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Agronomic Response of Soybeans and Soil Fertility Status under Application of Biocompostand Biocharon Entisols Lombok, Eastern Indonesia

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Abstract: *A field experiment was conducted on early dry season of April to July 2014 to evaluate the effect of applying biocompost and biochar on the growth and yield of soybean and soil fertility status. The experiment was set up using a Randomized Block Design. Two factors tested were biocompost and biochar. Biocompost consistist of four rates : 0, 5. 10, and 15 ton ha^{-1} and biochar consist of five rates: 0, 10, 20, 30 and 40 ton ha^{-1}. The results of the study showed that : plant height only increased significantly at plots treated with biocompostwhile no significant effect was recorded at all biochar treated plots. Biocompost increased yield of soybean up to 2.25 ton ha^{-1}while biochar at 10 ton ha^{-1} increased the yield reached to 2.09 ton ha^{-1}. Combination both of biocompost and biochar improved soybean nodulation by 67.22% resulted in increased of nitrogen uptake by plants. At control,no added organic amendements, the concentration of N in plant tissues was 4.4% which was much lower compared to plots treated with biocompost and biochar.Application of biocompost and biochar improved soil fertility (i.e. organic-C and CEC).*

Keywords:*agronomic, biocomost, biochar, soybean*

I. Introduction

Soybean *(Glycine (L.) Merr.)*is the second main food crops in Indonesia in which the current demand to this commodity has gradually increased along with increase the national population. Indonesian farmers cultivate soybean mostly under 60 of irrigated land following rice and 40% grown under upland or rainfedcropping system. Soybean production in Indonesia reached about 1,500,000 ton which was lower than national demand which was 2,071,011ton in 2015.

In Lombok, soybean is also cultivated on the second largest of agricultural area where the land is dominated by sandysoils of Entisols. The soils have generally poor fertility due to low soil organic carbon (SOC), low of nutrients status particularly N, P and K, as well as low of cation exchange capacity (CEC) (Suwardji et al., 2007;Sukartono et al, 2011).The positive effect of applying organic matter (i.e. manure and biocompost) have been shown to improve soil fertility, however, the benefits usually occurs in short period probably one year due to rapid mineralization of organic matter in the tropical environment (Diels et al., 2004).

In response to improve soil fertility status, the application of biocompost as a fresh organic matter and biochar is important to be taken into account. Sudantha (2007) explained that biocompost is fermented compost produced under lignoselulolitics microbiawhich has role as pest control and organic decomposer such as saprophite *T. harzianum* isolate SAPRO-07 and endofit *T. koningii* isolat ENDO-02. Sudantha (2009) reported that the use of biokompost (fermented compost from saprofit *T. harzianum* isolate of SAPRO-07 and endofit *T. koningii* isolate of ENDO-02) could improve crops tolerance to drought and withstand to patogen and improve soybean yield. As a fresh organic matter, biocompost in soil undergo mineralization easily for releasing nutrients and also releasing CO2 to atmosphere. Therefore, mixing biocompost and biocharas may have good effect for sustaining soil organic carbon.

Biochar is a rich carbonmaterials produced from heating of organic biomass without or limited oxygen. Biochar as a soil organic ammendments has been confirmed to improved soil fertility of sandy loam soils in the semi-arid tropical of northern Lombok, Indonesia(Sukartono, 2011). Application biochar in particular acid soils also increasedsoil fertility status such as soil pH, CEC and soil organic-C (Lehmann, et al., 2003), as well as biological changes in soils (Rondon et al, 2007). Improvementsin plant growth and yield following biochar applicationalso has been reported for some legume crops such as common beans (*Phasealus vugaris* L.(Rondon et al.,2007), soybean (*Glicine max* (L.) Merr. (Tagoe et al.,2007). However, application of mixing biocompost and biochar under soybean cropping system on light textured soils in the semi arid tropical regioan has been very limited.

Therefore, this paper addresses confirmation on effect of applying biocompost and biochar on growth and yield of soybean on Entisols Lombok, Indonesia.

