Prolife
Jurnal Pendidikan Biologi, Biologi, dan Ilmu Serumpun
https://ejournal.uki.ac.id/index.php/prolife

Insect Pest Problem in Industrial Forest Plantation and Their Management

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Article History

Received : 12 December 2023
Approved : 27 February 2024
Published : 31 March 2024

Keywords
Acacia, Eucalyptu, forestry, insect pest management, IPM.

ABSTRACT

The problem in Industrial forest plantations confront from insect pests, with an emphasis on Indonesian Acacia crassicarpa and Eucalyptus species The reported insect pests Glycyphana nicobarica, Helopeltis theivora, Altica sp., and Spodoptera exigua are examined in this paper. Chemical procedures are not used as a last resort in management strategies, which prioritise environmental sustainability. Instead, they are integrated into cultural, mechanical, and biological controls, along with preventive measures. In order to stop and prevent insect pest infestations, this article promotes an integrated strategy that gives priority to environmental and economic concerns. This article supports sustainable practises in industrial forest plantations by highlighting balanced control strategies and proactive planning.

INTRODUCTION

The area of forest plantations will continue to grow and market demand will increase; by 2070, it is projected that forest plantations will expand to around 379 million ha (Nepal et al., 2019). One of the barriers or obstacles faced in forest plantations is pest attack. Pest attacks have attacked *Acacia crassicarpa* and *Eucalyptus* spp. since the seedling stage. Various reports have long reported this attack from various types of insect pests and from various insect orders, such as Lepidoptera, Hemiptera, Thysanoptera, and others (Kkadan et al., 2020).

In fact, many new insect pest attacks have been reported in forest plantations in several regions of Indonesia, including *Myllocerus scapularis* Roelofs (Coleoptera: Curculionidae) and *Rhytiphora bankii* (Fabricius) (Coleoptera: Cerambycidae). This pest attack occurs in Acacia crassicarpa plantations in Riau and North Sumatra, Indonesia, with various levels of detrimental attacks. Attacks occur in nurseries up to 2 months old, and the visible symptoms of an attack are leaf damage caused by attacks by herbivore insects (Sirait et al., 2020).

There are many control options that can be used to overcome the problem of herbivorous insects, such as chemical and non-chemical applications. Although it cannot be denied that the forest plantation industry requires quick action to control insect pests, they tend to use chemical control. Although there are also many reports reporting the successful use of entomopathogens, bioinsecticides, natural enemies such as parasitoids and predators, resistant varieties, cultivation modification practices, and integrated pest management (IPM). The urgency of IPM can engineer the environment for the existence of various beneficial insects that are able to control the existence of herbivore insects. Dharma et al. (2018) found that organic cultivation efforts are able to increase the presence of parasitoids and predators in cultivated crops.

In an effort to control insect pests, it is necessary to know the economic threshold number of each type of pest insect at the point where pest attacks cannot be tolerated any longer, which can have fatal consequences if identification and control measures are too late. Control using chemicals is indeed the easiest to use, but there are many side effects produced, such as changes in the ecosystem, insect pest resistance, resuscitation, and killing beneficial insects. So preventive measures are also the most important part of efforts to manage the presence of insect pests in industrial forest plantations.

In this article, we will review the plants *A. crassicarpa* and *Eucalyptus* spp., which are generally cultivated in industrial forest plantations, as well as the types of insect pests that are reported to attack these two plants, a discussion of pest control that has been empirically proven to be able to control them, and various control techniques that can be integrated with each other to prevent and suppress insect pest attacks by prioritising economic and environmental factors.

FOREST PLANTATION CROPS

One of the trees used in industrial forest plantations is *Acacia crassicarpa*, because it is known to have the potential to be developed in various ecosystem conditions and is usually cultivated in wet land areas that are rich in organic material but minimal in minerals. *A. crassicarpa* is an endemic tree spread across Australia and Papua Island (Indonesia and Papua New Guinea), which has the ability to grow quickly and has strong wood and advantages for furniture, pulp and paper (Hanchor et al., 2016).

The strength of wood has an air-dry density of 710 kg per cubic metre and a basic density of 620 kg per cubic meter. A. crassicarpa is the best species of wood tree to be used as pulp and paper. Other advantages are the high nitrogen fixation ability and the rhizobium nodulation ability. The seeds of natural populations of A. crassicarpa originating from Papua New Guinea and Australia have been distributed in various countries in Asia, Africa, America, and various island countries such as the Leeward Islands, Hawaii, Micronesia, and Madagascar, although there are also many reports that not all areas are able to cultivate this tree (Pasieczni and McDonald, 2016).

