THE EFFECTIVITY OF CITRONELLA AND CLOVE OILS AGAINTS CABBAGE CATERPILLAR *Crocidolomia pavonana*

Efektivitas minyak serai wangi dan minyak cengkeh terhadap hama kubis Crocidolomia pavonana

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ABSTRACT

Crocidolomia pavonana is a major pest on cabbage crops. The use of chemical pesticides in pest control of *C. pavonana* is not the proper solution due to the fact that the chemical pesticides are not environmentally friendly, kill natural enemies and have negative impacts on human health. The aim of this study is to determine the effectiveness of the botanical pesticide consisting of citronella and eugenol oils to control *C. pavonana*. The treatment was conducted by using two methods based on the control target, firstly is direct spray, the larvae were sprayed and then infested onto cabbage plants. The second method is indirect spray, the larvae was infested onto cabbage plants after the plants were sprayed with botanical pesticide of cittronella and eugenol. Insect mortality was observed at 1; 3; 6; 24; 48; 72 and 96 hours after applications. The results show that the botanical pesticide of citronella and eugenol at concentration of 4.0 ml l^{-1} respectively was able to effectively control of *C. pavonana* pest on cabbage leaves.

Key words: Citronella oil, clove oil, *Crocidolomia pavonana*, cabbage

ABSTRAK

Crocidolomia pavonana *merupakan hama penting pada tanaman kubis. Penggunaan pestisida kimia dalam pengendalian hama* C. pavonana *bukan solusi yang tepat karena sifat dari pestisida kimia yang tidak ramah lingkungan, membunuh musuh alami dan berdampak negatif terhadap kesehatan manusia. Penelitian ini bertujuan untuk mengetahui efektivitas pestisida nabati dengan bahan aktif minyak serai wangi dan minyak cengkeh terhadap hama* C. pavonana*. Perlakuan dilakukan dengan dua metode, yaitu larva disemprot terlebih dahulu kemudian diinfestasikan ke tanaman kubis. Metode yang kedua, larva diinfestasikan ke tanaman kubis setelah dilakukan penyemprotan pestisida nabati citronella dan eugenol pada tanaman. Pengamatan mortalitas serangga dilakukan pada 1; 3; 6; 24; 48; 72 dan 96 jam setelah aplikasi (JSA). Hasil penelitian menunjukkan bahwa pestisida nabati serai wangi dan cengkeh masing-masing konsentrasi 4,0 ml l^{-1} efektif mengendalikan hama* C. pavonana *pada tanaman kubis.*

Kata kunci*: Minyak serai wangi, minyak cengkeh,* Crocidolomia pavonana*, kubis*

INTRODUCTION

Cabbage is one of vegetable commodities which have an important economic significance as a source of income for farmers and as a source of protein, minerals, carbohydrates, fats, vitamins A, B and C which are beneficial to health. In average, farmers in Indonesia owned around 0.4 hectares, and there are about 165,000 farmers who engaged in cabbage plants farming (Sastrosiswojo *et al*., 2005). Data from the Indonesian Agency for Statistics Centre showed that demand of cabbage is very high in Indonesia; however the local production of cabbage cannot still meet the demand in the market. In 2013, the production of

cabbage was approximately 1,480,625 tons (BPS, 2014).

There are many problems faced by farmers along the cultivation of cabbage, one of the obstacles is the existence of *Crocidolomia pavonana* pests. *C. pavonana* is a major pest on cabbage plants. *C. pavonana* larvae feed the young cabbage leaves. After the larvae destroy the central of the shoot, they move to the tip of the leaves and feed the older leaves (Prijono *et al.,* 2006). The affected plants will have severe damage if *C. pavonana* is not properly controlled. The income of farmers declines as consequence of the yields decrease (Asriani *et al*., 2013).

