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Biological Response *of Spodoptera frugiperda* to Uses of Vegetable Pesticides *Ipomoea pes-caprae Leaf Extract*

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Abstract

This study aims to evaluate the effectiveness of leaf extract (Ipomoea pes-caprae) as a plant pesticide in controlling (Spodoptera frugiperda), focusing on the effect of concentration and method of application on mortality, and feeding activity. This study was conducted to fill the limitations of previous studies that highlighted more pharmacological aspects (Ipomoea pes-caprae) and have not studied its potential as an insecticide against agricultural pests. The method used was a laboratory experiment with a factorial Complete Random Design (RAL), consisting of four concentration levels (0, 1000, 3000, and 5000 mg/L) and three application methods (feed dip, larval spray, and combination), with three replicas. The results showed that larval mortality was influenced by the interaction between concentration and application method, where at small and moderate concentrations the oral method was more effective, while at high concentrations the contact method was more dominant. In addition, the extract is able to significantly suppress eating activities. These findings confirm that the effectiveness of plant-based pesticides is contextual and depends on the entry pathways of the active compounds.

Keywords: Vegetable pesticide, *ipomoea pes-caprae, Spodoptera frugiperda*

INTRODUCTION

Pest attacks on corn plants are still the main factor in the obstacle to increasing production. One of the pests that is currently receiving serious attention is *Spodoptera frugiperda* (Lubis *et al*, 2020). This pest is invasive, has high adaptability, and multiplies quickly (Fu *et al,* 2024). The larvae attack the leaves to the point of growth, thereby interfering with the process of photosynthesis and plant growth (Tashiro *et al*, 2024). In severe attack conditions, damage can lead to a significant decrease in yield even to more than half of production (Supartha *et al*, 2021).

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Controls that are commonly carried out in the field still rely on synthetic pesticides. Repeated use often causes new problems, such as pest resistance, environmental pollution, and health risks for farmers and consumers (Sinambela, 2024). This condition encourages the need for safer and more sustainable control alternatives. Plant pesticides are present as a solution to control the dominance of plant pests. Secondary metabolite compounds produced by plants are known to have activities as stomach toxins, contact poisons, and food blockers.

One of the plants that has the potential to be used as a plant-based pesticide is *Ipomoea pes-caprae*. These plants contain flavonoids, alkaloids, terpenoids, tannins, and phenolic compounds that play a role in insecticidal activity (Nuskiya et al, 2023). However, most previous studies have focused more on pharmacological aspects, such as antibacterial and anti-inflammatory activity (Akinniyi et al, 2022)(Nuraliza & Hanifa, 2025). Studies related to its use as a plant pesticide against agricultural pests, especially *Spodoptera frugiperda*, are still very limited.

In addition, information on the most effective concentration and proper application method is also not adequately available. The effectiveness of plant-based pesticides is determined not only by the dose, but also by the entry route of the active compound into the insect's body. Application through feed and direct spraying allows for different working mechanisms, so it is necessary to study comprehensively. Therefore, it is hoped that this study can evaluate the effectiveness *of Ipomoea pes-caprae* leaf extract against *Spodoptera frugiperda* by comparing various concentrations and application methods. This research is expected to make a scientific contribution to the development of effective, environmentally friendly, and applicative plant-based pesticides in sustainable agricultural systems.

LITERATURE REVIEW

Dynamics of Spodoptera frugiperda

The pest Spodoptera frugiperda is the main focus in modern agricultural research because of its invasive, polyphage, and high reproductive nature (Fu et al, 2024)(Bakry & Abdel, 2023). In the past decade, the global spread of this pest has increased sharply, especially in tropical regions, including Southeast Asia. Studies show that damage to corn crops due to larval attacks can reach more than 50%, even up to 100% in severe attack conditions (Supartha et al, 2021).

The current scientific debate focuses on two main issues. First, high ecological adaptability makes this pest rapidly develop in various agroecosystem conditions (Early et al, 2018). Second, the emergence of resistance to synthetic insecticides due to repeated and uncontrolled use. A number of studies in the last five to ten years confirm that resistance to the active ingredients of chemical pesticides used continues to increase (Zhang, 2021)(Zhao et al, 2020)(Gutierrez et al, 2019). This condition confirms that conventional chemical-based control approaches are no longer effective enough. Therefore, the direction of research has shifted towards a more sustainable control strategy, one of which is through the use of plant-based

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pesticides.

Development of Plant Pesticides as an Alternative Control

Plant-based pesticides are developing as an ecological solution that is able to overcome the weaknesses of synthetic pesticides. In the literature of the last ten years, plant-based pesticides are understood as compounds based on secondary plant metabolites such as alkaloids, flavonoids, terpenoids, and phenolics that have insecticide, antifeedant, repellent, and growth inhibitor activity (Tampubolon et al, 2018)(Zuhro, 2024)(Pavela et al, 2025).

