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THE EFFECT OF LEGUME AND NON-LEGUME BIOMASS TOWARD N MINERALIZATION ON DEGRADATED SOILS IN LAMPUNG, INDONESIA

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ABSTRACT

This research aims to study the kinetics of N mineralization by using double-pool kinetics models on degradated soils in the cultivation of monoculture cassava as a result of providing organic matter of legume and non-legume. Incubation experiments were conducted in the laboratory at a constant temperature. The treatment was by giving non-legume and legume biomass on Ultisol in which cassava has been planted there with different lengths of time. In this research, to estimate the parameters of the mineralized N and the rate of mineralization (k), double-pool kinetics equation was used. Mean while, the relationship between the parameters of N mineralization with nutrient uptake was investigated by conducting a pot experiment in a greenhouse. The results showed that the application of organic matter derived from groundnut produced higher mineralization. The N mineralization of soil that has been planted by cassava less than ten years was higher than it was on soil that has been planted by cassava more than 30 years. The total amount of N released on soil that has been planted by cassava less than 10 years reached 1086 mg kg^{-1}. Whereas, the total amount of N released on soil already planted with cassava more than 30 years was 783 mg $kg^{-1.}$ Potential value of N (N0) and the mineralization rate coefficient (k) were higher in organic matter with a low ratio of C: N and on more fertile soil.

Keywords: N mineralization, legume - non legume biomass, double-pool kinetics equation, degradated soil.

INTRODUCTION

An increasing of number of people will continue to demand the fulfillment of basic needs, especially food. The world, including Indonesia, will be faced with a crisis to meet the basic needs due to the limited natural resources. Therefore, efforts to find sustainable food source must be done (Suwarto, 2010). Cassava has the highest potential productivity among other food source plants, reaching 71 tons ha^{-1} or 1045 kJ ha^{-1} (Alves, 2005). This plant grows in a wide area distribution, between 30^{o}NL dan 30^{o}SL (Akparobi, 2009). Cassava is drought tolerant, and still able to grow well on less fertile soil when other plants are not growing. Elsarkawwy and Cock (1989) reported that cassava has a high optimum temperature for photosynthesis (35^{o}C), the temperature range in cultivation area is between 25-35^{o}C; has higher light saturation point, low photorespiration, and low CO_2 compensation point. Based on those characteristics, cassava is very potential to be used as one of the main sources of food commodities. With a high optimum temperature for photosynthesis, cassava will be benefited when the temperature of the Earth increases by global warming. As a result, the effort of the plant cultivation to be used as a food source can be done continuously.

In Indonesia, most of the cassava productions are in dry land at Alfisol, Ultisol and Inceptisol which generally have low fertility (Suryana, 2007). In the Ultisol, the problems faced are related to deficiency of macronutrient, aluminum toxicity, cation exchange capacity (CEC) and low organic matter. Organic matter content in the Ultisol is generally low. It is because the process of mineralization of organic matter goes rapidly as a result of high temperatures and high rainfall. High rainfall can also cause intensive leaching process which causes nutrients draw farther away from the reach of roots. This situation is exacerbated when root growth is also limited by the existence of barrier layers such as aluminum toxicity. Loss of nitrogen (N) through leaching in Ultisols planted with maize and groundnuts range from 3 to 72% (Hairiah *et al*., 2000).

In Lampung Province, Ultisol is one of soil ordo that is widely used for the cultivation of cassava (Hairiah *et al*., 2000; Sarno *et al*., 2004). Commonly, cassava is grown in monoculture and continuously throughout the year. Monoculture planting gives negative effect on soil fertility and crop productivity. Nguyen Tu Siem (1992) reported that the planting of cassava for 10 years lowers soil organic matter content from 1.72% to 0.55%. Besides the effect on the decline in soil fertility levels, in this case the decrease of the amount of N, CEC, P, K and Mg available in the soil, planting cassava continuously will also decrease the yield of cassava. The result of the cassava production grown continuously for 20-30 years decreases from 26-30 $t.ha^{-1}$ to 10-12 $t.ha^{-1}$. In the Ultisols that has been planted with monoculture cassava continually, the amount of organic matter and N content in the soil can decrease to a critical level that causes soil degradation. Snakin *et al*. (1996) suggests that the disruption of nutrient cycling in the soil is an indicator of soil degradation.

