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The Use of Insecticides to Protect Cocoa Fruit from the Attack of Cocoa Pod Borer, *Conopomorpha cramerella* in Cocoa Plants

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Abstract : Cocoa pod borer is the main pest of cocoa in Indonesia because it can reduce yields in quality and quantity. The aim of the study was to examine the effect of insecticides on cocoa fruit damage, seed damage and yield loss. The experiment was arranged in a randomized block design of six treatments and repeated four times. The treatment consisted of synthetic insecticide (0.05% deltametrin) and botanical insecticides. Garlic 5.2%, 5.2% lemongrass, 5.2% Bitung seeds, fragrant lemongrass mixture (5.2%) + Bitung seeds (5.2%) + galangal (5.2%) and control (water). Each block of insecticide application was used two rows of cocoa plants. The application of insecticides was carried out five times, and 40 cocoa fruits (6-8 cm long) were used per treatment. Mature fruitswere harvested to obtain data on cocoa fruit damage. Synthetic and botanical insecticides are able to protect cocoa fruits from attacks by cocoa pod borer. The yield loss in some insecticidal treatments was as follows: deltametrin 17.80%, garlic 35.00%, lemongrass fragrant 37.70%, Bitung seeds 40.80%, mixed lemongrass fragrant + Bitung seeds + galangal 52.50%, and control 62.78%.Botanical insecticides that can significantly reduce damage to cacao fruits were garlic and fragrant lemongrass. Deltametrin, garlic, and lemongrass fragrant insecticides can be recommended to protect the attack of cocoa pod borer. The attack of cocoa pod borer caused a decrease in wet weight of 15.2%. Deltametrin and botanical insecticides do not show phytotoxic symptoms in cocoa fruit.
Keywords : Synthetic, botanicalInsecticides, *Conopomopha cramerella*, Cocoa fruit.

Introduction

Cocoa plants, *Theobroma cacao*, originated in Central and South American forest areas[1,2]. Indonesia cacao plants entered in 1560 by the Spaniards to the land of Minahasa, North Sulawesi, and then spread on the island of Java in 1880. Cocoa exports in 1928 were lost, due to the presence of cocoa fruit borer[1].Cocoa pod borer, *C. cramerella* was first reported to attack cocoa in the 1860s in Sulawesi[3]. Indonesia cocoa production fluctuated, the highest value was found in 2010, in 2016 cocoa production was around 750,000 tons and the

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average production was 799 kg / ha. National cocoa production has not increased significantly from year to year and is still below 1 ton / ha, while the area of cocoa plantations has increased from year to year. The area of cacao plants in 2000 was around 800,000 ha and in 2015 1,724,092 ha[4]. The main factor that causes cocoa production is still low due to cacao pod borer,*C. cramerella*[4,5,6]. Cocoa pod borer is a major problem in cocoa plantations in Southeast Asia and Oceania. Cocoa pod borer is the main pest in North Sulawesi [5,7].

Indonesia is the third largest cocoa producer in the world, after Pantai Gading, Ghana[4]. Indonesia has an annual gross production value of $ 700 million, the cocoa industry can lose around $ 300 million in cocoa annually as a result of cocoa fruit borer[8]. Cocoa production can contribute US $ 1.05 billion per year for foreign exchange[4]. Loss of yields of 184,500 tons per year of cocoa borer equivalent to 3.69 trillion[1]. Cocoa pod borer is widespread in Indonesia and yield loss is estimated to be around S $ 500 million US dollars per year and in Malaysia its production is greatly affected[9].

Cocoa pod borer laystheir eggs after the sun sets on the grooves of grooved cocoa fruit[10,11,12]. After the eggs hatch, the larvae immediately make a hole and enter the fruit for 12-14 days and broach the pulp and placenta tissue on the food channel leading to the seeds, so that when the skin of the fruit is opened there will be a pink hole that is tortuous inside the fruit[6,10,13]. Damage to the pulp causes the seeds to stick together and stick to the fruit wall. Damage to the placenta causes all seeds to be damaged and not developed[10]. The damaged fruit network causes physiological changes in the fruit skin to look green or frayed green[14].

