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Effectiveness of Green Betel Leaf Powder (*Piper betle* L.) as a vegetable biopesticide against the Mortality of Rice Weevil (*Sitophilus oryzae* L.)

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Abstract: This study addresses the persistent challenge of rice storage and food security, focusing on the post-harvest management of stored grains, particularly in mitigating damage caused by the rice weevil (*Sitophilus oryzae* L.). The research explores the impact of varying concentrations (2-8 grams) of green betel leaf (*Piper betle* L.) powder extract on rice weevil mortality. Employing a Completely Randomized Design, the study reveals that the highest mortality (15.6%) is achieved with an 8-gram concentration of green betel leaf powder. Correlation analysis establishes a positive relationship between concentration and weevil mortality (r = 0.84), with a significant correlation (r = 0.77) between concentration and the time taken for weevil mortality. Calculated efficacy demonstrates that the 8 gram concentration achieves a 70% effectiveness, meeting success criteria. Consequently, green betel leaf powder emerges as a promising botanical insecticide against rice weevils, warranting further investigation for dosage optimization and concentration. Future research should prioritize environmental and human safety considerations in the development and application of botanical insecticides in agricultural pest management.

Keywords: botanical insecticide; efficacy; Green betel leaf; *Piper betle* L.; rice weevil; *Sitophilus oryzae* L.

Introduction

One of the main issues in rice food security is the lack of proper storage management. Efforts to address the issue of rice storage in order to meet national food needs require effective post-harvest handling. Careful attention to rice storage can reduce crop damage due to warehouse pest attacks (Rustam et al., 2017). Storage plays a crucial role because during this period, rice experiences a decline in both quality and quantity. Common damages occurring during rice storage are caused by insect attacks, particularly by *Sitophilus oryzae* L., which can damage 5–15% of stored material (Setiawan, 2010).

Processed agricultural products, such as rice, are stored in warehouses, whether open or closed. The rice storage process typically takes a considerable amount of time, ranging from 2 to 3 months. During this storage process, rice is generally vulnerable to pest disturbances, leading to changes in texture and transformation into flour-like paste. One common pest is the Rice Weevil (*Sitophilus oryzae* L.), belonging to the Curculionidae family of the Genus *Sitophilus* (Parinduri, 2010).

Sitophilus oryzae L. is a warehouse pest insect that attacks various types of plants and can cause significant damage depending on population and storage duration. Symptoms of infestation include rice grains with holes or transformed into flour due to beetle activities (Susanti et al., 2018).

The application of various types of botanical pesticides and several rice varieties significantly influences the parameters of Pest Mortality and rice resistance (Pitri, 2022). According to Rahmawati et al.,

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(2019), various plant species are identified as potential botanical pesticides, and numerous observations have been conducted on pest control through the use of botanical pesticides. Several botanical pesticides have demonstrated effective outcomes in controlling rice pests, particularly rice aphids. Organic insecticides serve as an effective alternative to address the limitations of synthetic insecticides. Made from plant materials, they are easily biodegradable, relatively safe for humans, and can be produced by farmers (Rahmi et al., 2023). Some studies indicate the potential of green betel leaf powder extract in controlling rice weevil pests, such as the research by Rahman et al. (2021) and Rustam et al. (2017). Rahman et al. (2021) findings show that red betel leaf powder can suppress the population of *Sitophilus oryzae* L., although not entirely effectively. Conversely, Rustam et al. (2017) research indicates that the application of forest betel leaf powder at a dose of 6 g/100 g rice is effective in controlling rice beetle pests, with a death rate exceeding 80% within 31.25 hours and total mortality reaching 95%.

Based on the explanation above, the researcher aims to assess the performance of botanical insecticides as an alternative option for controlling insect pests, specifically rice weevils (*Sitophilus oryzae* L.), by utilizing extracts from green betel leaf powder. The expectation is that the findings of this research can contribute as a reference in the development of insect pest control strategies, particularly in addressing rice weevil infestations.

Method

Location

This research was conducted from June to October 2019 at the Integrated Research Laboratory of Universitas Sumatera Utara. The study utilized a Completely Randomized Design (CRD), and the factors tested were as follows: (K0) = Control (No green betel leaf powder application), (A1) = Green betel leaf powder 2 g, (A2) = Green betel leaf powder 4 g, (A3) = Green betel leaf powder 6 g, (A4) = Green betel leaf powder 8 g. There were a total of 5 treatments and 5 replications, resulting in 25 experimental units, including the control.

