APLIKASI INSEKTISIDA NABATI TERHADAP MORTALITAS ULAT GRAYAK (*Spodoptera litura*) PADA TANAMAN SAWI (*Brassica juncea* L.)

SKRIPSI

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ABSTRACT

Rio Saputra Silaban. 148210124. Application of Vegetable Insecticide on Mortality of Grayak Caterpillars (*Spodoptera litura*) on Mustard Plants (*Brassica juncea* L.). Thesis, under the guidance of Ir. Azwana MP., as Chairman of the Advisor and Ir. Asmah Indrawati. MP, as a Supervising.

This research has done at Sampali Village, Percut Sei Tuan District, North Sumatra, from January to February 2019. The method in this research by using Random Block Design method (RBD), with an extract of plant insecticide, consisting of 8 levels treatment, namely: I_0 = without treatment (control), I_1 = tuba root extract concentration of 5% (50 ml/L water), I_2 = tuba root extract concentration of 10% (50 ml/L water), I_3 = noni fruit extract 5% 50 ml/L water), I_4 = noni fruit extract concentration of 10% (50 ml/L water), I_5 = celery leaf extract 5% (50 ml/L water), I_6 = celery leaf extract 10% (50 ml/L water); and I_7 = insecticide Colombus 600 EC (0.5 ml/L water), with 3 replications. The parameters observed are mortality of armyworm, intensity of crop damage due to armyworm, effectiveness of vegetable insecticide, plant height and crop production per plot.

The results who get from this research by insecticides application of plant-based had a very significant effect on the percentage of mortality of armyworm, the intensity of crop damage, the speed of death of armyworm, plant height and production per plot of mustard plants. Application of tuba roots with a concentration of 50 ml/l water (I_1) very effective in controlling the attack of armyworm on mustard plants, because with this application the armyworm most quickly dies, ie at the age of 21 day after planting day with 100% mortality percentage, the intensity of damage is only 14.58% so that it, can produce the highest mustard production, the amount of total production is 173.33 kg/plot (1,73 ton/ha).

Keywords: vegetable insecticide, mortality, concentration and mustard greens

CHAPTER I

INTRODUCTION

1.1. Background of Study

Based on the part consumed, Indian mustard (*Brassica juncea* L.) can be categorized into leaf vegetables. Indian mustard has a high economic value behind cabbage and broccoli. Additionally, this plant contains minerals, vitamins, protein, and calories. Therefore, it becomes a popular vegetable commodity in Indonesia (Zulkarnain, 2009).

According to the statistic, the production of Indian mustard in North Sumatra in 2014 was 63,032 tons, which decreased by 9.72% from 2013 of 69,032 tons covering a harvested area of 5,932 ha. North Sumatra is the second largest mustard-producing province in Indonesia after West Java Province (Statistics Indonesia, 2017).

The increase in mustard production can be facilitated by fertilization. Fertilization through the soil can be carried out with artificial fertilizers and natural fertilizers. The decrease in fertilizer subsidies and the alternative compound fertilizers circulating perplex farmers due to a lack of farmer knowledge regarding the amount and type of nutrients required by plants (Barus, 2011).

In the application in agriculture, it appears that not all pesticides are dispensed at the target. Approximately, only 20% of the pesticides seize the target while the other 80% fall to the ground. The accumulation of pesticide residues results in the contamination of agricultural land. When it penetrates the food

chain, the toxic nature of pesticides can lead to various diseases such as cancer, mutations, and others (Sa'id, 2010).

Pesticides block the nitrogen-fixing process necessary for plant growth. Organochlorine pesticides such as DDT, organophosphate groups such as metal parathion, and pentachlorophenol are known to interfere with the symbiosis between legumes and rhizobium bacteria. The reduced symbiotic relationship between the two causes nitrogen fixation to be disrupted thereby reducing agricultural crop yields (Kardinan, 2011).

Pesticides can kill bees and give adverse effects on the pollination process of plants, the extinction of plant species that depend on bees for pollination, and the collapse of bee colonies. Applying pesticides to flowering plants can kill honey bees that will pollinate them. Farmers in the United States lose at least US$ 200 million per year due to reduced pollinators for their crops. Hence, it is essential to control environmentally friendly pests, such as using botanical pesticides (Kardinan, 2011).