The effectiveness of plant-based pesticides in the field has reaped various debates. Some studies show very effective results at the laboratory scale, but are less consistent in field conditions (Pavela, 2016) (Iswan, 2020). This is due to two main factors, namely, the low stability of the active compound (easily degraded by light and temperature) and the variability of phytochemical content which is highly dependent on the environment and extraction method. Recent research attempts to address this problem through formulation, encapsulation, and standardization approaches. However, until now there is no consensus on the best method that can guarantee the consistency of the effectiveness of plant-based pesticides.

Potential of Ipomoea pes-caprae as a Plant Pesticide

Recent studies have shown that local plants have great potential as a natural source of insecticides. One of the widely developed approaches is the exploration of secondary metabolite content. The Ipomoea pes caprae plant as a source of bioactive compounds contains alkaloids, flavonoids, terpenoids, phenolics and tannins (Akinniyi et al, 2022) (Gazali et al, 2024) (Islamy et al, 2024).

Recent research has more examined the pharmacological activities of this plant, such as antibacterial, anti-inflammatory and antimicrobial (Akinniyi et al, 2022)(Nuraliza & Hanifa, 2025). There is a significant research gap, where almost no studies have been found specifically testing the effects of Ipomoea pes-caprae on agricultural pests, especially Spodoptera frugiperda. Most research is still limited to compound identification and non-agricultural bioactivity tests.

Methodological Debate in Plant Pesticide Applications

In some literature, there are differences regarding the method of application of plant pesticides. The two main approaches that are often compared are Oral application (through feed) and Contact application (direct spraying). Several studies have shown that oral application is more effective at low to moderate concentrations because the active compounds enter the digestive system directly (Kelly et al, 2022). In contrast, contact application is more effective at high concentrations because it increases penetration through the cuticle (Jakobs et al, 2023). This debate suggests that the effectiveness of plant-based pesticides is contextual and

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influenced by the interaction between concentrations, application methods and biological characteristics of pests.

RESEARCH METHOD

This study uses a quantitative approach with experimental methods carried out in the laboratory, with the aim of directly testing the effect of Ipomoea pes-caprae leaf extract on the biological response of Spodoptera frugiperda larvae. Through a controlled experimental design, each treatment is administered systematically so that the results obtained reflect valid conditions and can be scientifically accounted for.

The data source in this study consists of primary data secondary data. Primary data were obtained directly from the results of experiments in the laboratory through observation of Spodoptera frugiperda larvae treated with Ipomoea pes-caprae leaf extract. This data includes all the results of the measurement of research parameters observed periodically. Meanwhile, secondary data was obtained from various sources of scientific literature such as national and international journals relevant to the topic of plant pesticides and insect biology, which was used as a theoretical basis to support the analysis and discussion of research results.

The sample used in this study was in the form of Spodoptera frugiperda instar 3 larvae, which were selected in healthy, active, and free morphological defects. The selection of instars is based on a good level of sensitivity and eating activity so that the response to treatment can be clearly observed. Each treatment was carried out with an experimental unit in the form of individual larvae in a separate container and repeated three times to improve the accuracy of the data.

The research instruments used include materials, tools, and observation instruments. The main ingredients in this study are *Ipomoea pes-caprae* leaf extract, and *Spodoptera frugiperda larvae*, as well as corn leaves as a source of larval feed. Tools used in making extracts include a laboratory oven for the drying process of leaves, a blender for the destruction of dried leaves, a water bath shaker for the extraction process, a centrifuge for the separation of solutions, and a rotary evaporator for evaporating solvents. In addition, manual sprayers are used for larval treatment applications, microscopes or magnifying glasses for larval observation, as well as measuring instruments such as digital scales and measuring cups to ensure the accuracy of treatment doses.

The research process began with the manufacture of *Ipomoea pes-caprae leaf extract* using the maceration method with ethanol solvent. Furthermore, the preparation of test insects was carried out by selecting instar III larvae that met the criteria. After that, treatment is given in three application methods, namely feed dip, larval spray, and a combination of the two with various concentration levels (1g/L - 3g/L - 5g/L). This study focuses on two biological observations, namely the Percentage of Larval Mortality and the Consumption Rate of the larvae tested. Biological observations of larvae were carried out periodically at time intervals of 24 hours, 48 hours, 72 hours, 96 hours, and 120 hours.

