

Efficacy of Kaffir Lime Leaves and Cinnamon Powder as Botanical Insecticides against the Rice Weevil (*Sitophilus oryzae*)

Henry Alpandari^{1*}, Farida Yuliani¹, Maulina Farhana¹

¹Agrotechnology, Faculty of Agriculture, Muria Kudus University, Indonesia

*Corresponding author: henry.alpandari@umk.ac.id

Keywords:

Botanical
pesticide; Grain
protection;
Postharvest pest
management;
Weevil control

Submitted:

16-11-2025

Accepted:

26-02-2026

Published:

29-09-2026

ABSTRACT

A major cause of post-harvest losses in rice is infestation by storage pests, particularly *Sitophilus oryzae*. Botanical insecticides are considered a safer, environmentally friendly alternative to synthetic pesticides. This study aimed to evaluate the effectiveness of kaffir lime (*Citrus hystrix*) leaf powder and cinnamon (*Cinnamomum burmannii*) powder as botanical insecticides against *S. oryzae*. The research was conducted from October to November 2025 using an experimental method with a factorial Completely Randomized Design (CRD). The first factor was the type of botanical insecticide, namely kaffir lime leaves (*Citrus hystrix*) and cinnamon powder (*Cinnamomum burmannii*), while the second factor was concentration, with three levels (10, 15, and 20 g of powder) and five replications. Data were analyzed using analysis of variance (ANOVA) followed by Duncan's Multiple Range Test (DMRT) at a 5% significance level. The observed variables included rice moisture content, *S. oryzae* mortality, and rice damage percentage. The results showed that cinnamon powder provided the most consistent and effective control, particularly at concentrations of 10–15 g, which significantly increased insect mortality up to 30 days after application and reduced rice damage to 0.26–0.50%. In contrast, kaffir lime leaf powder exhibited moderate effectiveness, with less stable mortality patterns and limited reduction in rice damage. Overall, cinnamon powder showed greater potential as a botanical insecticide than kaffir lime leaf powder for controlling *S. oryzae* during rice storage.

Copyright Authors © 2026 (CC BY-NC-ND 4.0)

1. Introduction

Rice is a staple food commodity with a high consumption rate in many countries, including Indonesia, where annual consumption reaches 93.79 kg per capita (Ministry of Agriculture, 2024). Despite its importance, rice production and supply chains face various challenges, particularly during post-harvest handling and storage (Lestari *et al.*, 2022). Improper storage conditions can cause quantitative and qualitative losses from physical, chemical, and biological factors (Nopiani *et al.*, 2025). Among these factors, infestation by storage pests is one of the most critical causes of post-harvest losses. Insects not only reduce the quantity of stored rice but also degrade its quality and nutritional value, making it unsuitable for consumption (Lopulalan, 2010). The warehouse pests that most frequently attack stored rice come from the insect group of the Coleoptera order, one of which is the rice beetle (*Sitophilus oryzae*), which is better known to the public as the rice weevil (Lisa *et al.*, 2024).

This pest makes rice grains hollow and brittle, resembling flour (Susanti *et al.*, 2022). Larvae and imago of *S. oryzae* damage rice grains by consuming the carbohydrate content in them, causing weight loss and a decrease in nutritional value (Khanal *et al.*, 2021). Rice has the potential to experience continuous damage if no control efforts are made (Pratama *et al.*, 2024).

The most widely used method for controlling storage pests is applying synthetic chemical pesticides, particularly through fumigation. However, this approach poses several drawbacks, including the risk of pesticide residues contaminating stored products, environmental pollution, and potential health hazards (Hidayat *et al.*, 2021). To address this issue, alternative methods for controlling *S. oryzae* during storage are needed that use natural insecticides. Botanical insecticides are easily biodegradable, leave no residue, and are environmentally friendly without causing side effects (Larasati *et al.*, 2022).

One promising approach is using botanical insecticides, which are derived from plant materials and are known for their biodegradability, environmental safety, and minimal residual effects. Several plant materials can be used as botanical insecticides, including kaffir lime leaves and cinnamon. Simanjuntak *et al.* (2021), Kaffir lime contains various chemical compounds, including saponins, tannins, steroids, triterpenoids, and essential oils consisting of citronellal, flavonoids, limonene, cyanidin, myricetin, peonidin, quercetin, luteolin, hesperetin, apigenin, isorhamnetin, β -citronellol, linalool, and sitoellol which can be used as repellents for insect larvae (Saadai *et al.*, 2020). Cinnamon contains several compounds with anti-feedant properties. In addition, essential oil components such as cinnamaldehyde, cinnamyl acetate, and eugenol are highly effective larvicides. (Kamal *et al.*, 2017).

