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Application of Turmeric Extract Botanical Insecticide On Feeding Activity And Mortality Of Spodoptera Litura Larvae

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ABSTRACT

This research aimed to evaluate the effectiveness of turmeric extract as a botanical insecticide on the feeding activity and mortality of Spodoptera litura larvae. The method used in this study was a toxicity test using the leaf dip method. The experiment employed a completely randomized design with combinations of turmeric extract concentrations (0, 4, 8, 12, and 16 grams per liter of water) and instar types (1 and 2). The results showed that the application of turmeric extract on cabbage leaves reduced the feeding activity of instar 2 and 3 larvae. Meanwhile, the turmeric extract had an effect on the mortality of instar 2 and 3 larvae only at a concentration of 16%. The symptoms observed in the dead larvae were changes in color and body texture. The conclusion of this research is that 16% is the minimum effective concentration of turmeric extract on instar 2 and 3 S. litura larvae. This study should be continued on other instar types at the field scale.
Keywords: Curcuma, efficacy, ethanol,Spodoptera

ABSTRAK

Penelitian ini bertujuan untuk mengevaluasi efektivitas insektisida nabati ekstrak kunyit terhadap aktivitas makan dan mortalitas ulat grayak. Metode yang digunakan dalam penelitian ini adalah uji toksisitas dengan menggunakan metode leaf dip dan Percobaan ini menggunakan rancangan acak lengkap kombinasi antara konsentrasi insektisida nabati ekstrak kunyit (0, 4, 8, 12 dan 16 gram per liter air) dengan tipe instar (1 dan 2). Hasil penelitian menunjukkan bahwa pemberian insektisida nabati ekstrak kunyit pada daun sawi menurunkan aktivitas makan larva instar 2 dan 3. Sementara pemberian ekstrak kunyit terlihat berpengaruh pada mortalitas larva instar 2 dan 3 hanya pada konsentrasi 16%. Gejala yang terlihat pada larva yang mati akibat ekstrak kunyit yakni perubahan warna dan tekstur tubuh. Kesimpulan dari penelitian ini yakni, 16% adalah konsentrasi minimal ekstrak kunyit yang berpengaruh terhadap larva Spodoptera litura instar 2 dan 3. Penelitian ini sebaiknya dilanjutkan pada instar lainnya pada skala lapangan.
Keyword: Kunyit, efikasi, etanol,Spodoptera

1. Introduction

Spodoptera litura, also known as the tobacco cutworm or the cotton leafworm, is a common pest that is found in Indonesia and other parts of Southeast Asia (Singh & Singh, 2014). This species of moth is known for its voracious appetite and can cause significant damage to a variety of crops, including tobacco, cotton, soybeans, and vegetables. Almost every region in Indonesia reports damage to agricultural crops caused by the population of S. litura. The body shape of S. litura larvae is long and slim, with a small head compared to its body. The color of S. litura larvae varies from greenish-yellow to grayish-brown, with clear lines on the sides of their bodies. The S. litura larvae's body consists of 13 segments, with the last three segments forming a protruding rear part of theSalah satu strategi untuk mengatasi buruknya hasil tanaman dalam budidaya teh adalah dengan menggunakan benih teh yang lebih baik. Bibit unggul dapat dikembangkan melalui perbanyakan secara vegetatif. Bahan tanaman klonal yang berasal dari stek sering digunakan dalam perbanyakan vegetatif (Setyamidjaja, 2010). body. Each segment has a pair of legs, except for the 3rd and 4th segments, which do not have legs. The S. litura larva's head is triangular, with short antennae and three pairs of strong jaw legs. The rear part forms three larger and striking segments. There is a special structure on the rear part called prolegs that functions as legs to help the larvae move and stick to surfaces. The size of the S. litura larvae depends on its developmental stage, where over several weeks to months, larvae will undergo several molts

