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BIODIVERSITY OF SOIL FUNGI ON INTEGRATED PEST MANAGEMENT FARMING SYSTEM

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ABSTRACT

The greatest problem of modern agricultural practices is the use of chemical pesticides and fertilizers. It is noted that about 40% of the world's land surface is used for agriculture. The way this agricultural land is managed has a great influence on the global environment. Integrated Pest Management (IPM) farming system produces fewer negative externally affects, can effectively restore ecosystems and deliver well ecosystem services. Depending on methods applied and degree of production, agricultural practices impact biodiversity in the ecosystem and it also influences conservation practices within the ecosystem. The result showed that diversity of soil fungi on IPM was higher than diversity on conventional one. *Trichoderma* sp. and *Acremonium* sp. which are known as antagonist fungi were found on IPM but not on conventional one. Domination Index on IPM was lower than conventional field. Bacterial leaf blight (*Xanthomonas oryzae*) disease intensity showed no difference on both systems. The yield on IPM was higher (6.34 ton/ha) than conventional field (5.56 ton/ha). It has been found that rich biodiversity in agricultural environment improves productivity of agricultural systems. The IPM system gives more regard to the soil fungi biodiversity and considers it as an integrated system upon which the success of the agricultural production depends.

Keywords: integrated pest management, biodiversity, soil fungi, modern agricultural

INTRODUCTION

More than a third of the world's land surface is used for agriculture (IFOAM, 2004). The way this agricultural land is managed has a great influence on the global environment. One of the greatest problems threatening global peace is how the global ecology is handled. Mismanagement of the environment due to indiscriminate exploitation of natural resources often leads to imbalance in the ecosystem with attendant problem chain that affects several other systems, mostly negatively (Pretty *et al*., 2005).

Integrated Pest Management (IPM) is a concept and technology that is carried out by managing the agricultural ecosystem through a combination of various pest control techniques (Untung, 2001). This system gives more regard to the agro-ecosystem and considers it as an integrated system upon which the success of the agricultural production depends. The decreasing of a hazardous chemical use in agriculture has some advantages such as restoring soil structure and soil biota (diversity, soil invertebrates, microorganisms, and soil insects) that are responsible for decomposition and nutrient cycling (Untung, 2001). IPM concept further developed not only as a concept and technology of pest control, but it also became a concept of pest control, a greater emphasis on considerations of ecological and economic efficiency as a fondation of environmentally sustainable agriculture.

Implementation of IPM such as applying an organic matter into the soil and minimizing the synthetic chemical application are expected to be able to increase the population of soil microorganisms that are beneficial for soil biodiversity and also increase the stability of ecosystem (Dabbert *et al.* 2004; Halberg *et al.* 2006).

The farmers in the Sumberngepoh village have been started implementing IPM since 1995. Based on some previous research, it is known that on the IPM field there is a higher diversity of arthropods than conventional field. This study was aimed to determine the effect of the application of IPM on the diversity of soil fungi.

MATERIALS AND METHODS

The experiment was conducted on Sumberngepoh village – Malang District and on the laboratory of mycology, Department of Plant Pests and Diseases-University of Brawijaya. The study began from March 2009 to December 2009. The survey was conducted on IPM field and conventional field. The conventional field used conventional method that means the conventional system or commonly production system that allows all manners of combination of agricultural inputs, viz agrochemicals, genetically modified organism/ crops, highly intensive cultivation without much regard for the environment. However, the IPM system operates in contrary to that of the conventional. This system gives more regard to the agro-ecosystem and considers it as an integrated system upon which the success of the agricultural production depends.

Soil Sampling

Soil samples were collected from the surface ($\pm$15 cm) soil depth in each of 5 plot samples of both IPM and conventional field after transplanting (3-10 days after planting) and after harvest (3-10 days after harvest) period. From each plot, soil samples were collected randomly and mixed thoroughly to get a homogenous mixture. About 250 g of the soil samples collected were stored at 4^0 C and was used for microbiological analysis (Rao, 1994).

