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EFFECT OF SEVERAL TUBA LEAVES (*Derris elliptica* (WALLICH) BENTH.) EXTRACT CONCENTRATIONS ON MORTALITY OF RICE BROWN PLANTHOPPER (*Nilaparvata lugens* STAL)

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ABSTRACT

Brown Planthoppers (BPH) (*Nilaparvata lugens* Stal) are the main pests of rice. It causes plant damage by sucking the sap from the stem, inhibiting growth, and causing plant failure. Infestation by *N. lugens* can reduce yields by up to 100%. The use of plant-based insecticides is one of the efforts to control insect pest infestations. Tuba plant (*Derris elliptica* (Wallich) Benth.) is one of the potential plants that can be used as botanical insecticides. The purpose of this research was to determine the effective concentration of tuba leaf extract against the mortality of *N. lugens*. This research was conducted at the Plant Pest Laboratory, Faculty of Agriculture, Universiti Riau, Indonesia from January to March 2023 using a Completely Randomized Design (CRD) with five treatments and four replications. The concentrations of tuba leaf extract with water as a solvent consisted of concentrations P0: 0%, P1: 2.5%, P2: 5%, P3: 7.5%, and P4: 10%. The results showed that the application of tuba leaf extract had a significant effect on the mortality of *N. lugens*. The concentration of 7.5% tuba leaf extract was effective in controlling BPHs as it was able to cause a mortality rate of 82.50% with an initial mortality time of 4.50 hours after application and a time to 50% mortality of 20.75 hours after application. In addition, the concentrations of tuba leaf extract for LC_{50} and LC_{95} lethality of *N. lugens* were 1.46% (14.6 g/L) and 23.29% (232.9 g/L), respectively.

Keywords: *Derris elliptica*, *Nilapavarta iugens*, botanical pesticides, rice, concentration

ABSTRAK

Benah Perang (*Nilaparvata lugens* Stal) merupakan perosak utama padi. Ia merosakkan tumbuhan dengan menghisap cecair batang, menghalang pertumbuhan dan menyebabkan kegagalan tanaman. Serangan perosak *N. lugens* boleh mengurangkan pengeluaran hingga 100%. Penggunaan racun serangga berasaskan tumbuhan merupakan salah satu usaha yang boleh dilakukan untuk membendung serangan serangga perosak. Tumbuhan tuba (*Derris* *elliptica* (Wallich) Benth.) merupakan salah satu tumbuhan yang berpotensi untuk digunakan sebagai racun botani. Tujuan penyelidikan ini adalah untuk menentukan kepekatan berkesan ekstrak daun tuba (*D. elliptica*) terhadap kematian *N. lugens*. Penyelidikan ini dijalankan di Makmal Perosak Tumbuhan, Fakulti Pertanian, Universiti Riau, Indonesia dari Januari hingga Mac 2023 menggunakan Rekabentuk Rawak Penuh (CRD) dengan lima rawatan dan empat replikasi. Kepekatan ekstrak daun tuba dengan air sebagai pelarut terdiri daripada kepekatan P0: 0%. P1: 2.5%, P2: 5%, P3: 7.5% dan P4: 10%. Hasil kajian menunjukkan pemberian ekstrak daun tuba mempunyai kesan yang signifikan terhadap kematian *N. lugens*. Kepekatan ekstrak daun tuba sebanyak 7.5% adalah kepekatan berkesan dalam mengawal *N. lugens* kerana ia mampu menyebabkan jumlah kematian sebanyak 82.50% dengan masa kematian awal 4.50 jam selepas aplikasi dan tempoh kematian 50% pada 20.75 jam selepas aplikasi rawatan. Selain itu, kepekatan ekstrak daun tuba untuk kematian 50% dan 95% bagi *N. lugens* masing-masing ialah 1.46% (14.6 g/L) dan 23.29% (232.9 g/L).

Kata kunci: *Derris elliptica*, *Nilapavarta iugens*, racun botani, beras, kepekatan

INTRODUCTION

Paddy plant is rice-producing food crop which is the main source of staple foodstuffs, especially in Indonesia, and meet most of the nutritional needs of life. Rice has a carbohydrate content of 79 g with an energy content of 360 cal (Utama 2015). The need for rice in Indonesia has increased from year to year along with the increasing population, so efforts are needed to increase and maintain rice production to prevent food shortages in Indonesia. According to the Badan Pusat Statistik (2022), rice production in Riau in 2018 increased from the previous year, reaching 266,375 tons, but in 2019, it decreased to 230,873 tons. In 2020, rice production increased to 243,685 tons, but rice production decreased again in 2021 to 217,458 tons. The attack of plant-disturbing organisms (OPT) is one of the factors affecting rice production. Efforts that can be made to increase rice production again controlling the OPT. One of the pests that often causes crop failure until rice production decreases is the Brown Planthopper (BPH), *Nilaparvata lugens* (Stal).

