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LAND HUSBANDRY: THE ROLE OF BIOCHAR AS A SOIL ENHANCER IN CASSAVA CROPPING SYSTEM

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ABSTRACT

Field experiments were carried out to examine the effect of increasing the crop yield on soil fertility in cassava-based cropping systems. The experiment was also aimed at showing that with proper soil fertility, soil enhancer the planting of cassava cropping system The experiment was done in a farmer's fields in Batu, about 15 km south east of Malang, East Java, Indonesia. The soils are Alfisols with a surface slope of about 8%. There were 8 experimental treatments with two replications. Experimental results showed biochar application can be improve soil physical and chemical properties in cultivation of intercropping of cassava and maize. At the beginning of the application showed different uptake, higher uptake in corn, also observed that nutrient uptake of cassava is lower than maize. In high yield, only K uptake from cassava is higher than corn, while N and P uptake is more or less the same. Plant management can be a symbiotic mutualism between cassava and maize. However, this only happens when there is appropriate crop management. Plant management, such as biochar applications, can significantly improve soil properties, both physical properties and soil chemical properties, even root uptake. The results of this study reveal that proper management can be increase the soil organic C, the weight of soil content and the aggregate stability of the soil. In addition, the role of soil fertility improvements, increased nutrient uptake of N, P, K, Ca, Mg and cation exchange capacity.

Keywords: Land husbandry, Role, biochar, Soil Enhancer, cassava, Cropping system

1. INTRODUCTION

In Indonesia, although cassava is an important crop and is planted in a very large area, it is still considered a minor crop by both the government and private sectors so it only receives little attention (Cheng et.,al, 2006). Recently, with the food crisis due to the difficulty in increasing cereal crop production and decreasing oil fuel reserves, cassava has attracted more attention, especially from businessmen. However, the development of cassava still faces many constraints;

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one of which is the assumption that planting cassava will accelerate soil and land degradation. In addition, some people believe that land degradation accelerates with the increase of cassava yield.

The soil biophysical aspect that becomes an important constraint to the current agricultural system is the low quality of soil fertility, among others, in characterized soil organic matter content and low nutrient retention. Soil organic matter plays an important role in determining the quality of soil fertility because it strongly affects the physico-chemical and biological properties of the soil. The addition of organic matter in the form of fertilizer and biochar play a role in improving soil fertility and lasting in a long time to two soil masses.

Notwithstanding the fact that land planted with cassava is usually in a degraded or nearly degraded condition, the hypothesis that growing cassava and/or increasing cassava yield causes soil and land degradation is still questionable. A better interpretation of the fact would probably be that only cassava crops can grow and produce a reasonable yield in such a poor soil condition. The common assumption that the nutrient uptake by cassava is higher than other crops is also not entirely correct. Howeler (2002) calculated that with a harvest of 35.7 fresh tubers/ha (equal to 13.53t/ha dry) cassava removes 55kg/ha of N, 13.2kg/ha of P, and 112kg/ha of K. As a comparison, Heckman *et al.* (2009) show that nitrogen, phosphorus and potassium removed by 10.3t/ha maize grain yield was 141 kg N, 39 kg P, and 49 kg K. In more recent studies conducted in Thailand, (Puttacaharoen *et al*,1998) showed that the amounts of N and P removed in the harvested plant areas were also much lower than those removed by other crops, while the amount of K removed by cassava was similar to other crops but much lower than that of pineapple or cassava grown for forage. In term of concentration of plant nutrient, a good comparison of nutrient removal by cassava and some other crops had been summarized by Howeler (2002).

Indeed, nutrient removal with harvesting will be influenced by crop management, and hence crop yields. Amanulah *et al.* (2001) showed that application of organic manure in cassava growing increased both tuber yields and nutrient uptake. Application of composted poultry manure had a positive soil nitrogen balance, while farm yard manure application had a negative soil nitrogen balance. In Java generally still many cultivated cassava intercropping with corn, but at a low fertility level. The soil fertility factor is the poor soil organic matter which is the limiting factor of soil fertility. In this case, land management is needed to improve the physical-chemical properties of soil that support soil health. Utilization of biochar can be an alternative option to improve soil quality and soil health.

The aim of this study is to demonstrate that planting cassava does not necessarily accelerate soil and land degradation. The study is also aimed at showing that increasing soil fertility and the enhancer soil in the cassava cropping system.

2. MATERIALS AND METHODS

The experimental treatments were set up according to the farmer's suggestions and the experiment was carried out on the farmer's field at Batu Village, 10 km south west of Malang, East Java, Indonesia. The soil was Alfisol, developed from volcanic materials with the top soil (up to 25cm depth) properties as given in Table 1. The experiment was carried out from September 2016 through to August 2017.