Cocoa fruits measuring 5-7 cm are not attacked by cocoa pod borer[14]. Fruit damage by cocoa pod borer starts from fruit size more than 8 cm to intersect harvesting[5,15] Suwitra et al., 2010). In addition to cocoa, these pests also attack *Nephellium lappaceum*, *Nephelium mutabile*, *Cola nitida*, *Pometia pinnata*, *Cynometracauliflora*[1,10]. Almost all types of plants as cacao pod borers are found in North Sulawesi. In North Sulawesi, the intensity of damage to cocoa fruit by cocoa pod borer is 36.67 - 88%[5]. The attack of cocoa pod borer can cause yield loss up to 90%[10,13]. The attack of cocoa fruit crackers can reduce production by up to 80% and damage seeds to 82%, making it very feared by farmers and cocoa plantation entrepreneurs[16,17]. As a result of the attack on cocoa pod borer which is categorized as heavy to lose seed production by 82.2%[18].

The use of black ants as predators, fungi *Beauveria bassiana* and *Verticillium tricorpus* were not significant in reducing the attack of cocoa fruit borer. Control of cocoa pod borer by utilizing the biological agent *Dolichoderus thoracicus* ant can suppress attacks 8.28%[19]. The experimental results of cocoa clones on the resistance of corkscrews to the percentage of sticky seeds were 35.78 - 91.72%[20], sticky seeds were still high, the value of seed damage was determined by sticky seeds[1,10]. The combination of frequent crop control, pruning, fertilization and sanitation is only able to suppress cocoa pod borer attacks below 5%[1].

So far, the control of cocoa pests carried out by farmers still relies on synthetic insecticides, even though if viewed ecologically, the use of synthetic insecticides that are not recommended can have a negative impact on the environment and can cause insecticide residues on harvested materials[21]. Control with insecticides by North Sulawesi farmers is still based on crop canopy and has not provided tangible results for increased production[5]. The application of insecticides carried out has not been right on target, causing the intensity of damage to cocoa fruit and losing seeds is still high. According to[22]that the application of azodrin, gusadrin, tamaron, and lannate insecticides through infusion of roots, stems, and direct spraying on cocoa plantations can suppress cocoa pod borer attacks 0 - 14.60%.

To overcome the problem of cocoa pod borer, other control alternatives are needed by using botanical insecticides that are relatively safe for humans and the environment and raw materials can be obtained easily and cheaply, and can be made in a simple way so that it is easy to be adopted by farmers. Several types of botanical insecticides have been proven to be effective in controlling several types of plant pests, including rotenone which can be taken from the root of the tuba (*Derris eliptica*)[23,24]. pplication of botanical insecticides, Bio Protector (cloves, lemongrass fragrant, ginger eugenol, citronellal, geraniol and xanthorizol), citronella, geraniol and xanthorrizol), 50 EC Cees (citronella and geraniol), Cekam 20 EC (citronella oil and cinnamon oil), Asimbo 50 EC (citronella and acid salicylate) in the cocoa canopy has not been significant for yield loss of 30.3 - 50%, deltamethrin synthetic insecticide 26.70%[25]. In addition to cinnamon, fragrant lemongrass is also potentially used as a botanical pesticide because it contains methyl heptanon which is repellant to insects[26]. Garlic contains sulfur and allium compounds. Allium is odorless, but when it reacts with sulfur or sulfur, it immediately changes to allicin. The sharp aroma of allicin (a distinctive aroma of garlic) is not liked by insects (repellant), because it will disrupt the insect communication system[27].

Management for the control of cocoa pod borer is very difficult to run because the larvae are in the fruit, so to solve the problem of fruit borer pests, the cocoa fruit must be protected so that the pest does not lay its eggs on the cocoa fruit. Botanical pesticides are classified as repellents, antifeedants, nerve poisons and attractants[27,28].The effectiveness of botanical pesticides is related to the content of their chemical compounds which are toxic (toxic), reject (repellent) or prevent eating (deterrent)[29,30]. The mechanism of action of plant materials in protecting plants can be in the form of active compounds in insects (insect hormones, pheromones, antifeedant, repellents, attractants and insecticides[31]. This research is to examine the effectiveness of synthetic and botanical insecticides in protecting cocoa fruits from the attacks of cocoa pod borer.

Research methods

Research has been carried out in Bolaang Mongondow Regency which is the center of North Sulawesi cocoa production. The position of the research location is $00^0$75589" N, 124.29999^0 E with a place height of 133 m above sea level. The day before the application of insecticides on cocoa fruit, 30 cacao fruits were randomly collected on 10 cocoa plants. The collection of cocoa fruit is intended as comparative data before and after the application of synthetic and botanical insecticides.

