

## UTILIZATION OF CASHEW NUTSHELL LIQUID EXTRACTION DREGS TO CONTROL GOLDEN APPLE SNAILS IN RICE

Dian Astriani\*, Ridho Kuntoro, and Warmanti Mildaryani

Department of Agrotechnology, Faculty of Agro-Industry, Universitas Mercu Buana Yogyakarta, Yogyakarta, Indonesia

\*Corresponding Author. E-mail address : dianastriani@mercubuana-yogya.ac.id

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### ABSTRACT

Rice is one of the major staple food crops in the world. Golden apple snail is an important pest that can reduce rice productivity. Cashew is a plant that has potential as a botanical pesticide. Extraction of cashew nutshell produce CNSL (Cashew Nutshell Liquid) which can be used as an effective botanical pesticide. The extraction process will leave behind the dregs that suspected still have toxicity and indicated as molluscide, so it is necessary to conduct research to determine the effectiveness of the dregs of cashew nutshell extraction against Golden apple snail in rice. This research had been conducted from June to December 2023 at UMBY. The study used a single factor that was concentration of dregs of cashew nutshell extraction which consisted of four levels namely 4, 2, 1%, and without the dregs of cashew nutshell application (0%) as a control. The research consisted of two steps. The first step was toxicity test of the dregs to Golden apple snail. The next step was application test of the dregs against the snail in rice cultivation. The results showed that the dregs of cashew nutshell extraction had toxicity to Golden apple snail, with LC<sub>50</sub> of 2.72% (27200 ppm). The dregs of cashew nutshell at a concentration of 4% was the most effective in controlling the Golden snail, meanwhile concentrations of 1, 2, or 4% did not affect rice growth until 35 days after planting but could increase the number of tillers and fresh weight of rice plants. These findings provide important evidence for the use of cashew nut shell extract as a molluscicide, particularly for controlling golden apple snails in rice.

## 1. INTRODUCTION

Research on rice in Indonesia remains crucial for ensuring national food security, reducing dependence on imports, and enhancing farmer welfare through the development of effective, efficient, and environmentally friendly crop cultivation technologies. This, in turn, supports environmental sustainability through low-carbon agricultural practices, given that rice is a staple food and a strategic commodity for the country. Research continues, particularly in the pursuit of innovative solutions related to seeds, integrated pest management, and efficient irrigation.

Rice production in Indonesia continues to experience unstable fluctuations, with a decline recorded in 2021. According to 2022 data from the Central Statistics Agency (BPS), national rice production in 2021 reached 54.42 million tons of dry milled rice. This figure decreased by 0.43% (233,900 tons) compared to the previous year. Converted to rice, production reached 31.36 million tons in 2021, a decrease of 0.45% (140,730 tons) from the previous year. This production decline was due to a decrease in harvested land area to 10.41 million hectares (Rochdian, 2022). In the last five years (2019-2023), Indonesia generally experienced a rice production surplus, with BPS data indicating that production exceeded consumption. However, this trend indicates increasing demand, which threatens long-term food sovereignty due to population growth and land conversion (Badan Pusat Statistik, 2025). The decline in rice production can also be caused by other factors, including, most significantly, climate change and pest or disease attacks. If the decline in rice production continues, there are concerns that Indonesia will experience food shortages in the future, given that rice is a staple food for the Indonesian people (Rochdian, 2022).

Climate change is having a significant impact on global rice production, which is particularly concerning in South and Southeast Asia, where many countries are major rice producers and exporters, such as India, Thailand, and Vietnam, which collectively produce over 180 million metric tons of rice and export over 30 million metric tons annually. Climate change is associated with rising temperatures and shifting rainfall patterns, which can directly reduce rice yields and indirectly increase the risk of agricultural diseases and pests (Panchot *et al.*, 2025).

