DEMOCRATIC AND POPULAR ALGERIAN REPUBLIC

MINISTRY OF HIGHER EDUCATION AND SCIENTIFIC RESEARCH

ECHAHID HAMMA LAKHDAR UNIVERSITY OF EL-OUED

FACULTY OF NATURAL LIFE AND SCIENCES

DEPARTMENT OF Agronomy

Master's Thesis

In order to obtain a diploma of an Academic Master In agricultural sciences

Major: Plant Production

Theme

Exploring potassium soap as an eco-friendly alternative for insect pest control

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Academic Year 2025–2026

إهداء

إلى أول فريق انتميت إليه دون اختيار: عائلتي، أبي وأمي، صانعي أولى بطولاتي في الحياة .

أخوتي، زملاء الدرب في دوري الأيام الصعبة والممتعة.

إلى قمري البعيد الذي أستدل بنوره كلما تاهت روحي في ليالي التعب.

إلى ريال مدريد، الفريق الذي علمني أن لا مستحيل مع الطموح، وأن الأمل دائما موجود مادامت الصافرة لم تسمع.

وإلى الأساطير الذين جعلو التحدي فناً : كريستيانو رونالدو، حيث الشغف يصنع الاستمرارية. رافاييل نادال، حيث القتال حتى النقطة الأخيرة.

إلى كل هؤلاء، أهدي كلماتي، كما تهدي الرياح أسرارها للبحر، وكما تهدي النجوم نورها لسماء الحالمين.

سناء

شكر وتقدير

الحمد لله أولًا وآخرًا، الذي بنعمته تتم الصالحات، والذي وفقني لإتمام هذا العمل المتواضع.

أتقدم بخالص الشكر والتقدير إلى أستاذي المشرف **محفوظ باباو اسماعيل** ، على توجيهاته القيّمة، ونصائحه العلمية السديدة، ومتابعته المستمرة طوال مراحل إنجاز هذه المذكرة.

كما أتوجه بالشكر الجزيل إلى أعضاء لجنة المناقشة الموقرة على تفضلهم بقراءة هذا العمل وتقييمه، وإلى جميع أساتذة قسم العلوم الفلاحية الذين ساهموا في تكويني العلمي خلال سنوات الدراسة.

ولا يفوتني أن أتقدم بالشكر إلى كل من ساعدني من قريب أو بعيد في إنجاز هذا البحث، سواء بالدعم العلمي أو التقني أو المعنوي.

وفي الأخير، أسأل الله أن يجعل هذا العمل خالصًا لوجهه الكريم، وأن ينفع به كل من يطلع عليه.

Abstract

The present study aimed to evaluate the effectiveness of four types of potassium soap (vegetable oil-based, olive oil-based, neutral pH, and low pH) against the cotton aphid *Aphis gossypii Glover* under laboratory conditions, as well as to investigate the level of awareness and commercialization of this product in the El Oued region through a field survey. Laboratory experiments were carried out using four concentrations (0.00%, 0.5%, 1%, and 5%) with three replicates for each concentration (10 aphids per replicate), and mortality rates were recorded after 48 hours. The lethal concentrations LC_{50} and LC_{90} were calculated using probit analysis. A survey was distributed to 37 participants representing agricultural pesticide shops and import companies in El Oued. The laboratory results showed that potassium soap formulated with vegetable oils (SVO and SOO) exhibited high effectiveness against aphids, with LC_{50} values of 0.409% and 0.431%, respectively. The third type (neutral pH) was practically ineffective (LC_{50} = 106.267%), while the fourth type (low pH) showed moderate effectiveness (LC_{50} = 2.067%). Phytotoxic effects (leaf burns) were observed at the 5% concentration across all soap types The survey results revealed that 64.9% of participants had never heard of potassium soap, and 78.4% considered lack of knowledge and awareness as the main obstacle to its use. This study confirms that potassium soap, especially when produced from vegetable oils and characterized by an alkaline pH, can be an effective and environmentally friendly alternative to chemical pesticides. However, its adoption remains low due to the lack of awareness and technical knowledge.

Keywords:

Potassium soap, *Aphis gossypii*, phytotoxicity, survey, Chemical pesticides , Eco-friendly alternative .

الملخص:

هدفت هذه الدراسة إلى تقييم فعالية أربعة أنواع من الصابون البوتاسي (بزيت نباتي، بزيت الزيتون، متعادلPH ، ومنخفض PH)ضد حشرة المن القطني *Aphis gossypii Glover* تحت الظروف المخبرية، بالإضافة إلى استقصاء مدى تراكيز (0.00%، 0.5%، 1%، و 5%) بثلاث مكررات لكل تركيز (10 حشرات لكل مكرر)، وسُجلت نسب الوفيات بعد 48 ساعة. تم حساي التراكيز القاتلة LC_{50} و LC_{90} بإستخدام تحليل البروبيت. تم توزيع استبيان على 37 مشاركاً من محلات الأدوية الفلاحية وشركات الاستيراد في وادي سوف. أظهرت النتائج المخبرية أن الصابون البوتاسي المصنوع بالزيوت النباتية (SVO و SOO) يتمتع بفعالية عالية ضد حشرة المن، حيث بلغت قيم LC_{50} لهما 0.409% و 0.431% على التوالي. كان الصابون البوتاسي (متعادل PH) غير فعال عملياً حيث بلغت قيم LC_{50} له 106.267% ، بينما أظهر الصابون البوتاسي(منخفض PH)فعالية متوسطة حيث بلغت قيم LC50 له 2.067% . لوحظ تأثيرات سمية نباتية (حروق على الأوراق) عند التركيز 5% عبر جميع أنواع الصابون. كشفت نتائج الاستبيان أن 64.9% من المشاركين لم يسمعوا عن الصابون البوتاسي، واعتبر 78.4% أن عدم المعرفة والتثقيف هو العائق الأكبر لإستخدامه. تؤكد هذه الدراسة أن الصابون البوتاسي، خاصة عند تصنيعه بالزيوت النباتية ورفع درجة الحموضة، يمكن أن يكون بديلاً فعالاً وصديقاً للبيئة للمبيدات الكيميائية. ومع ذلك، لا يزال اعتماده منخفضاً بسبب نقص الوعي والمعرفة التقنية.

الكلمات المفتاحية:

صابون بوتاسي، *Aphis gossypii Glover* ، سمّية نباتية، استبيان , مبيدات كيميائية, بديل صديق للبيئة .

ABBREVIATIONS LIST

Potassium soap formulated with vegetable oil: SVO

Potassium soap formulated with olive oil: SOO

Potassium soap with a neutral pH: SNP

Potassium soap with a low pH: SLP

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Summary

INTRODUCTION

Introduction

Introduction:

Conventional chemical insecticides are among the most widely used methods for controlling agricultural pests due to their rapid effectiveness and ease of application (Barathi et al., 2023) . However, numerous studies have revealed the serious negative impacts of these pesticides on both the environment and human health, including soil and groundwater contamination, poisoning of beneficial insects such as bees, the development of resistance in target pests, and the accumulation of toxic residues in agricultural products (Lavika et al., 2026). In this context, there has been an increasing need to search for safe and environmentally friendly alternatives that are equally effective in pest control without causing the harmful side effects associated with chemical pesticides (Barathi et al., 2023).

Among the environmentally friendly alternatives that can be used in agricultural pest management, potassium soap is considered a promising option. This natural product is a liquid compound produced through the reaction of potassium hydroxide with fatty acids derived from vegetable oils or animal fats (Sutrisno et al., 2022). It is characterized by its high solubility in water, which makes it easy to apply as a spray. Potassium soap possesses several characteristics that make it an attractive alternative to chemical pesticides, including rapid biodegradability, low toxicity to humans and beneficial insects, the absence of toxic residues on agricultural products, and effectiveness against many soft-bodied pests such as aphids, thrips, and spider mites (Hall and Richardson, 2013). The mode of action of potassium soap relies on direct contact with the insect, as it dissolves the waxy layer covering the insect's body, leading to water loss, dehydration, and ultimately death (Cranshaw, 2019). Studies indicate that the effectiveness of soap depends on several factors, including the concentration used, the type of vegetable oil incorporated into its formulation, the pH level, and the method of application (Imai et al., 1995).

Despite the numerous advantages of potassium soap, its use in Algeria remains limited, and the number of studies evaluating its effectiveness against local agricultural pests is still scarce.

Furthermore, the level of awareness and commercialization of this product within the Algerian agricultural sector, among both distributors and farmers, has not been sufficiently investigated.

Among the agricultural pests that may benefit from this type of control, the cotton aphid, *Aphis gossypii* Glover, is considered one of the most destructive pests affecting numerous crops, particularly vegetables, fruit crops, and ornamental plants(Celini, 2007). This insect feeds on plant sap by sucking it from leaves, stems, and buds, resulting in weakened plant growth, leaf deformation, transmission of serious viral diseases, and the production of honeydew on which fungi may develop. The cotton aphid is also characterized by its high reproductive capacity and remarkable adaptability, making its control a major challenge for farmers (Celini, 2007). Due to its economic importance and widespread distribution, it was selected as the target insect for evaluating the effectiveness of different types of potassium soap in the present study.

This dissertation consists of two main parts: a laboratory study evaluating the effectiveness of four types of potassium soap against the cotton aphid (Aphis gossypii), and a field survey targeting agricultural pesticide shops and companies in the El Oued region, alongside participants from other Algerian provinces who attended the International Agricultural Fair in El Oued.

In this context, the present study aims to answer the following research questions:

- What is the effectiveness of different types of potassium soap (vegetable oil-based, olive oil-based, neutral pH, and low pH) against the cotton aphid (*Aphis gossypii*) after 48 hours of treatment?

- What is the level of awareness and commercialization of potassium soap among agricultural supply stores and agricultural pesticide companies in the El Oued region?

- What are the main obstacles preventing farmers from using this product, and what solutions could be proposed to increase its adoption?

Based on these problem statements, the following hypotheses were formulated:

- Potassium soap enriched with vegetable oils is expected to exhibit high effectiveness against aphids.

- The level of awareness of potassium soap in the study area is expected to be low (less than 50%).

Introduction

- The main obstacle to the use of potassium soap is expected to be the lack of knowledge and awareness.

First part: Literature review

Chapter One (General Overview)

Chapter One : General Oreview

First part: Literature review

Chapter One (General Overview):

1 - Concept of agricultural control of insect pests and its types :

The sources identify six main control types: mechanical, cultural, physical, chemical, biological, and IPM(Kumar and Rathor, 2020). Biological control—using natural enemies and microorganisms—is extensively documented across 8 of 10 sources, reflecting strong research emphasis.(Sanda and Sunusi, 2014). define it as "non-chemical and environmentally friendly methods" employing natural control agents.

Biological control strategies include three approaches: conservation, classical importation, and augmentation(Sanda and Sunusi, 2014). Specific agents include predators, parasitoids, and entomopathogens (bacteria, fungi, viruses, nematodes)(Niaz and Ahmad, 2018). Habitat management and push-pull methods using plant volatiles represent emerging techniques(Akter et al., 2019).

2 - Drawbacks and environmental impacts of chemical pesticides :

Chemical pesticides pose significant environmental and health risks. Excessive use of toxic, broad-spectrum synthetic chemicals affects natural ecosystems, human health, and the environment (Niaz and Ahmad, 2018). Irrespective use of chemical pesticides like Benzene hexachloride, Endosulfan, Aldicarb, and Fenobucarb raises several environmental issues (Chattopadhyay et al., 2017).

Indiscriminate use of agrochemicals leads to:

- Pollution of soil, water, and food sources.
- Poisoning of non-target beneficial insects.
- Development of insect populations resistant to insecticides(Sindhu et al., 2017).

- Misuse of insecticides creates additional problems including population resurgence, pesticide residues, and pest resistance(Nazir et al., 2019). Chemical pesticides contaminate the environment, including soil and water, while killing non-target species and causing detrimental health effects to humans (Sanda and Sunusi, 2014).

3 - The importance of sustainable agriculture and environmental alternatives to chemical pesticides :

3 - 1 Biological Control Benefits :

Biological control offers environmentally correct techniques that should be considered as tools in Integrated Pest Management or organic farming systems(Marchiori, 2023). These biologically based approaches are eco-friendly, cost-effective, useful, and reliable (Niaz and Ahmad, 2018).

Key advantages include:

- Environmental safety: Non-chemical and environmentally friendly methods(Sanda and Sunusi, 2014).

- Species specificity: Safety, species-specific action, and long-term effects on target pests (Sanda and Sunusi, 2014).

- Biodegradability: Host-specific and biodegradable, resulting in minimal persistency of residual toxicity (Nazir et al., 2019).

3 - 2 Food Security and Safety:

Chapter One : General Oreview

Environmental stewardship and food security are the most important factors in agriculture (Nazir et al., 2019). Biological control helps establish food security through fighting against insect pests while ensuring food safety (Chattopadhyay et al., 2017). The growing demand for chemical-free food drives the exponential growth of biological control methods (Marchiori, 2023).

3 – 3 Sustainable Agricultural Practices:

To obtain higher yields sustainably, biological control using specific antagonistic microorganisms provides an effective alternative approach with minimum deleterious effects(Sindhu et al., 2017). The objective is to control and eliminate agricultural pests without leaving residues or causing damage to plants and the environment (Marchiori, 2023).

