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# PROCEEDING OF

## THE INTERNATIONAL SEMINAR AND THE 21ST NATIONAL CONGRESS OF THE INDONESIAN PHYTOPATHOLOGICAL SOCIETY

# PROMOTING THE ROLE OF PHYTOPATHOLOGY BASED ON THE ADVANCED BIOTECHNOLOGY FOR ENHANCING THE SUSTAINABLE AGRICULTURAL PRODUCTION

Faculty of Agriculture, the University of Sebelas Maret (UNS)  
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## BIOLOGICAL CONTROL OF FUNGAL PLANT DISEASES IN INDONESIA

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### ABSTRACT

Fungal plant diseases are major diseases providing economic loss in various crops in Indonesia. Biological control plays an important role to overcome those diseases. The paper discusses the current status, strategy, dissemination, problem facing and the future of biological control in context of Indonesian agricultural development. Research on biological control has been done in universities and research centers, however, registered biocontrol agent products and number of applied antagonists by farmers are still limited. Use of biocontrol agent by farmers e.g. *Trichoderma harzianum* and PGPR (*plant growth promoting rhizobacteria*) in controlling various fungal plant diseases of various commodities is also described. Dissemination of biocontrol agent is carried out through two ways- state-community-based route and institutional-based route, with each strength and weakness is elaborated. Development and application of biological control of fungal plant diseases is still promising, although it faces some technical, policy and institutional problems.

**Keywords:** biological control, Indonesia, PGPR, *Trichoderma*, problems, strategy

### INTRODUCTION

Fungal diseases provided losses for agricultural products in Indonesia, food crops, horticulture, estate crops and also industrial forests. Beside rapid development of other measures such as resistant varieties/clones and chemical control, biological control has its importance in the frame of IPM, both in farm scale and national agricultural development. Production of strategic plant commodities is facing plant diseases caused by fungi in which chemical and agronomical measures do not provide satisfactory control level. The following plant diseases are as examples: fusarial wilt of banana and plantain caused by *Fusarium oxysporum* f.sp. *cubense*, fusarial yellows of shallot caused by *Fusarium oxysporum* f.sp. *cepae*, fusarial wilt and rust of chrysanthemum caused by *Ganoderma* sp., white root on rubber tree caused by *Rigidoporus microporus*, black pod disease on cacao caused by *Phytophthora palmivora*, club root on crucifers caused by *Plasmodiophora brassicae*, antrachnose of chili pepper and of papaya, *Botryodiplodia* rot on citrus, white rust of *chrysanthemum*.

Chemical control in plant disease has some negative economic, social and ecological impacts. In addition, consumer awareness on environment

both national and international increase make chemical control did not has wide acceptance.

Other important aspect is that all active ingredients of chemical fungicides are imported from abroad,. Relying control strategy on fungicide will make dependency on foreign countries, thus weaken the national economic independency and furthermore national sovereignty. Therefore the use of fungicide will of microbial fungicides especially those with Indonesian-origin microbes can strengthen national independency in agricultural inputs.

### STRATEGY OF BIOLOGICAL CONTROL OF PLANT DISEASE

Strategy of biological control can be divided into two groups i.e. the utilization of indigenous microbes by means habitat management and introduction of selected antagonists

#### Enhancement of indigenous antagonists through habitat management

Some agronomical practices affect diversity, abundance, dominance of certain groups of soil microbes in soil and also on phyllosphere. Some technique are crop rotation, organic mulching, soil solarisation and selective nutrition application [1, 13,19, 26, 29]. Organic mulching could suppress leaf blight of tomato caused by *Phytophthora infestans* with efficacy rate 60%, it associated to



the increasing of abundance of total soil bacteria [19]. Soil solarisation was proven as effective control measures of clubroot of cabbage caused by *Plasmodiophora brassicae* on cabbage and *Sclerotinia alfalfae* on peanut, by weaken pathogen propagules to antagonist attack, enhance indigenous microbes activity and increase nutrients availability [29].

the technique to enhance indigenous microbes is by applying selective nutrients such as chitin-containing materials. Application of chitin containing materials such as crab shell powder effectively control the incidence of shalot caused by *Alternaria porri* [21]. Total chyllospheric, rhizospheric and chitinolytic bacteria increased with crab shell treatment. Moreover, crab shell powder application combined with media solarisation was very effective way ( 74 v%) to control club root in the nursery [27]. Even though enhancement of indigenous antagonist in some cases very effective –the development is limited, it may be due to the limit of commercialization is limited.