Of all the nutrients, nitrogen is mostly needed but its availability is always low because its mobility in soil is very high. The ability of soil to provide N is determined by the conditions and the amount of soil organic matter

(Benbi and Richter, 2002). The main source of soil nitrogen is organic matter, which will then undergo the process of mineralization. In this process the nitrogen is converted by microorganisms of organic nitrogen (protein and amine compounds) into inorganic forms (NH_4^+ and NO_3^-) so that it becomes available to be absorbed by plants. Mineralization of organic N into inorganic N is an important factor in determining the availability of N in the soil. The rate of mineralization of organic matter is determined by various factors such as soil pH, soil moisture, soil temperature and quality of organic matter (Samuel *et al*., 2002; Handayanto *et al*., 1997; Agehara and Warncke, 2005; Griffin and Honeycutt, 2000; Cookson *et al*., 2002, Kyveryga *et al*., 2004; Fritschi *et al*., 2005).

Several equations have been developed to predict the availability of N based on the time that is often called the N kinetics. First-order models can be used to describe the mineralized N. Double exponential models involving two sections that describe organic pool, which has a difference in the decomposition process of the fast and slow pools, are also widely used to describe N mineralization (Cartes *et al*., 2009, Heumann and Bottcher, 2004). Besides equations, logarithmic, parabolic and hyperbolic models are also developed in recent years (Donald and Mohammas, 1998; Narteh and Sahrawat, 2000). However, the most frequently used model is exponential. This equation is developed based on the assumption there are two components of N organic fractions; the active fractions and resistant fractions. The active fraction is a fraction that is rapidly undergoing a process of mineralization (fast pool), while the resistant fraction is a fraction that is relatively difficult to encounter mineralization (slow pool) (Molina *et al*., 1980; Richter *et al*., 1980). This equation is also assumed that the N mineralization process always involves microbial and enzyme activities. The activity is growing exponentially so that the estimated N mineralization also is built based on the exponential equation (Li *et al*., 2003). Ando *et al*. (1992) suggested that in wet soil conditions (anaerobic) the first order equation is able to estimate N mineralization well. On the contrary, in the dry soil (aerobic) double exponential equation is more suitable to be used to estimate N mineralization.

This research aims to study the kinetics of N mineralization by using double-pool kinetics models on degraded soils in the cultivation of monoculture cassava as a result of providing organic matter of legume and non-legume.

MATERIALS AND METHODS

Soil preparation and treatments in the experiment

The soil used was Ultisol taken from a depth of 0-20 cm (topsoil) (ICALRD, 2008). The analysis of soil properties are presented in Table-1. Incubation experiments were carried out at constant temperature (20^{o}C, 25^{o}C and 30^{o}C) in the incubator in the laboratory. The experiments were conducted by using a completely randomized factorial design with three replications. The first factor is the use of soils, consisting of soil that has been planted with cassava less than 10 years and soil which has been planted with cassava more than 30 years. The second factor is the type of organic matter, which consists of (1) Groundnut biomass, (2) Maize biomass, (3) Groundnut-maize biomass, with a ratio of 1:1 (w:w), (4) Groundnut- maize biomass, with a ratio of 2:1 (w:w), (5) Groundnut - maize biomass, with a ratio of 1:2 (w:w), and (6) without biomass.