Although both plant materials are widely available and commonly used in daily life, studies comparing their effectiveness as botanical insecticides against *S. oryzae*, particularly in terms of mortality and rice damage during storage, are still limited. Therefore, this study evaluated the effectiveness of kaffir lime leaf powder and cinnamon powder as botanical insecticides for controlling *S. oryzae* in stored rice.

2. Methodology

2.1 Time and Place of Research

This research was conducted from October to November 2025 at the Protection Laboratory, Faculty of Agriculture, Muria Kudus University. Observations were conducted for 30 days.

2.2 Research Materials and Tools

Tools and materials used include rice weevil pest *S. oryzae*, Inpari 32 variety rice, kaffir lime leaves, and cinnamon. The tools used are analytical scales, tea bags, measuring cups, test jars with a diameter of 8.5 cm and a height of 12.5 cm, ceruty cloth, rubber bands, blender, insect microscope, tweezers, oven, copper cup, 60 mesh sieve, magnifying glass.

2.3 Research Methods

This study employed an experimental method using a factorial Completely Randomized Design (CRD). The first factor was the type of botanical insecticide, namely kaffir lime leaves (*Citrus hystrix*) and cinnamon powder (*Cinnamomum burmannii*), while the second factor was the concentration, consisting of three levels (10, 15, and 20 g of powder) with five replications.

2.4 Propagation and Infestation *S. oryzae*

S. oryzae propagation was carried out by introducing adult insects (imago) into jars containing rice. After 15 days, the parent imagoes were removed, and the rice was kept until new individuals emerged. Imagoes aged 25 days were used in this study, as they are considered to have reached reproductive maturity (Isnaini *et al.*, 2015). The insects were then separated by sex and maintained in different containers (Rahma *et al.*, 2024). A total of 500 *S. oryzae* individuals (250 males and 250 females) were used. Prior to infestation, the insects were fasted for 24 hours to optimize feeding activity. Infestation was conducted at 18:00, coinciding with peak feeding activity (Fadhillah, 2018), by introducing 20 insects into each test jar according to the treatment.

2.5 Making Botanical Insecticides

Kaffir lime leaves are washed and dried indoors for 14 days until the color changes. (Nendissa & Nendissa, 2024). After that, the leaves were ground using a blender until they formed a powder, then sieved and weighed according to the treatment dosage (10, 15, and 20 g) before being placed into tea bags. Meanwhile, the dried cinnamon bark was cut into small pieces, ground using a blender until it became a powder, then sieved and weighed according to the treatment dosage (10, 15, and 20 g) to be placed into tea bags.

2.6 Observation Parameters

2.6.1 *Rice water content (%)*

Rice moisture content was measured at the initial conditions before *S. oryzae* infestation and at the final conditions after infestation. The method used was the oven method at a temperature of 130°C for 60 minutes (Sutopo, 2002 in Murrinie *et al.*, 2021). The calculation formula is as follows:

$$K = \frac{w_2 - w_3}{w_2 - w_1} \times 100\%$$

Keterangan:

K : Rice water content

w1 : Weight of container + lid

w2 : Weight of container + lid + weight of seeds before drying

w3 : Weight of container + lid + weight of seeds after drying

2.6.1 *Mortality (%)*

Observations on the number of dead *S. oryzae* individuals were conducted every three days over a 30-day period. The number of dead insects was expressed in units of individuals. Mayasari (2016), The tick mortality data is used to calculate the mortality percentage of *S. oryzae* using the following formula:

$$\text{Mortality} = \frac{\Sigma \text{Dead rice lice}}{\Sigma \text{Treated rice lice}} \times 100\%$$

2.6.1 *Damage to rice (%)*

The percentage of rice damage was calculated to determine the extent of damage caused by *S. oryzae* infestation. Observations were made at the end of the study by separating damaged rice grains from intact ones. Damage to the rice was characterized by the grains turning into frass, a dull color, and a crumbly texture. (Susanti *et al.*, 2022).

$$I = \frac{n}{N} \times 100\%$$

Information:

I : Damage to rice (%)

n : The weight of rice is damaged

N : Total weight of rice observed

Data were analyzed using analysis of variance (ANOVA) followed by Duncan's Multiple Range Test (DMRT) at a 5% significance level.

3. Results and Discussion

3.1 Rice Water Content

The rice storage process is influenced by many factors, one of which is moisture content. The moisture content of rice affects the quality and quantity of rice during storage (Susanti *et al.*, 2022). The following shows the water content of rice before and after the observation was completed.

