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POTENCY LEGUME COVER CROPS AS A SOURCE OF ORGANIC MATERIAL *IN SITU* AND ITS EFFECT ON THE GROWTH AND TUBER YIELD OF CASSAVA (*MANIHOT ESCULENTA*)

Suwarto[1*], Eko Saputra Parlindungan[2] and Retno Asih[2]
[1]Division of Crops Ecophysiology, Departement of Agronomy and Horticulture, Faculty of Agriculture, IPB University, Bogor, West Java, Indonasia
2Division of Crops Production, Departement of Agronomy and Horticulture,
Fac. of Agriculture, IPB University, Bogor, West Java, Indonasia
*Corresponding author: warto_skm@apps.ipb.ac.id

Abstract

A Research to know the potency of legume cover crops (LCC) as a source of organic material *in situ* and its effect on cassava (*Manihot esculenta*) growth and yield was conducted in two years experiment in Bogor, West Java, Indonesia. The two experiments used a randomized block design with 3 replicates. In 2017, the land prepared with four treatments, i.e. control, sprayed with Biohara plus, sprayed with Octabacter, and covered with mixed LCC. In 2018, the land prepared with five treatments, i.e. control, covered with *Calopogonium mucunoides* (Cm), covered with *Pueraria javanica* (Pj), covered with *Centrosema pubescens* (Cp), and covered with mixed LCC. The organic material dry weight produced of the mixed LCC in 2017 was 2.11 ton/ha. The organic material dry weight of LCC produced in 2018 was varied of 9.1, 4.17. 19.25. and 3.53 ton ha^{-1}, respectively for *Cm*, *Pj*, *Cp*, and the mixture. The growth response and tuber yield of cassava to LCC in 2017 and 2018 were not significantly different from the control. The LCC in solely or mixed can be grown together with cassava (*Manihot esculenta*) to be a source of organic material in situ. *Pj* was the most potential for supplying organic material and conserving the soil moisture content.

Keywords: Land preparation, soil degradation, soil C organic, soil moisture content

Introduction

As an important raw material, cassava (*Manihot esculenta*) is a valuable food source in developing countries and is also extensively employed for producing starch, bioethanol and other bio-based products. It is grown in tropical and subtropical areas (Li *et al.*, 2017). Cassava (*Manihot esculenta*) is important for food security in the tropics (Shackelford *et al.*, 2018). In Indonesia, cassava (*Manihot esculenta*) is classified as a secondary food crop. Beside for staple food, the most uses of the cassava is for tapioca industry.

Indonesia produced 19.05 M tons of cassava (*Manihot esculenta*) tuber in 2017 from about 0.77 million hectares of harvested area (ICBS, 2018). There are seven provinces as the center of cassava production, included West Java. The real productivity of the cassava (*Manihot esculenta*) is lower than its potential. The average fresh tuber production was 24.6 ton/ha. The potential productivity of Mangu variety is 70 ton/ha and UJ-5 is 38 ton/ha (ILETRI, 2017). The main problem related to low productivity is low soil fertility (Kintche *et al.*, 2017). The soil fertility of the area in the cassava (*Manihot esculenta*) production center is becoming declining because of the continuous planting throughout the year. Ratanawaraha *et al.* (1998) stated that the declining of soil fertility and soil erosion have become a major production problem of cassava in Asia, including Indonesia. Some of the cassava (*Manihot esculenta*) is cultivated on slope land. If it is not well managed, cassava cultivation can cause severe environmental impacts such as soil degradation (Shackelford *et al.*, 2018) including soil erosion and decreasing soil fertility. Decreasing soil fertility could be physically, chemically, and biologically. Some parameters for soil physical are soil aggregation, available water capacity, texture, saturated hydraulic conductivity, bulk density, infiltration rate, and rooting depth. Chemically is indicated through some parameters such as cation exchange capacity (CEC), total nitrogen and phosphorus, soil pH and extractable phosphorus, sulfur, exchangeable calcium, magnesium, and potassium. Moreover, some biological indicators are micro and macro-organism, rate decomposition of residue, seed weed numbers, and pathogen population.