Nilaparvata lugens is an important pest on rice plants and plant fluid-sucking insects (Wonorahardjo et al. 2015). BPH can attack rice plants in all phases of growth both from seedling to before harvest (Sujitno et al. 2014). BPH damage rice plants by sucking plant stem cell fluid, thereby inhibiting growth and causing crop failure or puso (Baehaki & Mejaya 2014). In large populations, BPH pests can cause rice plants to experience drought usually called *hopperburn*, where rice plants become dry, reddish-yellow-like burning (Chaerani et al. 2014). This pest can also be a vector carrier of the grass dwarf virus disease (Grassy stunt) and hollow dwarf *(*Ragged stunt*)* (Basri 2012).

Farmers still use many chemical pesticides in pest control in mild and severe attack situations because the practical way of using chemical pesticides can react very quickly and efficiently on a wide scale. However, the unwise use of chemical pesticides in pest control can cause more severe problems, including environmental pollution, pest resistance, pest resurgence, death of natural enemies, damaging ecosystem balance, and residues in agricultural products (Adriyani 2006). According to Dadang and Prijono (2008), efforts that can be made to suppress pest attacks on plant cultivation are recommended to use botanical pesticides. One plant that has the potential to become a botanical pesticide is the tuba plant. Tuba plants (*Derris elliptica* (Wallich) Benth.) belong to the family Fabaceae which consists of creeping and climbing plants. Tuba plants contain active compounds rotenone with other designations biotoxin and are included in the flavonoid group (Tarumingkeng 1992). Tuba plants are plants that have the potential to become insecticides that can reduce pest and fish populations (Kardinan 2004). Tuba plant parts such as roots, stems, and leaves are known to contain the dynamic compound rotenone (Kuncoro 2006).

Rotenone is contained in tuba plants by 0.3-12%. Rotenone works as stomach toxins and contact toxins (Kardinan 2004). Rotenone compounds enter the body of insects through natural holes in the body of insects or the mouth along with foodstuffs. Rotenone can also cause disruptions in metabolic processes including decreased ability of insects to change the food they consume so that it does not become a body-building substance. This results in a decrease in the growth and development rate of insects that cannot complete their life cycle (Tarumingkeng 1992).

According to Pasaru et al. (2022), tuba root extract can kill stink bug (*Leptocorisa acuta* Thunberg.) at a concentration of 8% with a mortality rate of 91.67%. This is according to Dadang and Prijono (2008) assertion that a botanical pesticide is considered effective if it can kill more than 80% of the pest while using no more than 10% water solvent. However, studies using tuba leaves are still not widely reported, especially against BPH pests. This study was conducted to obtain the concentration of tuba leaf extract that was effective against BPH under laboratory conditions.

MATERIALS AND METHODS

Sampling Site and Insect Sampling

The study was conducted in the Plant Pest Laboratory, Faculty of Agriculture, University of Riau, Bina Widya Campus, KM. 12.5, Simpang Baru Sub-district, Tampan District, Pekanbaru City, located in Riau Province, Indonesia. The study was conducted from January to March 2023. Adult of *N. lugens* were obtained from rice fields in Bangkinang, Kampar Regency, Riau Province, Indonesia. They were collected directly from the stems of rice plants using an aspirator. All stages of BPHs found in the field were collected. The collected BPHs were then brought to the Plant Pest Laboratory, Faculty of Agriculture, University of Riau, Indonesia.

Experimental Design and Concentration Applied

Experiment was experimentally conducted using a Completely Randomized Design (CRD) comprising of five treatments. Each treatment was replicated four times in order to get 20 experimental units. Below are the treatments used in this experiment:

P0 = Concentration of tuba leaf extract 0%
P1 = Concentration of tuba leaf extract 2.5%
P2 = Concentration of tuba leaf extract 5%
P3 = Concentration of tuba leaf extract 7.5%
P4 = Concentration of tuba leaf extract 10%

Propagation of *Nilaparvata lugens*

Nilaparvata lugens (BPH) aken from the field were propagated in plastic containers containing 14-day-old rice as their food source. Rice seedlings served as host plants for the BPH and were reared until a sufficient number of offspring were obtained. A total of 200 BPH insects were tested (10 per unit x 20 experimental units). The average room temperature was 26.4ºC and the average humidity was 77.6%.