Biomass dosage from groundnut, maize and groundnut + maize is equivalent of 5 t ha^{-1}. The soil used was first sieved <2 mm, then it was weighed for 10 g. Next, it was put into a plastic bottle, and then treated with organic matters. The moisture content of the soil was maintained at field capacity, and plastic bottles were placed in an incubator at the temperature of 20^{o}C, 25^{o}C and 30^{o}C. After 0, 2, 4, 8, 6, 10 and 12 weeks, an observation of N content (NH_4^+ and NO_3^-) with extract 1 M KCl was conducted and then determined by the Kjeldahl method.

The relationship between N mineralization kinetic parameters with the nutrient uptake was obtained by planting cassava in the greenhouse with the same treatment as the incubation treatment. The plants were grown in pots containing 15 kg of soil with field capacity conditions. The plants were harvested at the age of 4 months. After that, the analysis of plant dry weight, N uptake and soil analysis : C and N labile (C and N microbiomass, C and N water soluble and C, N particulate organic matter (C, N POM)) (Okore *et al*., 2007; Soon *et al*., 2007), pH H_2O (1:5), Al-exchange 1 N KCl extract was conducted.

Table-1. Chemical properties of soil experiment.

Soil properties	Soil has been planted with cassava less than 10 years	Soil has been planted with cassava more than 30 years
pH (H_2O)	5, 1	4, 6
N-total (%)	0, 073	0, 037
C-organic (%)	2, 06	0, 70
P-Bray (mg kg^{-1} P_2O_5)	15, 9	6, 8
CEC (cmol kg^{-1})	12, 54	4, 12
K (cmol kg^{-1})	0, 14	0, 05
Ca (cmol kg^{-1})	1, 68	0, 50
Mg (cmol kg^{-1})	0, 33	0, 15

Kinetics of N mineralization observation

The kinetic observation was carried out using double pool models (double-pool kinetics).

Double-pool kinetic equation (Ando *et al*., 1992; Heumann and Bottcher, 2004)

$$N = Na\ (1 - Exp - kat) + Nr\ (1 - Exp - krt) \qquad (1)$$

N is the amount of inorganic N (mg N kg $^{-1}$) on day t. Na is the fast pool mineralization (mg kg^{-1}). ka is the rate constant of pool rapid mineralization (day^{-1}). Nr is slow pool mineralization (mg kg $^{-1}$), kr is the rate constant of slow pool mineralization (day $^{-1}$).

To determine the activation energy (Ea, J mol^{-1}), the method of Kanda (2000) was used. In this method, T1 and T2 temperatures and k1 and k2 were applied using the formula as follows:

$$Ea = R / (1/T1 - 1/T2).\ \ln (k1/k2) \qquad (2)$$

R is the gas constant (8318 J k^{-1} mol^{-1}), in this study T1: temperature 30^{o}C, T2: temperature 20^{o}C, k1: constant at 30^{o}C, k2: constant at 20^{o}C.

Statistical analysis

Double pool kinetic equation models (double-pool kinetics) were fitted with the curve fit procedure using the Sigma Plot 11 program (Systat software Inc, 2008) (Wang *et al*., 2003).

RESULTS AND DISCUSSIONS

Nitrogen mineralization during incubation

Mixing of organic matters such as groundnut and maize biomass gives an effect to the pattern of N mineralization (Figure-1). In the last week of observations, it was seen that N mineralization in the provision of organic matter derived from maize biomass was lower than it was in the provision of organic matter derived from groundnut biomass. N mineralization from the highest to the lowest is as follows: groundnut: maize biomass (2:1) > groundnut: maize biomass (1:1) > groundnuts biomass > maize biomass > groundnut: maize biomass (1:2) > without organic matter. Mixing the two of organic matters caused a chemical composition change, especially the ratio of C: N. Organic matter derived from maize biomass that has a high ratio of C: N would turn lower when mixed with organic matter derived from groundnuts biomass. The low ratio of C: N made the organic matter susceptible to mineralization. These results are similar to those obtained by Singh *et al*. (2007) in which mixing organic matter with the low ratio of C: N (16) which is derived from *Sesbania* and the high ratio of C: N (82) derived from wheat straw yield N mineralization higher than that of without mixing. Ratio of C: N is often used to predict the N mineralization rate. Results of studies using different ratio of C: N indicated that the break even point between mineralization and immobilization occured in the ratio of C: N around 21 (Hadas *et a*l., 2004).