The experimental treatments were:

1. M: Control - cassava was planted on flat land (without ridging) in a mono-cropping system with no fertilizers applied.
2. MFB: Cassava was monoculture with farmyard biochar
3. MCcB: Cassava was monoculture with Corncob biochar
4. CS : Cassava was cassava cropping system Maize
5. CSFB : Cassava was cassava cropping system Maize with farmyard biochar
6. CSCcB : Cassava was cassava cropping system Maize with corncob biochar

These 6 treatments were arranged in Randomized Block Design with three replications. The crops were planted in field plots with the size of each 12m x 5m on a slope of about 8%.

Cassava cutting of about 25cm length was planted at a distance of 1.0 x 1.0m. For the treatment of maize intercropping, two maize seeds were planted with a 30cm interval on the sides of the cassava row (±25cm from the cassava row). After 2 weeks, the maize was thinned to one plant per hill. For the mono crop maize, maize was planted at a distance of 0.8 x 0.25m. Cassava, maize, and the hedgerow crops were planted at the same time. For the mono crop maize, maize was planted twice a year.

Observations were made for organik matter, porositas, pH, and weight of soil. Observation of soil chemical properties, includes: soil pH (in H_2O), soil organic matter content by wet digestion method Walkley and Black, total N (Kjeldhal), available P (Bray II), exchangeable K (NH_4OAc) as well as soil physical properties which include soil bulk density, aggregate stability (wet sieving, Yoder, 1928) and water content at ψm of -33kPa and -15MPa. Plant analysis was done (wet destruction) for total N (Kjeldhal), total P (spectrophotometer), and total K (Flame photometer).

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Biochar was made from corn-cob which collected from farmer around filed experimental field. Biochar was made according to the method described by Masulili *et al*. (2010) at a temperature of 300^0 C. Biochar was grinded passthrough 2.0 mm sieve diameter, afterwhich it was applied by mixing it with soil to adepth of about10-20 cm at a rate of 5 tones/ha. Some soil properties of soil and biochar used in this experiment was presented in Table 1..

Table 1: biochar characteristic form farmyard Biochar (FB) and corncob biochar (Cc Biochar) used in the experiment

Characteristic biochar	FB	CcB
Water content (%)	10.10	9.65
Ph H2O	6.0	7.0
Sand (%)	6.28	6.35
C (%)	10.24	50.26
N (%)	0.94	1.0
P (%)	0.62	0.75
C/N	10.89	40.23
K (%)	0.23	0.35
Ca (%)	0.65	0.85
Na (%)	0.35	0.54
Mg (%)	0.41	0.45
CEC (cmol/kg)	12.3	14.78

Maize, Pioner hybrid variety was planted at plant spacing of 1.0 x 0.3 m on on a plot of 6.0 m x 6.0 m. In the intercropping system, maize was planted in between cassava row. With this system, there were 120 maize plant in monoculture system and 100 maize palnt in the intercropping system. All treatments were given 100 kg Super Phosphate 36 and 100 kg KCl/ha. The nitrogen and biochar + nitrogen treatments were given 300 kg N/ha.All Super Phospahhate and KCl were given at planting time; and urea was given 3 times: 1/3 rate at planting time, 1/3 rate at 30 days after planting and 1/3 at 60 days after planting.

Measurements were done for BV, pore spaces, total pore spaces and water content. Soil chemical pH, C organic, N,P,K, Ca, Mg and CEC.

Soil data was collected before an after harvested mais. Two soil samples to a depth of about 15 cm was collected from each plot, mixed and processed for soil pH, organic carbon, nitrogen content and cation exchange capacity measurement. Soil pH in 1:1 H_2O water solutionwas measured with a pH meter (Jenway 3305), soil organic carbon was determined with the Walkley and Black method (Soil Survey Laboratory Staff, 1992). Total soilnitrogen contend was determined with Kjeldahl method (Bremner, and Mulvaney, 1982). Ammonium Acetat N, pH 7 was used to extract and determined Cation exchange capacity.

3. RESULTS AND DISCUSSION

Experimental results showed biochar application can be improve soil physical and chemical properties in cultivation of intercropping of cassava and maize. At the beginning of the application showed different uptake, higher uptake in corn, also observed that nutrient uptake of cassava is lower than maize. In high yield, only K uptake from cassava is higher than corn, while N and P uptake is more or less the same. Plant management can be a symbiotic mutualism between cassava and maize. However, this only happens when there is appropriate crop management. Plant management, such as biochar applications, can significantly improve soil properties, both physical properties and soil chemical properties, even root uptake. The results of this study reveal that proper management can be increase the soil organic C, the weight of soil content and the aggregate stability of the soil. In addition, the role of soil fertility improvements, increased nutrient uptake of N, P, K, Ca, Mg and cation exchange capacity (Table 2).

