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A Review - Simplicillium Lanosoniveum, Prospects as Biological Control Agents in Indonesia

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ABSTRACT

Simplicillium lanosoniveum is a species of Simplicillium, which included to the Cordycipitaceae. This fungus is known to have a dual role as an entomopathogen against insect pests and antagonist against disease pathogens in plants. There are no reports on the negative impact of *S. lanosoniveum* as biological control . In Indonesia,the research on two roles of *S. lanosoniveum* is still limited. Therefore, it is necessary to study the potential of these fungus to be worthy of research, based on the results of previous research. The purpose of this study is to provide information about the potential of *Simplicillium lanosoniveum* as an entomopathogenic fungus and antagonist against plant fungal pathogens, which has various characteristics of pests and diseases in tropical regions.It is hoped that it can increase the diversity of fungi that act as biological agents in Indonesia, in an effort to suppress the use of chemical pesticides.

Keywords: *Simplicillium lanosoniveum*; entomopathogen; antagonist

1. INTRODUCTION

The region of Indonesia, which has tropical climate, row of volcanoes, and tropical forest areas, supports the development of microorganisms that have an impact on the high biodiversity in Indonesia, including fungi. Annissa & Artuti, (2017) stated about 200.000 species of macroscopic and microscopic fungi from one and a half million species worldwide are contained in the territory of Indonesia. The large population and diversity of fungi are also influenced by the presence of trees or vegetation on them. This is related to the exudate from the roots it produces, which is a source of energy for fungus spore germination (Ohiwal,*et al*, 2017). The organic compounds that contained in it include ethylene, sugars, amino acids, organic acids, vitamins, polysaccharides, and enzymes, which trigger the development of microorganisms attracted by these compounds, especially in the plant rhizosphere environment(Garbeva,*et al*, 2004).

Along with the demand for food commodities and industrial raw materials, the management of agricultural and plantation cultivation activities has increased. Efforts to improve the quality and quantity of commodities include the use of synthetic pesticides. Currently, around two million tonnes are used per year globally, most of which are herbicides (50%), insecticides (30%), fungicides (18%) and other types such as rodenticides and nematicides (Sharma,*et al*, 2019). The report Mariyono, *et al*., (2018) stated that for more than the last three decades, the pesticide trade had increased in imports reaching the range of 410 million US in 2014 to keep domestic pesticide needs..

A part of agricultural cultivation that is often neglected by agricultural subjects is maintaining the existence of populations and diversity of microorganisms. Cultivation practices using synthetic pesticides to control pest organisms, can suppress the population and diversity of microorganisms in nature. This happens partly because the impact of microorganism degradation due to synthetic pesticides is not immediately visible in the field. The microorganisms play an important role in agricultural systems, and their abundance, diversity, and activity can be influenced by management practices. In the rotation system, cucumber (*Cucumis sativus* L) seedlings in sterile soil treatment had a greater decrease in growth than soil inoculated with soil biota (Zhou, *et al*. 2017). More Zhou *et. al* (2017) reported that although crop rotation increased soil bacterial community diversity but reduced fungal community, the biomass of cucumber shoots inoculated with fresh rotation soil was greater (71% and 69%) compared to treatments inoculated with fresh monoculture soil (40% and 41%). %).

The massive use of synthetic pesticides affects the presence of soil microorganisms. Pesticides are considered as a savior for farmers in the implementation of agricultural cultivation. The practical and effective nature of using pesticides makes it easier for farmers to eradicate pests that plants they cultivate. This phenomenon has occurred since the emergence of a fundamental innovation towards the beginning of the existence of synthetic insecticides, namely Zeidler's discovery of DDT (Dichoro Diphenyl

Trichlorethane) in 1874 (Djojosumarto, 2008, *in* Susanti,*et.al*. 2022). Meanwhile, its characteristics as an insecticide were discovered in 1939 by Dr. Paul Muller (Djojosumarto, 2008, *in* Susanti,*et.al*. 2022). This is a revolution in pest eradication, which relies on using pesticides

