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Efektivitas Serbuk Biji Pinang (*Areca catechu* L.) dalam Mengendalikan Kumbang Beras (*Sitophilus oryzae* L.) di Penyimpanan

Effectiveness of Areca Nut (*Areca catechu* L.) Seed Powder for Controlling Rice Weevil (*Sitophilus oryzae* L.) Infestation in Storage

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ABSTRACT

Background: Rice (*Oryza sativa* L) is the primary staple food in Indonesia, but its quality is frequently compromised during storage by the rice weevil (*Sitophilus oryzae* L.) **Objective**: This study aimed to evaluate the efficacy of areca nut (*Areca catechu* L.) seed powder as a botanical insecticide to control *S. oryzae* infestations. **Methods**: The study was conducted experimentally using a completely randomized design with 5 treatments and 4 replications. The study consisted of two series, the first series included 20 experimental units for observing time to initial mortality and total mortality, while the second series included 20 experimental units for observing population growth and rice weight loss. The doses of areca nut seed powder used for each experimental unit 0 g.100 g^{-1} rice, 2.5 g.100 g^{-1} rice, 5 g.100 g^{-1} rice, 7.5 g.100 g^{-1} rice, and 10 g.100 g^{-1} rice. **Results:** The results showed that a dose of 10 g.100 g^{-1} rice was the most effective for controlling *S. oryzae*, causing a total mortality of 82.5% with an initial mortality time of 28.25 hours after application. The 10 g.100 g^{-1} rice also resulted in the lowest rice weight loss percentage of 0.95% and the least population increase 3.25 individuals. **Conclusions:** In conclution, a dosage of 10 g.100 g^{-1} rice is the most effective dosage of areca nut seed powder for controlling *S. oryzae*.

Keywords**:** *Bettel nut; Botanical insecticide; Rice; Sitophilus oryzae*

ABSTRAK

Pendahuluan: Beras (*Oryza sativa* L) merupakan makanan pokok utama masyarakat Indonesia, namun kualitasnya sering mengalami penurunan selama masa penyimpanan akibat serangan hama kumbang bubuk beras (*Sitophilus oryzae* L.). **Tujuan**: Penelitian ini bertujuan untuk menguji efektivitas tepung biji pinang (Areca catechu L.) sebagai insektisida nabati dalam mengendalikan *S. oryzae*. **Metode**: Penelitian dilaksanakan di Laboratorium Hama Tumbuhan, Fakultas Pertanian, Universitas Riau, dari bulan November 2024 hingga Januari 2025. Penelitian dilaksanakan secara eksperimen menggunakan rancangan acak lengkap (RAL) dengan 5 perlakuan dan 4 ulangan. Penelitian terdiri dari dua seri, seri pertama terdiri dari 20 unit percobaan digunakan untuk pengamatan waktu awal kematian dan mortalitas total, sedangkan pada seri kedua terdiri dari 20 unit percobaan digunakan untuk pengamatan pertambahan populasi dan penyusutan bobot beras. Dosis tepung biji pinang yang berikan untuk setiap unit percobaan adalah 0 g.100 g^{-1} beras, 2,5 g.100 g^{-1} beras, 5 g.100 g^{-1} beras, 7,5 g.100 g^{-1} beras, and 10 g.100 g^{-1} beras. **Hasil**: Hasil penelitian menunjukkan pemberian tepung biji pinang dosis 10 g.100 g^{-1} beras merupakan dosis yang efektif untuk mengendalikan *S. oryzae* karena mampu menyebabkan mortalitas total sebesar 82,5% dengan waktu awal kematian 28,25 jam setelah pemberian, menghasilkan persentase penyusutan berat beras yang paling rendah yaitu 0,95% dan menghasilkan pertambahan individu yang paling sedikit yaitu 3,25 ekor. **Kesimpulan**: Dosis tepung biji pinang 10 g.100 g^{-1} beras merupakan dosis yang paling efektif untuk mengendalikan S. oryzae.

