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(REVIEW ARTICLE)

Plants suspected to contain bio insecticidal agents against mealybugs (Hemiptera: Pseudococcidae) in Indonesia

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Abstract

Mealybugs (Insecta; Hemiptera: Pseudococcidae) are the important pest of agricultural crops and ornamental plants worldwide, including in Indonesia. Beside their high invasive nature and high economic impact, mealybugs are difficult to control so that the presence of this insect is of serious concern. That is why research to find effective ways to control and eradicate mealybugs is continuously being carried out in many countries including Indonesia. This paper presents the results of research on the search for natural ingredients from plants that can be developed into bioinsecticides against mealybugs conducted in Indonesia in the last 20 years. The data were compiled by searching relevance papers containing researches done in Indonesia, by Indonesian researchers that have been published both in national and international journals that can be accessed using Google search engine. The result is as follows. There are three genera of mealybugs that are of the greatest concern because of the high losses they cause, namely: Planococcus, Pseudoccus, and Paracoccus. There are 19 plant species that have been reported as a potential source of insecticides against mealybugs including *Allium sativum, Anonna squamosa, Areca catechu, Azadirachta indica, Barringtonia asiatica, Carica papaya, Cassia spectabilis, Cinnamomum burmannii, Cymbopogon nardus, Eucalypus sp., Gliricidia sepium, Lantana camara, Moringa oleifera, Nicotiana tabacum, Piper betel, Piper retrofractum, Reutealis trisperma, and Tephrosia vogelii.*

Keywords: Mealybugs; *Papaya mealybugs; Cassava mealybugs*; Bioinsecticide; Plant-derived insecticide

1. Introduction

The mealybug (Insecta; Hemiptera: Pseudococcidae) is an important pest of agricultural crops and ornamental plants worldwide. Most areas across continents: America, Africa, Asia, Australasia and Europe with a suitable climate and host plant types are potentially invaded by this insect. [1]. The small, sap-sucking scale insect that is coated with a white, powdery wax that resembles mealare known the most polyphagous insects in at least 250 plant host families, includingMalvaceae, Rutaceae, Solanaceae, Caricaceae, Compositae, Poaceae, Asteraceae, Fabaceae, Rosaceae, Rubiaceae, Euphorbiaceae, Myrtaceae, Labiatae, Moraceae and Cyperaceae [2-4].

The polyphagous nature of the mealybug makes various types of crop plants susceptible to the invasion of these insects. *Planococcus citri* Risso, the citrus mealybug, for examples is a highly polyphagous mealybug that is reported to infect many types of economic crops, apart from its favorite host citrus, including tomatoes (Family Solanaceae) and cocoa (Familia Malvaceae) [5].The papaya mealybug, *Paracoccus marginatus* Williams and Granara de Willink whose favorite host is papaya (*Carica papaya*) has been reported to infect many economic plants genera including Acacia, Acalypha, Ananas, Annona, Bidens, Capsicum, Hibiscus, Ipomoea, Mangifera, Manihot, Persea, Plumeria, Punica, Solanum and Vigna. That's why the losses caused by the papaya mealybug in many areas, such as India and Indonesia (Oriental Region) are reported to be in the millions of dollars [6].

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Cassava mealybug, *Phenacoccus manihoti* Matile-Ferrero, for another example is also reported to infect and have tolerance to several types of plants such as the genera of Poinsettia and Talinum [7]. Other reports indicated that cassava mealybug feeding on hosts belonging to Cyperaceae, Euphorbiaceae, Fabaceae, Lamiaceae, Malvaceae, Nyctaginaceae, Portulacaceae, Rutaceae and Solanaceae [8].

Papaya mealybug (*Paracoccus marginatus*) and cassava mealybug (*Phenacoccus manihoti*) are among the invasive mealybugs that are reported to cause crop losses and economic impact worldwide. In Kenya, papaya is the most affected crop by this pest and estimated caused yield losses up to 57% with a national economic loss of US$29.8 million annually [9]. *Phenacoccus manihoti,* the cassava mealybug, is known to reduce cassava crop yields by 54.4% - 84.4% [10].

In addition to its high invasive nature and high economic impact, mealybugs are the insect pests group difficult to control so that the presence of this insect is of serious concern [11]. Many efforts to manage, prevent and control this pest have been developed in vulnerable invaded countries [12, 13]. One of the efforts made by agricultural pest researchers in many developing countries is to seek and develop plant-derived bio-insecticides. Some of the studies gave positive results.