Using of chemicals without being known can kill useful of soil organisms, thereby reducing their role in supporting the availability of natural nutrients for the soil. Whereas the existence of microorganisms is to maintain the ecological balance in the underground environment and also above the soil surface. Herbicide containing 2,4D compounds has a negative impact on reducing the useful activity of Rhizobium, Azotobacter, *Nitrobacter* sp in the nitrogenization process (Fabra, *et.al*, 1997; Chalam, *et.al*., 1997; Fox, *et.al*, 2001; *in* Meena, *et.al* 2020). Chemical compounds contained in fungicides adversely affect the beneficial processes of soil microbes. Apron, Arrest, Captan, Benomyl, and mancozeb reduced the nitrification process, Rhizobium, mycorrhiza and Aspergillus populations (Kyei-Boahen, *et.al*, 2001; Sàez, *et.al*, 2005; Chen, *et.al*., 2001; Shukla, 2000; in Ciocco and Rodrigues, 1997; Wainwright and Pugh, 1975; *in* Meena, *et.al*. 2020), as well as reducing the influence of biological agents microorganisms used to control Fusarium wilt (Fravel, 2005, *in* Meena, *et.al*, 2020). Compounds of Arsenic, DDT, and Carbamate in insecticides reduce microbial populations and enzymatic activity and their presence in the soil is not long (Singh and Singh, 2005; *in* Meena, *et.al*. 2020). Furthermore, long-term spraying of the Mancozeb fungicide on cabbage plantations resulted in a lower population of soil fungal spores (Lestari, *et.al.*, 2018). Dimethoate applied to mustard fields on Inceptisol soil reduced the population density of soil fungi by up to 26% (Benu, *et.al*., 2020).

On the other hand, global warming is caused by an increase in the concentration of greenhouse gases in the atmosphere. This is marked by increasing global temperatures and CO2 in the atmosphere, uncertain weather including erratic rain patterns, and relative humidity. In the global habitat environment, these conditions have an impact on biodiversity, distribution, phenology, population dynamics of pests and natural enemies, the environment and their interactions. Lehmaan *et al*. (2020) identified that temperatures that tend to increase play a role in increasing the severity of pest attacks. At high atmospheric CO2, it can affect the attack rate of *Popilia japonica* Newman, *Empoasca fabae* Harris, *Epilachna varivestis* Mulsant, and *Diabrotica virgifera* virgifera L on soybean plants reaching 57 percent (Hamilton, *et al*. 2005). In addition, *Helicoverpa zea* Boddi and *Helivcoverpa armigera* Hub. become a threat to maize cultivation in the United States. It was happened because increased survival and wider distribution along with increasing global temperatures (Fand *et al*. 2012). The effect of increased rainfall during the summer and the occurrence of drought actually causes an increase in population growth of *Agriotes lineatus* L (ground caterpillar) above the ground (Staley *et al*. 2007).

Yidego *et al.* (2019) stated the existence of herbivore insects in drought stress, with three mechanisms; 1) a dry climate supports environmental conditions suitable for the growth and development of insects, 2) plants that are experiencing drought stress will attract insect species. For example, when plants lose moisture due to transpiration, the water column in the xylem will break, causing emissions ultrasonic acoustics detected by insects, and 3) plants that are experiencing drought stress will be more susceptible to pest attacks. It decreased in the production of secondary metabolism which generally acts as plant defense.

The microorganisms around of the roots are associated with plant roots and have various roles. One of role microorganisms in the soil are role as the biological control, which are entomopathogenic for controlling insect pests, and antagonists against pathogenic fungi. The roles of these fungi are currently being developed as part of suppressing the use of chemical pesticides for pest control activities.