3 – 4 Integration with Modern Agriculture:

Application of effective biocontrol agents may reduce chemical insecticide use and support sustainable agriculture in an eco-friendly manner while improving crop productivity (Sindhu et al., 2017). Biopesticides make key contributions to IPM and can greatly reduce conventional pesticides (Nazir et al., 2019).

3 – 5 Economic and Practical Considerations:

Sustainable alternatives address the high cost of chemical pesticides that enhance production costs (Chattopadhyay et al., 2017). However, primary factors affecting biological control adoption include efficacy, predictability, and initial high costs (Sanda and Sunusi, 2014).

The efficiency of biocontrol products can be increased through genetic improvement, environmental manipulation, using mixtures of biocontrol agents, and optimization of formulations integrated with other alternative methods (Sindhu et al., 2017).

Chapter Two (Potassium Soap)

Chapter Two (Potassium Soap):

1 - The Concept of Potassium Soap :

Potassium soap is a surfactant and alkali salt produced by reacting triglyceride oils or fatty acids with potassium hydroxide through saponification. (Sutrisno et al., 2022).

The evidence base is substantial and spans seven decades (Adeyemi, 2022) demonstrated that potassium soaps exhibit superior qualities compared to sodium soaps, including higher foam ability, better hardness, and comparable performance to commercial toilet soaps.(Sutrisno et al., 2022) synthesized potassium soap from olive oil, confirming it as a yellowish-white solid with melting points of 200-204°C and strong antibacterial activity (MIC < 1% against Staphylococcus aureus and Escherichia coli).

Foundational research by (Mcbain et al., 1948) established solubility behavior and pH characteristics. Additional studies examined potassium soap's role in detergent formulations(Roup, 2013), cream soaps (Sagitani, 2014), and molecular association properties(Kung and Goddard, 1969).

2 - The Chemical Definition of Potassium Soap:

Chemically, potassium soap is the potassium salt of fatty acids, formed when triglyceride oils or fatty acids react with potassium hydroxide (KOH) through saponification.(Sutrisno et al., 2022).

The chemical structure is characterized by carboxylate groups (COO^-) associated with potassium ions (K^+).(Adeyemi, 2022) provided spectroscopic evidence showing a carboxylate band at 1560.46 cm^{-1} in FTIR analysis, indicating that potassium ions associate with the COO^- ions in monodentate structures - a key structural feature absent in the original fatty acid precursors. The general chemical formula can be represented as RCOOK, where R represents the fatty acid chain.(Mcbain and Sierichs, 1948) established that these are the "sodium and potassium soaps" - specifically the alkali metal salts of higher fatty acids that exhibit distinct colloidal properties in aqueous solution.

demonstrated that potassium soaps can form well-defined 1:1 acid-soap complexes, indicating their ability to associate molecularly with their corresponding fatty acids, adding to their chemical complexity beyond simple salt formation. (Kung and Goddard, 1969).

3 - The Chemical Composition of Potassium Soap and Its Essential Ingredients:

3-1 Chemical Composition:

Potassium soap is fundamentally composed of potassium salts of fatty acids, formed through the saponification reaction between fatty acids and potassium hydroxide (Adeyemi, 2022). The chemical structure features carboxylate (COO^-) ions that associate with potassium ions in monodentate structures, as confirmed by FTIR spectroscopy showing characteristic bands at 1560.46 cm^{-1} for asymmetric carboxylate ions and around 1421-1423 cm^{-1} for symmetric carboxylate ions (Adeyemi, 2022).

The molecular structure includes:

- Long-chain fatty acid components with varying carbon chain distributions (Roup, 2013).

- Potassium cations (K^+) that determine the soap's physical properties (Thangiah, 2019).

- Hydroxyl (OH) groups and C-O stretches from alcohol components (Adeyemi, 2022).

3-2 Essential Ingredients:

_ Primary Components:

The fundamental ingredients for potassium soap production include:

- Fatty acids or oils - Sources include beeswax (Adeyemi, 2022), olive oil (Sutrisno et al., 2022), coconut oil (Roup, 2013), and various other triglyceride oils.

- Potassium hydroxide (KOH) - The alkaline agent that enables saponification (Adeyemi, 2022).

- Water - Essential for the saponification reaction and final product formation (Sagitani, 2014).

_ **Specialized Formulations:**

For cream soaps specifically, additional essential ingredients include:

- Glycerol Crucial for forming stable lamellar gel phases and preventing phase separation (Sagitani, 2014).

- Fatty acid potassium soaps in 1:1 molar ratios with fatty acids for acid soap formation (Sagitani, 2014).

_ **Performance Additives:**

Various additives can enhance potassium soap properties:

- Potassium silicates - Used as detergent enhancers that increase pH and improve suds formation (Merrill and Getty, 1949).

- Different carbon chain fatty acids - Affect foaming, viscosity, and stability characteristics (Roup, 2013)

4 - Physical and Chemical Properties:

Potassium soaps exhibit distinct characteristics compared to sodium soaps:

- Higher solubility in water, methanol, and ethanol (Sutrisno et al., 2022).

- Softer texture or liquid consistency (Adeyemi, 2022).

- Better foaming qualities and foam stability (Adeyemi, 2022).

- Higher degree of hydrolysis compared to corresponding sodium soaps (Mcbain et al., 1948).

- The specific fatty acid composition determines properties such as melting point (200-204°C for olive oil-based potassium soap), antibacterial activity, and stability characteristics (Sutrisno et al., 2022).

5 - The mechanism of action of potassium soap on insects:

Potassium soap, composed of potassium salts of fatty acids, kills insects primarily through disruption of cellular membranes, though the exact mechanisms remain incompletely understood.The most widely accepted mechanism is that fatty acids in potassium soap disrupt the pest's cellular membrane, causing loss of cellular contents and cell death (Heide-Spravka and Watson, 1990). A secondary mechanism involves removal of protective cuticular waxes covering insects, leading to excessive water loss (Cranshaw, 2019).

However, evidence for these mechanisms is limited. (Cranshaw, 2019) explicitly states that "how soaps and detergents kill insects is still poorly understood," despite the popularity of the membrane disruption theory.

6 - The types of pests and crops targeted by potassium soap:

The sources document effectiveness against several categories of pests:

- Aphids: Multiple studies focus on aphid control, including black chrysanthemum aphid, green apple aphid (Siegler and Popenoe, 2010), and green peach aphid (Myzus persicae) (Imai et al., 1997) .

- Hemipteran pests: Beyond aphids, studies tested potassium soap against Asian citrus psyllid (Diaphorina citri) (Hall and Richardson, 2013) and harlequin bug (Murgantia histrionica) (Fulton, 1930).

- Lepidopteran larvae: Eastern tent caterpillar was successfully controlled with insecticidal soap (Heide-Spravka and Watson, 1990).

- Other insects: Testing included azalea lace bug (Heide-Spravka and Watson, 1990) and flour beetles (Tribolium confusum) (O'neill and Alexander, 1965).

Crops and Plants Targeted:

- Citrus: For Asian citrus psyllid control (Hall and Richardson, 2013).
- Apple: For green apple aphid control (Siegler and Popenoe, 2010).
- Ornamental plants: Including azaleas for lace bug control and chrysanthemums for aphid control (Heide-Spravka and Watson, 1990).

One source notes that soaps are "labelled for commercial use as well as for use by homeowners and organic growers" (Hall and Richardson, 2013), suggesting broad agricultural and horticultural applications, though specific crop details are limited in the available abstracts.

The research indicates that potassium soap is particularly effective against soft-bodied insects like aphids and shows promise as a tool for integrated pest management across various agricultural and horticultural systems (Curkovic, 2016).

7 - Environmental and health effects of using potassium soap :

7-1 Environmental Effects :

Potassium soaps have generally favorable environmental characteristics compared to conventional pesticides. (Curkovic, 2016) reports that environmental toxicity by soaps is considered very low, and they have low acute toxicity, particularly non-ionic or anionic detergents, which are by far less dangerous than conventional insecticides. The environmental impact quotient

(EIQ) values for soaps indicate their low impact (e.g., 19.45 for M-Pede), which is close to most botanicals or insect growth regulators, and smaller than those of horticulture oils.

Potassium soaps are highly biodegradable and have low persistence in the environment (Curkovic, 2016.) They are considered strictly contact pesticides with no residual activity, which prevents long-term environmental contamination. This lack of residual effect is actually advantageous as it prevents mortality of beneficial arthropods released after residues dry, making soaps compatible with biological control and integrated pest management programs.

However, (Curkovic, 2016) notes that detergents in wastewater can be important pollutants when they reach rivers and streams in large concentrations, where they form foam layers and affect aquatic fauna. The greater biodegradability of current surfactants has significantly reduced these problems.

7-2 Health Effects:

Potassium soaps demonstrate low toxicity to humans and mammals. (Curkovic, 2016) reports that the soap Safer has an oral LD_{50} of 16,500 ppm, which is by far less dangerous than conventional insecticides, including botanicals. The risk is even lower considering the necessary dilution and small chance of ingestion.

Unlike conventional pesticides, potassium soaps do not require reentry intervals after application (Curkovic, 2016). Detergents can cause dermal or eye irritation, but this represents a very low risk to agriculture workers wearing basic personal protective equipment. Some respiratory disorders have been reported from detergent exposure, mainly in asthma sufferers.

An important advantage is that most potassium soaps are not subject to maximum residue limit (MRL) restrictions (Curkovic, 2016). Some can be applied right before harvest and others are authorized for postharvest treatments, being easily washed off from fruit and vegetable surfaces by rinsing before consumption.

7-3 Impact on Beneficial Organisms:

indicates that potassium soaps have been considered more selective than conventional insecticides, being compatible with biological control due to their low adverse impact on non-sprayed insects and mites and lack of residual activity. The only threat occurs from direct spray or when the solution persists on foliage for short periods (Curkovic, 2016).

However, some studies show differential effects on beneficial species. (Hall and Richardson, 2013) found that a 2% concentration of insecticidal soap applied as a direct spray was non-toxic to adult lady beetles but acutely toxic to parasitoid wasps, suggesting soaps may be compatible with some biological control agents but not others.

7-4 Limitations:

While generally safer, potassium soaps do have some limitations. (Curkovic, 2016) notes potential plant toxicity at concentrations above 1-2%, particularly on plants with pubescent surfaces or during certain growth stagesmentions that soaps may remove protective waxes from insects, but this same mechanism could potentially affect beneficial insects if directly contacted. (Cranshaw, 2019).

Chapter three (Target Pest)

Chapter three (Target Pest):

1. *Aphis gossypii* (Glover) :

is a cosmopolitan and polyphagous aphid species that feeds on cotton, melon, and numerous other crops, causing significant economic damage through direct feeding and the transmission of plant viruses. This insect is considered a worldwide agricultural pest comprising several biotypes that differ greatly in their adaptation to host plants (Quan et al., 2019).

It is also regarded as a destructive pest affecting more than twenty agricultural crops, with its major threat resulting from its role as a vector of plant viruses (Ebert and Cartwright, 1997). This species is characterized by its highly invasive nature, broad host range, polymorphism, and ability to reproduce parthenogenetically (Rebijith et al., 2015).

This species reproduces continuously through viviparous parthenogenesis and develops in colonies that cause leaf deformation, plant growth retardation, and contamination with honeydew (Celini, 2007). In addition, considerable variation in color and morphology has been observed within this species (Wall, 1933). Several studies also suggest the existence of different host races or subspecies associated with various plant families, indicating that this species exhibits considerable biological diversity (Margaritopoulos et al., 2006).

2. Classification:

Table 1 : Scientific classification of Aphis gossypii Glover.

Kingdom:	Animalia
Phylum:	Arthropoda
Clade:	Pancrustacea
Class:	Insecta

Order:	Hemiptera
Suborder:	Sternorrhyncha
Family:	Aphididae
Genus:	Aphis
Species:	*A. gossypii*
Binomial name : *Aphis gossypii* (Glover, 1877)	

Figure 1 : Cotton aphid *Aphis gossypii Glover*

Source: Personal photograph, 2026.

3. Life cycle of *Aphis gossypii Glover*:

Aphis gossypii Glover completes its life cycle through four nymphal instars before reaching adulthood, with total development usually lasting from 6 to 9 days (Shim et al., 1979), while the reproductive lifespan extends from 10 to 20 days (Shim et al., 1979). Each female produces between 30 and 70 nymphs depending on environmental conditions (Shim et al., 1979).

The total duration of the nymphal stages reaches 8.64±0.20 days, and the average total lifespan is 23.76±0.65 days, with the production of 46.50±0.65 nymphs per female (Patil and Patel, 2013). The nymphal period also ranges from 7.07 to 8.24 days depending on the host plants (Singh and Singh, 2015). The life cycle shows seasonal variation, reaching 8.4 days in winter compared to 6.8 days in summer (Swelam, 2020). This species completes an annual egg-to-egg cycle with facultative host migration (Kring, 1959). Temperature also greatly affects developmental rates, and 25°C is considered the optimal temperature for development (Xia et al., 1999).

