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The Effect of a Combination of Turmeric Rhizome Extract (*Curcuma longa L.*) and Temulawak Rhizome Extract (*Curcuma xanthorrhiza R.*) on the Mortality of Grayak Caterpillar Pests (*Spodoptera litura F.*)

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Abstract

Determine effect of a combination of turmeric rhizome extract (Curcuma longa L.) also temulawak (Curcuma xanthorrhiza R.) on the mortality of Spodoptera litura F.. The experiment used a CRD with five treatment concentrations (0%, 35%, 40%, 45%, and 50%), each replicated five times. Mortality data were analyzed using one-way ANOVA followed by LSD test. Combination of turmeric and temulawak extracts significantly affected armyworm mortality, with the highest mortality rate of 80% observed at a 50% concentration. These findings suggest that plant-based pesticides derived from turmeric and temulawak have potential as an eco-friendly pest control alternative.

Keywords: *Curcuma longa L., Curcuma xanthorrhiza R., Spodoptera litura F., botanical pesticide, mortality.*

Introduction

Indonesia has high biodiversity, which plays an important role in life and encompasses various forms of life that are interdependent. Indonesia's tropical climate allows for the flourishing of diverse flora and fauna. One example is insects, which play a very important role in the ecosystem as pollinators, decomposers, predators, and parasitoids. There are also insect pests that are a major factor in the destruction of crop cultivation. Pests can cause damage by attacking plants even from the seedling stage. The damage caused by insects reduces production and even leads to plant death (Rahayu et al., 2021: 40).

Pest insects are a major factor in the damage to cultivated plants, leading to a decline in crop production. The damage caused by these pest insects can occur in terms of both quality and quantity. There are many types of plant pests, one of which is the armyworm. These caterpillars can cause damage to plants by eating the leaves of young plants, leaving only the leaf veins. The damage caused by armyworm caterpillars can reach 80% if not properly controlled (Saputri et al., 2020: 210).

Caterpillar infestations often cause crop failure and economic losses for farmers. To combat this, many farmers rely on synthetic pesticides because they are considered effective and easily available. However, these compounds are difficult to break down, leaving residues that accumulate in the soil, contaminate the agroecosystem, and trigger selection pressure that promotes pest resistance. In the field, many farmers still do not understand the long-term impacts of pesticide use on health, soil and water quality, and control effectiveness, making repeated application practices risky and unsustainable (Bilker Roensis Sinambela, 2024).

Previously, it was reported that armyworms attacked corn crops in several provinces in Indonesia, namely West and South Sumatra, Lampung, Banten, West Java, and East Nusa Tenggara. In 2019, the East Kalimantan Provincial Food, Food Crops, and Horticulture Service reported that in East Kalimantan Province, specifically in Berau Regency, which is one of the largest corn-producing areas in

Indonesia, armyworms attacked corn crops covering an area of 1,352 ha out of a total land area of 10,133 ha spread across 13 subdistricts. (Widhayasa, 2020: 94) Because armyworms are polyphagous pests capable of attacking various types of plants or vegetables, appropriate control methods are needed to reduce the level of attack (Serdani, 2022: 2).

Farmers generally still rely on synthetic (non-plant-based) pesticides to control plant pests because they are readily available and highly effective, despite their negative impact on the environment (Harianie et al., 2020: 176). The types of synthetic pesticides that are often used include organophosphates, carbamates, and pyrethroids. Some synthetic pesticide products, such as fipronil, have been shown to reduce damage caused by armyworm attacks by up to 81% with a pest mortality rate of 100% (at a concentration of 2.5–5%), which is comparable to the use of diafentiuron at a concentration of 1.25–5% (Uge, 2020: 65).

Synthetic (non-plant-based) pesticides, if used continuously at high intensities, can cause negative impacts, such as pest resistance, secondary pest outbreaks, and the killing of unintended organisms. In addition, they can leave insecticide residues on plant products. Therefore, an alternative to chemical insecticides is needed in the form of natural insecticides that are more selective against insects and environmentally friendly, making them suitable for use as part of Integrated Pest Management (IPM). Plant-based insecticides are insecticides that contain secondary metabolites from various plants that have biological and physiological activity and affect the behavior of insect pests (Nuraida et al., 2021: 27). In addition, it is reported that every year around 25 million agricultural workers worldwide die from pesticide poisoning (Irfan, 2016: 39-40).