C. pavonana is a nocturnal insect pest, active during night time, and always avoiding from exposing to the light. The female lay it eggs on abaxial leaf in groups that consist of 30 to 80 eggs. A single female can lay up to 1,460 eggs within 24 days of its life span. After the eggs hatching, the larvae start to eat the leaves, particularly the inside part tissue (Uelese *et al.,* 2014). Instar larvae are gregarious, feed the leaves on the lower surface of the upper layers of the epidermis and leaving white patches. Within the fourth to fifth days, the larvae eat the leaves from the bottom and will cause severe damage to the leaves before the larvae move to the center of the plant. The third and fifth instar larvae scatter and eat the top of the cabbage plants and destroy the growing point. As a result, the plants die or cabbage stems forming branches and the crops size eventually becomes small and consequently the cabbage cannot be harvested. In high populations the green debris mixed with silk threads can be found on attacked cabbage (Lina *et al*., 2010).

Farmers usually eradicate the cabbage caterpillar using chemical pesticides intensively, either applying single or combine of multiple pesticides. Therefore the cost of using pesticides is approximately 30% of total costs of production. This control measure leads to negative impacts which are the resistance of *C. pavonana* to chemical pesticides, resurgence of *C. pavonana to* which is resistance against Asefat, Permetrin and Kuinalfos, disruption of life and the role of the parasitoid *Diadegma semiclausum* as important natural enemies of *C. pavonana*, damaging ecosystems, and pesticide residues which may harm consumers (Grzywacs *et al.,* 2010).

The use of botanical pesticides in controlling the pests has been carried out in several countries recognizing and taking advantage of botanical pesticides (Thorsell *et al.,* 2006). Botanical pesticide is potential for controlling the major pests of agricultural crops owing to utilizing the plant secondary compounds as the active ingredient. The compounds serve as a repellent, attractant, killer and inhibiting appetite of targeted pests (Charleston *et al.,* 2006). The use of botanical pesticides is expected to reduce the use of chemical pesticides/ synthetic, so that the residues of chemical pesticides carrying a variety of negative effects on the environment can be minimized as low as possible (Wiratno, 2011).

Some examples of plant secondary compounds characterized to reject the insects are geraniol and citronella from citronella plant and eugenol from cloves. It has been reported that a combination of citronella and eugenol at a concentration of 5.0 ml l^{-1} was able to control the cocoa fruit borer *Conophomorpa cramerella Snell* by around 46.26 to 65.01% at severe infestation (Laba *et al.,* 2011). Citronella oil can also cause mortality of *D. hewetti* (pepper flower sucking insect pest) by 47% at a concentration of 2.5%; combination of citronella oil and galangal (1: 1) at a concentration of 2.5% was able to cause mortality of *D. hewetti* by 82% (Wiratno *et al*., 2011). Previous study showed that methyl eugenol compound contained in clove oil can be used as an attractant of the male fruit flies, therefore it can be used to control fruit flies with environmentally friendly (Towaha, 2012). With all the benefits, it is necessary to study the potential of citronella and clove oils as active compounds of botanical pesticides against *C. pavonana*. The

purpose of this study is to determine the effectiveness of the botanical pesticide with active ingredients of citronella and clove oils against *C. pavonana*.

MATERIALS AND METHODS

This study was conducted at the green house of Plant protection Department of Indonesian Spice and Medicinal Crops Research Institute, Bogor, from May to June 2014. The temperature in the greenhouse ranged between 25 and 27°C. Materials used in this study were 1 month-old of cabbage plants in polybag, *C. pavonana* larvae instar two obtained from cabbage farms in Pacet, West Java, gauze cloth as a cover, citronella oil, clove oil, and water. Botanical pesticides were obtained from Manoko Research Station at Lembang West Java, tested botanical insecticides were clove oil and eugenol of fallen clove leaves and citronella oil obtained by destillation process.

Randomized block design was applied, consisting of nine treatments and five replications; control group, citronella oil at concentration of 1, 2, 3, and 4 ml l^{-1} and clove oil at concentration of 1, 2, 3, and 4 ml l^{-1} (Table 1). Cabbage leaves were putted into the plastic box with size of 15 cm x 10 cm x 5 cm, and covered by gauze for air circulation. Three leaves were used for each treatment. This research was carried out with two methods. The first method, larvae were sprayed topically and then infested onto cabbage plants (Dirjen PSP, 2014). The second test was the food poisoning method of spraying the plants with cittronella and clove oils before infesting the larvae onto leaves (Atmadja, 2010). Insect mortality was observed at 1; 3; 6; 24; 48; 72 and 96 hours after applications.