Cong Doan Sat and Deturck in Howeler (2017) reported that long-term cassava (*Manihot esculenta*) cultivation caused the most serious reduction in the organic C and total N content of the soil, as well as that of the CEC and K and Mg status. The low soil C organic has also been a major problem for obtaining a good growing and high yield of cassava in Indonesia. Cassava (*Manihot esculenta*) will produce more tuber if it is grown in a soil with high C organic content. However, it was found only a few soils with high soil C organic. Generally, in the center of cassava production such as Lampung, West Java, and East Java, the soil C organic was range form very low to low, 0.70 – 2.06 % (Wijanarko and Purwanto, 2017). It was caused by removing almost all parts of the cassava biomass from the field at harvest. The addition of organic material like manure or crop residue in the soil can increase the N and C organic in the cassava (*Manihot esculenta*) cultivated soil (Fließbach *et al.*, 2007).

Organic material has a function to improve the physical, chemical, and biological characteristics of soil (Susetyo *et al.*, 2017). However, how to return the organic material to be a source for increasing soil C-organic has become a problem in cassava that usually cultivated in monoculture. One source of organic material in situ that has been used in a plantation is the cover crop. Kaspar and Singer (2011) stated that cover crops are used for many different reasons. One of the first uses was to reduce soil erosion. Soils are generally more susceptible to erosion when they are not covered with the canopies of living plants or their plant residues. Cover crops is also fungtioned as a green manure and a living mulch. Green manure cover crops are usually legume that fix N. Living mulch are cover crops that are growing both during and after the cash crop growing season. Sharma *et al.* (2018) also stated that cover crops are grown to improve soil fertility, prevent soil erosion, enrichment and protection of soil, and enhance nutrient and water availability, and quality of soil. Similarly, by using some kinds of legume cover crops (mucuna, cowpea, and dolichos), Mulinge *et al.* (2017) reported that the soil moisture content increase with the range of 13.6 – 49.0% compared to the control, without legume cover crops. Several studies indicate that cover crops could replace anthropogenic inputs and enhance crop productivity (Wittwer, 2017)

Candog-Bangi & Cosico (2007) reported that using a legume cover crop is an effective way of decreasing soil erosion on agriculture land. Chozin *et al.* (2014) stated that bio-mulch can be used to increase crop production. *Pueraria javanica* (Pj), *Colopogonium mucunoides* (Cm), and *Centrocema pubescens* (Cp) have been used as bio-mulch, insole or in the mixture. Feedipedia (2016) desribed that Pj is a vigorous, dense-growing vine cultivated in tropical countries as cover crop, green manure and fodder for livestock. The stems of Pj may root from the nodes and then develop many branches. Cm is a vigorous, hairy annual or short-lived perennial trailing legume. The Cm can reach several meters in length and form a dense, tangled mass of foliage, 30-50 cm deep. The root system of Cm is dense and shallow, at most 50 cm deep. Cp is is evergreen perennial climber growing to 0.5 m at a fast rate. The Cp is shade tolerant, and can persist even with shade levels as high as 80%. The LCC in the mixture was more suggested for decreasing some effects of the unfavorable environment such as the present of drought and the attack of pests and disease.

The legume cover crops has been used in plantation as a cover crop for decreasing erosion, suppressing weed growth, maintaining soil moisture content, adding organic material and enriching soil fertility. Refer to the use of legume cover crops in plantation, the research for studying the potency of the legume as a source of organic material and its effect on the growth and yield of cassava is necessary to be conducted.

