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Research Article

Effect of land use and organic matter on nitrogen and carbon labile fractions in a Typic Hapludult

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Abstract: A study that was aimed to determine the effect of organic matter from groundnut and maize biomass on the availability of N and C labile fraction was conducted in laboratory and glasshouse, Iletry, Malang. Research used randomized block design with three replications. The first factor was land use : (1). Soil from land cultivated by cassava crops for less than 10 years, and (2). Soil from land cultivated by cassava crops for more than 30 years. The second factor was type of organic matter: (1). Groundnut biomass, (2). Maize biomass, (3). Groundnut-maize biomass, with a ratio of 1:1, (4). Groundnut – maize biomass, with a ratio of 2:1, (5). Groundnut – maize biomass, with a ratio of 1:2, and (6). Without organic matter. The results showed that application of groundnut and maize biomass were affect the N and C labile fraction. Application of groundnut + maize biomass increases N and C labile fraction more 40% than without biomass as well as the landuse of planted with cassava less than 10 years was 20 % higher N and C labile fractions than the land that has been planted with cassava more than 30 years. This research showed that analysis of N or C labile fraction is more sensitif than analysis of N total or C organic. It indicates that analysis of labile fractions can be used to analyze of N and C availability in the soil, beside of N total and C organic analysis.

***Keywords** : labile fraction, land use, organic matter quality, Typic Hapludut*

Introduction

Intensive agricultural and regardless of the balance between the input and output in the farming system will accelerate of soil fertility decline. This situation is exacerbated by the farmers who carry out all of the crops biomass without any effort to return to farm land. In addition, soil fertility management are usually focused on the replacement of nutrients through fertilization, without any effort to maintain soil fertility management as a whole, thus causing a decrease in crop productivity and environmental (Hairiah et al., 2000).

The decline in crop productivity is one indicator that the system is not sustainable. Cassava is one of the most widely cultivated plants in Lampung, Indonesia (Sarno et al., 2004). Planting cassava monoculture in Ultisol may decrease soil fertility, which results in decreasing in soil organic matter, nitrogen (N), and ultimately reduced the yield of cassava. The productivity of cassava cultivation continuously for 20-30 years, decreased from 26-30 t/ha to 10-12 t/ha (Howeler, 1992). Hairiah et al. (2000) suggested that planting cassava monoculture in Pakuan Ratu, Lampung for 8 years decreasing of cassava yield from 30 t / ha to 10 t / ha. Planting cassava monoculture can reduce C-organic, CEC, P, K, Mg available and a decrease in soil pH and soil aggregate stability (Phien and Vinh, 1998). However, addition of organic matter like manure or crop residue in the soil can increase the N and C content in the Cassava cultivated soil (Fließbach et al., 2007).

Returns of plant biomass would be useful in maintaining soil fertility through increased soil organic matter and nutrient content in the soil, mainly Nitrogen (N). Bundy and Andraski (2005) reported that the maize crop residues are returned to farm land could contribute between 50-100 kg N/ha, about 5-20% residue can still be used by the next crop. Marthens et al. (2006) suggested that improvement of soil N due to biomass of soybeans reach 47-56 kg N/ha, while the groundnuts around 48 kg N/ha. The study of organic matters are generally only seen in the form of N and C total, whereas the N and C totals are lack describe of nutrient availability. Behavior of organic forms such as the fraction of N (N-labile and N organic) and fraction C as C-labile in soil more important because this fraction have an effect on soil quality. The labile fraction of organic matter are good indicators for assessing the soil quality (Laik et al., 2009, Benbi et al., 2015).

Fraction labile C such as microbial biomass C, light fraction C and water extractable C, C mineralized (potential mineralizable C) and C-particulate organic matter C is one of the components are used as an indicator of soil quality, that influenced by soil management and cropping system (Ruimin et al., 2016, Li et al., 2016). Carbon extracted water is important as an energy source for microorganisms, that play a role in the mineralization process (Hayness, 2000; Laike et al., 2009). Fractions of N labile and C labile are important source of energy for microorganisms which plays important role in the mineralization process.

