Abundance of soil microbial communities and plant growth in agroecosystems and forest ecosystems

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Abstract

The objective of this study was to review natural ecosystems and agroecosystems to compare the abundance of soil microbial communities and also plant growth. This study used a random block design method, each soil from both ecosystems is planted with corn and string beans. Each treatment is repeated three times and arranged in random block design. At the end of the study, head height, root display and leaf count were calculated. The results showed that soils from agroecosystems had greater microbial abundance and good plant growth responses. The results showed that agroecosystems are ecosystems that have an abundance of microbial communities that are the most good compared to forest ecosystems. This has an impact on good growth responses in agroecosystems compared to forest ecosystems.

Keywords: Agriculture ecosystem, plant growth promoting agents, natural ecosystem

Introduction

Healthy soils are the capacity of soils to function, within the boundaries of natural and managed ecosystems, to maintain crop productivity, maintain water and air quality, support human welfare, and provide habitat for biodiversity (Doran and Zeiss, 2000; Gugino et al., 2009). Human impacts on soil health largely arise from the need to meet the growing food, fiber and fuel needs of the population. In recent decades significant efforts have been made to increase agricultural productivity through increased fertilization and application of pesticides, increased irrigation, land and crop management, and large-scale land conversion (Tilman et al., 2001).

Recently, awareness and concern have begun to emerge that agricultural intensification is putting tremendous pressure on the capacity of soils to maintain other functions that lead to large-scale ecosystem degradation and long-term loss of productivity (Foley et al., 2005; Vitousek et al., 2009). For example, the conversion of natural ecosystems into agricultural land has caused huge environmental costs, including desertification, increased greenhouse gas emissions, decreased organic matter in the soil, loss of biodiversity, and changes in biogeochemical and hydrological cycles (Balmford et al., 2005). Modern agriculture thus faces major challenges not only in terms of ensuring global food security by increasing crop yields but also reducing environmental costs especially in the context of a changing environment and increasing competition for land, water and energy (Chen et al., 2014). Therefore, this study aims to examine the natural ecosystems represented by pine forests and agroecosystems to compare the abundance of soil microbial communities and also plant growth. The hypothesis are microbes in forest soils are higher than in agroecosystem soils because forest land is still virgin and there is no additional input from humans

Material and Methods

Site Properties

The experiment was conducted at the pine forest ecosystems Mount Halimun Salak National Park, sub district Pamijahan Bogor district, West Java -6.689177, 106.680534 and Cikabayan Experimental Station, Dramaga Campus of IPB University, Bogor district West Java -6.550665, 106.715212.

Material

The materials used were soil samples from pine forest ecosystems were taken from the Mount Halimun Salak National Park, Bogor, and soils from agroecosystems from the Cikabayan Experimental Station, Dramaga Campus of IPB, Bogor, sweet corn seed varieties of bonanza and peanut varieties of zebras, sterile aquades, Pikovskaya media, Martin jelly and TSA. The equipment used is equipment for analyzing soil properties in the field and laboratories, stationery, and a computer set.

Method

Time and Place of Implementation

The research activities were carried out from September to December 2019 in the Experimental Station and Education Laboratory, Plant Protection Department, Faculty of Agriculture, Dramaga Campus of IPB.

Planting Media Preparation

The planting media used in this study were soil samples with soil depth 0-20 cm latosol type soil, clay soil texture with pH 6, this soil belongs to the type of Mediterranean land with moderate sensitivity to erosion from pine forest ecosystems taken from the Mount Halimun Salak National Park, Bogor, and soil from agroecosystems latosol type soil with soil depth 0-20 cm, clay soil texture with pH 6 from the Cikabayan Experimental Station, Dramaga Campus of IPB, Bogor. Each soil sample is then prepared in a planting tub with a size of 38 x 30 x 15 cm.

Planting of planting material

The planting material used consists of sweet corn seeds of bonanza varieties and peanut varieties of zebra. Each tub is planted with 5 seeds. Then maintained until the age of 4 weeks with treatment in the form of watering and weeding.

Plant growth measurement

At the end of the study it was observed that plant growth included 1) the height of the canopy measured from the ground surface to the highest canopy, 2) the number of leaves, and 3) the length of the roots measured from the base of the stem to the tip of the root.

Population Observation and Enumeration of Soil Microbes

Each soil sample was taken from each treatment as much as 1 g and put in 10 mL of sterile aquades. Then it is diluted serially until dilution 10^{-4}. Soil suspensions at dilutions 10^{-3} and 10^{-4} were taken 0.1 mL and grown on Pikovskaya, Martin jelly, and TSA media by the scatter method. Microbial enumaration is done by calculating the total plate count based on BSN (2006) using the formula:

$$N = \frac{\sum c}{[(1 \times n1) + (0.1 \times n2]x(d)}$$

The items in the formula refer to:
N = Number of product colonies, expressed in CFU per mL
$\sum c$ = Number of colonies in all plates was counted
n1 = Number of plates in the first dilution is calculated
n2 = Number of plates in the second dilution is calculated
d = The first dilution is calculated

Data analysis

This study used a randomized block design with 3 replications. The data obtained were processed using SAS program version 9.1. The treatments that showed significant differences were further tested by Duncan's test at 5% level.

Results

Abundance of Soil Microbial Communities

Exploration results of soil microbial communities from agroecosystems and forests found bacteria, fungi, and phosphate solubilizing bacteria in each treatment (Table 1). However, the abundance of soil communities tends to be more common in soils from agroecosystems than in pine forest ecosystems. Meanwhile, soil from agroecosystems planted with peanuts showed the greatest abundance of soil microbes, namely bacteria of 2.74 x 10^5 CFU mL^{-1}, fungi of 1.86 x 10^4, fungi of CFU mL^{-1}, phosphate solubilizing bacteria of 2.74 x 10^5 CFU mL^{-1}. Meanwhile, the smallest abundance of microbes is shown by soil from pine forest ecosystem planted with peanuts, with a number of bacteria of 6.27 × 10^3 CFU mL^{-1}, fungi with too little amount to count, and phosphate solvent bacteria of 4.36 × 10^4 CFU mL $^{-1}$.