Temperature has different effects on N mineralization. The higher the temperature, the greater the N mineralization. On all treatments, temperature 30^{o}C produced greater mineralized N than other temperatures, although in the temperatures between 30^{o}C and 25^{o}C N mineralization did not look different (Figure-1). According to Nicolardot *et al*. (1994) and Stark and Firestone (1996) maximum N mineralization is in the range of temperatures between 25-35^{o}C.

The same pattern of N mineralization was also obtained on the treatment with the use of soil that has been planted with cassava for more than 30 years (Figure-2), where the provision of organic matter derived groundnut biomass yields higher mineralization. The highest N mineralization is groundnut: maize biomass (2:1)> groundnut biomass> groundnut: maize biomass (1:2)> groundnut: maize biomass (1:1)> maize biomass> without organic matter.

Soil fertility gives effects on the amount of N released during the mineralization process. The N mineralization in soil that has been planted with cassava for less than 10 years was higher than it was in soil that has been planted with cassava for more than 30 years. The total amount of N released, on soil that has been planted with cassava for less than 10 years reached 1086 mg kg^{-1}, while the total amount of N released on soil already planted with cassava more than 30 years was 783 mg kg^{-1}. The soil that planted with cassava less than 10 years has a higher fertility. pH, N total, C-organic, P, and CEC are higher than those in the soil which has been planted with cassava more than 30 years (Table-1). Gonzalez-Prieto *et*

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al. (1992) suggest that mineralization is negatively correlated with Al and Fe. The increase in soil pH will increase N mineralization (gang-Li *et al*., 2007).