before reaching the pupal and adult stages. Immature larvae are usually smaller, about 1-3 mm in size, and mature larvae can reach a size of up to 4-14 cm (Taufika et al., 2022).
The percentage of crop loss due to S. litura attack on plants can vary depending on the type of plant attacked, the intensity of the attack, and the plant's growth phase during the attack. Some studies have shown that S. litura attacks can cause a yield reduction of up to 20-30% on some plants, such as tobacco and soybeans (Gaur & Mogalapu, 2018). However, on other plants such as cotton, the percentage of yield loss due to S. litura attack can be higher, reaching 50% or even more (Gaur & Mogalapu, 2018). Significant yield losses can also occur if S. litura attacks during the early growth phase of the plant or during the flowering and fertilization period. In 2013, damage caused by the population of S. litura larvae reached 80% in crops such as mustard greens, tobacco, and cabbage (Gopika et al., 2022). Even in West Java, Central Java, and East Java provinces, the damage reached 100% (Taufika et al., 2020).

The attack of S. litura on cabbage plants can cause serious damage, especially to the leaves. Some symptoms of damage that can occur due to the armyworm attack on cabbage plants include holey and unevenly eaten leaves. Cabbage plants become more fragile and prone to breaking because the armyworm also feeds on the stem. If the armyworm attack occurs when the cabbage plant is entering the flowering and fruit formation phase, fruit production may be disrupted or may not produce fruit at all. In severe attacks, cabbage plants can die due to the leaves and stem being eaten by the armyworm, thus reducing harvest yields. Several control techniques that can be done include pruning infected leaves or leaves that have been eaten by the armyworm. The utilization of natural enemies of the armyworm such as parasitoids and predators. Some types of parasitoids and predators that can be used to control the armyworm on cabbage plants include Cotesia plutellae and Trichogramma chilonis. Applying crop rotation and environmental sanitation around the plants. This aims to reduce the armyworm population that can survive on the remains of previously planted crops. Proper fertilization and good irrigation scheduling can help improve the resistance of cabbage plants to pest attacks, including the armyworm. In controlling the armyworm on cabbage plants, it is important to take preventive measures from the beginning so that the pest population does not multiply rapidly. This can be done by maintaining the cleanliness of the environment around the plants and applying proper agricultural practices. Of various methods, controlling the population of S. litura larvae generally still uses insecticides derived from synthetic chemical compounds.

The use of chemical insecticides among farmers in Indonesia is still considered one of the ways to control the population of plant pests and diseases quickly and effectively. The long-term use of chemical insecticides has many drawbacks, namely causing pest resistance, non-target organism death, the presence of residues that have an impact on human health, persistent in the environment, and negative impacts on the environment, which can cause water, air, and soil pollution (Taufika et al., 2021). One effort that can be done to minimize problems caused by the use of non-chemical pesticides is to find natural alternatives to replace the use of synthetic insecticides (Sari et al., 2019). The use of plant-based insecticides in farming activities is considered an environmentally friendly pest control method, so their use in agriculture is permitted (Souto et al., 2021).
The use of plant-based insecticides sometimes called natural insecticides. Natural insecticides are insecticides whose basic ingredients come from plants (Harahap et al., 2022).

Plants that can be used as plant-based insecticide ingredients are turmeric plants (Curcuma domestica Val.), specifically the rhizome. C. domestica is one of the plants in the Zingiberaceae family that contains phenolic compounds, namely curcumin, which plays a role in rhizome pigmentation (Wathoni et al., 2018). Turmeric rhizome extract (Curcuma longa) has been used as a natural insecticide in various contexts. Research has shown that active compounds in turmeric such as curcumin, turmerone, and α- phellandrene have insecticidal properties and can help control insect pest populations.(Taufika et al., 2021)reported that turmeric extract with a concentration of 1% provided mortality of 20% against S. Litura in the second instar. Therefore, to reduce agricultural crop damage and increase crop production, it is necessary to control the population using plant-based insecticides such as turmeric extract to suppress the population below the economic threshold value.