Botanical pesticides are natural products derived from plants containing bioactive compounds such as secondary alkaloids which will reach the target (pests) and affect the nervous system, disrupt the reproductive system, hormonal balance, behavior of attracting, repellent, reduce appetite and disrupt the respiration system of the plant. Botanical pesticide ingredients can be applied in entire, powder/flour, or extracts (Kardinan, 2011).

A severe attack of pest organisms on plants causes the leaves to be damaged or consumed so it can reduce production and finally kill the plant. The tobacco cutworm (Spodoptera litura F.) of the order Lepidoptera and the family Noctuidae is one of the important pests on soybean, cabbage, and mustard plants. Yield loss due to pest attacks can reach 85%, or worse, crop failure. This pest has polybag properties so it can consume various types of plants to survive (Azwana and Adikorelsi, 2009).

The control of leaf-eating caterpillars by farmers still depends on the use of synthetic pesticides which are deemed to be practical in application and the control results are visible. However, farmers tend to use pesticides excessively, thus the use of pesticides should be managed and controlled effectively and safely for the environment (Julaily et al, 2013).

Primarily, nature has provided natural ingredients that can be utilized to overcome pests and diseases on plants. One component of pest and disease control currently being developed is botanical pesticides or natural bioactive compounds derived from plants. In addition to producing primary metabolites (primary metabolites), in their metabolic processes, plants also produce other compounds.

1.2. Formulation of Study

Are botanical insecticides more effective in controlling tobacco cutworm (*Spodoptera litura*) pests than chemical insecticides?

1.3. Objectives of Study

1. To determine the effect of using botanical insecticides on tobacco cutworm pests that attack Indian mustards and the production of Indian mustards.
2. To understand the comparison of the effectiveness of chemical and botanical insecticides in controlling tobacco cutworm pests on Indian mustards.

1.4. Research Hypothesis

1. The tested botanical insecticide extracts give different effects on tobacco cutworm mortality.
2. Botanical insecticides are more effective in controlling tobacco cutworm pests than chemical insecticides.

1.5. Significance of Study

1. As one of the environmentally friendly vegetable insecticides in controlling pests in horticultural and vegetable crops.
2. Availability of information for all parties in need, especially vegetable farmers to increase production without using chemicals.

CHAPTER II

LITERATURE REVIEW

2.1. Indian Mustard (Brassica juncea L.)

2.1.1. Classification and Morphology of Indian Mustard

In agriculture, Indian mustard is classified as follows: Kingdom: Plantae, Division: Spermatophyta (seed plants), Subdivision: Angiospermae (seeds are enclosed within the fruit), Class: Dicotyledonae (seeds in pair or split seeds), Order: *Rhoeadales* (*Brassicales*), family: *Cruciferae* (*Brassicaceae*), Genus: *Brassica*, Species: *Brassica juncea* (Edi and Yusri, 2010).

In general, Indian mustard plants are fallen into three types that can be cultivated, namely white mustard (head mustard), mustard greens, and caisim. White mustard (B. juncea L. var. Rugosa Roxb & Prain) has a short, erect stem, and also has broad, dark green leaves. Mustard greens have short stems and whitish leaves and also have a bitter taste. Meanwhile, Caisim has short, small stems, and is mini or stunted. According to Edi and Yusri (2010), the morphology of the mustard plant is as follows:

1. Root; Mustard plants bear taproots and branches that form oblong shapes, spreading laterally on the soil surface. These roots can penetrate the soil 30-50 cm in depth. It serves to absorb water and nutrients from the soil.
2. Stem; Mustard plants have short and segmental stems, making them not visible. The stem of this plant supports the establishment of mustard leaves. Mustard greens have very fine, hairless leaves, and flat stems.

3. Leaves; Mustard plants grow leaves that are oval and round, wide, light green, dark, and without hair. The leaves on this plant have long and short petioles, narrow or wide, white to green, strong and smooth.
4. Flowers; Mustard plants have flowers that are elongated and many branches. This plant sprouts flowers of four petals, four bright yellow flower crowns, four stamens, and one hollow petal. Pollination of these plants is assisted by wind and micro animals.
5. Fruits and seeds; Mustard plants have round or oval fruit, whitish to greenish, and each fruit accommodates 2-8 seeds. The seeds of the mustard plant are small round brown to black and have smooth, shiny, rigid, and slimy surfaces.