Light fractions are transit pool between fresh organic and humidified organic, contributing to reserve of C organic and energy sources for microorganisms (Haynes, 2000; Burton et al., 2007; Laik et al., 2009). A labile organic matter fraction has a significant effect on reserves of soil organic matters. A change in the quantity of these fractions is an early indicator to predict the effect of soil management (Soon et al., 2007; Lou et al., 2011). Under these conditions, determinations of the effect of organic matter from groundnut and maize biomass on the availability of N and C labile fraction are needed.

Materials and Methods

Soil preparation and experimental treatments

The research was conducted in Iletri, Malang from April to July 2013. ATypic Hapludult from Lampung taken at 0-20 cm soil depth was used for this experiment. The result of soil analysis is presented in Table 1.

The research used a randomized block design with three replications. The first factor was land use : (1). Soil from land cultivated by cassava crops for less than 10 years, and (2). Soil from land cultivated by cassava crops for more than 30 years(1). Soil from land cultivated by cassava crops for less than 10 years, and (2). Soil from land cultivated by cassava crops for more than 30 years. The second factor was type of organic matter: (1). Groundnut biomass, (2). Maize biomass, (3). Groundnut-maize biomass, with a ratio of 1:1, (4). Groundnut – maize biomass, with a ratio of 2:1, (5). Groundnut – maize biomass, with a ratio of 1:2, and (6). Without organic matter. The dosage of groundnut, groundnut-maize and maize were equivalent to 5 t/ha. Biomassa of groundnut and maize obtained from Lampung. Soil for research was sieved through a 2 mm sieve, then weighed of 15 kg and put into polybag then each treatment of organic matter was given. All treatments were incubated for 2 weeks. After that, the polybag is planted with cassava and maintained until the 3 months.

The observations at the end of the research were N total, C-organic, C-labile pool (microbial biomass C, water extractable C and C particulate organic matter), pool N-labile (microbial biomass N, N extracted water and N particulate organic matter). Water extractable organic C and water extractable N were determined from 4 r of dry soil with 40 mL deionized water and shaking 10 minutes on a mechanical shaker. Samples were centrifuged for 5 minutes at 3500 rpm, filtered though whatman paper and analyzed for Water extractable organic C and water extractable N (Hanay et al., 2012).

Particulate organic Carbon (POC) and N determined according to Fiqueiredo et al. (2010). The air-dried samples were 2 mm sieved. Of these, 20 g were placed in plastic bottles (volume of 250 mL) and 70 mL of sodium hexametaphosphate added at a concentration of 5.0 g L-1. The mixture was shaken for 15 h in a horizontal shake. After this process, the entire content of the vial was placed in a 53 μm sieve and washed with a weak jet of distilled water. The material retained on the sieve, defined as total particulate organic matter (> 53 μm) was dried at 50 °C. After drying, the sample was ground in a porcelain mortar and passed completely through a 0.149 mm sieve. Then aliquots were weighed and analyzed for their C and N contents, representing the particulate organic Carbon (POC) and N in particulate organic matter. Soil microbial biomass C and N were measured by fumigation–extraction using ethanol-free chloroform as the fumigant followed by extraction with potassium sulfate (K_2SO_4).

Extracts of fumigated and unfumigated soil were analysed for extractable organic C and N. Microbial C and N were calculated as the difference in the respective nutrient between fumigated and unfumigated extracts, and corrected for unrecovered biomass using k factors of 0.35 for microbial C and 0.54 for microbial N (Nottingham et al., 2015).

Table 1. Chemical properties of soil samples

Soil analysis	Soil from land cultivated by cassava crops for less than 10 years	Soil from land cultivated by cassava crops for 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 1 (ppm P_2O_5)	15.9	6.8
CEC (cmol (+) kg^{-1})	6.54	4.12
K (cmol(+)/ kg)	0.14	0.05
Ca (cmol(+)/kg)	1.68	0.50
Mg (cmol(+)/kg)	0.33	0.15
Al exchange (cmol(+)/kg)	1.40	2.50
Al saturation (%)	33	54

Statistical analysis

Analysis of variance of crop data was processed using Mstat-C, and mean comparisonwith Duncan Multiple Range Test (DMRT) at 5% probability. Linear regression and correlation as well as graphical presentation were performed using Microsoft Excel Program.