2. Materials and Methods

This research was conducted from March to August 2022 at the Plant Protection Laboratory of the Faculty of Agriculture, Borneo Tarakan University. The tools used were ventilated plastic containers, tweezers and toothpicks, and glass containers. The tools used for extract testing were disposable petri dishes, rulers, and knives. The main materials used in this research were organic cabbage, turmeric, distilled water, 96% ethanol, tissue, and gauze.

The experiment used a completely randomized design combination between plant insecticide concentration and instar type with the following details: (1) K1I2, distilled water on instar 2 larvae; (2) K2I2, turmeric extract 4 g per liter of distilled water on instar 2 larvae; (3) K3I2, turmeric extract 8 g per liter of distilled water on instar 2 larvae; (4) K4I2, turmeric extract 12 g per liter of distilled water on instar 2 larvae; (5) K5I2, turmeric extract 16 g per liter of distilled water on instar 2 larvae. (6) K1I2, distilled water on instar 3 larvae; (7) K2I2, turmeric extract 4 g per liter of distilled water on instar 3 larvae; (8) K3I2, turmeric extract 8 g per liter of distilled water on instar 3 larvae; (9) K4I2, turmeric extract 12 g per liter of distilled water on instar 3 larvae; (10) K5I2, turmeric extract 16 g per liter of distilled water on instar 3 larvae. Each treatment was repeated twice, resulting in a total of 20 experimental units.

The S. litura larvae were carefully taken with tweezers to avoid damaging their body structure and placed in a cloth-covered plastic container. After the S. litura larvae turned into pupae, they were placed in an imago maintenance cage. The imago was fed with honey using cotton and placed in the maintenance cage. Cabbage was also placed in the cage as a place for egg laying. The eggs were then placed in a plastic container with cabbage as larval food. The phases used in the testing were instar II and instar III larvae. F1 was taken from eggs that were raised until they became instar II and instar III larvae. Before testing, the larvae were fasted (stopped from eating) for 1 hour. The turmeric rhizome criteria used were yellow in color with a thickness of ±4.5 cm and a length of ±3.5 cm. The turmeric rhizomes were washed under running water, drained, cut into pieces, and spread on paper until the water was absorbed. The turmeric was dried for 2 weeks. Then it was powdered using a blender and stored in a glass jar. Extraction was carried out by soaking the simplicia with ethanol for three days. After that, the extract solution was filtered and concentrated using a rotary evaporator to obtain a crude extract. The application method used was the dipping method of cut cabbage leaves with a size of 25 cm2 according to the treatment for 60 minutes and dried at room temperature for 10-20 minutes. The leaves were placed in disposable petri dishes. One larva was placed in each dish, and there were five test larvae in each repetition. Observations were made every 6 hours.

The observation parameters in this study were the percentage of larval feeding activity, the percentage of larval mortality, and the mechanism of death. The percentage of larval feeding activity was calculated using the formula:

$$A = (Bk - Bp) / Bk \times 100\% \qquad \ldots(1)$$

Explanation:
A : Percentage of feeding activity (%) Bk : Initial leaf weight
Bp : Leaf weight after testing

Percentage of larval mortality was calculated using the formula:

$$M = a / b \times 100\% \qquad \ldots(2)$$

Explanation:
M : P ercentage of mortality (%)
a : Number of dead larvae
b : Number of tested larvae

The mechanism of death is determined by observing the behavior of the test insects after the experiment. Mortality and feeding activity data are analyzed using variance analysis. When a difference was identified, Tukey test with a 95% confidence interval would be performed.

3. Results And Discussion

Eating activity is the process of taking, chewing, and swallowing food into the body to fulfill nutritional and energy needs. Eating activity involves several stages, such as searching and selecting food to be eaten, cutting and crushing food with teeth to facilitate digestion and nutrient absorption, pushing the chewed food into the throat and then into the stomach, breaking down food into nutrients that can be absorbed by the body, and finally, absorbing nutrients from digested food into the bloodstream to be distributed throughout the body (Nagata & Zhou, 2019).

