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The use of litterfall from various land agroecosystems to increase the fertility of the land of community cocoa plantations

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Abstract. This study aimed to determine the effect of organic fertilizer application from the litter on increasing soil fertility in various cocoa-based agroecosystems around the Lore Lindu National Park (LLNP). Based on the initial survey, 5 (five) types of agroecosystems were obtained, namely (A) cocoa + mixed wood trees, (B) cocoa + fruit trees, (C) cocoa + teak, (D) cocoa + candlenut, and (E) cocoa + gliricidia. Litter found on the floor or under farmers' gardens in each type of agroecosystem was made from organic fertilizer. The research was designed in the form of an experiment using a factorial randomized block design method, with the treatment of organic material sources (various types of agroecosystems) as the first factor, and the dose of organic fertilizer as the second factor. Doses tried were 0; 15; 30; 45; 60 $Mg.ha^{-1}$. The experiment was carried out in a double manner; firstly, the organic material was incubated in a pot without plants; secondly, it was applied to cocoa plant seeds in the pot. Variables measured were aspects of the growth of cocoa seedlings in the pot: plant height, number of leaves, stem diameter, leaf area, chlorophyll content, and seed dry weight. While changes in soil properties were observed in the nursery and incubation media, the measured variables were: pH, C-organic, nutrient content of N, P, and K and CEC. The results showed that organic fertilizer made from the litter of cocoa agroecosystem + mixed wood trees and cocoa fruit + produced better cocoa seedling growth than other agroecosystem types. The difference was caused by changes in some physical and chemical properties of the soil due to organic fertilizer. The plant response model to the dose tried was quadratic with an optimal dose of 15 to 45 $Mg.ha^{-1}$.

1. Introduction

There were various forms of land use patterns that have been converted from forest cover by communities living around the Lore Lindu National Park (LLNP). The research results of [1] revealed that land-use patterns around the LLNP area were generally forest gardens or mixed gardens of cocoa plants with various types of woods, as well as annual plants with slash-and-burn systems.

Conversion of forests into agroecosystems decreased soil organic matter content through the process of increasing the rate of decomposition, which will ultimately increase the rate of carbon dioxide (CO2) release into the atmosphere [2]. In terms of quantity, the thickness of the soil on the land and the availability of nutrients in the soil was determined by the amount of litterfall of its cover vegetation [3]. Factors that determined the amount of litterfall in ecosystems were vegetation type, environmental conditions such as temperature and rainfall. The fall of litter and decomposition were two important events for the ecosystem, namely as input and output for the soil and had an important role in the nutrient cycle and energy flow in nature [4]. According to Amelia (2006), in Monde (2009), forests could produce as much as 32.5 $Mg.ha^{-1}.year^{-1}$. On acid soils in North Lampung, monoculture petaian (Peltophorum) trees provided litter input of about 12 $Mg.ha^{-1}.year^{-1}$; Gliricidia (gamal) monoculture of about 5 Mg $ha^{-1}.year^{-1}$. Whereas secondary forest provided litter input of around 8-9 $Mg.ha^{-1}.year^{-1}$ [5]. Nutrient returned in the form of litter could not be reabsorbed directly by plants, but had to go through the decomposition process first [6]. The speed of litter decomposition was determined by the quality of the content of dissolved carbohydrates, amino acids, active polyphenols, lignin, and the C / nutrient ratio [7].

Land management by the community around the LLNP area created different agroecosystem conditions that would have an impact on the sustainability of their farming. Today, the fall of litter from various ecosystems was increasingly becoming a concern of experts because, in the process of decomposition, it was considered as the key component of the carbon cycle, the nutrient cycle, and energy transfer [8]. The results of research conducted by Wasrin (1997) in [5] on various land management or agroecosystems produced different litter production.

This study aimed to determine the effect of organic fertilizer sourced from various types of litters of cocoa-based agroecosystems on the growth of cocoa seedlings and changes in the soil chemical properties of community cocoa plantations around the LLNP area.

2. Methods

The study was conducted at the Greenhouse, Faculty of Agriculture, University of Tadulako, at an altitude of 90 meters above sea level (masl). Land litter for each type of agroecosystem was taken in Palolo Subdistrict, Sigi Regency, which was directly adjacent to the Lore Lindu National Park area, Central Sulawesi, at an altitude of 700 to 850 meters above sea level. There were five types of cocoa-based agroecosystems that would be used as sources of litter to be further processed into organic fertilizer as a treatment, namely: A = Cocoa planted with various types of wood trees; B = Cocoa planted with various types of fruit trees; C = Cocoa planted with Teak trees; D = Cocoa planted with Candlenut trees, and E = Cocoa planted with gliricidia shade trees.

Litter found on the floor or under the farmer's garden in each type of agroecosystem was made of organic fertilizer (compost). To speed up the composting process, litter was mashed by chopping up to < 1 cm in size and then fermented by adding decomposer solution obtained in the market. The study was designed in the form of an experiment using the Randomized Block Design (RBD) method. The experiment was carried out in a double manner, firstly applied to plant seedlings and secondly incubated on soil without a plant in the pot, each treatment was grouped according to microenvironmental conditions in a greenhouse into three groups as a test.