Research Procedure

Selection of Green Betel (Piper betle L.*)*

Leaves green betel leaves were selected while still fresh, choosing those that were green and from healthy plants.

The provision of *Sitophilus oryzae* L.

The provision of *S. oryzae* L. began by preparing two large boxes (21 x 17 cm), each containing a jar with 1000 g of rice, used for mass breeding as a living medium and one of the food sources for rice weevils. The breeding involved placing male and female imagoes, distinguishing males by their smaller size, shorter and slender rostrum, and a curved and pointed shape of the abdomen when viewed laterally and posteriorly. Females, on the other hand, were larger, had a longer and larger rostrum, and their abdomen appeared not curved but straight and enlarged (blunt) (Manaf, 2005). The life cycle of *S. oryzae* L. imagoes takes about 30-35 days from eggs to adults. The imagoes used in this application were 25 days old, as at this age, they are fertile (Isnaini et al., 2015). The pest was bred for 25 days.

Preparation of Sitophilus oryzae L.

The preparation of *S. oryzae* L. involved setting up two large boxes (21 x 17 cm) with each container containing 1000 g of rice, used for mass breeding as a living medium and one of the rice weevil's food sources. The breeding process involved distinguishing between male and female imago by their size; males are smaller with shorter and slender rostrums, and their abdomen appears curved and pointed from the lateral and posterior views. In contrast, females are larger with longer and broader rostrums, and their abdomen appears not curved but straight and enlarged (blunt) (Manaf et al., 2005).

The life cycle of *S. oryzae* L. lasts for 30-35 days from egg to imago, and the imago used in this study were 25 days old, as this age represents the fertilization period of *S. oryzae* L. Therefore, the pest breeding was carried out for 25 days (Isnaini et al., 2015).

Production of Green Betel Leaf Powder Extract

The process of making green betel leaf pesticide powder started by collecting 0.5 kg of green betel leaves directly from the field. The leaves were then cut into small pieces for easier drying, and they were sun-dried until completely dry. After drying, the green betel leaves were finely ground using a blender to produce a fine powder.

Implementation Stage

Treatment on Test Containers

A total of seventy-five plastic cup containers, sized 11 x 7 cm, were readied and labeled. Ventilation openings situated at the cup tops were sealed using gauze or mesh fabric. Each specific treatment was supplied with 100 g of rice, followed by the application of green betel leaf powder through a controlled sprinkling corresponding to the assigned treatment onto the rice. The amalgamation was uniformly mixed by shaking it for a duration of 30 seconds.

Infestation of Sitophilus oryzae L.

Sitophilus oryzae L. was collected in the form of 250 imagoes, separated into different containers, and subsequently starved for one day (Makal, 2011). The purpose of this fasting was to encourage *S. oryzae* L. to consume the rice treated with each respective treatment. Insect infestation was conducted in the evening at 16:00 WIB, as *S. oryzae* L. tends to be more active in consuming food at night, ensuring a higher consumption rate compared to daytime. The *S. oryzae* L. used were imagoes at the 25th day of their life cycle. In general, the morphological characteristics of *S. oryzae* L. imagoes at 25 days play a crucial role in identifying and distinguishing the rice weevil species from other insects. Understanding these characteristics is expected to aid in the development of more effective and efficient pest control strategies (Hagstrum & Subramanyam, 2018). Subsequently, 10 insects were placed in each small plastic container that had been treated with green betel leaf powder, mahogany seed powder, and a combination of both (Andrianto *et al*., 2016), followed by observations.

Data Analysis

Percentage of total mortality of Sitophilus oryzae L.

Observations of dead insects were conducted every day starting 24 hours after pesticide application. This involved counting the number of dead rice weevils every 24 hours for seven days until all pests were dead. The percentage of mortality data was expressed in percentage units. The obtained data were then used to calculate daily total mortality (Rahmadiyanti, 2018). Mortality indicates the level of ability or the number of pest deaths caused by the used botanical pesticide and is expressed in percentage. Mortality can be calculated using the formula (Epi, 2016):

$$\text{Mortality} = \frac{\text{Number of Dead Insects}}{\text{Total Insects Tested}}\ x\ 100\% \quad (1)$$

The relationship between the concentration of green betel leaf powder, mahogany seed powder, and their combination on the mortality of rice weevils (*Sitophilus oryzae* L.).