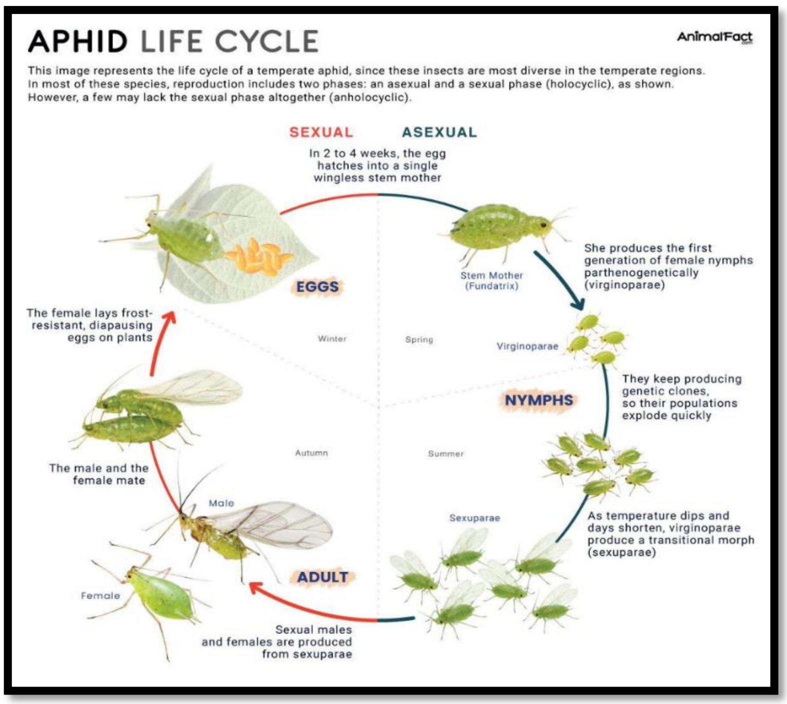

Figure 2 : Life Cycle of the Aphid (Chatterjee, 2026)

4. Taxonomic characteristics of the different life stages of *Aphis gossypii Glover*:

Studies document that the species passes through four nymphal instars with a gradual increase in body size from 0.510 to 1.390 mm and a color change from greenish-brown to emerald green, while the adult reaches approximately 1.68 mm in length (Patil and Patel, 2013).

In addition, three egg stages and four embryonic stages have been identified, where eye spots appear in the second embryonic stage, while body structures such as antennae, legs, and body segmentation become visible in the third and fourth embryonic stages (Patm et al., 2004).

Regarding sexual female development, progressive body darkening, increased body size, elongation of antennae with darkened tips, and a protruding cauda at adulthood are observed, along with rapid ovarian development starting from the second nymphal instar (Lü et al., 2024).

However, the complexity of the life cycle and the presence of high polymorphism make morphological identification difficult, highlighting the need for molecular approaches to support morphological taxonomy (Rebijith et al., 2012).

Second part: Experimental part

Materials and Methods

Materials and Methods :

1. Laboratory Study:

1.1. Studied Insect:

The study was conducted on the cotton aphid *Aphis gossypii Glover*, found on the leaves of the cantaloupe plant (Cucumis melo L.). The aphid species *Aphis gossypii Glover* was identified based on clear photographic images that were sent to a specialist in entomology (Dr. Ghozoul Nesima, Faculty of Natural Sciences, University of Chahid Hamma Lakhdar, El Oued), where its classification was confirmed using the morphological characteristics known for this species.

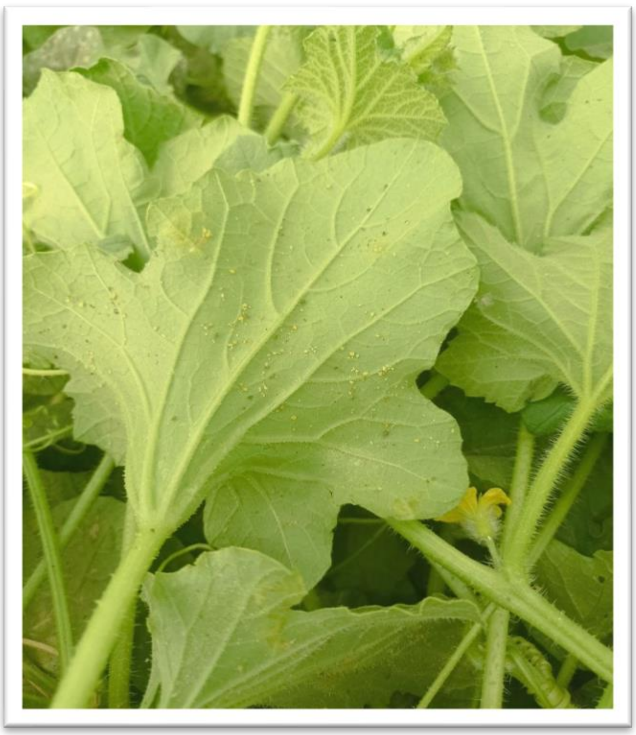

Figure 3 : Leaves of Cucumis melo L. showing infestation by the cotton aphid *Aphis gossypii Glover*.(Personal photograph, 2026).

1.2 Materials Used:

Four types of potassium agricultural soap were used in this study, namely:

- potassium soap based on vegetable oils (SVO).

- potassium soap based on olive oil (SOO).
- potassium soap with a neutral pH (SNP).
- potassium soap of the same type but with a low pH (SLP).

In addition, a set of laboratory equipment was used, including Petri dishes, glass beakers, a pipette, an agitator, and filter paper, as well as distilled water and Polysorbate 20 (Polysorbate 20). A manual sprayer was also used to apply the treatments.

Figure 4 : Glass bottles and Micropipette.

Source: Personal photograph, 2026.

1.3 Preparation of Concentrations:

Three concentrations were prepared for each type of potassium soap: 0.5%, 1%, and 5%, using distilled water as a solvent. Drops of Polysorbate 20 (Polysorbate 20) were added to all prepared solutions, including the control, in order to improve the spreading of the solution on the surface of leaves and insects.

The 0.5% concentration was prepared by adding 0.5 mL of potassium soap to 99.5 mL of distilled water, while the 1% concentration was prepared by adding 1 mL of soap to 99 mL of distilled water. The 5% concentration was prepared by adding 5 mL of soap to 95 mL of distilled water.

The control consisted of distilled water containing only drops of Polysorbate 20, without the addition of potassium soap.

1.4 Bioassays :

Twelve Petri dishes were assigned to each type of potassium soap. Cantaloupe leaves were placed in each dish, and then 10 aphids were introduced per replicate. The experiment included three replicates for each concentration, in addition to three replicates for the control treatment.

After that, the different concentrations were sprayed directly onto the insects inside the Petri dishes using a manual sprayer from a distance of 20 cm.

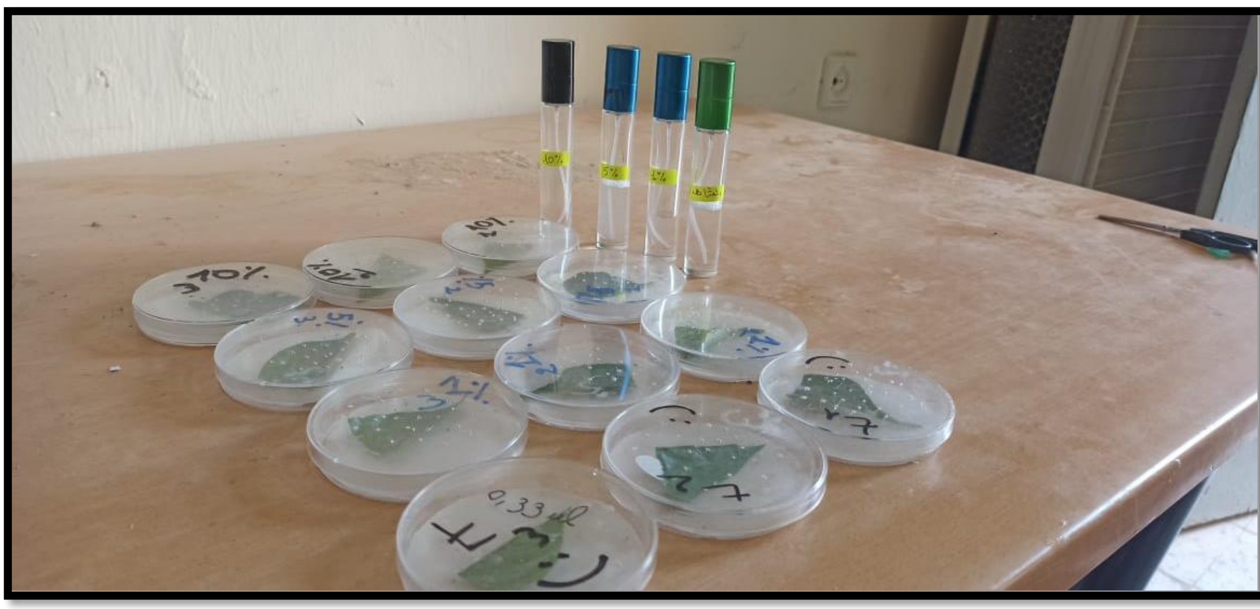

Figure 5 : Distribution of insects and plant leaves inside Petri dishes with sprayers containing the concentrations. Source: Personal photograph, 2026.

1.5 Efficacy Assessment:

The efficacy of the treatments was evaluated by calculating the mortality rate after 48 hours of treatment, by comparing the number of dead insects in the different treatments with the control. Insects were considered dead if they showed no movement when gently touched with a fine brush and did not respond to stimulation. The lethal concentrations (LC_{50} and LC_{90}) were calculated using probit analysis. The following steps were followed: concentrations were converted to $\log_{10}$; mortality percentages were converted to proportions; if control mortality exceeded 10%, mortality was corrected using Abbott's formula; a curve was plotted between log10 concentration and probits; the regression equation was obtained; LC_{50} and LC_{90} were calculated from the equation; and the 95% confidence limits were calculated.

2. Field Study:

2.1 Study Area:

The field study was conducted in El Oued Province and covered most of its municipalities. It also included representatives of agricultural pesticide companies from several Algerian provinces, during the International Agricultural Fair held in El Oued Province.

2.2 Survey :

The study relied on a Survey directed to owners of agricultural pesticide shops and company representatives, with a total of 37 participants.

The Survey included questions about the level of knowledge and use of potassium agricultural soap, its effectiveness, and the difficulties associated with its use, in addition to participants' suggestions for encouraging its adoption among farmers (see Annexe 1) .

2.3 Analysis of Results:

The results of the field Survey were analyzed using the automatic statistical tools available on the Google Forms platform, where percentages and response frequencies from the 37 participants were extracted. The results were also presented in the form of pie charts and graphs based directly on the data obtained from the system, without the need for additional statistical processing.

This analysis relied on the quantitative representation of data in order to facilitate the interpretation of general trends in participants’ opinions regarding the use and effectiveness of potassium agricultural soap in the agricultural sector.

Results

Results :

I. Laboratory results:

1. Effectiveness of SVO :

1.1 Mortality Rates Recorded After 48 Hours:

(Table02) : Mortality rates of the aphid Aphis gossypii after treatment with different concentrations of SVO (3 replicates, 10 insects per replicate).

Concetraction(%)	**Total**	**Dead**	**Mortality Rate (%)**
0.00	30	4	13.33
0.5	30	17	56.67
1	30	22	73.33
5	30	26	86.67

The results presented in (Table 02) show that the mortality rate increased with increasing concentrations of SVO. The lowest mortality rate (13.33%) was recorded in the control treatment (distilled water), whereas the highest mortality rate (86.67%) was observed at the highest tested concentration (5%). This indicates a positive correlation between concentration and mortality rate, as the percentage increased from 56.67% at 0.5% concentration to 73.33% at 1%, and then to 86.67% at 5%.

Results

1.2 Dose–response curve (Probit analysis) :

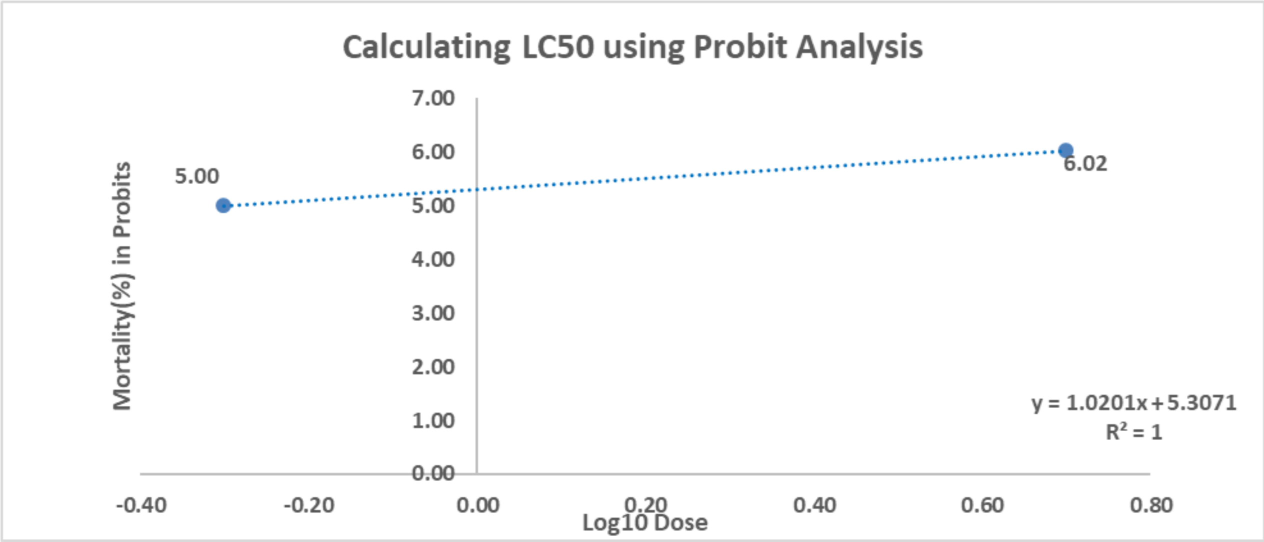

Figure 6 : Dose–response relationship of SVO after converting mortality percentages into probit units.