Preparation of Tuba Leaf Extract
Tuba leaves were collected from community gardens in Bencah Kelubi Village, Tapung District, Kampar Regency, Riau. The characteristics of the collected plant leaves were mature and perfectly green and were taken to the Plant Pest Laboratory, Faculty of Agriculture, University of Riau, then cleaned thoroughly and air-dried for seven days. The dried leaves were cut and ground into powder using a blender. The powdered Tuba leaves were then sieved using a 40-mesh sieve to obtain Tuba leaf powder (Dadang & Prijono 2008). The Tuba leaf powder was weighed according to the treatment: 25 g, 50 g, 75 g, and 100 g. Each treatment was mixed with 1,000 ml of water. After adding 1,000 ml of water to each treatment, the Tuba leaf powder solution was stirred using a stirring rod and left to stand for one hour to allow the chemical compounds to dissolve properly. Then, 1 ml of liquid soap was added to each treatment and stirred again. The solution was filtered using filter paper and poured into a 250 ml hand sprayer.

Treatment of Tuba Leaf Extract
The application was done by spraying the tuba leaf extract using a 250 ml hand sprayer. The spraying of tuba leaf extract was carried out in the morning at 10:00 AM local time. Before applying the tuba leaf extract, the hand sprayer containing the extract solution was stirred first to ensure no sedimentation. The tuba leaf extract solution was sprayed directly onto the base of the rice plant stem evenly and onto the BPH imago in each experimental unit according to the calibration results.

Data Analysis
Data from the observation of the initial time of death, lethal time (LT_{50}) and total mortality were analyzed statistically using variance analysis and further tested for honest real difference (BNJ) at the 5% level using the SAS version 9.1 application. Lethal concentration observations (LC_{50} and LC_{95}) were analyzed by probit using POLO-PC program.

RESULTS AND DISCUSSION

Time of Initial Death (Hours)
The results of observing the initial time of death of BPHs after fingerprint analysis demonstrated that treatment with various tuba leaf extract concentrations significantly impacted the BPH initial time of death. The average results of BNJ follow-up tests at the initial time of death of BPHs at the level of 5% can be seen in Table 1.

Table 1. Time of initial death of Brown Planthopper (BPH) after application of several concentrations of tuba leaf extract (hours)

Tuba Leaf Extract Concentration (%)	Time of Initial Death (Hours)
0	120.00 a
2.5	12.75 b
5	7.50 c
7.5	4.50 c
10	3.00 c

The numbers in the column followed by unequal lowercase letters differ markedly according to the BNJ test at the level of 5% after being transformed by $\sqrt{y}$.

Table 1 shows that the initial mortality of BPH varied significantly depending on the dosage of tuba leaf extract given, with a range of 3.00 - 12.75 hours. However, the treatment of 0% until the end of the observation period, 120 hours after application, did not result in BPH mortality. This is because no tuba leaf extract was provided, hence there were no toxic compounds acting on the 0% treatment. The application of 10% concentration of tuba leaf extract resulted in a tendency for earlier initial mortality, occurring at 3.00 hours after application, which was not statistically significant compared to the 7.5% and 5% treatments but significantly different from the 2.5% and 0% treatments. This is suspected to be due to the high content of active compounds in the tuba leaf extract, leading to earlier initial mortality. This aligns with Natawigena (2000) view that the pest mortality process will be faster with increasing concentration provided. Meanwhile, the application of a 2.5% concentration resulted in initial mortality of BPH occurring at 12.75 hours after application. This condition is attributed to the low content of compounds in the tuba leaf extract. This opinion is supported by Hasfita et al. (2013), stating that at low concentrations, the active ingredient content in the solution is also low, resulting in slower mortality.

The active compound responsible for the effects of tuba leaf extract is rotenone, which enters the body of BPH as a contact and stomach poison. According to Tarumingkeng (1992), rotenone enters the insect's body through natural openings or the mouth along with food. Rotenone can disrupt the insect's metabolism, reducing its ability to convert consumed food into body-building substances, thus slowing down its growth and development and preventing it from completing its life cycle. The symptoms of BPH mortality begin with changes in behaviour, such as becoming immobile and a decrease in feeding activity. This is supported by Tarumingkeng (1992), stating that the inhibition of metabolism due to rotenone causes paralysis in the insect's respiratory system and disrupts the functioning of other parts such as the digestive organs, leading to inhibited feeding, starvation, and symptoms of inactivity (inability to feed), paralysis, and eventual death.