In Thailand, Roddee et al. (2020) for instance succeeded in applying botanical extracts of bird chili, garlic, black pepper, and and neem to kill tomato mealybug of *Ferrisia virga*ta (Hemiptera: Pseudococcidae) in tomato up to 100% in their toxicity assay experiment [14]. Still from Thailand, Pumnuan et all. (2021) revealed that plant extract of teak (*Tectona grandis*) potential to be developed as botanical insecticide against cassava mealybug [15]. Avila et al. (2023) in their review paper indicated that essential oils extracted from several plant of Myrtaceae, Lamiaceae, Rutaceae, Zingiberaceae and Euphorbiaceae families and the genera of Citrus, Cymbopogon, Syzygium, Cinnamomum and Jatropha can be used as an biopesticide formulation against mealybug pests belonging to Pseudococcidae family [16]

This paper presents and discusses the results of research on the search for plant-based bioinsecticides against mealybugs that have been conducted in Indonesia in the last two decades.

2. Methodology

Mealybug, Pseudococcidae, bioinsecticide, plant-derived insecticide, pest control, pest management, and kutu putih (Indonesian terms for mealybugs) are the keywords used in searching relevant papers via internet. The inclusions criteria of the papers retrieved are that have been published both in national and international journals that can be accessed using Google search engine. All indexing journal databases (Google Scholars, Science Direct, Scopus, SCI, DOAJ) were considered, but none of which is prioritized. Only papers containing the results of research conducted in Indonesia, by Indonesian researchers, which were published within the last 20 years (2004 -2023) were compiled.

3. Results and discussion

In Indonesia there are three genera of mealy bugs that are of the greatest concern because of the high losses they cause, namely: Planococcus, Pseudoccus, and Paracoccus . Among the genus of Planococcus, *Planococcus citri* Rissocauses damage to coffee and cocoa plantations. *Pseudoccus ciitriculus* infects secondary crops such as rosella *(Hibiscus sabdariffa L.)* and purple eggplant *(Solanum melongena L.).* Meanwhile, *Paracoccus marginatus* is not only destructive against its favored host, the papaya *(Carica papaya L.),* but also against other plants such as chili pepper (*Capsicum frutescens* L) and *Acacia mangium.*

The bioassay results against those three genera of mealybugs using plant-derived insecticide ingredients that have been done in Indonesia in the last two decades are presented in Table 1.

Table 1 Test results of several types of plant extracts against mealybugs in Indonesia

Type of mealybug	Host crops	Insecticide source plant	Efficacies	Reference
Planococcus citri	Coffee (*Cofea* sp)	*Cassia spectabilis* *Nicotiana tabacum*	In field applications, the extracts of the two plants, at a concentration of 3%, proved to be as effective as standard insecticides (Methidation 0.8 l/ha) in suppressing mealybug populations in coffee plantation.	17
Planococcus citri Risso	Coffee *(Coffea robusta* L)	Gliricidia sepium (Jacq.) Kunth ex Walp	LC_{50} and LT_{50} values suggest that both crude aqueous and methanol extracts of *Gliricida sepium* leaves are toxic and lethal to the coffee mealybugs, water extract is more effective in comparison to the methanol extract	18
Planococcus sp.	Cacao (*Theobroma cacao*)	*Cassia spectabilis* *Gliricidia sepium* *Cinnamomum burmannii* *Allium sativum* *Reutealis trisperma* *Cymbopogon nardus*	Application of the crude extracts and essential oils of the 6 plants at a concentration of 5% on the insect and host plant resulted in a mortality rate on the mealybug as the same as deltamethrin, the standard pesticide.	19
Pseudoccus sp	Roselle plant (*Hibiscus sabdariffa*)	*Lantana camara* L.	At the concentration of 6,25%the plant extract of *L. camara* siginicantly caused mortality of the pest as effective as chemical insecticide (Decis 0,1% and Propineb 0,2%)	20
Pseudococcus citriculus	Eggplant (*Solanum melongena* L)	*Piper betel* *Carica papaya*	Betel extract of 100 g/l suppress mealybug populationup to 35%. The treatment of betel leaf of 100 g/l also gave the highest yields on the number of fruits per plant and fruit length and total plant weight	21
Pseudococcus longispinus	Rose apple (*Syzygium aqueum*)	*Gliricidia sepium* (Jacq.) Kunth ex Walp	The toxicity of the extract remained unchanged for 3 years of storage. The leaf extract of the *G. sepium* has the potential to be developed into a plant-derived insecticide.	22
Pseudococcus sp	Puring (*Codiaeum variegatum*)	1. *Moringaoleifera* 2. *Areca catechu* L.	Areca seed extract increases the mortality of mealybugs up to 31.63%, while moringa leaf extract increases mortality up to 22.03%.	23
Paracoccus marginatus	Papaya *(Carica papaya)*	*Tephrosia vogelii* *Piper retrofractum* *Anonna squamosa* L.,	LC_{95} at 72h of each extract, consecutively are: 1.25% (Tv),1.48% (Pr), 0,46% (As)	24
Paracoccusnarginatus	*Tree seedling of Acacia mangium*	*Eucalypus sp*	At 30 g/l the water extract is resulted in LT50 of 56.50 hours and the total mortality up to 90%.	25