Table 2: Soil properties before n after experiment

Treatment	C	N	P	K	CEC	BV	MWD	0-33 kPa	0-15MPa
	%	%	ppm	Me/100g	Me/100g	Mg/m3	mm	%	%
before	1.14	0.09	11.61	1.61	12.5	1.31	2.04	32.32	21.25
M	0.78	0.06	10.97	1.63	12.3	1.30	1.46	25.46	20.78
MFB	0.87	0.07	10.85	1.70	12.7	1.29	1.56	24.40	20.19
MCcB	1.05	0.08	11.45	1.54	13.9	1.34	2.06	31.25	21.46
CS	1.25	0.08	9.76	1.60	13.8	1.32	1.98	32.54	20.96
CSFB	2.20	0.14	11.71	1.41	14.1	1.08	2.19	35.12	21.18
CSCcB	2.26	0.15	12.70	1.58	14.8	1.19	2.58	36.16	21.07

In the figure below, the organic C content increases in biochar administration, and is followed by an increase in the weight of the soil content. Biochar as a soil enhancer serves as a supplier of organic C, improves nutrient status and increases the weight of the soil content (Utomo et al, 2006).

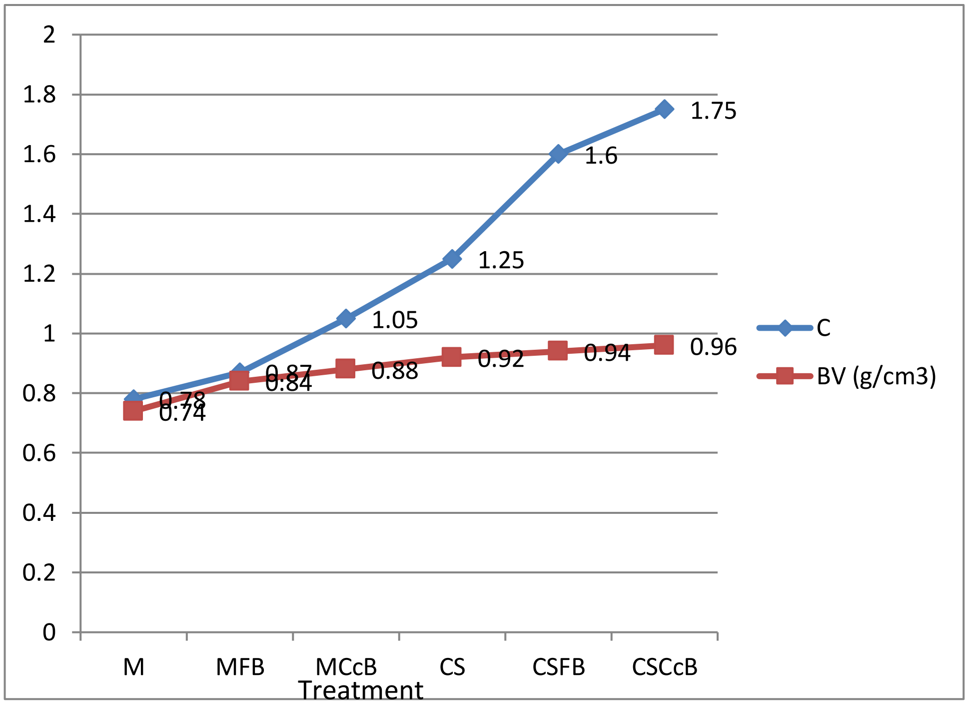

Figure 1: Graphic effect of biochar application on organic C status and weight of soil contents.

Table 3: Effect of biochar application on some soil Physical properties in monoculture and cropping system

Treatment	BV (g/cm3)	Total pore space (%)	Drainase pore (%)	Water pore available (%)
M	0.74 c	55.54 c	28.94 cd	6.52 cd
MFB	0.84 bc	59.32 cd	30.08 c	7.61 c
MCcB	0.88 c	60.31 bc	35.09 b	8.91 b
CS	0.92 ab	58.43 c	33.22 bc	8.25 bc
CSFB	0.91 ab	63.21 b	35.41 b	9.15 ab
CSCcB	0.95 a	65.62 a	37.61 a	9.36 a

The experimental results presented in Table 3 show that biochar application is very influential on soil physical properties, the weight of soil contents on the treatment of corncob biochar 0.95 g / cm3 and farmyard biochar 0.91 g / cm3 on croppingsystem pattern. The same for the monoculture of corncob biochar is higher than farmyard biochar. This is in accordance with Sukartono et al, 2011, application farmyard biochar will increase the soil organic matter and soil

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contents, so the soil is more loose. Effect of corncob biochar application, increasing soil pore capacity, total pore space 65.62% on cropping system, 60.31% on monoculture. Increased drainage pores and available pore water also increased 37.61% and 9.36%. This suggests that biochar can improve soil structure so that the pore space is more and the capacity of the chamber increases, and affects the availability of groundwater. On the cassava cropping system, improved soil physical properties can reduce land degradation and improve soil fertility (Yuniwati, ED, 2012).