Results and Discussion

Organic C and total N

The interaction between application of legume - non legume biomass and duration of land use for the cassava cultivation have effect on soil organic C. The highest concentration of C organic in the soil obtained at groundnut + maize (1: 1). This treatment increases the C organic by 115% compared with no biomass application. At the land that has been planted cassava monoculture over 30 years, the C organic concentration in the soil as follows groundnut + maize (2: 1) > groundnut + maize (1: 2) = groundnut > groundnut + maize (1:1), maize, and without plant biomass. On land planted cassava monoculture less than 10 years, the concentration of C organic in the soil from the highest is the treatment of groundnut + maize (1: 1), groundnut + maize (2: 1), groundnut + maize (1: 2), maize, groundnut and without biomass plants (Table 2).

N total in the soil is influenced by biomass legume - non legume and duration of land use for cassava cultivation. Statistically, N total for all application of legume - non legume biomass not significant, while the duration of land use for cassava cultivation more than 30 years has lower of N total than soil has been planted with cassava less than 10 years (Table 3).

Fraction of N and labile C

The interaction between legume - non legume biomass and duration of land use for cassava cultivation significant on N water-soluble (Table 3). Application of groundnut biomass has the highest of N water-soluble. At the land that has been planted cassava monoculture more than 30 years, application of groundnut biomass has the highest N water soluble, followed by groundnut + maize 2: 1, groundnut + maize 1: 1, groundnut + maize 1: 2, maize and without biomass. The same result also occurs on land that has been used cassava cultivation less than 10 years.

Table 2. Organic C (%) a Typic Hapludult due to the addition of legume and non-legume biomass

Treatment	Soil from land cultivated by cassava crops for more than 30 years	Soil from land cultivated by cassava crops for less than 10 years	Means
Without biomass	1.3 f	1.3 f	1.3
Groundnut biomass (G)	1.9 cd	1.7 def	2.1
Maize biomass (M)	1.4 ef	2.0 bcd	2.5
G : M (1:1)	1.8 cde	2.8 a	1.7
G : M (2:1)	2.1 bc	2.4 b	1.7
G : M (1:2)	1.9 cd	2.1 bc	2.0
Means	1.7	2.0	1.9

[1)]Values in same column followed by same letter were not significantly different based on Duncan Multiple Range Test at 5% level.

Table 3. Total N (%) of a Typic Hapludult due to the addition of legume and non-legume biomass

Treatment	Soil from land cultivated by cassava crops for more than 30 years	Soil from land cultivated by cassava crops for less than 10 years	Means
Without biomass	0.23	0.28	0.25 a
Groundnut biomass (G)	0.23	0.23	0.23 a
Maize biomass (M)	0.22	0.26	0.24 a
G : M (1:1)	0.25	0.26	0.25 a
G : M (2:1)	0.24	0.29	0.26 a
G : M (1:2)	0.16	0.18	0.17 b
Means	0.22 b	0.25 a	

[1)]Values in same column followed by same letter were not significantly different based on Duncan Multiple Range Test at 5% level.

Table 4. Water extractable N (mg/kg) of a Typic Hapludult due to the addition of legume and non-legume biomass

Treatment	Soil from land cultivated by cassava crops for more than 30 years	Soil from land cultivated by cassava crops for less than 10 years	Means
Without biomass	37 f	43 ef	40
Groundnut biomass (G)	83 ab	93 a	88
Maize biomass (M)	60 cdef	53 def	57
G : M (1:1)	73 bc	77 abc	75
G : M (2:1)	77 abc	87 ab	82
G : M (1:2)	60 cde	70 bcd	65
Means	65	71	68

[1)]Values in same column followed by same letter were not significantly different based on Duncan Multiple Range Test at 5% level.