Materials and Methods

There were two experiments conducted in two locations in Bogor, West Java, Indonesia, in two years experiment. In the first year, a Mangu variety was planted from August 2016 to June 2017 with four treatments of land preparation in Ciampea Udik, as one area of the cassava production center in Bogor. The treatments were the land without any treatment as control (P0), the land sprayed with Biohara Plus (P1), the land sprayed with Octabacter (P2), and the land covered with mixed LCC (P3). The experiment used a randomized block design with 3 replicates. Biohara plus and Octabacter are organic liquid fertilizers contain macronutrients, micronutrients, and microorganisms. The mixed LCC consists of Cm, Pj, and Cp. The each experimental unit (20 m x 8 m) was prepared by plowing and harrowing, then it formed to be 8 ridges with 20 m length. At 1 week before planting, the ridges were sprayed by Biohara plus (P1) and by Octabacter (P2) with a concentration of 5 ml L^{-1} and spray volume 300 L ha^{-1}. The mixed LCC (P3) was also planted at 1 week before planting with the composition dose of *Cm*, *Pj*, and *Cp* were respectively 6, 4, and 4 kg ha^{-1}. The mixed LCC was planted on the ridge with a planting space of 20 cm x 20 cm. Each hole was planted 0, 28 g seed of the mixed LCC. The stem cutting of cassava (*Manihot esculenta*) with 25 cm length was planted on the ridge with 1 m distance. The fertilizers applied were 90 kg N, 54 kg P_2O_5, and 90 kg K_2O per hectare, refer to Suwarto *et al.* (2015). The fertilizers of Urea (45%N) was applied 1/3 dose at planting time and 2/3 dose at 4 weeks after planting. All dose of SP-36 (36%P_2O) and KCl (60%K_2O) were applied at planting time. The fertilizers were applied with band placement at 10 cm surrounding the cassava (*Manihot esculenta*) stem. The total fresh weight (FW) and dry weight (DW) of LCC were determined at harvest (10 months after plating/ MAP). All stem and leaves biomass of the LCC above the ground in 1 m2 area was cut. The biomass about 0.5 kg was taken as a sub-sample and dried in an oven with 80^{o}C for 2 x 24 hours (SERAS, 1994), then weighed. The plant growth and tuber yield were measured monthly until harvest (10 MAP) using the method according to Fukuda *et al.* (2010). Soil bulk density and moisture content were measured monthly at 4-10 MAP. Other soil properties such as pH, C-organic, and N-total were measured in the middle of cassava (*Manihot esculenta*) growth (6 MAP).

In the second year, two varieties of Mangu and UJ-5 were planted from September 2017 until July 2018 in Cikabayan Experimental Station (CES), IPB University. In this experiment, the land prepared with five treatments i.e. without planted LCC as control (L0), covered with *Cm* (L1), covered with *Cp* (L2), covered with *Pj* (L3), and covered with mixed *Cm, Cp, Pj* (L4). The experiment also used a randomized block design with 3 replicates. Each experimental unit (4 m x 5 m) was prepared by plowing and harrowing and then formed to be 5 ridges with 4 m length. At 1 week before planting cassava cutting, the LCC according to the treatment was planted with the seed dose of 14 kg ha^{-1}. The procedure of planting cassava (*Manihot esculenta*) cutting, applying fertilizers, and observing of LCC and plant growth, and analyzing soil properties was the same as the experiment in the first year. Data were analyzed using the analysis of variance, then continued with Duncan's Multiple Range Test (DMRT).

Results and Discussion

Organic Material Production

The organic material produced *in situ* in the first (2017) and the second year (2018) experiment at harvest (10 MAP) is shown in Table 1 and Table 2. The organic material of the land prepared with mixed LCC in 2017 was higher (7.0 ton FW or 2.11 ton DW hectare^{-1}) than other treatments included control. The source of organic material of other treatments (control, Biohara plus, and Octabacter) were weeds that growing surrounded the cassava plant.

In the second year (2018), the *Pueraria javanica* produced the highest organic material (19.2 ton FW or 5.77 ton DW hectare^{-1}) among other LCC. So, it will be a potential LCC for increasing the soil C-organic on the cassava field and for suppressing weeds growth due to area covered. The *Pueraria javanica* has extremely fast-growing and resistant to drought. It has covered area more than 90% at 8 MAP and near to a hundred percent (98.08%) at harvest (Table 3). Consequently, it produced organic material higher than other LCC. Agung *et al.* (2015) also reported that *Pueraria* *javanica* produce higher biomass dry weight than *Mucuna pruriens* and *Centrosema pubescens*.

Soil Bulk Density and Moisture Content

The soil in Ciampea Udik has higher bulk density than in CES for all treatment (Table 4). It correlated to the soil C organic. On the contrary to the bulk density, the soil C organic in Ciampea Udik was lower than in CES (Table 6). The value of bulk density and soil C organic of the land that prepared with mixed LCC (2017) and also sole and mixed LCC (2018) were not significantly different from the control.

