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## Effects of biochar residue and cow manure residue on entisol chemical properties, growth, and production of peanut (*Arachis hypogaea* L.) in second planting season

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# Effects of biochar residue and cow manure residue on entisol chemical properties, growth, and production of peanut (*Arachis hypogaea* L.) in second planting season

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**Abstract.** Agricultural improvement (AI) in dryland became a priority for agricultural development in Aceh Province, Indonesia. AI is in line with government programs to increase the productivity of several types of second food crops such as peanuts. Up to now, the productivity of food crops, especially peanut on dryland in Aceh Province, based on farmers' practice, was still very low, i.e 0.95 tons ha<sup>-1</sup>. Biochar is one of the options for soil management and has the potential to improve soil fertility. The objectives of this research were to study the effect of rice husk biochar residue, cocopeat biochar residue, and cow manure residue on Entisol chemical properties, peanut growth, and production. Rice husk biochar, cocopeat biochar, and cow manure were applied on the first season of peanut growth. The research was conducted using factorial 6 x 3 with three replications, and the treatment units were allocated based on Randomized Block Design. The first factor was rice husk biochar residue and cocopeat biochar residue with 3 doses (0; 2.5; 5 t ha<sup>-1</sup>) and cow manure residue with 3 doses (0; 2.5; 5 t ha<sup>-1</sup>) as the second factor. The soil chemical properties and root samples were analyzed on 45 days after planting and peanut production after harvest. The observed variables of crops were (1) plant height, (2) branches number (3) plant dry weight ; (4) root dry weight; (5) root nodules number, (6) pods weight, (7) pods total, (8) filled pods, (9) seed weight, and (10) weight of 100 seeds. The observed variables of soil chemical properties were (1) pH, (2) C-organic; (3) Total N; (4) P available; and (5) K exchangeable. The results showed that rice husk biochar residue and cocopeat biochar residue does not affect soil chemical properties significantly, such as plant height 15 and 30 DAP, peanut pods, and seed weight per plant. Nevertheless, both had a positive effect on plant height 45 DAP, branches number 15, 30, 40 DAP, root dry weight, plant dry weight, root nodules number, and 100 seeds weight. The best residual dosage of rice husk biochar and cocopeat biochar was 2.5 t ha<sup>-1</sup>. Cow manure residue did not give a significant effect on soil chemical properties, plant height 15, 30 and 45 DAP, branches number 30, 45 DAP, root dry weight, plant dry weight, root nodules number, peanut pods, seed weight per plant, and 100 seeds weight, but had a positive effect on the number of branches 15 DAP. The best dosage of cow manure residue was 2.5 t ha<sup>-1</sup>.

**Keywords:** soil amendment, manure, soil chemical, legume, yield

## 1. Introduction



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Indonesia has a dryland of 144.5 Mha and is divided into non-acid soil 37.1 Mha and acid soil 107.4 Mha [1]. Most of the dryland has degraded and is not well managed, so the dryland is difficult to produce optimum crop yield.

Dryland agriculture is a priority in agricultural development in Aceh Province, which is in line with government programs to increase the productivity of several types of food crops such as peanuts. The productivity of food crops, especially peanut on dryland in Aceh Province, based on farmers' practice, is still very low, i.e., 0.95 tons ha<sup>-1</sup>.

The productivity of dryland for peanut crops in Aceh Province could still be improved. There were 5 (five) key successes of land management for dryland under dry climate ecosystem, namely: (1) Water management technology; (2) Soil organic matter management; (3) Rock Phosphate management; (4) Biochar management; and (5) Farmer's institution empowerment [1]. In this research, management applied to improve the dryland productivity in Aceh province, especially for peanut crops, was conducted using rice husk biochar residue, cocopeat biochar residue, and cow manure residue.

Biochar is one of the options for soil management and has the potential to improve soil fertility. Biochar is used as a soil amendment, but it is an organic fertilizer because biochar does not add nutrients to the soil. Still, it has only high CEC (cation exchange capacity), so it binds soil cations that can be utilized for plant growth. Although biochar is not a fertilizer, the biochar can be used as a mixture of fertilizer [2].

The research objectives were to study rice husk biochar residue, cocopeat biochar residue, and cow manure residue effect on Entisol chemical properties, growth, and peanut production.

## 2. Materials and Methods

This research was conducted at Campus experimental site and laboratory of Syiah Kuala University and Assessment Institute for Agricultural Technology Aceh from April to July 2018. Biochar and cow manure had been applied to the first planting season of peanut.