The variables measured in terms of growth of cocoa seedlings in pots were: (a) plant height, (b) Number of leaves, (c) Stem diameter, (d) Widest leaf area, measured by tools of Leaf area meter, (e) total chlorophyll, measured by spectrophotometer method at wavelengths of 645 and 663 nm, total chlorophyll was calculated = (2.20 x A645) + (8.02 x A663) x 1.25 [9] ; (e) Canopy dry weight, namely by weighing plant canopy weight after roasting at 80^0C for 48 hours. Observation data were analyzed by the F test, and if there was a real or very real effect, it would be further tested using the Tukey test at a level of 95%.

Furthermore, in incubation pot and plant pot, the measured variables were the changes in soil physical-chemical properties before and after incubation. Soil physical-chemical properties observed were soil texture by the pipette method, pH was measured by glass electrodes, C-organic by the Walkey and Black method, total N nutrient content was measured by the Kjeldahl method, phosphorus and potassium nutrient potential were determined using 25% HCl extractor, measured by

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spectrophotometer for P and flame photometer for K, as well as CEC extracted with NH4Ac [10]. Data from the soil analysis results were interpreted descriptively by comparing the results of the initial soil analysis with the results of soil analysis from incubation pot media and plant pot.

3. Results and discussion

3.1. Cocoa seedling growth

The giving of organic fertilizer made from a litter from various types of agroecosystems and doses significantly affected the growth component of cocoa seedlings, although their interaction with the doses of organic fertilizer that were tested did not have a significant effect. Data on average observations are presented in table 1 below.

Table 1. Effects of giving of organic fertilizers made from a litter from various types of agroecosystems and doses on the cocoa seedling growth in greenhouses

Treatment	Plant height (cm)	Number of Leaves	Stem Diameter (mm)	Leaf Area (cm^2)	Total Chlorophyll (mg/l)	Canopy Dry Weight (g)
Types of agroecosystems:						
Cocoa + Mixed woods	28.75a	13.68ab	3.92a	106.1a	35.91ab	3.92a
Cocoa + Fruits	28.71a	14.88a	3.91a	109.6a	38.22a	3.91a
Cocoa + Teak plant	25.94ab	12.71b	3.53a	110.3a	38.78a	3.53a
Cocoa + Candlenut	25.48b	12.93b	3.53a	95.7a	34.93b	3.53a
Plant	20.75c	10.24c	2.71b	55.7b	27.75c	2.71b
Cocoa + Gamal Plant						
The dose of Organic Fertilizer ($t.ha^{-1}$) :						
0	tn	11.61b	3.17b	78.9b	32.75b	3.17b
15	tn	13.03ab	3.53ab	96.9ab	35.60ab	3.53ab
30	tn	13.37ab	3.73a	102.7a	38.10a	3.73a
45	tn	13.56a	3.70a	100.7ab	35.47ab	3.70a
60	tn	12.88ab	3.48ab	98.3ab	33.66b	3.48ab

Note: Numbers followed by the same letter are not significantly different according to the Tukey test ($P < 0.05$)

3.2. Changes in soil chemical properties

The giving of organic fertilizer made from a litter from various types of agroecosystems could change some of the chemical properties of the soil, both in incubation pot and in the indicator plant pot. These changes were measured by the percentage difference before and after the experiment. Data on the percentage of change in some of the chemical properties of the soil are presented in table 2 below.

Table 2. Percentage of changes of some soil chemical properties in giving of organic fertilizer from various types of cocoa-based agroecosystems

soil chemical properties	Media	types of agroecosystems *)				
		Cocoa + Mixed woods	Cocoa + Fruits	Cocoa + Teak	Cocoa + Candlenut	Cocoa + Gamal
pH (H_2O)	Incubation Pot	-3.57	-4.59	-6.12	-9.18	-9.18
	Plant pot	-8.16	-8.84	-9.52	-10.03	-9.52
C-organic	Incubation Pot	66.19	69.78	-2.88	1.44	2.88

	Plant pot	45.32	58.99	-15.83	-25.18	-21.58
N-total	Incubation Pot	38.89	44.44	0.00	5.56	11.11
	Plant pot	22.22	33.33	-22.22	-11.11	0.00
C/N	Incubation Pot	1.36	-2.52	-12.62	17.48	19.61
	Plant pot	-3.88	-11.84	-15.83	19.22	18.83
P2O (Bray)	Incubation Pot	12.29	30.89	5.46	-0.68	0.34
	Plant pot	5.63	26.96	0.68	-8.19	-4.27
P2O5 (HCl 25%)	Incubation Pot	12.26	34.30	5.45	0.30	-0.71
	Plant pot	5.63	27.07	0.53	-4.32	-8.23
K2O (HCl 25%)	Incubation Pot	48.11	40.04	16.06	7.99	4.00
	Plant pot	32.12	24.06	0.15	-7.99	-11.99
CEC	Incubation Pot	28.11	26.55	-12.55	-5.52	-12.05
	Plant pot	22.59	15.67	-19.13	-17.35	-25.88

Note: negative signs in the numbers in the table show a decrease and vice versa show an increase in the value of the initial soil state before the experiment

The data in table 2 shows that the application of litter organic fertilizer for various types of agroecosystems could reduce soil pH of 3.57% until 10.03%, increase C-organic up to 58.99% in the type of cocoa + fruits, but decrease up to 25.18% in the type of cocoa + candlenut. Likewise, soil N-total level generally increased, except for the types of cocoa + teak and cocoa + candlenut. Phosphorus and potassium levels tended to increase except in the types of cocoa + candlenut and cocoa + Gamal. CEC values increased in the type of cocoa + wood trees and cocoa + fruits, but the value decreased in other types of agroecosystems.