The experiment was arranged in a randomized block design (RBD) and consisted of six treatments divided into synthetic insecticides and botanical insecticides. Synthetic insecticides used are deltametrin (decis 2.5 EC), while botanical insecticides are bitung, *Baringtonia asiatica*, garlic tuber *Allium sativum*, fragrant lemongrass stem, *Cymbopogon nardus* and Mix (Bitung seeds + Lengkuas tuber (*Alpinia galanga*) + lemongrass) and control is applied with Aqua brand bottled water. Each treatment was repeated four times, and each replicate was used 10 cocoa fruits, so that one treatment was used 40 cacao fruits. Experiments used four blocks based on many replications. Each block for the application of insecticides is used two arrays, and the distance between the paths for the application of insecticides is an array. The placement of each treatment in the block is randomized, so that it can represent each treatment in the block. Each treatment in the block used 3-4 trees per replicate to obtain 10 cocoa fruits. This experiment used 12-16 cacao trees per treatment to get as many as 40 cacao fruits which were applied with insecticides.

Cocoa fruits that are applied with insecticides are still easy cocoa fruits measuring 6 - 8 cm long. The application of insecticides to the size of the fruit is assumed to be free from the attack of cocoa fruit borer. The application of insecticides on the same cocoa fruit is carried out five times at seven days intervals. The amount of spray applied to the size of the cocoa fruit is 1.5 - 3 ml, the greater the amount of cacao fruit the more liquid the spray. The method of making botanical insecticide extracts follows the instructions[24]. After the application of insecticides, cacao fruits were observed showing symptoms of phytotoxicity.

Table 1. Treatment of insecticide formulas

No	Treatments	Insecticide Solutions	Insecticide Concentrations
1	Garlic tubers	50 ml + 950 ml water	5.2%
2	Lemongrass	50 ml + 950 ml water	5.2%
3	Bitung seeds	50 ml + 950 ml water	5.2%
4	Mix (lemongrass fragrant + Bitung seeds + galangals)	(50 ml + 950 ml water) + (50 ml + 950 ml water) + (50 ml + 950 ml water)	5.2% +5.2% + 5.2%
5	Deltametrin (Decis 2.5 EC)	0.5 ml + 1000 ml of water	0,05 %
6	Control	Aqua brand bottled water	

Calculating the percentage of cocoa fruit borer attacks used formula:

$Is = (a / (a + b)) \times 100\%$
Is = Percentage of attacks
a = Number of cocoa fruits attacked
b = number of healthy cocoa fruits
The intensity of damage to cocoa beans refers to[32]:

$$I = \frac{(1 \times R + 3 \times S + 9 \times B)}{AT} \times 100\%$$

I = intensity of damage,

Calculation of percentage loss results refers to[32] as follows:

$Y = - 0.0210 + 0.1005 X$

Y = Loss of results

X = intensity score for damage to seeds. CPB damage score (X) is calculated by the formula:

$$X = \frac{(0 \times Sh + 1 \times R + 3 \times S + 9 \times B)}{AT}$$

X = Seed damage intensity score
Sh = Number of healthy fruits
R = Number of lightly attacked fruits (1-10%),
S = Number of medium-attacked fruits (11 - 50%);
B = Number of severely attacked fruits> 50%);
A = Highest score;
T = Number of fruits observed.

The value obtained from the yield loss equation (Y) is multiplied by 100% to indicate the percentage of yield loss due to the attack of the cacao pod borer. Healthy and damaged cocoa beans with 1000 seeds each were weighed to obtain data on the decrease in cocoa wet weight. Data obtained from the results of this study were carried out by analysis of variance, descriptive and regression using the SPSS application program statistics version 20.0 for windows.

Result

Deltametrin and botanical insecticides have significantly affected the decrease in fruit damage caused by cocoa pod borer, although in the application of insecticides it has rained and has not had a negative impact on the efficacy of insecticides to protect cocoa fruit so that female cocoa pod borer does not lay eggs on the fruit cocoa. Imago only lays eggs on the cocoa fruits so that if the egg has laid the eggs on the cocoa fruit will hatch into larvae then broiling the cacao fruit will cause damage to the cocoa fruit. This experiment has found cocoa pod borers on the leaves of cocoa trees and dried leaves on the ground. The pupa has no effect on the application of insecticides, because the pupa drops from cocoa fruit.

