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Testing Extracts of Pigpea Seeds (Tephrosia vogelii) Against Fall Armyworm (Spodoptera frugiperda) in the Laboratory

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Abstract. One of the invasive pests that target corn plants is the armyworm *Spodoptera frugiperda*. This pest can cause damage to every area of the corn plant. Botanical insecticides can be used to control *S. frugiperda* since it is better for the environment. Rotenone found in the *T. vogelii* is toxic to insects. The purpose of this study was to assess the effect of the botanical pesticide *T. vogelii* seed extract mortality of *S. frugiperda*. *T. vogelii* seed extract was produced by using a Soxhlet extractor. The tests were conducted using contact poison and stomach poison methods, with the concentrations of the extract solution tested being 0.0625, 0.125, 0.25, and 0.5%. *T. vogelii* seed extract demonstrated the highest mortality value against *S. frugiperda*, which is 100% at a concentration of 0.5% in both the contact poison and stomach poison methods. *T. vogelii* seed extract shows strong toxicity with LC50 = 0.221% and the shortest mortality at 0.5% concentration with LT50 = 2.214 days against *S. frugiperda*, with an LC50 of 0.316% and the fastest mortality at 0.5% concentration, with an LT50 of 2.457 days. Further research is needed to determine the effect of *T. vogelii* seed extracts both in the screen house and in the field.

Keywords: Spodoptera frugiperda, Corn, Botanical pesticide, Tephrosia vogelii

1 Introduction

Corn (Zea mays L.) is a very important food crop because, to date, corn is a substitute for rice for some of the Indonesian population. In addition, corn is also a strategic commodity because it has a significant impact on economic stability. However, efforts to increase corn production in Indonesia face various challenges, including attacks by the Fall Armyworm (FAW) or S. frugiperda [1].

Efforts to boost corn production are challenged by pests, especially the Fall Armyworm (*Spodoptera frugiperda*), which has caused major damage across several regions [2].

Farmers often rely on synthetic pesticides, which despite their effectiveness pose risks to human health, beneficial organisms, and the environment, while also contributing to pest resistance [3].

As a safer and more sustainable alternative, plant-based insecticides (botanical pesticides) are gaining attention due to their biodegradable nature and affordability, especially for small-scale farmers with limited access to modern technologies[4].

Tephrosia vogelii, a leguminous plant, has emerged as a promising botanical insecticide due to its rotenone content, a natural compound with strong insecticidal properties [5].

Rotenone acts as both a contact and stomach poison, disrupting pest physiology upon ingestion or surface exposure [5].

In the study by Nenotek and Ludji (2020), the seeds of *T. vogelii* obtained through maceration extraction (soaking samples using organic solvents) and then evaporated with a *rotary evaporator* have stomach and contact toxicity effects against the larvae of *Helicoverpa armigera* on corn plants and in the laboratory. At a concentration of 1.50%, it showed the highest mortality rate of 86.67% using stomach and contact methods. Given the potential of *T. vogelii* in controlling *H. armigera*, it is necessary to conduct research on the cutworm pest *S. frugiperda* [6].

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2 Research Method

This research was conducted in the laboratory of the Faculty of Agriculture, Islamic University of North Sumatra, Jl. Karya Wisata Gedung Johor, Medan Johor District, Medan City, North Sumatra. The research was carried out from June 24, 2021, to November 2, 2021.

This study uses a Completely Randomized Design (CRD) Non-Factorial with treatment of T. vogelii seed extract. According to Prijono (2003), initial testing for the crude extract obtained with organic solvents is conducted at a concentration not exceeding 0.5% [7]. This study uses five levels of concentration which are:

T0 = control (chloroform)
Solvent concentration 0,5%
$\frac{0,5}{100} x100\ ml$: 0,5 ml
water : 100 ml – 0,5 = 99,5 ml

T1 = Concentration of Extract 0,0625%
$\frac{0,0625}{100} x100\ ml$: 0,625 ml
water : 100 ml – 0,0625 = 99,93 ml

T2 = Concentration of Extract 0,125%
$\frac{0,125}{100} x100\ ml$: 0,125 ml
water : 100 ml – 0,125 = 99,87 ml