Golden apple snails are a significant pest of lowland rice. Rice fields in Indonesia are primarily divided into paddy fields and dryland (upland) fields. In the past five years (around 2020-2024), the area of lowland rice fields in Indonesia has significantly outnumbered that of upland rice fields, with the latter accounting for the majority of total rice fields, at around 14-16 million hectares, while upland (dryland/field) rice fields typically cover only around 1-2 million hectares (Badan Pusat Statistik, 2025). Among rice pests, snails of the genus *Pomacea* are the most destructive, causing significant agricultural and economic losses worldwide. *Pomacea* snails cause significant agricultural losses, especially in tropical rice-growing regions such as Southeast Asia. *Pomacea canaliculata* rapidly invades rice paddies, causing significant damage in the early stages of crop growth. The estimated economic impact is US\$1.59 billion in the Philippines, US\$0.50 billion in China, and US\$1.61 billion across the Philippines, Thailand, and Vietnam. Annual regional losses can exceed US\$2 billion. In Ecuador, total productivity losses reached US\$32.71 million due to crop loss, increased labor, control efforts, and wasted inputs such as seeds and fertilizers. In many Southeast Asian countries such as Indonesia, Singapore, and Malaysia, rice fields are infested with several snail species, but *Pomacea* is invasive and has a greater impact on rice production due to its superior environmental tolerance and competitive ability (Panchot *et al.*, 2025).

The most damaging stage is when the shells start to measure 10 mm (the size of a corn seed) to 40 mm (the size of a table tennis ball). Golden apple snails like young rice plants, where these pests will start to damage rice plants from the seedling process to rice plants that are about 4 weeks old. Golden apple snails attack rice plants by cutting the base of the young rice plants, causing damage to the entire rice clump. The Golden apple snail can damage rice plants with an intensity ranging from

13.2 to 96.5%. A study in Indonesia showed that the Golden apple snail can reduce rice yields by around 8 to 97%, with an average rate of 49% (Pratama *et al.*, 2023; Rusli *et al.*, 2023).

The Golden apple snail or *P. canaliculata*, lives in shallow waters up to three meters below the water surface with habitat conditions that are abundant in water and mud. The snail is very suitable in flooded areas, does not dry out easily, and the water flow is slow. Calcium and water are the most important chemicals for mollusca, including golden snails. The compound is a building block for the shells of mollusca. The process of shell formation begins with a high content of carbohydrate compounds and is always alkaline. The golden apple snail can survive up to 6 months in dry soil. This animal can live in a pH of 5-8, and a temperature tolerance of 14-25 °C to 18-28 °C. Higher temperature causes Golden apple snail to eat, move, and grow faster. Golden apple snails become inactive and hide in colder temperatures. But at temperatures above 32 °C, this animal has a high mortality rate (Pratama *et al.*, 2023).

Pratama *et al.* (2023) reviewed the habitat and life cycle of the Golden apple snail. The snail has the characteristics of a round shell with a height that can reach 10 cm and has a yellowish color. The opercula of the golden apple snail are round, blackish brown on the outside and yellowish brown on the inside. Adult Golden apple snail has a shell that is about 4 cm in diameter and weighs 10-20 grams. Shell growth is influenced by the availability of calcium as a shell-forming material. Moreover, a nutrient-rich environment forms a larger, thicker, and stronger shell. The head of the Golden apple snail is triangular and tapers towards the back. The flesh is soft, whitish cream to golden red or yellowish orange, approximately 10 cm in size, with a shell diameter of 4-5 cm.

The golden apple snail has separate male and female sexes. Mating of golden apple snail are not affected by the time of the season, meaning it occurs throughout the year. During copulation, the Golden apple snail will fertilize the egg cells found in the body of the female parent. Golden apple snail needs about 3-4 hours to mate in areas that have received water throughout the year. Female golden snails generally lay their eggs at a height of 10-50 cm above the water surface, where the eggs are in groups shaped like mulberries and pink in color. Female snails lay eggs at night, and the eggs are laid on objects around the water, such as rice stalks, grass, rocks, and so on. Golden snail eggs will hatch 7-15 days later, depending on environmental conditions. The reproductive output can reach hundreds of eggs in one group. Egg hatching success is more than 85%. Shortly after the egg hatches, the young snail immediately leaves its eggshell and dives into the water, and the shell will harden two days later.