Efficacy of tested insecticides was calculated by the Abbott formula (DG PSP , 2004):

EI = $((Ca-Ta) \times Ca^{-1}) \times 100\%$

EI = Efficacy of insecticides tested (%)

Ca = Population on control after insecticide aplication

Ta = Population on treatment after insecticide aplication

Table 1. Treatment arrangement of tested insecticides.
Tabel 1. Susunan perlakuan insektisida uji.

No.	Treatments	Concentration (ml l^{-1})
1	Eugenol	1.0
2	Eugenol	2.0
3	Eugenol	3.0
4	Eugenol	4.0
5	Citronella	1.0
6	Citronella	2.0
7	Citronella	3.0
8	Citronella	4.0
9	Untreated	-

RESULTS AND DISCUSSION

Results of this study demonstrated that mortality of *C. pavonana* and insecticide efficacy in the treatment of spraying larvae before being infested onto host plants indicates increasing the number of dead larvae along with increasing observation time (Table 2). Citronella at 4.0 ml l^{-1} concentration showed to have the fastest action, caused mortality of 34.0% with 34% efficacy of insecticide (EI) at three hours after application. Cittronella and eugenol treatments at 4.0 ml l^{-1} concentration showed mortality more than 50.0% at 48 hours after application. The highest mortality and efficacy were occurred on citronella treatment at 4.0 ml l^{-1} concentration. This is in accordance with a previous study conducted by Pinheiro *et al*. (2013) indicating that citronella at concentration of 1.0% was able to reduce the development of *Franklinella schultzei* and *Myzus persicae* pest in soybean plants. The study conducted by Rohimatun and Laba (2013) showed that citronella oil treatment at concentration of 5.0 ml l^{-1} effectively reduced the population of *D. piperis* of black pepper in the field.

Meanwhile, at three hours after application of eugenol treatment at concentration of 3.0 ml l^{-1} with spraying method onto larvae before being infested onto host plants demonstrated mortality and EI of 18.00 and 18.0%

respectively. The highest mortality at 48 hours after application with concentration of 4.0% occurred on eugenol treatment is 56.0% (Table 2). Study of Shola and Kehinde (2010) indicated that eugenol at concentration of 0.1; 0.2; 0.3; 0.4 and 0.5 g in one g solid compounds (silica gel, alumina and kaolin), caused mortality of *C. maculatus* by 13.3; 26.7; 73.3; and 100% at one hour after application.

In spraying onto plants method, the highest mortality and EI of *C. pavonana* are 42.0% resepctively at three hours after treatment with 4.0% citronella concentration (Table 3). Similar to the spraying onto larvae method of 4.0%, citronella treatment was the treatment showed the highest efficacy (Table 3). This is due to the highest concentration used which leads to the highest mortality of *C. pavonana*. At 24 hours after application, citronella treatment with concentration of 3.0 and 4.0% were able to generate the mortality more than 50.0%.

The result of this research was similar to the one reported by Suriati and Atmadja (2010) that 3 and 4% concentration of citronella was effective against 3th instar larvae of *Spodoptera litura* with more than 50% mortality for 24 hours after application.

The treatment of 4.0% eugenol generated 24.0% mortality of *C. pavonana* at three hours after application. Eugenol at 4.0% concentration caused mortality above 50.0% at 48 hours after application. Results of the study conducted in the field on *S. litura* indicated that botanical pesticide of citronella and eugenol effectively controlled *S. litura* with 10 ml l^{-1} concentration respectively (Atmadja, 2010). Clove plants contain various volatile compounds such as eugenol, eugenol asetate and methyl eugenol. Eugenol is easy to evaporate. The concentration of eugenol in clove oil is approximately between 70 and 90%. The eugenol is colorless and if exposed to direct sunlight, the color turns to dark brown and emitting specific odor (Haq *et al*., 2014).