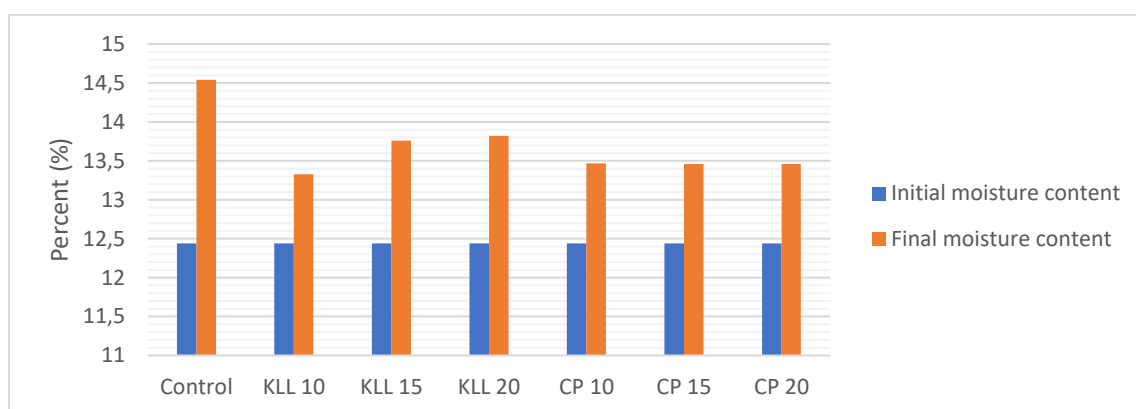


Figure 1. Water content before and after treatment

Based on the analysis results in Figure 1, the initial moisture content remained the same at 12.44%. This is the level commonly used for storing rice. After the study, the moisture content changed in each treatment. Moisture content increased after each treatment by 0.89% to 2.1%. This aligns with the research results of Hendrival & Mayasari (2017), which found that after the study, the moisture content of rice increased from 12.1% to 17.51%. Factors causing the increase in moisture content include water absorption by rice grains, moisture released through post-harvest insect respiration, and the influence of ambient air humidity. (Mahanani & Inrianti, 2021). The increase in water content in rice infested with weevils can also be caused by the respiratory activity of *S. oryzae*. Respiration is the process by which carbohydrates are broken down into carbon dioxide, water, and energy, producing water vapor, which contributes to the increase in water content in rice (Juniarti *et al.*, 2022).

The increase in water content in rice during storage is closely related to the level of rice damage caused by warehouse insects' metabolic and respiratory activities. According to Hendrival *et al.* (2022), high water content can accelerate the development of *Sitophilus oryzae*, thereby increasing physical damage to rice during storage. Juniarti *et al.* (2022) also stated that *S. oryzae* infestation increases humidity because respiration produces water vapor, accelerating the decline in rice quality.

3.2 Mortality

Based on the observations (Table 1), the application of kaffir lime leaf powder at different concentrations exhibited varying responses across the observation periods (6–30 DAA). At 6 DAA, the 15 g treatment (3.24 a) showed a significantly higher mortality rate compared to the control (1.72 b) and the 20 g treatment (1.98 b), while the 10 g treatment (2.23 ab) was not significantly different from either the control or the other treatments. At 12 DAA, the 15 g treatment (3.45 a) remained significantly different from the 20 g treatment (1.98 b), but was not significantly different from the control (2.23 ab) and the 10 g treatment (2.48 ab). Similarly, at 18 DAA, the 15 g treatment (3.45 a) showed significantly higher mortality compared to the control (2.22 b) and the 20 g treatment (2.48 b), whereas the 10 g treatment (2.99 ab) was not significantly different from the other treatments. At 24 DAA, the 10 g and 20 g treatments (3.25 a) as well as the 15 g treatment (3.45 a) showed significantly higher mortality than the control (2.73 b), indicating that the effectiveness of kaffir lime leaf powder became more evident with longer exposure time. However, no significant differences were observed among the three concentrations. At 30 DAA, clearer differences among treatments were observed. The 10 g concentration resulted in the highest mortality value (4.40 a), which was significantly different from the control (2.73 b). Meanwhile, the 15 g and 20 g concentrations (3.95 ab) showed intermediate responses and were not significantly different from either the control or the 10 g treatment. These findings indicate that the efficacy of kaffir lime leaf powder against *S. oryzae* became more apparent at longer observation periods, particularly after 24–30 DAA, with the 10 g concentration showing the strongest effect at the end of the observation period.