Paracoccus marginatus	Papaya *(Carica papaya)*	Gliricidia sepium (Jacq.) Kunth ex Walp	Both types of *G. sepium* leaves extract, the aqueous and methanolic, are lethal to the papaya mealybug *P. marginatus* with LD_{50} values of 0.063% and 0.09% respectively	26
Paracoccus marginatus	Papaya *(Carica papaya)*	*Gliricidia sepium*	The bioassay test of the formulation showed a a mortality rate up 86.7%.	27
Paracoccus marginatus	Papaya *(Carica papaya)*		The extract reducing fecundity and causing mortality.	28
Paracoccus marginatus	Chili pepper (*Capsicum frutescens* L)	*Nicotiana tabaccum (cigarette waste)*	Decreased infestation rate	29
Paracoccus marginatus	Papaya *(Carica papaya)*	*Azadirachta indica* *Barringtonia asiatica*	At a concentration of 3% the extract suppress the densities of mealybug up tot 65%.	30

Those invasive mealybugs (Hemiptera Pseudococcidae) listed in Table 1 above are relatively new insect pests in Indonesia. At least, until the 1960s, the highly destructive mealybugs had not been identified in the preserved collections of plant pests in Indonesia [31]. However, currently the distribution of invasive mealybugs is very widespread and has become a serious threat to agriculture and plantations in Indonesia. This condition encourages researchers of plant pests and diseases in this country to continuously study various aspects of the mealybugs. Studies of host plant species revealed that certain plants were potentially infected by several species of mealybugs. Dragon fruit plant (*Hylocereus undatus*; Cactaceae) as an example, is known to be invaded by at least four types of whitefly such as *Ferrisia virgata, Planococcus minor, Phenacoccus solenopsis and Pseudococcus jackbeardsleyi* [32]

Another aspect studied is the role of mealybugs in the spread and transmission of pathogenic diseases in plants which include viruses, bacteria, or fungi.In black pepper (Piper nigrum) it is known that three types of mealybugs (*Planococcus minor, Ferrisia virgata* and *Paracoccus marginatus*) can be vectors of mottle disease caused by piper yellow mottle virus (PYMoV) [33]. Symptoms of PYMoV -infected pepper plants include mild to moderate yellow mottling followed by deformation of the leaf, reduction in the intermodal length and stunting of plants [34].

The research of greatest interest, of course, is research into finding ways to control and eradicate mealybugs. In addition to the search for natural ingredients that have the potential to be used as insecticides which have been presented in Table 1 above, various biological control experiments were also developed. A study carried out in North Minahasa of Sulawesi (western Indonesia) found that there are natural enemies of papaya mealybug, *Paracoccus marginatus*. Chilocorus sp. Scymnus sp. (Coleoptera), Oecophylla smaragdina and some of the family Formicidae (Hymenoptera), earwig (Dermaptera), mites (Acari) and Tetragnatha sp, Tetragnatidae; Plexippus sp. Telamonia sp; Lycosidae (Aranea) are among the natural enemies of the mealybugs [35]. Furthermore, field trials conducted in several areas in Indonesia (Lampung, Java, and Nusa Tenggara) showed that the cassava mealybug *Phenacoccus manihoti* Matile-Ferrero (Hemiptera: Pseudococcidae) can be controlled by introducing the exotic parasitoid *Anagyrus lopezi* (De Santis) (Hymenoptera: Encyrtidae) with parasitism rates reaching59.18% [36].

Regardless of whether research to find plant-derived insecticides in Indonesia in the last 20 years has yielded reliable results or not in eradicating mealybugs, their efforts are worth appreciating. At least, the researches that have been performed are part of the effort to preserve consumers health, because plant-derived pesticides maybe a green alternative to synthetic ones [37]. In terms of quality, the research conducted by the Indonesian researchers still needs to be improved, among others, by ascertaining the type, nature and mechanism of the active ingredients contained in the plants that will be nominated as insecticides. Only when the type, class, nature and mechanism of action of the metabolite constituents are known can the drug product be approved and meet commercial standard requirements [38].

4. Conclusion

In Indonesia, the invasive mealybugs hve spread widely and is a threat to agricultural and plantation crops in this country. In an effort to control and eradicate these pests, plant pest and disease researchers are actively searching for plant-derived substances that can be developed as natural bioinsecticides that are safe for the environment and health. There are at least 19 plant species that have been reported as a potential source of insecticides against mealybugs. These plants are *Allium sativum, Anonna squamosa, Areca catechu, Azadirachta Indica,Barringtonia asiatica, Carica papaya, Cassia spectabilis, Cinnamomum burmannii, Cymbopogon nardus, Eucalypus* sp., *Gliricidia sepium, Lantana camara, Moringa oleifera, Nicotiana tabacum, Piper betel, Piper retrofractum, Reutealis trisperma,* and *Tephrosia vogelii.* However, in order to obtain bioinsecticides that met the commercial standard requirements the researches still need to be improved especially regarding the type, nature and mechanism of the active ingredients contained in the plants.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare no conflict of interest.

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