II. Materials and Metods

2.1. Location

A field trial was conducted in the early dry season (April to July 2014) on upland agricultural area in Montong Village, Kediri Sub-district, Lombok, eastern Indonesia (08º 38' 10.71" S, 116º 10' 13.31" E; altitude 30.50 m above sea level).Annualrainfall of site in 2014 was 2099 mm,distributed between November/December to April/May, mean air temperature was 30ºC and atmospherichumidity about 89%. Soil type of the experimentalsiteswas Ustipssamment (Soil Survey Staff, 1998) derivedfrom volcanic materials. The top soil has asandy loam texture (45% sand and 15% clay) with pHof 6.10 and soil organic carbon (1.40%), 0.15% N and cation exchange capacity, CEC 18.90 cmol kg^{-1} .

2.2. Biocompost and biochar preparation

Composted materials used in the experiments were derived from rice straw and leaf litter. Those materials were chopped using chopping machine and subsequently air dried. Those organic materials were throughly mixed with cattle dung and powder rice husk and sprayed with endofit*T. polysporum*(isolate ENDO-04) and *T. harzianum*isolate (isolate SAPRO-07) contained solution. Then, the water content of those mixied materials was made to reach ranges of 30 to 40 (% w/w) (Fig 1) and after that it was wrapped for three weeks incubation to alow complete fermentation .

Fig. 1. Biocomposting process of organic materials (rice straw, leaf litter and cattle dung).

Biochars used in the study was produced from coconut shell and prepared through the auto thermal combusting in pits (1.0 m deep, 1.0 m wide, and 1.5 m long) for 10 hours untill the whole feedstock changed to black coloured chars which introduced as Sukartono *et al* (2011). The production of the biocharswas completely conducted under home industry in Lembah Village, Sub-district of Gunung Sari, Western Lombok. The biochars were crushed and sieved in laboratory to reach 1.0 mm particle size which characteristics as shown in Sukartono, *et al* (2011).

2.3. Experimental design and plots constructions

A field factorial trial was set up using a Randomized Block Design (RBD) in which treatments of biocompost and biochar were applied with four replications in plots of size 4 m x 4 m. Biocompost consisted of four rates : 0; 5; 10 and 15 ton ha^{-1} and biochar tested were 0; 10; 20; 30 and 40 ton ha^{-1} . Each combination treatment had four replications in which soybean cropping system had been grown.

Plots were established after rice harvested by removing standing rice straw and ploughing the soil to 20 cm depth using a hand tractor. Plots were constructed with size of 4 m x 4 m. Each plot was separated by furrow (30 cm wide and 30 cm depth) for external drainage. Distance between block was 0.75 m.

Three seeds were sown per hole at every single plot with row spacing of 20 cm x 25 cm. One week after sowing, two plants were allowed for growing season. Fertilizers containing N,P and K (Phonska 16-16-16) was applied at 14 days after sowing (14 DAS) with rates of 200 kg ha^{-1}. Fertilizers were banded 5 cm depth in between rows of crops. Soil moisture of was controlled through watering plotson the basis of soil water content at field capacity. This was measured usingtensiometer.

2.4. Measurements

Measurements were carried out for agronomics and soil parameters. Agronomic parameters measured during experiment wereplant height, yields on the basis of dry seeds, number of nodules, and nitrogen uptake. Plant height was measured at 8 weeks (56 DAS). Soil variabels involved pH, organic-C, CEC, N, P, and K. Soil pH was determined in 1:2.5 ratio of soil: water,organic carbon by Walkley and Black method, and totalN by Kjeldhal method; available P was extracted byBray-1 method; CEC and exchangeable K usingammonium acetate at pH 7.0. The data were analyzedusing ANOVA and the significance was tested by HSD test (p=0.05) with MINITABVersion 13.

III. Results and Discussion

3.1. Plant height

There was no interaction between biocompost and biochar oberved in plant height. Biocompost, fermentedcompost generated from endofitfungy and saphrophite of *Trichoderma*spphad only a significant effet on plant height as sown in Fig2. The highest plant height (57 cm) was performed by crops grown on plots treated with 15 ton ha^{-1} of biocompost and the lowest was recorded at crops received 5 ton ha^{-1} (52 cm). This data confirmed positive contribution of biocompost in improving early growth of soybean. Biocompost mostly soluble nutrients which are readily available for crops. Herlina and Dewi (2011) reported that the application of biocompost could produce healthy crops and improve crops flowering and growth. Sudantha (2008) also explained that compost generated from fermented of *Trichoderma* spp. improve crops growth as a results of better microbia activities and controll external soil pathogen.