Morphological changes in BPH include body wrinkling, softening, and melanization, characterized by a darkening of the insect's body color. This is believed to be caused by the inability of BPH to eliminate the poison from their bodies, resulting in melanization. The theory proposed by Sofiyana et al. (2014) that rotenone in the intestines is transported to the liver through the bloodstream, where it accumulates and undergoes detoxification, supports this explanation for why the body becomes dark. Melanization symptoms typically become apparent after 24 hours of application.

Lethal Time (LT_{50}) (hours)

The results of observations of LT_{50} BPHs after variety analysis showed that applying different concentrations of tuba leaf extract had a notable impact on the time needed to kill BPH as much as 50%. The average results of BNJ's follow-up test at the level of 5% can be seen in Table 2.

Table 2. Lethal time 50 (LT_{50}) Brown Planthoppers (BPHs) after application of several concentrations of tuba leaf extract (hours)

Tuba Leaf Extract Concentration (%)	Lethal Time 50 (Hours)
0	120.00 a
2.5	62.75 b
5	25.00 bc
7.5	20.75 c
10	15.00 c

The numbers in the column followed by unequal lowercase letters differ markedly according to the BNJ test at the level of 5% after being transformed by $\sqrt{y}$.

Table 2 shows that the application of various concentrations of tuba leaf extract resulted in significant changes in LT_{50} (median lethal time) in BPHs, ranging from 15.00 to 62.75 hours. However, the treatment with 0% tuba leaf extract concentration did not achieve an LT_{50} until the end of the observation period due to the absence of applied tuba leaf extract, resulting in the absence of toxic compounds. The highest concentration treatment of tuba leaf extract at 10% tended to induce an LT_{50} at 15.00 hours after application, significantly different from the 7.5% and 5% treatments at 20.75 and 25.00 hours, respectively, but significantly different from the 2.5% and 0% concentration treatments. This indicates that the differences in concentration also have varying effects on the time required to kill 50% of the BPH population. The difference in time required to kill 50% of the pests is believed to be related to the concentration given, where higher concentrations contain more active ingredients, thus accelerating the process of BPH mortality. This is supported by the statement from Rustam and Tarigan (2021) that the higher the concentration of active ingredients, the higher the toxicity, leading to faster mortality of test insects.

The treatment with a concentration of 2.5% tuba leaf extract tends to be slower in killing 50% of the pests, taking 62.75 hours after application, and significantly differs from the treatment with 5% tuba leaf extract concentration, which takes 25.00 hours after application, but significantly differs from the treatment at 7.5% and 10% tuba leaf extract concentrations. This could be due to the active compounds present in the tuba leaf extract at low concentrations having low toxicity levels because there are fewer active compounds compared to higher concentration treatments, resulting in slower effectiveness that is still acceptable to BPHs for survival. This statement is consistent with the statement by Rizal et al. (2010), which states that the lower the concentration, the longer it takes to kill 50% of the insects because fewer active ingredients enter the insect's body.

Lethal Concentration (LC_{50} and LC_{95}) (%)

Based on the POLO-PC program's probit analysis results, the tuba leaf extract concentration revealed LC_{50} and LC_{95} were 1.46% and 23.29%, respectively. The results of probit analysis shown in Table 3. Result showed that 1.46%, or 14.6 g/L of tuba leaf extract in water, is the appropriate concentration to kill 50% of the test insects. According to Hasyim et al. (2019), a botanical pesticide is more hazardous if its LC_{50} value is smaller than another botanical pesticide. However, 23.29%, or 232.9 g/L of tuba leaf extract in water, is the amount required to kill 95% of the test insects. This concentration is higher than the maximum recommended concentration of botanical pesticides, which is 10% or 100 g/L of water. The high concentration needed to kill 95% of the BPH population is believed to be due to the survival ability of the BPH and the ease of decomposition of the active ingredients in tuba leaf extract. This opinion is supported by Dadang and Prijono (2008), who state that some shortcomings of botanical pesticides include their low persistence, requiring repeated applications for maximum control effectiveness, especially in high pest populations.