Mode of action of eugenol by spraying onto larvae method was faster than that was sprayed onto the plants method, as well as the use of eugenol compared to the use of citronella with the same method,the effect of citronella is faster than eugenol (Figure 1). This is consistent with the study conducted by Fikri *et al.* (2010) showed that at a concentration of 5.0 ml l^{-1} citronella compound works as a stomach poison due to it is able to control *Trips* sp. on *Jatropha* around 49,4% at 96 hours after application.

At the end of the observation, it is showed that the mortality of *C. pavonana* was around 48-88% for the citronella treatment. This indicates that eugenol and sitronella do not kill all *C. pavonana* but keeping them at low population. This unique characteristic of both botanical pesticides corresponds to the principle of Integrated Pest Management (IPM), which does not kill all the pests in the field, but keeping them at low population to maintain the balance of pest population with its natural enemy, hence the natural enemy can act as its role (Wiratno *et al.,* 2013).

The resistance of *C. pavonana* against synthetic pesticide can be overcome by using botanical pesticide (cittronella and eugenol) because of the mode of action of botanical pesticide differences between synthetic pesticides. Cittronella and eugenol do not directly kill the larvae quickly, but the feeding activity of *C. pavonana* becomes disrupted and lead to declining the nutrition intake which is required by insects for growth and development. This is because the delivery of feed stimuli (*phagostimulant*) has been disturbed by cittronella and eugenol.

Citronella and eugenol treatments did not eradicate all *C. pavonana*, due these two botanical pesticides tend to have more a contact action with insects pest, this is shown from the mortality rate of spraying larvae method. Mode of action of citronella and eugenol is to inhibit activity of

Table 2. The efficacy of botanical insecticides: eugenol and citronella against *C. pavonana* with the spraying onto larvae method.
Tabel 2. Efikasi insektisida eugenol dan sitronelal terhadap C. pavonana dengan *metode semprot larva.*

Treatments	Efficacy of Insecticide (%)													
	1 hour	EI	3 hour	EI	6 hours	EI	24 hours	EI	48 hours	EI	72 hours	EI	96 hours	EI
Eugenol 1.0 ml l^{-1}	0.00 B	0.0	16.00 B	16.0	18.00 C	18.0	28. 00 B	28.0	40.00 C	40.0	64.00 A	64.0	72.00 B	72.0
Eugenol 2.0 ml l^{-1}	2.00 B	2.0	16.00 B	16.0	18.00 C	18.0	26.00 B	26.0	40.00 C	40.0	66.00 A	66.0	76.00 AB	76.0
Eugenol 3.0 ml l^{-1}	4.00 B	4.0	18.00 B	18.0	20.00 BC	20.0	40.00 A	40.0	48.00 ABC	48.0	78.00 A	78.0	80.00 AB	80.0
Eugenol 4.0 ml l^{-1}	6.00 B	6.0	16.00 B	16.0	20.00 BC	20.0	40.00 A	40.0	56.00 A	56.0	78.00 A	78.0	86.00 A	86.0
Citronella 1.0 ml l^{-1}	20.00 A	20.0	24.00 AB	24.0	24.00 BC	24.0	40.00 A	40.0	46.00 AB	46.0	68.00 A	68.0	76.00 AB	76.0
Citronella 2.0 ml l^{-1}	18.00 A	18.0	20.00 B	20.0	32.00 AB	32.0	38.00 A	38,0	48.00 ABC	48.0	66.00 A	66.0	78.00 AB	78.0
Citronella 3.0 ml l^{-1}	22.00 A	22.0	32.00 A	32.0	32.00 AB	32.0	40.00 A	40.0	48.00 ABC	48.0	70.00 A	70.0	78.00 AB	78.0
Citronella 4.0 ml l^{-1}	24.00 A	24.0	34.00 A	34.0	36.00 A	36.0	44.00 A	44.0	52.00 AB	52.0	76.00 A	76.0	88.00 A	88.0
Control 0 ml l^{-1}	0.00 B	0	0.00 C	0	0.00 D	0	0.00 C	0	0.00 D	0	0.00 B	0.0	0.00 C	0.0

Note: Value in one column followed by the same letter is not significantly difference based on Duncan test at 5%. EI = efficacy of insecticide (%).
Keterangan: Nilai dalam satu kolom yang diikuti huruf yang sama tidak berbeda nyata berdasarkan uji Duncan pada taraf 5%. EI = efikasi insektisida (%).