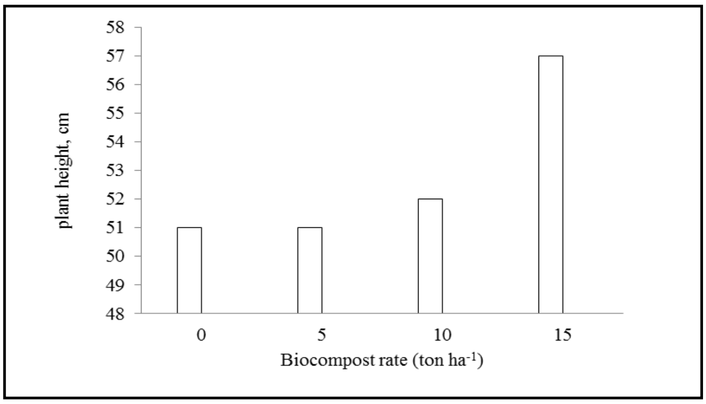

Fig 2. Mean of plant height at 8 weeks (56 days after sowing)

3.2. Yields.

Biocompost and biochar has a single effect on dry weight of seeds (Table 2). Table 2 show that yield of soybean increased by 25 % up to 30%at plots treated with biocompost and 10 % up to 16 at biochar treated plots. The highest yield of soybean reached 2.36 ton $ha^{-1}$was found at plots applied by 15 ton ha^{-1} of biocompost. The increased yield as reported here is associated with better growth as a results of improvement of soil nutrients availability (data shown in Table 3). This results was in accordance with Sudantha(2008) reported that fertmented biocompost derived from endophitet of *T. polysporum*, and saprophite of *T. harzianum*improved significanly of vegetative growth as well as yields. Crops treated by fermented biocompost tend to have better growth performance compared to control. The endophite fungy (*T. Polysporum*) and saprophite of *Trichoderma* spp. hosted in biocompost produced special hormone which promote growth of the crops (Sudantha, 2010).

Table 2. Yield of soybean on the basis of dry weight seeds at different rates of biocompost and biochar

Treatments	Yields($gplot^{-1}$)	Yields ($tonha^{-1}$)
Biocompost		
0 ton ha^{-1}	449.38 ^{a} *)	1.8
5 ton ha^{-1}	496.29 ^{b}	1.99
10 ton ha^{-1}	563.24 ^{c}	2.25
15 ton ha^{-1}	588.65 ^{c}	2.36
HSD 5 %	31.34	
Biochar		
0 ton ha^{-1}	478.37^{a}	1.91
10 ton ha^{-1}	521.84^{b}	2.09
20 ton ha^{-1}	528.58^{b}	2.11
30 ton ha^{-1}	538.91^{b}	2.16
40 ton ha^{-1}	554.25^{b}	2.22
HSD 5 %	37.41	

**) Mean with the same superscript letters do not differ significantly at 5% .*

In respect to biochar, the yields of soybean also increased by 14% to control. However, there was no significant differents of yields between rates. This sugest that application of 10 up to 40 ton $ha^{-1}$of biochars is likely rates for improving soil quality of Entisols. Growth performance of crops wasmuch better under biochars and biocompost treatments compared to no added organic amendments. This result was associated with of soil quality improvement as presented in Table 3. Previous study by Sukartono*et al* (2011)reported that biochar had positive contribution in improving soil properties and yields of maize.

3.3. Number of root nodules

The analysis varians show that there was a significant interaction between biocompost and biochar oberved at number of root noodles. The positive interaction pattern was depicted in Fig. 3. Overall, Fig.3 shows that total number of root nodules increased along with increased amountorganic amendments being added to soils. The highest number of root noodles was 119 at plots treated with 10 ton $ha^{-1}$of biocompost plus 20 ton ha^{-1} biochar (B2C2).