The analysis of the relationship between the concentration of green betel leaves and the mortality of rice weevils (*Sitophilus oryzae* L.) was conducted using Pearson Correlation. The results of the Pearson correlation calculation will reveal the relationship between the variables being assessed. Typically, if the analysis shows a value above 0.5, approaches 1, and moves in a positive direction, it indicates a close relationship between the two calculated variables. Additionally, if the statistical calculation results also show (**) symbols, it signifies a strong relationship between the concentration and mortality of rice weevils.

The relationship between the concentration of, green betel leaf powder, mahogany seed powder and their combination on the time of death of rice weevils (*Sitophilus oryzae* L.).

The analysis of the relationship between the concentration of green betel leaves and the mortality time of rice weevils (*Sitophilus oryzae* L.) was conducted using Pearson Correlation. The results of the Pearson correlation calculation will reveal the relationship between the calculated variables. Typically, if the analysis results show a value above 0.5, approaching 1, and moving in a positive direction, it indicates a close relationship between the two calculated variables. Moreover, if the statistical calculation results also indicate (**) significance, there is a strong relationship between the concentration and the mortality time of rice weevils.

Insecticide Efficacy

The efficacy of an insecticide can be considered effective if the insecticide efficacy (EI) value is ≥ 70%, calculated using the formula:

$$\text{EI}=\frac{ca-ta}{ca}\times 100\% \quad (2)$$

Description:
EI = Insecticide efficacy (%)
ca = Intensity of target pest on the control plot
ta = Intensity of target pest on the treatment plot after insecticide application (Abbott, 1925).

The mortality data were statistically analyzed using the Duncan's New Multiple Range Test (DNMRT) in SPSS 22® software, while the insecticidal efficacy was analyzed using Microsoft Excel 2007. Furthermore, the analysis of the relationship between the concentration of green betel leaf powder and the mortality and time of rice weevils (*Sitophilus oryzae* L.) was conducted using Pearson correlation analysis in SPSS 22® software.

Result and Discussion

Rice Weevil Mortality (*Sitophilus oryzae* L.)

The results of observations on the mortality of adult *S. oryzae* L. revealed that the highest mortality occurred in treatment A4, with a mortality rate of 35 individuals per sample, while the lowest mortality was observed in treatment B1, with a mortality rate of 12 individuals. Based on the analysis of variance (ANOVA), the Duncan's multiple range test indicated significant differences among all treatment codes from A1 to A4. Furthermore, A1 did not show a significant difference from A2, while A3 and A4 showed significant differences. Additionally, A2 did not differ significantly from A3 but differed significantly from A4. Lastly, A3 exhibited a significant difference from A4, as presented in Table 1.

Table 1. Table of *Sitophilus oryzae* L. Rice Weevil Mortality.

Treatment	∑	Average	(%)
K0	0 aa	0	0
A1	18 b	6.0	8.0
A2	22 b	7.3	9.8
A3	23 b	7.7	10.3
A4	35 cc	11.7	15.6

Description: Values followed by the same letter indicate a significant difference in the DNMRT (the Duncan's New Multiple Range Test) test at the 5% level of significance ($P<0.05$). (K0): Control; (A1): Green betel leaf powder 2 g; (A2): Green betel leaf powder 4 g; (A3): Green betel leaf powder 6 g; (A4): Green betel leaf powder 8 g.

Based on the analyzed percentage of *S. oryzae* L. imago mortality, the highest percentage of mortality was observed in treatment A4, with a mortality rate of 15.6% for rice weevils. In contrast, the lowest percentage of mortality was found in treatment A1, with a mortality rate of 8.0%, as illustrated in Figure 1.