Table 3. The efficacy of botanical insecticides: eugenol and citronella againts *C. pavonana* with the spraying onto plants method.
Tabel 3. Efikasi insektisida eugenol dan Sitronelal terhadap C. pavonana *dengan metode semprot tanaman.*

Treatments	Efficacy Insecticide (%)													
	1 hour	EI	3 hours	EI	6 hours	EI	24 hours	EI	48 hours	EI	72 hours	EI	96 hours	EI
Eugenol 1.0 ml l^{-1}	0.00 A	0.0	16.00 BC	16.0	18.00 C	18.0	30.00 BC	30.0	34.00 C	34.0	48.00 D	48.0	52.00 B	52.0
Eugenol 2.0 ml l^{-1}	0.00 A	0.0	12.00 C	12.0	18.00 C	18.0	20.00 C	20.0	30.00 C	30.0	50.00 CD	50.0	54.00 B	54.0
Eugenol 3.0 ml l^{-1}	0.00 A	0.0	22.00 B	22.0	26.00 BC	26.0	40.00 B	40.0	60.00 B	60.0	72.00 AB	72.0	80.00 A	80.0
Eugenol 4.0 ml l^{-1}	0.00 A	0.0	24.00 B	24.0	28.00 B	28.0	40.00 B	40.0	60.00 B	60.0	74.00 AB	74.0	82.00 A	82.0
Citronella 1.0 ml l^{-1}	0.00 A	0.0	18.00 BC	18.0	20.00 BC	20.0	26.00 C	26.0	30.00 C	26.0	40.00 D	40.0	48.00 B	48.0
Citronella 2.0 ml l^{-1}	0.00 A	0.0	16.00 BC	16.0	22.00 BC	22.0	24.00 C	24.0	34.00 C	34.0	62.00 BC	62.0	82.00 A	82.0
Citronella 3.0 ml l^{-1}	0.00 A	0.0	42.00 A	42.0	42.00 A	42.0	72.00 A	72.0	76.00 A	76.0	84.00 A	84.0	88.00 A	88.0
Citronella 4.0 ml l^{-1}	0.00 A	0.0	42.00 A	42.0	44.00 A	44.0	64.00 A	64.0	80.00 A	80.0	84.00 A	84.0	88.00 A	88.0
Control 0 ml l^{-1}	0.00 A	0	0.00 D	0	0.00 D	0	0.00 D	0	0.00 D	0	0.00 E	0.0	0.00 C	0.0

Note: Value in one column followed by the same letter is not significantly difference based on Duncan test at 5%. EI = efficacy of insecticide (%).
Keterangan: Nilai dalam satu kolom yang diikuti huruf yang sama tidak berbeda nyata berdasarkan uji Duncan pada taraf 5%. EI = efikasi insektisida (%).

acetyl cholinesterase enzyme, so the amino acid phosphorylate in the astatic center of the enzyme is occurred. The toxicity signs of insect arose because of acetylcholine accumulation generating disruption of central nervous system, femor, respiratory paralysis, and mortality. Citronella and eugenol do not kill the insect quickly, but has an impact on decreasing the appetite, growth, reproduction, ecdysis process, inhibition to be mature insect and sterilizer of *Conophomorpa cramerella* (Willis *et al.*, 2013). Synthetic pesticide only has one action which is to disrupt nervous system by inhibiting the activity of acetyl cholinesterase (AChe) and causing the accumulation of acetyl choline. In resistance insect pests, the AChe enzyme which is the target of synthetic pesticide becomes unsusceptible; as a result insect will be more resistance if being sprayed with synthetic insecticide and does not develop paralysis or die as normally found in common insects (Dono *et al.,* 2008).

Mortality of *C. pavonana* from all the treatments varied according to the increasing time observation, this means that botanical pesticide of citronella and eugenol has different actions to kill *C. pavonana* larvae. This is in line with the study conducted by Wirahadian (2007) in which it shown that botanical insecticide of *B. asiatica* seed extract has various actions in killing the insect; containing compound that toxic, antifidan, antiovipotition, influencing fecundity, inhibiting the development of larvae, and effect the efficiency of food utilization of *C. pavonana* on the plant.