Golden snails with high fertility can live between 2 and 6 years. Golden snails reach reproductive maturity at the age of 3 months to 2 years. Young golden snails (2-5 mm) will start eating young plants and algae, which lasts throughout their life. At 15-25 days is the beginning of their growth, at 26-59 days they eat plants very intensively, and at 60 days, they are ready to breed.

Female golden snails are almost always larger and heavier than males, and the growth rate of female snails is generally faster. Male snails will also stop growing more quickly than female snails, and it is even said that female snails can continue to grow throughout their lives. However, it turns out that male snails show a higher survival rate than females. This shows that the body size of female snails does not indicate a better survival rate but is due to a faster growth rate.

Various control techniques that have been used for Golden apple snails in rice are collecting eggs and golden snails, installing plastic barriers in seedbeds, replanting plants, placing sticks/wood on rice plants, making ditches around rice fields, releasing ducks, installing filters in channels entering, placing bait, adjusting planting patterns, with botanical pesticides or synthetic chemicals (Dinas Pertanian dan Pangan Kabupaten Demak, 2021; Harahap, 2017). Studies on controlling Golden apple snails with biological agents have also been carried out by Wang *et al.* (2023) by using the giant prawn *Macrobrachium rosenbergii* to control the early stage of Golden apple snail. However, the golden snail *P. canaliculata* has strong reproductive ability and has spread rapidly in Asian

countries. Current control methods, such as physical, chemical, and biological approaches, will be effective and sustainable if they are combined into an integrated control program, and that would be great with many more environmentally friendly control alternatives, such as CNSL dregs as a botanical molluscicide.

Biopesticides are types of pesticide that comes from natural ingredients such as animals, plants, bacteria, and certain materials (Samada & Tambunan, 2020). The selection of plant species that have the potential to be a source of bio-pesticide materials must at least (1) consider their bioactivity towards the target organism, (2) their existence is quite abundant and easy to obtain, and (3) there is no conflict with external interests. To avoid conflicts of interest, the priority is selecting plant materials are not or less useful. One of them is cashew nutshell waste, which is generally not optimally utilized.

The use of biopesticides is the wisest alternative pest control strategy to minimize the use of synthetic pesticides in plant cultivation. Cashew has the potential to be a source of bio-pesticides because the seeds are poisonous, anti-insect, repellent, and allelopathic, while the leaves are anti-nematode (Astriani *et al.*, 2019). CNSL can have toxicity as an insecticide, termicide, bactericide, or fungicide (Kamble *et al.*, 2016). The processing of cashew nut shells to produce Cashew Nutshells Liquid (CNSL) or cashew nutshell oil as a biopesticide will increase its functional value. The use of natural materials such as CNSL will be more environmentally friendly because they are more easily degraded into non-toxic compounds, so that when applied in plant cultivation, it will conserve land and support sustainable agriculture towards increasing the quality of food. CNSL biopesticide become support for environmentally friendly cultivation technology towards agriculture. This research can be a solution to the strategic issue of agricultural dependence on synthetic chemicals and environmental damage.

Several previous studies have shown that CNSL has potential toxicity to control pest attacks both from the chewing type group, such as *Helicoverpa armigera* larvae, *Cricula trifenestrata*, *Sitophilus* spp., *Tribolium castaneum*, and *Crocidolomia pavonana* (Mahapatro, 2011; Dewi *et al.*, 2018), or pests from the sucking type of group, such as ticks or true bugs, including *Helopeltis antonii* and *Bemisia tabaci* (Astriani *et al.*, 2019; Andayanie *et al.*, 2019).