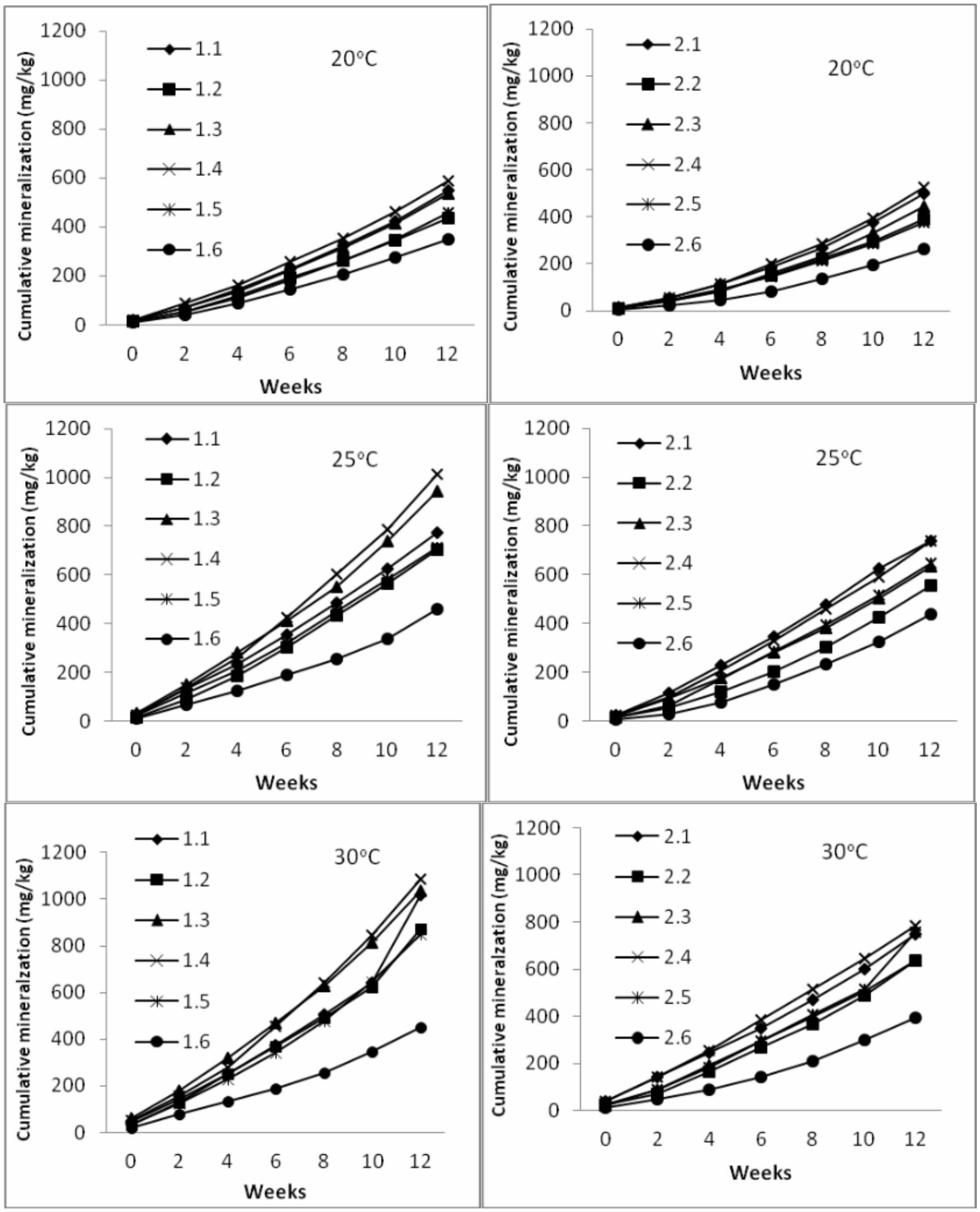

Figure-1. The effect of application some proportion of organic matter from groundnuts and maize biomass on soil used for planting cassava less than 10 years (left) and more than 30 years (right) on the cumulative of N mineralized.

Mineralization rate coefficient (ka and kr) and potential N (Na and Nr)

N mineralization measured using a double-pool kinetics equation estimated the rate of mineralization of fast and slow pools. This study indicated that the value of mineralization rate coefficient of (ka and kr) and mineralization of N (Na and Nr) was affected by temperature and organic matter. The increase of temperature would also increase k and N value. On soil that has been planted with cassava less than 10 years, the ka value in the temperature of 20^{o}C to 30^{o}C was 0.028 to 0.031 per week, while the value of kr pool was 0.026 to 0.029 per week. Whereas, on soil planted with cassava more than 30 years, the value of the mineralization rate of fast pool (ka) was 0, 023 per week at a temperature of 20°C, 0, 025 and 0, 029 per week at a temperature of 25°C and 30°C, while the value of the slow pool (kr), respectively were 0, 021, 0, 023 and 0, 026 per week at a temperature of 20°C, 25°C and 30°C (Table-2). Temperature is one of the factors affecting N mineralization rate (Sierra and Marban, 2000). Guntinas *et al*. (2011) suggest that the value of k is strongly influenced by temperature. The value increases significantly between the temperatures of 25°C and 35°C. The increase of the k is caused by the decomposition process of organic matter which becomes faster (Nordmeyer and Richter, 1985). The results of Stanford's and Smith's (1972) study showed k values range from 0.035 to 0.095 per week, with an average value of 0054 per week. In addition, Sierra (2002) found the k value in tropical soil ranged from 0.007 to 0.014 per day. Results of this study showed that coefficient (k) value of mineralization rate on soil that has been planted with cassava less than 10 years has higher value than that of the soil which has been planted with cassava more than 30 years. This shows that the soil that has been planted with cassava more than 30 years has low mineralization rate. The low rate of mineralization is caused by the low chemical fertility such as pH and low nutrient availability. A mineralization process involves microorganisms that are significantly influenced by soil pH and nutrient availability in the soil used as an energy source.