Each treatment is carried out with three repetitions to improve the reliability of the results, the use of controls without extract treatment is carried out as a comparison to ensure

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that the changes that occur are caused by the treatment given. The conditions of the laboratory environment such as temperature and feed availability are kept constant to avoid the influence of external variables. In addition, the entire research procedure was carried out consistently on each treatment to minimize experimental errors.

The data analysis technique was carried out using statistical analysis with a factorial variance analysis approach (ANOVA) at a significance level of 5 percent to determine the influence of each factor and the interaction between treatment factors. If the results of the analysis show a significant difference, it is followed by the Duncan Multiple Range Test (DMRT) to find out the differences between treatments in more detail.

RESULT and DISCUSSION

Feed Consumption Rate

The results showed that the use of the plant pesticide Ipomoea pes-caprae, was able to reduce the consumption rate of Spodoptera frugiperda larvae.

Table 1. Average consumption in feed soaking treatment

Soak Feed	Average Consumption	Notation
Control	7692	a
1 gram	4651	b
3 Grams	4251	b
5 grams	3387	b

Ket: The average value followed by the same letter in the same column shows no real difference according to the Duncan Test at a significant level of 5%.

In the feed soaking application method (Table 1), the use of pesticide Ipomoea pes-caprae extract was able to suppress feed activity (p-value < 0.05), seen by reducing the number of larval feeding when given the extract treatment. Although the concentrations used did not show a statistically significant difference.

The results of the consumption level test in this study indicated that the decrease in feeding activity of larvae was most likely influenced by the active compounds in plant pesticides that entered the insect's digestive system. In line with a study conducted by Iduwo & Alabi (2024), the use of plant-based pesticides focused on egg poisons is able to rival the consistency of chemical pesticides.

The application method of larval spray shows that it statistically affects the amount of larval leaf consumption (P-value < 0.05). At the highest concentration, the average consumption showed the smallest value (3193), which differed significantly from other concentrations

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accompanied by control (Table 2). Direct exposure through the cuticle or spiracle of larvae is thought to cause disturbances in the nervous system and its metabolism. In line with the study conducted by Sun et al (2024), it is explained that direct exposure to plant-based pesticides can cause physiological stress and have an impact on reducing eating activities.

Table 2. Average leaf consumption in larval spray treatment

Treatment Combinations	Average Consumption	Notation
Controls	7421	a
1 gram	5799	b
3 Grams	5097	c
5 grams	3674	d

Ket: The average value followed by different letters in the same column shows a real difference according to the Duncan Test at a significant level of 5%.

Table 3. Average leaf consumption in a combination of treatments

Spray Larvae	Average Consumption	Notation
Controls	7748	a
1 gram	5097	b
3 Grams	4795	b
5 grams	3193	c

Ket: The average value followed by different letters in the same column shows a real difference according to the Duncan Test at a significant level of 5%.

The application method, which combines the application of larvae and feed immersion, showed statistically significant differences between the concentrations treated. The differences in letter notation in table 3 above indicate that any increase in the concentration of the plant pesticide Ipomoea pes-caprae results in a decrease in the average rate of leaf consumption by larvae when a combination of methods is treated.

The application of plant pesticides combined in this study is likely to cause changes in the taste and aroma of the feed given scientifically, so that the sensory system of the larvae detects it and the larvae reduce their feeding activity. This is explained in a study conducted by Pefluloglu et al, (2025) where changes in the taste and aroma of feed can reduce insect eating activities. Sun et al, 2024 also explained that bioactive compounds from plant pesticides can interfere with

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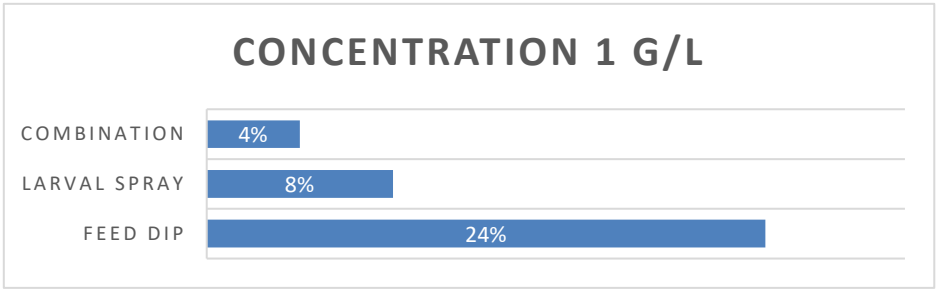
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physiological processes in the insect's body, so larvae tend to reduce feed consumption.

Mortality

Larval mortality testing showed that the larval mortality rate of spodoptera frugiperda was not only determined by the concentration of plant pesticides, but also influenced by the way the active compound entered the larva's body.