There have been many results of exploration and isolation of soil microbes that play a role in pest control, including fungi in the Entomopathogenic.. Among these fungi are *Beauveria* sp, *Metarhizium* sp., and *Lecanicillium lecanii*. They are types of fungi whose ability to control insect pests in cultivated plants is known. *Beauveria bassiana* was reported to be able to control *Trialeurodes vaporariorum* (Barra-Bucarei *et al*., 2020), *Lipaphis erysimi* on hydroponic kale (Thaochan *et al*., 2021), *Aphis craccivora* on string beans (Sopialena *et al*., 2022). *Metarhizium robertsii* suppresses the growth rate of *Agrotis ipsilon* on maize (Ahmad *et al.,* 2020), *Tenebrio molitor* caterpillar (Sopialena *et al.,* 2019), natural controller of oil palm shoot borer (Erawati&Irma, 2021), sugarcane pest (*Cleanus punctiventris*), horn beetle (*Oryctes rhinocheros*), coffee powder pests, (*Helopeltis* spp (Wijonarko *et al*., 2017). *Lecanicillium lecanii* was able to suppress *Aphis glycines* (Riri Widariyanto *et al*., 2017), also through tritropic interactions was able to control aphid *(*Lin *et al., 2016)*, and suppressing the population of *Thrips palmi* in potato plants (Prabaningrum *et al*., 2018). Some of the fungi mentioned above have been widely explored and used for research in pest control in Indonesia, even up to mass production.

Currently, research on the dual role of entomopathogenic fungi, apart from being potential as insect pest control, is also explored further as antagonists to plant pathogens. The research of Lozano-Tovar *et al.,* (2017) showed the ability of the *Metarhizium brunneum* EAMb 09/01-Su in suppressing wilt symptoms due to infected with the *Verticillium dahliae* which reached 38,9% until 58.9%. The active metabolism of the entomopathogenic fungi was able to suppress the germination of microsclerotia, hyphae, the number of reproductive structures, and prevent the formation of new microsclerotia from *V. dahlia.* Deb dan Dutta (2021) also reported that *Beauveria bassiana* (Balsamo) Vuillemin from insect isolates at several different locations in Meghalaya - India, under in vitro conditions was able to inhibit the growth of *Phytium myriotylum* mycelium by 68-82%, with high germination of 87, 34%, and suppressed disease attacks on tomato seeds to a lower level of up to 33.45% through a combination of treatments. In addition, *B. bassiana* also demonstrated the ability of its cell wall degrading enzymes with the colonization percentage reaching 72–80%

through inoculation of tomato plant seeds. *Lecanicillium lecanii* 4181 was able to inhibit conidia's germination of *Cercospora arachidicola* and *Phaeoisariopsis personata*, which causes leaf spot on pea plants (a disease that causes major loss of peanut yield in West Africa) up to 87%, and seed tube elongation was around 56% is compared to distilled water as control, with the score of significant severity between 2.3 and 4.7 in vitro (Nana, *et al*., 2022).

Microorganisms that are around the roots associated with plant roots, have a variety of roles. These roles include helping in the process of forming soil structure, nutrient cycling, and the activities of microorganisms that are harmful or beneficial to plant growth and development (Ritz, Karl & Iain. 2004; Hussain, *et.al*., 2021; : Bridžiuviene, *et.al.* , 2022). The results of research and field evidence regarding entomopathogenic fungi, which are potential types of fungi as biological agents, have been widely carried out and have been shown to be capable of controlling pests. However, entomopathogenic fungi also have a role in helping the growth of host plants. Several studies related to this matter have been carried out. Jaber and Enkerli (2016) tested the ability of several strains of *B. brongniartii, B. bassiana*, and *Metarhizium brunneum* Petch (Ascomycota: Hypocreales). They colonize long bean (*Vicia faba* L.) plants and promote their growth after inoculation of the fungus with the foliar spray method. The study wanted to know the percentage of colonization of different plant parts with entomopathogenic fungal pathogens which were inoculated by foliar spraying method. The results showed that all parts of the plant were colonized by the fungus, especially the stems. The percentage of fungal colonies decreased at 14 days after inoculation. *Beauveria bassiana* (NATURALIS®) gave a consistent increase in growth in the test plants, compared to the control plants, followed by *M. brunneum* (BIPESCO5), and *B. brongniartii* (2843) and (BIPESCO2) strains. Saragih, *et.al* (2019) inoculated of the fungus using the *B. bassiana* strain derived from cocoa, coffee, wheat and *Leptocorisa acuta* plants. They used three inoculation methods on chili plants; dipping seeds, wetting the soil, and spraying on leaves. Results Inoculation of *B.bassiana* by spraying on leaves resulted in the highest colonization. The method of soaking the seeds was less infected with *B.bassiana*. Application of *Beauveria bassiana* wheat isolate using the spray method on the leaf surface of chili plants had a significant effect on plant height (32.50 cm) 42 days after inoculation, compared to other methods and control (24.30 cm). Furthermore, Afandhi, *et.al* (2019) also tested the effect of the *B. bassiana* inoculation method on the growth of endophytic fungi in long beans (*Phaeseolus vulgaris* L.). The results showed a difference with Saragih, *et.al.* (2019), where inoculation of *B. bassiana* to *Phaseolus vulgaris* L. through soil wetting showed that it was able to maximize *B. bassiana* conidia and increase the growth of *P. vulgaris* L. at 10 days post-inoculation. The average plant growth of *P. vulgaris* L. at 10 days after inoculation of *B.Bassiana* on soil ranged from 49.25 cm, compared to controls (25.25 cm). Gonzalez, *et.al* (2022) tested by inoculating *Metarhizium anisopliae* Ma-20, Ma-25, and Ma-28 strains using the seed soaking method (*Zea mays*). Research shows evidence that They have potential to enhance plant growth, which makes these entomopathogenic fungi more attractive as biostimulants. The results showed that the three *Metarhizium anisopliae* lines were able to increase plant fresh weight, opening up promising prospects for field production, with superior insect pest biocontrol and triggering plant growth caused by this type of fungus. *Simplicillium lamellicola* strain JC-1, through the production of antifungal metabolites, is able to suppress infection by S. sclerotiorum on oilseed rape leaves, and induce systemic resistance (ISR) (Li, *et.al.,* 2022)