Table 1. Mortality Percentage of *S.oryzae* After Application of Kaffir Lime Leaf Powder

Concentration of lime leaf powder	Days After Application (DAA)				
	6 DAA	12 DAA	18 DAA	24 DAA	30 DAA
control	1,72 b	2,23 ab	2,22 b	2,73 b	2,73 b
10 g	2,23 ab	2,48 ab	2,99 ab	3,25 a	4,4 a
15 g	3,24 a	3,45 a	3,45 a	3,45 a	3,95 ab
20 g	1,98 b	1,98 b	2,48 b	3,25 a	3,95 ab

Note: Numbers followed by different letters are significantly different in the 5% DMRT test. DAA (Days After Application).

Several previous studies have shown that the effectiveness of botanical bioinsecticides is not always directly proportional to the concentration applied. In some cases, lower concentrations actually show a faster or greater insecticidal effect than higher concentrations. This may occur because high concentrations of botanical insecticides often act as repellents, reducing insect feeding and contact with the treated substrate. This reduces insect exposure to the active compounds that actually cause mortality (Isman, 2020).

At low concentrations, insects tend to maintain normal feeding behavior, resulting in more active compounds being ingested or coming into contact with the insect's body, accelerating death. Furthermore, high concentrations of essential oils can evaporate more rapidly or cause clumping of the active compounds, reducing their bioavailability (Fajarwati et al., 2015)

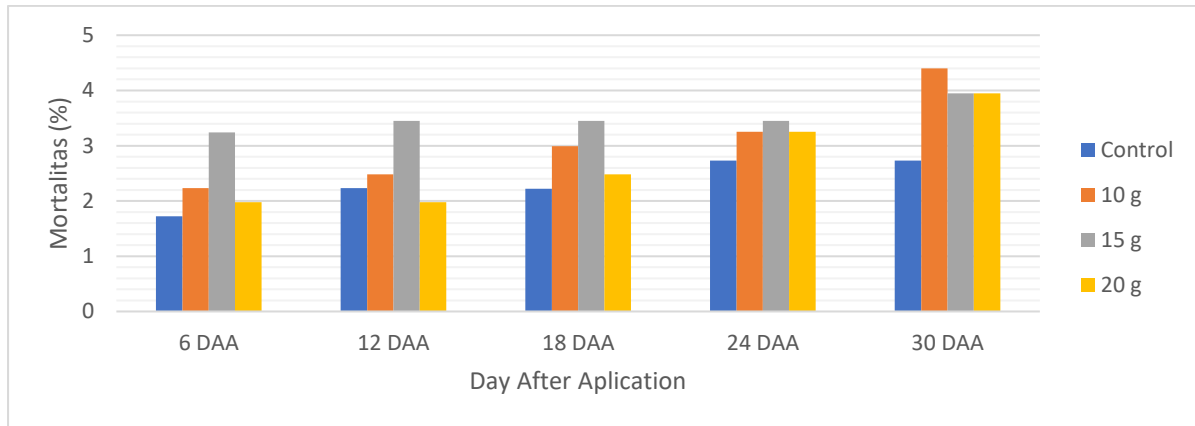


Figure 2. Mortality diagram of *S. oryzae* after application of kaffir lime leaf powder

Figure 2 illustrates the mortality (%) of *S. oryzae* at different concentrations of kaffir lime leaf powder (10 g, 15 g, and 20 g) compared with the control, observed at 6, 12, 18, 24, and 30 days after application (DAA). At the early observation periods (6–18 DAA), the mortality values were relatively low and did not differ substantially among treatments, with the 15 g concentration showing slightly higher mortality compared to the other treatments. By 24 DAA, all treatments exhibited increased mortality, with 10 g, 15 g, and 20 g concentrations outperforming the control. The most notable differences were observed at 30 DAA. The 10 g concentration recorded the highest mortality (~4.4%), followed by 15 g (~3.95%) and 20 g (~3.9%), while the control remained the lowest (~2.7%). These results indicate that kaffir lime leaf powder becomes more effective against *S. oryzae* with longer exposure time, particularly at 30 DAA, with the 10 g treatment showing the strongest effect.

Mortality data showed that the response of test organisms to cinnamon powder was significantly influenced by the concentration and duration of exposure. The 15 g concentration consistently produced the highest mortality across all time intervals, indicating a more stable biological effectiveness compared to the other treatments. In contrast, the 20 g treatment showed a fluctuating mortality pattern, suggesting that increasing the dose does not always correlate with effectiveness. The low mortality in controls confirms that the changes were a direct result of the treatment. Overall, this pattern underscores the need for a more in-depth evaluation of the mechanism of action, the threshold for effective dosage, and the potential for response irregularities at high concentrations.