Eucalyptus is a forest plant that is cultivated in industrial forest plantations apart from *Acacia crassicarpa*. The species commonly used is *Eucalyptus pellita*, which is used as raw material in the pulp and paper industry in the world. In Indonesia, for example, this species is used in mineral land areas. *E. pellita* has the ability to grow quickly and is usually harvested after 7 years; currently, it is even harvested at 5 years of age (Muhdi et al. 2019).

E. pellita is naturally distributed in Papua New Guinea, Australia, and Papua (Indonesia). Generally, *E. pellita* grows at an altitude of 0-800 m, with rainfall of 1000 to 3000 mm/year and a dry season of up to 5 months. For productivity, it is known that *E. pellita* will be more productive in areas with high rainfall. It is known that the productivity of *E. pellita* is between 9.4 and 34.9 m3/ha/year. not only in high rainfall areas, *E. pellita* is also able to grow in low rainfall (1000–1200 mm/year) and lower temperatures (22 °C), provided that many other factors will also influence its productivity, such as soil type, silvicultural practices, and season duration. Each of these factors will greatly influence; for example, a record increase of 100 mm of rainfall in Brazil can influence the biomass of the *E. grandis* × *E. urophylla* clone above ground to 2.3 Mg/ha/year (Hutapea et al., 2023)

INSECT PESTS OF FOREST PLANTATION

At the beginning of the Industrial Plantation Forest (HTI) industry, the *Acacia mangium* species was the dominant species chosen for mineral and wet land types. However, this type is starting to be replaced by *Eucalyptus* sp. and *A. crassicarpa* due to several reasons, one of which is pest and disease attacks. However, currently, it cannot

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be denied that insect pest attacks also frequently attack *E. pellita* and *A. crassicarpa* plants. Several reports of new insect pest attacks on industrial forest plantations have been reported.

Sirait et al. (2020) reported pest attacks on *A. crassicarpa* in North Sumatra, Indonesia, and also in Riau, Indonesia. It was reported that attacks by *Myllocerus scapularis* and *Rhytiphora bankii* were reported to attack many young plants in nursery and under-6-month-old plants. Previously, pests such as *M. scapularis* and *R. bankii*, known by the common names Ash weevil and Longhorn beetle, were only reported on soybean and cutton plants in South Asian countries such as Sri Lanka and Bangladesh (Ali, 2008; Thakur et al., 2021). Next, in Table 1, several types of insect pests that often attack industrial forest plantations will be presented, as well as several new reports that have been recorded as attacking and causing harm to industrial forest plantations in the species *A. crassicarpa* and *E. pellita*.

Table 1. Major insect pest of industrial forest plantation

Forest Plantation Crop	**Insect Pest**			**References**
	Common Name	Scientific Name	Damage	
Acacia crassicarpa	Flower Beetle Cetoniinae	*Glycyphana nicobarica*	Damage caused on the leader shoot can create multiple leader shoots.	Sinulingga et al. 2020
	Tea Mosquito Bug	*Helopeltis theivora*		Roy et al. 2015
	Ash weevil	*Myllocerus scapularis*	Damage notching on leaf margins and defoliation leaving only the midrib.	Sirait et al. 2020
	Longhorn beetle	*Rhytiphora bankii*	Chews the branches of young.	
	Flea beetle	*Altica sp.*	Injuring and perforating the leaves.	Wilcox 1979, Tavares et al. 2022
	Red beetle	*Aulacophora sp.*		
	Leaf beetle	*Aulacophora coffeae*		
	Black-back cucumber beetle	*Aulacophora flavomarginata*		
	Beet armyworm	*Spodoptera exigua*	Damage of the leaves.	Sulistyono et al. 2020; Khan et al. 2023.
	Cutworm	*Spodoptera litura*		
	Termite	*Coptotermes curvignathus*	Destroy the wood or attacking trees, they	Haneda et al. 2017