S. litura is a leaf-feeding insect that usually feeds on plant leaves. Factors that affect the feeding activity of

Spodoptera larvae include food type, population density, temperature and humidity, larval age, larval health, and other environmental factors. Spodoptera larvae tend to prefer young and fresh leaves, so feeding activity will be higher when there is enough fresh and abundant leaves available. The density of Spodoptera larval population can affect their feeding activity. In high population densities, competition for food will be higher, and feeding activity will increase. Environmental factors such as temperature and humidity also affect the feeding activity of Spodoptera larvae. Feeding activity will be higher under optimal temperature and humidity conditions. The feeding activity of Spodoptera larvae tends to be higher in older larval stages, during molting and entering a new stage. Larval health conditions can also affect their feeding activity. Healthy larvae tend to be more active in searching and feeding on food. Other environmental factors such as the presence of predators, diseases, and chemicals used in agriculture can also affect the feeding activity of Spodoptera larvae. The presence of predators or exposure to certain chemicals can reduce their feeding activity. Meanwhile, diseases or unfavorable environmental conditions can decrease their feeding activity (Shen et al., 2022) (Ghosh et al., 2022) (Tang et al., 2016).

In Figure 1, it can be seen that treatments K3I2, K4I2, K5i3, and K5I3 did not significantly differ from other treatments except for K1I3. While K1I1, K1I2, K2I3, K3I3, K4I3 did not significantly differ from K1I3. As previously explained, feeding activity is influenced by many factors. In this study, several factors have been standardized, so the influential factors are the food conditions and larval age.