Table 2. Mortality Percentage of *S.oryzae* After Cinnamon Powder Application

Cinnamon Powder Concentration	Mortality Rate (%)				
	6 DAA	12 DAA	18 DAA	24 DAA	30 DAA
Control	1,72 b	2,23 b	2,22 b	2,73 b	2,73 b
10 g	2,63 ab	3,81 ab	3,81 ab	4,65 ab	5,56 a
15 g	3,25 a	4,16 a	4,84 a	5,83 a	5,35 a
20 g	1,47 b	1,98 b	2,24 b	3,40 ab	5,35 a

Note: Numbers followed by different letters are significantly different in the 5% DMRT test. DAA (Days After Application).

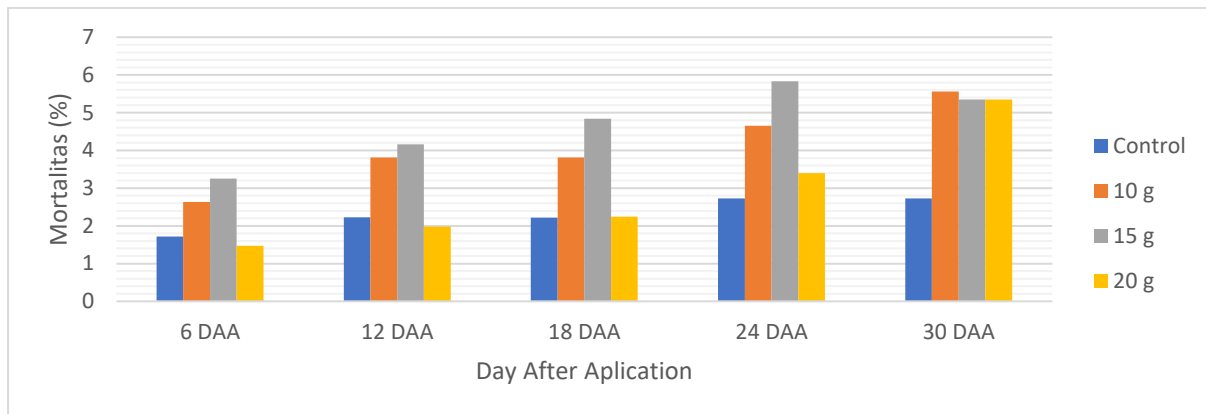


Figure 1. Mortality Diagram of *S. oryzae* after Cinnamon Powder Application

Figure 3 shows the mortality (%) of *S. oryzae* under different concentrations of cinnamon powder (10 g, 15 g, and 20 g) compared with the control across observation periods of 6, 12, 18, 24, and 30 days after application (DAA). At 6 DAA, the 15 g treatment (3.25 a) showed significantly higher mortality than the control (1.72 b) and the 20 g treatment (1.47 b), while the 10 g treatment (2.63 ab) did not differ significantly from the other treatments. At 12 DAA, the 15 g treatment (4.16 a) remained significantly different from the control (2.23 b) and the 20 g treatment (1.98 b), whereas the 10 g treatment (3.81 ab) did not differ significantly from the 15 g treatment or the control. At 18 DAA, the 15 g treatment (4.84 a) continued to produce significantly higher mortality compared to the control (2.22 b) and the 20 g treatment (2.24 b), while the 10 g treatment (3.81 ab) showed intermediate results and was not significantly different from the other treatments. A more pronounced effect was observed at 24 DAA, when the 15 g treatment (5.83 a) showed significantly higher mortality than the control (2.73 b), while the 10 g (4.65 ab) and 20 g (3.40 ab) treatments were not significantly different from either the control or the 15 g treatment. At 30 DAA, all cinnamon powder treatments showed significantly higher mortality compared to the control. The 10 g treatment produced the highest mortality value (5.56 a), followed closely by the 15 g and 20 g treatments (5.35 a), while the control remained the lowest (2.73 b). No significant differences were observed among the three cinnamon powder concentrations at this observation period.

These results indicate that cinnamon powder significantly increased *S. oryzae* mortality over time, with the most consistent and stable effects at 10 g and 15 g. The high mortality of *S. oryzae* directly contributed to the low level of rice damage. Khanal *et al.* (2021) reported that increasing storage pest mortality through botanical pesticide application can reduce weight loss and grain damage during storage. Furthermore, Isman (2020) explained that active compounds in botanical pesticides can inhibit insect feeding, thereby significantly reducing rice damage during storage.

3.3 Rice Damage

Research conducted by Hendrival *et al.*, (2022) shows that water content affects the quality and level of damage to cereals, as well as affecting the growth and duration of development of *S. oryzae* pests during storage.