The soil type in the Campus Experimental Site was Entisol with sandy loam texture with coarse class. This location is above marine alluvial plains with a flat area (0-2%) and altitude of 3 m above sea level. Based on the Meteorology and Geophysics Agency/BMKG Blang Bintang data, this location has a tropical climate type, an average annual rainfall of 2,500 mm year<sup>-1</sup> with an average temperature of 27.2°C and classified in climate type B (Schmidt-Ferguson). The average minimum temperature was 23°C, and the maximum 36°C [3].

From the chemical aspect of the soil, this site's experimental has a soil pH of neutral to slightly alkaline (pH 7.20-8.60), very low to low of organic C and N total (0.74-1.54% C and 0.05-0.11% N) and very low exchangeable Al content. Total P and K contents (extracted with 25% HCl) and available P (Bray II) are high to very high. The exchangeable cations (Ca, Mg, K, and Na) varies from low to high, but the number of exchange base cations and the base saturation is high but a low of potential CEC (<16 cmol kg<sup>-1</sup>), because the sand fraction dominates this soil. From the aspect of soil chemistry, the soil in this site has low soil organic matter (C soil <1.0%) and low total N and low of water holding capacity [3].

Data analysis using Randomized Block Design, factorial 6 x 3 with 3 replications. The first factor was three rates (0; 2.5; 5 t ha<sup>-1</sup>) of rice husk biochar residue and cocopeat biochar residue and the second factor was three rates (0; 2.5; 5 t ha<sup>-1</sup>) of cow manure residue.

The experimental plot was 1.5 m x 1.5 m, and the planting space was 30 cm x 30 cm. The peanut seed used was Bima variety. The soil chemical properties and root crop samples were analyzed on 45 days after planting and yield after harvest. Inorganic fertilizer was applied in all plots as base fertilizer. The inorganic fertilizers were ZA 100 kg ha<sup>-1</sup>, urea 50 kg ha<sup>-1</sup>, and KCl 50 kg ha<sup>-1</sup>. The observed variables of crops were (1) plant height, (2) branches number, (3) plant dry weight; (4) root dry weight; and (5) root nodules number, (6) pods weight, (7) pods total, (8) filled pods, (9) seed weight,

and (10) weight of 100 seeds. The observed variables of soil chemical properties were (1) pH, (2) C-organic; (3) Total N; (4) P available; and (5) K exchangeable.

### 3. Results and Discussion

#### 3.1 Entisol Chemical Properties

The experiment in the first peanut planting season showed that rice husk biochar and cocopeat biochar application gave significant effect on pH, C: N ratio, and P available, but not significant on cow manure application [4]. In this experiment (peanut planting season 2) showed that rice husk biochar residue, cocopeat biochar residue, and cow manure residue were not significant on pH, Organic Carbon, Total Nitrogen, available phosphorus, and exchangeable Potassium (Table 1).

Organic Carbon, Total Nitrogen, available Potassium content in the soil can be caused by soil conditions that have soil type Entisol sub-order Fluvents with sandy loam soil texture, and coarse class. According to [3], this type of soil has more macropores that function in the water and air movement, so the rate of infiltration is very fast. These soil characteristics cause nutrients in the soil to be easily washed so that the availability of nutrients for plants is reduced. This result indicated that it is important to give rice husk biochar, cocopeat biochar, and cow manure on the next planting season.

**Table 1.** Effect of biochar residues and cow manure residues on Entisol chemical properties

Treatments	pH (H <sub>2</sub> O)	Organic C (%)	Total N (%)	Available P (ppm)	Exchangable K (cmol kg <sup>-1</sup> )
<b>Biochar Residue</b>					
Rice husk biochar residue 0 t ha <sup>-1</sup>	7.03	0.89	0.08	33.11	1.47
Rice husk biochar residue 2.5 t ha <sup>-1</sup>	7.20	0.82	0.09	32.81	1.72
Rice husk biochar residue 5 t ha <sup>-1</sup>	6.76	0.93	0.08	32.52	1.50
Cocopeat biochar residue 0 t ha <sup>-1</sup>	7.25	0.91	0.08	35.66	1.83
Cocopeat biochar residue 2.5 t ha <sup>-1</sup>	6.93	0.87	0.08	31.67	1.65
Cocopeat biochar residue 5 t ha <sup>-1</sup>	7.33	0.88	0.08	37.08	1.62
<b>Cow Manure Residue</b>					
Cow manure residue 0 t ha <sup>-1</sup>	7.29	0.85	0.08	34.11	1.58
Cow manure residue 2.5 t ha <sup>-1</sup>	6.85	0.91	0.08	32.89	1.85
Cow manure residue 5 t ha <sup>-1</sup>	7.11	0.89	0.09	34.42	1.46