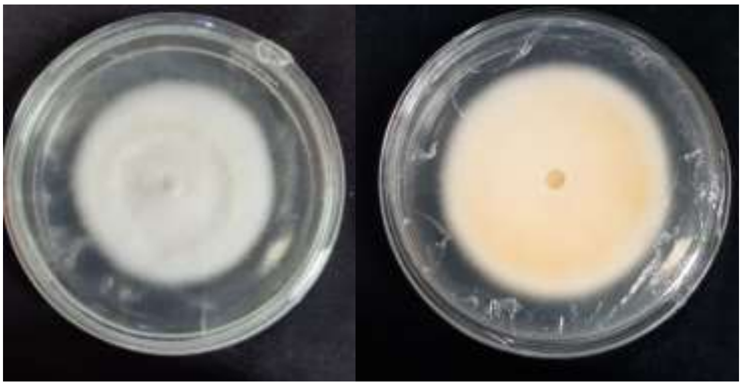
There are still many entomopathogenic fungi that have not been found and research has been carried out on the potential contained in it. This was due to difficulties in obtaining target fungal isolates, limited isolates identified, the possibility that there are not all exploration sites contained target fungi, and limited of information about it. Among these fungi, *Simplicillium lanosoniveum* become a study to look for potential in its dual role as a biological agent. The purpose of this study is to provide information about the potential of *S. lanosoniveum* as an entomopathogenic for insect pest and antagonist against pathogens in Indonesia, which has various characteristics of pests and diseases in tropical regions.

2. REVIEW

Simplicillium lanosoniveum, potential fungus for biological cntrol

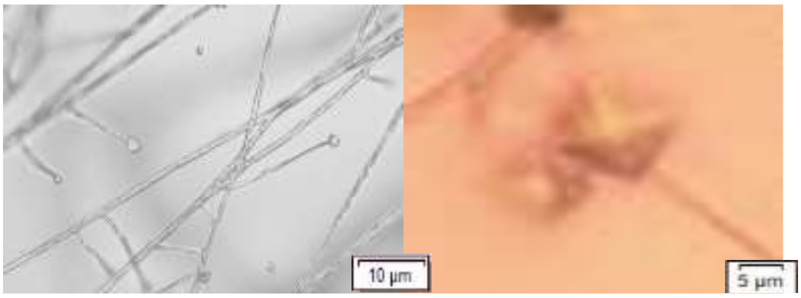
Simplicillium lanosoniveum, is a species of Simplicillium, included in the Cordycipitaceae (Hypocreales, Hypocreomycetidae, Sordariomycetes (Sung *et al*., 2007). This fungus is anamorphic to the genera Beauveria and Isaria ((Zare & Gams, 2001); (Ward *et al.,* 2012)), even previously Simplicillium and Lecanicillium were types of *Verticillium* spp ((Zare & Gams, 2001); (Sung *et al.,* 2007); (Ward *et al*., 2012)). In addition to having a habitat on the ground, *S. lanosoniveum* is saprophytic at fungi, endophytes, pathogens in plants, parasites on nematodes and insects (Wei, *et al*., 2019).