2.1.2. Requirement to Grow Mustard Plants

Indian mustard (*Brassica juncea* L.) is part of the Brassicaceae family; the leaves are long, smooth, hairless, and have no cropping. It grows well in either hot or cold climates so it can be cultivated in lowlands and highlands. However, it is more recommended in the highlands. Appropriate planting areas are from an altitude of 5 meters to 1,200 meters above sea level. Nevertheless, it is usually cultivated at an altitude of 100-500 m above sea level, with loose soil conditions, rich in humus, fertile, and good drainage (Edi and Yusri, 2010).

1. Climate

   Mustard can be planted in the highlands and lowlands. However, it is generally grown by farmers in the lowlands, including yards, fields paddy fields, and rarely cultivated in mountainous areas (Anonimous, 2009).

2. Rainfall

Mustard plants can be planted all year round (all season). Sufficient rainfall throughout the year can support plant survival due to the availability of sufficient groundwater. Suitable rainfall for the cultivation of mustard plants is 1000 – 1500 mm/year. Areas with rainfall intensity of about 1000-1500 mm/year are those with an altitude of 1000-1500 m above sea level (Cahyono, 2008). Mustard is resistant to rain, therefore it can be planted all year round. In the dry season, it is necessary to pay attention to regular watering. Since the growth of this plant requires cool air, mustard greens grow faster when planted in a humid atmosphere. However, this plant also does not favor stagnant water. Thus, this plant is suitable when planted at the end of the rainy season (Zuldesigns, 2011).

3. Sunlight

Plants can carry out photosynthesis requiring sufficient energy. Sunlight is the energy needed for plants to carry out photosynthesis. The optimal solar kinetic energy needed by plants for growth and production ranges from 350-400 cal/cm^2 per day. Mustard greens require high sunlight (Cahyono, 2008).

Light factors greatly affect plant growth and production. The high light intensity can increase the photosynthesis process occurs, yet the increase in the photosynthesis process will stop at the saturation point of sunlight. Insufficient sunlight can also result in declining growth and yield, weak, pale, thin, and elongated growth, and eventually decrease productivity (Cahyono, 2008).

To obtain sufficient sunlight intensity, mustard plants require a length of sunlight (photoperiodicity) of 12-16 hours daily (Cahyono, 2008).

4. Soil Condition

Growing requirements for this type of commodity are rather natural. Caisim can grow and adapt well to almost any type of soil, both on mineral soils with a light texture to heavy clay, or organic soils such as peat soil. The optimal soil pH for caisim cultivation is between 6-6.5. The most favorable planting media for mustard is loose soil, which contains a lot of humus, is fertile, and has good drainage (Edi and Yusri, 2010).

Recommended planting area is from an altitude of 5 - 200 meters above sea level. However, it is commonly cultivated in areas with an altitude of 100-500 meters above sea level. Mustard plants can grow both in hot and cold places, so they can be cultivated in the lowlands and highlands. However, in practice, the yields are better in the highlands. Mustard plants are resistant to rain, making them good to be planted all year round. In the dry season, it is necessary to pay attention to regular watering. The most superior variety for lowlands is mustard greens (Anonymous, 2012).

2.2. Botanical Insecticide

Botanical pesticide is a pesticides derived from nature, such as plants. This type of pesticide is biodegradable inside so it does not pollute the environment and is relatively safe for humans and livestock as the residue will decompose and easily disappear. Some of the insecticides frequently used come from mashed

plants, flowers, leaves, or roots which can be directly used as insecticides, or the toxic materials are extracted first and then applied (Budiyanto, 2011).

Principally, natural materials containing bioactive compounds can be classified into 3 parts; natural materials containing anti-phytopathogenic compounds (agricultural antibiotics), phytotoxic or plant growth regulating (phytotoxins, plant hormones, and the like), and natural ingredients containing compounds that are active against insects (insect hormones, pheromones, antifeedants, repellents, attractants, and insecticides). Traditionally, the action mechanism of botanical pesticides in protecting plants from pests is to directly inhibit the reproduction process of insect pests, especially female insects, reduce appetite, causing insects to refuse food, damage the development of eggs, larvae, and pupae so that the breeding of insect pests is impeded, and inhibit skin cell turnover. (Saenong, 2016).