A day after the application of insecticides, 30 cacao fruits were harvested on eight trees randomly. The results showed that the percentage of cocoa fruit borer attacks reached 100% with the intensity of seed damage 72.22%. The preliminary data on the attack on the cocoa pod borer is compared to before and after the application of insecticides. Although it has been applied with synthetic and botanical insecticides, cocoa fruits are attacked by fruit borer pests based on the percentage of fruit damage, but the application of synthetic and botanical insecticides has provided positive results to protect cocoa fruits from attacks by cocoa pod borer. The percentage of attacks on cocoa pod borer is the number of healthy and attacked cocoa fruits in each treatment. The results of insecticide application have provided a significant percentage of cocoa fruit damage F = 6,200; P = <0.002. Likewise the intensity of seed damage gave a significant effect on the application of insecticides P = 10,583 <0,000.

Table 2. Average percentage of cocoa podborer attack on synthetic and botanicalinsecticides

No.	Treatments	Pest Attack	
		Attack Percentage (%)	Intensity of Seed Damage (%)
1	Deltametrin	60,0 a	23.33 a
2	Lemongrass	72,5 b	41,94 b
3	Mix	75,0 bc	48,89 c
4	Garlic	77,5 cd	37,35 b
5	Bitung seeds	80,0 d	55,61 d
6	Control	95,0 e	63,67 e
		BNT 5 % = 3,92	BNT 5 % = 4,90

In general, the percentage of cocoa pod borer attacks in the study locations is still quite high. The insecticide application showed that the percentage of cocoa fruit borer attacks resulted in a low percentage of fruit damage and damage to seeds compared to the control applied with water and cocoa fruit before being

applied with insecticides. Data shows that synthetic insecticides result in a lower percentage of cocoa pod borer attacks than botanical insecticides. Judging from the aspects of botanical insecticides which caused the percentage of fruit damage to be low, it was found in the treatment of garlic and citronella lemongrass compared to mixtures and beets. The percentage of cocoa fruit damage is largely determined by the cocoa pod borer imager to detect cacao fruits to lay their eggs after being applied with insecticides.

The intensity of damage to cocoa beans is determined by the ability of larvae to grind cocoa fruit and eat the contents of cocoa fruits such as the placenta which is the food channel to the seeds.The percentage of damage to cocoa fruit has not shown the intensity of damage to seeds. Botanical insecticides mixed with the percentage of damage to cocoa fruit are lower than garlic, but damage to garlic seeds is lower than mixed insecticides. The high percentage of damage to cocoa fruit has not shown the intensity of damage to seeds. Low seed damage data was found in the treatment with deltamethrin insecticide compared to botanical insecticides. Likewise for the low level of botanical insecticides the damage value of seeds is found in garlic and lemongrass and the highest is found in beet fruit

The percentage of cocoa fruit damage correlates with the intensity of seed damage. The percentage of cocoa fruit damage has an impact on the intensity of seed damage. The greater the percentage of damage to cocoa fruit shows the intensity of seed damage which is indicated by regression analysis R^2 = 0.878. So the contribution of the influence of the independent variable is 87.8% while the remaining 22.2% is influenced by unexamined factors or other variables. The results of the regression analysis show that the linear regression equation model formed is Y = -21,098 + 0,886 X. All packages for controlling cocoa pod borer with the application of synthetic and botanical insecticides can reduce yield loss. The results of the statistical analysis showed that insecticide treatment gave significance to the loss of cocoa beans F = 12,703; P = <0,000.

Table 3. Loss of results by cocoa podborer

No.	Treatments	Loss of Results (%)
1	Delltametrin	17,80 a
2	Garlic	35,00 b
3	Lemongrass	37,70 bc
4	Mix	40.80 c
5	Bitung seeds	52,50 d
6	Control	62,78 e
	BNT 5 % = 5,37	

The percentage of yield loss in insecticide treatments, both botanical and synthetic, varies and is under control. Based on the correlation coefficient value R^2 = 0.980 obtained from the results of the analysis, it can be categorized that there is a high degree of correlation between the intensity of damage to cocoa beans and loss of yield. The regression analysis equation shows that the linear regression model formed is Y = -3,748 + 1,031 X. The loss of cocoa fruit results in insecticides, both botanical and synthetic, has a significant effect on the decrease in cocoa bean loss. Delltametrin synthetic insecticide contributes the lowest yield loss compared to botanical insecticides, but the lowest yield loss for botanical insecticides is found in garlic and lemongrass fragrant.