Generally, these fungi have white mycelia, with a creamy yellow underside (Lim *et al*., 2014), at the edges of a fine cotton-like mycelia structure (Wei, *et al*., 2019). *Simplicillium lanosoniveum* strain CG888 (MT 081944.1) (Figure 1.)(Susanti*,et.al*., 2023) which was found in the rhizosphere region, showed the same macroscopic morphology as described above, where the upper surface of the mycelia colony was white like thick layers of cotton, with a wavy surface texture. The underside of the colony was yellowish. , whereas in older colonies it will be dark yellow and have a wrinkled texture. Wei, *et al*., (2019) reported that the mycelia of *S. lanosoniveum* had fast growth, reaching 10-38 mm in the range of ten days.



(a) (b)

Figure 1 Macroscopic appearance of *Simplicillium lanosoniveum* strain CG888 (MT 081944.1); (a) top surface, (b) bottom surface (Personal document, 2022)



(a) (b)

Figure 2. Microscopic appearance of *Simplicillium lanosoniveum* strain CG888 (MT 081944.1);(a) mycelium, (b) conidia (Personal document, 2022)

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Microscopically, as described by Wei *et al*., (2019) that the mycelium of *S. lanosoniveum* is thin and hyaline, branching with each morphological branch is long tapering to the tip. At the end of branching is a phialide. Furthermore, Wei *et al*., (2019) described the conidia of these fungi which are circular, imbricate or zigzag, sometimes in the form of a branched chain or not. When synchronized with *S. lanosoniveum* strain CG888 (MT 081944.1) (Figure 2.), the hyphae branched with regular branching. The hyphae are transparent and septate. The hyphae branches taper to the tip, and form a phialid at the tip, producing conidium with conidia that are round, transparent and small in size.

The distribution of *S.lanosoniveum* as reported by Wei, *et al*., (2019) showed the fungus was identified in Asia such as Taiwan, China, India, Japan, South Korea, Thailand, and Malaysia; Americas such as Colombia, Venezuela, Brazil, USA; and the Netherlands and Iran. The fungi hosts and habitats are generally endophytic in plants, insects, and even leaf rust pathogens and humans (Wei, *et al*., 2019). *Simplicillium calcicola* can be found in Karst where conditions of low temperature and high humidity are found (Zhang, *et.al*., 2021). Until the end of 2021, there are still few publications on it identified in Indonesia. As for *Simplicillium* sp., it has been reported that Nurtiati *et al*., (2021) tested its effectiveness against *Spodoptera frugiperda* J.E. Smith scale in vitro.

Dual Roles of *Simplicillium lanosoniveum* as Biological Control

Simplicillium lanosoniveum is able to act as an entomopathogen and mycoparasite (Ward *et al*., 2012). The reports of interactions of *S. lanosoniveum* with other microorganisms are still limited. Based on its role as insect pest control, the researched by Lim *et al*., (2014)) showed that it was able to infect one-third of the *Bombyx mori* larvae tested, which affects the metamorphosis process of *Bombyx mori* larvae so that they cannot reach the pupa stage. Skaptsov *et al.,* (2017) reported mortality of *Coccus hesperidum* larvae, twenty days after it was inoculated by *S. lanosoniveum*. Nematodes that are plant parasites can also be controlled by these fungi (Zhao *et al.,* 2013). Chen *et al.,* (2017) reported that *Hysteroneura setariae,*that pest attacked plum plant, can be controlled by *S. lanosoniveum* Cs0701, 5 days after inoculation with an average mortality of 86.33 percent. Nurtiati *et al.,* (2021) reported on a laboratory scale, *Simplicillium* sp. with 20 percent secondary metabolism capable of causing the death of the larvae of *Spodoptera frugiperda* J.E. Smith was around 36.67 percent. Furthermore*, Simplicillium* sp. also virulence against *Nilaparvata lugens* Stål which caused mortality between 80–100 percent in the range of 3.22–5.47 days (Minarni *et al.,* 2021). However, the specific *Simplicillium* sp species used was not mentioned in the study. The other study, *S. lanosoniveum* is suppressing all the developmental stages of RSW at 1 × 108 conidia/mL in the egg and nymphal population by 57.8% and 56.3%, respectively (Sujhitra,*et.al*, 2021).

