LAND HUSBANDRY: THE EFFECT OF CHICKEN MANURE AND CORN COB BIOCHAR ON SOIL FERTILITY AND CROP YIELD ON INTERCROPPING PLANTING PATTERN OF CASSAVA AND CORN

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ABSTRACT

The use of chicken manure and corn cob Biochar is proven to be able to improve soil quality, plant growth crop yield of cassava and corn. This study also aims to show that different types of biochar applications (chicken manure and corncob biochar) are able to improve soil physical and chemical properties, the yield of cassava and corn kernels biomass.This study was conducted in a farmer field in Batu, about 15 km southeast of Malang, East Java, Indonesia. The study was conducted on alfisol land having 8% surface slope. The method used was 1) field experiment using Randomized Block Design (RBD) with the following treatment: 1. Monoculture (without soil enhancer, M). 2) Monoculture with Chicken Biochar Pump (MMcB), 3. Monoculture with Corncob Biochar (MCcB), 4. Intercropping of cassava and corn (CS), 5. Intercropping of cassava and corn with chicken manure biochar (CSMcB), 6. Intercropping of cassava and corn with Corn Cobs biochar (CSCcB). The observations included measurements of plant height, soil sampling for observation of soil physical and chemical properties and crop yield of cassava and corn kernels. The results showed that biochar application can improve soil quality, physical and chemical properties of soil, and crop yield on intercropping system. The management of plants in land husbandry becomes a symbiotic mutualism between cassava and corn. C organic soil, total pore, drainage, water availability and soil aggregate stability increased after being treated using chicken manure biochar (MMcB). The increase on pH and N, P, K, Ca, Mg and cation exchange capacity showed good soil quality in MMcB treatment, and CSMcB treatment on intercropping planting pattern. After harvesting the corn, the chemical properties of soil after being treated using biochar has increased in term of its high pH into 6.26, 0.14% nitrogen content , 6.13 ppm P content, 0.26 (me / 100g) K content, 12.7 KTK , 2.38 (cmol / 100g) Ca, and 1.40 (cmo / / 100 g) Mg. The application of both chicken manure and corn cob biochar is proven to be able to improve yield of cassava and corn both in monoculture system and intercropping. The highest yield of cassava is obtained from monoculture planting system with chicken manure biochar (MMcB) for 33,14 ton / ha and intercropping of chicken manure biochar (CSMcB) for 30.16 ton / ha, and corn seed yield for 4.89 ton / ha

Keywords: Biochar, chicken manure, corncobs, soil fertility, crop yield, intercropping pattern.

INTRODUCTION

The production of cassava in Indonesia still has not reached its maximum level for its cultivation has not received priority handling yet. Cassava cultivation can be done by monoculture or using intercropping pattern combined with corn applied both on dry land and on critical land. Actually, the potential of production of cassava is still high because cassava is easy to plant in any land condition. However, the development of cassava cultivation still

encountered many obstacles one of which is there is an assumption that the cultivation of cassava accelerates the degradation of soil and land. In addition, some people assume that high cassava production depletes nutrient needs in the soil, thus reducing soil health (Yuniwati, 2017)

Soil quality factor becomes an important aspect in maintaining the quality of soil fertility, including soil organic matter content, which is characterized by soil nutrient retention. Soil organic matter greatly determines soil fertility and is very important in affecting the physical, chemical and biological properties of the soil. (Sukartono *et al*, 2011) The addition of biochar from various types of materials has been practiced in increasing soil fertility for a long time (Nur,T *et al* 2014)

Some facts on biochar research show that there are organic amendments contained in the soil for a longer time compared to other organic fertilizers and it will increase soil carbon uptake. The research results (Amanullah *et al*. 2007), (Islami, et al, 2011), (Islami *et al*, 2011) show that an organic soil amendment is a technology to improve soil fertility and cassava productivity and can stabilize crop yields, especially on degraded land. The addition of repeated organic soil amendment annually to land conditions will improve soil fertility and result in improved soil health (Yuniwati *et al*, 2012).