Interaction legume - non legume biomass and land use have affect on N-particulate organic matter (POM). The highest concentration of N-POM obtained through by application of groundnut : maize biomass (2:1) or increase about 234% compared without biomass (Table 5). The same result is also obtained in N microbial biomass. Application of groundnut + maize biomass (2: 1) resulted the highest of N microbial biomass. In the land that has been planted cassava more than 30 years, application of groundnut + maize biomass (2:1) > groundnut = groundnut + maize (1:1) > groundnut + maize (1: 2) > maize > without biomass. On land planted cassava less than 10 years, application of groundnut + maize biomass (2: 1) > groundnut + maize (1: 1) > groundnut> maize> groundnut +maize (1:2) > without biomass (Table 6).

Table 5. N- particulate organic matter (mg/kg) due to the addition of legume and non-legume biomass to a Typic Hapludult

Treatment	Soil from land cultivated by cassava crops for more than 30 years	Soil from land cultivated by cassava crops for less than 10 years	Means
Without biomass	47 g	47 g	47
Groundnut biomass (G)	97 de	137 b	117
Maize biomass (M)	80 f	90 ef	85
G : M (1:1)	93 ef	113 cd	103
G : M (2:1)	120 bc	157 a	138
G : M (1:2)	113 cd	107 cde	110
Means	92	108	100

[1)]Values in same column followed by same letter were not significantly different based on Duncan Multiple Range Test at 5% level.

Table 6. Microbial biomass N (mg/kg) of a Typic Hapludult due to the addition of legume and non-legume biomass

Treatment	Soil from land cultivated by cassava crops for more than 30 years	Soil from land cultivated by cassava crops for less than 10 years	Means
Without biomass	30 d	31 d	30
Groundnut biomass (G)	53 cd	50 bc	42
Maize biomass (M)	33 d	47 bcd	40
G : M (1:1)	53 cd	59 ab	47
G : M (2:1)	59 ab	71 a	65
G : M (1:2)	34 d	33 d	33
Means	38	48	43

[1)]Values in same column followed by same letter were not significantly different based on Duncan Multiple Range Test at 5% level.

Labile fraction of the organic matter is a short-term indicators that can be used to assess the soil quality as a result of changes in soil and crop management (tillage, organic and inorganic fertilizer, crop rotation). This fraction has a turnover time between a few days to several years (Sequeira et al., 2011).

Analysis of labile fractions is very important because soil analysis in form of total in some cases are often less satisfactory. In this study, analysis of N total showed less sensitive. This is shown in the statistical analysis where the interaction between the biomass application and the duration of landuse not significant to the total N in the soil, the opposite is the analysis of the fraction of labile N that shows significant. This shows that the fraction of labile N is a sensitive parameter.Analysis of C water soluble showed that the legume - non legume biomass was significant to C water soluble, as well as the duration of landuse for cassava. The use of land more than 30 years have C water-soluble lower than the land that has been planted with cassava less than 10 years (Table 7). Application of groundnut biomass was the highest of water-soluble C, followed by application of groundnut : maize biomass 2: 1, maize, groundnut : maize 1: 2, groundnut : maize 1: 1 and without biomass. Application of groundnut biomass incrase of water soluble C about 60% higher than without biomass. Water-soluble C generally reflect of the soil organic matter composition and it is an indicator of soil quality. Changes in the management of soil and crops such as organic and inorganic fertilizers or crop rotation affect C water soluble. N fertilization can stimulate or increase the water-soluble C, but the increase is only briefly because it is rapidly used by microorganism as an energy source. Organic matter application increases of the water-soluble C, this shows that the organic matter contains more water-soluble organic matter (Chantigny, 2003; Gong et al., 2009).