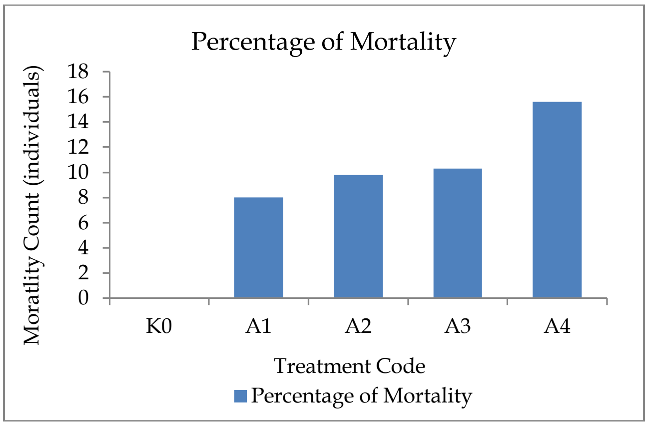

Figure 1. Percentage of Mortality of Rice Weevil (*Sitophilus oryzae* L.)

Description= (K0): Control; (A1): Green betel leaf powder 2 g; (A2): Green betel leaf powder 4 g; (A3): Green betel leaf powder 6 g; (A4): Green betel leaf powder 8 g.

Table 1 shows that, in general, botanical insecticides, such as green betel leaf, mahogany seeds, and their combination with different concentrations, have an impact on the mortality of rice weevils (*S. oryzae* L.). This finding is supported by (Dewi, 2010), who noted that increasing doses can elevate toxin content affecting rice weevils, leading to mortality. Piperamidin, the active ingredient in the highest dose, is believed to accelerate the total mortality of rice weevils. The treatment with the highest dose resulted in the highest mortality due to its high toxicity, including the high content of piperamidin and dillapiol, entering the bodies of rice weevils. The use of green betel leaf powder has proven effective in controlling rice weevils, with the highest mortality reaching 15.6% in treatment A4 (Table 1). These results align with.

Due to the decreasing chemical content in red betel leaf powder, which undergoes several stages in its production process, there is a decline in its effectiveness. The obtained mortality results for S. oryzae align with the findings of (Afifah et al., 2015) highlighting the drawback of botanical pesticides, namely their relatively low toxicity, resulting in delayed lethality (slow action), short persistence, and rapid degradation upon exposure to sunlight. The observed mortality of rice weevils shows the highest average in treatment A4 (11.7), while the lowest average is found in treatment A1 (6.0) (Table 1).

Studies by Fara et al. (2016) and Moelyaningrum (2020), yield similar findings regarding the effectiveness of green betel leaf powder, mahogany seeds, and their combination on the mortality of rice weevils. Therefore, it can be concluded that green betel leaf powder, mahogany seeds, and their combination can be used as effective botanical insecticides to control rice weevils. However, attention should be paid to factors such as the targeted insect species, environmental conditions, and doses that are safe for humans and the environment. Research by Nugraha et al. (2017), highlights that fumigants, including forest betel leaf powder, can penetrate the insect's body through respiration or the tracheal system, disrupting the nervous system and causing death. Ole (2017) found that forest betel leaf powder is effective in controlling armyworms (*Spodoptera litura*).

Sari et al. (2018) also noted that mahogany leaf extract has insecticidal effects on cabbage loopers. Based on the average death of rice weevils in the concentration treatments of mahogany seed powder and green betel leaf powder, the highest value is found in treatment A4 (8 g), while the lowest value is in treatment A1 (2 grams). Rice weevil mortality increases with the rise in powder concentration, consistent with

(Nazilah, 2020) study showing that dose and concentration significantly influence pest mortality. This confirms that the addition of mahogany seed powder, green betel leaf powder, and their combination in different storage conditions results in significant differences in rice weevil mortality. Therefore, further investigation into doses and concentrations is required to obtain optimal results (Rubianti et al., 2022). Research by Sari et al. (2018) indicates that the higher the concentration of red betel leaf extract (*Piper crocatum),* the higher the mortality and repellency against *Riptortus linearis*. This suggests that the compound content and concentration of betel leaf and mahogany powder or dust can affect the rate of pest mortality. Similar findings are also expressed in other studies, indicating that the higher the concentration of mahogany leaf extract (*Swietenia mahagoni* L.), the higher the mortality rate against *Spodoptera litura*. Thus, the concentration of betel leaf playsa crucial role in increasing insect mortality. (Rahman et al., 2021) stated that red betel leaf powder (*Piper crocatum*) is effective against rice weevils (*S. oryzae* L.). This affirms that the compound content and concentration of betel leaf, mahogany seeds, and their combination can influence the speed of rice weevil mortality.