One of the technologies to improve soil health is corncob biochar, (Njurumana at al, 2008), (Gleser, 2001). Corncobs biochar had a positive effect between C and N, increased nutrients and soil acidity, and improved the growth of corn crops with significant results [8]). While chicken manure biochar contains 7.9 pH, 255.5 g / kg organic C content, 7.8 g / kg nitrogen, 8.5 g / kg; K 7.9 g / kg Pospat and 17.7 cmol cation exchange capacity (CEC). (Islami, *et al*, 2017).

Biochar application improves soil fertility status, especially soil organic C, CEC, available P, K, Ca, and Mg, and increased nutrient uptake and yield of corn. C organic soil increased from 0.9% (before treatment) to 1.20% (after being treated using biochar and CM) Soils treated with biochar consistently have higher organic C content, which also remains more stable than those treated with CM, implying a higher biochar potential for soil carbon uptake (Masulini *et al*, 2010) .

Biochar applications increase porosity and aggregate size by as much as 16% and increase the water content available significantly on soil. It also significantly boosts the macropore. Biochar application could availably raise soil quality and physical properties for tilth increasing in the degraded mudstone soil (Zeng-Yei Hseu *et al*, 2014)

The highest yield of corn during the rainy season was recorded for CM, followed by CDB and CSB (5.98, 5.87, and 5.71 Mg ha - 1 respectively). However, the second crop yield in a single CM application treatment decreases. This is not the case for corn yields on soil fed biochar. (Sukartono, *et al*, 2011).

Other results indicate that biochar stimulates the amount of lettuce leaves and total biomass, improving total soil amounts of nitrogen and phosphorus, as well as total carbon, and enhancing related microbial communities. Combinations of compost and biochar can enhance and maintain soil biophysical and chemical characteristics and increase crop productivity over time (Dalila Trupiano,*et al*, 2017)

The results showed that Biochar application increased the growth of cassava in monoculture and intercropping system. The growth of cassava in intercropping system is slower than monoculture system. Corn yield, in both planting systems increased with biochar application, but not significantly influenced by planting system (Islami *et al*, 2011)

The highest yield of corn (4.62 t.ha-1) was obtained with monoculture corn applied to biochar. The lowest corn yield was obtained from monoculture maize without biochar (3.87 t.ha-1) but not significant in intercropping crop without biochar (3.96 t.ha-1) (Yuniwati *et al*, 2017)

MATERIALS AND METHODS

Location

The field experiment was carried out in eroded soil at Junrejo, Batu, East Java, Indonesia. Laboratory analysis was done at the Soil Science Department, Brawijaya University, Malang. The field experiment was conducted from March 2 to October 25 2017.

Biochar was made from chicken manure and corncobs collected from farmers' poultry and farmers surrounding the field and done according to the method described by Masulili *et al, 2010* at the temperature of 300^0 C. Some properties of soil and biochar used for the experiment were presented on Table 1.

Table 1.Some properties of soils and biochar used in the experiment

Experimental materials	Chemical properties					
	pH	Carbon (%)	Nitrogen (%)	Cation Exchange Capacity ($cmol.kg^{-1}$)	Sand (%)	Clay (%)
Soil	6.34	0.91	0.10	14.96	24.35	34.20
Manure on chicken	7.90	32..45	0.04	17.50	-	-
corncobs	8.14	47.06	0.02	19.75	-	-

Experimental treatments and management

The tested treatment consisted of two factors, namely: biochar application (without biochar, with chicken manure biochar, corncob biochar), and planting system (cassava monoculture, corn monoculture, and intercropping of cassava and corn). The design of this study was a Randomized Block Design with three replications. The experimental plot has a size of 2.0 mx 5.0 m having 15% slope