T3 = Concentration of Extract 0,25%
$\frac{0,25}{100} x100\ ml$: 0,25 ml
water : 100 ml – 0,25 = 99,87 ml

T4 = Concentration of Extract 0,5%
$\frac{0,5}{100} x100\ ml$: 0,5 ml
water : 100 ml – 0,5 = 99,5 ml

Each treatment is repeated three times. The data in the study was obtained through direct observation of mortality that occurred in each treatment and replication. To determine the effect of pig peanut extract (T. vogelii) on the mortality of S. frugiperda, the collected data was then analyzed using Analysis of Variance (ANOVA) tested at a 5% level; if there was a significant effect, it was followed by Duncan's Multiple Range Test (DMRT). Meanwhile, to determine LC50% and LT50%, Probit analysis was used. Data analysis was performed using SPSS.

3 Results and Discussion

3.1 Contact Poison Testing

Observation data on the mortality of S. frugiperda and analysis of variance from the contact toxicity test at 1-5 Days After Application (DAA) indicate that the treatment of concentration of crude extract from T. vogelii seeds tested as a contact poison has a significant effect on the mortality of S. frugiperda. The mortality of S. frugiperda larvae from 1 DAA to 5 DAA can be seen in the following Figure 1.

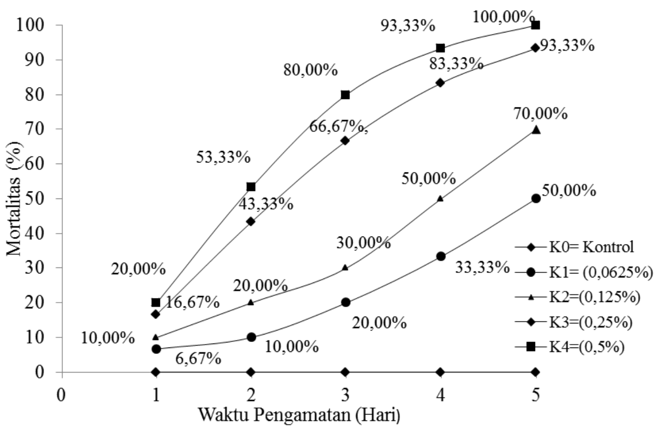

Figure 1. Graph of S. Frugiperda Mortality on the Application of T. Vogelii Seed Extract as a Contact Poison

The trend of mortality development in fall armyworm (*Spodoptera frugiperda*) under each treatment of crude *Tephrosia vogelii* extract as a contact poison is presented in Figure 1. The trend shows that from 1 to 5 days after

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application (DAA), the treatment K4 (0.5% concentration) resulted in a consistent increase in mortality, reaching the highest rate of 20–100% within that period. This finding is consistent with the report by Mukui (2013), which indicated that *T. vogelii* extract applied as a contact poison affected the mortality of the flea beetle (*Aphthona whitfleldi*) at concentrations of 0.25%, 5.0%, and 10.0% using water as a solvent. At 168 hours, the mortality rate ranged between 50–62%, with an LC_{50} value of 1.9% [8].

Treatment K3 (0.25% concentration) showed a similar effect, with 93% mortality recorded at 5 DAA. In contrast, treatments K1 (0.0625%) and K2 (0.125%) also led to increased mortality of *S. frugiperda*, but the rate of increase was relatively slower, as indicated by mortality levels of only 50–70% at 5 DAA. This is likely due to the lower concentrations applied, which reduced the toxic efficacy of the extract. Supporting this, Afifah (2015) reported that higher concentrations of botanical biopesticides lead to greater levels of active compounds in the solution, thereby enhancing the insecticidal potency. In the control treatment (K0), no mortality of *S. frugiperda* was observed throughout the 1–5 DAA period [9].

Based on the probit analysis, which serves as a standard measure of a substance's toxicity, Figure 2 confirms that *T. vogelii* seed extract is effective against *S. frugiperda* when applied as a contact poison.