The regression model of the effect of organic fertilizer doses on the growth of cocoa seedlings shown by canopy dry weight shows a different equation pattern, as shown in the following figure.

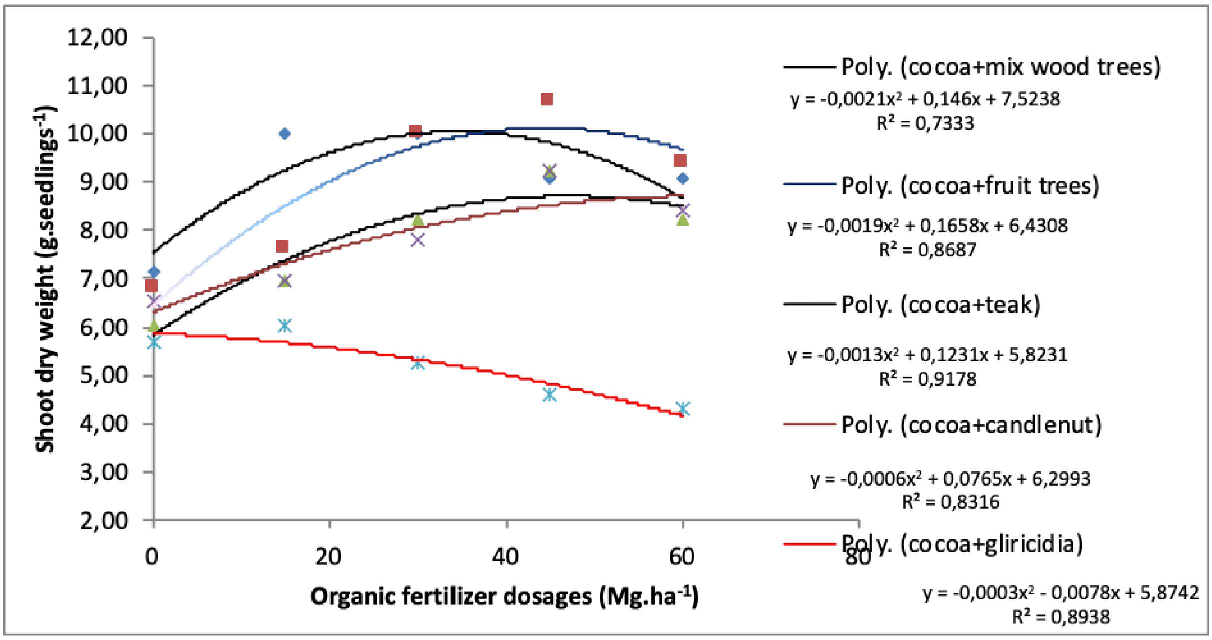

Figure 1. Model of the effect of administering various doses of organic fertilizer on the dry weight of cocoa seedlings in a nursery

The figure above shows that the equation model of each type of agroecosystem type differs from one another. As follows:

1. Agroecosystem type of cocoa + mixed wood trees, $Y = -0.00211x^2 + 0.146x + 7.528$; $R^2 = 0.733$
2. Agroecosystem type of cocoa + fruits, $Y = -0.0019x^2 + 0.1658x + 6.4308$; $R^2 = 0.8687$
3. Agroecosystem type of cocoa + teak, $Y = 0.0013x^2 + 0.123x + 5.8231$; $R^2 = 0.9178$
4. Agroecosystem type of cocoa + candlenut, $Y = -0.0006x^2 + 0.0765x + 6.2993$; $R^2 = 0.8316$
5. Agroecosystem type of cocoa + gliricidia, $Y = -0.0003x^2 – 0.0078x + 5.8742$; $R^2 = 0.8938$

The equation gave the meaning of the model tendency of the effect of quadratic organic fertilizer dose, with different optimum doses. The highest optimum dose was in the agroecosystem type of cocoa + candlenut, while the lowest optimum dose was cocoa + gliricidia, although it had no implications on the growth or dry weight produced.

4. Conclusion

The giving of organic fertilizer made from a litter from various types of agroecosystems and doses significantly affected the growth component of cocoa seedlings but did not interact significantly with the doses that were tried. Agroecosystem Type of cocoa + mixed wood trees and cocoa + fruits produced a litter, which was generally better at affecting the growth of cocoa seedlings. Both types of agroecosystems also appeared to be effective in improving the chemical properties of soil. Thus, the two types of agroecosystems referred to could be recommended to farmers to apply.

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