Cashew nut shells can be extracted to produce CNSL, which has the potential to become a pesticide to control pests. CNSL produced from mechanical extraction tends to have higher toxicity to insect pests than the result from chemical extraction, which can cause 100% mortality at a CNSL concentration of 20%. However, the CNSL yield from mechanical extraction is lower than that from chemical extraction (Astriani *et al.* 2017), so the CNSL content in the extraction dregs is certainly still greater. Therefore, the chemical extraction dregs of CNSL production still have the potential to be used as a bio-pesticide. Cashew nutshell is waste from cashew production, while CNSL extraction dregs are waste from CNSL bio-pesticide production. Therefore, the utilization of CNSL extraction dregs is a big step towards efficiency and increases the use of primary productivity plants towards zero waste agricultural model. The zero-waste agricultural model can reduce costs so that efficiency is expected in the management of rice that will re-enter the cycle of the environment and is oriented towards sustainable agriculture (Ramadhani *et al.*, 2019). Research that tests the effectiveness of CNSL extraction dregs will further support the issue of utilizing agricultural materials and utilizing waste to support sustainable agriculture, so that it becomes a solution the problem of agricultural dependence on chemical synthetic and environmental damage.

The formulation of CNSL was tested and showed efficacy as a seed dressing compound for corn seeds against the maize weevil. The CNSL was derived from mechanical extraction using a mechanical press centrifugal (Astriani *et al.*, 2019; Astriani *et al.*, 2020). The mechanical extraction dregs left behind were sticky, brownish-black cashew nut shells and still contained quite a lot of oil, which also had pesticide properties. This research will be carried out by applying CNSL extraction dregs as

molluscide, and it is expected to obtain information on toxicity and efficacy against pests from the mollusc group.

The purpose of this study was to obtain information about the toxicity and effectiveness of CNSL dregs control against Golden apple snail pests and to determine the most effective concentration of CNSL extraction dregs to control Golden apple snails on the rice plant. The results of this study are expected to provide information and knowledge regarding the optimization of cashew nutshell waste utilization for plant pest control, where CNSL extraction dregs still have toxins to be utilized as well. This will further increase the functional waste value of cashew nutshell waste as a raw material for biopesticide.

## 2. MATERIALS AND METHOD

### 2.1 Place and Time

This research was conducted from June to December 2023 at the Agronomy Laboratory and Plant Protection Laboratory, Agro-industry Faculty, Yogyakarta Mercu Buana University.

### 2.2. Tool and Material

The tools used include a mechanical centrifugal press, gloves, bucket, para-net, sprayer, ruler, oven, scale, measuring cup, plastic tub, scissors, camera, and stationery. The materials used included 3-4 cm adult Golden apple snails, seeds of rice Ciherang variety, taro leaves, vertisol, roasted husk, and CNSL production extraction dregs (hereinafter referred to as CNSL dregs). The CNSL dregs used in this study are the residue from the extraction of CNSL production.

The CNSL extraction process begins with cutting the cashew nut shells into 2-3 cm pieces and heating them at 80 °C in an oven for 8 hours until the water content reaches 12.8%. Then, the cashew nut shells are pressed using a mechanical centrifugal press (Honda GX 160 H1, Capacity: 0.6 L) (Astriani *et al.*, 2019). Each extraction process, pressing was carried out twice for the same material, and in this study, 310 ml of CNSL was produced from 4.4 kg of cashew nut shells, where the extraction produced a yield of 70.45 ml/kg, and left a residue in the form of 2.8 kg of cashew nut shell dregs (CNSL dregs).

### 2.3. Toxicity Test of CNSL Dregs on Golden Apple Snail

This experiment used a CNSL dregs concentration level of 4, 2, 1, and 0%. Toxicity test carried out on 10 Golden apple snails placed in a bucket containing a mixture of 6 kg of soil, 4 liters of water, and CNSL dregs according to the previous concentration treatments. In this experiment, the Golden apple snail was fed taro leaves as needed. The experiment was carried out with 3 replications, so that there were 12 experimental units arranged in a Completely Randomized Design. A concentration of 1% is 10 g of CNSL dregs applied to a bucket containing 10 liters of the planting medium. To make other concentration treatments, are done like the 1% treatment. The technical implementation of this research was modified from the research of Wibowo *et al.* (2008).

Observations on the mortality of Golden apple snail were carried out after 3 days (72 hours). Mortality data of the Golden apple snails were used to determine toxicity using the Polo Plus version 1.0 program. Golden snail mortality data were also analyzed to determine the differences between treatments with  $\alpha=5\%$  level of variance analysis, and the treatment that was significantly different was further tested using Duncan's test at  $\alpha=5\%$  level.