Several plants can potentially be developed into botanical pesticides, including cashew nuts (*Anacardium occidentale*), billygoat weed (*Ageratum conyzoides*), poison berry (Anamirta coccolus), soursop (*Annona squamosa*), neem (*Azadirachta indica*), daisy (*Chrysanthemum cinerariifolium*), derris (*Derris elliptica*), mahogany (*Swietenia mahagoni*), celery (*Apium graveolus L.*), and others (Kardinan, 2011).

2.2.1. Tubal Root (*Paraderris elliptica* (Wall.) Adema)

The tuba root belongs to the Fabaceae (*Leguminosae*) family. Tuba plants have different names in each region in Indonesia. For example, in Java it is known as *besto, oyod ketungkul, oyod tungkul, tuba, tuba akar, tuba jenu* and in Sunda it is referred to as *tuwa, tuwa lalear,* and *tuba leteng.* To date, more than 80 species

of tuba roots spread from South-East Asia (Adharini, 2008). The taxonomy of tubal roots is as follows:

Phylum : Magnoliophyta

Class : Magnoliopsida

Order : Rosales

Phylum : Caesalpiniaceae

Genus : *Derris*

Species: *Derris elliptica* Benth.

The tuba root is a twisted climbing species spanning 5-12 meters with a leaf length of 15-30 cm. The underside of the leaves is grayish-green and the young leaves are purple. The length of the stem and flower stalks is 12-6 cm and the number of seeds is 1-3 in each fruit.

The most used part of tuba is its root because it contains rotenone ($C_{23}H_{22}O_6$) 0.3-12%, which is an active compound to kill pests and wild fish (Starr et al, 2008).

Rotenone that enters the body will impede organisms to breathe due to the difficulty of obtaining oxygen. The rotenone compound may occupy the fish gills directly and it serves to inhibit the NADH2 double oxidation process, therefore the fish cannot perform respiration. To eliminate the effects of rotenone is to use potassium permanganate chlorine, methylene blue, activated carbon, or water that is strongly aerated (Hinson, 2000).

Toxic compounds from tuba roots should not be transferred into rivers because they can kill aquatic ecosystems (Olufayo, 2009).

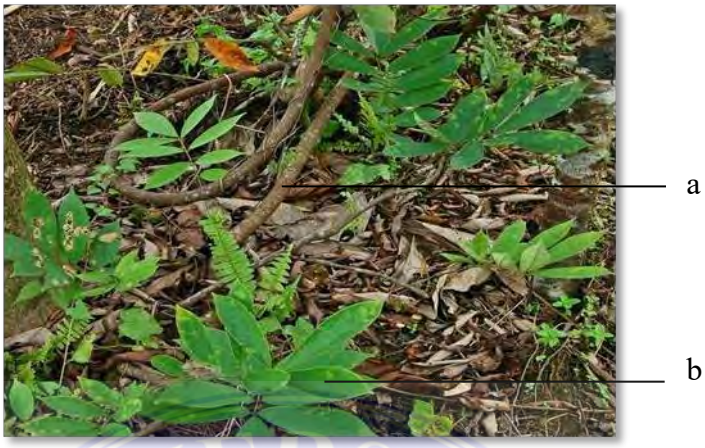

Figure 1. Tuba Plant (Derris elliptica)
Description: a = tuba root; b = tuba leaf
Source: id.wikipedia.org (accessed November 8, 2019)

Based on research conducted by Budiyanto (2011), it was found that the use of tuba root extract (*Derris elliptica*) as an environmentally-friendly insecticide was effective for killing caterpillar pests (*Lymantria beatrix*) at a concentration of 50% and an LD50 value of 66.99%; Triyawati (2006) reports that at a concentration of 5% tuba root extract (*Derris elliptica*) was effective in tobacco cutworm mortality with a mortality rate as of 15%. Thus, 5% tuba root extract concentration could be used for in vitro mortality of tobacco cutworm. In line with that, Valentino, et al. (2013) state that the tuba root extract treatment had a significant effect on the mortality of P. canaliculate in the 10% concentration treatment with a mortality rate of 5.0 (2.34%) in 42 DAP and tuba root extract treatment also significantly affected the intensity of damage to rice tillers at a concentration of 10% with a total damage intensity of 3.67 (2.04%) at 42 DAP.