Table 3. Lethal concentration 50 and 95 (LC_{50} and LC_{95}) Brown Planthoppers (BPHs) after application of several concentrations of tuba leaf extract

Lethal concentration (LC)	Concentration (%)	SK 95% (%)
LC_{50}	1.46	0.07 – 2.64
LC_{95}	23.29	11.63 – 950.39

SK = Trust interval

Daily Mortality (%)

The results of daily mortality observations of BPHs showed that treatment with several concentrations of tuba leaf extract led to an unstable percentage of BPH mortality from the first day to the fifth day. The daily mortality percentage of BPHs can be seen in Figure 1.

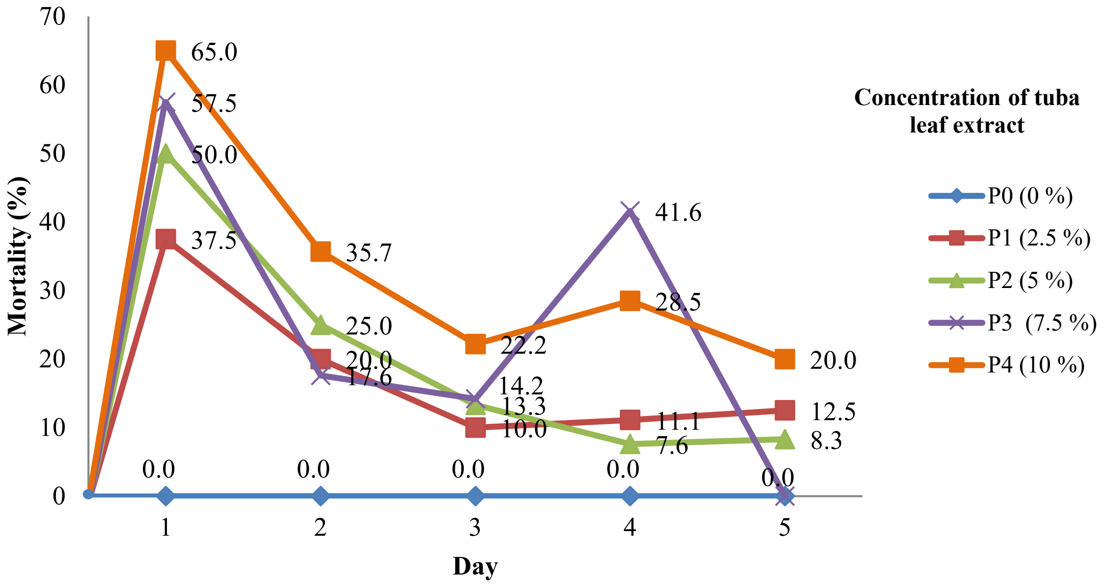

Figure 1. Mortality percentage of Brown Planthopper (BPH) per day after application of multiple concentrations of tuba leaf extract

Figure 1 demonstrates the fluctuations in the BPH daily mortality graph. This demonstrates that administering tuba leaf extract at various concentrations, namely concentrations of 10%, 7.5%, 5%, and 2.5%, gives a difference in the percentage of daily mortality BPH pests, except that the 0% treatment does not show the presence of BPH pests that die until the end of the observation.

The peak daily mortality of BPH pests occurred on the first day with a range of 37.5 – 65.0%, where at a concentration of 10% caused the highest death of brown stem leafhoppers at 65.0%, at a concentration of 7.5% caused mortality of 57.5%, a concentration of 5% with a mortality of 50.0%, and at a concentration of 2.5% caused mortality of 37.5%. This is thought to be because rotenone contained in tuba leaf extract work as contact poisons, then rotenone accumulates in the body of BPH. According to Hutasoit et al. (2015), The active ingredient contained in the tuba root extract, namely rotenone, will first damage the fat or cuticle layer to enter the body and then affect the respiratory and nervous systems.

The daily mortality of pests on the second and third days decreased compared to the percentage of daily mortality on the first day. On the second day, the daily mortality of BPHs decreased within the range of 17.6% to 35.7%, and on the third day, the daily mortality of BPH further decreased within the range of 10.0% to 22.2%. The decrease in the percentage of BPH is estimated because the pests have passed the peak mortality phase on the first day, and BPHs have developed resistance to the botanical pesticide, tuba leaf extract. Prijono's statement (1999) that insect metabolism can break down and eliminate harmful substances from the body, along with the fact that insects can develop resistance to poisoning, supports this.

