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The effect of biochar and cowmanure to increase soil fertility in entisol Darussalam

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Abstract

The availability of fertil land for agriculture was the main factor to support the cultivation activity. The utilization of dryland in Indonesia did not optimise yet especially in Aceh. The solution to support the utilization of dryland and improve soil fertility especially Entisol that dominated in Aceh through application biochar and cow-manure. The research was conducted in Campus Experimental Site The ACIAR Project from April to October 2017. The randomized complete block design with 2 factors and 3 replications used in the experiment. The first factor was kinds of biochar with some rates (rice husk biochar: 0 t ha^{-1}; 2.5 t ha^{-1}; 5 t ha^{-1}, and cocopeat biochar: 0 t ha^{-1}; 2.5 t ha^{-1}; 5 t ha^{-1}) and the second factor was cow manure with some rates (0 t ha^{-1}; 2.5 t ha^{-1}; 5 t ha^{-1}). The result showed that the kinds of biochar with some rates were effected to soil pH and ratio C:N soil. The used of rice husk biochar 5 t ha^{-1} was the optimum rate to improved soil pH Entisol.

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Introduction

Agriculture field in Indonesia does not use optimiselly and dryland is one of that. The optimising of dryland has a big potential for agricultural sector. International Institute of Rural Reconstruction (2002) in Managing Dryland Resources book said the dryland related to precipitation, rain times, rain in a year, vegetation, and field utilization. According to Abdurachman *et al.* (2008), dryland in agriculture concept is an agroecosystem which has a big potential to cultivation activity, horticultures (vegetables and fruits), crops, annual plant, and livestock. Aceh Province in the fourth position category for temporary dryland did not use which is higher than Riau with the total around 437.518 ha. The temporary dryland did not use in Aceh was natural resources with high potential to use optimally in cultivation activity. Food security in Indonesia is unstabil yet so the utilization of dryland has a good potential to provide it. Some soil ordo develop in dryland and one of the ordo is Entisol. Entisol physical-chemical properties according to Tan (1986) have the low agregation, vulnerable to erosion, and low nutrients. Subagyo *et al.* (2000) said Entisol in Aceh Province around 870.000 ha and Ultisol around 700.000 ha and spread in North Aceh with low topography and low organic matter content.

According to Suriadikusumah *et al.* (2011) in Aceh Besar disctrict there were many soil ordos and Entisol around 34.529 ha. The soil analysis of Entisol in Krueng Raya sub-district has done by Muyassir *et al.* (2012) showed that the soil chemical properties with some characteristics were low, soil pH 6.22%-5.64% (rather acid), organic C 1.12% (low), total N 0.11% (low), available P 4.42 ppm (low) so the improvement needed to increase Entisol fertility. The inorganic fertilizer application and maximize agriculture activity without improvement or giving input to increasing soil quality (soil physical, soil chemical, and soil biology) will giving negative impact to soil ecosystem, soil fertility, and soil health. Organic matter like biochar and cow manure application were one of the solution to increase soil fertility. Biochar according to Lehman and Joseph (2009) was charcoal by-product throughbiomass product combustion like wood, manure, leaves, and organic litter which can used as the raw material.

Biochar known as carbon sequestration, reduced green house effect, and improved soil fertility (Lehmann *et al.*, 2006). Biochar content 90% carbon and depends on the raw material (Chan and Xu, 2009). Biochar also increase soil fertility, soil quality, soil pH, water holding capacity, and soil CEC. Rice husk biochar used in agriculture activity and research about the impact of using rice husk biochar to soil quality is very wide. So the experiment about the effect of biochar application in dryland to increase soil fertility in Entisol was needed.

Materials and methods

Experimental site

Soil ordo in Campus Experimental Site The ACIAR Project (5° 34' 4,4" N:95° 22' 36" E) Agriculture Faculty, Syiah Kuala University was Entisol with class texture was sandy loam and soil class was coarse. The rain during experimental activity from April to October 2017 was 5 mm. In 2016 soil sample taken in some points to analyzed chemical properties. In the first experimental activity the land was tillaged used tractor so the soil will loose and grass population decrease. The size of land that used in the experiment was $34.6\ \text{m} \times 10.6\ \text{m}$. Each plot size was $3\ \text{m} \times 1.5\ \text{m}$, width of drainage was 40 cm and depth was 20 cm. After that, each plot was applicated N fertilizer with dose 22.5 g plot^{-1}. The experimental arranged in a randomized complete block design with 2 factors and 3 replications. The first factor was kinds of biochar with some rates (rice husk biochar: 0 t ha^{-1}; 2.5 t ha^{-1}; 5 t ha^{-1}, and cocopeat biochar: 0 t ha^{-1}; 2.5 t ha^{-1}; 5 t ha^{-1}) and the second factor was cow manure with some rates (0 t ha^{-1}; 2.5 t ha^{-1}; 5 t ha^{-1}).