Enumeration of Fungi Population

Isolation and identification of fungi population using soil plate method were carried out using Potato Dextrose Agar (PDA) media. Media were prepared according to the composition and sterilized in autoclave. Microorganism was enumerated using soil plate and serial dilution method on PDA media plates and the inoculated plates were incubated at the temperature of 25 – 30^0 C at the duration of 5-7 days.

Physico-chemical Properties

pH of the samples was taken using an electronic digital pH meter in 1:5 soil water suspension. Organic Carbon (C) was determined by the method given by Anderson and Ingram (2003). Total Nitrogen (N), available Phosphorus (P) and exchangeable Potassium (K) were determined by kjeldahl distillation, molybdenum blue method, and flame photometer method, respectively.

Fungus Identification

Fungus identification is based on Compendiun of Soil Fungi (Domsch *et al*., 1980) and Illustrated Genera of Imperfect Fungi (Barnett, 1969).

Statistical Analysis

Fungi diversity was analyzed using the diversity index (H ') analysis according to Shannon-Wiener (Krebs, 1999) and Dominance index (C) analysis according to Simpson (Krebs, 1999). Diversity index analysis was used to calculate the soil fungus diversity and Dominance index was used to determine the dominance of soil fungi species in a community.

Rice yield and disease intensity were analyzed using t-test on 5% error level to compare the intensity of bacterial leaf blight on IPM and conventional field.

Intensity of Xanthomonas Campestris pv. Oryzae

The disease intensity was calculated using the following equation:

$$P = \frac{\sum (nxv)}{(ZxN)} x100\%$$

Remarks:
P: Percentage of plant infected
n: Number of plant in each attack category
v: The scale of each attack category
Z: The scale of the highest attack category
N: Number of plant observed.
The scales of attack category:
0 = no symptom
1 = 1-20% leaf show symptom
2 = 21-40% leaf show symptom
3 = 41-60% leaf show symptom

4 = 61-80% leaf show symptom
5 = 81-100% leaf show symptom

RESULTS AND DISCUSSION

Microbial Populations

Fungal population known was higher on IPM than that on conventional field. On IPM was found 45 species (the total number was 14700 colonies per g soil) and on conventional was found 31 species (total number 8100 colonies per g soil). The fungi were classified based on their role: pathogen, decomposer, and unknown role. On IPM field was found 2 genera of pathogen i.e. *Cladosporium* sp. (1 species) and *Monilia* sp. (1 species). It was found 5 genus decomposer fungi, i.e. *Trichoderma* sp. (1 species), *Acremonium* sp. (1 species), *Chaetomium* sp. (1 species), *Aspergillus* spp. (10 species), and *Penicillium* spp. (10 species). Twenty species of unknown fungi were also found.

On conventional field was found 2 genus pathogens such as *Curvularia* sp. (1 species) and *Monilia* sp. (1 species). On this field also found 3 genus of decomposer fungi: *Chaetomium* sp (1 species), *Aspergillus* spp. (9 species), and *Penicillium* spp. (5 speces). There are 14 unknown spesies on this field.

Some species fungi not found on conventional field (only found on IPM field) were *Trichoderma* sp., *Acremonium* sp., *Cladosporium* sp., *Aspergillus* sp. 1, *Aspergillus* sp. 6, *Aspergillus* sp. 7, *Penicillium* sp. 1, *Penicillium* sp. 2, *Penicillium* sp. 4, *Penicillium* sp. 5, *Penicillium* sp. 6, *Penicillium* sp. 7, *Penicillium* sp. 9, and unidentified fungus number 1, 4, 5, 6, 7, 10, 11, 12, and 14, while some species found on conventional, but not found on IPM, were *Curvularia* sp., *Aspergillus* sp. 8, *Aspergillus* sp. 10, *Penicillium* sp. 10, *Penicillium* sp. 11, and unknown fungi number 18, 19, and 21. Table 1 and Table 2 show the population of soil fungi found on IPM and conventional.