2.2.2. Celery (*Apium graveolus L.*)

Celery (*Apium graveolus* L.) is a herbaceous vegetable plant in the form of grass originating from the Americas used as a food seasoning and is effective in reducing high blood pressure, treating hair loss, overcoming insomnia, facilitating urination, and strengthening nerves. (Kardinan, 2011).

Celery can grow 1 to 2 feet facilitating urination. The stems are rather rigid and crescent-shaped and have compound leaves (segmented) with a serrated margin. In June and July, it produces small white flowers which later develop into fruit with fine seeds. Wet soil with acidic properties is a suitable growing environment for celery. Celery seeds have a distinctive odor with a slightly bitter taste (Kardinan, 2011).

Figure 2. Celery Plant (*Apium graveolus* L.)
Source: Personal Documentation (2019)

There are also a number of flavonoids such as graveobiosid A (1-2%) and B (0.1-0.7%) as well as phenolic compounds. Other components are apiin,

isoquercitrin, furanocoumarins, and isoimperatorins. The main fatty acid content is petroselinic acid (40-60%). Leaves and petioles contain steroids such as stigmasterol and sitosterol, 0.005 mg riboflavin, 0.003 mg thiamine, 0.4 mg nicotinamide, 15 mg ascorbic acid, and 95 ml water (Kardinan, 2011).

2.2.3. Noni

One of the medicinal plants that are often consumed by the community is noni (*Morinda citrifolia*). Noni is a plant that is widely used by the community as a traditional medicine for various diseases. Several studies have reported on the efficacy of noni, including the effects of chemotherapy (Karamchesi et al, 2014), anti-depressants (Deng et al, 2011), hepatoprotective activity (Wang et al, 2008), antioxidants (Saminathan et al, 2014), antidisplipedemia (Mandukhail et al, 2010), antimicrobial (Usha et al, 2010), and immunomodulatory effect (Palu et al, 2008). This activity is deemed to be partly due to the antioxidant activity in noni carrying flavonoids and phenolic compounds (Rao and Subramanian, 2009).

Noni flowers are white, fragrant, and have a trumpet-shaped crown. The content of chemical compounds in noni comprises two parts, namely primary metabolites, referred to as large-molecular compounds, and secondary metabolites, or small-molecular compounds (Sirait, 2008).

According to Solomon (2008), compounds anthraquinones, alkaloids, and glycosides are found in almost all parts of the noni plant, especially the leaves and fruit which function to treat digestive disorders and heart disorders. The active compound is bactericidal in *Staphylococcus* bacteria, promoting infection of the heart and *Shigella*, causing dysentery, besides killing bacteria inducing infection, such as *Salmonella* sp., *E. coli,* and *Bacillus* sp. (Solomon, 2008). According to

Sirait (2008), alkaloids are the outcome of the largest secondary metabolic compounds in plants lodging basic nitrogen atoms as a combination of the heterocyclic system.

Figure 3. Noni (*Morinda citrifolia*)
Source: Personal Documentation (2019)

Based on the results of research conducted by Mega (2018), it was discovered that botanical insecticides made from ripe noni fruit extract were more likely to control *S. litura* pests and the best concentration of noni fruit extract was 100% without water mixture. Furthermore, Elfri (2005) reported that noni leaf and noni flower extracts were able to suppress the development of the occurrence and severity of anthracnose disease in chili plants.

2.3. Tobacco Cutworm (*Spodoptera litura* L.)

The classification of tobacco cutworm pests is as follows:

Kingdom: Animalia

Division : Arthropoda

Class : Insecta

Order : Lepidoptera

Family : Noctuidae

Genus : Spodoptera

Species : *Spodoptera litura* F.

Eggs are almost elongated in shape with flat parts attached to the leaves (for some cases arranged in 2 layers), yellowish-brown, grouped (each containing 25-500 eggs) covered with velvety hairs (Tenrirawe and Talanca, 2008). The egg stage lasts for 3 days (Rahayu, et al., 2009).

After 3 days, the eggs hatch into larvae. The caterpillars that emerge from the eggs are clustered on the leaf surface. Following a few days, the caterpillars begin to live apart. The body length of a fully grown caterpillar is 50 mm (Balitbang, 2006). The larval stage lasts for 15-30 days (Rahayu, et al., 2009).