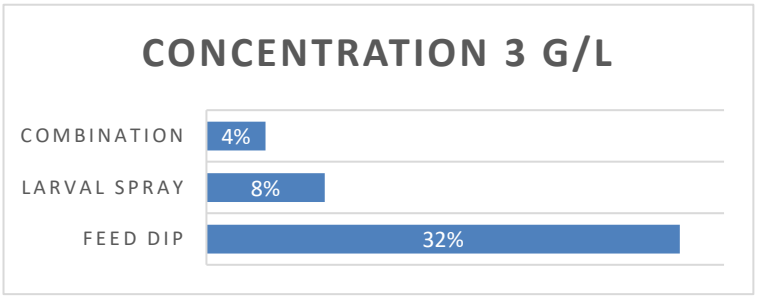
Graphics 1. Percentage of larval mortality



The graph above shows the percentage of larval mortality at a plant-based pesticide concentration of 1g/l, which is applied by three different methods. In the application method of soaking feed for initial concentration, it showed higher results than in other application methods. When the concentration of plant-based pesticides was increased, the data showed a pattern consistent with the previous one, but with increased effectiveness in certain methods (Graph 2). The highest mortality still occurred in the feed soaking treatment, which was 32%.

This value increases compared to the previous concentration of 1g/l, which confirms that the increase in concentration reinforces the toxic effects that enter through the digestive system. Pan et al, (2025) and Motta et al, (2023) in their study explained that the penetration of vegetable pesticides in the oral pathway is able to interfere with the metabolic process of exposed larvae, thus causing death.

Graphics 2. Percentage of larval mortality



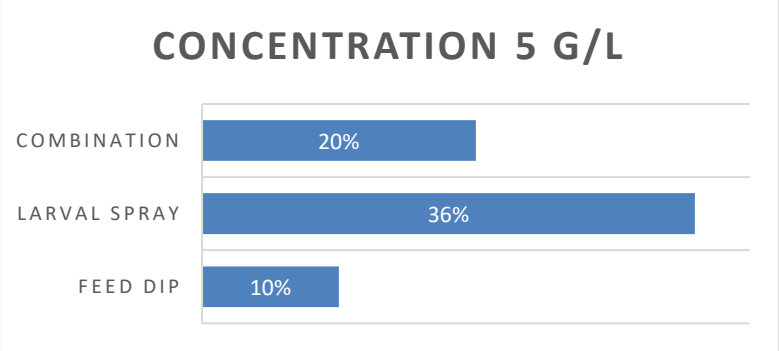
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Graphics 3. Percentage of larval mortality



The graph at the highest concentration (5g/l) shows a fairly sharp change in response pattern compared to the previous two concentrations. At this concentration, the larval spray application method resulted in the highest mortality, which was 36%. These results show that at high concentrations, the active compound begins to be able to penetrate the larval cuticle more effectively, thereby increasing the toxicity through the contact route. In line with a study conducted by Ibrahim & Rustam (2024), it is stated that increasing concentration is able to accelerate the mortality rate of the larvae tested.

CONCLUSION

This study shows that the application of the vegetable pesticide Ipomoea pes-caprae has a significant effect on reducing the consumption rate and mortality rate of Spodoptera frugiperda larvae.The results of the study showed different responses depending on the application method and concentration used.

In terms of consumption level, all application methods were able to reduce the larval feeding activity compared to control, which indicates the antifeedant effect of the active compounds contained. The feed soaking method significantly reduced the consumption rate, but the concentrations showed no real difference. Then for the larval spray method, it showed a decrease in concentration-dependent consumption, and the strongest effect was at the highest concentration. Meanwhile, the combination method provides a consistent decrease in consumption as well as a noticeable difference in each increase in concentration.

In terms of mortality, the results showed that effectiveness was not only influenced by concentration, but also by the entry route of the active compound. The feed soaking method shows the highest results at low to moderate concentrations. However, when concentrations were increased, the larval spray method resulted in the highest mortality, indicating that with increased concentrations, penetration through the cuticle became stronger, thus amplifying the effects of contact toxicity.

The results of the study confirmed that the consumption rate was more likely to the

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antifeedant effect, while mortality was more influenced by the interaction between concentration and method of application. The practical implication of these findings is that *Spodoptera frugiperda control strategies* using plant-based pesticides need to consider the purpose of application, whether to suppress feeding activity or increase larval mortality.

This study is limited to laboratory conditions and has not considered environmental factors, stability of active compounds, and population dynamics in the field. In addition, the identification of specific active compounds and their mechanism of action has not been carried out. Therefore, further research is needed to test its effectiveness in field conditions and examine the mechanisms of toxicity in more depth.

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