The used cassava in this study was the Faroka variety, planted at a distance of 1.0 m x 1.0 m, and corn, a hybrid varieties of Pioneer, planted at a distance of 1.0 mx 0.3 m. In the intercropping treatment, corn is planted among cassava. Cassava monoculture is fertilized using 300 kg Urea.ha-1; 100 kg Super Phosphate 36.ha-1; and 100 kg of KCl.ha-1. Monoculture of corn is grown with 200 kg Urea.ha-1; 100 kg Super Phosphate 36.ha-1; and 50 kg KCl.ha-1. Intercropping cassava + corn in fertilizer with 300 kg Urea.ha-1; 100 kg Super Phosphate 36.ha-1; and 200 kg of KCl.ha-1. All phosphate fertilizers and super KCl are given at planting time, and urea is given 3 times: 1/3 at planting; 1/3 at 45 days after planting, and 1/3 at 110 days after planting.

The data are: soil pH, weight of soil content, aggregate stability, soil organic C, soil nitrogen, macro nutrient content, growth and yield of cassava and corn. The observation of soil

physical and chemical properties was done before planting and after biochar application and after harvest. Soil samples were collected before harvesting corn for soil physical properties, soil nitrogen, soil aggregates and the availability of soil nutrient content.

The soil organic matter was measured with Walkley and Black method, The Kjeldhal method was employed for soil nitrogen determination with the Kjeldhal method. The soil aggregate water stability was determined by wet sieving method according to the description by Utomo and Dexter, and the results were expressed as the mean weight diameter (MWD) of stable aggregate with an equation of:

$$\text{MWD} = \sum_{i=1}^{n} diwi$$

Here d_i is the mean diameter of any particular size ranges of aggregates separated by sieving, and $iw_i$is the weight of aggregates in that size range as a fraction of the total dry weight of soil used.

Analysis of variance (ANOVA) with 95% degree of confidence was used for data analysis. When there was a significance, the Least Significant Difference (LSD) test was employed to further analysis the significant difference between treatment.

RESULTS AND DISCUSSION

Soil Physical Properties

Table 2. The 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 (%)	MWD (mm)
M	0.74d	55.54 b	28.94 bc	6.52 ab	1.46 a
MMcB	0.84 bc	59.32 a	32.08 a	7.61 a	1.56 a
MCcB	0.88 b	58.31 a	30.09 ab	7.91 a	1.06 b
CS	0.82 c	55.43 bc	28.22 bc	6.25 ab	1.38 ab
CSMcB	0.91 a	57.21 ab	32.41 a	7.57 a	1.49 a
CSCcB	0.85 bc	55.62 b	29.61 b	7.36 a	1.08 b

From table 2, it can be seen that the data showing the weight of soil volume (BV) and pore on the best treatment drainage was obtained from the treatment of intercropping of corn and cassava with additional Biochar (CSMcB), which obtained 0.91 g / cm3 and 32.41%. meanwhile, the total pityity is 59.32% and 1.56 mm of aggregate stability in MMcB treatment, and 7.91% on pore space availability in Monocultur corn with corncob (MCcB) biochar.

In accordance to that opinion (Sukartono *et al*, 2011), it is stated that biochar application improves soil physical properties and soil quality, especially in soil weight, total porosity, drainage and soil aggregate stability. Chicken manure biochar is better than corn cob biochar both on monoculture planting pattern and in intercropping pattern. This is in accordance to Islami's opinion (Islami, *et al*, 2017) regarding intercropping planting pattern which is stated that chicken manure biochar improves soil quality in intercropping planting pattern. In accordance to that opinion (Gleser, 2001), it is stated that biochar can be applied on intercropping planting pattern of cassava and corn. This will become a model of sustainable agriculture in the future and prepare the productivity of soil quality in the long term (Howeler, 1991). This is in accordance with the result of that study Zeng-Yei Hseu *et al*

(2014). Biochar applications increase porosity and aggregate size by as much as 16% and increase the water content available significantly on soil. It also significantly boosts the macropore.