Based on both tables below, it can be seen that the population number of soil fungi on IPM was higher than that on conventional. Species number of soil fungi on IPM was also more diverse than that on conventional field. It may be due to the addition of organic amendments that might have large impact on the size and activity of microbial population. Increases in microbial count in response to fertilization. Other researchers have shown that incorporated organic amendment increased soil microbial activity and microbial diversity (Muhibuddin *et al*, 2008; Fließbach and Mäder, 2000). Also stated by Lotter *et.al.* (2003) that an applied manure will increase at 20-40% of microorganism population than conventional cultivation. It is also shown that C-organic content on IPM was higher (1.66%) than that on conventional (1.39%).

According to Bartram and Perkins (2003), the dependence of soil microorganisms on organic soil is determined by utilization of organic materials as a food. Heterotrophic microorganisms like fungi that use C-organic as an energy source have a high dependence on the presence of organic matter in soil. So, organic matter can increase soil microorganism population and its activity in the soil.

Lotter *et al.* (2003) also stated that the use of organic materials in cultivation can increase soil microorganism activity and increase the diversity of microorganisms in the soil. Table 4 shows the role of fungi on IPM and conventional.

Table 4 shows that there are many decomposer fungi on both field. Most soil microorganisms found have a beneficial role for agriculture, such as destroying organic waste, absorbing the nutrients, and controlling the soil pathogens. Several soil microorganisms are able to produce hormones that can stimulate plant growth. On IPM field was also found an antagonist fungi such as *Trichoderma* sp. and *Acremonium* sp. However, higher number of pathogen fungi on IPM field was found than those on conventional affected by the richness of organic content on IPM. These pathogen fungi would be automatically suppressed by the presence of decomposer and antagonist fungi.

Diversity of the fungi on soil will make soil ecosystem more stable because there is a complementary cyclic between each other in that it can create a stable condition without domination by particular microorganism. According to Reijntjes *et al*. (1999), community stability is supported by the condition of complementarities between the components within the communities that carry out different functions and interact synergistically. Decreasing number of the species of fungi will lose one component in the ecosystem that affects diversity in ecosystems. Table 5 shows a diversity and dominance of soil fungi on IPM and conventional management.

Diversity index on IPM tends to increase from 2.96 on the first sample to 3.28 on the second sample (Figure 1). Value index diversity in conventional field is relatively equal, which has a value 2.45 on first samples and 2.47 on second samples.

The high diversity index shows the better of soil fungi diversity. Addition of soil organic materials is a major factor to increase microorganism number (Sutedjo *et al*. 1996; Altieri *et al*., 2005). The more the population in the community is, the more diverse the community will be, and it will make the ecosystem become stable (Oka, 1995). Untung (2001) suggested that in stable ecosystem, the dominance organism would not exist. The dominance index on IPM was lower than that on conventional.

Tabel 1. Average of soil fungi population number on IPM (on 10^{-2} dilution)

NO	Species name	Number Found	Population density (Coloni per g of soil)	Role
1	*Cladosporium* sp.	1species	60	Patogen
2	*Monilia* sp.	1 species	10	Patogen
3	*Trichoderma* sp.	1 species	100	Decomposer
4	*Acremonium* sp.	1 species	40	Decomposer
5	*Chaetomium* sp.	1 species	10	Decomposer
6	*Aspergilus* spp.	10 species	310	Decomposer
7	*Penicillium* spp.	10 species	470	Decomposer
8	Not identified	20 species	470	Unknown

Tabel 2. Average of soil fungi population number on conventional (on 10^{-2} dilution)

NO	Kinds	Found	Population (Coloni perg of soil)	Role
1	*Curvularia* sp.	1 species	20	Patogen
2	*Monilia* sp.	1 species	30	Patogen
3	*Chaetomium* sp.	1 species	30	Decomposer
4	*Aspergilus* spp.	9 species	220	Decomposer
5	*Penicillium* spp.	5 species	170	Decomposer
6	Not identified	14 species	340	Unknown

Tabel 3. Composition of fungi on IPM and conventional

Role	Kinds	Total number (Coloni per g soil)	
		IPM	Conventional
Patogen	*Cladosporium* sp., *Curvularia* sp., *Monilia* sp.	700	500
Decomposer	*Trichoderma* sp., *Acremonium* sp., *Chaetomium* sp., *Aspergillus* sp., *Penicillium* sp.	9300	4200
Unknown	23 isolat were unknown yet	4700	3400