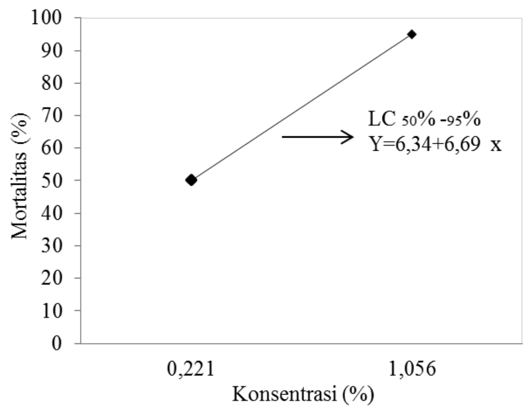

Figure 2. Probit Regression Relationship of S. Frugiperda Mortality Against the Log Concentration of T. Vogilii as a Contact Toxin

Based on Figure 4.2, the LC_{50} value at a concentration of 0.221% (with a confidence interval ranging from 0.002% to 0.358%) is identified as the optimal concentration capable of killing 50% of *Spodoptera frugiperda* larvae. The probit regression equation for *T. vogelii* extract as a contact poison is expressed as **Y = 6.588 + 2.419x**. A lower LC value indicates that the compounds present in the *T. vogelii* extract are more toxic.

The LT_{50} observation results, after being analyzed using analysis of variance (ANOVA), show that different concentrations of *T. vogelii* seed extract have a significant effect on the time required to kill 50% of *S. frugiperda* larvae. These findings are presented in Table 1.

Table 1. Average LT_{50} Under Different Concentration Treatments of *T. Vogelii* Seed Extract

Concentration	LT50 (days)	Lower limit	Upper limit
0,0625%	5,295	4,017	16,166
0,125%	4,214	2,935	5,347
0,25%	2,525	1,419	3,122
0,5%	2,214	1,467	2,650

Table 1 shows that treatment with *T. vogelii* seed extract resulted in LT_{50} values for *S. frugiperda* larvae ranging from 2.214 to 5.295 days. The fastest time to kill 50% of *S. frugiperda* insects occurred at a concentration of 0.5%, which was 2.214 days (with an interval of 1.467–2.650 days) and had a probit regression equation of Y = 2.964 + 5.898x. The probit regression graph is shown in Figure 3 below.

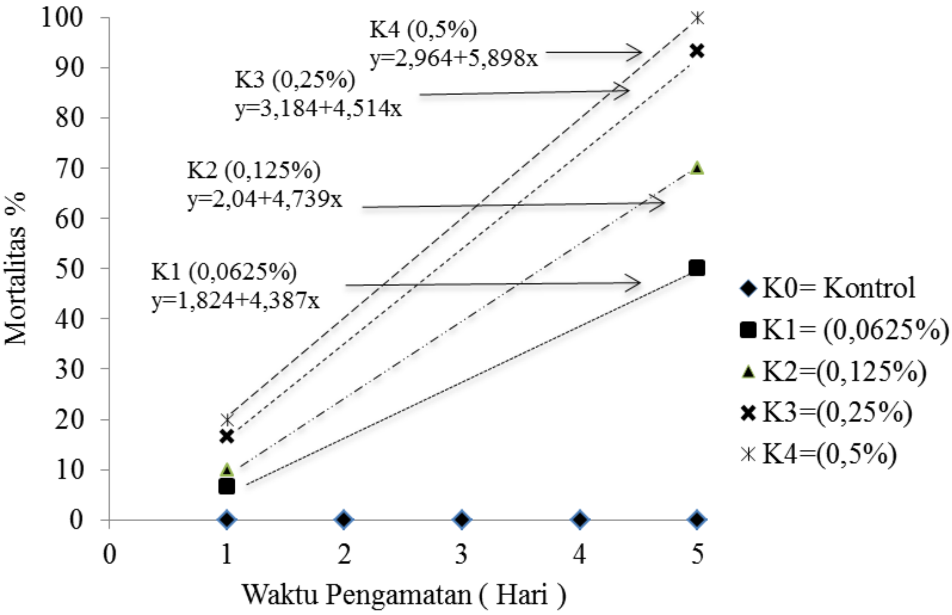

Figure 3. Probit Regression Relationship Between *S. Frugiperda* Mortality and Log Concentration of *T. Vogilii* as a Contact Poison

3.2 Stomach Poison Testing

The mortality observation data for *S. frugiperda* and the analysis of variance in the stomach poison test observations 1-5 days after application (DAA) can be seen in Figure 4. This indicates that the treatment with *T. vogelii* seed extract concentrations as stomach poison had a significant effect on the mortality of *S. frugiperda* in the 1-5 DAA observation, as shown in Figure 4 below.