Kata kunci**:** *Beras; Biji pinang; Insektisida nabati; Sitophilus oryzae*

BACKGROUND

Rice is the primary staple food for the Indonesian population, and its demand continues to escalate annually in line with population growth. To ensure national food security, the Indonesian government maintains strategic rice reserves. However, the storage phase is a critical stage in rice processing; improper storage conditions can lead to significant quality degradation (Wahap and Munawarah, 2023).

Based on data from Badan Pusat Statistik (2024), Indonesia's rice production in 2023 was equivalent to 31.10 million tons, a decline of 439.24 thousand tons (1.39%) compared to the 31.54 million tons produced in 2022. A similar decline occurred in Riau Province, where production fell by 3.5% (4.3 tons) in 2023. This reduction in available rice is frequently caused by infestations of storage pests, specifically the rice weevil (Sitophilus oryzae L.) (Hendrival et al., 2019).

Yield losses resulting from *S. oryzae* infestations can reach up to 70% (Andrianto et al., 2016). Damage during storage includes significant weight loss, chemical alterations, and contamination by mycotoxins (Okpile et al., 2021).

Conventionally, *S. oryzae* is controlled through fumigation using synthetic insecticides, such as phosphine. As a volatile gas, phosphine enters the insect's respiratory system and spreads throughout the body, disrupting the nervous system and causing paralysis or death (Untung, 1993). Although effective and rapid, the long-term use of synthetic fumigants can lead to pest resistance (Wakil et al., 2021). To address these issues, botanical insecticides derived from plants offer a sustainable alternative (Hendrival et al., 2017). One such potential plant is the areca nut (*Areca catechu* L.). Areca seeds contain arecoline, an active compound that acts as a stomach, contact, and nerve poison, leading to paralysis and respiratory failure in insects (Salbiah and Putri, 2021). Recent studies have explored various botanical powders as fumigants; for instance, lime and soursop leaf powders at a dosage of 10 g.100 g^{-1} rice achieved 67.5% mortality and limited weight loss to 2.47% (Yuliani and Jadmiko, 2023). Building on this evidence, the current study titled "Effectiveness of Areca catechu L. Seed Powder Against to Mortality of *S. oryzae*. in Storage" was conducted. This research aims to determine the most effective dosage of *A. catechu* seed powder to control *S. oryzae* mortality during storage.

METHODS

Study Site and Experimental Period

The research was conducted at the Plant Pest Laboratory, Faculty of Agriculture, University of Riau. The study was carried out over a three month period, from November 2024 to January 2025. The daily average temperature during the storage period was 26.4ºC with an average relative humidity of 75%.

Experimental Design and Isolates

The materials utilized in this study included *S. oryzae* L. adults, areca nut (*Areca catechu* L.) seeds, and rice of the IR-64 variety. The apparatus consisted of 600 mL plastic jars (10.5 cm in height), an analytical balance, a blender, and sieves. Additional equipment included labels, gauze, scissors, aspirators, seed envelopes, adhesive tape, tissue paper, a thermo-hygrometer, stationery, and documentation tools.

The preparation of areca nut seed powder was initiated by washing the seeds thoroughly and cutting them into small pieces, which were then air dried at room temperature for 7 days. The dried seeds were ground using a laboratory blender and sieved through an 80 mesh sieve to obtain a fine powder. The powder was weighed using an analytical balance according to the respective treatments, amounting to 0 g, 2.5 g, 5 g, 7.5 g, and 10 g. Each treatment was wrapped in 7 x 7 cm tissue paper and packaged. The areca nut seed powder was ready for application.

This experimental study employed a completely randomized design (CRD) consisting of five treatment levels and four replications. The research was conducted in two series, totaling 40 experimental units. The first series (20 units) was dedicated to observing behavioral and morphological changes in *S. oryzae*, and initial mortality time as well as daily and total mortality. The second series (20 units) focused on assessing population growth and rice weight loss. Each experimental unit contained 10 *S. oryzae* adults, requiring a total of 400 insects.The applied dosages of areca nut seed powder were 0 g, 2.5 g, 5 g, 7.5 g, and 10 g.100 g^{-1} rice.

Statistical Analysis

Results showing significant effects were further analyzed using Duncan's new multiple range test (DNMRT) at the 5% level.