After fairly matured, approximately 2 weeks old, the caterpillars begin to cocoon. Pupae take place in the soil and are covered with soil. After 9-10 days the cocoons will turn into adult moths (Balitbang, 2006).

Adult insects are gray moths, laying eggs in groups. The size of the female moth is 14 mm while the male moth is 17 mm (Balitbang, 2008). Imago *Spodoptera litura* L. has a short lifespan.

Tobacco cutworms actively ingest at night, leaving the upper epidermis and leaf bones so that the eaten leaves appear to be white from afar (Balitbang, 2006). The small larvae can damage the leaves and attack simultaneously in groups leaving the upper epidermis, which is transparent, and only the leaf bones. Principally, the larvae are on the underside of the leaves, and the process occurs in the dry season (Tenrirawe and Talanca, 2008). In addition to the leaves, adult caterpillars eat young pods and young leaves, while the bones of old leaves will remain. In addition to damaging soybeans, tobacco cutworms also attack corn, potatoes, tobacco, green beans, spinach, and cabbage (Balitbang, 2006).

The damage caused by this pest can damage, diminish production, and even cause crop failure. Therefore, it is very important to learn and recognize the important pests which are harmful to these vegetable crops, which later can then be applied as guidelines for management.

CHAPTER III

RESEARCH METHODOLOGY

3.1. Research Time and Site

This research was conducted in Sampali Village, Percut Sei Tuan Subdistrict, North Sumatra, with an altitude of 6 meters above sea level, flat topography, and Alluvial soil type. This research lasted from May to June 2019.

3.2. Material and Tool

The materials to be used in this research are: mustard seeds of the Tosakan variety, celery leaf extract, noni fruit extract, tuba root extract, and insecticide with the active ingredient Chlorpyrifos 530 g/l + Cypermethrin 60 g/l. Meanwhile, the tools used are polybag, hoe, watering can, tape measure, hand sprayer, knife, magnifying glass, and scales.

3.3. Research Method

The method used in this research is a non-factorial randomized block design (RBD method, with the research factor of plant insecticide extracts, encompassing 8 levels of treatment as follows:

I_0 = no treatment (control)

I_1 = tuba root extract concentration 5% (50 ml/l water)

I_2 = tuba root extract concentration 10% (100 ml/l water)

I_3 = noni fruit extract concentration 5% (50 ml/l water)

I_4 = noni fruit extract concentration 10% (100 ml/l water)

I_5 = celery leaf extract 5% (50 ml/l water)

I_6 = 10% celery leaf extract (100 ml/l water)

I_7 = chemical insecticide, active ingredient Chlorpyrifos 530 g/l + Cypermethrin 60 g/l (0.5 ml/l water)

Research unit:

Number of replication = 3 replications

Number of studied plots = 24 plots

Number of plants per plot = 16 plants

Distance between plots = 75 cm

Distance between replicaitons = 75 cm

Plot size = 100 cm x 100 cm

Plant space = 25 cm x 25 cm

Number of sample per plot = 6 samples

Total number of plants = 448 plants

3.4. Analysis Method

After the research data were obtained, data analysis was carried out using a non-factorial randomized block design (RBD) with the formula:

where :

Y_{ij} = plant response to botanical insecticide treatment at the j-level and the i-th replication level

μ = median (mean)

τi = i-th block effect

βj = effect of the j-th botanical insecticide treatment

Σij = effect of error from the treatment of botanical insecticides at the j-th and at the i-th replication

If the variance displays a significant effect, it is continued with Duncan's Multiple Distance Test (DMRT) (Sastrosupadi, 2000).

3.5. Research Implementation

3.5.1. Sowing

The seedbed was made with a size of 2 m x 1 m. The planting medium was soil. The seeds spread were covered with seedling media, then covered with banana leaves or gunny sacks for 2 - 3 days.

3.5.2. Plowing

Land preparation was done by weeding and clearing garbage. Subsequently, the soil was processed by plowing, and plots were arranged with a size of 100 cm x 100 cm, distancing between plots was 75 cm, and basic fertilizer was dispensed. The basic fertilizer used was cow manure as much as 1 kg/plot by mixing cow manure and soil.