Soil Chemical properties

Table 3. The Effect of biochar application on some soil Chemical properties in monoculture and cropping system

Treatment	pH	N (%)	P (ppm)	K (me/100g)	CEC	Ca (cmol/100g	Mg (cmol/100 g
M	5.80 ab	0.11 b	5.59 ab	0.20 ab	12.3 a	2.22	1.37
MMcB	6.26 a	0.14 a	6.13 a	0.26 ab	12.7 a	2.38	1.40
MCcB	6.18 a	0.12 ab	6.10 a	0.21 ab	11.9 ab	2.34	1.32
CS	5.01 b	0.10 b	5.04 ab	0.21 ab	10.4 b	2.21	1.32
CSMcB	6.21 a	0.14 a	6.27 a	0.31 a	12.1 a	2.39	1.42
CSCcB	6.16 a	0.11 ab	6.16 a	0.24 ab	11.8 ab	2.30	1.40

On table 3, the soil chemical properties, especially pH, N, P, K and CEC, are significantly different. The pH was significantly different in biochar treatment of manure, MMcB (pH 6.26), N was significantly different for the monoculture pattern of biochar manure MMcB (0.14%) and cropping pattern of intercropping biochar manure (CsMcB) (0.14%), P was significantly different for cropping patterns Monoculture of manure biochar (6.27 ppm) and cropping pattern of intercropping of biochar manure (6.27 ppm), K is significantly different for planting method for intercropping of biochar manure (0.31 me / 100g). CEC is significantly different for the biochar monoculture pattern of MMcB manure (12.7) and the cropping pattern of biochar manure (CsMcB) (12.1).

The same is true of soil chemical properties. It is stated that chicken manure biochar can significantly improve soil pH, Nitrogen content, Pospor, potassium, Ca, Mg and CEC. It is in accordance to the opinion (Yuniwati, *et al,* 2017*,* Nur T, 2014, Hana Hlavacikova *et al,* (2018) stating that chicken manure biochar increases nutrient availability of land, either on monoculture or intercropping cropping pattern. While on intercropping cropping pattern, corncob biochar improves soil chemical properties, although not as good as chicken manure biochar . This is in accordance to the opinion (Widowati *et al*, 2014) Hana Hlavacikova *et al,* (2018). This is similar in pointed out by Dalila Trupiano *et al* (2017), Combinations of compost and biochar can enhance and maintain soil biophysical and chemical characteristics and increase crop productivity over time.

Crop Yield

Figure 1 explained chicken manure biochar (MMcB) and (CSMcB) both on monoculture and intercropping patterns providing the highest yield for the amount of biomass which is 3.85 tons / ha, and 4.89 tons / ha for corn kernels ..