Generally, entomopathogenic fungi are capable of infecting target insects by penetrating the cuticle and/or body openings, then degrading these tissues with enzymes released by these fungi. Meanwhile, research on the pathogenicity of *Simplicillium lanosoniveum* against insect pests is still limited, especially on a research scale in Indonesia. Zare and Gams (2001) reported that one of the species belonging to the genera Simplicillium and Lecanicillium is Akanthomyces, while the species reported by Butt *et al*., (2001) is generally applied to control insect pests of aphids and thrips.

Pathogenicity test of *S. lanosoniveum* against insect pests in vitro was carried out using different techniques. Skaptsov et. al, (2001) tested its pathogenicity through infection of the test plants to be invaded by *Coccus hesperidum* in the green house with conidia solution. While research Lim *et. al*, (2014) by placing *Bombyx mori* larvae on PDA media containing pure cultures of *S. lanosoniveum.*

On the other hand, *S. lanosoniveum* also has a role as an antagonist against fungal pathogens. These fungi are able to suppress diseases caused by pathogenic fungi. *Pakhopsora pachyrhizi* on soybean leaves was able to suppress its development by *S. lanosoniveum* (Ward *et al*., 2012), and *Aecidium elaeagni latifoliae* which causes *E. latifolia* rust (Baiswar *et al.,* 2014), *S. lamellicola* species was able to suppress Fusarium which causes head blight on wheat reached 82 percent (Abaya *et al*., 2021), and was able to inhibit the growth of 14% powdery mildew spores in *Murraya paniculata* citrus plants compared to no treatment (55.17%) *(Chen et al.*, 2017). Researched by García-Nevárez dan Hidalgo-Jaminson (2019) showed that

Simplicilium lanosoniveum strain in the form of a biofungicide from the Tropical Agriculture Research and Training Center - CATIE with EC code in Costa Rica showed a high level of virulence against *Hemiliea vastatrix*. It mycoparasites were more effective against *H. vastatrix* by infecting coffee rust pustules in a shorter time than Leecanii. One of the test techniques for pathogenicity of *S.lanosoniveum* against *P. pachyrhizi* was carried out by Ward (2011). The technique is to spread one ml suspension of *S.lanosoniveum* conidia over the abaxial surface of trifoliolate soybean leaves that have been infected with P. pachyrhizi, with severity ranging from 5 to 10%.

In Indonesia, *S. lanosoniveum* has not been widely studied. Therefore, it is necessary to study the potential of these fungi to be worthy of research, based on the results of previous research. It is hoped that it can increase the diversity of fungi that act as biological agents.