Biochar production

The raw material for biochar was used dry rice husk and dry cocopeat. Rice husk was got from centre of rice mill in Tungkop village, Aceh Besar district, Indonesia. Cocopeat was got from Syiah Kuala sub-district, Banda Aceh, Indonesia.

Each raw material filled in the drum with volume 224.46 L. Then, the raw material was burned from the above as the source of fire so whole of raw material will combustion. The fan in the below side of drum was switched on and closed tightly.

The rice husk raw material was needed around 50-60 minutes to burned and cocopeat raw material was needed 60 minutes more which the processing time depends on the kinds of raw material. Before biochar was out from the drum, the temperature was needed to measured use thermocouple thermometer (BARNANT 100). After the combustioned was done biochar watered soon to prevent become ash.

If the biochar was wet, it must dried below the sun untill the biochar was enough dry. The dry biochar was took a little as the sample to analysis the elements of biochar used Energy Dispersive Analysis (EDS) at Laboratory of Physical UNIMED, Medan, Indonesia.

Soil amendment application

Biochar and cow manure were soil amendment. Before the application, biochar and cow manure were scaled with rate per plot (0 t ha^{-1}; 0 kg ha^{-1}; 2.5 t ha^{-1};1.1 kg ha^{-1};5 t ha^{-1}; 2.3 kg ha^{-1}) and applicated in line each plot 2 weeks before peanut planted. Cow manure was analyzed and contained total N 0.53%, organic C 5.51%, and available P 3.35%.

Planting

Each plot was applicated biochar and cow manure 2 weeks before peanut planted. It was aimed to homogenity the soil amendments and soil in experimental site. The variety of peanut was Bima. The seeds were selected with the criteria was 3 seeds each pod. After that, the seeds were soaked for 30 minutes and wrapped use moist fabric to break dormantion time. Then, the seeds were planted with the range 30 cm × 30 cm, depth of planted 3 cm and 3 seeds each hole.

Soil analysis

When the peanut aged were 45 days after planted, the soil sample were taken each plot as much as 3 points sample diagonally use soil auger.

The soil sample were wrapped use plastic bag and analyzed in BPTP, Banda Aceh, Indonesia. The chemical properties parameter for soil analysis were soil pH, ratio C:N (%), and available P (mg.kg^{-1} P_2O_5). Soil pH analyzed with mixtured 10 g dry soil and 25 ml water destillated and homogenized use shaker for 15 minutes and measured use pH meter (Lutron-pH 208). Total carbon (%) analyzed use Walkley and Black method which organic C destroyed through the excess of oxidation calium bicarbonate because the addition of sulfate acid. Then, the excess of chromate and did not reduction by organic C will titrated use ferro solvent.

The total nitrogen (%) analyzed with Kjeldhal method which changing organic N become ammonium N by sulfate acid heated in 380° C and use Cu-sulfate + Selenim + Na-sulfate as the catalisator. Ratio C:N (%) was get with compare total C (%) and total N (%) data. P available (mg.kg^{-1} P_2O_5)analyzed use Bray I method which available P were extracted use NH_4F solvent and HCl. Then, P were released and reacted use molybdic acid so the color will be blue and measured as P level spectrometry.

Data analysis

Soil data were analyzed use SPSS version 21 and next tested use Duncan's New Multiple Range Test (DNMRT).

Results and discussion

The first soil analysis

According to soil analyzed from Team Survey ACIAR in 2016 at Campus Experimental Site The ACIAR Project Syiah Kuala University known the soil ordo was Entisol with soil texture was sandy loam and soil class was coarse. In the Table 1 known the problems at Campus Experimental Site The ACIAR Project were organic C content, total N, total P, and CEC have criteria were low to very low and soil texture was sandy loam and need an improvment to increase Entisol fertility and productivity through application biochar and cow manure.

Table 1. Chemical properties at ACIAR experimental site campus.