The growth of cassava (*Manihot esculenta*) was responsive to soil moisture content (SMC). The cassava that growing in the SMC 80 – 100% of field capacity (FC) was better than 60 – 80% and 40 – 60% of FC (Suwarto *et al.*, 2018). In the two years experiment (Table 5), the SMC of all treatment was upper than the permanent wilting point (19.56%). The SMC of FC was 35.64%. Table 5 shows that the SMC at 10 MAP of the land with mixed LCC in 2017 was 34.63% (97.17% of FC), it was higher than the control (27.45% or 77.02% of FC). The mixed LCC increased SMC by 26.16% compared to the control. Similarly, by using some kinds of LCC (mucuna, cowpea, and dolichos), Mulinge *et al.* (2017) reported that the SMC increase with the range of 13.6 – 49.0% compared to the control.

In the second year, due to the rainy season during the experiment, the SMC of all treatment was in the range 80 - 100% of FC. However, the nearest SMC to the FC was the land covered with *Pueraria javanica* (35.30% or 99.04% of FC). It indicated that legume cover crops could conserve SMC especially in dry season such as in 2017. Due to the fast-growing and high percentage area coverage of *Pueraria javanica*, it was better than other LCC for conserving the SMC.

Soil pH, C Organic and Total N

Table 6 indicates that the soil pH of the two locations of the experiment was low, less than 5.0 or acid. The average soil C organic in Ciampea Udik (1.43%) was lower than CES (2.29%). It has correlated to the higher soil bulk density in Ciampea Udik than in CES (Table 3). The total N of soil in Ciampea Udik was at a low level (0.15%) and CES at a moderate level (0.21%).

The effect of the treatment with LCC on the soil pH, C organic, and total N was a little and did not know yet for the two experiments (Table 6). The LCC that was being grown together with cassava (*Manihot esculenta*) will be an organic material when it has been cut and returned to the soil as a residue. Then the decomposing process of the residue will contribute to the soil properties, including soil pH. Therefore, it will need additional time to know the effect of the LCC on the soil properties. To get the effect of organic material of LCC, it should be incorporated in the soil at least 30 days (Agung *et al.*, 2015). After incorporating the organic material (residue) into the soil during the time, bulk density was lower, whereas soil C organic and N total have noted to be higher than the control.

Plant Growth and Tuber Yield

Table 7 indicates that at the end of growth, the plant height of cassava (*Manihot esculenta*) planted on the land with mixed LCC in 2017 was lower than with Biohara plus and Octabacter. However, it was relatively the same with control. In the second year (2018), consistently the plant height was not influenced by the kind of LCC sole and mixed. The plant height of all treatment with LCC was not significantly different compared to the control. The plant height at 8 MAP was in the range of 2.50 – 3.00 m. The length of cassava (*Manihot esculenta*) stem observed by Hamzah *et al* (2016) was in the range of 2.40 – 2.70 cm. So, the plant height in the experiment was normal.

In 2017, the leaves number response followed the plant height at early growth. However, at the end of growth (10 MAP), it was not significantly different among the treatment. In 2018, the LCC did not influence the number of leaves from the beginning to the end of cassava growth (Table 8). The average number of leaves that were higher in 2018 than 2017 was contributed from UJ-5. Genetically, UJ-5 produces more leaves number than Mangu (ILETRI, 2016). At 8 MAP Mangu produced 55.2 leaves and UJ-5 produced 112.9 leaves per plant.

Stem diameter was not significantly influenced by the LCC and other treatments in the two experiments. The stem diameter continuously increased during the growth from 2 – 10 MAP in 2017 and 2 – 8 MAP in 2018 (Table 9). The stem diameter was relatively the same at the same age in the two experiments. At the end growth, the stem diameter was normal. Hamzah *et al.* (2016) reported that the stem diameter range 2.36 – 2.87 cm.

The influence of all the treatments was also not significantly to the fresh weight of stem and leaves in 2017. The fresh weight of stem increased until 9 MAP then decreased at harvest (Figure 1A). The highest of fresh leaves was at 5 MAP then decreased (Figure 1B). The decreasing of the stem fresh weight could be related to the stem moisture content at harvest (62.4 %) which was lower than at 9 MAP (76.8%). The decreasing weight of fresh leaves correlated to the number of falling leaves. The leaves fall started at 3 MAP and increased at 5 MAP to 8 MAP. Suwarto and Abrori (2018) reported that the leaves falling of cassava was increase started at 5 MAP (26.6 leaves plant^{-1}).