The results illustrated in Figure 6 show the dose–response relationship of SVO after converting mortality percentages into probit units. The linear regression equation was calculated as follows:

Y = 1.0201x + 5.3071

The coefficient of determination was **R^2 = 0.954** , indicating a good fit between the data points and the regression line (i.e., all points lie exactly on the line). The slope value (1.0201) reflects the insect's response to the soap; the higher the slope, the greater the insect sensitivity. This equation was used to estimate the lethal concentrations LC_{50} and LC_{90}.

1.3 Lethal concentrations (LC_{50} and LC_{90}):

Table 3 : Estimation of the lethal concentrations (LC_{50} and LC_{90}) of SVO using probit analysis.

LC	**LC**	**95%Fiducial CI**	
(%)	**ppm**	**Lower**	**Upper**
LC_{50}	**0.409**	**0.131**	**1.280**
LC_{90}	**8.535**	**2.726**	**26.727**

Table 3 shows that the LC_{50} value of SVO was 0.409%, whereas the LC_{90} value was approximately 8.535%. The 95% confidence limits for LC_{50} ranged from 0.131% to 1.280%, while those for LC_{90} ranged from 2.726% to 26.727%. A wider confidence interval was observed for LC_{90} compared to LC_{50}.

2. Effectiveness of SOO :

2.1 Mortality rates recorded after 48 hours:

Table 4 : Mean mortality rates of the aphid Aphis gossypii after treatment with different concentrations of SOO (3 replicates, 10 insects per replicate).

Concetraction(%)	**Total**	**Dead**	**Mortality Rate(%)**
0.00	30	7	23.33
0.5	30	19	63.33
1	30	23	76.67
5	30	28	93.33

Results

Table 4 shows that the mortality rate increases with increasing concentrations of SOO . The lowest mortality rate (23.33%) was recorded in the control treatment, whereas the highest mortality rate (93.33%) was observed at the 5% concentration. The rate increased from 63.33% at 0.5% to 76.67% at 1%, and then to 93.33% at 5%.

2.2 Dose–response curve (Probit analysis):

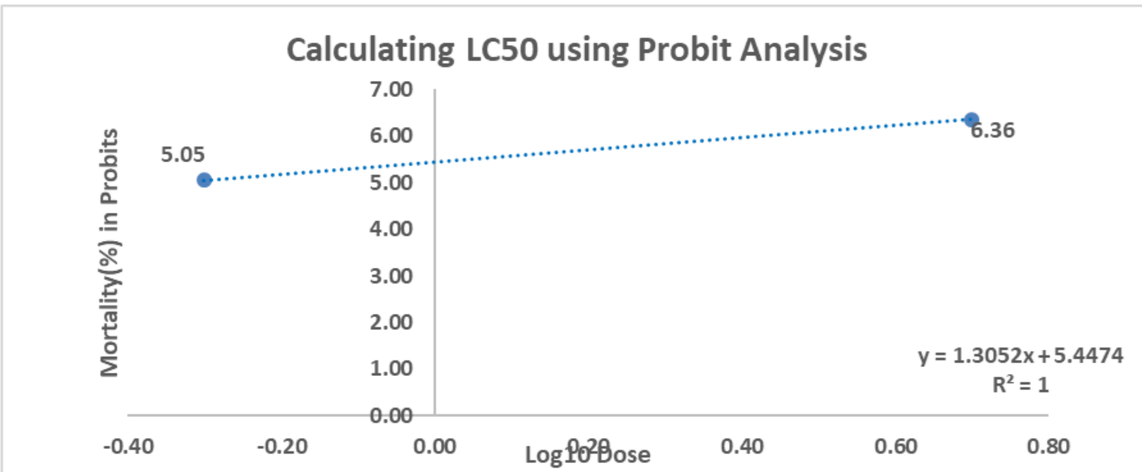

Figure 7 : Probit curve showing the relationship between the logarithm of concentration and transformed mortality rates of SOO.

The results illustrated in Figure 7 show the dose–response relationship of SOO after converting mortality percentages into probit units. The linear regression equation was calculated as follows:

Y= 1.3052x + 5.4474

The coefficient of determination was **R^2 = 0.997** , indicating a perfect fit between the data points and the regression line (i.e., all points lie exactly on the line). The slope value (1.3052) reflects the insect's response to the soap; the higher the slope, the greater the insect sensitivity.

2.3 Lethal concentrations (LC_{50} and LC_{90}):

Table 5 : Lethal concentrations (LC_{50} and LC_{90}) of SOO.

LC	**LC**	**95%Fiducial CI**	
(%)	**ppm**	**Lower**	**Upper**
LC_{50}	**0.431**	**0.176**	**1.054**
LC_{90}	**4.255**	**1.740**	**10.404**

Table 5 shows that the LC_{50} value of SOO was 0.431%, whereas the LC_{90} value was approximately 4.255%. The 95% confidence limits for LC_{50} ranged from 0.176% to 1.054%, while those for LC_{90} ranged from 1.740% to 10.404%.

3. Effectiveness of SNP :

3.1 Mortality rates recorded after 48 hours:

Table 6 : Mean mortality rates of the aphid Aphis gossypii after treatment with different concentrations of SNP (3 replicates, 10 insects per replicate).

Concetraction(%)	**Total**	**Dead**	**Mortality Rate(%)**
0.00	30	3	10
0.5	30	5	16.67
1	30	7	23.33
5	30	9	30

Table 6 shows that the mortality rate increases with increasing concentrations of SNP. The lowest mortality rate (10.00%) was recorded in the control treatment, whereas the highest mortality rate (30.00%) was observed at the 5% concentration. The rate increased from 16.67% at 0.05% to 23.33% at 1%, and then to 30.00% at 5%.

3.2 Dose–response curve (Probit analysis):

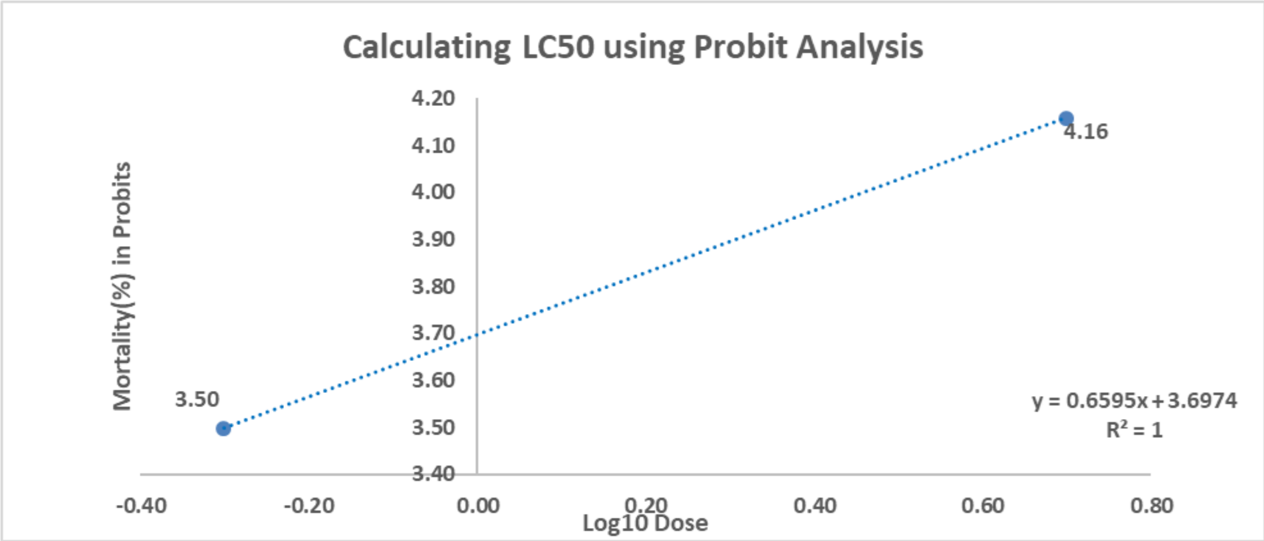

Figure 8 : Probit curve showing the relationship between the logarithm of concentration and transformed mortality rates of SNP.

The results illustrated in Figure 8 show the dose–response relationship of SNP after converting mortality percentages into probit units. The linear regression equation was calculated as follows:

Y = 0.6595x + 3.6974

The coefficient of determination was $\mathbf{R^2 = 0.894}$, indicating a perfect fit between the data points and the regression line. The slope value (0.6595) reflects the insect's response to the soap. This equation was used to estimate the lethal concentrations LC_{50} and LC_{90}.

3.3 Lethal concentrations (LC_{50} and LC_{90}):

Table 7 : Lethal concentrations (LC_{50} and LC_{90}) of SNP.

LC	LC	95%Fiducial CI	
(%)	ppm	Lower	Upper
LC_{50}	106.267	12.119	931.822
LC_{90}	13922.249	1587.726	122079.599

Table 7 shows that the LC_{50} value of SNP was 106.267%, whereas the LC_{90} value was approximately 13,922.249%. The 95% confidence limits for LC_{50} ranged from 12.119% to 931.822%, while the lower confidence limit for LC_{90} was approximately 1,587.726%, whereas the upper limit was not determined (shown as 122079.599% due to the very wide interval).

4. Effectiveness of SLP :

4.1 Mortality rates recorded after 48 hours:

Table 8 : Mean mortality rates of the aphid Aphis gossypii after treatment with different concentrations of SLP (3 replicates, 10 insects per replicate).

Concetraction(%)	Total	Dead	Mortality Rate(%)
0.00	30	6	20
0.5	30	10	33.33
1	30	18	60
5	30	21	70

Results

Table 8 shows that the mortality rate increases with increasing concentrations of SLP. The lowest mortality rate (20.00%) was recorded in the control treatment, whereas the highest mortality rate (70.00%) was observed at the 5% concentration. The rate increased from 33.33% at 0.5% to 60.00% at 1%, and then to 70.00% at 5%.

4.2 Dose–response curve (Probit analysis):

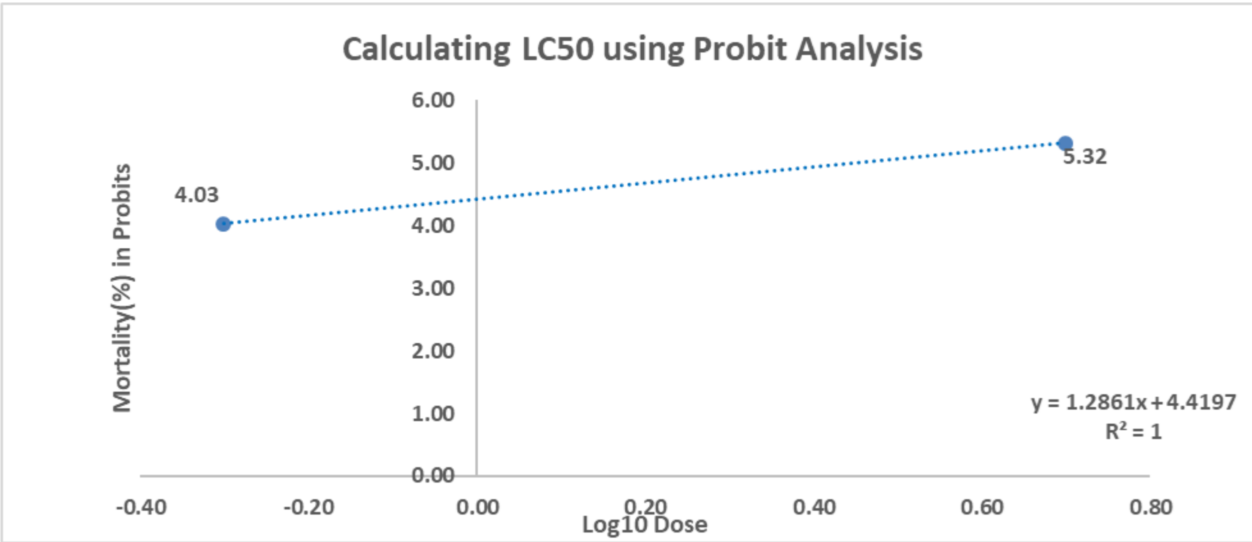

Figure 9 : Probit curve showing the relationship between the logarithm of concentration and transformed mortality rates SLP.

The results illustrated in Figure 9 show the dose–response relationship of SLP after converting mortality percentages into probit units. The linear regression equation was calculated as follows:

Y = 1.2861x + 4.4197

The coefficient of determination was **R^2 = 0.762** , indicating a perfect fit between the data points and the regression line. The slope value (1.2861) reflects the insect's response to the soap. This equation was used to estimate the lethal concentrations LC_{50} and LC_{90}.

4.3 Lethal concentrations (LC_{50} and LC_{90}):

Table 9 : Lethal concentrations (LC_{50} and LC_{90}) of SLP.

LC	LC	95%Fiducial CI	
(%)	ppm	Lower	Upper
LC_{50}	2.067	0.798	5.355
LC_{90}	29.309	11.313	75.934

Table 9 shows that the LC_{50} value of SLP was 2.067%, whereas the LC_{90} value was approximately 29.309%. The 95% confidence limits for LC_{50} ranged from 0.798% to 5.355%, while those for LC_{90} ranged from 11.313% to 75.934%.