Most plants in Indonesia contain active ingredients that can be used as natural insecticides. For example, temulawak (Curcuma xanthorhiza R.) contains essential oils, curcuminoids, germacrene, xanthorhizol, alpha-beta-curcumena, flavonoids, and saponins, which act as natural insecticides against insects. The compounds in temulawak (Curcuma xanthorhiza R.) can cause respiratory and digestive disorders, leading to death. In addition, essential oils can also cause direct toxicity to insects (Berri et al., 2020: 55). Apart from temulawak (Curcuma xanthorrhiza R.), there is also turmeric (Curcuma longa L.) which can function as a plant-based pesticide. Turmeric (Curcuma longa L) is a plant from the Zingiberacea family with the main compounds of essential oil and curcuminoids which have biological activities as antibacterial, antioxidants and hepatotoxic. The content found in turmeric (Curcuma longa L.) is what makes it a natural insecticide (Yanti, et al., 2023: 360).

Turmeric has various natural compounds that have the potential to be used as insecticides, including cineole, curcumin, quercetin, and eugenol. Various studies have proven that these compounds have an insecticidal effect on several types of mosquitoes. The administration of turmeric extract to salted fish showed the highest protection at a dose of 3% (65.4%) and the lowest at a dose of 6% (44.1%). Turmeric rhizome extract is also able to prevent attacks by lice and cabbage worms. The flavonoid content in turmeric rhizomes acts as a respiratory poison for insects, while tannins as bioactive compounds play a role in killing larvae. In addition, turmeric has a distinctive pungent taste and aroma that repels or is disliked by insects (Aditama et al., 2023: 161).

Based on the description, the researcher wanted to study the effect of turmeric rhizome extract and temulawak rhizome extract on the mortality of armyworm insects by combining the two extracts into a botanical pesticide and obtaining the effective concentration of the combination of the two extracts.

Method

2.1 Time and Place of Research

This research was conducted at the Biology Education Laboratory of the Faculty of Teacher Training and Education, Mulawarman University, from November 12, 2024, to November 23, 2024.

2.2 Research Tools and Materials

The tools used in this study consisted of digital scales, a blender, beakers, plastic jars, sieves, measuring pipettes, funnels, label paper, spray bottles, stirrers, and cameras. The materials used were armyworms (Spodoptera litura F.), turmeric rhizomes (Curcuma longa L.), temulawak rhizomes (Curcuma xanthorrhiza R.), and distilled water.

2.3 Work Procedure

2.3.1 Extract Preparation

A total of 500 grams of turmeric rhizome (Curcuma longa L.) and 500 grams of temulawak rhizome (Curcuma xanthorrhiza R.) were prepared by peeling off the outer skin. After peeling, the rhizomes were washed with clean running water to ensure that no dirt remained. Next, the clean rhizomes were blended until they became a smooth paste. The paste was then filtered using a strainer to separate the liquid from the pulp. This process produced a pure extract from each rhizome with a concentration of 100%. After that, the turmeric and temulawak extracts were combined into a single mixture. This extract mixture is then used to make solutions with various concentrations according to research needs. The calculation of the amount of extract and solvent required for each concentration is done using a dilution formula.

$$V1\ M1 = V2\ M2 \qquad (1)$$

Description:
V1: Volume of solution to be diluted (ml)
M1: Concentration of available extract juice (%)
V2: Desired volume of solution (ml)
M2: Concentration of extract juice to be made (%)

2.3.2 Spraying of Extracts

Armyworms (Spodoptera litura F.) contained in jars were placed in plastic containers, three worms per container, and labeled according to the test concentration, namely 0% (control), 35%, 40%, 45%, and 50%. The extract was then sprayed on the armyworms (Spodoptera litura F.) according to the concentrations provided. Spraying was carried out in the morning at 9:00 a.m. WITA and in the afternoon at 4:00 p.m. WITA for each treatment for 2 days or 48 hours.