Tuber yield

The number and fresh weight of tubers were not influenced by the treatments. The average of tuber number and fresh weight were 13.9 tubers and 5.7 kg plant^{-1} in 2017 and 15.92 tubers and 4.8 kg plant-1 in 2018 (Table 10). The tuber number was normal (ILETRI 2016). Similarly, Abdullahi *et al.* (2014) reported that cassava with various planting methods produces range 11.0–17.3 tubers plant^{-1}. Generally, the cassava (*Manihot esculenta*) planted with the sole LCC or mixed in the two experiments resulted in the value of yield components that were not significantly different from the control and other treatment.

Almost all variables of the soil properties during the growing together of cassava (*Manihot esculenta*) and LCC did not significantly change (Table 3, 4, and 5). Consequently, all the cassava growth variables were not significantly affected by the surrounded LCC. It means that to meet the need in improving organic material, the LCC can be grown together with cassava (*Manihot esculenta*) without competition to its growth. One problem of cover crops is not immediate benefits of using them (Sharma *et al.*, 2018). Residue from the LCC will be useful for the next cassava

(*Manihot esculenta*) planting that usually there is lag time at about 1 month between the first to the second planting.

Conclusions

For producing organic material *in situ* in improving soil quality, LCC could be grown together with cassava (*Manihot esculenta*). All cassava growth variables and tuber yield were not significantly affected by the LCC. *Pueraria javanica* was very potential for supplying organic matter and conserving the soil moisture content. To know further about the effect of LCC on the soil properties, the experiment needs to be continued by planting cassava (*Manihot esculenta*) after incorporating organic material (residue) from the LCC into the soil.

Table 1 : The organic material produced *in situ* in the first experiment (2017)

Organic matter	**unit**	**Treatment**				**Average ± STDev**
		Control	**Biohara Plus**	**Octabacter**	**Mixed LCC**	
Fresh weight	g m^{-1}	582,3	515,7	649,0	702,3	612,3±81.0
	ton ha^{-1}	5,82	5,16	6,49	7,02	6,12±0.81
Dry weight	g m^{-1}	174,7	154,7	194,7	210,7	183,7±24.3
	ton ha^{-1}	1,75	1,55	1,95	2,11	1,84±0.24

Note: *Cm* (*Calopogonium mucunoides*), *Cp* (*Centrosema pubescens*), *Pj* (*Pueraria javanica*); Mixed LCC consisted of *Cm, Cp* and *Pj*

Table 2 : The organic material produced *in situ* in the second experiment (2018)

Organic matter	Unit	Treatment					Average±STDev
		Control	Cm	Cp	Pj	Mixed LCC	
Fresh wight	g m^{-1}	Nd	961,4	417,4	1924,7	1176,2	1119,9±624.4
	ton ha^{-1}	Nd	9,61	4,17	19,25	11,76	11,2±6.2
Dry weight	g m^{-1}	Nd	288,4	125,2	577,4	352,9	335,98±187.32
	ton ha^{-1}	Nd	2,88	1,25	5,77	3,53	3,36±1.87

Note: nd = no data; *Cm* (*Calopogonium mucunoides*), *Cp (Centrosema pubescens)*, *Pj (Pueraria javanica);* Mixed LCC consisted of *Cm, Cp* and *Pj*

Table 3 : The percentage of cassava area coverage by LCC in the second experiment (2018)

Plant age (MAP)	**Treatment**				
	Contol	**Cm**	**Cp**	**Pj**	**Mixed LCC**
	Area coverage (%)				
2	0.00c	19.17a	9.17b	15.25ab	15.17ab
3	0.00b	35.08a	22.83a	25.63a	27.08a
4	0.00c	44.50a	30.00b	32.33b	33.17b
5	0.00c	40.67a	25.67b	40.42a	40.67a
6	0.00d	42.91ab	18.87c	53.92a	36.08b
7	0.00d	59.50ab	22.00c	63.75a	46.25b
8	0.00d	77.33b	38.00c	90.91a	75.33b
9	0.00d	68.83b	38.58c	93.33a	74.92b
10	0.00c	44.33b	39.33b	98.08a	84.83a

Note: Figures in the same row and the same year followed by the same letter were not significantly different based on Duncan Multiple Range Test at 5% level; MAP = month after planting, *Cm* (*Calopogonium mucunoides*), *Cp* (*Centrosema pubescens*), *Pj (Pueraria javanica)*