5. Notes on Phytotoxicity:

Mild to moderate burn symptoms were observed on plant leaves with all tested types of potassium soap only at the 5% concentration, whereas no symptoms were recorded at the lower concentrations (0.5% and 1%). This result indicates that the 5% concentration may be phytotoxic to plants, which requires caution when using it under field conditions.

II. Field results (The survey):

1. General Information About the Entity :

1.1 Type of Entity:

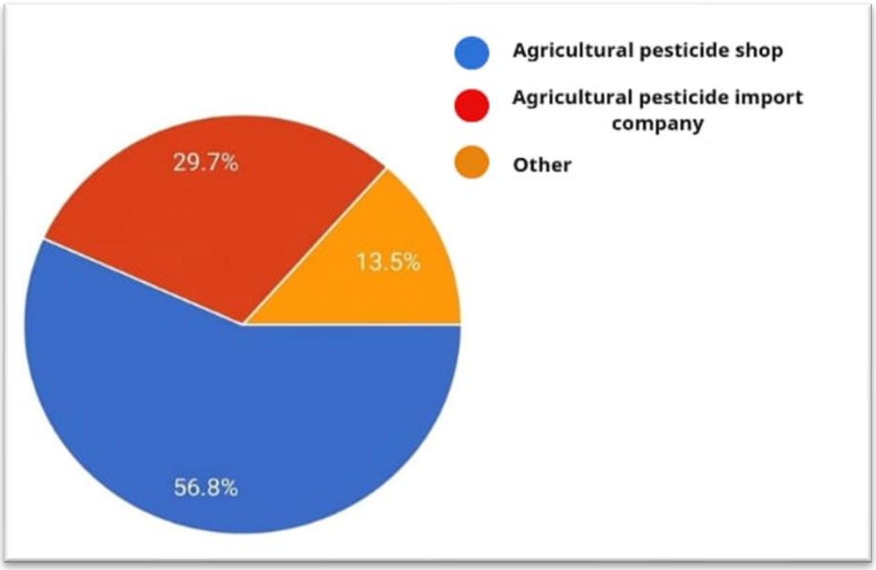

Figure 10 : Distribution of the survey sample according to type of institution.

Figure 10 shows that the highest proportion of survey participants came from agricultural pesticide stores, representing 56.8% (21 individuals), followed by pesticide import companies at 29.7% (11 individuals), and finally the "Other" category at 13.5% (5 individuals).

1.2 Sample Distribution by Region:

Table 10 : Distribution of survey Participants by Region.

Region	Number of Participants
El Oued (Total)	**28**
El Oued (Unspecified)	5
El Oued – El Tarefawi	1
El Oued – El Rekiba	1

El Oued – Hassi Khelifa	3
El Oued – El Bayadha	2
El Oued – El Robbah	3
El Oued – Oued El Alenda	2
El Oued – El Meghren	1
El Oued – Guemar	1
El Oued –El Debila	1
El Oued – El Ogla	2
El Oued – El Nakhla	1
El Oued – Taghzout	1
Outside El Oued (Total)	**9**
Algiers, the capital of Algeria	3
Blida	1
Batna	1
Biskra	3
Boumerdès	2
Sétif	3
Overall Total	**37**

Table 10 shows that the total number of participants in the survey was 37 individuals. The participants were distributed between 28 individuals from the El Oued region (75.7%) and 9 individuals from other provinces (24.3%).

Results

Within the El Oued region, the participating municipalities were diverse, with the highest number of participants recorded in Hassi Khelifa (3 participants), El Robbah (3 participants), El Bayadha (2 participants), El Ogla (2 participants), and Oued El Alenda (2 participants). The sample also included 5 participants classified under “El Oued” without specifying a precise municipality.

Outside El Oued, participation was recorded from Algiers, the capital of Algeria (3 participants), Biskra, Algeria (3 participants), Sétif, Algeria (3 participants), Boumerdès, Algeria (2 participants), as well as one participant from each of Blida, Algeria and Batna, Algeria. These participants represented owners or representatives of agricultural pharmaceutical companies who took part in the International Agricultural Fair held in El Oued.

1.3 Number of Years of Activity:

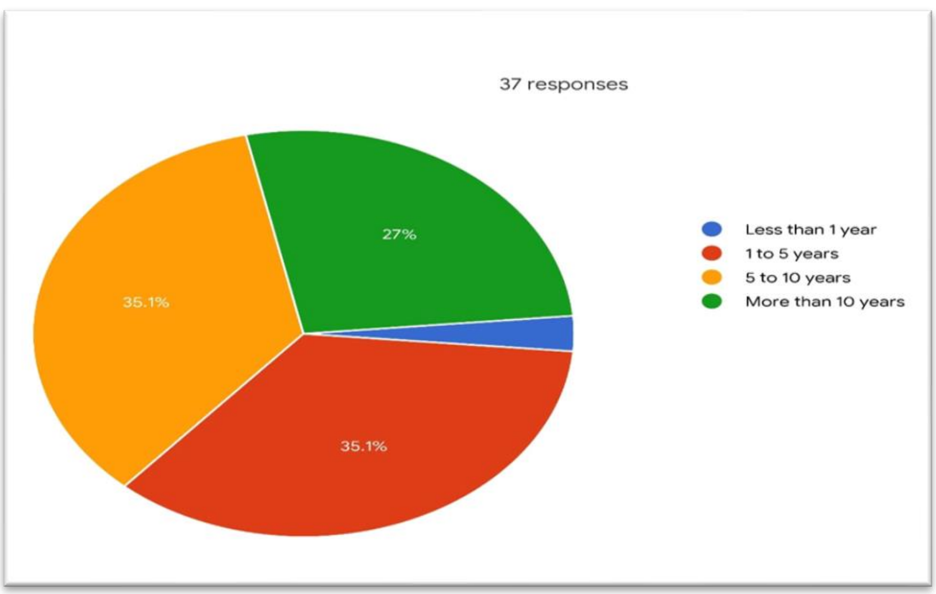

Figure 11 : Distribution of the questionnaire sample according to years of experience.

Figure 11 shows the distribution of participants according to their years of experience in the field. The highest percentage of participants had between 1 and 5 years of experience, representing 35.1%, followed directly by those with less than one year of experience at the same percentage

(35.1%). Participants with 5 to 10 years of experience accounted for 27% of the sample, whereas the lowest percentage was observed among those with more than 10 years of experience, representing only 2.7%.

1.4 Participants' Education and Specializations :

Table 11 : Distribution of Participants According to Education and Specialization.

Training – Specialization	Frequency
Higher Education – Agricultural Sciences	32
Senior Technician – Plant Protection	2
Special Training	3
Total	37

Table 11 shows that the vast majority of participants (32 individuals, 86.5%) have a higher education background in agricultural sciences. The number of senior technicians in plant protection was 2 individuals (5.4%), while 3 individuals (8.1%) had special training.

2. Product Availability and Distribution:

2.1 Level of Knowledge of Potassium Agricultural Soap:

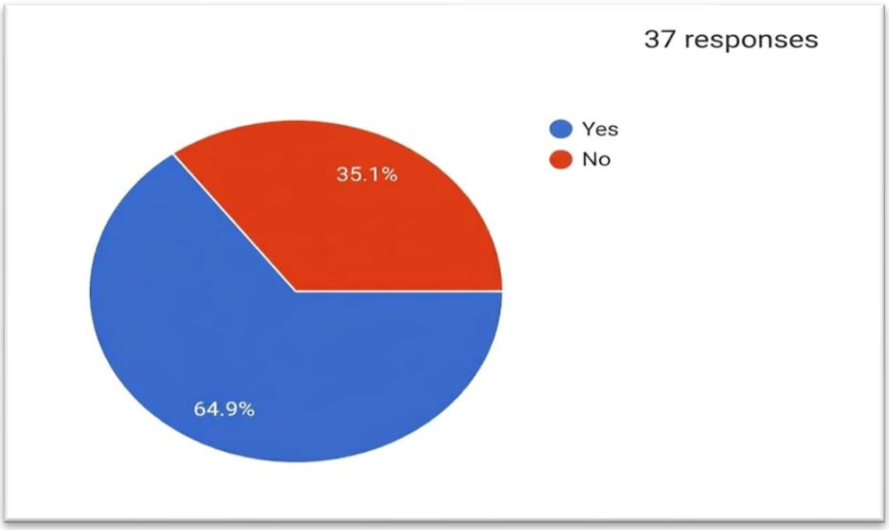

Figure 12 : Percentage of participants who have heard of potassium agricultural soap.

Figure 12 shows that the majority of participants (64.9%) had never heard of agricultural potassium soap, whereas only 35.1% were familiar with it.

2.2 Availability and Sale of Potassium Agricultural Soap:

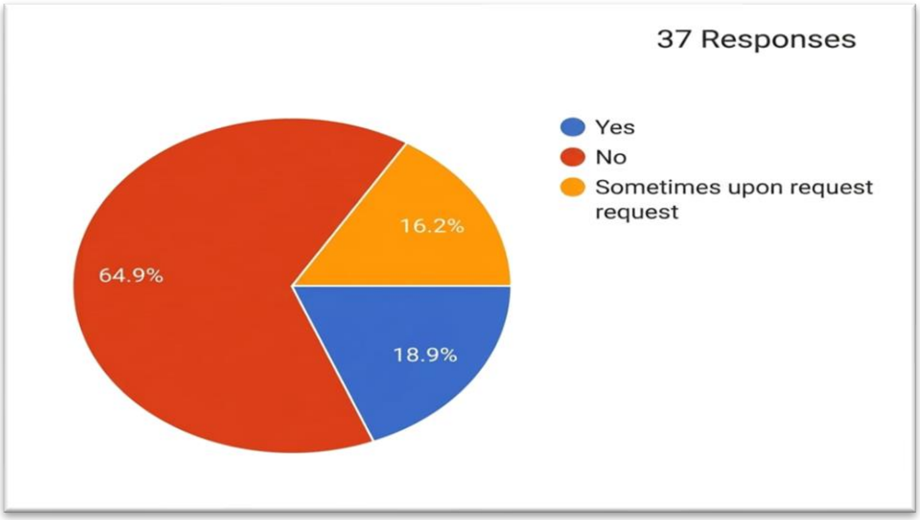

Figure 13 : Percentage of participants who sell potassium agricultural soap.

Figure 13 shows that the majority of participants (64.9%) do not sell agricultural potassium soap in their stores or companies, whereas 18.9% reported that they sell it occasionally upon request, and only 16.2% stated that they sell it regularly.

2.3 Duration of Availability of Potassium Agricultural Soap Among Sellers:

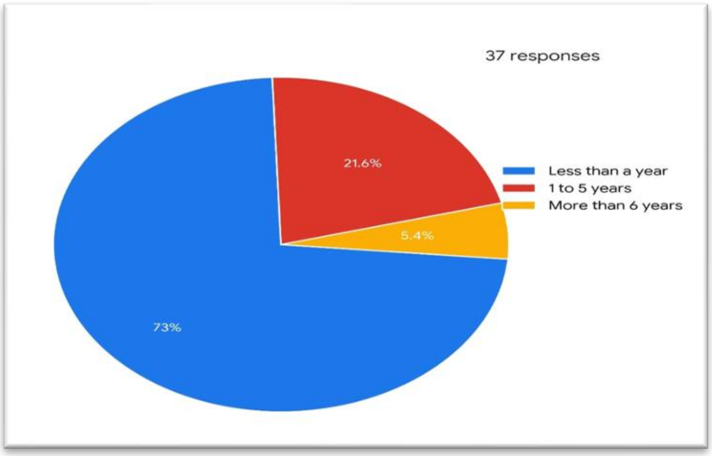

Figure 14 : Distribution of sellers of potassium soap according to duration of availability.

Figure 14 shows that among the participants who reported selling agricultural potassium soap (either regularly or occasionally), the vast majority (73%) stated that the product had been available in their stores or companies for more than 6 years. Meanwhile, 21.6% reported that the product had been available for less than one year, and only 5.4% stated that it had been available for 1 to 5 years.

2.4 Availability of Multiple Types or Brands of Agricultural Soap:

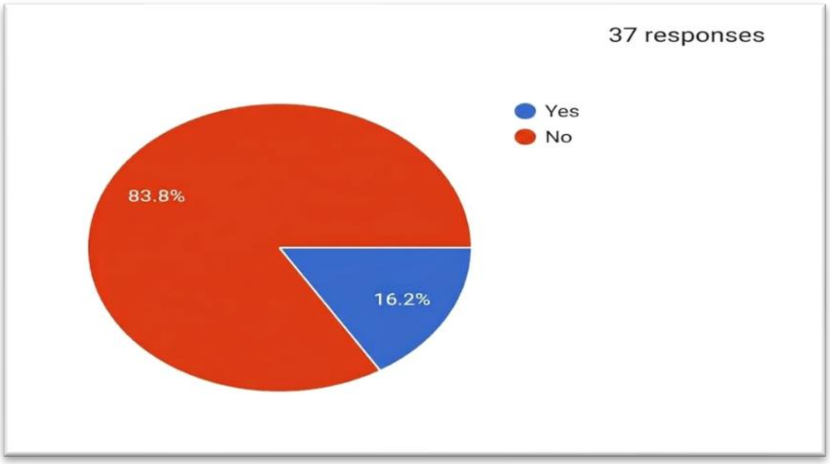

Figure 15 : Percentage of participants who offer multiple types or brands of agricultural soap.