## 2.4. The Application Test of CNSL Dregs on Rice Cultivation

This experiment was carried out by using techniques and treatments like those used for toxicity tests, but in a bucket as the plant medium of rice. Four clumps were planted, and each clump consisted of four rice seedlings, and 10 Golden apple snails were released after the rice seedlings were 3 days old, after being transplanted. Before the seedling was sown from the rice seeds, they were planted with seedling medium consisting of a mixture of soil, manure, and roasted husk, in a ratio of 1:1:1, until the seedling was 14 days old, before being transplanted into the bucket. Maintenance was carried out on rice plants until they were 35 days old after transplanting, including during the early vegetative period, because after that period, rice plants will begin to harden, and in general, the Golden apple snail pests are no longer active in eating rice plants. The variables observed are the Golden apple snail mortality, the height of the plant, the number of saplings, and the weight of fresh and dry shoots of the rice plants. Observations on the mortality of the Golden apple snail were carried out every 12 hours up to 7 days (168 hours). Observations on plant height are carried out once a week, while observations on other growth variables are carried out until the age of 35 days after transplanting. The details obtained from the observation results were then analyzed using ANOVA (Analysis of Variance) at  $\alpha=5\%$  level. If there is a significant difference in the treatment, it is continued with Duncan's test at  $\alpha=5\%$  level.

## 3. RESULTS AND DISCUSSION

### 3.1 Toxicity Test (%)

The result of the CNSL dregs toxicity test on Golden apple snail showed that the concentration of CNSL dregs in the planting medium would affect the mortality of Golden apple snail. All levels of CNSL dregs concentration could increase the mortality of Golden apple snail, where the higher concentration of CNSL dregs will increase the mortality rate of Golden apple snail (Table 1), and this shows that the concentration of CNSL dregs at 4% has the highest toxicity. The golden apple snail that was exposed to the CNSL dregs became immobile and no longer wanted to eat taro leaves and then died, with the characteristics of their inner body appearing to come out of their shell and floating off the surface of the water. CNSL dregs are small pieces of cashew nutshell, like blackish brown, that have corrosive, viscous, bitter, spicy corrosion it encounters the skin, it is suspected that it will be toxic to Golden apple snail who are affected by the CNSL dregs (Astriani *et al.*, 2019).

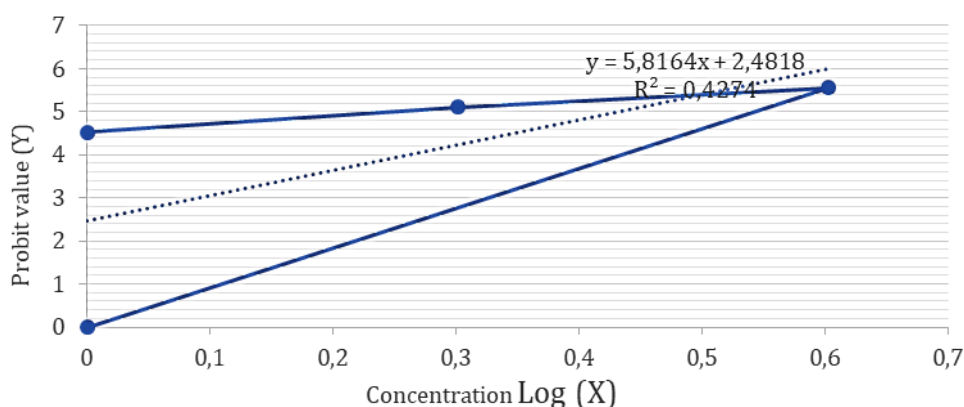
The results of the probit analysis of the Golden apple snail mortality (Figure 1) show that CNSL dregs have quite high toxicity to Golden apple snail with a value of  $LC_{50}$  at percentage 2.72% or 27200 ppm. CNSL has high toxicity mainly due to the content of anacardic acid, cardanol, and cardol. The content of CNSL in general was dominated by anacardic acid (76,93-90%); besides that, there is also cardanol and cardol (Andayanie *et al.*, 2019; Astriani *et al.*, 2019). Isolation and identification of CNSL have been carried out and obtained three cardanol derivative such as: (1) fenol (Z)-3-(8-pentadecenyl), (2) fenol(8Z,11Z)-3-(8,11 pentadecadienyl), and (3) fenol (8Z,11Z,14Z)-3-(8,11,14-pentadecatrienyl). Furthermore, it was reported that fenol (3) has the highest bacterial activity with a value of  $LC_{50}$  60.36 mg/mL (Buxton *et al.*, 2017).