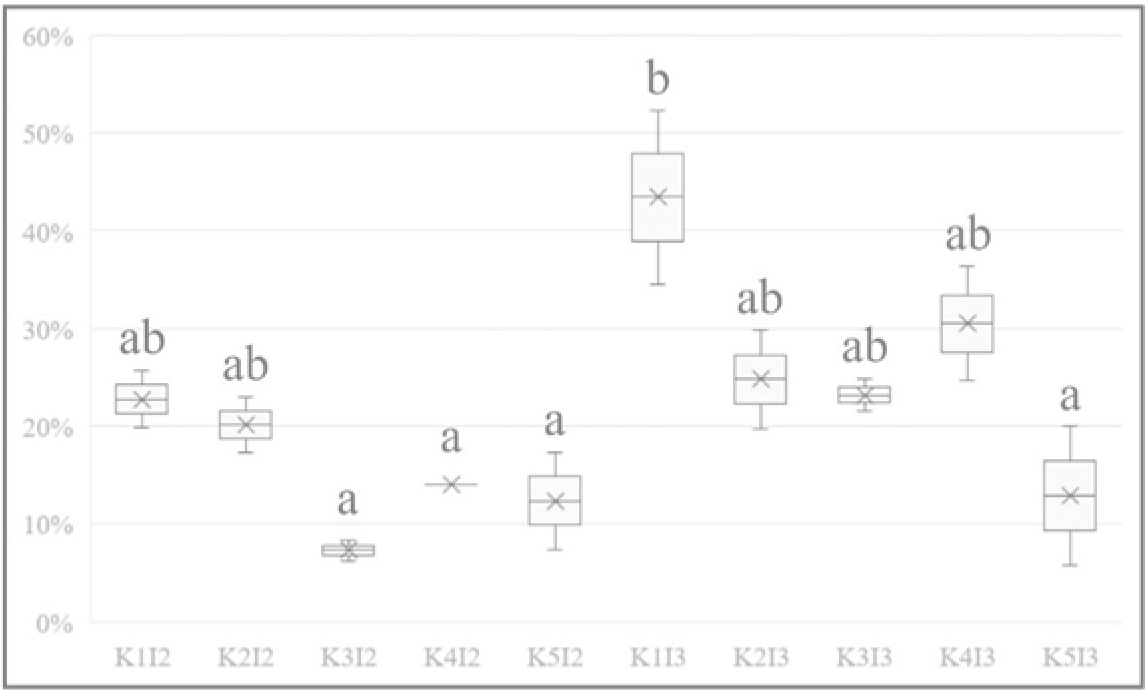

Figure 1. Percentage of larva feeding activity

Figure 1 shows that the highest feeding activity of instar 2 larvae (K1I2) is 23%. Meanwhile, the highest feeding activity of instar 3 larvae (K1I3) reaches 43.5%. Instar 3 larvae have higher feeding ability than instar 2 larvae. Instar 2 and instar 3 larvae are different growth stages in the life cycle of the armyworm or S. litura. There are several factors that affect feeding activity at each growth stage, so that instar 3 larvae have higher feeding activity than instar 2 larvae. Instar 3 larvae have a larger body size than instar 2 larvae. A larger body size can allow instar 3 larvae to eat more and faster than instar 2 larvae. The digestive organs of instar 3 larvae have developed better and are more efficient in digesting food compared to the digestive organs of instar 2 larvae (Zulkifli et al., 2018). This can make instar 3 larvae more active and effective in digesting and processing food. Instar 3 larvae require more nutrition to support the growth and development of body organs, so their feeding activity is higher to meet those nutritional needs. (Truman, 2019) adds that hormonal factors also play a crucial role in regulating feeding activity in larvae. Molting hormones in instar 3 larvae are different from those in instar 2 larvae, which can affect their feeding activity.

Larval mortality refers to the rate of death or loss of insect population at the larval stage before the insect reaches the next stage in its life cycle. Larval mortality can be caused by various factors, both biotic (related to other organisms) and abiotic (related to environmental conditions). Predators or parasites that prey on or infect larvae can cause high mortality (Truman, 2019) (Kanyile et al., 2022). Some predators whose bioecology is known can even be mass-produced through breeding (Susanti & Bakti, 2017). In addition, high population density and competition for resources can cause higher mortality in weaker or less competitive larvae. Infection by bacteria, viruses, or fungi can also cause high mortality in larvae.

Abiotic factors that can affect larval mortality include temperature and humidity (Ment et al., 2017). Extreme or unsuitable temperature and humidity for the larvae's living needs can cause high mortality. Lack of food sources or poor food quality can also cause high mortality in larvae (Krams et al., 2015). Exposure to chemicals such as insecticides or herbicides used in agriculture can cause high mortality in larvae (Hanlon & Parris, 2014). Furthermore, the level of larval mortality can vary depending on the insect species, environmental conditions, and interactions between biotic and abiotic factors that affect the health and survival of larvae.

Figure 2 shows that the highest mortality occurs in treatments K5I2 and K5I3. Both of these treatments are not significantly different from treatment K3I2. Meanwhile, treatment K3I2 is not significantly different from all other treatments.