Potential Compound Content of *S. lanosoniveum*

Similar to other biological agents fungi as supporting virulence against pests or target pathogens, *S. lanosoniveum* contains several secondary metabolic compounds to support its pathogenicity against targets. Hypocrealeane includes entomopathogenic fungi which also produce various secondary metabolites. In the Simplicillium genus, there is Verlamelin B which is antifungal against plant pathogenic fungi *Magnaporthe grisea* (rice blast), *Bipolaris maydis* and *Botrytis cinerea* (Zhang et al., 2020). *Simplicillium sp*. also produces phenylalanine, N, Nbis(trimethylsilyl)-trimethylsilyl ester; papaverine; and octadecanoic acid trimethylsilyl ester (Minarni *et al*., 2021). The reported by Dong *et al*., (2018) showed that the ALM (antibiotic-like-metabolism) produced by *S. lanosoniveum* protects cyanobacteria that are useful in procuring protein compounds and antibiotic drugs, from bacterial infections. . In addition, a new pyrrolidin alkaloid, preussin B (1), was obtained from the isolation of the fungal culture extract *S. lanosoniveum* TAMA 173 from dead insects of the Aphidoidea family collected from the leaves of *Cinnamomum* sp. in Tsukuba, Japan (Fukuda *et al*., 2014). The secondary metabolic ability of Simplicillium against nematodes was recently reported by Zhao *et al.,* (2020) where there was an anatomical disorder in *Meloidogyne incognita* stage J2 due to exposure to 2,6-pyridindicarboxylic acid from *Simlpicillium chinese*. There have been no significant reports on the use of secondary metabolism of it against plant parasitic nematodes**.**

Until the last report was published, there has been no negative impact of *S. lanosoniveum* on human health. On the other hand, the compounds contained in these fungi actually play more of a role as antibiotics against human health problems. Rukachaisirikul *et al.,* (2019) reported *S.lanosoniveum* PSU-H168 and PSU-H261 which were isolated from *Hevea brasiliensis*, produced Simplicildone K for antibacterial against *Staphylococcus aureus*, gram-positive bacteria, the cause of disease that causes suppuration the human body. Based on the research above, it shows that *S. lanosoniveum* is safe to apply as a biological agent for controlling pests and diseases in cultivated plants.

The ability of *S. lanosoniveum* to act as Biological Agent in Indonesia

Until now, *S. lanosoniveum* has not been able to attract attention among agricultural actors, producers of biological agents, and also researchers in Indonesia. There are several things that are suspected to influence these conditions, sometimes getting S. *lanosoniveum* isolates is not as easy as other fungi, especially those explored in the rhizosphere of plants, corals, or in other places other than as endophytes in plant tissues. In addition, these fungi have macroscopic morphological characteristics similar to *L. leecanii* and *Isaria* sp. or *Beauveria* sp. As previously explained, *S. lanosoniveum* is an anarmorphic species of these fungi. Therefore, it is necessary to carry out a molecular test to determine the species of Simplicillium.

On the other hand, *S. lanosoniveum* as a pathogen was first reported by Chen Ruey-Shyang *et al*., (2008), where the fungus causes brown spots on *Salvinia auriculata* and *S. molesta* which are endangered ferns in Taiwan. There are several reports on the virulence ability of *S. lanosoniveum* which is still inferior to other biological agent fungi that have been widely used in controlling target pests. Hubner-Campos *et al*.(2013) showed *S. lanosoniveum* ARSEF 962 avirulent (0%) to cockroach nymph *Periplaneta americana* compared to *Metarhizium robertsii* and *Beauveria* sp. which was able to cause nymph mortality ranged from 81.7% at 25 days after inoculation.

However, *S. lanosoniveum* has the potential to make the fungus capable of acting as a biological agent. It has moderate UV tolerance at LT50 with an irradiation time of 120 and 150 minutes compared to Beauveria which can only last LT50 <120 minutes through the QSUN Xenon Test Chamber XE3 test equipment (Dias et al., 2018). Another reported (Dias *et al*., 2021) showed the conidia of *S. lanosoniveum* had similar stress tolerance when produced under light, dark conditions or on limited media. Based on these characteristics, it is possible that *S. lanosoniveum* can be developed in the tropics and has the potential as a biological agent fungus.

The advantages of *S. lanosoniveum* need to be explored further to obtain the potential of it as a biological agent to increase Indonesia's biodiversity in controlling insect pests or plant pathogens.

3. CONCLUSION

Simplicillium lanosoniveum is a species of Simplicillium, which belongs to the Cordycipitaceae. This fungus is known to have a dual role as an entomopathogen against insect pests and an antagonist against disease pathogens in plants. It does not have a negative impact on health, even as an antibiotic for humans. These fungi have the potential as biological agents that can be used to suppress the use of chemical pesticides. There is a need for a wider exploration of the use of these role in an effort to to increase Indonesia's biodiversity in controlling insect pests or plant pathogens.

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