Tabel 4. Average of diversity index and dominance index

Index Value	Treatment	
	IPM	Not IPM
Diversity (H')	3.505	2.771
Dominance (Id)	0.039	0.059

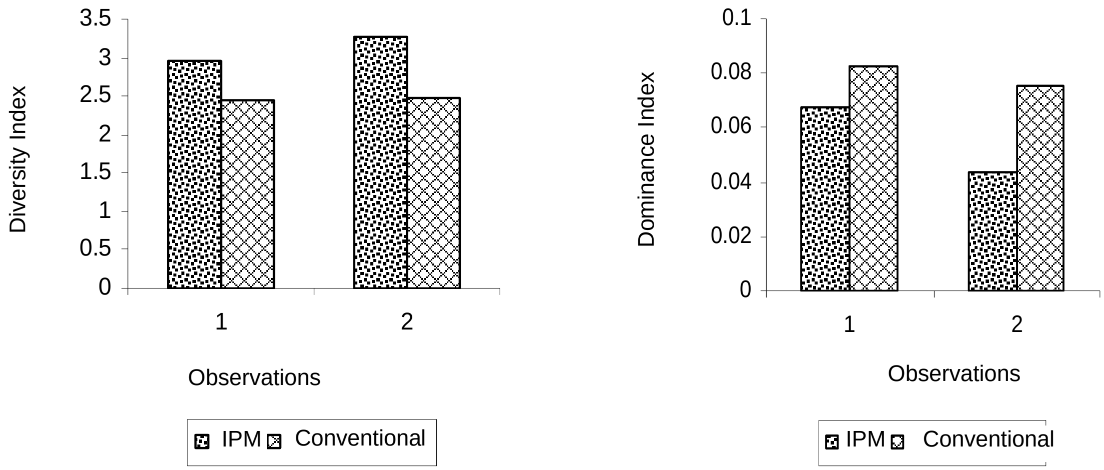

Figure 1. Histogram values diversity index on IPM and Not IPM

Remakrs:
Categories for diversity index:
- H '<1 categoriy is very low
- H '<1-2 low category
- H '<2-3 medium category
- H '<3-4 high category
- H '<4 categories is very high (Djufri, 2004)

Disease Intensity

Based on the observation, it was known that the major disease on the Sumberngepoh Village was bacterial leaf blight caused by the *Xanthomonas oryzae* pv. *Oryzae*), and the dominant pests were rat and white stem borer. Physical factors such as environment and weather (Muhibuddin, 2008; Fließbach, and Mäder, 2000; Bellarby *et al.,* 2008), pathogens virulence, and farming techniques influence the intensity of bacterial leaf blight disease. N fertilization at a high dosage will increase the damage of moderate resistance cultivar, although it is relatively small. Therefore, the provision of N fertilizer to the recommended dosage is important to increase vegetative growth and productivity.

On the first observation, disease intensity of IPM field shows a fairly low percentage, i.e. 8.16%, while on conventional field, the disease intensity shows 16.24%. At the end of the observation (2 weeks before harvest), the high intensity on both field was apparent. The intensity of bacterial leaf blight disease on IPM and conventional field was 51.36% and 60.54% respectively. Table 5 presents the intensity of bacterial leaf blight disease.

Table 5. The intensity of bacterial leaf blight disease on IPM and Non-IPM

Observation time (weeks)	Treatments	
	IPM (%)	Conventional (%)
1st	8.1	16.24
2nd	15.3	32.64
3th	32.4	48.96
4th	51.3	60.50

Based on the statistical analysis, it is known that the intensity of bacterial leaf blight disease on both field, IPM and conventional, is not significantly different. On IPM, it is showed that the intensity of the disease tends to increase although it is apparent that intensity is lower than that on conventional one. The result shows that the intensity of the disease increased continually until the end of the observation (Figure 2).