The compounds anacardic acid, cardanol, and cardol contained in CNSL dregs are integrated to cause insecticidal toxicity and bioactivity against Golden apple snail. The combination of these three secondary metabolite compounds with other phytochemical compounds, which, even though they are present in small amounts in CNSL dregs, will provide specific bioactivity characteristics that may not be obtained when compared with the isolation of these three compounds. Therefore, the mode of action of a botanical extract is often not specific; some even belong to a group of unknown or non-specific modes of action (IRAC, 2024).

Table 1. Golden Apple Snail mortality in CNSL extraction dregs toxicity test after 72 hours (3 days) after infestation

| CNSL dregs concentration (%) | Mortality (%) |
|------------------------------|---------------|
| 0                            | 0.00 d        |
| 1                            | 32.14 c       |
| 2                            | 53.57 b       |
| 4                            | 71.42 a       |

Note: Average values followed by different letters indicate significantly different based on Duncan's test at  $\alpha=5\%$  level.

Figure 1. Probit analysis of  $LC_{50}$  values in the *Pomacea canaliculata* toxicity test

### 3.2. The Application Test of CNSL Dregs on Rice Cultivation

Application of various concentrations of CNSL extraction dregs in the planting medium can cause mortality, and all concentrations cause the death of all Golden apple snails at 7 days after infestation (Table 3). However, the cumulative mortality 100% of Golden apple snail with the application of various concentrations of CNSL extraction dregs occurred at different times. Figure 2 shows the mortality rate in the toxicity test on Golden apple snail from 12 hours until 168 hours (7 days). The 100% mortality of Golden apple snail with CNSL dregs concentration 4% had already occurred 3 days (72 hours) after infestation, while the concentration was 2% had occurred at 6 days (144 hours) after infestation, and at a concentration of 1%, death occurred 7 days after Golden apple snail infestation. The mortality of Golden apple snail that occurs was caused by the content of active insecticidal ingredients of CNSL dregs, where the higher concentration of CNSL dregs results in a greater content of active insecticidal ingredients, causing mortality to occur faster.

Growth is a process where a plant will experience changes in size to become taller, bigger, or have more tillers. Changes in plants that continue to increase with the age of the plant that increases indicate that the plant has good growth. Giving CNSL dregs in the planting medium can affect the height of rice plant, even though it is not done every week showed a significant difference. A significant effect occurred in the height of plants at the age of 14 and 28 days after transplanting, where there was a tendency that the greater concentration of CNSL dregs, would be produce the taller plants. At the end of observation, when the rice plants were 35 days old after transplanting, it was also seen that the provision of CNSL dregs at the concentration of 4, 2 or even 1% could increase the height of the rice plants (Table 2).

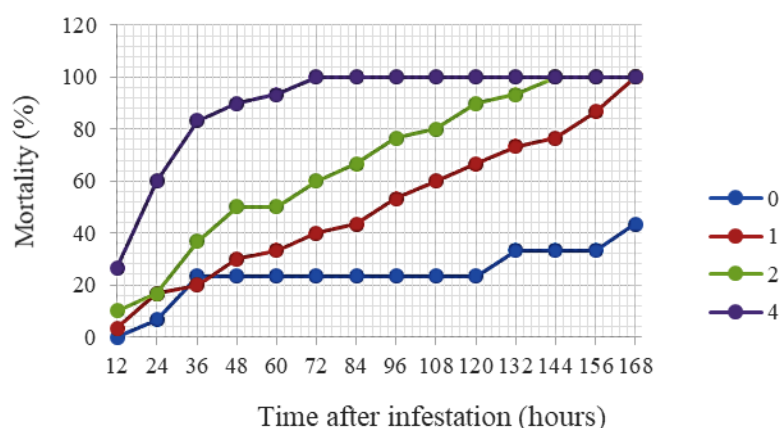


Figure 2. Mortality of Golden apple snail in application tests of various concentrations of CNSL dregs in rice

