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

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Edited By :
Hadiwiyono (the University of Sebelas Maret, Indonesia)
Sapyani (the University of Sebelas Maret, Indonesia)
John E. Thomas (the University of Queensland, Australia)
Nabuhiro Suzuki (the University of Okayama, Japan)
Suryo Wiyono (Bogor Agricultural University, Indonesia)
Sri Hendrastuti Hidayat (Bogor Agricultural University, Indonesia)

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Sofranita Syifa F.
e-mail : sofranita@gmail.com

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BIOLOGICAL CONTROL OF FUNGAL PLANT DISEASES IN INDONESIA

Suryo Wiyono and Meity S Sinaga
Department of Plant Protection, Faculty of Agriculture, Bogor Agricultural University, Bogor, Indonesia.
Contact Author: suryow@hotmail.com

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, research, 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. The 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 industrial-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 plants 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 chrysant, basal stem rot on oil palm caused by *Ganoderma* sp, white root on rubber tree caused by *Rigidoporus microporus*, black pod disease on cacao caused by *Phytophthora palmivora,* club root of crucifers caused by *Plasmodiopohora 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 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 *Sclerotium rolfsii* on peanut, by weaken pathogen propagules to antagonist attack, enhance indigenous microbes activity and increase nutrients availability [5; 29].

Other technique to enhance indigenous microbes is by applying selective nutrients such as chitin-containing materials. Aplication of chitin containing materials such as crab shell powder effectively control purple blotch of shallot caused by *Alternaria porri* [26]. Total phyllospheric, rhizospheric and chitinolitic bacteria increased with crab shell treatment. Morever 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, Scelerotium, Rhizoctonia, and Colletotrichum.* Antagonism mechanism of Trichoderma and Gliocladium are comp antibiosis, lytic enzyme production and som 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 pro using soil fungi are poorly characterized is undeveloped formulation make relatively application doses, and the need of cont additional organic matter amendment to suppo live and survival.

Arbuscular Mycorrhizal Fungi (AMF)

AMF can act as biocontrol agent, by protecting from plant pathogens through: better host nutrit improving nutrient status of the plant, competit infection/colonization sites, increased plant de metabolites: phenolics, chitinase, gluca peroxidase, phytoalexin, higher lignification i xylem, stronger vascular system . AMF intensively studied in Department of Plant Prot Bogor Agricultural University and effective a several plant pathogens, *Fusarium oxyporum cubense, Ganoderma boninense, P. paln Botryodiplodia* sp.

Yeasts Antagonists

The use of yeast s as biocontrol agents a various fungal plant diseases is widely repor abroad. Yeast is promising to be develope antagonist due to natural features grow resistance against desiccation and ultra radiation therefore make it possible for foliar dis control and post harvest horticultural dise Antagonistic mechanism of yeast varies, but competition and induced resistance, Research i Department of Plant Protection Bogor Agric University show that some yeasts *Cryptoc albidus, Pichia guilliermondii* can effectively c fruit rot of mango caused by *Botryodi theobromase* [30]. Field application of other *Cryptococcus terreus* affectively control petal bl dendrobium caused by *Curvularia palles*

Endophytic Fungi

Endophytic fungi is newest group of biocontrol agent against 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 mainly antibiosis by producing toxic substances into plant tissue and induced resistance. *Curvularia lunata* endophytes effective control club root of cabbage [1] and sterile hypha against chili antrachnose [23].

Antibiotic and Lytic Bacteria

Antibiosis 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 ie. fluorescent pseudomonads effective against fusarium wilt of shallot [17].

PGPR

The new generation of biocontrol agent in Indonesia is PGPR (*plant growth promoting rhizobacteria*). The term of PGPR was firstly introduced and examined by Kloepper [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 *Paeninacillus 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 e 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 */ad 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 tinvolve in R and D of biofungicides, even in finishing step of product development, in which Generally, does not have support from state source. The problems may cause the number of registered biofungicides is very low.

State-Community production and distribution

There two ways for dissemination, firstly is a state-driven through national, provincial and regional plant protection institutes, and bio-agent posts. Bioagent post (Pos Agen Hayati) are managed by farmers group. 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 Jakarta. 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 FARMERS

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, antibiosis-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 antibiosis 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	*Plasmodiophora brassicae*	60	Wide-scale farmers application (Cipanas-Cianjur)	Plant Clinic of IPB Document (2011)
Basal stem rot	*Ganoderma boninense of oil palm*		Wide scale application	Plant Clinic of IPB Document (2011)
Stem blight of chili pepper	*Phytophthora capsici*	65	Field Trial and farmers application (Tegal)	[27]
Rice blast	*Pyricularia grisea*	73	Field Trial	[3]

Table 2. Field Trial and Farmers Application of PGPR

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

Increasing awareness of people on environment, the presence of some diseases which can not be controlled chemically, and conducive governmental policy support are driving forces for development and uses 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, research on appropriate formulation are still important area for 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 road map of biopestcide 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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