Silaban (2021), research also shows that forest betel leaf powder (*Piper aduncum* L.) can affect the mortality of rice weevils (*S. oryzae* L.) at various doses. Therefore, the results of this study support the claim that green betel leaf powder, mahogany seeds, and their combination have the potential as effective botanical insecticides in controlling rice weevils.

The process of rice weevil mortality induced by this piperamide compound indirectly occurs through the feeding activity of the rice weevil. This aligns with the assertion of Ardiansyah & Mahajoeno (2002) that, in addition to penetrating the cuticular layer of pests, the mechanism of action of contact toxins can also enter the pest's body through natural openings or orifices on its body or directly through the pest's mouth. Once inside the body, the piperamide compound functions as a neurotoxin by inhibiting nerve impulse conduction along the axon, leading to irregular movements and convulsions, ultimately resulting in death (Zarkani & Prijono, 2010).

Relationship between the Concentration of Green Betel Leaf Powder and Rice Weevil Mortality (*Sitophilus oryzae* L.)

Based on Table 2, it can be observed that the concentration of green betel leaf powderis associated with rice weevil (*S. oryzae* L.) mortality with a significance level of 0.01, i.e., 0.836> 0.001 (significant). This implies that there is a relationship between the increase in the concentration of mahogany seed powder, green betel leaf powder, and their combination with rice weevil (*S. oryzae* L.) mortality.

Table 2. Relationship between the Concentration of Green Betel Leaf Powder and Rice Weevil Mortality (*Sitophilus oryzae* L.)

Calculation Method	R calculate	R table
Pearson Correlation	0.84	0.001

Figure 2. illustrates a direct or positive correlation between the concentration of green betel leaf powder on the mortality of rice weevils (*Sitophilus oryzae* L.).

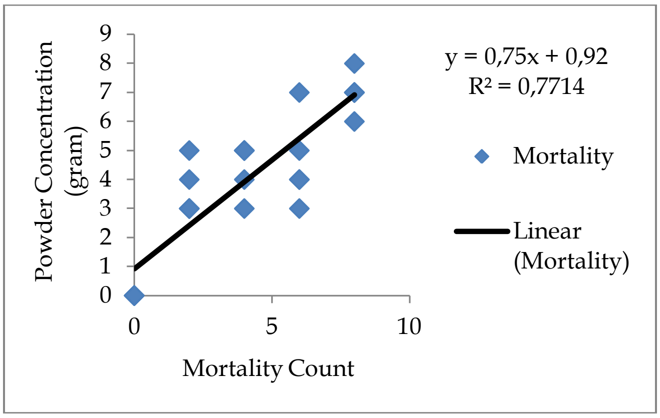

Figure 2. Graph of the Relationship between Concentrations of Green Betel Leaf Powder and Mortality of Rice Weevils (*Sitophilus oryzae* L.)

This implies that the higher the concentration of green betel leaf powder, the higher the level of rice weevil mortality. This finding aligns with the research conducted by Matondang (2023), which indicates that the application of betel leaf powder from various betel leaf types influences the mortality of *S. oryzae* L. The results of the study show that the lowest percentage of rice damage was obtained from the application of black betel leaf powder at 11.04%, while the highest mortality of rice weevils occurred in the treatment with black betel leaf powder, with a value of 92.50%, and an efficacy value of 80.50.

Looking at Table 2, the Pearson correlation calculation shows that the calculated r value is 0.84, exceeding 0.5, approaching 1, and moving in the positive direction. Additionally, the (**) sign indicates a strong relationship between concentration and rice weevil mortality. This finding is consistent with the research conducted by Lestari (2021), stating that lemongrass and galangal leaf powder affect the mortality of rice weevils (*Sitophilus oryzae* L.) in storage. Other studies, such as those conducted by Sugiyono and widriyati (2016), show that the use of red betel leaf powder also results in a significant mortality rate of rice weevils (*Sitophilus oryzae* L.). Furthermore, the results of the study by Sari *et al*. (2018), state that the higher the concentration of insecticides, the higher the rate of pest insect mortality due to the increase in active compounds in the insecticides that can affect the nervous system of pest insects.

Relationship between the Concentration of Green Betel Leaf Powder and the Time of Rice Weevil Mortality (Sitophilus oryzae L.).