	Termite	*Coptotermes gestroi*	eat the cellulose material.	
	Termite	*Schedorhinotermes javanicus*		
	Termite	*Longipeditermes longipes*		
	Termite	*Pericapritermes mohri*		
	Ambrosia beetle	*Euwallacea perbrevis* *Euwallacea fornicatus* *Eewallacea similis*	They bore acacia stems and are associated with *Fusarium rekanum* sp. nov.	Lynn et al. 2020 Tran et al. 2022; Hulcr et al. 2017
	Bagworm	*Pteroma plagiophleps*	Causes holes on the upper surface of the leaves, first yellow, then turning brown as if burned, and finally falling off.	Asmaliyah et al. 2019
	Bagworm	*Pagodiella sp.*		Lelana et al. 2022
	Mole cricket	*Gryllotalpa africana*	They feeds on young seedlings and low shoots.	Thu et al. 2010
	Spiny moth	*Parasa pastoralis*	Larvae damage leaves.	Suka et al. 2022
	Wood-feeding cockroach	*Panesthia angustipennis angustipennis*	These insects eat wood, thus creating cavities in the wood and producing wood chips and fecal pellets or frass in quite large quantities.	Hawari et al. 2016
Eucalyptus pellita	Whiteflies	*Bemisia tabaci*	Chlorotic spotting, growth distortion, and premature leaf drop.	Jufenlin et al. 2023
	Leafroller	*Strepsicrates macropetana*	Feeding on the shoot tips, buds and developing flowers, which are adhered together with webbing.	Mauchline et al. 1999; Walker, 1866
	Horsfield's tussock moth	*Calliteara horsfieldii*	Damage of the leaves.	Chung et al. 2015; Nair, 2001
	Geometer moth	*Hyposidra picaria*	Damage caused by the Leaf-cutting	
	Nettle caterpillar	*Darna trima*	Caused necrotic, elongated holes surrounded by brown tissue.	

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Green weevil	*Hypomeces squamosus*	Produce cuts, holes, or leaf falls.	
Leaf-cutting Bee	*Megachile* sp.	Damage caused by the Leaf-cutting.	Ruzzier et al. 2020;Akram et al. 2022
Termite	*Microcerotermes* sp.	Termites can attack and spread around trees, causes damage, and death of good at any stage of development from young or mature trees.	Prastyaningsih et al. 2020; Chung et al. 2015
Termite	*Discupiditermes nemorosus*		
Termite	*Termes rostatus*		
Termite	*Macrotermes gilvus*		
Termite	*Nasutitermes matangensis*		
Termite	*Schedorhinotermes medioobscurus*		
Termite	*Amitermes dentatus*		
Termite	*Coptotermes havilandi*		
Longhorned borers	*Phoracantha semipunctata*	Chewing through the frass plugs, Foliage can discolor and wilt, and limbs can die back.	Paine et al. 2009

Longhorned borers	*P. recurva*		
The red coffee borer	*Zeuzera* spp.	They cause holes in the stem, swelling, breaking/forking, and/or bending.	Suheri et al. 2022
	Polyphagozerra coffeae		Tavares et al. 2020
Wood grasshopper	*Valanga nigricornis*	Usually eat leaves starting at the edges, while nymphs eat between the vein leaves creating holes in leaves.	Saputri et al. 2023
Asian ambrosia beetle	*Xylosandrus crassiusculus*	Beetles can cause tree death, because they associated with pathogenic fungi.	Thu et al. 2010
White grub	*Holotrichia trichophora*	Feeding on the shoot tips, buds and de on roots of young trees, girdling the stem below ground.	Thu et al. 2010
Scarab beetle	*Anomala* spp.	Causing a characteristic jagged, ripped pattern	Thu et al. 2010
Mole cricket	*Gryllotalpa africana*	They feeds on young seedlings and low shoots.	Thu et al. 2010
Guava moth	*Ophiusa disjungens*	Damage (defoliation) on Eucalyptus is up to 80.2% in Sumatra.	Raimon et al. 2020

MANAGEMENT OF INSECT PESTS OF INDUSTRIAL FOREST PLANTATION

Control of insect pests on forest plants is carried out both chemically and non-chemically. In industrial forest plantations, treatment has even been carried out on the seeds that will be used as seedlings, and fungicide has been soaked on the seeds that

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will be planted in the field. Control measures are not just actions after an insect pest attack occurs but also planning actions to prevent insect pest attacks, planned day by day and every month. because it is known that industrial forest plantations only cultivate homogeneous plants, so they are very susceptible to insect pest attacks.