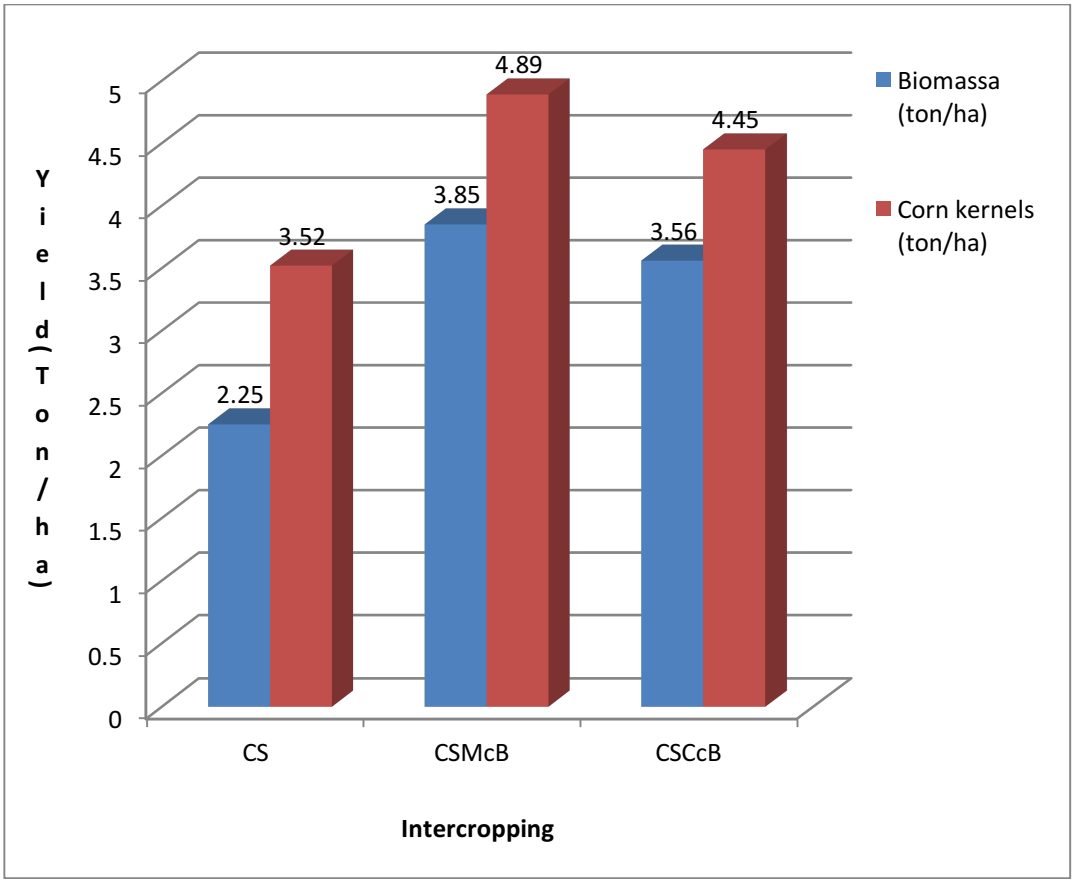

Figure 1. Relationship between Intercropping and biochar manure chicken treatment and Corn cob biochar treatment with biomassa and corn kernels (ton/ha)

From the yield of corn biomass and weight it showed that the application of chicken manure biochar was higher that is 3,85 ton / ha for biomass and 4,89 ton / ha for corn kernel. This happens after being treated using chicken manure biochar so it resuts on the improvement of nutrient availability and the effect of improved soil physical properties and soil quality which is better compared to corncob biochar on intercropping cropping pattern. This is similar to what is mentioned by Yuniwati (2017), Islami, *et al* (2011) and Sukartono *et al* (2010)

Figure 2 explains biochar chicken manure (MMcB) and (CSMcB) both on monoculture and intercropping patterns providing the highest yield for cassava biomass amount of 35.45 tons / ha and 33.14 tons / ha for cassava harvest.