Table 7. Water soluble C (mg/kg) of a Typic Hapludult due to the addition of legume and non-legume biomass

Treatment	Soil from land cultivated by cassava crops for more than 30 years	Soil from land cultivated by cassava crops for less than 10 years	Means
Without biomass	19	22	20 c
Groundnut biomass (G)	29	35	32 a
Maize biomass (M)	21	29	25 b
G : M (1:1)	21	22	22 bc
G : M (2:1)	24	27	25 b
G : M (1:2)	20	27	24 bc
Means	22 b	27 a	

[1)]Values in same column followed by same letter were not significantly different based on Duncan Multiple Range

Test at 5% level. Interaction of legume-non legume biomass and duration of landuse was significant on C-particulater organic matter. On land that planted by cassava less than 10 years showed that the legume-non legume biomass were not significant, while the land has been planted with cassava more than 30 years application of groundnut : maize biomass 1: 1 was the highest of

C-POM. C-POM in the soil that cassava planted more than 30 years was lower than in land planted cassava less than 10 years (Table 8). Results of recent studies indicate that the C-POM is a good indicator for soil quality and more sensitive to changes in tillage and fertilization compared with analysis of total of organic matter (Ouédraogo et al., 2006, Bonilla et al., 2014). Lou et al. (2011) suggested that the concentration of C-POM about 15-25% of the total C. N fertilization increases C-POM but application of organic matter or chicken manure increases the concentration of C-POM is higher than by N fertilization only (Li and Han, 2016). Microbial biomass C in this research was affected by the application of legume-non legume biomass as well as duration of landuse for the cultivation of cassava. Application of groundnut : maize biomass 2: 1 and the land planted with cassava less than 10 years were the highest microbial biomass C (Table 9).

Tabel 8. Particulate organic matter C (POM) (mg/kg) of a Typic Hapludult due to the addition of legume and non-legume biomass

Treatment	Soil from land cultivated by cassava crops for more than 30 years	Soil from land cultivated by cassava crops for less than 10 years	Means
Without biomass	125 e	153 cd	139
Groundnut biomass (G)	144 de	177 ab	161
Maize biomass (M)	147 de	182 a	165
G : M (1:1)	158 bcd	181 a	169
G : M (2:1)	142 de	172 abc	156
G : M (1:2)	147 de	181 a	164
Means	144	174	159

[1)]Values in same column followed by same letter were not significantly different based on Duncan Multiple Range Test at 5% level.

Table 9. Microbial biomass C (mg/kg) of a Typic Hapludult due to the addition of legume and non-legume biomass

Treatment	Soil from land cultivated by cassava crops for more than 30 years	Soil from land cultivated by cassava crops for less than 10 years	Means
Without biomass	5.0	8.0	6.0 b
Groundnut biomass (G)	5.0	9.0	7.0 b
Maize biomass (M)	9.0	11.0	10.0 b
G : M (1:1)	7.0	12.0	12.0 b
G : M (2:1)	7.0	37.0	22.0 a
G : M (1:2)	6.0	9.0	8.0 b
Means	7.0 b	14.0 a	10.5

[1)]Values in same column followed by same letter were not significantly different based on Duncan Multiple Range Test at 5% level.

Application of groundnut : maize biomass increases 50% of microbial biomass C compared without biomass, as well as the landuse of planted with cassava less than 10 years also increased microbial biomass C by 50% compared with the soil that was planted cassava more than 30 years. Microbial biomass C have play role in the organic matter decomposition and nutrient cycling in the soil. Microbial biomass C is also an indicator of soil quality (Emmerling et al., 2002). Lou et al. (2011) reported that organic matter increases microbial biomass C higher than the fertilization N. This is due to increase of carbon substrate that is used as an energy source of microorganisms and the application of organic matter also improves soil physical properties such as improving soil porosity which play a role in the growth of microorganisms.

Conclusion

Application of groundnut and maize biomass were affect the N and C labile fraction. Groundnut biomass was higher of N and C labile fraction than maize biomass. Application of groundnut + maize biomass increases N and C labile fraction more 40% than without biomass as well as the landuse of planted with cassava less than 10 years was 20 %o higher of N and C labile fractions than the land that has been planted with cassava more than 30 years. This research showed that analysis of N or C labile fraction is more sensitif than analysis of N total or C organic. It indicates that analysis of labile fractions can be used to analyze of N and C availability in the soil, beside of N total and C organic analysis.

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