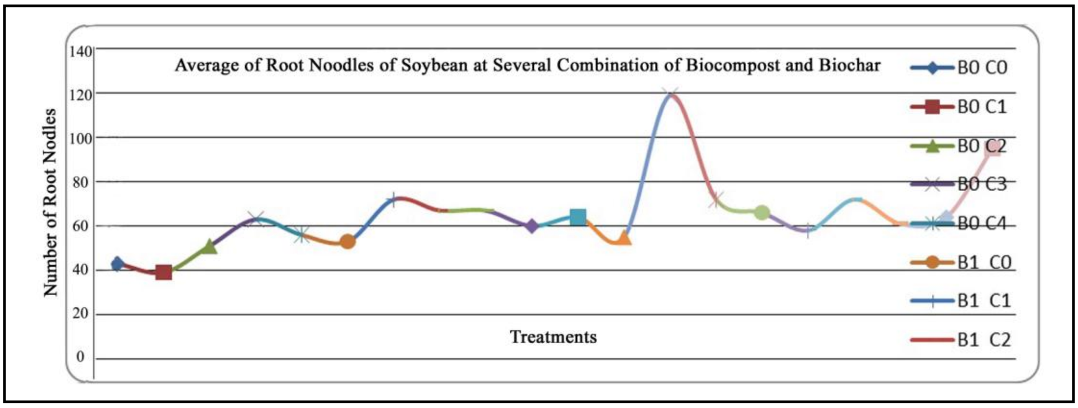

Fig. 3. Number of root noodles of soybean at several combinations of biocompost and biochar

The greatest number of root nodules sugest better root proliferation resulted in favorable rhyzosfere environment for *Rhizobium sp*. as the bioactivator in promoting nodulation. Suharjo (2001) stated that environmental factors controling the activities of bioactivators such as *Rhizobium*bacteria are soil pH, soil organic carbon as well as soil nutrients availability. Thus from soil fertility prespective, combination application of biocompostas fresh organic matter and biocharwould likely perform suitable organic amendements to improve soil fertility of light textured soils and eventually promoting *Rhizobium*sp. activity. Tate (1995) reported that water stressunder dry condition, the roots nodulation of legume crops was mostly suppressed due to very low population of Rhyzobium bateria.

Root nodules is firstly formed through a secretion process of metabolic productinto the root zone in which it stimulate the growth of bacteria. Then, bacteria performed colonization within rhizosfer of legume crops. Collino *et al*.(2000) showed that colonisation of *B. Japonicum*occured after 5 days of innoculation of bacteria through thesoybean roots. In white clover, however, Collino *et al*.(2000) showed that coinnoculation of *A. lipoferum* T1371 and *R. Leguminosarum*resulted in collonisation at secondary hair roots. Formation of root noodles of soybean is affected by essential soil nutritions (i.e. P, K, Ca, S and Mo), soil moisture and temperature. Optimum soil moisture for bacteroid formation is soil water status at a field capacity and soil temperature ranges from 20ºC to 30ºC. The effectiveness of noodle formation is mostly indicated by size of noodles formed at primary roots of soybean observed at around 42 days after sowing (Suharjo, 2001).

3.4.Concentration of N in plant

Plants analysis for nitrogen content was conducted for assessing nitrogen uptake by plant during growth period. The nitrogen uptake for this experiment wasmeasured for only treatments of B0C0, B2C2 and B3C4, in order to simplify differenciatebetween nutrient uptake of soybean at plots control and added-organic amendment plots (Fig.4).