RESULTS AND DISCUSSION

Behavioral and Morphological Alterations in *Sitophilus oryzae*

Observations of the behavioral and morphological symptoms of *S. oryzae* revealed distinct changes following the application of areca nut seed powder at dosages of 2.5 g, 5 g, 7.5 g, and 10 g.100 g^{-1} rice, whereas no changes were observed in the control group 0 g.100 g^{-1} rice. These behavioral alterations were characterized by a gradual decline in imago activity; the once-active adults exhibited increasingly sluggish movement and attempted to migrate to the upper surfaces of the container to minimize direct contact with the powder. This reduction in mobility eventually culminated in mortality. These results align with Sari and Salbiah (2020), who noted that botanical insecticides cause active imagos to become lethargic and congregate near the container lids. Furthermore, Yuliani and Jadmiko (2023) suggest that the diminished movement in *S. oryzae* is due to the toxic constituents of the botanical powder entering the insect's respiratory system, ultimately leading to death.

The morphological changes in deceased *S. oryzae* adults are characterized by drooping antennae, inwardly flexed legs, body rigidity, and a lateral recumbent position. Additionally, a distinct chromatic shift occurs, with the body color transitioning from dark brown to black. These observations are consistent with Pitri (2022), who reported that dead rice weevils exhibit dark discoloration, desiccation, and stiffness. Similarly, Djaya et al. (2024) noted that mortality symptoms in this species include melanization of the cuticle, body dehydration, rigidity, an inwardly curved rostrum, and ventrally flexed appendages.The morphological distinctions between living and deceased *S. oryzae* adults are illustrated in Figure 1.

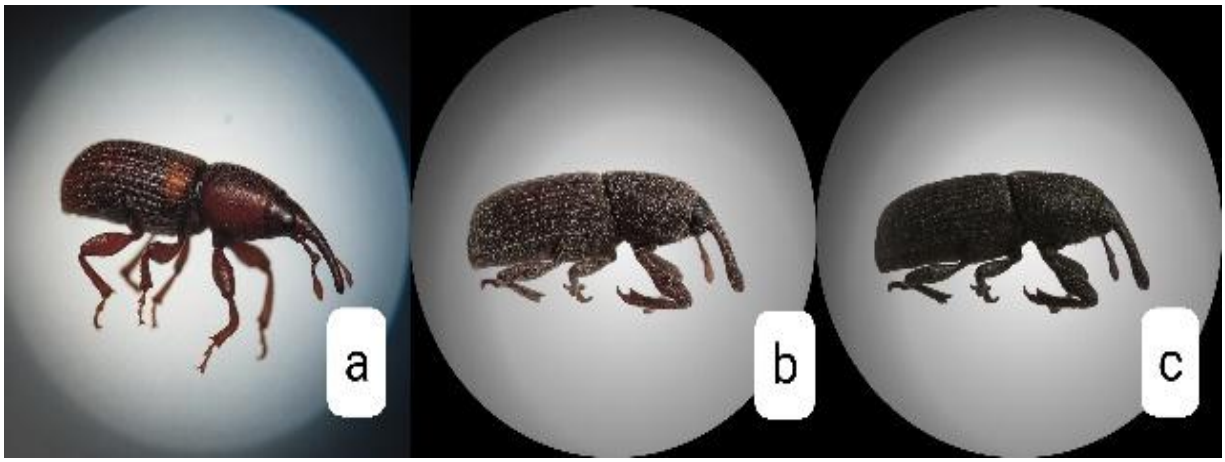

Figure 1. Morphological changes of *S. oryzae*: (a) live adult (blackish-brown) before treatment; (b) dead adult at 28 h post-application (legs bent inward, rostrum and antennae drooping); (c) dead adult at 48 h post-application (exoskeleton entirely black).

Initial Time of Mortality

The average initial mortality time of *S. oryzae* is presented in Table 1. The DNMRT results at the 5% level indicate that the treatments had a significant effect on the initial time of mortality ($p < 0.05$).