According to the observations of farmers in the village of sumberngepoh, the high intensity of the disease was suspected to be affected by bad weather in the form of strong wind which is sometimes accompanied by heavy rain. The data on rainfall intensity which appears to be quite high at around February to June is revealed in the following table (Table 6).

Table 6. The intensity of rainfall

Months	Rainfall Intensity
February	219 mm/28 days
March	146 mm/31 days
April	295 mm/30 days
May	129 mm/31 days
June	113 mm/30 days
July	8 mm/31 days

Suspected bad weather is capable of supporting the spread of the bacteria *Xanthomonas oryzae* on rice field area, so the progression of the disease also increases. This is in accordance with the opinion of Semangun (1991); Gams (2011) which states that the paddy crop that is wide enough, the bacterium *Xanthomonas oryzae* can be spread by windy rain. Ou also said that high wind did not just disperse the bacteria, but it could also cause injuries due to friction in the leaves of rice making it easier for bacteria to penetrate through the leaves of wounded plants. Although IPM technology has less influence on the intensity of bacterial leaf blight disease attack, it allegedly affects the other pathogens that are not observed. Thus it is expected to affect the average rice production on field that proved IPM was higher than on conventional field.

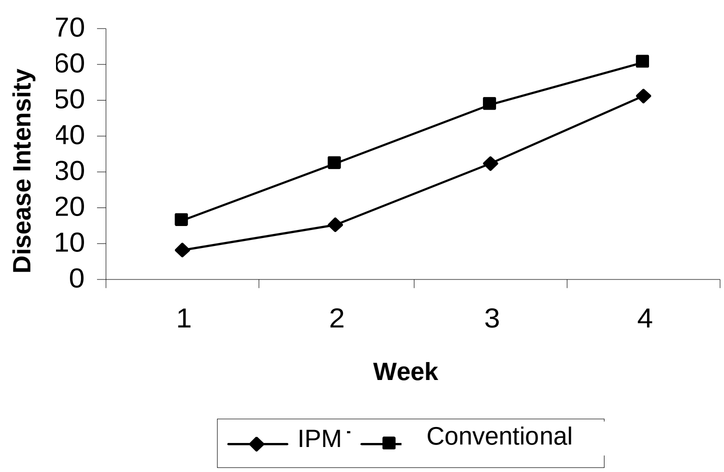

Figure 2. The intensity of bacterial leaf blight disease on IPM and conventional field

Based on personal interviews, the rice production on field that implements IPM technologies can increase two folds. In 1995 the production was about 5-6 tons and in 2005 grain production could reach 12 tons. In July 2008, it, however, showed that the production decreased.

Table 8. Average rice production in IPM and conventional (tons / ha)

Treatments	Production (ton/ha)
IPM	6.34
No IPM	5.56

Decrease in rice production is due to the high intensity of bacterial leaf blight disease, or commonly known as crackle disease. However, the results of IPM production on field still show a higher value than that on conventional field. Based on the result of T test, the average production on both field showed significant different. This is in accordance with the results of experiments revealed by Bartram and Perkins (2003) where the use of inorganic fertilizers will improve plant growth and crop yields in the short term, but in the long-term soil fertility is declining. Meanwhile, the addition of organic materials such as embedding rice straw on the field is capable of improving growth and yield of crop production and simultaneously improves the physical and chemical properties of soil (in accordance with soil analysis) so as to increase field productivity in the long term.

CONCLUSIONS

Diversity of soil fungi on field IPM (index value = 3.504877118) is higher than the diversity of soil fungi in the area of conventional (index value field = 2.77). On field, 45 species of fungi IPM were obtained with the total of all the colonies as much as 14700 colony per g soil, whereas in conventional field, 31 kinds of mushrooms were obtained with a total of 8100 colonies colonies per gram soil.

The dominance of a type of soil fungi on field IPM (dominance index value on the field IPM = 0.039) was lower than that in conventional field (field value dominance in conventional index = 0.059). Application of IPM technology can give effect to increase the diversity of soil fungi and suppress the occurrence of domination by a certain type of microorganisms that can cause disease, helping to reduce the likelihood of the disease, which will give effect to the crop.

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