From Table 3. it can be concluded that the concentration of green betel leaf powder is correlated with the time of rice weevil mortality (*Sitophilus oryzae* L.) at a significance level of 0.01, i.e., 0.77 > 0.001 (significant). This means that there is a relationship between the increase in the concentration of green betel leaf powder and the time of rice weevil mortality (*Sitophilus oryzae* L.).

Table 3. Relationship between the Concentration of Green Betel Leaf Powder and the Time of Rice Weevil Mortality (*Sitophilus oryzae* L.)

Calculation Method	R calculate	R table
Pearson Correlation	0.77	0.001

Figure 3 illustrates a direct or positive correlation between the concentration of green betel leaf powder on the mortality of rice weevils (*Sitophilus oryzae* L.).

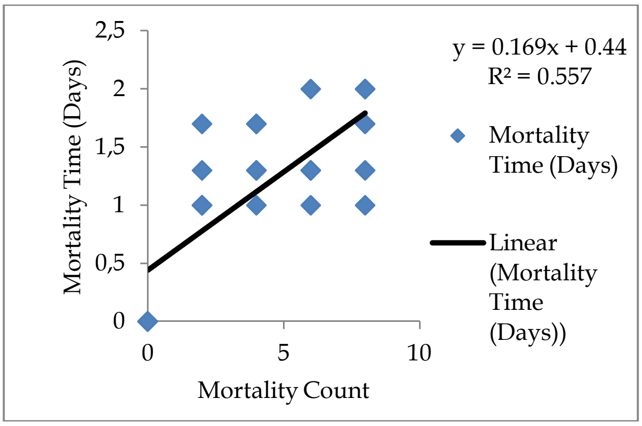

Figure 3. Graph of the Relationship Between the Concentration of Green Betel Leaf Powder and the Time of Rice Weevil Mortality (*Sitophilus oryzae* L.)

Figure 3. indicates that the correlation between concentration and the time of rice weevil mortality has a positive direction, meaning that the higher the concentration of green betel leaf powder, the longer the time of rice weevil mortality. This finding aligns with the research conducted by (Aminah, 1995), stating that the concentration level affects the content of active ingredients and influences the time of death of test insects. It suggests that the dose or concentration of the insecticide has an impact on the level of pest insect mortality.

Table 3. shows that the Pearson correlation calculation with an r value of 0.772 exceeds 0.5, approaches 1, and moves in a positive direction. Additionally, the (**) sign indicates a strong relationship between concentration and the time of rice weevil mortality. This finding is consistent with the study by (Mulyana, 2002), which found that a high dose causes rapid insect death due to the abundance of active substances entering the insect's body. This statement is further supported by (Natawigena, 1993), who stated that the pest's death process will occur more quickly with an increase in the dose of the powder used. Therefore, it can be concluded that an increase in the dose contributes to an increase in toxin content affecting the mortality of *Sitophilus oryzae* L., leading to death (Natawigena, 2000) adds that the pest's death process also becomes faster with the increasing dose used. Treatment with a dose of 6 g/100 g of rice from forest betel leaf powder is considered effective because it can kill rice weevils (*Sitophilus oryzae* L.) by 95%.

Insecticide Efficacy

Based on observations conducted over 7 days, the concentration of green betel leaf powder on the mortality of rice weevils (*S. oryzae* L.) is effective. According to the Abbot formula (1925), the treatment with a dose of 8 g in treatment A4 has achieved an efficacy percentage of 70%, indicating effectiveness against the mortality of rice weevils. The following is Figure 4. depicting the percentage effectiveness of green betel leaf powder, mahogany seeds, and their combination.

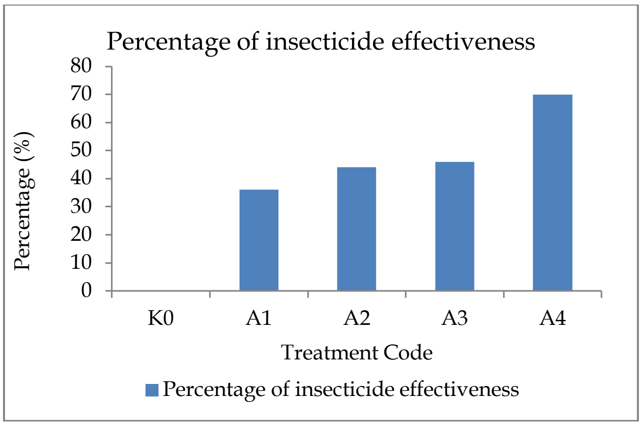

Figure 4. Percentage of Insecticide Effectiveness.