3.5.3. Making Tuba Root Extract

A total of 20 kg of cleaned tuba roots were cut into small/thin pieces, then dried in the sun until dried. Then, it was blended to powder. A total of 10 g of tuba root powder was extracted using the maceration method by adding 100 ml of methanol as a solvent to the Erlenmeyer. Then, it was shaken using a shaker for 3 days and filtered. The filtrate obtained was accommodated in a glass beaker. The maceration was repeated several times until the macerate yielded was relatively

transparent. Furthermore, filtering was done, and the filtrate obtained was combined with the first filtrate. Then evaporation was carried out by placing the filtrate in a container with a large surface and left at room temperature for up to 48 hours. The precipitate obtained was brown and formed gel consistency. This gel was applied as research material.

The tuba root extract used as a treatment refers to Muharsini, et al (2006) with modifications consisting of rotenone 1%, 2%, and 3%. A solution of tuba root extract (rotenone) 1% was attained by weighing 1 g that was included in a 100 ml volumetric flask and appended with distilled water to 100 ml. Tuba root extract (rotenone) 2% was obtained by weighing tuba root extract 2 g which was put into a 100 ml volumetric flask and aquades were poured until reaching 100 ml. Meanwhile, rotenone 3% derived from tuba root extract weighing 3 g and placed into a 100 ml volumetric flask where distilled water was added to 100 ml. Then the solution was transferred into a sprayer and was ready to use.

3.5.4. Making Celery Extract

Making simplicia of celery (*Apium graviolens* L.) was done by selecting celery (the qualified leaves were selected, neither dry nor rotten), then washed until clean from soil and dirt. Then, it was dried in an oven at 40^{o}C for 5 hours until the water content was constant (weighed). After that, it was mashed using a blender so celery powder was obtained. Subsequently, it was extracted with the following steps: 50 g of celery simplicia was dissolved in 200 cc of ethanol 80%. It was then allowed to sit for one day and filtered. The results from the filter were gathered in form of residue and filtrate. The filtrate was stored and evaporated at a

temperature of 30º C so that did not damage the active ingredients. Finally, a concentrated extract was obtained (Ranti, 2018).

3.5.5. Making Noni Extract

The half-ripe noni fruit was harvested, washed thoroughly, and drained to remove the remaining water. Noni fruit chopping was carried out in an open space that was protected from direct sunlight or used a black cloth as a cover. Drying was done using an oven at a temperature of 50ºC-60ºC for 5 hours. It was done in the oven to avoid the discrepancy of soggy inside and dried outside texture. Once this happens, it may damage or rot the inside part of the dried material. Drying in the oven also allows an even distribution and the drying time is faster without being affected by weather conditions. Meanwhile, the purpose of drying is to reduce the moisture content and stop the enzymatic reactions that will damage the sample. After drying, the fruit was powdered and sieved using a grinder attached to a sieve, hereinafter referred to as simplicia powder. Simplicia making aimed to expand the surface of the particles in contact with the solvent so that the filtering process could run effectively and facilitate the solvent to bind the compounds contained in the cell. A total of 300 g of simplicia powder was weighed and put into a glass jar with a lid and placed in a dark area. Following that, the simplicia was macerated with the addition of 1500 ml of hexane solvent. In maceration extraction, it is necessary to stir to even out the concentration of the solution outside of the simplicia powder grains, in this way the difference in concentration between the solution outside and inside the cell is maintained. After two days, the bath was filtered using a funnel and filter paper to separate the simplicia powder from the solvent. The results of this filter were then concentrated with a vacuum

rotary evaporator. It was followed by evaporation on a water heating to vaporize the remaining solvent until the noni fruit hexane extract with a thick concentration was obtained. In a vacuum evaporator, heating was carried out below the boiling point of the solvent so that the content of compounds contained in the thick extract was obtained.

3.5.6. Planting

Planting was carried out after the seedlings were 12 days old after sowing, for each plot 16 plants were planted, then each treatment unit was covered with gauze (mosquito net).

3.5.7. Breeding *Spodoptera litura*

To acquire as many as 240 *Spodoptera litura* larvae, breeding was conducted by planting 4 Indian mustard plants in polybags, then laying 2 colonies in the prepared plants. After undergoing the egg period and entering the larval stage, the larvae were bred for 14-16 days to get the second instar larvae. Next, the larvae were ready to be invested in plants.

