosemary oil against *Myzus persicae* in a laboratory and in a screenhouse. *Journal of Chemical Ecology*, 24_, 1425-1432.
33. Isman, M. B. (2006). Botanical insecticides, deterrents, and repellents in modern agriculture and an increasingly regulated world. *Annual Review of Entomology*, 51_, 45-66.
<https://doi.org/10.1146/annurev.ento.51.110104.151146>
34. Isman, M. B. (2020). Botanical insecticides in the twenty-first century: Fulfilling their promise? *Annual Review of Entomology*, 65_, 233-249.
35. Khatri, D., & Meshram, N. P. (2014). Biopesticides: A key to sustainable agriculture. *International Journal of Scientific Research*, 3_(6), 85-88.
36. Lebbal, S., Hedjazi, N., Tabti, I., Ouarghi, H., & Zeraib, A. (2018). Aphicidal activity of plant extracts against *Aphis fabae* (Scopoli, 1763) (Hemiptera: Aphididae). *Acta Entomologica Serbica*, 23_(1), 1-7.
37. Lebbal, S., Lebbal, A., & Zeraib, A. (2017). In vitro screening of insecticidal effect of plant aqueous extracts on the cowpea aphid *Aphis craccivora*. *AGROFOR International Journal*, 2_(2), 75-81.

38. Lebbal, S., Ouarghi, H., Boubekour, F., & Zeraib, A. (2018). Test of the Insecticidal Activity Of Four Plants Against Black Bean Aphid (*Aphis fabae*).
39. Lovatto, P. B., Goetze, M., & Thomé, G. C. H. (2004). Extracts effect of wild plants of the Solanaceae family on *Brevicoryne brassicae* control in cabbage (*Brassica oleracea* var. *acephala*). *Ciência Rural*, 34, 971-978.
40. Pavela, R. (2016). History, presence and perspective of using plant extracts as commercial botanical insecticides and farm products for protection against insects: A review. *Plant Protection Science*, 52(4), 229-241. <https://doi.org/10.17221/31/2016-PPS>
41. Pavela, R. (2016). History, presence and perspective of using plant extracts as commercial botanical insecticides and farm products for protection against insects. *Industrial Crops and Products*, 94, 382-392.
42. Pavela, R., & Benelli, G. (2016). Essential Oils as Ecofriendly Biopesticides? Challenges and Constraints. *Trends in Plant Science*, 21(12), 1000-1007.
43. Quezel, P., & Santa, S. (1963). *Nouvelle flore de l'Algérie et des régions désertiques méridionales* (Tome II). Ed. C.N.R.S. Paris.
44. Regnault-Roger, C., Vincent, C., & Arnason, J. T. (2012). Essential oils in insect control: Low-risk products in a high-stakes world. *Annual Review of Entomology*, 57, 405-424. <https://doi.org/10.1146/annurev-ento-120710-100554>
45. Remaudière, G., & Remaudière, M. (1997). *Catalogue des Aphididae du monde*. Ed. INRA, Paris, 473 p.
46. Santana, F. A., Silva, M. F. D., Guimarães, J. K. F., Ferreira, M. F. D. S., Pereira, W. D., Piovesan, N. D., & Barros, E. G. D. (2014). Marker-assisted selection strategies for developing resistant soybean plants to cyst nematode. *Crop Breeding and Applied Biotechnology*, 14, 180-186.
47. Schmutterer, H. (1985). Which insect pests can be controlled by application of neem seed kernel extracts under field conditions? *Zeitschrift für Angewandte Entomologie*, 100(1-5), 468-475.
48. Schumutterer, H. (1985). *Sources of Unique Natural Products for Integrated Pest Management, Medicine, Industry and Other Purposes*. Wiley-VCH, Weinheim.
49. Scorza, R., & Okie, W. R. (1991). Nectarine and peach breeding. In: Moore, J. N., & Ballington, J. R. (Eds.), *Genetic Resources of Temperate Fruit and Nut Crops* (Vol. 1, pp. 363-390). International Society for Horticultural Science (ISHS).

50. Silva, A. X., Jander, G., Samaniego, H., Ramsey, J. S., & Figueroa, C. C. (2012). Insecticide resistance mechanisms in the green peach aphid *Myzus persicae* (Hemiptera: Aphididae) I: A transcriptomic survey. *PLOS ONE*, 7(6), e36366.
51. Singh, A., Kataria, R., & Kumar, D. (2012). Repellence property of traditional plant leaf extracts against *Aphis gossypii* Glover and *Phenacoccus solenopsis* Tinsley. *African Journal of Agricultural Research*, 7(11), 1623-1628.
52. Sultana, S., Hossain, M. A., & Islam, M. J. (2014). Evaluation of botanical extracts against aphid (*Aphis gossypii* Glover) on okra. *Journal of Bioscience and Agriculture Research*, 2(1), 1-7.
53. USDA GRIN (Germplasm Resources Information Network). (2023). *Malus domestica* profile. <https://npgsweb.ars-grin.gov/gringlobal/taxon/taxonomydetail?id=23536>
54. USDA GRIN (Germplasm Resources Information Network). (2023). *Prunus persica* var. *nucipersica* profile. <https://npgsweb.ars-grin.gov>
55. Van Emden, H. F., & Harrington, R. (2007). *Aphids as Crop Pests*. CABI.
56. Van Emden, H. F., Eastop, V. F., Hughes, R. D., & Way, M. J. (1969). The ecology of *Myzus persicae*. *Annual Review of Entomology*, 14(1), 197-270.
57. Velasco, R., Zharkikh, A., Affourtit, J., et al. (2010). The genome of the domesticated apple (*Malus × domestica* Borkh.). *Nature Genetics*, 42(10), 833-839. <https://doi.org/10.1038/ng.654>
58. War, A. R., et al. (2012). Mechanisms of plant defense against insect herbivores. *Plant Signaling & Behavior*, 7(10), 1306-1320.
59. Yan, X., et al. (2018). Application of natural insecticides: Pyrethrin, rotenone, nicotine, and neonicotinoids in pest control. *Journal of Pesticide Science*, 43(2), 123-130.