Table 4. Wet weight of broken cocoa beans and healthy cocoa beans

No	Weight of 1000 Cocoa Beans / kg	
	Broken Seeds	**Healthy Seeds**
1	1,60	2,30
2	1,87	2,35
Average	1.74	2.33

After the cacao fruit which is attacked by the fruit borer is split, the seeds appear to stick together and stick to the fruit wall. Most of the treatment of insecticides of cocoa fruit which are split into seeds is attached to one another, so that the young cocoa beans are separated. In the control treatment, most damage to the seeds

is sticking together and sticking to the fruit walls. Cocoa beans are intertwined between the seeds and followed attached to the fruit walls are very difficult to separate, this has an impact on increasing the cost of work for cocoa farming. The flesh of the fruit is blackish brown to black, the seeds become wrinkled, black, the size of the seeds becomes small and light. Data obtained from observations in the field that cocoa fruit was attacked by cocoa pod borer without cooking earlier with an uneven yellow or orange or brindle. Based on the wet weight for damaged seeds caused by cocoa pod borer pests can cause a decrease in wet weight of 15.2% cocoa beans

Discussion

The percentage of fruit damage caused by the attack of cocoa pod borer can be the basis for measuring the damage of cocoa beans because the percentage of fruit damage is proportional to the intensity of damage to seeds. The percentage of fruit damage correlated with the intensity of damage to cocoa fruit, as well as the intensity of damage to cocoa beans correlated with the loss of seeds. The high percentage of damage to cocoa fruit and the percentage of damage to seeds by cocoa pod borer resulted in a large yield loss. To avoid damage to seeds and loss of yield, the cocoa fruit must be protected with insecticides so that the cocoa pod borer does not lay the eggs on the fruit. When the cocoa fruit has been laid by the cocoa pod borer it is difficult to control it with insecticides, because the eggs hatch into larvae and enter directly into the cocoa fruit. The larvae will come out in the cacao fruit after the pupa is approaching[10].

Although the controls were not treated with insecticides, insecticidal residues had an effect on protecting cocoa fruits from the attacks of cocoa pod borer. The percentage of seed damage in the control was lower than the initial data percentage of seed damage before insecticide application. Before the application of insecticides the intensity of seed damage was 72.04%, and after application of insecticides it dropped to 63.67%.[5]reported that the intensity of damage to seeds in the BolaangMongondow area was high, ranging from 69.01-78.22%. The intensity of seed damage in the BolaangMongondow area depends on the location of the cocoa farm.

The application of synthetic and botanical insecticides such as garlic and fragrant lemongrass can protect cacao fruits from the attack of cocoa pod borer.Botanical insecticidescan reduce the percentage of fruit damage and loss of yield. For the three insecticides, deltametrin provide a significant reduction in the percentage of fruit damage. Deltametrin insecticide is one of the synthetic insecticides recommended in the control of cocoa pod borer[23,34]. Spraying insecticides against cocoa pod borer has been reported by[35]. They applied alfamethrin insecticides to the branches and all fruits with a time interval of spraying once every two weeks until harvest and fruit samples. The results of this study indicate the percentage of damage to fruit with a minimum length of 9 cm was 71.24% with a yield loss of 12.22%, and the application of the insecticide to fruit with a length of 6-8 cm and applied five times with intervals for 7 days resulted in a yield loss of 17.80%.One of the factors causing high yield loss is rain.Rain falls after 3-4 hours of application of insecticides to 2, 3 and 4 times, while the first and fifth applications do not rain.The existence of rainfall becomes less effective in synthetic and botanical insecticides in suppressing damage to cocoa fruit, because synthetic and botanical insecticide residues cannot last long on cocoa fruit due to water washing. Besides that, the size of the cocoa fruit used is very influential on the damage of cocoa fruit, because the size of the cocoa fruit that was previously considered free of pest attacks may have been attacked by cocoa pod borer after being applied with insecticides.If the cocoa fruit has been attacked by a cocoa pod borer, then applied with insecticides cannot influence the reduction in damage to the cocoa fruit. Control of cocoa pod borers with synthetic insecticides shows that not all insecticides have a positive impact. Fipronil synthetic insecticide with a dose of 1 ml / liter of water applied to cocoa fruits measuring 8-10 cm and botanical insecticides with active ingredient a-eleostearic acid at a dose of 4 ml / liter which is applied once a week for 3 months has given the percentage of fruit damage to insecticides synthetic 83.33% and botanical 80.00%[36].