Tabel 1. illustrates that the application of areca nut seed powder at a dosage of 10 g.100 g^{-1} of rice resulted in the shortest initial mortality time for *S. oryzae*, recorded at 28.25 hours post treatment. This suggests that higher dosages correlate with an increased concentration of arecoline compounds entering the insect's body, thereby accelerating the lethal

effect. This is consistent with Insani and Salbiah (2021), who stated that higher doses of botanical insecticides contain more active compounds, leading to faster mortality rates. Areca nut powder contains arecoline, which functions as both a respiratory and neurological toxin in *S. oryzae*. Arecoline enters the body via the respiratory system and is distributed through neurons and muscles, where it binds with blood enzymes

Table 1. Mean initial mortality time of *S. oryzae* following the application of various dosages of areca nut seed powder

Dosage of Areca Nut Seed Powder (g.100 g^{-1} rice)	Initial Mortality Time of *S. oryzae* (hour)
0.0	528.0 a
2.5	65.50 b
5.0	57.75 c
7.5	44.25 d
10.0	28.25 e

*Means within the same column followed by different lowercase letters are significantly different according to DNMRT at the 5% level, following $\sqrt{y}$ transformation.

As a neurotoxin, arecoline binds to the enzyme acetylcholinesterase, which is responsible for hydrolyzing acetylcholine. This inhibition prevents the transmission of nerve impulses, resulting in nervous system failure and subsequent death. Gassa (2011) noted that arecoline acts as a nerve poison that inhibits the function of muscles and other vital organs. Similarly, Salbiah and Putri (2021) reported that arecoline disrupts the nervous system, leading to paralysis and respiratory failure. Mubarokah et al. (2018) further explained that the inhibition of cholinesterase causes an accumulation of acetylcholine, leading to muscular spasms, paralysis, and death. In contrast, the control group 0 g.100 g^{-1} of rice showed no mortality throughout the 528 hour observation period, which was significantly different from the other treatments. The absence of mortality in the control group is attributed to the lack of secondary metabolites, allowing the pests to survive until the end of the study, as supported by Djaya (2024).

Total Mortality (%)

The mean total mortality of *S. oryzae* is presented in Table 2. The DNMRT results at the 5% level indicate that the treatments had a significant effect on the total mortality ($p < 0.05$).

Table 2. Mean total mortality of *S. oryzae* following the application of areca nut seed powder dosages

Dosage of Areca Nut Seed Powder (g.100 g^{-1} rice)	Total Mortality (%)
0.0	0.00 d
2.5	32.5 c
5.0	42.5 c
7.5	62.5 b
10.0	82.5 a

*Means in the same column followed by different lowercase letters are significantly different according to DNMRT at the 5% significance level, based on data transformed using arcsin $\sqrt{y+0.5}$.

Table 2. illustrates that the application of areca nut seed powder at a dosage of 10 g.100 g^{-1} of rice resulted in the highest total mortality at 82.5%, which was significantly different from other treatments. This high mortality rate is attributed to the elevated concentration of arecoline at this dosage, a greater volume of active compounds entering the pest's body enhances the lethal impact on *S. oryzae*. This is consistent with Jauhari et al. (2022), who observed that increasing the dosage of areca seeds enhances the toxicity of arecoline, leading to higher mortality rates.

The 5 g.100 g^{-1} of rice dosage yielded a total mortality of 42.5%, which was not significantly different from the 2.5 g.100 g^{-1} of rice dosage (32.5%), though both differed significantly from other treatments. The lower

mortality observed at the 2.5 g.100 g^{-1} of rice dosage is linked to the reduced concentration of arecoline available to affect the pests. These results align with Ningsih et al. (2021), who stated that lower dosages contain fewer active ingredients, thereby resulting in minimal pest fatalities.

The control group 0 g.100 g^{-1} of rice showed 0% mortality, differing significantly from all treated groups. The absence of mortality in this group is due to the lack of areca nut powder and the toxic compound arecoline. This indicates that without the presence of active compounds entering the body of *S. oryzae*, no lethal effects occur. This finding is supported by Agustian et al. (2023), who noted that pest mortality is absent in the absence of toxic compounds. Overall, the mortality observed in this study is directly caused by the insecticidal properties of arecoline present in the applied areca nut powder.