**Introduction of Selected Antagonists**

The second strategy of biological control of plant diseases is using selected antagonists. The microbes are selected from soil, plant parts, the effective antagonistic microbes applied to control target diseases. Various antagonistic microbes against diverse plant diseases have been investigated in Indonesia. The antagonists can be grouped into Group of *Trichoderma* and *Gliocladium*, mycorrhiza, yeasts antagonists, endophytic fungi, antibiosis bacteria and lytic bacteria, and plant growth promoting rhizobacteria.

**Trichoderma and Gliocladium**

This group probably is the most widely applied by farmers in Indonesia. *Trichoderma/Gliocladium* is a potent biocontrol agents and used extensively for seeds and soil-borne diseases. It has been used successfully against pathogenic fungi belonging to various genera, viz. *Fusarium*, *Phytophthora*, *Ganoderma*, *Sclerotium*, *Rhizoctonia*, and *Colletotrichum*. Antagonism mechanism of

*Trichoderma* and *Gliocladium* are competitive antibiosis, lytic enzyme production and some also induced resistance. The two antagonists advantages easy to be mass produced with and cheap media, it make them to be most used antagonist in Indonesia. Common products using soil fungi are poorly characterized is undeveloped formulation make relatively application doses, and the need of continuous additional organic matter amendment to support live and survival.

**Arbuscular Mycorrhizal Fungi (AMF)**

AMF can act as biocontrol agent, by protecting from plant pathogens through: better host nutrient improving nutrient status of the plant, competition infection/colonization sites, increased plant defense metabolites: phenolics, chitinase, glucanase, peroxidase, phytoalexin, higher lignification xylem, stronger vascular system. AMF intensively studied in Department of Plant Protection Bogor Agricultural University and effective against several plant pathogens, *Fusarium oxysporum cubense*, *Ganoderma boninense*, *P. palm*, *Botryodiplodia* sp.

**Yeasts Antagonists**

The use of yeasts as biocontrol agents against various fungal plant diseases is widely reported abroad. Yeast is promising to be developed as antagonist due to natural features growth resistance against desiccation and ultraviolet radiation therefore make it possible for foliar disease control and post harvest horticultural disease. Antagonistic mechanism of yeast varies, but natural competition and induced resistance, Research in Department of Plant Protection Bogor Agricultural University show that some yeasts *Cryptococcus albidus*, *Pichia guilliermondii* can effectively control fruit rot of mango caused by *Botryodiplodia theobromase* [30]. Field application of other *Cryptococcus terreus* affectively control petal blight dendrobium caused by *Curvularia palles*

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## Endophytic Fungi

Endophytic fungi is newest group of biocontrol agent in plant diseases developed in Indonesia and in the world. Tight interaction of endophytic fungi with plants make advantage for its use as biocontrol agent, persistence in plant and minimum adverse environmental effects. Antagonistic mechanism is antibiosis by producing toxic substances into host tissue and induced resistance. *Curvularia lunata* is effective control club root of cabbage [1] and hypha against chili antrachnose [23].

## Antibiotic and Lytic Bacteria

Antibiotic bacteria is also widely studied and developed by research institution and universities in Indonesia. *Bacillus* spp. and fluorescent pseudomonads are most intensively studied. Some strains of this group i.e. fluorescent pseudomonads effective against fusarium wilt of shallot [17].