Deltametrin synthetic insecticide experiments are more effective than those of garlic and fragrant insecticides in protecting cocoa from borer pests, this is related to the resistance of insecticides in nature. [37]reports that synthetic insecticides including deltametrin after application can survive in the target field or in the environment for a relatively long period of time. Pesticides are easily degraded by ultraviolet light and not competitive against synthetic pesticides[6,38,39,40]. Botanical insecticides (garlic and lemongrass) and deltametrin insecticides do not cause phytotoxicity symptoms in cocoa fruit, so that both types can be used to protect cocoa fruits against attacks by cocoa pod borer. The deltametrin insecticide can be recommended to protect cocoa

fruits from the attack of cocoa pod borer and will be more effective on cocoa fruits which are smaller than 6 cm in length.

Botanical insecticides (garlic)have a positive impact on cocoa pod borer in protecting cocoa from cocoa pod borer. The percentage of seed damage and loss of yield is still lower in fruit and mixture, except lemongrass fragrant. Garlic can act as a botanical insecticide because it contains chemical compounds as a repellent for fruit borers. Novisan, (2002) reported that garlic extract can serve as a repellent for the presence of insects. Garlic is known to have antifeedant, insecticidal and repellent properties. In addition to allicin, garlic also contains sulfur compounds that function to prevent the crop is not eaten by insects[42,43]. The aroma released by allixin makes the pest avoid approaching the smell it has. Plant secondary metabolites can act as repellents, inhibitors, development inhibitors, and poisons that can kill insects quickly[44]. The application of garlic insecticide has provided a significant reduction in damage to cocoa fruit, so garlic can be recommended to protect cocoa fruits from the attack of cocoa pod borer. To successfully control pests with garlic in various plants, it should be known that pest activity such as laying eggs by pests, so that insecticides can be effective in protecting parts of the plant in laying eggs.

[45]reported that garlic dissolved in water was then sprayed to the entire surface of cocoa fruit evenly, twice at once a month interval resulting in the intensity of damage to cocoa fruit seeds 75.2% and yield loss 42.26%.Compared to the results of the experiments in Bolaang Mongondow, the application of the garlic solution that we did caused damage to seeds and yield losses were still low. In order to protect cocoa fruit, the application of botanical insecticides must be repeated repeatedly in short time intervals, because insecticides are easily decomposed by environmental factors. The number and time interval of the application should be based on the critical period of the plant or when the pest attacks the plant. The garlic extract with a dose of 85 g / 9 liters of water is equally effective with the dimethoate insecticide in controlling aphids, so garlic insecticides are recommended for controlling aphids[46].

Based on the reduction in damage to cocoa fruit, it can be assumed that lemongrass can be used as a repellent for cocoa pod borer. Lemongrass fragrant as a repellent has been explained by[26] the main content of fragrant essential oils of citronella is citronellal, geraniol and methylheptanon which are resistant to insects. Essential oils with the trade name citronella oil can be used as insecticides, fungicides, bactericides, molluscicides and are repellent in plant pests[23,47,48]. Lemongrass fragrant as repellent and insect poisons was examined by[49]. In vitro, citronella oil and citronellal fraction are repellent at low concentrations and insecticides at high concentrations, at concentrations of 4,000 ppm can kill cocoa fruit sucking pests, *Helopeltis antonii*. Lemongrass oil is known to contain ester active ingredients from citronellal and geraniol[50,51], which is known to cause mortality of *Diconocoris hewetti* 47% at a concentration of 2.5%[39].