Table-2. Effect of application legume and non legume on N kinetic parameters at Ultisol, Lampung, Indonesia.

Treatment	20°C						25°C						30°C					
	Na	ka	Nr	kr	Na+Nr	R^2	Na	ka	Nr	Kr	Na+Nr	R^2	Na	ka	Nr	kr	Na+Nr	R^2
Soil has been planted with cassava less than 10 years																		
Groundnut(G)	1002	0.028	469	0.025	1472	0.861	1529	0.034	1102	0.031	2631	0.983	1719	0.027	1078	0.027	2797	0.980
Maize (M)	931	0.027	675	0.025	1606	0.977	432	0.029	596	0.027	1028	0.859	1222	0.030	959	0.027	2181	0.955
G : M (1:1)	1089	0.028	459	0.025	1549	0.896	1303	0.023	832	0.019	2135	0.974	1969	0.027	1601	0.027	3570	0.982
G : M (2:1)	1667	0.030	870	0.027	2537	0.970	1308	0.028	905	0.024	2213	0.972	1569	0.034	1301	0.031	2870	0.956
G : M (1:2)	663	0.031	589	0.030	1252	0.948	1343	0.027	886	0.022	2229	0.983	519	0.026	737	0.033	1256	0.897
Without OM	309	0.025	294	0.025	603	0.811	649	0.023	531	0.024	1180	0.954	519	0.027	417	0.027	936	0.964
Average	943	0.028	560	0.026	1503	0.910	1094	0.027	809	0.025	1903	0.954	1253	0.029	1016	0.029	2268	0.957
Soil has been planted with cassava more than 30 years																		
Groundnut(G)	614	0.023	557	0.021	1171	0.935	1226	0.027	936	0.024	2162	0.985	1374	0.030	944	0.023	2318	0.980
Maize (M)	520	0.025	465	0.024	985	0.944	806	0.013	800	0.011	1606	0.929	766	0.029	625	0.028	1390	0.977
G : M (1:1)	648	0.025	651	0.021	1298	0.928	1596	0.026	959	0.026	2555	0.979	1192	0.031	796	0.025	1988	0.982
G : M (2:1)	779	0.021	727	0.017	1506	0.938	1564	0.029	954	0.027	2518	0.974	1251	0.033	1037	0.032	2288	0.987
G : M (1:2)	541	0.021	483	0.020	1024	0.947	1522	0.031	735	0.028	2257	0.971	996	0.035	898	0.025	1894	0.939
Without OM	370	0.021	409	0.020	779	0.897	477	0.023	266	0.022	743	0.829	485	0.027	451	0.025	936	0.925
Average	579	0.023	549	0.021	1127	0.932	1198	0.025	775	0.023	1973	0.945	1011	0.031	792	0.026	1802	0.965

In this study N mineralization was also determined by the type of organic matter. N mineralization in organic matter derived from legumes was larger than N mineralization in organic matter derived from maize (non legume). Mixing organic matter derived from groundnut biomass and maize biomass increased N mineralization when compared to organic matter only derived from maize. Mineralization of the fast pool (Na) was higher than that of slow pool (Nr). On soil that planted with cassava less than 10 years, mineralization of the fast pool ranged between 943 - 1253 mg kg^{-1}, whereas the slow pool ranged between 560 - 1016 mg kg^{-1}. Observations at temperature of 30° showed that application of groundnut: maize biomass (1:1) produced the highest mineralization that was 3570 mg kg^{-1}. The increase was 284% compared to no provision of plant biomass. On the soil planted with cassava more than 30 years, mineralization of fast pool was between 579-1011 mg $kg^{-1}$and of the slow pool it was between 549-792 mg kg^{-1}. The returns of groundnut biomass on soil that has been planted with cassava more than 30 years produced the highest N mineralization that was 2318 mg kg^{-1} or an increase of 147% compared with no return of plant biomass. Plant biomass affected N mineralization. Groundnut biomass and mixing of groundnut and maize biomass increased N mineralization. Groundnut is a legume crop that has a low ratio of C: N that is easy to mineralize, so it will speed up the process of mineralization when mixed with maize biomass. Sholihah *et al*. (2012) suggest that the mineralization rate correlates with the ratio of C: N (0.582 *). N mineralization is

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affected by the ratio of C: N. Organic matter that has low ratio of C: N produces a higher mineralization rate compared to organic materials with high ratio of C: N (Abera *et al*., 2012).