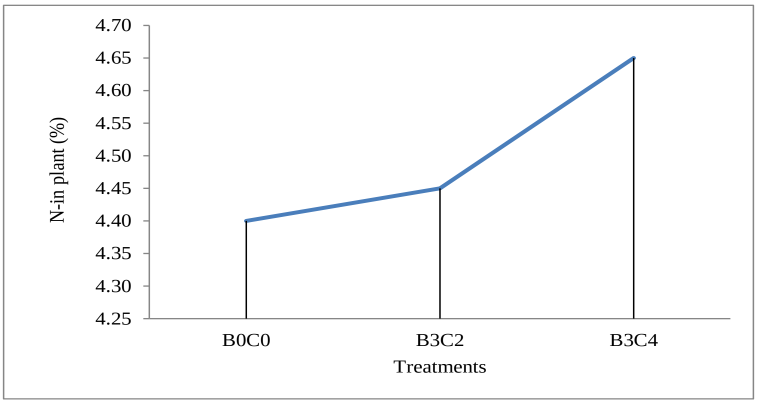

Fig 4. Concentration of N in plant under application of organic amendments. .

It is cearly shown in Fig 4 that N content in plant tissue increased as a result of addition of organic amendments (biocompost and biochar). Nitrogen concentration in planst were 4,4 %, 4.45% and 4.65% at control, B0C0, B2C2 and B3C4 repectivelly. This sugest that application of organic amendements under those combination could provide better soil nitrogen availability.Biocompost improved natural soil biodiversity and nutrient cycling which resulted in increasing soil productivity and crops performance. A biocompost fermented from*Trichoderma* spp. has several advantages as nutrients and energy sources for soil microbia, promote soil aggregation, increase soil-water holding capacity, alowfavourablesoilaeration as well as provide better root ploferation for crops (Sudantha, 2010).

3.5. Soil properties

The application of a fermented *Trichoderma* - biocompost and biochar under soybean cropping system improved soil properties. This was indicated by soil chemical measurements (Table 3) after the end of cropping syste.

Table 3. Soil chemical properties following biocompost and biochar application on soybean cropping system.

Soil properties	Before experiment	Treatments			HSD
		B0C0	B2C2	B3C4	5 %
pH	6.2	6.1[a]	6.3[ab]	6.5[b]	0.34
Organic-C	1.48	1.40[a]	1.73[c]	2.26[d]	0.0008
Total-N	0.14	0.15[a]	0.17[b]	0.20[c]	0.0003
CEC	18.89	18.91[a]	22.39[ab]	22.67[b]	2.64

B0C0 = no added biocompost and biochar , B2C2= biocompost 10 ton ha^{-1} and biochar 20 ton ha^{-1}; B3C4 = biocompost of15 ton ha^{-1} and biochar of 40 ton ha^{-1}

*) *Mean with the same superscript letters within rows do not differ significantly at 5%* .

Data presented in Table 3 show that the application of biocompost and biochar had significant effect on changing soil properties including soil pH, organic-C, total-N and CEC. In respect to improve soil fertility status, the total soil organic-C(SOC) increased significantly after application of organic amendments. SOC was actually 1.40% at control andit reached to 1.73 and 2.26% atB2C2 and B3C4 respectivelly.In addition, other than SOC as key soil variables, the CEC alsoincreased significantly higher (22.39 me% and 22.67me%) at organic amendments treated soils compared to control.This sugest that under short cropping system periods, those organic amendments could improved soil fertility status. As soil have high value of soil organic-C (SOC) and CEC means that the soil would provide better condition for water and soil nutrient availability to crop ptoduction. Similar results have been reported by Sukartono *et al* (2011) that application of biochar and cattle manure on sandy loam soils under maize cropping system increased soil organic-S (SOC) and soil-water holding capacity.

IV. Conclusion

Application of organic amendments (biocompost and biochar) improvedgrowth and yield of soybean. Both biocompost and biochar at rates of 10 ton ha^{-1} contributed 25 and 10% respectively increased of soybean yield compared to control. The yields were reached to2.25ton ha^{-1} and 2.09 ton ha^{-1}.Combination of biocompost and biochar improvednodulation and nitrogen uptake by plants. The highest content of N in plant tissue was 4.65% at combination treatment of 15 ton ha^{-1} biocompost and 40 ton ha^{-1} biochar. So, this study was likely confirms that both biocompost and biochar are valuable amendments for improvingsoil fertility of sandy loam soils and soybean crop production. Althouh applying biocompost produced relatively higher yields, in term of maintaining stability of soil organic-C for long term basis, the application biochar mixed with biocompostwould be more promising.

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