Table 4: Effect of biochar application on some soil Chemical properties in monoculture and cropping system

Treatment	pH	N (%)	P (ppm)	K (me/100 g)	KTK	Ca (cmol/100 g	Mg (cmol/100 g
M	5.80	0.11	5.59	0.20	12.3	2.22	1.37
MFB	6.26	0.14	6.13	0.26	12.7	2.38	1.40
MCcB	6.18	0.12	6.56	0.7	13.9	2.44	1.42
CS	6.01	0.12	5.04	0.25	13.8	2.31	1.38
CSFB	6.21	0.14	6.47	0.31	14.1	2.39	1.42
CSCcB	6.30	0.15	6.76	0.34	14.8	2.40	1.45

In addition to increasing the soil organic C, biochar applications also lead to the improvement of some soil properties (Table 4). The high pH of CSCcB (6.30) and MFB (6.26) is due to the addition of organic and soil nutrients, as seen from the changes in N, P, K, Ca and Mg observations. Each shows an increase in the control appeal, either on Monoculture or on the Cropping system. High nutrient availability, the CEC in each biochar application also increases. Increasing soil pH after biochar application is closely related to the alkaline nature of biochar materials. Higher nutrient concentration in corncob's biochar and manure contributed positively as a soil enhancer to improved soil nutrient availability. However, to maintain the good effect of biochar, biochar applications should be given at the beginning of the season and mid-season planting for longer effects. Increasing the CEC value of soil with the addition of corncob and manure biochar will minimize the risk of cation leaching such as K + and NH4 +. Increasing the availability of nutrients and CEC in this study is consistent with the results of previous research Sukartono and Utomo, WH (2012), Yamato et al. 2016, Novak et al 2009). The high negative surface charge produced by the oxidation of the carboxylic and phenolic groups on the outer surface of the particles and the biochar surface area is a major cause of the high cation adsorption

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capacity of biochar (Cheng et al. 2006). It is this property that contributes to lower cation leaching (Lehmann et al 2009).

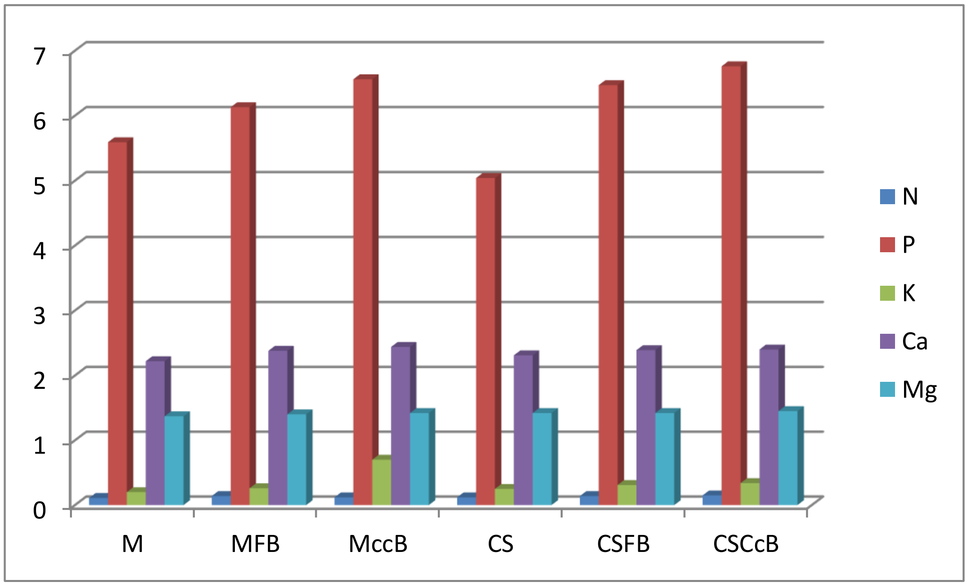

Figure 2: Effect of biochar monoculture treatment and cropping system on various soil nutrient status (N, P, K, Ca, Mg)

Biochar as a soil amendment material, has a long stay in soil, so the use of biochar as a soil enhancer in addition to improving the physico-chemical properties of the soil can also be a good carbon store. The soil enrichment of carbon through the addition of biochar has a positive effect on the soil chemistry properties such as soil nutrient status, N, P, K, Ca, Mg, CEC, soil C-organic content, water and nutrient retention (Massulili et al, 2010). With the increased nutrient status in expecting cassava and maize production on cropping system cropping patterns may increase as in the experiments of Yuniwati et al (2015).

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