Based on double-pool kinetics equation, N mineralization in the fast pool was higher than it was in the slow pool, as well as the mineralization rate coefficient (k) of the fast pool was greater than the value of k in the slow pool. This indicates that the mineralization process of organic matter that is easily decomposed will happen quickly, but some of the organic material that is resistant will be mineralized slowly and it is linear with time. These results are consistent with the results obtained by Li *et al*. (2003) in which the value of Na and ka is greater than the value of Nr and kr.

Apparent activation energy (Ea)

A number of researchers have observed the temperature dependence on the rate of mineralization. So far the temperature dependence coefficient of the mineralization uses Q_{10}, but the Q_{10} value varies. It is very big on the ambient temperature, so the apparent activation energy (Ea) can be used as a more suitable parameter to assess the dependence of the mineralization process toward temperature (Saito and Ishii, 1987). Activation energy values are not consistent between the fast pool and slow pool. Activation energy in the fast pool in some treatments was higher than it was in the slow pool. But in the other treatments, activation energy of fast pool was lower (Table-3). The same results were also obtained by Ando *et al*. (1992), in which a fast pool did not always have high activation energy or otherwise a slow pool did not always have low activation energy. This is due to the mineralization pattern of the soil is always associated with the physic-chemical properties of the soil.

Table-3. Activation energy (Ea, J mol^{-1}) as the effect of the application of organic matter in the Ultisol, Lampung, Indonesia.

Treatment	Ea fast pool	Ea slow pool
Soil has been planted with cassava less than 10 years		
Groundnut (G)	13337	7567
Maize (M)	15166	12822
G : M (1:1)	6402	14503
G : M (2:1)	40079	52613
G : M (1:2)	17765	18561
Without organic matter	20904	18561
Soil has been planted with cassava more than 30 years		
Groundnut (G)	5739	6402
Maize (M)	5944	6402
G : M (1:1)	8466	6402
G : M (2:1)	7928	11491
G : M (1:2)	10095	7928
Without organic matter	6402	6402

Relationship of mineralization kinetics parameters with the chemical properties of the soil

The correlation coefficient between the kinetic parameters of mineralization with soil chemical properties is presented in Table-4.

Table-4. Relationships between N mineralization kinetics parameters (Na, ka, Nr and kr) with the chemical properties of the soil.

Soil analysis	Na	Ka	Nr	Kr
pH	0.554**	0.047	0.715**	0.132
Al-exc(me/100g)	-0.632**	-0.316	-0.702**	-0.135
Water soluble N (%)	0.770**	0.227	0.722**	0.040
N-POM (%)	0.720**	0.464*	0.788**	0.321
N Mikrobiomass (mg kg^{-1})	0.760**	0.353*	0.833**	0.293
Water soluble C (%)	0.460*	-0.145	0.345*	-0.311
C-POM (%)	0.468*	-0.212	0.568**	-0.313
C Mikrobiomass (mg kg^{-1})	0.369*	0.345*	0.480*	0.356*
N (%)	0.551**	0.114	0.667**	0.200
C (%)	-0.311	-0.310	-0.276	-0.290
C:N ratio	-0.065	-0.049	-0.178	-0.075

* significant at $P<0.05$, ** significant at $P<0.01$.