The new generation of biocontrol agent in Indonesia is PGPR (*plant growth promoting rhizobacteria*). The term of PGPR was firstly introduced and examined by Klueber [10]. It has advantage i.e. beside antibiosis, PGPR induces systemic resistance of plant [15], therefore it is able to control diseases of aerial plant parts such as chili anthracnose, rice blast, white rust of chrysanthemum. PGPR is developed and widely disseminated by Plant Clinic of IPB (Bogor Agricultural University) to farmers through numerous activities [27]. Induced systemic resistance by PGPR make possible for controlling viral plant diseases [21]. There are numerous species and strain of PGPR i.e. IPB strain *Pseudomonas fluorescens* and *Penicillium polymixa*.

## RESEARCH AND DEVELOPMENT

Research on development of microbial biofungicides in Indonesia has been done for long time ago carried out by various institution i.e. Universities with Dept of Plant Protection, Dept of Microbiology, Research Center under Ministry of Agriculture, Research Center under Association of State-owned

Plantation. Diverse biocotrol agents has already investigated consist soil fungi, mycorrhiza, yeasts antaonists, endophytic fungi, antibiosis bacteria, lytic bacteria, and plant growth promoting rhizobacteria. Regarding to the steps, research on microbial fungicide in Indonesia published in last 10 years in National Seminar of Indonesian Phytopathological Society, show that *Trichoderma* is the most frequently studied (34 % of topic), followed by fluorescent pseudomonads (29% of topic). Moreover most of the research was carried out up to the stage of green house testing *lad planta screening*. It was very rare (6 of 82 or 7.3%) the development up to field testing and technology of mass production and formulation ( 2 of 82 or 2.4%) [18]. Intensive and convergence research on biological control of fungal plant diseases is need on discover of new isolates/species of antagonists, physiological and molecular and also biocontrol performance in various agroecosystem, development of mass production and formulation technology. Other issue in R & D of biocontrol agent, the involvement of private sectors in research on biocontrol is very low. This make slow development for commercialization.

## DISSEMINATION OF BIOCONTROL AGENTS

There two ways for dissemination of biocontrol agents, firstly is a state-driven through national, provincial and regional plant protection institutes, and bio-agent posts (managed by farmers). Second way is through private companies in which only limited microbial pesticides has registered in Ministry of Agriculture, and sale commercially.

## Commercial-based production and distribution

Till now, the number of microbial pesticides registered by Pesticide Committees Ministry of Agriculture of Republic Indonesia is very few i.e. only 4 brand the total active registered ingredients is 261 fungicides only 4(1.5%) [2]. Those four with a.i *Trichoderma* and *Gliocladium*. The route has advantage with sufficient quality insurance. Problem arise on product registration, microbial pesticides is treated same as



synthetic chemical pesticides. Other problems  
 reluctance of private sectors involve in R and D of  
 biofungicides, even in finishing step of product  
 development, in which Generally, does not have  
 sufficient state source. The problems may cause  
 the number of registered biofungicides is very low.

**State community production and distribution**

There are ways for dissemination, firstly is a state-  
 production through national, provincial and regional plant  
 protection institutes, and bio-agent posts. Bioagent  
 posts (PAs - Aen Hayati) are managed by farmers  
 groups. Plant Clinic of IPB actively play important role  
 in biocontrol agent dissemination through cooperation  
 with plant protection institutes and also local plant  
 clinic partners i.e. Plant Clinic of Tegal, Plant Clinic of  
 Jember. Based on our knowledge on the success of  
 microbial pesticides production by farmers groups for  
 their own use, the production in local farmer  
 cooperatives may be promising in the future. The  
 similar problems was also faced by biocontrol agent  
 production through cooperatives in Cuba, ensure the  
 distribution and availability for farmers in Cuba,  
 although it faced quality problem [16].