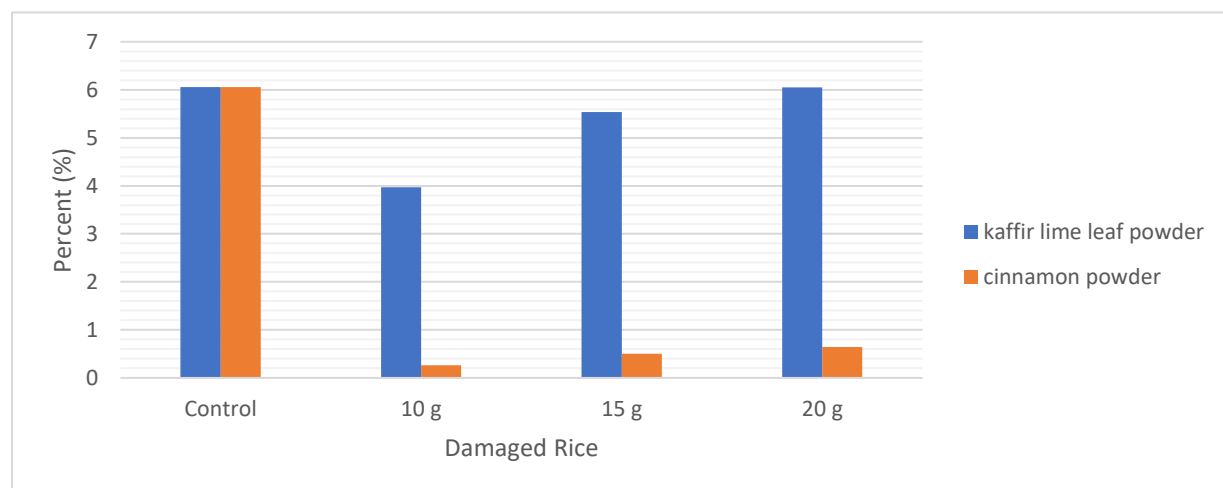
Table 3. Percentage of Rice Damage After Bioinsecticide Treatment

Consentration	kaffir lime leaf powder	cinnamon powder
Control	6,06 a	6,06 a
10 g	3,97 b	0,26 d
15 g	5,54 ab	0,50 d
20 g	6,05 a	0,64 d

Note: Numbers followed by different letters are significantly different in the 5% DMRT test. DAA (Days After Application).

Table 3 presents the effect of kaffir lime leaf powder and cinnamon powder on the mortality of *S. oryzae*. The results show that treatments differed significantly between the two botanical insecticides. For kaffir lime leaf powder, mortality values ranged from 3.97% to 6.05%, with no clear separation from the control (6.06%), as indicated by the notations (a-c). This suggests that kaffir lime leaf powder had limited effectiveness in reducing weevil survival.

In contrast, cinnamon powder produced markedly lower survival rates, with values ranging from 0.26% to 0.64%, all of which were significantly different from the control (6.06%). The uniform letter notation (d) indicates a consistent and strong insecticidal effect across all tested concentrations. These findings demonstrate that cinnamon powder exhibits greater efficacy as a botanical insecticide against *S. oryzae* compared to kaffir lime leaf powder.

**Figure 2.** Percentage of rice damage due to *S. oryzae* after being treated with lime leaf powder and cinnamon powder

The results showed that both kaffir lime leaf powder and cinnamon powder affected *S. oryzae* mortality and rice damage levels compared with the control treatment. In the kaffir lime leaf powder treatment, the 15 g concentration showed significantly higher mortality during the early observation periods (6–18 DAA) than the control, while the 10 g concentration differed significantly at 24–30 DAA. However, the effectiveness of kaffir lime leaf powder was not consistent across all observation periods, as some treatments showed no significant differences from the control. For rice damage, only the 10 g treatment significantly reduced damage (3.97%) compared to the control (6.06%), whereas the 15 g (5.54%) and 20 g (6.05%) treatments were not significantly different from the control. Meanwhile, cinnamon powder showed a clearer and more consistent pattern of effectiveness. The 15 g treatment produced significantly higher mortality than the control at 6–24 DAA, while the 10 g treatment also showed increased mortality, particularly at the later observation periods. At 30 DAA, all

cinnamon powder concentrations (10 g, 15 g, and 20 g) produced significantly higher mortality than the control, although no significant differences were observed among concentrations. In addition, all cinnamon powder treatments significantly reduced rice damage compared to the control, with damage levels ranging only from 0.26% to 0.64%. The 10 g cinnamon treatment resulted in the lowest rice damage (0.26%), followed by the 15 g (0.50%) and 20 g (0.64%) treatments.