Figure 15 shows that the vast majority of participants (83.8%) do not provide multiple types or brands of agricultural potassium soap, whereas only 16.2% reported that they offer more than one type or brand.

2.5 Farmers' Demand for Potassium Agricultural Soap Observation:

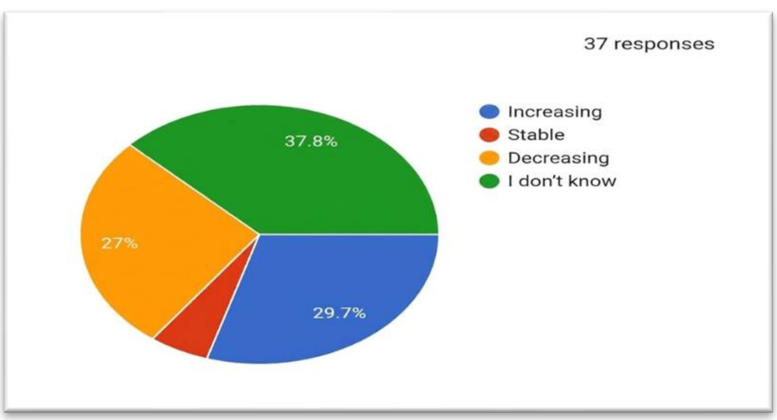

Figure 16 : Distribution of participants' opinions regarding farmers' demand for potassium soap.

Figure 16 shows that 37.8% of the participants considered the farmers' demand for agricultural potassium soap to be low, whereas 29.7% considered the demand to be stable, and only 27% believed that it was increasing. In addition, 5.4% of the participants reported that they did not know the level of demand for this product.

3. Technical Knowledge:

3.1 Effectiveness of agricultural potassium soap against soft bodies insects:

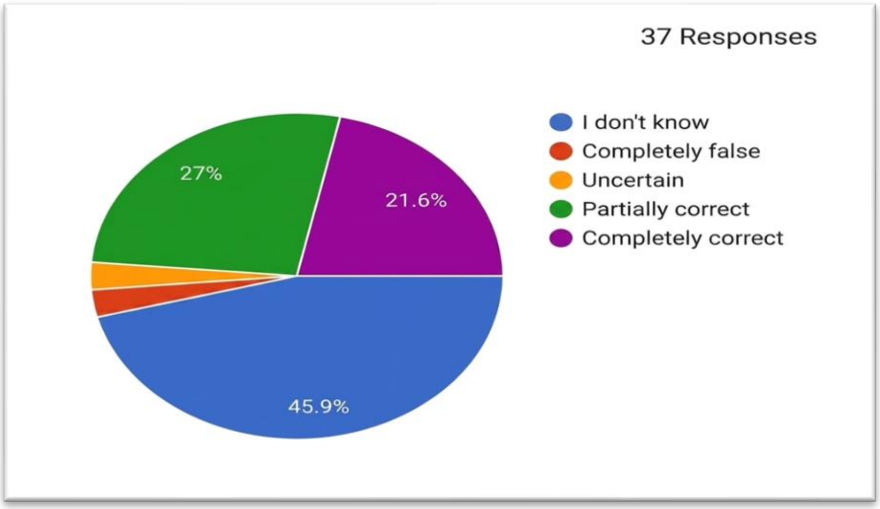

Figure 17 : Participants' opinions on the effectiveness of potassium soap against small insects.

Figure 17 shows that the highest proportion of participants (45.9%) answered "I do not know" when asked about the effectiveness of agricultural potassium soap against small insects (such as aphids and mites). Meanwhile, 27% considered the statement to be "partially correct," and 21.6% stated that it was "completely correct." In addition, 2.7% answered "completely incorrect," and 2.7% responded with "uncertain.

3.2 Participants' knowledge of the mode of action of potassium agricultural soap (internal toxicity):

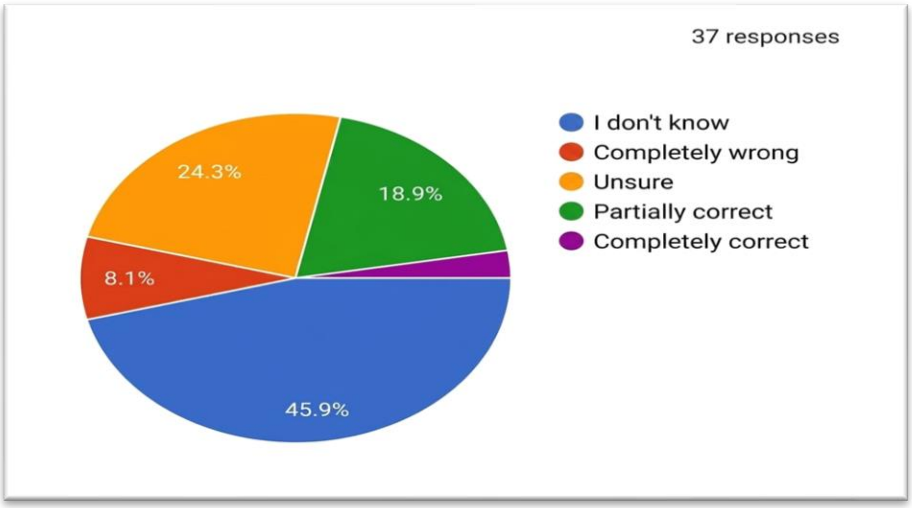

Figure 18 : Participants' opinions on the statement "Potassium agricultural soap acts through internal toxicity".

Figure 18 shows that the highest proportion of participants (45.9%) considered the statement "agricultural potassium soap works through internal poisoning" to be "partially correct." Meanwhile, 24.3% answered "I do not know," 18.9% "completely incorrect," and 8.1% "uncertain." No responses of "completely correct" were recorded for this statement.

Results

3.3 Safety of potassium soap on vegetables and fruits (from participants' perspective):

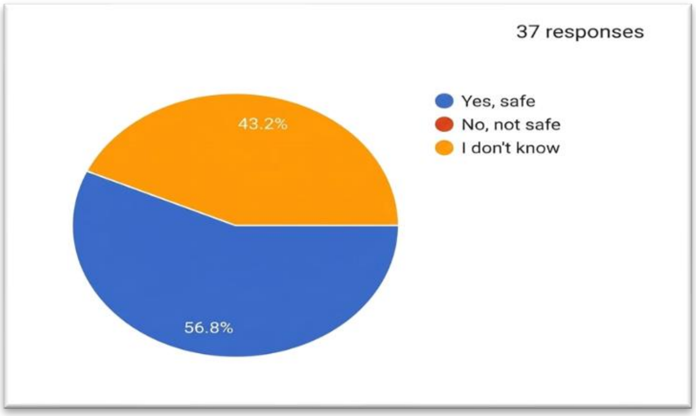

Figure 19 : Participants' opinions on the safety of potassium soap on vegetables and fruits when used at appropriate concentrations.

Figure 19 shows that the majority of participants (56.8%) considered potassium soap unsafe for use on vegetables and fruits even when applied at correct concentrations, whereas 43.2% considered it safe. No responses of "I do not know" were recorded for this question.

3.4 Possibility of using potassium agricultural soap with other pesticides:

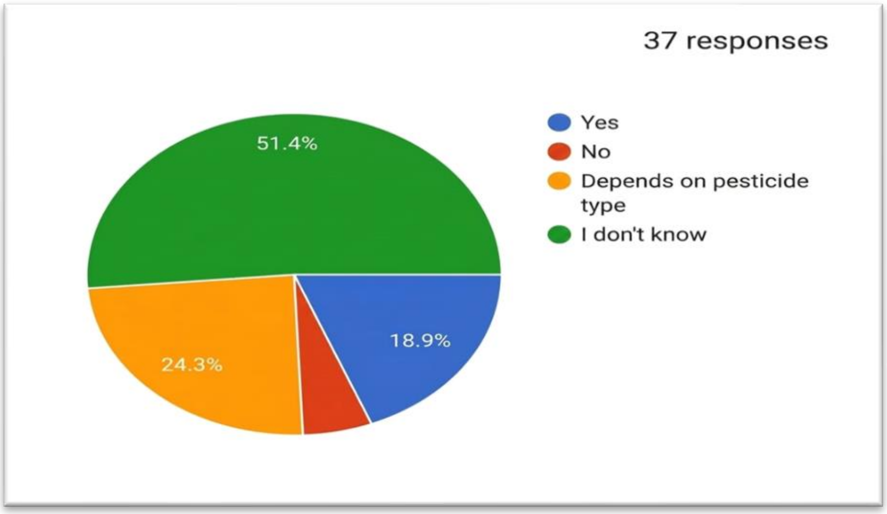

Figure 20 : Participants' opinions on the possibility of mixing potassium soap with other pesticides.

Figure 20 shows that the highest proportion of participants (51.4%) believed that agricultural potassium soap can be used with other pesticides without problems. Meanwhile, 24.3% stated that it depends on the type of other pesticides, 18.9% said it cannot be used in combination, and 5.4% answered “I do not know.

3.5 Side effects of potassium soap on plants (from participants’ perspective):

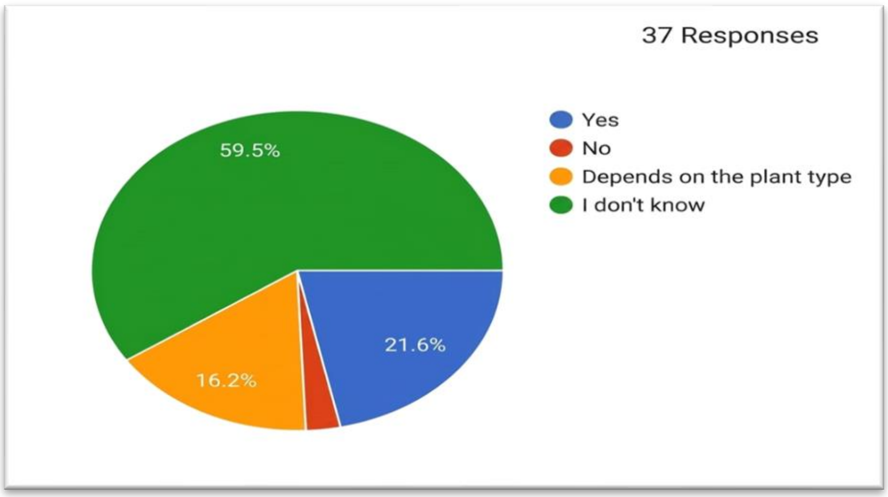

Figure 21 : Participants’ opinions on the presence of side effects of potassium soap on plants when used at high concentrations.

Figure 21 shows that the majority of participants (59.5%) confirmed that potassium soap has a side effect on plants (burning or browning) when used at high concentrations. Meanwhile, 21.6% stated that this depends on the type of plant, 16.2% said that there are no side effects, and 2.7% answered “I do not know.

3.6 Extent to which potassium soap is considered environmentally friendly (from participants' perspective):

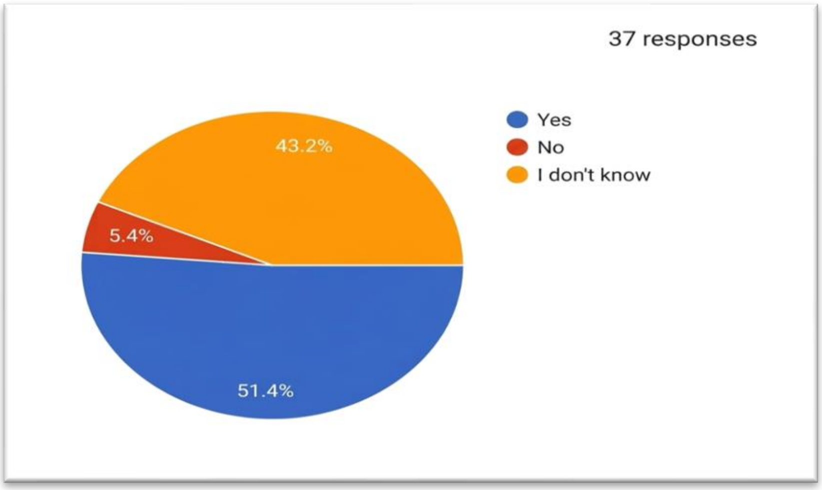

Figure 22 : Participants' opinions on whether potassium soap is environmentally friendly compared to conventional pesticides.

Figure 22 shows that more than half of the participants (51.4%) answered "I do not know" when asked whether potassium soap is environmentally friendly compared to conventional pesticides. Meanwhile, 43.2% considered it environmentally friendly, and only 5.4% believed that it is not.