2.4 Data Collection Techniques

The data collection method in this study was conducted by observing the number of armyworms (Spodoptera litura F.) that died or showed mortality within 48 hours after treatment. Data were obtained after spraying a mixture of turmeric rhizome (Curcuma longa L.) and temulawak rhizome (Curcuma xanthorrhiza R.) extracts on each of the predetermined treatment groups. Spraying was carried out twice a day, in the morning and afternoon, for a period of 48 hours. After 48 hours, the armyworms were observed to identify the number of dead individuals. The data obtained was then analyzed by calculating the mortality rate of the caterpillars using a predetermined formula to calculate the mortality rate due to the extract treatment.

Mortality Formula:

$$P = \frac{a}{b} \times 100\% \qquad (2)$$

Description:
P = Percentage of mortality of test animals
a = Total number of test animals that died in each treatment
b= Total number of test animals in each treatment

2.5 Data Analysis Techniques

The analysis approach applies RAL as an experimental design. The main observation parameter is the number of deaths or mortality of armyworms in each treatment. The collected data is analyzed using a one-way statistical test, namely one-way Analysis of Variance (ANOVA), which is carried out using SPSS statistical software. This one-way ANOVA test was used to test for significant differences between treatments, assuming that the data analyzed must meet the requirements of normal distribution and homogeneity of variance. If the ANOVA showed significant differences, the BNT test was continued to determine whether the treatment had a real effect on mortality.

Result and Discussion

Based on testing the effect of a combination of turmeric rhizome and temulawak rhizome extracts on the mortality of armyworm pests, which was conducted from Tuesday, November 12, 2024 to Saturday, November 23, 2024 at the Biology Education Laboratory, Faculty of Teacher Training and Education, Mulawarman University, showed an increase in the number of deaths (mortality) in armyworm pests. These results indicate that the combined treatment of extracts from both types of rhizomes is effective in causing death in armyworm pests, as seen from the increasing mortality rate along with the increase in the concentration of extracts given during the trial process.

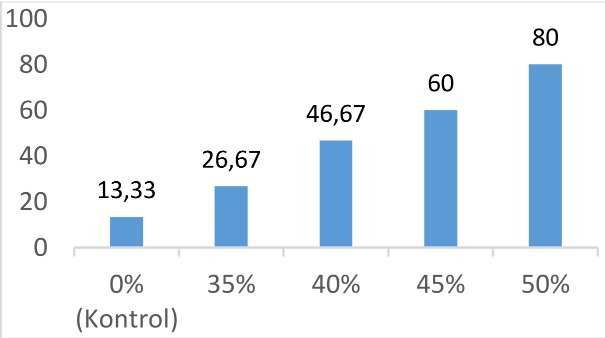

Figure 1. Mortality Graph of Grayak Caterpillars After 48 Hours

Based on Figure 1, it is known that at a concentration of 0% (control) in replicates 1 and 5, there was 1 larval death with a mortality rate of 6.67%. Meanwhile, in replicates 2, 3, and 4, no larval deaths were found. The average mortality rate at a concentration of 0% (control) was 13.333%. Larval mortality in the 0% (control) treatment was caused by other factors, such as the inability of the caterpillars to adapt. This is in line with Nuraida's (2021: 32) statement that mortality can occur in the control treatment due to adaptation failure or contamination from other treatments. Contamination can occur when the spray solution reaches the control area due to the absence of barriers between treatments, so that larvae in the control are also exposed to botanical insecticides. Larval mortality in the control can also be triggered by natural factors, such as failure to adapt to the environment, with a mortality rate of 1.50%. Then, at a concentration of 35%, repetition 1 and repetition 3 showed 1 larval death with a mortality rate of 6.67%. Furthermore, in repetition 2, there were 2 larval deaths with a mortality rate of 13.33%.

Meanwhile, in repetitions 4 and 5, no larval deaths were found. The average mortality rate at a concentration of 35% was 26.65%. Then, at a concentration of 40%, in repetitions 1, 2, and 4, there was 1 larval death with a mortality rate of 6.67%. Meanwhile, in repetitions 3 and 5, there were 2 deaths with a mortality rate of 13.33%. The average mortality rate at a concentration of 40% was 46.67%. Then, at 45% in repetitions 1 and 4, there were 2 deaths with a mortality rate of 13.33%. In repetitions 2 and 3, there was 1 death with a mortality rate of 6.67%.