**THE APPLICATION BIOCONTROL AGENTS BY FARMER**

Diverse species and isolates of microbes are used by  
 farmers as microbial fungicides. There are four groups  
 of microbes of biocontrol agent i.e. rhizospheric/soil  
 fungi, antibiotics-bacteria, plant growth promoting  
 rhizobacteria (PGPR). Some species of *Trichoderma*,  
 and *Gliocladium* are examples of soil/rhizospheric  
 fungi which widely used by Indonesian farmers to  
 control many soil-borne diseases (stem blight of chili,  
 stem rot of peanut, wilt of tomato). Moreover, the  
 antibiotics bacteria such as fluorescent pseudomonads  
 has more limited application by farmers, generally also  
 for controlling soil-borne diseases.

The use of microbial pesticides in Indonesia has  
 promising result. There is no available data of the  
 number of applying farmers in Indonesia. Number of  
 farmers assisted by Plant Clinic of IPB applied  
 microbial pesticides and efficacy rate is depicted in

Table 1 and Table 2. These table show the  
 effectiveness of microbial pesticides is relatively high  
 (42-90%).

Table 1. Research and Application of *Trichoderma harzianum*

Disease	Pathogen	Efficacy Rate (%)	Step	Reference
Club root of cabbage	<i>Plasmiodiophora brassicae</i>	60	Wide-scale farmers application (Cipanas-Cianjur)	Plant Clinic of IPB Document (2011)
Basal stem rot	<i>Ganoderma boninense of oil palm</i>		Wide scale application	Plant Clinic of IPB Document (2011)
Stem blight of chili pepper	<i>Phytophthora capsici</i>	65	Field Trial and farmers application (Tegal)	[27]
Rice blast	<i>Pyricularia grisea</i>	73	Field Trial	[3]

Table 2. Field Trial and Farmers Application of PGPR

Diseases	Pathogen	Efficacy rate (%)	Step	Reference
Antraknosa-Cabai	<i>Colletotrichum sp.</i>	54	Wide scale farmers application, IPB Plant Clinic Network	[27, 20]
Antraknosa-pepaya	<i>Colletotrichum gloeosporioides</i>	75.25	Field Trial	[28]
Stem rot - Citrus	<i>Botryodiplodia theobromae</i>	34	Green house	[22]
	<i>Botryodiplodia theobromae</i>	45	Farmers Field Application (Magetan)	Plant Clinic of IPB Document (2011)
Karat Putih-Krisan	<i>Puccinia horiana</i>	58.89	Field Trial	[11]
Blast of Rice	<i>Pyricularia grisea</i>	87	Field Trial	[3]

**PROBLEMS**

The use of microbial pesticides is limited due to some  
 reasons. Species and genetic diversity of applied  
 isolates has made sometime inconsistent result.  
 Technique of mass production and formulation  
 ensuring quality and storability are also still problems.  
 Institution disseminating and producing microbial  
 pesticides still has problems in ensuring the product in  
 mass scale, therefore availability of ready-for used  
 microbes pesticides is still a problem.

## CHALLENGE AND FUTURE PROSPECT

Increase awareness of people on environment, the presence of some diseases which can not be controlled chemically, and conducive governmental policies support are driving forces for development and use of microbial pesticides. Massive campaign of chemical pesticides and problem of continuity of supply are the main inhibiting factors. The invention of new effective species or isolates of biocontrol agent, rational formulation are still important for the academia of universities. Improvement of supply mechanism and national roadmap on biopesticide development are needed to push the nationwide-use of microbial fungicides. Nowadays, research, development, dissemination, commercialization are conducted by various institutions with various step of product development, that frequently fragmented and poor synchronization. In order to provide significant impact of biological control on agricultural, industrial and economic development, Indonesian government should have a national roadmap of biopesticide development.

Powell et al. [14] stated the requirement for success of microbial antagonist i.e. viable market size, high performance and consistency, safety, stability, product differentiation, indigenous microbes, saprophytes, minimal capital cost, cheap and easy to produce, and applied using conventional technology. Regarding to the future, special strategy should be build to gear the development of microbial biofungicides in research and development, production strategy, positioning of governmental institutions and conducive government policy. Better research policy, mass production technology and improved production distribution will favor the wider use of microbial fungicides and also microbial pesticides.

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