Parameters	Value	Criteria
pH (H_2O)	7,2-8,6	neutral-rather base
Organic C (%)	0,74-1,54	low-very low
Total N (%)	0,05-0,11	low-very low
Total P (mg 100 g^{-1})	49-122	high-very high
Total k (mg 100 g^{-1})	49-42	high-very high
Available P(ppm)	28-85	high-very high
Cation exchange(cmol kg^{-1})		
Ca	5,33-15,97	low-high
Mg	3,51-6,27	High
K	0,12-0,39	medium-low
Na	0,08-1,60	high-very high
Cation amount(cmol kg^{-1})	10,77-19,75	very high
CEC(cmol kg^{-1})	9,42-14,57	Low
Al-dd	0	very low
H-dd	0,02-0,04	very low
Base saturation(%)	>100	very high
Soil fertility status		medium

Soil pH

Kinds of biochar application (rice husk biochar and cocopeat biochar) and cow manure with some rates were effected significantly to soil pH in the kinds of biochar factor, but it didn't effect significantly to cow manure factor and the interaction. Cocopeat biochar application with 2.5 t ha^{-1} effected significantly to all treatments except without treatment (0 t ha^{-1}).

Table 2. Rice husk biochar and cocopeat biochar EDS analysis.

El	Rice husk biochar			Cocopeat biochar		
	Unn.C	Norm.C	Atom.C	Unn.C	Norm.C	Atom.C
C	20.00	32.07	46.77	81.22	81.22	86.96
O	14.40	23.09	25.28	14.00	14.00	11.25
K	-	-	-	2.87	2.87	0.94
Si	27.96	44.83	27.96	1.14	1.14	0.52
Cl	-	-	-	0.52	0.52	0.19
Mg	-	-	-	0.25	0.25	0.13

The application of rice husk biochar and cocopeat biochar mixtured cow manure with some rates level (0 t ha^{-1};2.5 t ha^{-1}; 5 t ha^{-1}) were effected significantly to the kinds of biochar factor and not effected significantly to cow manure factor and the interactions (Table 3). The rice husk biochar application with 5 t ha^{-1} has the soil pH is 7.15 (neutral) and soil pH without rice husk biochar (0 t ha^{-1}) was only 7.05 (neutral).

The application of cocopeat biochar with 5 t ha^{-1} caused the soil pH was 7.08 (neutral) and the control treatment was 6.94 (neutral).

Biochar was soil amendment and many experimentals have done by some researchers to know the effect of biochar to soil fertility and improve soil physical, chemical, and biology (Kookana *et al*, 2011; Ogawa, 1987).

Table 3. Soil pH at 45 days after planted.

Cow manure	Kinds of biochar and rates						Mean
	Rice husk biochar			Cocopeat biochar			
	0 t ha^{-1}	2,5 t ha^{-1}	5 t ha^{-1}	0 t ha^{-1}	2,5 t ha^{-1}	5 t ha^{-1}	
0 t ha^{-1}	6,93	7,09	6,95	7,10	6,92	7,01	7,05
2,5 t ha^{-1}	6,77	6,81	7,13	6,78	6,77	7,10	7,01
5 t ha^{-1}	7,11	7,06	6,79	6,96	6,82	7,05	7,03
Mean	7,05^{b}	7,12^{b}	7,15^{b}	6,94^{ab}	6,83^{a}	7,08^{b}	

Note: The number followed by the same letters was not significantly different from DNMRT test of 5%.

Liang *et al.* (2006) said the biochar was able to improved CEC value, increased water holding capacity in sandy loam soil (Kammann *et al.*, 2012), soil pH (Aciego and Brookers, 2008) and soil organic matter (Mitchell *et al.*, 2015). Beside that, biochar application according to Preston and Schmidt (2006); Verheijen *et al* (2010) was able to hold the decomposition process for 10 to thousands years. Rice husk and cocopeat used as the main raw materials contained carbon, hydrogen, and another elements like silica in rice husk.

Table 4. Ratio C:N Soil (%) at 45 days after planted.

Cow manure	Kinds of biochar and rates						Mean
	Rice husk biochar			Cocopeat biochar			
	0 t ha^{-1}	2,5 t ha^{-1}	5 t ha^{-1}	0 t ha^{-1}	2,5 t ha^{-1}	5 t ha^{-1}	
0 t ha^{-1}	17,63	11,88	14,14	13,34	12,97	11,69	13,61
2,5 t ha^{-1}	16,19	14,21	14,35	16,01	15,65	8,24	14,11
5 t ha^{-1}	9,15	16,37	13,19	21,07	11,49	11,52	13,80
Mean	14,32^{ab}	14,15^{ab}	13,89^{ab}	16,80^{b}	13,37^{ab}	10,49^{a}	

Note: The number followed by the same letters was not significantly different from DNMRT test of 5%.