Description= (K0): Control; (A1): Green betel leaf powder 2 g; (A2): Green betel leaf powder 4 g; (A3): Green betel leaf powder 6 g; (A4): Green betel leaf powder 8 g.

The research results indicate that the treatment can be considered successful because, according to the Abbot formula (1925), an insecticide is considered successful if the insecticide efficacy value is ≥ 70%. In the calculations performed, only the treatment with a dose of 8 g in group A4 achieved an efficacy value of 70%. In this test, the 8 g dose showed the highest average effectiveness rate, reaching 70%, while the 2 g dose in group A1 showed the lowest effectiveness rate with an average of only around 36%. The low effectiveness at low doses is suspected due to a decrease in the toxicity level of that treatment.

The alkaloid compounds present in red betel leaves contain toxins that impart a bitter taste and act as stomach poisons. Additionally, alkaloids can inhibit acetylcholinesterase enzymes, which can damage cell membranes. Red betel leaves comprise various chemical constituents, including flavonoids. According to (Inrianti & Paling, 2018) flavonoids have a bitter taste, thus serving as insect deterrents. Tannin compounds found in red betel leaves can disrupt the impulse transmission system to muscles, potentially causing paralysis in insects (Wientarsih et al., 2017). Essential oils affect insect respiration, feeding, or skin absorption, a mechanism commonly referred to as neurotoxicity (Balfas & Mardiningsih, 2016). The essential oils contained therein also have the potential to act as insect repellents (Wardhana & Wijaya, 2015).

According to {Citation}, botanical pesticides have weaknesses such as slow performance, susceptibility to sunlight, relatively short shelf life, and requiring repeated spraying or treatment. In all treatments, there was mortality of *S. oryzae* L., except in the control treatment, which did not show mortality of *S. oryzae* L. This indicates that the chemical content of red betel leaves has side effects on the development of *S. oryzae* L. According to Rahman *et al*. (2021), red betel leaf extract is effective as a botanical insecticide against pest insects. This is in line with the statement by (Dadang & Prijono, 2008) that a dose of botanical pesticide can also be considered effective if the treatment with that dose results in the mortality of pests exceeding 80%. This study shows that green betel leaf extract can reduce the mortality of pest insects such as Plutella xylostella on cabbage plants. Similarly, research of (Qhoir, 2023) shows that mahogany leaf extract (*Swietenia mahagoni* L.) has the potential as a botanical pesticide with compounds such as flavonoids that can be used to control termites on wooden products. However, this study requires further testing to assess the effectiveness of botanical insecticides from mahogany leaf extracts against pest insects on plants. Research of (Marpaung, 2021) also mentions that mahogany leaf extract (*Swietenia mahagoni* L.) and mahogany seeds (*Swietenia macrophylla* L.) are effective as botanical insecticides against pest insects. The results of this study show that mahogany leaf extract and mahogany seeds can reduce the mortality of pest insects such as *Spodoptera litura* on cabbage plants. However, this study also requires further testing to evaluate the effectiveness of botanical insecticides from mahogany leaf extracts and mahogany seeds against pest insects on other plants.

Conclusion

In conclusion, the study found varying mortality rates among different treatments, with the highest mortality observed in treatment A4 (35 individuals) and the lowest in treatment A1 (18 individuals). Pearson correlation analysis indicated a significant relationship ($p < 0.01$) between the concentration of green betel leaf powder and the mortality of rice weevils (S. oryzae L.), with a correlation coefficient of 0.836. Similarly, a significant correlation ($p < 0.01$) was observed between the concentration of green betel leaf powder and the time of mortality of rice weevils, with a correlation coefficient of 0.772. The research results demonstrated the effectiveness of the botanical insecticide against rice weevils, with the highest efficacy (70%) achieved in the treatment with 8 grams of green betel leaf powder (A4), meeting the criterion for success. Conversely, the lowest effectiveness (36%) was observed in the treatment with a dose of 2 grams (A1).

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Author Contributions

The author is involved in the overall making of this article.

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Conflicts of Interest

In writing this article, we sincerely declare that there are no conflicts of interest that may affect the objectivity and integrity of the results.

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