Table 2. Plant height of rice at 7-35 Days After Planting (DAP) with various concentration of CNSL dregs application

| CNSL dregs concentration (%) | Plant Height (cm) |          |         |         |         |
|------------------------------|-------------------|----------|---------|---------|---------|
|                              | 7 DAP             | 14 DAP   | 21 DAP  | 28 DAP  | 35 DAP  |
| 0                            | 19.21 a           | 28.33 d  | 36.17 a | 43.82 b | 49.87 b |
| 1                            | 18.63 a           | 29.55 bc | 41.77 a | 49.75 a | 60.68 a |
| 2                            | 18.58 a           | 31.20 ab | 43.53 a | 51.73 a | 63.69 a |
| 4                            | 20.23 a           | 32.36 a  | 44.96 a | 53.96 a | 64.25 a |

Note: Average values followed by different letters, in the same column, indicate significantly different based on variance analysis or Duncan's test at  $\alpha=5\%$  level.

Table 3. Golden apple nail mortality and growth variables of rice with various concentrations of CNSL dregs application

| CNSL Dregs Concentration (%) | Mortality of Golden Snail 7 DAI (%) | Growth Variables       |                           |                         |
|------------------------------|-------------------------------------|------------------------|---------------------------|-------------------------|
|                              |                                     | Number of Rice tillers | Fresh Weight of Plant (g) | Dry Weight of Plant (g) |
| 0                            | 43.33 a                             | 1.67 b                 | 7.98 b                    | 1.08 a                  |
| 1                            | 100.00 a                            | 4.67 a                 | 19.57 a                   | 1.61 a                  |
| 2                            | 100.00 a                            | 4.08 a                 | 21.75 a                   | 1.69 a                  |
| 4                            | 100.00 a                            | 5.17 a                 | 22.43 a                   | 2.30 a                  |

Note: Average values followed by different letters indicate significantly different based on BNT at the 5% significance level. DAI: Days After Infestation.

The growth of rice plants is affected by several factor on of which is due to pest attacks. The attack of the Golden apple snail pest causes the growth of rice plants in their seedling to be hampered. If rice plants that are still 1-30 days old are continuously attacked by the Golden apple snail, there is a possibility of crop failure for farmers (Mawardi *et al.*, 2018). This can happen because the attack on early vegetative growth by the Golden apple snail results in disrupted generative phase growth, which will then reduce the growth and formation of rice panicles, until they can not form grains perfectly.

The addition of CNSL dregs in the planting medium will also increase the number of tillers and the fresh weight of the plant. The increase in plant height, number of tillers, and plant fresh weight indicates that the addition of CNSL dregs to the planting medium can increase the growth of rice. The dry weight that tends to be heavier is also seen in the application of CNSL dregs in 4% concentration, although there was no significant difference between all concentrations (Table 3).

The effect of adding CNSL dregs in the planting medium, which can increase the growth of rice plants, is thought to be caused by this treatment causing an increase in the mortality of the Golden apple snail, so that the attack of the pests will be lighter and the plant healthier. The healthier plants will be able to do photosynthesis optimally. This is in line with the statement Hamdan *et al.* (2015) that the materials used to form the plants parts including stems, leaves, or saplings is the result of photosynthesis, and the result of photosynthetic are influenced, among other things, by the level of damage to plant tissue, in this case the damage to rice due to attacks by Golden apple snail.

The results of this study prove that CNSL dregs are effective in controlling Golden apple snail in rice cultivation. This is in accordance with several previous studies, which stated CNSL showed its effectiveness in addition to being an insecticide; there were also indications that it could act as a molluscicide (Matias *et al.*, 2017). Previously, there was very limited information about the role of CNSL as a molluscicide, although there were several farmers in Imogiri, Yogyakarta who spread cashew nut shells with the intention of controlling snails in rice field, before this, there had never been a research study on this matter.