And in repetition 5, there were 3 deaths with a mortality rate of 20%. The average mortality rate for concentration (percentage) 45 was assessed at 60%. Meanwhile, for concentration 50 in repetitions 1 and 5, there were 3 deaths with a mortality rate of 20%. Meanwhile, in repetitions 2, 3, and 4, there were 2 deaths with a percentage of 13.33%. The average mortality rate at a concentration of 50 was 80%.

Based on the data obtained, it is known that the highest mortality rate occurred in the treatment with a concentration of 50%, which resulted in an average mortality rate of 80%. Graph 1 shows the trend of increasing mortality rates of armyworms along with increasing concentrations of the mixture of extracts from temulawak rhizome and turmeric rhizome. This finding reinforces the conclusion that the higher the concentration of plant extracts used, the greater the effect on the mortality of armyworm pests.

These results are in line with the opinion of Nuraida (2021: 29), who states that an increase in extract concentration will strengthen the biological effects produced, because the effectiveness of a compound is highly dependent on its concentration or level. In addition, plant-based insecticides are known to have the ability to cause insect death in a relatively short time, because they have a toxic mechanism that is both contact and systemic. When these compounds are applied and come into contact with the body of the target insect, they cause physiological disturbances that lead to death.

Interestingly, in the treatment with a concentration of 35%, four caterpillar deaths were found that were not entirely caused by the effects of the extract, but rather by cannibalism among the caterpillars. This can be recognized from the discovery of caterpillar carcasses with missing body parts and the observation of other caterpillars eating their own kind. According to Sari (2018: 50), cannibalism is a natural trait of insects, whereby weak or dying individuals tend to be eaten by other individuals of the same species as a form of adaptation for survival. This phenomenon is also a density-dependent factor, which is a natural population control mechanism in species such as armyworms.

Figure 2. Cannibalistic Behavior of Grayak Caterpillars

Meanwhile, at concentrations of 40%, 45%, and 50%, high mortality rates were observed in caterpillars due to feed sprayed with botanical pesticides. as indicated by decreased feeding activity, slowed movement or immobility, and death of the armyworms (Spodoptera litura F.). Their bodies also changed color to yellowish brown to black and appeared shrunken. This occurs because of the compounds contained in the mixture of turmeric rhizome and temulawak rhizome extracts sprayed on the feed. According to Iqbal (25, 2023), "bioactive compounds from rhizome extracts that enter the caterpillar's body will cause mortality in armyworms (Spodoptera litura F.) with characteristics such as changes in the color of the outer abdomen, the body shrinking further, and the release of fluid." In addition, other compounds such as tannins, essential oils, and flavonoids found in turmeric rhizomes (Curcuma longa iL.) and temulawak rhizomes (Curcuma zanthorrhiza R.) are also known to act as toxins for insect respiration and digestion.

Compounds that can cause caterpillar death include tannins, which function as astringents capable of shrinking tissue and degrading protein structures in the skin and mucosa. This compound is thought to trigger changes in the caterpillar's skin tissue, as seen in the characteristics of dead larvae, such as a soft body, blackened color, and a shrinking and shriveling body size. The tannin, essential oil, and flavonoid content can act as stomach poisons that disrupt the caterpillar's digestive system, causing the caterpillar to weaken, its body to soften, and eventually die from lack of energy. Tannins can reduce the ability of digestive enzymes to digest food, while essential oils can inhibit the larva's appetite by attacking the nervous system, thereby reducing feeding activity and stunting growth. In addition, the death of larvae at various concentrations is also triggered by the saponin content in temulawak and turmeric rhizomes, which have hemolytic and toxic properties.

Figure 3. Grayak Caterpillars Experiencing Mortality

The results of the study indicate that the combination of temulawak rhizome extract and turmeric rhizome extract has a significant effect on the mortality of armyworms. This is in line with insecticide efficacy testing standards, whereby according to Agustin et al. (2025: 81), botanical pesticides are effective if the mortality rate of pests is more than 50%.