Table 4 : The response of soil bulk density to the treatment in the two years (2017 and 2018) experiment

First year (2017)					Second year (2018)					
Plant age (MAP)	Treatment				Plant age (MAP)	Treatment				
	Contol	Biohara Plus	Octabacter	Mixed LCC		Contol	Cm	Cp	Pj	Mixed LCC
	Bulk density (g cm-3)					Bulk density (g cm-3)				
4	0,94a	0,93a	0,94a	0,95a	4	0.81a	0.83a	0.78a	0.82a	0.76a
5	0,95a	0,95a	0,95a	0,95a	5	0.85a	0.82a	0.79a	0.85a	0.82a
6	0,94a	0,95a	0,95a	0,96a	6	0.82a	0.81a	0.78a	0.81a	0.79a
7	1,08a	1,00a	1,05a	1,09a	7	0.80a	0.84a	0.80a	0.82a	0.80a
8	0,94a	0,94a	0,93a	0,99a	8	0.81a	0.81a	0.77a	0.81a	0.79a
9	0,96a	0,97a	0,95a	0,97a	9	0.84a	0.80a	0.80a	0.80a	0.79a
10	1,07a	0,99 b	1,07a	1,04ab	10	0.81a	0.82a	0.78a	0.84a	0.76a

Note: Figures in the same row and the same year followed by the same letter were not significantly different based on Duncan Multiple Range Test at 5% level; *Cm* (*Calopogonium mucunoides*), *Cp* (*Centrosema pubescens*), *Pj (Pueraria javanica)*

Table 5 : The response of soil moisture content to the treatment in the two years (2017 and 2018) experiment.

First year (2017)					Second year (2018)					
Plant age (MAP)	Treatment				Plant age (MAP)	Treatment				
	Contol	Biohara Plus	Octabacter	Mixed LCC		Contol	Cm	Cp	Pj	Mixed LCC
	Soil moiture content (%)					Soil moiture content (%)				
4	20,62a	22,39a	21,22a	21,89a	4	28.90a	29.58a	28.43a	28.41a	26.18a
5	22,91a	22,91a	22,64a	21,89a	5	35.70a	35.81a	35.06a	35.86a	34.47a
6	23,45a	22,08a	22,97a	21,33a	6	32.71a	31.20a	30.38a	30.46a	30.38a
7	26,51a	32,84a	30,06a	24,98a	7	32.54a	33.99a	33.40a	34.23a	33.84a
8	25,15a	25,67a	23,38a	22,32a	8	33.37a	34.04a	33.40a	34.33a	31.77a
9	23,19a	23,45a	22,23a	23,93a	9	19.11a	20.68a	20.87a	22.42a	21.03a
10	27,45a	31,84a	32,27b	34,63ab	10	32.22b	32.61b	31.64b	35.30a	31.76b

Note: Figures in the same row and the same year followed by the same letter were not significantly different based on Duncan Multiple Range Test at 5% level; *Cm* (*Calopogonium mucunoides*), *Cp* (*Centrosema pubescens*), *Pj (Pueraria javanica)*

Table 6 : The response of chemichal soil properties to the treatment at 6 MAP in the two years (2017 and 2018) experiment

Year of the experiment	Treatment	pH H20	Walkey & Black Soil C-org (%)	Kjedhal N-Total (%)
2017	Contol	4.25	1,67	0,15
	Biohara Plus	4.43	1,41	0,16
	Octabacter	4.33	1,24	0,13
	Mixed LCC	4.66	1,38	0,14
	Average	4.42 + 0.18	1.43+ 0.18	0.15+0.01
2018	Contol	4.54	2,29	0,22
	Cm	4.53	2,31	0,21
	Cp	4.88	2,38	0,22
	Pj	4.71	2,25	0,21
	Mixed LCC	4.75	2,26	0,21
	Average	4.68+0.15	2.29+0.05	0.21+0.01

Note: *Cm* (*Calopogonium mucunoides*), *Cp* (*Centrosema pubescens*), *Pj (Pueraria javanica)*

Table 7 : The response of plant height of cassava to the treatment in the two years (2017 and 2018) experiment.