4. Opinions and Perceptions:

4.1 Participants' opinions on the effectiveness of potassium soap compared to conventional pesticides:

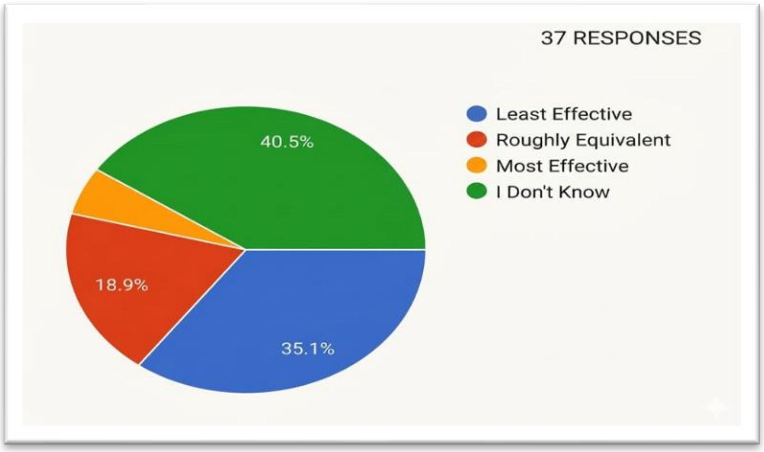

Figure 23 : Distribution of participants' opinions on the effectiveness of potassium soap compared to other pesticides.

Figure 23 shows that 40.5% of the participants believe that potassium soap is less effective than conventional pesticides, while 35.1% consider it more effective, and 18.9% think that the effectiveness is similar. In addition, 5.4% answered "I do not know.

4.2 Main obstacles preventing farmers from using potassium soap:

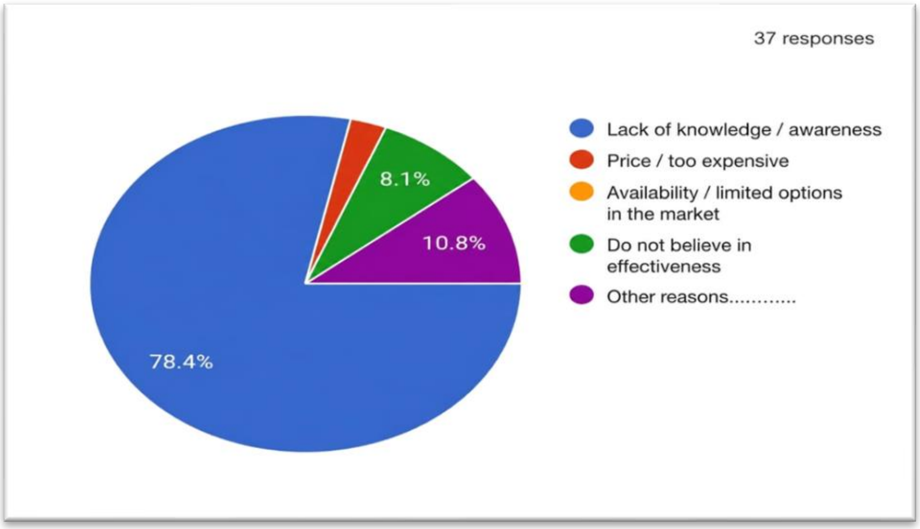

Figure 24 : Distribution of participants' opinions on the obstacles preventing the use of potassium soap.

Figure 24 shows that the main barrier preventing farmers from using potassium soap, according to the participants' opinions, is "lack of knowledge/education" at 78.4%. This is followed by "lack of confidence in its effectiveness" at 10.8%, then "higher price/cost" at 8.1%, and finally "difficulty of availability in the market" at 2.7%.

5. Open Questions:

5.1 Advice Provided to Farmers When Selling Potassium Agricultural Soap:

Table 12 : The most common advice provided to farmers when selling potassium agricultural soap according to participants’ opinions.

Provided advice	Number of repetitions
Respecting the dosages and the correct method of use	5
Do not use during high-temperature periods	4
Emphasizing the product's effectiveness and environmental safety	4
Emphasizing the product's effectiveness and environmental safety	3
Using it under suitable conditions and at appropriate times	3
No withdrawal period or pre-harvest interval	2
Other miscellaneous tips	2

The results of the open-ended question regarding the most common advice given to farmers when purchasing potassium soap revealed that most participants focused on the necessity of respecting the dosages and the correct method of use, as these are among the most important factors ensuring product effectiveness and avoiding potential damage to plants.

A significant number of participants also emphasized the need to avoid using potassium soap during periods of high heat, recommending its use under moderate weather conditions and at appropriate times for treatment.

On the other hand, several responses highlighted the effectiveness of potassium soap in controlling certain insects and plant diseases, in addition to being a safe, environmentally friendly product compared to traditional chemical pesticides, noting that there is no long withdrawal period after treatment.

Some responses included additional tips, such as the need to wash plants thoroughly, seek technical advice if any issues arise, and the possibility of mixing the product with certain vegetable or mineral oils to improve its effectiveness.

5.2 Suggestions for Increasing the Use of Potassium Agricultural Soap Among Farmers (from Participants' Perspective):

Table 13 : Proposed factors to increase the use of potassium agricultural soap among farmers according to participants' opinions

Suggestions provided	Number of repetitions
Awareness, education, and agricultural extension	11
Conducting field trials and practical workshops	6
Reducing prices and making the product available at a reasonable price	6
Proving the product's effectiveness and quality	5
Product availability and variety of packaging and concentrations	3
Supporting reliable companies and technical follow-up	2

Other miscellaneous suggestions	2

The results of the open-ended question regarding the factors that could help increase the use of agricultural potassium soap among farmers showed that awareness, education, and agricultural extension were among the most frequently mentioned suggestions. Participants emphasized the importance of organizing study days, workshops, and training sessions to introduce the product's benefits and proper usage methods.

A significant number of participants also stressed the need to conduct field trials and practical applications to demonstrate the effectiveness of potassium soap in real-world conditions, which would help gain farmers' trust and encourage them to adopt it instead of traditional chemical pesticides.

Among the other important factors addressed was the issue of reducing prices and making the product available at competitive prices that suit farmers' purchasing power, in addition to the need to improve product quality and enhance its effectiveness to achieve results similar or close to those of chemical pesticides.

Some participants pointed out the importance of diversifying packaging and concentrations to facilitate purchase, along with providing technical support from specialized companies and agricultural engineers to ensure optimal use of the product.

Discussion

Discussion:

I.Discussion of Laboratory Results:

1. Discussion of the Effectiveness of SVO :

The first type of SVO showed remarkable effectiveness against aphids, reaching a corrected mortality rate of 84.62% at the 5% concentration after 48 hours, with an LC_{50} value of 0.409%. This result agrees with the findings of (Tremblay et al., 2010), who reported that the LC50 of potassium soap against aphids ranged between 0.3% and 0.6%. In addition, the addition of vegetable oils to potassium soap increases its spreading ability on the insect surface and enhances its effectiveness. (Emami, 2016) also reported that coconut oil-based potassium soap at a concentration of 3 g/l achieved 78.47% mortality against Aphis gossypii three days after treatment, which is consistent with our findings. Similarly, (Kaur and Singh, 2013) demonstrated that neem soap and pongamia soap at 1.0% concentration significantly reduced aphid populations on capsicum.

A gap was observed between LC_{50} (0.409%) and LC_{90} (8.535%), indicating variability in the response among individuals within the insect population. This phenomenon was also reported in the study by (Ebeling, 1961), which attributed it to individual differences in the thickness of the wax layer, insect age, or physiological condition.

Mild leaf burns were also observed at the 5% concentration, confirming that potassium soap may cause phytotoxicity at high concentrations, especially on young or sensitive leaves. However, (Emami, 2016) observed no signs of phytotoxicity on cucumber plants at the recommended field rate of 3 g/l (0.3%), and (Kaur and Singh, 2013) reported no phytotoxic effects at 1.0% concentration. This supports that lower concentrations (1% or less) are safer for plants.

2. Discussion of the Effectiveness of SOO:

The results of SOO showed relatively higher effectiveness compared to the first type, as the mortality rate at the 5% concentration reached about 93.33%, while the LC_{50} value was 0.431%, which is very close to that of the first type. This indicates that both vegetable oils (vegetable oil and olive oil) provide similar effectiveness to the soap. This result agrees with what was reported by (Cranshaw, 2019), who found that the source of vegetable oil may not significantly affect effectiveness as long as the soap retains its alkaline properties and its ability to dissolve the waxy layer. (Falta and Psota, 2014) also reported that coconut soap (Cocana) at 2% concentration effectively removed the waxy covering of woolly apple aphid (Eriosoma lanigerum), achieving efficacy of 97.7% to 98% when combined with insecticides.

The second type was characterized by a lower LC_{90} value (4.255%) compared to the first type (8.535%), meaning that eliminating 90% of the insects requires a lower concentration. This may be due to differences in the chemical composition of the oil or the purity level of the soap. As noted by (Boopathi et al., 2025), some vegetable oils contain short-chain fatty acids that increase the speed of penetration.

Leaf burns were also observed at the 5% concentration in this type, confirming that high concentrations cause damage to the plant regardless of the type of oil used. This is consistent with (Baird et al., 2016), who stated that conventional soaps have a narrow margin between effective concentrations (1-2% fatty acids) and phytotoxic concentrations.

3. Discussion of the Effectiveness of SNP:

The results of SNP showed very weak effectiveness against aphids, as the mortality rate did not exceed 30% even at the 5% concentration. The LC_{50} value reached 106.267%, which is higher than the tested concentrations, indicating that this formulation does not exhibit practical effectiveness under the experimental conditions.

These findings suggest that the reduction in effectiveness cannot be attributed to a single factor such as pH alone, but is mainly related to the surfactant properties of the soap and its direct contact mechanism with the insect. Insecticidal soap activity primarily depends on its ability to dissolve the insect's protective wax layer, leading to water loss, desiccation, and ultimately death, a mechanism well documented in the literature (Cranshaw, 2019) ; (Boopathi et al., 2025). According to (Emami, 2016), insecticidal soaps work by suffocation (blocking the spiracles) or disruption of cuticular waxes and membranes, leading to desiccation, which is consistent with (Isman, 2006).

The results also showed that the slope value in the probit curve was 0.6595, the lowest among all treatments, indicating a weak response of the insect population to this treatment and suggesting clear variability in susceptibility among individuals. This is consistent with studies reporting differences in insect resistance related to cuticle characteristics and developmental stage (Ebeling, 1961).

Overall, these findings agree with the scientific literature on insecticidal soaps, which confirms that their effectiveness depends mainly on direct contact with the insect body and disruption of the wax layer, rather than on chemical properties such as pH alone (Isman, 2006).

4 -Discussion of the Results of SLP:

The results showed moderate effectiveness of SLP, as the mortality rate reached approximately 70% at the 5% concentration, with an LC_{50} value of 2.067%. This indicates variation in effectiveness compared to the other treatments.

These findings suggest that the variation in effectiveness among treatments may be related to differences in the physical properties of the soap, such as its ability to spread and cover the insect surface. These factors directly influence the efficiency of contact between the active substance and the insect body. (Kaur and Singh, 2013) demonstrated that neem soap and pongamia soap at 1.0% concentration achieved significantly low aphid counts (0.72-1.05 per plant), with effectiveness comparable to chemical insecticides such as imidacloprid and acephate.

Studies confirm that the effectiveness of insecticidal soap primarily depends on direct contact and the dissolution of the insect's wax layer, rather than secondary chemical properties such as pH (Cranshaw, 2019) ; (Ebeling, 1961). The moderate effectiveness of SLP (low pH) compared to

SNP (neutral pH) suggests that lowering pH partially restores the soap's insecticidal activity, but not to the level of alkaline soaps enriched with vegetable oils.

Some leaf damage was also observed at the high concentration (5%), indicating that phytotoxic effects may occur with increased dosage, which is consistent with the general use of surface-active pesticides at high concentrations. (Baird et al., 2016) noted that one of the major limitations of insecticidal soap use is the possibility of phytotoxic effects on plants, especially in young or stressed plants.

5. General Observation on Phytotoxicity (Leaf Burns):

Leaf burn symptoms ranging from mild to moderate were observed in all tested types of potassium soap only at the 5% concentration, while no symptoms were recorded at lower concentrations (0.5% and 1%). This observation suggests that phytotoxic effects may be related to the concentration of the applied substance, as high concentrations of surfactants can lead to undesirable effects on the leaf surface. According to (Baird et al., 2016), one of the major limitations of insecticidal soap use is the possibility of phytotoxic effects on plants, especially in young or stressed plants, and conventional soaps have a narrow margin between effective concentrations (1-2% fatty acids) and phytotoxic concentrations. Similarly, (Sajay et al.,2020) reported that pongamia oil soap at concentrations of 1% and 2% showed high efficacy against aphids without any phytotoxic effects on cowpea plants. (Gachev, 2016) also found that sunflower oil-based soap at 1.0% concentration caused no phytotoxic manifestations on treated apple leaves. In contrast, (Jadhav et al., 2024) evaluated soapnut-based formulations at doses of 3-10 g/L and observed no phytotoxic effects on various crops, which further supports that low to moderate concentrations are safe for plants.

From a practical perspective, although the 5% concentration showed higher effectiveness in some treatments, the occurrence of leaf symptoms at this level may limit its field application. Therefore, lower concentrations (such as 1%) may be considered relatively safer in terms of maintaining plant integrity, while still achieving acceptable levels of insect control depending on the treatment type.

6. Mechanism of Action of Potassium Soap and the Importance of Application Method:

The results of this study confirm that potassium soap acts through direct contact with the insect, rather than through systemic toxicity via plant absorption. This is consistent with what was explained by (Cranshaw, 2019), who stated that soap works by dissolving the insect's waxy layer, leading to water loss, desiccation, and death. In contrast, the initial trials (spraying the leaf first and then adding the insect) did not produce satisfactory results, confirming that the mechanism depends on direct contact. This finding was crucial in guiding subsequent experiments toward the correct method, which is spraying the soap directly onto the insect's body.