3.5.8. Investing Tobacco Cutworm

After the Indian mustard plants were 2 days old after planting (DAP), 5 larvae of *Spodoptera litura* in the second instar were added to each treatment unit and 5 larvae were then covered with gauze (net).

3.5.9. Applying Vegetable Insecticide

The application of vegetable insecticides according to the treatment was carried out using a sprayer equally distributed onto the plants. Spraying was carried out 4 times with an interval of 2 days; at the age of 14, 16, 18, and 20 DAP, and the application was carried out in the afternoon (17.00 -18.00 WIB).

3.5.10. Maintenance

Watering was carried out at 07.00-08.00 AM and in the afternoon at 16.00-17.00 PM evenly on all plants using a watering can and clean water. Weeding was completed manually by removing weeds on the plot or around the research plot.

Then, the application of ghost fertilizer was carried out 2 times, namely at the age of 7 DAP and 14 DAP with a concentration of 2 ml/l of water.

3.6. Observation Parameter

3.6.1. Caterpillar Mortality (%)

Observations were made 1 day following the application of botanical insecticides; at the age of 15, 17, 19, and 21 DAP. Observations were stopped when the armyworm mortality rate had reached 100%. Armyworm mortality was calculated using the formula: $P = \frac{a}{b} \times 100\%$, where: P = percentage of insect mortality; a = number of dead insects; b = number of initial insects (Anonimus, 1993).

If there was the mortality of the test insects in the control treatment, the data were corrected using the Abbot formula: $Ms = \frac{Mp-Mk}{100-Mk} \times 100\%$, where Ms = percentage of actual mortality; Mp = percentage of treatment mortality; and Mk = percentage of control mortality (Grainge, 1998).

3.6.2. Intensity of Damage Due to Caterpillar Attack (%)

The intensity of damage was observed and calculated together with spraying the application of botanical pesticides (1 day after inoculation of the test insects), carried out by assessing that indicated the damage stage.

The values of the damage score are as follows :

0 = if no plants are damaged

1 = if 1 – 25% of plants are damaged

2 = if 26 – 50% of plants are damaged

3 = if 51 – 75% of plants are damaged

4 = if more than 76% are damaged

The percentage of damage intensity was calculated using the Tarigan formula (2012) in the Online Journal of Agroecotechnology Vol. 1, No. 1, December 2012 as follows:

$$I = \frac{\sum (n_i \times v_i)}{Z \times N} \times 100\%$$

I = damage intensity

n_i = the number of damaged plants or parts of plants

v_i = the scale value of each damage category.

N = the number of parts of plants observed in the sample

Z = the scale value of the highest damage category

3.6.3. The Effectiveness of Botanical Insecticides Against the Mortality Rate of Tobacco Cutworm

Calculations were carried out using the following formula:

$$V = \frac{N}{n}, \text{ where:}$$

V = mortality rate

N = number of dead insects

n = number of test insects

Meanwhile, the effectiveness of the treatment application for all parameters was conducted by the following formula:

$$EF = \frac{NIT\text{-}NIK}{NIK} \times 100\ \%$$

Information :

NIT = Value (data) on the i-th treatment indicator

NIK= Value (data) on the i-th control indicator

3.6.4. Plant Height (cm)

The height of the Indian mustard plant was measured from 1 WAP to 4 WAP, with a measurement time interval of 1 week.

3.6.5. Indian Mustard Yield per Plot (g)

The wet weight of the mustard plant per plot was drawn based on the weight of the entire plant in each plot that had removed the old leaves and roots, after which it was converted to hectares.

CHAPTER V

CONCLUSION AND SUGGESTION

5.1. Conclusion

From the results of this study, it can be concluded that:

1. The application of botanical insecticides had a very significant effect on the percentage of tobacco cutworm mortality, the intensity of crop damage, the mortality rate of tobacco cutworm, plant height, and Indian mustard yield per plot.
2. The application of botanical insecticides with a tuba root concentration of 50 ml/l was more favorable than the use of chemical insecticides because it caused the mortality of 100% at the age of 21 DAP, while chemical insecticides did not reach 100%.

5.2. Suggestion

1. Tuba roots can be used to control tobacco cutworms in mustard plants with a concentration of 50 ml/l water.
2. Research on the use of tuba roots can be probed for other pests.

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