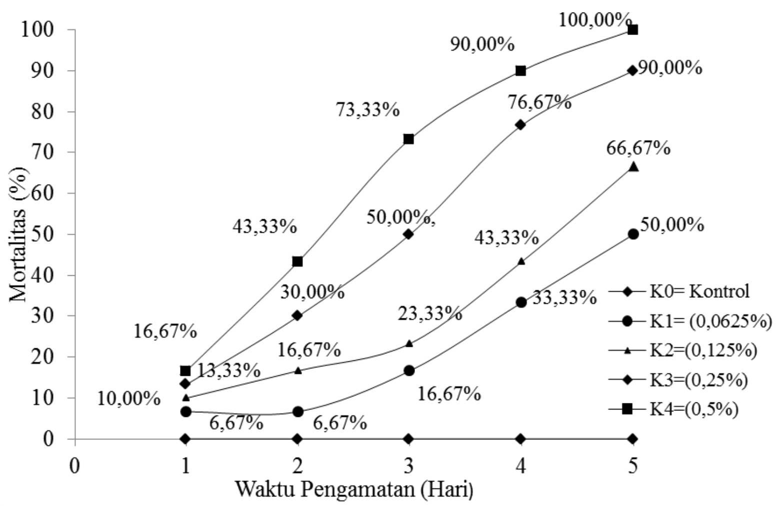

Figure 4. Mortality Graph of *S. Frugiperda* in the Application of *T. Vogelii* Seed Extract as a Stomach Poison

The trend in mortality of the fall armyworm (*S. frugiperda*) in each treatment with crude *T. vogelii* extract as a stomach poison can be seen in Figure 4, showing that the trend in mortality of *S. frugiperda* at 1-5 DAA increased significantly, as seen in treatment K4 (concentration 0.5%) with mortality of S. frugiperda showed 16.67–100% mortality from 1–5 DAA, and treatment K3 (concentration 0.25%) showed 90% mortality at 5 DAA. *T. vogelii* has a stomach poison effect in the form of rotenone compounds that enter the body of S. frugiperda larvae through the digestive tract. According to Hollingwort (1994), rotenone acts as a cell poison in the mitochondria, causing insects to lack energy, cell death, and tissue death, ultimately leading to the death of the insect [10].

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Meanwhile, the mortality trend in treatments K1 (concentration 0.0625%) and K2 (concentration 0.123%) showed an increase in mortality of *S. frugiperda*, but relatively slowly, can be observed at 5 DAA mortality rates of 50-66.67%. This is due to the application of low concentrations, which affects the mortality rate of *S. frugiperda*. This aligns with Prijono's (1999) view that the higher the concentration used, the greater the active ingredient content in the solution, thereby increasing the pesticide's toxicity. In treatment K0 (control using the organic solvent chloroform), there was no mortality of *S. frugiperda* at 1-5 DAA [11].

T. vogelii extract has an effect on *S. frugiperda* larvae through stomach poisoning. This is consistent with the research by Abizar and Prijono (2010), which explains that *T. vogelii* leaf extract with concentrations of 0.05, 0.08, 0.11, 0.14, 0.18, and 0.22% can inhibit the feeding of *C. pavonana* larvae, there by inhibiting their development [12]. In the study by Susanto and Prijono (2015), testing of *T. vogelii* extract against the yellow rice stem borer Scipophaga incertulas showed that at a concentration of 0.08%, treatment with *T. vogelii* extract resulted in 50% mortality of the test insects within 72 hours after treatment. At concentrations ranging from 0.20% to 0.60%, treatment with *T. vogelii* extract could kill 60% to 95% of the test insects within 72 hours after treatment. In general, it was observed that the mortality rate increased with higher concentrations [13].

Based on the results of probit analysis, which is a measure of the toxicity of a substance, Figure 5 shows that *T. vogelii* seed extract is effective against *S. frugiperda* as a stomach poison.