Compared with kaffir lime leaf powder, cinnamon powder showed significantly greater potential to control *S. oryzae*, as indicated by consistently higher mortality rates and substantially lower rice damage across all treatment concentrations. Overall, cinnamon powder at 10–15 g proved the most effective treatment, while kaffir lime leaf powder provided only moderate and less stable effectiveness during the storage period. The low rice damage observed in the cinnamon powder treatments indicates that active compounds such as cinnamaldehyde and eugenol effectively inhibited the feeding activity and development of *S. oryzae*. Kamal *et al.* (2017) reported that cinnamon essential oil components possess strong insecticidal and antifeedant activities against storage insects. In contrast, kaffir lime leaf powder showed lower effectiveness because its active compounds tend to function more as repellents than as contact poisons, resulting in less optimal suppression of rice damage compared to cinnamon powder Fajarwati *et al.*, (2015)

4. Conclusion

The results showed that cinnamon powder and kaffir lime leaves both affected pest mortality, but their effectiveness differed significantly. Cinnamon powder provided the most consistent and strongest response, especially at a concentration of 10–15 g, increasing mortality up to 30 days after application (DAA) and drastically reducing rice damage (0.26–0.50%). In contrast, kaffir lime leaf powder showed only moderate effectiveness, with limited reductions in rice damage and less stable mortality patterns between observation periods. Thus, cinnamon powder proved to be more effective as a biological control agent than kaffir lime leaf powder in all observed parameters.

Acknowledgements

The authors would like to express their sincere gratitude to the Institute for Research and Community Service, Universitas Muria Kudus, for providing financial support for this research. Appreciation is also extended to the Faculty of Agriculture, Universitas Muria Kudus, for the full support and facilities that greatly contributed to the successful implementation of this study.

References

- Andrianto, B. S., Rusli, R., & Sutikno, A. (2016). Dosage Test of Forest Betel Fruit Flour (*Piper aduncum* L.) on Mortality of *Sitophilus oryzae* L. Pests in Rice During Storage. *Jurnal JOM Faperta*, 3(1), 1-10.
- Fadhillah, N. Q. (2018). *Effectiveness Test of Lemongrass Leaves (Cymbopogon citratus) in Controlling Rice Weevil Pests (Sitophilus oryzae L.)*. Yogyakarta : Fakultas Pertanian Universitas Muhammadiyah Yogyakarta.

- Fajarwati, D., Himawan, T., & Astuti, L. (2015). Repellency test of kaffir lime (*Cytrus hystrix*) leaf extract against rice pest (*Sitophilus oryzae*) Linnaeus (Coleoptera: Curculionidae). *HTP*, 3(1), 102–108.
- Hendrival, H., & Mayasari, E. (2017). Vulnerability and Damage of Rice to Post-Harvest Pest Attacks by *Sitophilus zeamays* L. (Coleoptera: Curculionidae). *Jurnal Agro*, 4(2), 68-79.
- Hendrival, Khairunnisa, R., & Munauwar, M. (2022). Variation in susceptibility and damage of cereals after infestation by powderpost beetle (*Sitophilus oryzae* L.) based on water content. *Agriprima: Journal of Applied Agricultural Sciences*, 6(1), 73–84.
- Hidayat, T., Novita, P., Yandi, F., & Ulpah, S. (2021). P Potential Use of Forest Betel Leaves and Neem Leaves to Control Peanut Warehouse Pests Using the Gauze Pad Method. *Dinamika Pertanian*, 27(1), 29-36.
- Isman, M. B. (2020). Botanical Insecticides in the Twenty-First Century—Fulfilling Their Promise? *Annual Review of Entomology*, 233–249.
- Isnaini, M., Rosa P, E., & Wiridianti, S. (2015). Testing of Several Types of Botanical Insecticides Against Rice Weevils (*Sitophilus oryzae* L.). *Jurnal Biota*, 1(1), 1–8.
- Juniarti, R., Udayana, S., Nurdjanah, S., Subekti, & Hasanudin, U. (2022). K Chemical and Physical Characteristics of Rice Infested with Weevils (*Sitophilus oryzae*, sp). *Agroindustri Halal*, 8(2), 222-232.
- Kamal, M. R., Syafei, N. S., & Nasution, G. T. (2017). Comparison of the Effectiveness of Cinnamon Bark Essential Oil (*Cinnamomum burmannii*) with Temephos as Larvicides for *Aedes aegypti*. *Pharmaceutical Sciences and Research*, 4(1), 25–31.
- Khanal, D., Neupane, S. B., Bhattarai, A., Khatri-Chhetri, S., Nakarmi, N., Sapkota, S., . . . Sharma, V. (2021). Evaluation of Botanical Powders for the Management of Rice Weevil (*Sitophilus oryzae* L.) (Coleoptera: Curculionidae) in Rupandehi, Nepal. *Advances in Agriculture*.
- Larasati, M., Gunadi, P., Yulinda, R., & Sari, M. M. (2022). The Effect of Dry Powder of Bintaro Fruit (*Cerbera manghas* L.) on the Mortality of Rice Weevils (*Sitophilus oryzae* L.) in Various Storage Media. *Jurnal Sains Dan Terapan*, 1(3), 2809–7750.
- Lestari, A., Gazali, A., & Apriani, R. (2022). The Effect of Lemongrass Powder and Kaffir Lime Leaves on the Mortality of Rice Weevils (*Sitophilus oryzae* L.) in Storage. *AGRITROP: Jurnal Ilmu-ilmu Pertanian*, 20(2), 155-160.
- Lisa, O., Lizmah, S., Sari, P., & Rosmanita. (2024). Efficacy of Starfruit Leaf Powder and Pandan Wangi as Botanical Insecticides in Controlling Rice Weevil Pests (*Sitophilus oryzae*). *Agrium*, 27(1), 21-31.
- Lopulalan, C. (2010). Analysis of Food Security of Several Rice Varieties Against Storage Pest Attacks (*Sitophilus zeamais* Motschulsky). *Jurnal Budidaya pertanian*, 6(1), 11-16.
- Mahanani, A., & Inrianti. (2021). Comparison of Bulog Rice Piles with Rice Weevil Population (*Sitophilus oryzae*) and Rice Quality During Storage Period in Jayawijaya Regency. *Jurnal Ilmiah Pertanian*, 17(2), 86-92.