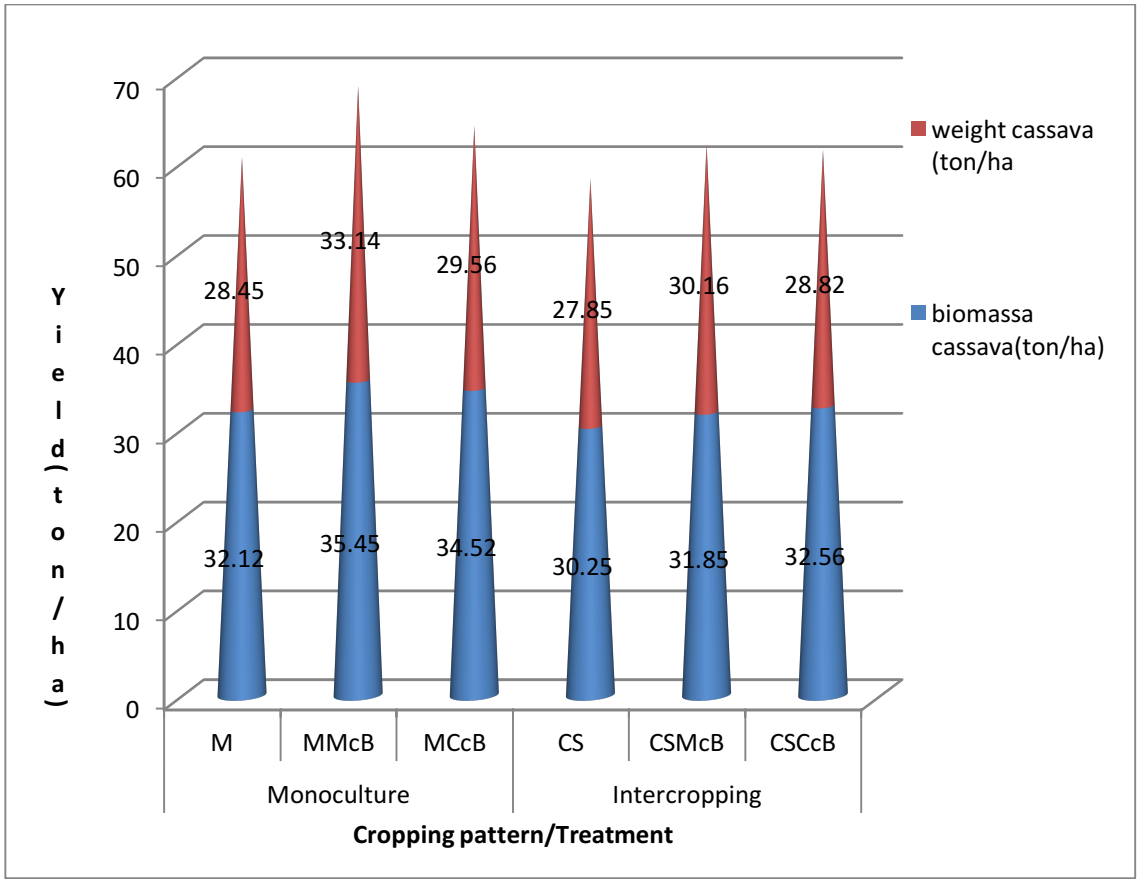

Figure 2. Relationship between Cropping pattern and biochar treatment with biomassa and weight cassava (ton/ha)

The results of cassava on intercropping cropping pattern is still high for 30.16 ton / ha after being treated using chicken manure biochar and 28.82 ton / ha for those treated using corn cob biochar . For monoculture cropping pattern, the yield of cassava is higher for 33.14 ton / ha after being treated using chicken manure biochar and 29.56 ton / ha after being treated using corn cob biochar. Overall, after adding biochar as land amendment, it is very significant to improve soil quality, nutrient availability and there is no population competition in intercropping cropping pattern. This opinion is consistent with the results of Islami *et al* (2011), sukartono *et al* (2011), Yuananto *et al* (2018), and Yuniwati *et al* (2017) research

CONCLUSION

From the research results, it can be concluded that the type of biochar (chicken manure and corncob) determines the changes in soil quality, both physical properties, chemical and plant yield on intercropping system. The management of plants in land husbandry becomes a symbiotic mutualism between cassava and corn. C organic soil, total pore, drainage, water availability and soil aggregate stability increased, in the treatment of chicken poultry biochar (MMcB). Increased pH and N, P, K, Ca, Mg and cation exchange capacity showed good soil quality in MMcB treatment, and CSMcB treatment on intercropping cropping pattern. After harvesting corn, the soil chemical after being treated using biochar has an increase of pH, 6.26, nitrogen content of 0.14%, P content of 6.13 ppm, K 0.26 (me / 100g), KTK 12.7, Ca 2.38 (cmol / 100g) and Mg 1.40 (cmo / / 100 g).

The aplication of both chicken manure and corn cob biochar is proven to be able to improve the yield of cassava and corn to higher number, both in monoculture system and intercropping. The highest yield of cassava is obtained from monoculture croppingsystem with chicken manure biochar (MMcB) 33,14 ton / ha and cropping of chicken manure biochar (CSMcB) 30.16 ton / ha, and corn kernel yield for 4.89 ton / ha.

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