According to EDS analyzed (Table 2), rice husk biochar was contained 46.77% C, 27.96% Si, and 25.28% O. The cocopeat biochar was contained 86.96% C, 11.25% O, 0.94% K, 0.52% Si, 0.19% Cl, and 0.13% Mg. Silica in rice husk around 14-25% and the content of Si depends on the variety of paddy, climate, and soil type (Chandrasekhar *et al.*, 2005). Shen *et al.* (2014) said when the combustion of rice husk untill become biochar, the contents of Silica increase 60% and carbon contents increase 10 to 40%.

The availability of silica, carbonate, and bicarbonate in biochar was able to increase soil pH. Chintala *et al.* (2014) said biochar was contained high carbon and others elements like phenolic, carboxyl, and hydroxyl at the surface of biochar so able to fixatation H^+ ion from soil solvent and decrease the concentration of H^+ion so the soil pH increased.

The increasing of soil pH was related to carbon availability from biochar as the souce of organic matter to decomposition process by soil microbe.

Ratio C:N (%)

Ratio C:N as the soil chemistry quality was measured (Table 4). The application kinds of biochar (rice husk biochar and cocopeat biochar) and cow manure with some of rates was effected significantly to ratio C:N in kinds of biochar factor, but it's not effected significantly to cow manure factor and the interactions. The application of rice husk biochar 5 t ha^{-1} showed the soil ratio C:N was 10.49 (low). Ratio C:N was meant as the level of decomposition organic matter by decomposer. The excessevie of carbon availability from rice husk biochar and cocopeat biochar become the food for soil macro-microorganisms.

The carbon availability as the organic matter was break down and contained carbon, hydrogen, oxygen, nitrogen, and phosphate. The decomposer were involved in decomposition process was fungi and bacteria according to Persson *et al.* (1980). Ratio C:N from this experimental in the low category and it means that the organic matter degradation process faster so plant can use as nutrient. But it is not good if the ratio C:N category was high, because it was meant that the organic matter degradation was low and plant can not absorb as nutrient.

Table 5. Available Soil P (mg.kg^{-1} P_2O_5) at 45 days after planted.

Cow manure	Kinds of biochar and rates						Mean
	Rice husk biochar			Cocopeat biochar			
	0 t ha^{-1}	2,5 t ha^{-1}	5 t ha^{-1}	0 t ha^{-1}	2,5 t ha^{-1}	5 t ha^{-1}	
0 t ha^{-1}	19,43	17,74	19,33	18,04	16,51	21,31	18,73
2,5 t ha^{-1}	17,86	18,19	18,10	18,18	19,63	21,24	18,87
5 t ha^{-1}	19,25	19,38	20,19	19,94	18,51	17,78	19,18
Mean	18,85	18,44	19,20	18,72	18,22	20,11	

Soil P Available (mg.kg^{-1} P_2O_5)

The application kinds of biochar (rice husk biochar and cocopeat biochar) and cow manure with some rates didn't show the significant effect to soil P available and the interaction also (Table 5). The highest soil P available caused by cocopeat biochar and rice husk biochar application with dose 5 t ha^{-1}. The soil P available from rice husk biochar application was 19.20 ppm (medium) and cocopeat biochar was 20.11 (medium). P is one of the limited factor for plant growth but it's not mobile element. The soil microorganisms activity help the changes of P anorganic become P organic to absorb nutrient P available in $H_2PO_4^-$ and HPO_4^{2-} form for plant and correlate with P immobilisation in the soil.

Conclusion

The application kinds of biochar with some rates was significantly effected to soil productivity like soil pH and soil ratio C:N. The application of rice husk biochar with 5 t ha^{-1} was the best dose to increase soil pH in Entisol.

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References

IIRR. 2002. Managing Dryland Resources- An extension manual for Eastern and Southern Africa. International Institute of Rural Reconstruction, Nairobi, Kenya.

Abdurachman A, Dariah A, dan Mulyani A. 2008. Strategi dan Teknologi Pengelolaan Lahan Kering Mendukung Pengadaan Pangan Nasional. Jurnal Litbang Pertanian **27,** 43-49.