II. Discussion of the Survey Results and Their Relationship to the Laboratory Findings:

1. Limited Knowledge and the High Percentage of "I Don't Know" Responses:

The survey results showed that 64.9% of participants had never heard of potassium agricultural soap, and 64.9% did not sell it. This finding contrasts with the high effectiveness demonstrated by the first and second soap types in the laboratory experiments (where the LC_{50} values were below 0.5%), indicating a significant gap between the scientific effectiveness of the product and the level of awareness within the agricultural sector. This phenomenon was also reported in the study by (Khan and Damalas, 2015)., which found that environmentally friendly products are often insufficiently known among farmers and distributors despite their effectiveness.

It was also observed that the highest proportion of participants (45.9%) answered "I don't know" when asked about the effectiveness of soap against small insects, while 45.9% also believed that the soap acts through systemic toxicity (partially correct). This confusion in concepts reflects limited technical awareness regarding the mechanism of action of insecticidal soap, which is consistent with what was reported by (Aldosari et al., 2018), indicating that most workers in the agricultural pesticide sector do not receive sufficient training on alternative products.

Discussion

These results confirm the importance of the finding identified at the beginning of this study (the first incorrect method), where the mistaken belief that soap acts through systemic toxicity may lead farmers to apply it incorrectly (spraying only the leaf surface), resulting in unsatisfactory outcomes and reducing their confidence in the product. As noted by (Cranshaw, 2019), the success of potassium soap largely depends on the user's understanding of its direct contact mode of action.

2. The Contradiction Between Product Availability Duration and Low Demand:

Among the participants who sell potassium soap, 73% reported that the product has been available in their stores for more than six years. However, only 37.8% of participants indicated that demand for the product is low, while only 27% stated that demand is increasing. This contradiction suggests that the product is known among a limited group of distributors but has not become widely adopted among farmers. This phenomenon may be explained by the lack of sufficient promotional or awareness campaigns, as mentioned by (Morse et al.,2002) in a similar study.

The results also showed that 83.8% of participants do not provide multiple types or brands of potassium soap, which limits farmers' choices and reduces the likelihood of product adoption. This finding is consistent with the recommendations of (Kumar et al.,2025), who indicated that product diversity and the availability of different sizes and concentrations increase the chances of wider dissemination.

3. Misconceptions About the Mechanism of Action of Potassium Soap and Confirmation by Laboratory Results:

The survey showed that 45.9% of participants believed that potassium soap acts through systemic toxicity (partially correct). This misconception completely contradicts the laboratory findings of the present study, where the correct application method (direct spraying on the insect) produced effective results, while the method simulating systemic toxicity (spraying the leaf first and then adding the insect) did not produce satisfactory results.

This finding highlights the need to correct misconceptions among workers in the agricultural sector. As noted by (Struelens et al., 2022), most farmers and distributors believe that biological pesticides act through the same mechanism as chemical pesticides (systemic toxicity), which is not accurate in the case of potassium soap, whose action depends mainly on direct contact.

On the other hand, 59.5% of participants reported that potassium soap causes side effects (leaf burns) at high concentrations. This result is fully consistent with our laboratory observations, where leaf burns appeared on plant leaves at the 5% concentration in all soap types tested. This agreement strengthens the reliability of the responses provided by participants with field experience.

4. The Main Barrier: Lack of Knowledge and Education:

The results showed that the main barrier preventing farmers from using potassium soap was ‘lack of knowledge/education’ (78.4%), followed by ‘lack of confidence in effectiveness’ (10.8%), and finally ‘high price’ (8.1%).

This finding confirms that the problem is not the effectiveness of the product (which has been demonstrated in laboratory experiments), but rather the lack of awareness and insufficient information. This is consistent with what was reported by (Struelens et al., 2022), who stated that(Struelens et al., 2022) the main barrier to adopting biopesticides and environmentally friendly products is lack of knowledge rather than cost or availability.

In addition, 40.5% of participants believed that potassium soap is less effective than conventional pesticides, whereas our laboratory results showed that the first and second formulations (with vegetable oil and olive oil) achieved LC_{50} values below 0.5%, indicating very high effectiveness compared to many conventional pesticides. This discrepancy reflects a perception gap that needs to be addressed through awarenes campaigns.

5. Proposals for Increasing Adoption: Alignment with Study Findings:

Discussion

When participants were asked about ways to increase the use of potassium soap, ‘awareness and education’ ranked first (11 mentions), followed by ‘field trials’ (6 mentions) and ‘price reduction’ (6 mentions).

These suggestions are strongly consistent with the laboratory findings, which demonstrated the effectiveness of potassium soap. Awareness alone is not sufficient without providing farmers with practical evidence through field experiments that demonstrate its effectiveness under real conditions.

Some participants also suggested improving product quality and formulation, which aligns with the observation that the third type (neutral pH) was ineffective, whereas the first and second types (with vegetable oils) were highly effective. This indicates that improving the soap formulation (by adding vegetable oils and maintaining its alkaline properties) may enhance its effectiveness and encourage its adoption.

Participants also recommended diversifying package sizes and concentrations, which is consistent with our observation that the 5% concentration may cause leaf burns, while the 1% concentration is safe and effective (with mortality rates between 50% and 77%). Therefore, it can be recommended to provide the product at a 1% concentration as a practical and safe formulation.

6. Synthesis: Linking Laboratory Results with Survey Findings:

Overall, the laboratory results demonstrated that potassium soap (particularly formulations enriched with vegetable oils and with an alkaline pH) exhibits high effectiveness against aphids, with LC_{50} values below 0.5% for the first and second formulations. (Emami, 2016) reported that coconut oil-based potassium soap achieved 78.47% mortality against Aphis gossypii three days after treatment, which supports our laboratory findings. Similarly, (Kaur and Singh, 2013) demonstrated that neem soap and pongamia soap at 1.0% concentration significantly reduced aphid populations on capsicum, with effectiveness comparable to chemical insecticides. (Falta and Psota, 2014) also showed that coconut soap (Cocana) at 2% concentration effectively removed the waxy covering of woolly apple aphid, achieving efficacy of 97.7% to 98% when combined with insecticides.

Discussion

However, the survey results revealed a significant gap between this scientific effectiveness and the level of awareness and adoption of the product within the agricultural sector of El Oued. The main barrier to the spread of potassium soap was identified as lack of knowledge and education (78.4%), followed by lack of confidence in its effectiveness (10.8%). This highlights that future efforts should focus on:

- Organizing awareness campaigns and workshops to correct misconceptions (especially regarding the contact mode of action). According to (Emami, 2016), insecticidal soaps work by suffocation (blocking the spiracles) or disruption of cuticular waxes and membranes, leading to desiccation, a mechanism that farmers need to understand.

- Conducting field trials under real agricultural conditions to demonstrate effectiveness. (Kaur and Singh, 2013) successfully demonstrated the effectiveness of botanical soaps under net house conditions, achieving results comparable to chemical insecticides.

- Providing the product at safe and effective concentrations (such as 1%) at competitive prices. Emami (2016) observed no signs of phytotoxicity at 3 g/l (0.3%), and (Kaur and Singh, 2013) reported no phytotoxic effects at 1.0% concentration, supporting that lower concentrations are safe for plants.

These recommendations are consistent with those proposed by (Marrone, 2007) and (Fusar et al., 2025) in previous studies on the marketing and adoption of biopesticides, and are further supported by the findings of (Emami, 2016), (Kaur and Singh, 2013), and (Falta and Psota, 2014) who all confirmed the effectiveness and safety of potassium-based soaps as promising biopesticides.

Conclusion

Conclusion:

This study aimed to evaluate the effectiveness of four types of potassium soap (vegetable oil-based, olive oil-based, neutral pH, and low pH) against the cotton aphid (*Aphis gossypii Glover*) under laboratory conditions, in addition to investigating the level of awareness and commercialization of this product in the El Oued region through a field survey.

The laboratory results showed that potassium soap formulated with vegetable oils (SVO and SOO) exhibited high effectiveness against aphids, with LC_{50} values of 0.409% and 0.431%, respectively. In contrast, the third type (neutral pH) was practically ineffective, with an LC_{50} value of 106.267%, while the fourth type (low pH) showed moderate effectiveness, with an LC_{50} value of 2.067%. Phytotoxic effects (leaf burns) were observed at the 5% concentration across all soap types, limiting its practical use.

The survey results revealed a significant gap between the scientific effectiveness of potassium soap and its level of awareness in the agricultural sector in El Oued, as 64.9% of participants had never heard of it, and 78.4% considered lack of knowledge to be the main obstacle to its use.

The integration of laboratory and field results confirms that potassium soap, especially when made with vegetable oils and with a basic pH, can be an effective and environmentally friendly alternative to chemical pesticides. However, its adoption remains low due to lack of awareness.

Perspectives:

· Intensify awareness and extension campaigns to correct misconceptions about the mode of action of potassium soap.

· Conduct field trials to determine optimal concentrations (e.g., 1%) that balance efficacy and plant safety.

· Encourage the production of potassium soap made with vegetable oils and with a basic pH.

· Make the product available at competitive prices with diverse packaging sizes and concentrations.

· Study the effectiveness of the soap against other small soft-bodied pests.

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Annexe 1

إستبيان : حول مدى معرفة وتداول الصابون الزراعي البوتاسي لدى محلات الأدوية الفلاحية وشركات استيراد الأدوية والمدخلات الزراعية

السلام عليكم، نُجري هذا الاستبيان كجزء من دراسة بحثية حول المعرفة، التوفر، الإستخدام، والتصورات المتعلقة بالصابون الزراعي البوتاسي لدى الفاعلين في قطاع الأدوية الفلاحية (محلات وشركات استيراد)، نرجو من حضرتكم الإجابة بصراحة، كل الإجابات ستبقى سرية وتُستخدم لأغراض بحثية فقط.

تعليمات : ضع علامة (X) حول الإجابة المناسبة أو املأ المكان الفارغ عند الحاجة.

القسم الأول : بيانات عامة عن الجهة

1 - نوع الجهة

□ محل أدوية فلاحية

□ شركة استيراد أدوية

□ أخرى : ....

2 - الولاية / البلدية : ....

3 - عدد سنوات النشاط :

□ أقل من سنة

□ من 1 إلى 5 سنوات

□ من 5 إلى 10 سنوات

□ أكثر من 10 سنوات

4 - ما هو تكوينك؟ وفي أي تخصص؟

التكوين : ....

التخصص : ....

القسم الثاني : توفر وتداول المنتج

5 - هل سمعت من قبل عن الصابون الزراعي البوتاسي؟

□ نعم

□ لا

6 - هل تقومون ببيع الصابون الزراعي في محلكم / شركتكم؟

□ نعم

□ لا

□ أحيانًا حسب الطلب

7 - إذا كانت الإجابة نعم أو أحيانًا، منذ متى يتوفر لديكم المنتج؟

□ أقل من سنة

□ من 1 إلى 5 سنوات

□ أكثر من 6 سنوات

8 - هل توفرون أنواعًا أو ماركات متعددة من الصابون الزراعي؟

□ نعم

□ لا

9 - هل تلاحظ طلبًا متزايدًا من المزارعين على هذا المنتج؟

□ نعم متزايد

□ ثابت

□ قليل

□ لا أعلم

القسم الثالث: المعرفة التقنية

10 - الصابون الزراعي البوتاسي هو منتج فعال ضد الحشرات الصغيرة (مثل المن، العناكب...).

□ لا أعرف

□ خاطئ تمامًا

□ غير مؤكد

□ صحيح جزئيًا

□ صحيح تمامًا

11 - الصابون البوتاسي يعمل عن طريق التسمم الداخلي.

□ لا أعرف

□ خاطئ تمامًا

□ غير مؤكد

□ صحيح جزئيًا

□ صحيح تمامًا

12 - الصابون البوتاسي آمن الاستخدام على معظم الخضروات والفواكه إذا استُخدم بالتراكيز الصحيحة.

□ نعم آمن

□ لا غير آمن

13 - يمكن استعمال الصابون الزراعي في نفس الوقت مع مبيدات أخرى دون مشاكل.

□ نعم

□ لا

□ حسب نوعية المبيدات الأخرى

14 - للصابون البوتاسي تأثير جانبي على النباتات (حروق أو إسمرار إذا استُخدم بتركيز عالٍ).

□ نعم

□ لا

□ حسب نوع النبات

15 - الصابون البوتاسي يُعتبر صديقًا للبيئة مقارنة بالمبيدات الحشرية التقليدية.

□ نعم

□ لا

القسم الرابع: الآراء والتصورات

16 - ما رأيك في فعالية الصابون مقارنة بالمبيدات؟

□ أقل فعالية

□ فعالية متقاربة

□ أكثر فعالية

□ لا أعلم

17 - أبرز العوائق التي تمنع المزارعين من استخدام الصابون البوتاسي:

□ عدم المعرفة / التثقيف

□ السعر / التكلفة أعلى

□ توافر ضعيف في السوق

□ لا يثقون في الفعالية

□ أسباب أخرى : ....

القسم الخامس: أسئلة مفتوحة

18 - ما هي أشهر النصائح التي تقدمونها للفلاح عند بيع هذا المنتج؟

....

19 - من وجهة نظرك، ما الذي يمكن أن يساعد في زيادة استخدام الصابون الزراعي البوتاسي بين المزارعين؟ ....