The mixture of lemongrass fragrant + Bitung seeds + galangal as a botanical insecticide is not synergistic in protecting cocoa fruit against cocoa pod borer. The percentage of cocoa fruit damage and seed damage in mixed insecticides is still quite high compared to garlic and citronella. Various studies carried out by a mixture of several insecticides had a positive impact, but on the other hand had a negative impact. The formula (bandotan, goatweed, 5% + garlic 5%) at a concentration of 10 ml / l caused the intensity of damage to the lowest cocoa fruit among several treatments 10.73%, while goatweed 10% + 5% fragrant lemongrass produced high intensity of fruit damage 17.90%[45]. Furthermore, [35]reported that a combination of citronellal 34% + eugenol 80% + azadirachtin 0.6% with a dose of 10 ml l / liter caused 14.28% yield loss, and this was considered low compared to other botanical insecticidesBotanical insecticide mixture is less effective in controlling pests because the doses used by the three insecticides are the same. When one of the plant insecticides is raised in dose, it is assumed that it can be more effective in controlling cocoa pod borer. Although the insecticide mixture is less effective in protecting cocoa fruit from damage to fruit by cocoa borer pests but mixed insecticides are assumed to be more influential on the stage of cocoa pod borer larvae which can cause mortality. Synergism or antagonism of different pesticides the way it works can only be proven by applying directly to the pest organisms of the target plant[52].

Bitung seed do not show the existence of a typical compound produced by beetles as a repellent against fruit borer for laying eggs on cocoa fruit, but it can be assumed that Bitung seedscan cause mortality in cocoa pod borer, because botanical insecticides can be a contact or nerve poison cause mortality. Bitung seed has been widely used in research on controlling larvae and imago of pest insects in the field, and gives positive results.[53]reported that the Bitung seeds applied to chili plants gave significance to the population of *Aphis* sp.

This shows that the botanical insecticides whichwere applied to *Aphis* sp.were contact poison. Bitung seed contains saponin and terpenoid compounds[24]. Most insecticides contain saponin compounds as insect repellents. It is assumed that the saponin compound in the beetle may be too high or very low, so it is less effective in suppressing cocoa pod borer attacks. Some secondary metabolic chemicals can be insect attractors[27].

To be more competitive with botanical insecticides, lemongrass and garlic with synthetic insecticides on the effect of decreasing the percentage of fruit damage and yield loss, the application of botanical insecticides should be carried out for 7 days for 1 month for fruit size smaller than6 cmbecause the intensity of seed damage and yield loss has decreased significantly so as to increase cocoa production.The size of the cocoa fruit used is assumed to have been free from cocoa pod borer attacks. According to [54]the infestation of cocoa pod borer on fruit occurs when the fruit is around three months old and infestations are rarely found in ripe fruit or too young. The results of observations in the field if the cocoa fruit is old age is attacked by fruit borer intensity of damage to seeds is classified as low based on the category of sticky seed damage. Data shows that the critical period of cocoa fruit from the attack of fruit borer occurs in young fruit, if the fruit is attacked by young cocoa beans are not able to develop properly, because the seeds stick together and stick to the fruit wall, consequently the seeds become small, light, and wrinkles and meat harden. The attack on young cocoa fruit results in greater yield loss because the fruit will suffer early damage and cannot be harvested[55].

The wet weight of damaged seeds caused by cocoa pod borer can cause a decrease in the wet weight of cocoa beans. The average cocoa bean without the attack of cocoa pod borer is greater than that of cacao fruit with the attack of cocoa fruit crackers. The percentage of the decrease in wet weight of cocoa beans by the attack of cocoa pod borer is high reaching 15.2%. The value of the decrease in seed wet weight has affected the yield of cocoa beans in broad units. [56]added that in addition to reducing production, the attack of cocoa pod borer also causes the quality of seeds to be low. The large decrease in weight of cocoa beans in this experiment was related to the intensity of damage to cocoa beans. Of course the greater the intensity of the damage, the impact on the weight of cocoa beans will be. To be able to address cocoa production, the application of synthetic and botanical insecticides is time to be done on target.

Conclusion

1. Spraying synthetic and botanical insecticides can reduce the level of damage to cocoa fruit due to the attack of cocoapod borer.
2. The use of deltametrin synthetic insecticides can reduce the percentage of attack, the intensity of damage to cocoa beans and loss of yield compared to botanical insecticides.
3. The application of botanical insecticides that can significantly reduce the percentage of fruit damage, intensity of seed damage and yield loss due to the attack of cocoa pod borer is garlic and lemongrass fragrant.
4. Synthetic and botanical insecticides do not cause phytotoxicity in cocoa fruit.

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