Aciego PJC, Brookes PC. 2008. Relationships between soil pH and microbial properties in a UK arable soil. Soil Biology & Biochemistry **40**, 1856–1861.
http://dx.doi.org/10.1016/j/soilbio.2008.03.020

Badan Pusat Statistik. 2010. Statistik Indonesia. Badan Pusat Statistik Indonesia. Jakarta.

Chan KY, Xu Z. 2009. Biochar: nutrient properties and their enhancement. In: Lehmann, J., Joseph, S. (Eds.), Biochar for Environmental Management. Earthscan, London.

Chandrasekhar PN, Pramada L, Praveen. 2005. Effect of organic acid treatment on the properties of rice husk silica. Journal Mater Science **40,** 6535-6544. http://dx.doi.org/10.1007/s10853-005-1816-z.

Kammann C, Ratering S, Echard C, Mueller C. 2012. Biochar and hydrochar effects on greenhouse gas (Carbon dioxide, nitrous oxide, and methane) fluxes from soils. Journal Environment Quality **41,** 1052-1066 http://dx.doi.org/10.2134/jeq2011.0132.

Khusrizal. 2009. Karakteristik, klasifikasi dan arahan pengelolaan tanah terpengaruh tsunami di Nanggroe Aceh Darussalam (Studi Kasus Aceh Utara). Disertasi Fakultas Pertanian Pascasarjana Universitas Sumatera Utara. 188.

Kookana RS, Van Zwieten L, Krull E, Singh B, 2011. Biochar Application to Soil: Agronomic and environmental benefits and unintended consequences. Advances in Agronomy, **112,** 103-143. http://dx.doi.org/10.1016/B978-0-12-385538-1.00003-2.

Lehmann J, Gaunt J, Randon M. 2006. Bio-char sequestration in terrestrial ecosystems- A review. Mitigation and Adaptation Strategies for Global Change, **11**, 403–427. http://dx.doi.org/10.1007/s11027-005-9006-5.

Mitchell PJ, Simpson AJ, Soong R, Simpson MJ. 2015. Shifts in microbial community and water-extractable organic matter composition with biochar amendment in a temperate forest soil. Soil Biology Biochemical Journal **81,** 244–254.

Muyassir, Sufardi, Iwan S. 2012. Perubahan sifat kimia entisol Krueng Raya akibat komposisi jenis dan takaran kompos organik. Lentera Jurnal **12**, 37-48.

Ogawa M. 1987. Symbiosis of people and nature in the tropics. Farming Japan, **28**, 10-34.

Persson TBE, Clarholm M, Lundkvist H, Söderström BE, Sohlenius B. 1980. Trophic structure, biomass dynamics and carbon metabolism of soil organisms in a scots pine forest. Ecological Bulletins No**. 32,** 419-459.

Preston CM, Schmidt MWI. 2006. Black (pyrogenic) carbon: a synthesis of current knowledge and uncertainties with special consideration of boreal regions. Biogeosciences Journal **3**, 397–420. http://dx.doi.org/10.5194/bg-3-397-2006.

Shen Y, Peitao Z, Qinfu S. 2014. Porous silica and carbon derived materials from rice husk pyrolysis char. Journal Microporous and Mesoporous Materials **188,** 46-76. http://dx.doi.org/10.1016/j.micromeso.2014.01.005.

Subagyo H, Suharta N, Siswanto AB. 2000. Tanah-tanah pertanian di Indonesia. Sumberdaya Lahan Indonesia dan Pengelolaannya. Puslittanak, Balitbang Pertanian. Departemen Pertanian RI.

Suriadikusumah A, Talkuputra ND, Alemina E. 2011. Rancangan pengembangan kawasan agropolitan berdasarkan karakteristik lahan di kabupaten Aceh Besar. Jurnal Ilmu-Ilmu hayati dan fisik **13,** 47-57.

Tan K, Im H. 1986. Degradation of soil minerals by organic acid. SSSA Publ **17,** 1-25.

Vanlauwe B, Bationo A, ChianuJ, Giller KE, MerckxR, Mokwunye U, OhiokpehaiO, Pypers P, Tabo R, Shepherd KD, Smaling EMA, Woomer PL, Sanginga N. 2010. Integrated soil fertility management: operational definition and consequences for implementation and dissemination. Outlook Agriculture Journal **39,** 17–24. http://dx.doi.org/10.5367/000000010791169998.

Verheijen F, Jeffery S, Bastos AC, van der Velde M, Diafas I. 2010**.** Biochar application to soils: a critical scientific review of effects on soil properties, processes and functions. Joint Research Center, European Commission. Luxembourg.