- Mayasari. (2016). *Effectiveness Test of Rice Weevil Pest Control with Pandanus Fragrant Leaf Extract*. Fakultas pertanian. Yogyakarta: Universitas Muhammadiyah Yogyakarta.
- Murrinie, E. D., Sudjianto, U., & Faizah, I. (2021). Study of Temperature and Storage Duration on the Viability and Vigor of Kawista Seeds (*Feronia limonia* (L.) Swingle). *Seminar Nasional Dalam Rangka Dies Natalis Ke-45 UNS Tahun 2021* (pp. 135–144). Solo: Universitas Sebelas Maret.
- Nendissa, D. M., & Nendissa, S. J. (2024). Antibacterial Activity Test of Kaffir Lime (*Citrus hystrix*) Leaf Extract Against *Listeria monocytogenes* Bacteria. *Jurnal Sains Dan Teknologi Pangan*, 9(3), 7492–7505.
- Nopiani, S., Afifah, L., & Adhi, S. (2025). Effectiveness Test of Botanical Pesticides on the Survival of Rice Weevil Pests (*Sitophilus oryzae* L.). *Jurnal Ilmiah Hijau Cendekia*, 10(1), 91-98.
- Pertanian, K. (2024). *Rice Trade Performance Analysis*. Jakarta : Kementerian Pertanian.
- Pratama, R., Hendrival, Khaidir, Usnawiyah, Hafifah, & Putri, N. (2024). Classification of Rice Susceptibility to Radiation Mutations Against *Sitophilus oryzae* L. Based on Moisture Content. *AGRITECH: Jurnal Ilmu-Ilmu Pertanian*, 28(2), 32-40.
- Rahma, Pramudi, M. I., & Liestiany, E. (2024). Organic Control of Rice Weevils (*Sitophilus oryzae* L.). *Proteksi Tanaman Tropika*, 7(1), 823-830.
- Saadai, R., Yunus, M., & Pasar, F. (2020). The Effectiveness of Kaffir Lime Leaves (*Citrus hystrix* DC.) in Controlling Rice Weevils (*Sitophilus oryzae* L.) (Coleoptera : Curculionidae). *Agrotekbis*, 8(1), 54–159.
- Simanjuntak, T. O., Mariani, Y., & Yusro, F. (2021). Chemical Components of Essential Oil of Kaffir Lime Leaves (*Cytrus hystrix*) and Its Bioactivity against *Salmonella thypi* and *Salmonella typhimurium* Bacteria. *Jurnal Ilmiah Cendekia Eksakta*, 6(1), 49-56.
- Susanti, S., Hendrival, Usnawiyah, Hafifah, & Nazaruddin, M. (2022). Relative Susceptibility of Rice Types to *Sitophilus oryzae* L (Coleoptera: Curculionidae) in Conditions of Low Water Content. *Jurnal Mahasiswa Agroteknologi*, 1(1), 10-17.