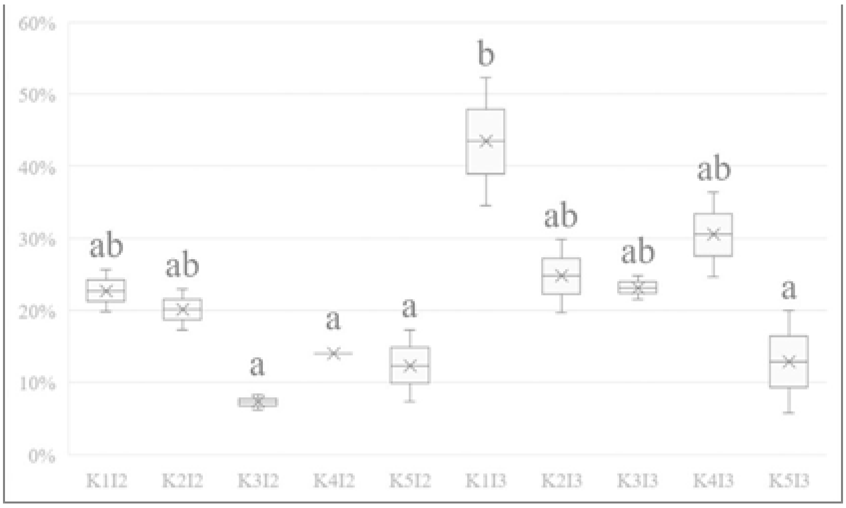

Figure 2. Percentage of S. litura larvae mortality

The environmental conditions, presence of predators and parasitoids, entomopathogens, resource availability, and species have been conditioned to be homogeneous in the design. Thus, the factors affecting the percentage of mortality are age and their interactions with humans. It can be seen from Figure 2 that no dead S. litura larvae were found in the control treatments (K1I2 and K1I3). In addition, the application of turmeric extract-based botanical insecticide at concentrations of 4 g, 8 g, and 12 g per liter (K2I2, K3I2, K4I2, K2I3, K3I3, K4I3) did not significantly affect the mortality percentage of S. litura larvae. Although in the K3I2 treatment, 20% dead larvae were found, this number was not significantly different from the treatment that had a value of 0 in the mortality percentage parameter. This was due to the fact that the concentration of botanical insecticide was not strong enough to reach the biological target inside the insect's body. (Bajwa & Sandhu, 2014) said that low levels of pesticide residues had no significant effect to the target. The biological target is the parts of the insect's body that are targeted by the insecticide, such as the nervous system or certain enzymes. If the concentration of the insecticide does not reach the necessary biological target, the insect may still be able to survive and reproduce.

The resistance of young and old insects to insecticides was different. Several factors can affect an insect's resistance to insecticides, such as the type of insecticide used. Some insects may have resistance to certain types of insecticides, while other types of insecticides may be more effective against certain insects. The frequency of exposure to insecticides can also affect their resistance. Exposure that is too frequent or too high can reduce the effectiveness of insecticides and increase the likelihood of resistance to insecticides. Environmental conditions such as temperature, humidity, and sunlight can also affect an insect's resistance to insecticides. Insects living in less supportive environments may be more vulnerable to insecticides. The health of the insect also affects their resistance to insecticides. Healthier and stronger insects may be more capable of resisting the effects of insecticides than weaker or sick insects. Since these factors are in a homogeneous condition, the factors that affect the percentage of mortality are age and their interactions with humans.

Young insects are generally more susceptible to insecticides than adult insects. This is related to the fact that young insects have thinner skin and are not fully developed, making them less able to protect themselves from chemicals. This can be seen in instar 2 insects where two treatments have a mortality percentage > 0%. While for S. litura larvae in instar 3 (I3), only in the K5I3 treatment were dead larvae found. This is supported by the opinion of (Sánchez-Bayo, 2021) who states that Coleoptera larvae are more susceptible than adults for similar reasons.

The next factor is the interaction with humans. Human activities such as the use of insecticides, habitat destruction, and hunting of insects for commercial or hobby purposes can significantly affect insect mortality. What is closely related to this research is the use of insecticides. It can be seen in Figure 2 that the application of turmeric extract-based botanical insecticide at a concentration of 16 grams per liter significantly affected the mortality percentage of S. litura instar 2 and 3 larvae (K5I2 and K5I3). The other treatments were not significantly different from the control because the concentration of botanical insecticide used was not yet able to kill the insects. This is in line with the opinion of (Taufika et al., 2021) who state that LC50 value of the experimental extracts on the second and the third instar larvae were 5.252 ppm and 10.559.