3.1 Normality Test

Table 1. Testing the Normality of Grayak Caterpillar Mortality

Concentration	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistics	df	Significance	Statistics	df	Significance.
0% (Control)	.367	5	.026	.684	5	.006
35%	.231	5	.200*	.881	5	.314
40%	.367	5	.026	.684	5	.006
45%	.230	5	.200*	.881	5	.314
50%	.367	5	.026	.684	5	.006

Source: Processed Data (2024)

Normality testing on the mortality table for armyworm pests has been conducted, revealing that at a concentration of 0% (control), the significance level is 0.006. At a concentration of 35%, the significance level is 0.314. At a concentration of 40%, the significance level is 0.006. At a concentration of 45%, the significance level was 0.314. At a concentration of 50%, the significance level was 0.006. According to Nuryadi (2017: 87), a significance level > 0.05 is said to be normally distributed. Based on the test, it is known that the overall concentration significance (sig.) > 0.05. Therefore, it is declared to be normally distributed and tested for homogeneity.

3.2 Homogeneity Test

Table 2. Homogeneity Test of Grayak Caterpillar Mortality

Levene's Statistic	df1	df2	signifikan
.465	4	20	.760

Source: Processed Data (2024)

The results of the homogeneity test on the mortality data of armyworm pests have been conducted, and it is known that the data value shows a significance value (sig.) of 0.760 > 0.05. This means that the variance is similar and the data is homogeneous, in accordance with Nuryadi (2017: 93), where a Levene statistic > 0.05 means that the data variation is homogeneous and can proceed to ANOVA testing.

3.3 ANOVA Test

Table 3. ANOVA Test for Grayak Caterpillar Mortality

		ANOVA			
Group	Sum	df	Mean	F	Significance
Among	557.975	4	139.494	6.825	.001
In	408.765	20	20.438		
Total	966.740	24			

Source: Processed Data (2024)

The ANOVA results show that the mortality data for armyworm pests obtained (Sig.) 0.001 is less than 0.05. According to Eric Wijaya (2024: 127) Fcount > Ftable, then hypothesis H0 is rejected, meaning that there are at least two differences in the mean between factor categories. From this data, it can be said that there is a significant impact on the treatment. The administration of turmeric rhizome extract and temulawak rhizome extract has been proven to have a significant and distinct effect on the mortality rate of armyworms. This can be seen through the results of the one-way ANOVA statistical test, which indicates that there are differences between treatments that are not caused by chance alone. Therefore, to find out more about which treatments have the most significant effect and how the effects between the tested concentrations compare, a further test was conducted.

The follow-up test applied BNT, aiming to identify significant differences between each treatment individually, so that it could be determined which combination or concentration of extract was most effective in increasing the mortality of armyworms. Thus, the BNT test provided a more detailed picture of the effectiveness of the treatments applied in the experiment.

3.4 Uji BNT

Table 4. BNT Mortality Test for Grayak Caterpillars

No.	Extract Concentration (%)	Mortality (Mean ± SD)	Letter Notation
1.	0% (Control)	2,67 ± 3,65	a
2.	35%	5,33 ± 5,58	ab
3.	40%	9,33 ± 3,65	bc
4.	45%	12,00 ± 5,58	c
5.	50%	15,99 ± 3,65	c

Source: Processed Data (2024)

BNT with a significant 5% above shows that treatment at a concentration of 0% (control) differs significantly from treatment (percentage): 40, 45, and 50. Treatment at a concentration of 35 is not significant with a concentration of 0% (control) and 40%, and is not significant with 45 and 50. The 45% concentration is not significantly different from the 50% concentration, where the 45% and 50% concentrations have a stronger effect on increasing the mortality of armyworms. The combination of turmeric rhizome and temulawak rhizome extracts affects the mortality of armyworms.

Conclusion

The conclusion is that a mixture of turmeric rhizome (Curcuma longa L.) and temulawak rhizome (Curcuma xanthorrhiza R.) extracts has an effect on the mortality of armyworms (Spodoptera litura F.). An increase in the concentration of the extract mixture increases the mortality of armyworms (Spodoptera litura F.). The most effective concentration of the extract mixture in causing mortality in armyworms is at a concentration of 50%.

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