Application of Synthetic Insecticides

Synthetic insecticide applications are generally carried out in industrial plantation forests. Applications are carried out at plant age levels, starting with seedlings and 12-month-old plants. At the nursery stage, pest attacks on *A. crassicarpa* and *E. pellita* were very diverse. Pesticide applications in industrial plantation forests use low-hazard insecticides because they are regulated by international regulations. Kkadan et al. (2020) conducted research on Acacia and Eucalyptus and found that the application of spinetoram was very effective in controlling *S. exigua* and thrips, with 100% and 95% effectiveness on each object tested using a spinetoram-based solution (0.12%).

Application of spinetoram to *Eucalyptus* also shows high effectiveness against attacks against *Strepsicrates semicanella*. Insecticide applications are also often carried out in various combinations to measure the level of effectiveness on insect pests, as was done by Saputra and Aluyah (2019). They tried to combine thuricide insecticide, which has the active ingredient *Bacillus thuringiensis*, with cassava tape suspension. In the application of insecticides to several insect pests, it was not only carried out using the spraying technique but also using the fogging technique. It was also found that, in some cases, the fogging technique was more effective in reducing pest attacks. Jufenlin et al. (2023) stated that the application of the insecticide Matador 250 EC with the active ingredient Lamda Sihalothrin using a spraying technique was able to reduce *B. tabaci* to 44% while the fogging technique was 56%, with the fogging application on Strepsicrates macropetana to 41% and to 26% on the spray technique.

Table 2. Some recommended synthetic insecticides for insect pest

Crop	Synthetic Insecticide	Target Insect Pest	References
A. crassicarpa	Spinetoram Chlorpyrifos	*S. exigua; Scirtothrips sp* *S. exigua; Scirtothrips sp*	Kkadan et al. 2020
	Dimehipo	*X. Crassiusculus*	Saputra & Aluyah, 2019
	Amitraz Piridaben Propargite Sulfur	*Tetranychus Sp.*	Lumbantobing et al. 2023

	Spinoteram	*Strepsicrates semicanella*	Kkadan et al. 2020
	Lamda Sihalotrin	*Bemisia tabaci; Strepsicrates macropetana*	Jufenlin et al. 2023
E. Pellita	Siantraniliprol + Lufenuron Imidakloprid Permetrin + Abamektin Dinotefuran	*Strepsicrates sp*	Agustin et al. 2023
	Tefluthrin Fonotos Fipronil Disufolton + Triadimenol Acephate	Various Termite	Wilcken et al. 2002

Cultural Control

Adopting appropriate silvicultural practices to prevent insect pests has been implemented in industrial forest plantations. Appropriate silviculture practices have been chosen as preventive measures against insect pest attacks, so that they become a holistic unit in preventive action steps. The practical practices that can be considered are as follows:

Land Preparation

In forest industrial plantings, one of the typical technical practises is land preparation. Tilling the soil generally aims to loosen the soil mass to allow sufficient room for the growth and development of plant roots in the soil. One of the things that can affect the emergence of disease and insect attacks is the preparation of the land. This procedure has the ability to control weeds in addition to influencing the presence of diseases and pests. According to Nuri (2005), the best way to prevent white root rot disease is to prepare the site mechanically. This is because machinery can remove stumps and leftover roots from the soil.

Plant Population Manipulation

Planting distances for *A. crassicarpa* and *E. pellita* are regulated in such a way, not only guided by quantitative wood production, that research results show that planting distances have a significant effect on growth in height and diameter, and planting distances do not have a significant effect on survival percentage and competition index. 12 month-old plants (Purwanti et al., 2022). Plant spacing is also considered a preventive measure to control insect pests. A. crassicarpa, which is cultivated in peat areas, has a planting distance of 3 x 2 metres, while E. pellita, which is generally cultivated in mineral soil, has a planting distance of 3 x 2 and also has other options such as 3 x 2.5 m, 3.5 x 2 m, and 3.3 x 2.2 m. Asmaliyah & Rostiwati (2015) stated that a planting distance of 3 x 4 m is an effective planting distance for suppressing the development of the *Cycnotrachelus* sp. beetle pest and the pathogen *Cephaleuros* sp. on land island plants in the third year after planting. This condition is indicated by a decrease in the percentage of attacks by 0.57% and a reduction in the intensity of attacks by beetle pests by 2.48% and pathogenic diseases by 8.44%.