Active compounds found in turmeric rhizome extract affect the feeding activity and mortality of S. litura larvae. Application of turmeric extract plant pesticide on cabbage leaves can cause direct and indirect mortality to the target. After giving cabbage turmeric extract, S. litura larvae respond by trying to climb the sides of the container used. This is done to obtain clean air and be free from compounds contained in the extract given. When there are foreign substances around their living environment, the caterpillars will detect these substances and try to protect themselves from being contaminated by toxic substances. This response occurs because turmeric extract has a repellent activity that can prevent insects from approaching plants or specific areas. This is in line with the opinion that states that turmeric extract has insecticidal activity against several types of insects (Roy et al., 2014a). Turmeric extract is also known to have plant-based insecticidal activity against several types of insects. The main component responsible for the insecticidal activity in turmeric extract is curcuminoid, which is a compound that gives the distinctive yellow color to turmeric (Roy et al., 2014b). Several studies have shown that turmeric extract can kill insects (Kumar et al., 2022). Curcuminoid in turmeric extract is known to have a toxic effect on the target insects by damaging their cell membranes (contact poison), disrupting their nervous system (nerve poison), and inhibiting enzymes that are important for their metabolism.

Curcuminoid in turmeric extract can cause damage to the cell membranes of target insects. Cell membranes are thin layers that protect cells and regulate the entry and exit of substances from the cell. Damage to the cell membrane can cause leakage and death of the cell. Several studies have shown that curcuminoid can affect the cell membranes of target insects by damaging the lipid membrane structure (Yun & Lee, 2016), disrupting the function of membrane proteins, and increasing membrane oxidation. This can cause leakage of ions and proteins from cells and eventually lead to insect death. This is in line with the opinion that states that curcuminoid in turmeric extract can act as a nerve poison on target insects (Amalraj et al., 2017). Nerve poisons usually work by affecting the insect's nervous system, which can cause convulsions, numbness, or death. Several studies have shown that curcuminoid can affect the insect's nervous system by inhibiting nerve impulse transmission or damaging nerve cells (Venkatesh et al., 2019). This can disrupt the function of the insect's nervous system and eventually cause death.

In addition, curcuminoid can also inhibit enzymes that are important for insect metabolism. These enzymes are responsible for breaking down and converting substances necessary for insect life. Enzymes that function to break down and convert substances necessary for insect life are called metabolic enzymes. Metabolic enzymes are involved in various important processes in the insect's body, such as food digestion, hormone regulation, waste disposal, and energy production. If these enzymes do not function properly, the insect cannot produce the energy needed to survive . This is in line with the opinion that curcuminoid in turmeric extract can inhibit enzymes important for insect metabolism (Hanlon & Parris, 2014). In Figure 3, the color of the test insect is slightly yellowish, and the texture is still normal (A). However, at 12 hours after testing, the body parts of the test larvae changed color to orange-yellow, and the body structure of the larvae slightly wrinkled. At 18 hours after testing, the color of the test insect began to turn black.

(A) (B) (C)

Description:
(A) 6 hours after testing
(B) 12 hours after testing
(C) 18 hours after testing

Figure 3. Symptoms of S. litura larvae death due to turmeric extract insecticide.

Symptoms in S. litura larvae that die due to turmeric extract insecticide can vary depending on the concentration and duration of exposure to the insecticide. Some symptoms that may occur in the larvae are slow movement, convulsions, color changes, cessation of feeding, and death (Rezende- Teixeira et al., 2022). Larvae exposed to turmeric extract insecticide may experience slow movement or even complete immobility. Larvae exposed to turmeric extract insecticide may experience convulsions, which can damage the nervous system and eventually cause death. Larvae exposed to turmeric extract insecticide may undergo color changes, becoming paler or even grayish. Larvae exposed to turmeric extract insecticide may stop feeding or experience a decrease in appetite due to damage to their digestive system. If the concentration of turmeric extract insecticide is high enough or exposure occurs for a long time, S. litura larvae can die.

4. Conclusion

The application of turmeric extract plant insecticide at concentrations of 4%, 8%, 12%, and 16% can reduce the percentage of feeding activity, although the values are not significantly different from the control. Meanwhile, for the percentage of mortality parameter, only the administration of turmeric extract plant insecticide at 16% had a significant effect on the percentage of mortality in second and third instar larvae of S. litura. The visible symptoms of death in larvae due to turmeric extract were changes in color and body structure. To complete this research series, further research can use larvae of instars 1, 4, 5, and 6. Then the research can be continued on a greenhouse scale.

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