The change of larvae resistant against a poison contact pesticide is caused by the change of cuticle; cuticle thickness and reduction of lipid content. Larvae are usually susceptible against poison contact pesticide after ecdysis process, and the resistance increases along with the age, and then decrease at the time of ecdysis. Penetration rate on one part of cuticle depends on the structure and thickness of that particular part. Pesticide generally tends to enter insect body through the parts of the body covered by thin cuticle, such as inter-part membrane, joint

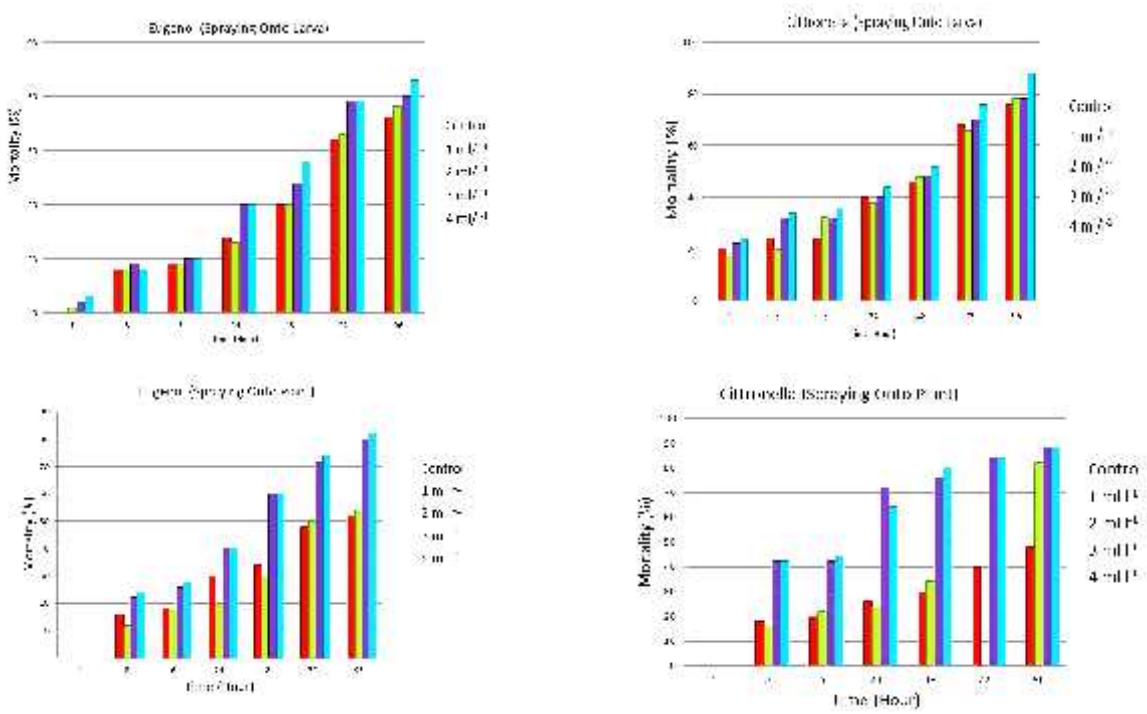

Figure 1. Effect of Eugenol and Cittronella on mortality of *C. pavonana.*
Gambar 1. Pengaruh Eugenol dan Sitronela terhadap mortalitas C. pavonana.

membrane on the base of embelan and chemoreceptor on tarsus (Dono *et al.,* 2010).

CONCLUSION AND RECOMMENDATION

Botanical pesticides with active ingredients of citronella and eugenol have a contact action. In the spraying onto larvae treatment method, citronella and eugenol were effective at a concentration of 2-4 ml l^{-1} with a mortality rate of 76-88 and 72-86% respectively. While the mortality rate in the spraying onto plant treatment method ranged between 48-88 and 52-82%. Further studies need to be conducted to improve the formulation of botanical pesticide of citronella and eugenol.

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