Supplemental Application of Soil Nutrients

In addition to determining a plant's resistance to several pest and disease attacks, good soil has a significant role in plant yield (Herliyana et al. 2012). In industrial plantation forests, organic materials such as ameliorant materials obtained from factory processing residues are used in conjunction with additional nutritional supplements and fertilisers to increase soil fertility. These materials improve the physical, chemical, and biological conditions of the soil. In industrial planted forests, almeiron material is typically used prior to *A. crassicarpa* planting on peatlands. You must be careful when applying the right type and amount of fertiliser, though, as some fertilisers have the potential to exacerbate pest assaults.

Weed Control

Pest attacks in industrial plantation forests are not the only problem; another problem that will be faced is the presence of weeds, because they will become competitors for the main plants for sunlight, nutrients, water, and space to live (Wibowo, 2006). It is well known that several types of weeds that are similar to the main crop usually become nests for several insect pests (Capinera, 2005). In plantations around A. crassicarpa, there are generally many other types of acacia that are not cultivated, such as A. mangium, which has been studied and can be a place for insect pests to colonize. So by understanding proper weed control, we can suppress the presence of insect pests, and unwanted weeds such as A. mangium can also become a diversionary plant from the main crop.

Trap Cropping

One way to combat insect pests is through cultural control methods such as trap plants, which are plants that are planted alongside or ahead of the primary plant. By concentrating pests in one area, trap crops can improve the effectiveness of pest control. Biological control agents can also be released into trap crops, where they serve as a haven for beneficial organisms that eventually spread to the main crop (Reddy, 2017). When crop diversification and the reduction of synthetic inputs are given priority over crop output alone, trap crops can do particularly well on lower production settings.

Use of Bioinsecticide

Natural substances like pheromones, plant bioactive chemicals, and microorganisms like bacteria, fungus, viruses, or protozoa are the sources of bioinsecticides. Numerous chemical defence mechanisms against insects are known to exist in plants. Plants possess phytochemicals that serve as insect repellents, toxins, feeding deterrents, and growth regulators.

The entire body of small plants, a combination of different plants, or sections of higher plants can be utilised as components to manufacture bioinsecticides or botanical insecticides. (Demirak Şengül & Canporat, 2022). Rusandi et al. (2016) stated that mahogany seeds have the potential to control S. litura on A. crassicarpa; giving mahogany seed extract at a concentration of 30 g/l of water is the best concentration for controlling Spodoptera litura F., with the fastest initial death time of 2.75 hours. (2 hours, 45 minutes), the fastest time of death is 2 hours, 45 minutes, and there are many other plants that can be used as biopesticides.

Use of Insect Resistant Varieties

Planting plant clones that are fully or partially resistant to pest attacks is an effective way to reduce damage to industrial forest plantations. so that currently many forestry companies are developing clones that are resistant to pests and diseases (Hutasuhut et al. 2015). Resistant clones are obtained from the selection of certain individuals with characteristics in accordance with the purpose of breeding, so that a breeding population is formed. From the breeding population, further selection can be carried out to obtain individuals with certain advantages, which can then be crossed or hybridised to produce new individuals with combined characteristics from both parents (Sunarti, 2018).

Mechanical Control

Mechanical control is physical pest control, namely the direct treatment of plants using certain tools or manually. This technique relies on real action, in the form of using tools to ward off animals and diseases. Mechanical techniques do not rely on chemicals such as insecticides or drugs. Instead, they use tools such as handpicks, sickles, sticky yellow traps, lamp traps, plant scissors, machetes, and so on. According to Dudley et al. (2012), one mechanical engineering procedure involves treating the seeds, which involves cleaning them of any foreign things and sealing them in plastic bags that are laminated and contain carbon dioxide for a period of two weeks before storing them.

To prevent contamination, methyl bromide is also applied to the seeds. Additional protection against insect pest attacks comes in the form of hot water and acid scarification techniques to break dormancy. However, when insect larvae are isolated in big seed treatments, these procedures might not be entirely effective. Cans, jute bags, and baskets can all be used to store seeds.

The use of pheromone traps to regulate *Zeuzera* sp. imago in *E. pellita* is one type of mechanical control that has been implemented in industry. *Zeuzera* sp. is responsible for broken lower portions of the plant, swollen stems, and broken upper crowns, according to Suheri et al. (2020). The study he carried out produced encouraging findings. The installation of delta traps and *Zeuzera* pheromones pyrine was used to manage pests. Still, the outcomes are insufficient, necessitating comprehensive pest management.