First year (2017)					Second year (2018)					
Plant age (MAP)	Treatment				Plant age (MAP)	Treatment				
	Contol	Biohara Plus	Octabacter	Mixed LCC		Contol	Cm	Cp	Pj	Mixed LCC
	Plant hegiht (cm)					Plant hegiht (cm)				
2	34,3 b	38,0 a	40,8 a	33,6 b	2	26.77a	25.83a	25.90a	26.53a	26.42a
3	113,8 b	125,6 a	126,8 a	111,0 b	3	69.46a	67.79a	70.73a	64.27a	70.12a
4	153,0 b	162,7 a	161,3 a	142,3 c	4	117.25a	117.43a	121.27a	111.56a	120.39a
5	194,6 b	206,9 a	203,4 a	186,3 c	5	170.23a	168.58a	175.42a	163.55a	175.95a
6	221,3 b	231,2 a	231,9 a	211,8 c	6	201.75a	195.37a	207.77a	194.89a	203.88a
7	260,9 b	273,9 a	274,5 a	251,4 b	7	227.60a	228.63a	234.08a	220.82a	234.86a
8	292,4 ab	302,9 a	301,7 a	281,2 b	8	257.57a	252.07a	260.53a	243.33a	259.47a
9	328,0 ab	332,2 a	331,4 a	312,0 b	9	No	no	No	no	no
10	372,2 ab	380,0 a	383,8 a	357,7 b	10	No	no	No	no	no

Note: Figures in the same row and the same year followed by the same letter were not significantly different based on Duncan Multiple Range Test at 5% level; MAP = month after planting, *Cm* (*Calopogonium mucunoides*), *Cp* (*Centrosema pubescens*), *Pj (Pueraria javanica),* no= not observed

Table 8 : The response of leaves number of cassava to the treatment in the two years (2017 and 2018) experiment

First year (2017)					Second year (2018)					
Plant age (MAP)	Treatment				Plant age (MAP)	Treatment				
	Contol	Biohara Plus	Octabacter	Mixed LCC		Contol	Cm	Cp	Pj	Mixed LCC
	Number of leaves plant^{-1}					Number of leaves plant^{-1}				
2	14,2 b	15,1 ab	15,8 a	15,0 ab	2	13.9a	13.7a	13.2a	13.4a	13.8a
3	32,4 a	33,3 a	32,5 a	33,1 a	3	46.9a	46.2a	45.9a	43.9a	47.2a
4	36,3 a	36,3 a	35,6 a	35,8 a	4	80.0a	81.6a	78.1a	75.7a	81.2a
5	44,3 a	43,6 a	42,0 a	43,9 a	5	93.9a	95.9a	90.7a	85.2a	97.3a
6	45,2 a	44,5 a	43,3 a	44,7 a	6	99.3a	98.4a	95.5a	91.4a	105.4a
7	43,2 ab	44,4 a	44,6 a	41,3 b	7	90.4a	89.6a	88.9a	77.4a	97.8a
8	43,2 ab	44,8 a	44,2 a	41,6 b	8	80.5a	78.9a	85.1a	70.8a	85.1a
9	49,2 a	49,7 a	48,6 a	45,0 b	9	no	no	no	no	No
10	42,2 a	40,3 a	38,2 a	40,3 a	10	no	no	no	no	No

Note: Figures in the same row and the same year followed by the same letter were not significantly different based on Duncan Multiple Range Test at 5% level; MAP = month after planting, *Cm* (*Calopogonium mucunoides*), *Cp* (*Centrosema pubescens*), *Pj (Pueraria javanica)* no= not observed

Table 9 : The response of stem diameter of cassava to the treatment in the two years (2017) and 2018) experiment

First year (2017)					Second year (2018)					
Plant age (MAP)	Treatment				Plant age (MAP)	Treatment				
	Contol	Biohara Plus	Octabacter	Mixed LCC		Contol	Cm	Cp	Pj	Mixed LCC
	Stem diameter (cm)					Stem diameter (cm)				
2	1,03a	1,03a	1,03a	1,04a	2	1,33a	1,29a	1,33a	1,31a	1,33a
3	1,88a	1,97a	1,88a	1,91a	3	2,04a	1,99a	2,07a	2,01a	1,99a
4	2,28a	2,28a	2,18a	2,23a	4	2,36a	2,31a	2,42a	2,34a	2,41a
5	2,60a	2,61a	2,50a	2,55a	5	2,67a	2,58a	2,78a	2,67a	2,74a
6	2,72a	2,72a	2,61a	2,66a	6	2,79a	2,67a	2,85a	2,72a	2,83a
7	2,83a	2,81a	2,77a	2,79a	7	2,84a	2,73a	2,89a	2,81a	2,89a
8	2,92a	2,90a	2,87a	2,89a	8	2,96a	2,83a	2,97a	2,91a	3,02a
9	3,00a	2,99a	2,98a	2,97a	9	No	No	no	No	no
10	3,09a	3,08a	3,07a	3,07a	10	No	No	no	No	no