Like CNSL bio-pesticides, CNSL dregs can act as a contact poison or stomach poison. It is suspected that CNSL poisoning against snails can also be contracted or systemic. These characteristics will cause CNSL to have broad poisoning capabilities so that it can be flexible for several types of pests. The effect of CNSL dregs bio-pesticides on pest organisms is thought to be able cause a feeding deterrent, inhibit egg laying, decrease population due to hatching disorders, changes in stage to cause mortality (Dewi *et al.*, 2018; Andayanie *et al.*, 2019; Astriani *et al.*, 2019, Astriani *et al.*, 2020; Ramadhani *et al.*, 2019).

Several molluscicide sourced from natural ingredients that have previously been studied have also shown their effectiveness against the Golden apple snail. Othman & Latip (2021) explained that molluscicide made from *Peltophorum pterocarpum* (yellow-flamboyant) extract in methanol is more effective than *Ipomoea aquatica* (water spinach) extract, in methanol or ethanol, against Golden apple snail. Other research states that turmeric essential oil has good potential as an effective molluscicide compared to wood vinegar for controlling golden snails (Azemi *et al.*, 2024). In addition, *Aralia armata* roots have the potential to be used in controlling Golden apple snail too (Nguyen *et al.*, 2022).

The mechanism of action of the CNSL dregs molluscicide is thought to be by disrupting energy metabolism, thus disrupting motility and other important processes. Molluscicide biopesticide can also act as an antifeedant, such as *P. pterocarpum* extract in Golden apple snail (Othman & Latip, 2021). Meanwhile, *A. armata* root molluscicide, whose main active ingredient is saponin, molecular docking analysis shows its application to Golden apple snail, causing acetylcholinesterase (PcAChE) and the actin-binding villin protein (PcVillin) to become potential bio-molecular targets of *A. armata* saponin. (Nguyen *et al.*, 2022).

The results of research by Wijayanti *et al.* (2016), which tested the resistance of rice plants to attacks by Golden apple snail, showed that the highest attack intensity was found in rice plants that were 8 and 15 days after planting, while the lowest was at age 29 days after planting. Based on the results of the research, the attack of Golden apple snail caused the rice plants clumps not be able to growth his stems caused Golden apple snail to attack the rice plants from the stems that was covered with water until they knocked down the rice plants, and then ate all floating parts of the plants until the clumps of plants became empty and died. This statement is in accordance with the results of this study, where not adding CNSL dregs to the planting medium will result in the highest population of Golden apple snails and their attacks, and will produce the least number of rice seedlings (Table 3).

An important benefit of this research is that it provides information on natural molluscicide alternatives that strongly support sustainable agriculture, such as organic farming. The use of CNSL dregs as a biopesticide in lowland rice cultivation is in line with organic rice cultivation, which will

better ensure soil conservation. Supriyadi *et al.*'s research (2021) stated that the SQI (soil quality index) value for organic rice fields (2.3) is the highest compared to inorganic rice or semi-organic rice fields. This shows that organic agricultural management can bring changes towards better soil quality, even though it takes a long time.

Organic rice farming in Indonesia, especially in Yogyakarta, turns out to have the highest sustainability index value compared to semi-organic and non-organic cultivation practices. This is seen from an ecological perspective and sociocultural dimensions (Pratama *et al.*, 2024). Of course, findings of alternative natural ingredients as cultivation inputs will be very relevant to support this.

#### 4. CONCLUSIONS

Based on the results of the research that had been carried out, it could be concluded Dregs of cashew nutshell extraction had toxicity to Golden apple snail, with an LC50 of 2.72% (27200 ppm) and Dregs of cashew nutshell at a concentration of 4% was the most effective in controlling the Golden snail; meanwhile, concentrations of 1, 2, or 4% did not affect rice growth until 35 days after planting, but could increase the number of tillers and fresh weight of rice plants.

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