Biological Control

Biological control is currently getting more and more popular as people realise how crucial it is to preserve sustainability and environmental balance. The truth is that, independent of the environment, natural creatures regulate approximately 98% of pest populations. Due to their persistent nature, ongoing buildup in the environment, toxicity to biotic components of life, and potential health risks to humans, chemical pesticides and insecticides are used far less frequently these days.

Utilising beneficial insects, such as parasitoids and predators, that are either naturally occurring in the environment or purposefully released to manage insect pests, is known as biological control. Pathogens, such as fungi and viruses, can also be used to manage undesirable insects. The entomapotogenic fungus *Beauveria bassiana* and *Lecanicillium lecanii*, which both have significant mortality capacity but are in different life stages of insect pests, can control *Helopeltis* sp., one of the major pests on *Acacia*. Laboratory research revealed that the entomopathogenic fungus *B. bassiana* was successful in causing 100% mortality of *Helopeltis* sp. imago at conidia density of 10^8 and 10^9/mL, while the entomopathogenic fungus *L. lecanii* caused 100% mortality of third instar nymphs of Helopeltis sp. at a conidia density of 10^9/mL (Anggarawati et al. 2017).

Sycanus sp. is a naturally occurring predatory insect that is commonly found in peatland areas. It is the natural enemy of several insect pests of *A. crassicarpa*. Interestingly, the presence of Geronggang (*Cratoxylon arborescens*), a native tree species in peat areas that serves as a habitat for *Sycanus* sp., can maximise the potential of *Sycanus* sp. (Sucahyono et al. 2022). *S. litura*, which is a dangerous polyphagous pest in *A. crassicarpa* and *E. pellita* nurseries, has been able to be controlled by utilising the nuclear polyhedrosis virus (NPV) (Gafur et al. 2012) (Yasin et al. 2020).

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Integrated Pests Management in Industrial Forest Plantation

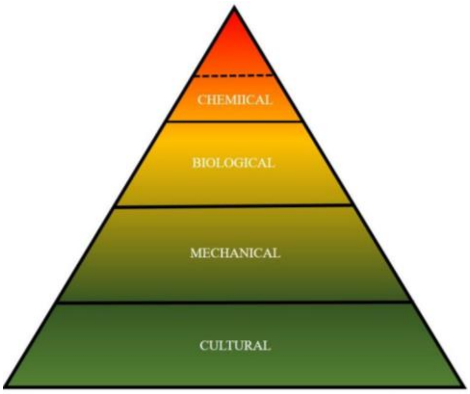

Figure 1. Pyramid of Pest Management Tactics

Integrated Pest Management (IPM) is a strategy used by nature to control pests by integrating various types of control (**Figure 1**), such as cultural, mechanical, and biological. which aims to be environmentally friendly and sustainable. IPM has been widely carried out in industrial forest plantations on *A. crassicarpa* and *E. pellita* plantations. In research conducted by Saputra and Aluyah (2019), they combined cassava extract with insecticides to control Ambrosia pests on *A. crassicarpa* plants and got effective results. Sucahyono et al. (2022) conducted research on the effect of *C. arborescens* plants on the release of *Sycanus* sp., which is a natural enemy for many insect pests in industrial forest plantations, especially peatland areas.

IPM strives for both temporal and spatial sustainability, according to Luo and Shen (1998). The goal is to focus on natural preventative and control methods and to always act cautiously when implementing any control techniques that may have negative environmental effects. When the pest has surpassed the economic threshold, this has to be given priority as well. As a matter of fact, IPM has emerged as a benchmark for the management of industrial plantation forests, bolstered by numerous rules that prioritise the preservation of the ecosystem. The non-governmental organisation Forest Steward Council (FSC) forbids the use of specific chemicals in insect pest management programmes (Lemes et al., 2017).

CONCLUSION

There are many insect pests that cause damage and losses to industrial plantation forests, starting from seedlings and also after being transplanted into the field. These pests attack at various stages of insect life. However, there are many solutions that can be used to control these pests, and IPM seeks to integrate each type of control, excluding the application of chemical insecticides, which are highly effective but are feared to produce dangerous environmental impacts such as pest resistance and also changes in the behaviour of other insect pests. There are many things that need to continue to be developed, such as combining various types of control, such as continuing to develop pest-resistant clones, using entomopathogens, and so on.

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