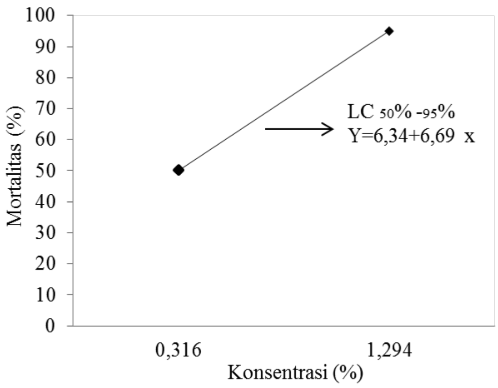

Figure 5. Probit Regression Relationship Between *S. Frugiperda* Mortality and Log Concentration of *T. Vogilii* as a Stomach Poison

From Figure 5 above, it can be seen that a concentration of 0.316% (with an interval of 0.082% to 0.470%) has a probit regression equation Y=6.34+6.69x, which is the exact concentration that can kill 50% of *S. frugiperda* larvae in stomach toxicity testing. The smaller the LC value, the more toxic the compound present in the *T. vogelii* extract.

The results of LT_{50} observations after analysis showed that the treatment of *T. vogelii* seed extract concentration had a significant effect on the time required for *T. vogelii* seed extract to kill 50% of *S. frugiperda* larvae, as shown in Table 2.

Table 2. Average LT50 with Treatment of Several Concentrations of *T. Vogelii* Seed Extract

Concentration	LT_{50} (days)	Lower limit	Upper limit
0,0625%	5,142	4,487	8,762
0,125%	4,252	3,396	6,532
0,25%	3,100	2,272	3,615
0,5%	2,457	1,833	2,859

Table 4.2 shows that treatment with *T. vogelii* seed extract resulted in LT_{50} values for *S. frugiperda* larvae ranging from 2.457 to 5.142 days. At a concentration of 0.5%, the LT_{50} showed the fastest time, namely 2.457 days (with an interval of 1.833–2.859 days), with a probit regression equation of Y = 2.538 + 6.306x. As the concentration increases, the LT_{50} value of *T. vogelii* seed extract against *S. frugiperda* larvae decreases. The probit regression graph is shown in Figure 6 below.

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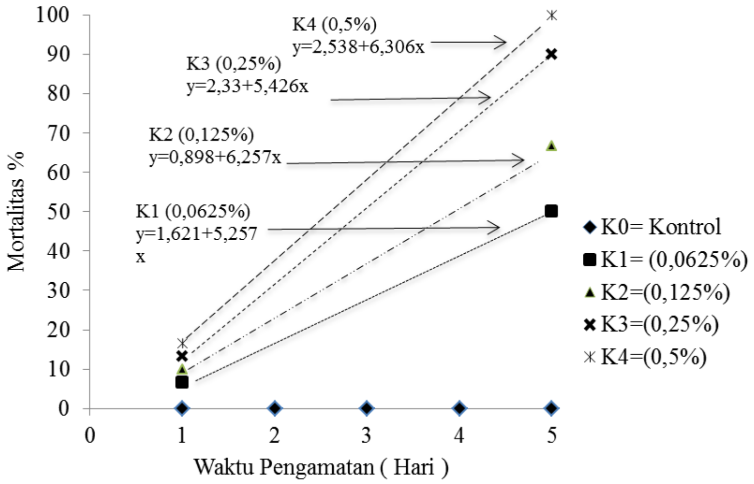

Figure 6. Probit Regression Relationship Between *S. Frugiperda* Mortality and Log Concentration of *T. Vogilii* as a Stomach Poison

4 Conclusion

The contact toxicity test method using *T. vogelii* seed extract showed 100% mortality of *S. frugiperda* at a concentration of 0.5%, and the stomach toxicity test method showed 100% mortality at a concentration of 0.5%. High toxicity was observed in the contact toxicity test of *T. vogelii* seed extract (LC_{50} = 0.221) and in the stomach toxicity test (LC50 = 0.316%). The fastest time to kill *S. frugiperda* was observed at a concentration of 0.5%, with LT_{50} showing a time of 2.214 days in the contact toxicity test and LT_{50} in the stomach toxicity test showing a time of 2.457 days at a concentration of 0.5%.

5 Acknowledgements

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