The daily mortality of BPHs generally increased on the fourth day, ranging from 7.6% to 41.6%. This is due to the ability of rotenone, which functions as a stomach poison, to kill target insects. This is supported by Tarumingkeng's statement (1992) that rotenone kills target insects by entering the digestive system through food consumption. According to Santi and Sukadana (2019), active compounds entering the digestive organs cause intestinal muscles to tense up. This leads to food being trapped in the intestines, directly reducing the appetite of target insects and eventually causing death. On the fifth day, the percentage of daily mortality of BPHs decreased again. This is suspected because the active compound content of rotenone in the applied tuba leaf extract gradually decreases, due to the botanical pesticide's easily degradable and volatile nature, causing the active compounds in the botanical pesticide to diminish over time. This opinion is supported by Naria (2005), stating that active compounds in botanical pesticides are unstable and easily degrade in nature, resulting in their effectiveness not lasting long.

Total Mortality (%)

The application of different amounts of tuba leaf extract had an important effect on the total mortality of BPHs, based on observations of BPH deaths following analysis. The average results of BNJ follow-up tests at the level of 5% can be seen in Table 4.

Table 4. Total mortality of Brown Planthoppers (BPHs) after application of multiple concentrations of tuba leaf extract (%)

Tuba Leaf Extract Concentration (%)	Total Mortality (%)
0	0.00 b
2.5	65.00 a
5	72.50 a
7.5	82.50 a
10	90.00 a

The numbers in the column followed by unequal lowercase letters differ markedly according to the BNJ test at the level of 5% after being transformed by $\sqrt{y}$.

Table 4 shows that treatment with tuba leaf extract at various concentrations resulted in total mortality of BPHs ranging from 65.00% to 90.00%. The 0% concentration treatment did not cause any mortality of BPHs until the end of the observation period, as no tuba leaf extract was applied, hence no toxic compounds were present. Observations on the total mortality of BPHs indicated that the highest concentration, 10%, resulted in a higher percentage of total mortality reaching 90.00%, insignificantly different from the concentrations of 7.5%, 5%, and 2.5%, but significantly different from the 0% treatment. This suggests that increasing the concentration does not affect the difference in total mortality percentage of BPHs. This is likely because the active compound rotenone contained in tuba leaf extract has relatively high toxicity, thus resulting in higher lethality.

Rotenone is a toxic compound found in tuba leaf extract. According to Yama (2018), rotenone is 15 times more toxic than nicotine and 25 times more toxic than potassium ferrocyanide. Rotenone enters the body of BPHs as a stomach poison and contact poison, disrupting the insect's metabolism. This is supported by Tarumingkeng (1992), stating that rotenone enters the insect's body through natural holes in the body or through the mouth along with food. Rotenone can also disrupt metabolic processes, including reducing the insect's ability to convert consumed food into body-building substances, resulting in decreased growth and development rates and an inability to complete their life cycle.

The performance of rotenone is supported by other active ingredients present in tuba leaf extract, increasing its toxicity because many active ingredients play a role in killing pests. This is supported by Prijono's statement (1999) that the more active ingredients a pesticide contains, the higher its toxicity level, resulting in increased pest mortality. According to Kuncoro (2006), other active ingredients present in the tuba plant are deguelin, tephrosin, and toxicarol. The effective concentration of tuba leaf extract in controlling BPH pests is 7.5%, as it has been able to cause a total mortality rate of 82.50%. This aligns with the statement by Dadang and Prijono (2008), which suggests that botanical pesticides are considered effective if they can kill more than 80% of pests and contain no more than 10% water solvent.

CONCLUSION

Testing various concentrations of tuba leaf extract to control BPH pests concludes that the effective concentration for killing BPHs is at 7.5%, as it has resulted in a total mortality rate of 82.50% with an initial mortality time of 4.50 hours after application and a median lethal time of 20.75 hours after application. The most effective concentration of tuba leaf extract in reducing the BPH population by 50% is 1.46% or 14.6 g/l water. Meanwhile, 232.9 g/l water or a concentration of 23.29% is sufficient to kill 95% of the BPH population. Further field research is conducted to assess the effectiveness of applying tuba leaf extract in different quantities to control BPH pests.

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Conflict of Interest
The authors declare that they have no conflict of interest.

Ethics Declarations
No ethical issue is required for this research

Authors' Contributions
Rusli Rustam (RR) contributed to formal analysis, investigation, writing, reviewing and editing. Rizke Skar Nolla Utari (RSN) contributed to methodology, writing original draft, visualization, investigation and supervision. Mukhlis Ibrahim (MI) contributed to conceptualization, investigation, resources, supervision, visualization, reviewing and editing. All authors read and approved the final manuscript.

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