Popupation Increase

The mean population increase of *S. oryzae* is presented in Table 3. The DNMRT results at the 5% level indicate that the treatments had a significant effect on the population increase ($p < 0.05$).

Table 3. Mean population increase of *S. oryzae* following the application of various dosages of areca nut seed powder

Dosage of Areca Nut Seed Powder (g.100 g^{-1} rice)	Population Increase (individuals)
0.0	18.25 a
2.5	14.50 b
5.0	13.75 b
7.5	7.750 c
10.0	3.250 d

* Means in the same column followed by different lowercase letters are significantly different according to DNMRT at the 5% significance level, based on data transformed using arcsin $\sqrt{y+0.5}$.

Table 3. demonstrates that varying dosages of areca nut seed powder significantly influenced the population increase of *S. oryzae*. The application of 10 g.100 g^{-1} of rice dosage resulted in the lowest population increase, averaging 3.25 individuals, which was significantly different from other treatments. This result is closely linked to the total mortality rates (Table 2), higher dosages contain elevated levels of arecoline, which enhance mortality. The high mortality rate at this dosage minimizes the number of surviving pests capable of reproducing, thereby restricting population growth. This aligns with Rustam et al. (2017), who stated that high dosages of botanical insecticides lead to low population increases due to high pest mortality.

In contrast, the control group 0 g.100 g^{-1} of rice exhibited the highest population increase at 18.50 individuals, differing significantly from all treated groups. This high growth rate is attributed to the zero mortality observed in the control group throughout the observation period. In the absence of arecoline exposure, *S. oryzae* is able to carry out its reproductive processes optimally, leading to a high number of offspring. This is consistent with Sari and Salbiah (2020), who noted that no mortality occurs in pests untreated with botanical insecticides due to the lack of active compound ingestion, allowing the pests to maintain high reproductive capacities and population growth.

Rice Weight Loss

The mean rice weight loss is presented in Table 4. The DNMRT results at the 5% level indicate that the treatments had a significant effect on the weight loss of rice ($p < 0.05$).

Table 4. illustrates that different dosages of areca nut seed powder significantly affected rice weight loss, ranging from 0.95% to 7.5%. The application of a 10 g.100 g^{-1} of rice dosage resulted in the lowest weight loss at 0.95%, which was significantly different from other treatments. Rice weight loss is closely associated with the total mortality and population increase of *S. oryzae*.

High mortality rates at the 10 g.100 g^{-1} of rice dosage lead to a lower population increase, which subsequently reduces the feeding activity of the pests. Consequently, the resulting grain damage and weight loss are minimized. This is consistent with Aflah (2021),

who noted that rice weight loss is intrinsically linked to pest mortality and population growth; higher mortality rates suppress population increases, thereby reducing overall weight loss.

Table 4. Mean rice weight loss following the application of various dosages of areca nut seed powder

Dosage of Areca Nut Seed Powder (g.100 g^{-1} rice)	Rice Weight Loss (%)
0.0	7.50 a
2.5	5.55 b
5.0	4.90 b
7.5	2.70 c
10.0	0.95 d

*Means in the same column followed by different lowercase letters are significantly different according to DNMRT at the 5% significance level, based on data transformed using arcsin $\sqrt{y}$+0.5

In contrast, the control group 0 g.100 g^{-1} of rice exhibited the highest weight loss at 7.50%, differing significantly from all treated groups. This result is attributed to the low mortality and high population increase of *S. oryzae* in the absence of treatment. A larger pest population leads to intensified feeding activity, which exacerbates grain damage and weight loss. This aligns with Hendrival et al. (2022), who stated that a high population increase in *S. oryzae* enhances feeding intensity, resulting in substantial commodity weight loss.

CONCLUSION

Based on the results of this study regarding the application of various dosages of areca nut (*A. catechu* L.) seed powder against *S. oryzae*, it is concluded that a dosage of 10 g.100 g^{-1} of rice is the most effective for controlling this pest. This dosage achieved a total mortality of *S. oryzae* at 82.5%, with an initial mortality of *S. oryzae* observed at 28.25 hours post application, restricting the population increase to 3.25 individuals, and minimizing rice weight loss to the lowest level of 0.95%

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