Table 1. Soil microbial populations in the treatment of agroecosystems and pine forests.

No	Treatments	Bacteria (CFU mL^{-1})	Fungi (CFU mL^{-1})	Phosphate Solvent Bacteria (CFU mL^{-1})
1	T_1E_1	9.04 x 10^4	TSUD	2.61 x 10^4
2	T_2E_1	2.74 x 10^5	1.86 x 10^4	2.74 x 10^5
3	T_1E_2	1.97 x 10^4	6.56 x 10^3	4.36 x 10^4
4	T_2E_2	6.27 x 10^3	TSUD	4.36 x 10^4

Remarks : T1E1 = corn plants on agroecosystem soils, T2E1 = peanut plants on agroecosystem soils, T1E2 = corn plants on exocytes of pine forests, T2E2 = peanut plants on soils of pine forest ecosystems.

Growth response of corn and peanut plants

Based on plant growth parameters, the best ecosystem for maize and long bean growth is agroecosystem compared to pine forest ecosystem (Table 2). The results of the analysis of variance showed that the two plants growing media from the agroecosystem had a significant influence on the height of the canopy compared to the pine forest ecosystem. The difference in height of the canopy between corn in the agroecosystem and forest ecosystem planting media was 30.75 cm, and the difference in the canopy between the peanuts in the agroecosystem and forest ecosystem planting media was 9.85 cm. Meanwhile, for the root length variation, in the long bean plant based on the analysis of variance, there was no real effect of the use of growing media from both ecosystems.

Table 2. Response of growth of corn and peanuts in planting media from different ecosystems

No	Treatments	Canopy Height	Root Length	Number of Leaves
1	T_1E_1	49.40a	44.76a	4.80c
2	T_2E_1	30.58b	36.87a	15.60a
3	T_1E_2	18.65c	6.93b	3.67c
4	T_2E_2	20.73c	44.33a	10.93b

Remarks : T1E1 = corn plants on agroecosystem soils, T2E1 = peanut plants on agroecosystem soils, T1E2 = corn plants on exocytes of pine forests, T2E2 = peanut plants on soils of pine forest ecosystems. The numbers in the same column followed by the same letter are not significantly different at the 5% test level (Duncan's test).

However, the corn planted in agroecosystem planting media showed a significant effect on increasing root length compared to pine forest ecosystem planting media by selecting root length increase of 37.83 cm. In the parameters of the number of leaves, the only real effect is on the planting of peanuts. The results of the analysis showed that the agroecosystem planting media showed a real effect on the number of peanut leaves compared to the pine forest ecosystem.

Discussion

Soil microbial communities show that their abundance is high in agroecosystems compared to forest ecosystems. Agroecosystem which is an artificial ecosystem occurs practices of soil management, crop rotation, periodic fertilization; and the application of pesticides resulting in temporal and spatial changes in the physical and chemical properties of soils in agricultural systems (Carbonetto et al., 2014). Such agroecosystems represent a rapidly fluctuating environment with highly variable resource gradients and create greater bio-physical and chemical heterogeneity compared to forest ecosystems, thus providing a variety of gaps for microbial growth (Trivedi et al. 2016). Microbial communities in natural systems

may be limited by the availability of nutrients and therefore the addition of fertilizers can allow colonization by new species from regional ponds (Crowther et al., 2014; Figuerola et al., 2015).

In this study, the composition of soil microbes found in abundance in agroecosystem soils correlated with the growth parameters of corn and peanuts in soil media from agro-systems. The presence of microbial communities on the soil has several roles including as biological fertilizer, providing phosphorus to be absorbed by plants, nitrogen fixation, siderophor production, and phytohormone production (Mehmood et al., 2018). The presence of microbes in the form of bacteria from the PGPR group in the soil not only rapidly colonizes the rhizosphere soils and enhances the absorption ability of plant nutrients but also is beneficial in suppressing disease through various mechanisms. One of the nutrients that plants need is phosphorus.

Phosphorus is an important nutrient taken from the soil by plants in the form of phosphate anions (Nautiyal et al., 2000). Because of its highly reactive nature, phosphate anions can be obtained by plants with cation precipitation (Al_3^+, Mg_2^+). The availability and unavailability of phosphorus for plants depends on the quality of the soil because phosphorus is very insoluble in the soil, therefore only a limited amount of phosphorus is available for plants (Yadav and Dadarwal, 1997). It has been documented by many researchers that Hydroxyapatite, di-calcium phosphate, rock phosphate and tricalcium phosphate are transformed into soluble forms by various species of beneficial bacteria present in the soil and these beneficial bacterial species are called phosphate solvent bacteria (PSB) (Chen et al., 2006; Rodríguez and Fraga, 1999). Various mechanisms are followed by PSB to dissolve phosphates that are not available including the release of enzymes and the production of certain acids (Greiner et al., 2001). PSB inoculation not only increases plant growth parameters but also significantly increases overall crop yields (Moura et al., 2001).

Conclusion

The results showed that agroecosystems are ecosystems that have an abundance of microbial communities that are the most good compared to forest ecosystems. This has an impact on good growth responses in agroecosystems compared to forest ecosystems. The limitation in this study are, this study has not been able to identify the type and function of microbes, but this study has implications that can determine the level of soil health through the observed abundance of microbes.

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