Note: Figures in the same row and the same year followed by the same letter were not significantly different based on Duncan Multiple Range Test at 5% level; MAP = month after planting, *Cm* (*Calopogonium mucunoides*), *Cp* (*Centrosema pubescens*), *Pj (Pueraria javanica),* no= not observed

Table 10 : The response of tuber yield of cassava to the treatment in the two years (2017) and 2018) experiment

First year (2017)				Second year (2018)			
Treatment	No. of tuber per plant	Fresh weight of tuber (kg plant^{-1})	Harvest index	Treatment	No. of tuber per plant	Fresh weight of tuber (kg plant^{-1})	Harvest index
Control	14,1a	5,9a	0,6a	Control	16,0a	5,2a	0,6a
Biohara Plus	14,1a	5,2a	0,6a	*Calopogonium mucunoides*	14,7a	4,9a	0,6a
Octabacter	13,3a	5,5a	0,6a	*Centrosema pubescen*	16,9a	4,7a	0,6a
Mixed LCC	14,0a	6,0a	0,6a	*Pueraria japanica*	15,8a	4,5a	0,6a
-				Mixed LCC	16,2a	4,8a	0,6a
Average	13,9	5,7	0,6	Average	15,9	4,8	0,6

Note: Figures in the same row and the same year followed by the same letter were not significantly different based on Duncan Multiple Range Test at 5% level; MAP = month after planting

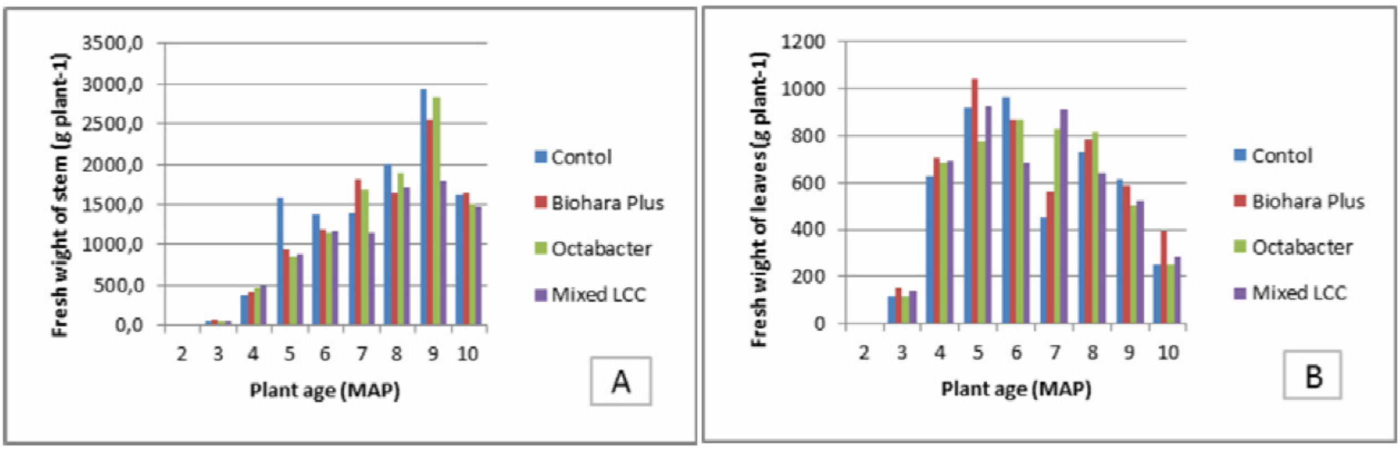

Fig. 1 : The response of cassava growth variables to the treatments on land preparation: stem fresh weight of stem (A), fresh weight of leaves (B) in the first experiment (2017); MAP = month after planting

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