Mineralization of fast pool (Na) and slow pool (Nr) was positively correlated with soil pH, water-soluble N, N-POM, N microbiomass, water-soluble C, C-POM, C microbiomass, total N and negatively correlated with Al-exchange, C-organic and the ratio of C: N. Although the correlation coefficient of rate mineralization at the fast pool (ka) and slow pool (kr) was low, it tended to be positively correlated with soil pH, water-soluble N, N-POM, N microbiomass, C microbiomass, N total and negatively correlated with Al-exchange, water soluble C, C -POM, C-organic and the ratio of C:N. Ratio of C: N is the best parameter to predict the amount of N mineralized (Chaves *et al*., 2004). The role of microorganisms is very crucial in mineralization. In this study N and C microbiomass was correlated positively with N mineralization. Marinari *et al*. (2010) suggest that microorganisms are capable of degrading organic matter. Soil that contains a lot of organic matter has increasing amount of microorganisms. The increase of N mineralization processes in the soil with the increase of amount and activities of microorganisms will increase the availability of N (Tu *et al*., 2006). Source of N in soils depends on organic matter mineralization process. The mineralization rate is influenced by the quality of organic matter, soil chemical properties and other environmental factors. Soil chemical properties that affect the mineralization process are pH, Al-exchange, N microbiomass, C microbiomass, and N total in the soil. Funakawa *et al*. (2009) suggest that soil acidity relates to pH and Al-exchange affected N mineralization. On acid soils with high Al concentration, mineralization goes slowly. N mineralization is not only influenced by time, but also influenced by environmental factors such as temperature, humidity and soil chemical properties (Chaves *et al*., 2004).

The relationship between kinetic parameters of N mineralization with N uptake

The N mineralization kinetics parameter i.e., mineralization of fast (Na) and slow (Nr) pools has an obviously positive correlation with N concentration of plant, plant dry weight and N uptake of the plant Table-5. In this study, it showed that N mineralization of fast pool and slow pool contributed to the growth of the cassava plant. The setting of high and low quality organic matter was able to arrange the release of N from organic matter so that the N availability was better.

Cassava plant is an annual plant. In this study, the plant was harvested at the age of 4 months. The availability of N up to 4 months could be fulfilled by the mineralization process of the fast pool and slow pool. It could be seen from Na and Nr which were positively correlated to plant growth parameters. In other words, the arrangement of organic matter was able to increase the synchronization of N availability to the crop needs. The main objective of N nutrient management is to maximize the plant yields and minimize the loss of N from the soil through the appropriate provision of N with the crops needs (synchronization) (Crews and Peoples, 2005). The main components of the synchronization are (1) N mineralization, (2) the appropriate availability of N for plants and (3) N uptake by plants. The amount of N uptake was about 50-100% derived from inorganic N taken from organic N (soil organic matter, crop residues and organic amendment) (Loecke *et al*., 2012).

Table-5. Relationships between N mineralization kinetics parameters with plant dry weight, N concentration and N uptake.

Observation	Na	Ka	Nr	Kr
N concentration (%)	0.684**	0.060	0.705**	0.060
Dry weight (g)	0.526**	0.129	0.681**	0.193
N uptake (mg plant^{-1})	0.666**	0.011	0.723**	0.104

* significant at P<0.05, ** significant at P<0.01.

CONCLUSIONS

a) The application of groundnut plant biomass or mixing groundnut biomass with maize biomass can reduce the rate of degradation in the Ultisol through the increase of N mineralization in the soil. On soil planted with cassava less than 10 years, the application of groundnut and maize biomass (1:1) produces the highest N mineralization, whereas on soil planted with cassava more than 30 years, the application of groundnut biomass produces the highest mineralization.
b) On soil that planted with cassava less than 10 years, the mineralization rate coefficient (k) and N mineralization values are higher than on soil planted with cassava more than 30 years.
c) N mineralization is positively and significantly associated with the water-soluble N, N-POM, N microbiomass, C-POM, C microbiomass, N total and the ratio of C: N and is positively correlated with plant dry weight, N concentration and N uptake.

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