#### 3.2 Plant growth of peanut

In the first planting season, rice husk biochar, cocopeat biochar, and cow manure application have no significant effect on plant height and peanut branches number at aged 15, 30, and 45 DAP [5]. The result was different in the second planting season, where rice husk biochar residues and cocopeat biochar residue significantly affected plant height at 45 DAP and branches number at 15, 30, 45 DAP (Table 2). The cocopeat biochar residue 2.5 t ha<sup>-1</sup> treatment gave the highest and significantly different results on the plant height parameters at 45 DAP (31.64 cm). In the parameters of the branches number aged 15, 30, and 45 DAP, the treatment of cocopeat biochar residue 2.5 t ha<sup>-1</sup> gave the highest yield and significantly different from other treatments.

Cow manure residue did not significantly affect the height of plants aged 15, 30, 45 DAP, and number of branches 30 and 45 DAP, but significantly different in the branches number aged 15 DAP (Table 2). The treatment of cow manure residue 2.5 t ha<sup>-1</sup> gave the highest results and significantly different in the branches number aged 15 DAP. Significantly effect in plant height and branches number of peanut plants in the second planting season showed that the rice husk biochar residue and cocopeat biochar residue application in the land had a significant effect on plant growth in the second planting season

Biochar residue significantly affected root dry weight (Table 3). The highest peanut root dry weight was found in rice husk biochar residue 2.5 t ha<sup>-1</sup> (4.7 g plant<sup>-1</sup>), but it was not different from the treatment of cocopeat biochar residue 2.5 t ha<sup>-1</sup> (4.4 g plant<sup>-1</sup>). The cow manure residue did not make significant on root dry weight.

Biochar residue significantly affected the dry weight of the upper part of the plants (Table 3). The highest dry weight of the top peanut crop was founded in rice husk biochar residue 5 t ha<sup>-1</sup> (18.4 g plant<sup>-1</sup>). The cow manure residue did not make any significant effect on the upper part crop dry weight.

**Table 2.** Effect of biochar residues and cow manure residues on plant height and branches number of peanut

Treatments	Plant height (Cm)			Branches number (Total)		
	15 DAP	30 DAP	45 DAP	15 DAP	30 DAP	45 DAP
<b>Biochar Residue</b>						
Rice husk biochar residue 0 t ha <sup>-1</sup>	10.79	18.81	28.87 <sup>bc</sup>	9 <sup>bc</sup>	28 <sup>bc</sup>	52 <sup>c</sup>
Rice husk biochar residue 2.5 t ha <sup>-1</sup>	10.57	18.74	27.81 <sup>ab</sup>	9 <sup>bc</sup>	26 <sup>ab</sup>	46 <sup>ab</sup>
Rice husk biochar residue 5 t ha <sup>-1</sup>	10.40	18.26	30.44 <sup>bc</sup>	9 <sup>bc</sup>	29 <sup>bc</sup>	50 <sup>bc</sup>
Cocopeat biochar residue 0 t ha <sup>-1</sup>	9.33	17.00	25.72 <sup>a</sup>	7 <sup>ab</sup>	25 <sup>ab</sup>	47 <sup>abc</sup>
Cocopeat biochar residue 2.5 t ha <sup>-1</sup>	10.99	19.48	31.64 <sup>c</sup>	9 <sup>c</sup>	31 <sup>c</sup>	52 <sup>c</sup>
Cocopeat biochar residue 5 t ha <sup>-1</sup>	9.47	16.53	25.42 <sup>a</sup>	7 <sup>a</sup>	23 <sup>a</sup>	42 <sup>a</sup>
<b>Cow Manure Residue</b>						
Cow manure residue 0 t ha <sup>-1</sup>	10.34	18.36	28.19	8 <sup>ab</sup>	28	48
Cow manure residue 2.5 t ha <sup>-1</sup>	10.68	18.65	29.25	9 <sup>b</sup>	28	49
Cow manure residue 5 t ha <sup>-1</sup>	9.75	17.40	27.51	8 <sup>a</sup>	26	47

Note: Letters in superscript indicate differences at 5% level

**Table 3.** Effect of biochar residues and cow manure residues on peanut roots dry weight, plant dry weight, and root nodules number.

Treatments	Peanut roots dry weight (g)	Dry weight of top plant (g)	Root nodules number
<b>Biochar Residue</b>			
Rice husk biochar residue 0 t ha <sup>-1</sup>	3.8 <sup>bc</sup>	16.9 <sup>bc</sup>	97.3 <sup>bc</sup>
Rice husk biochar residue 2.5 t ha <sup>-1</sup>	4.7 <sup>c</sup>	17.8 <sup>bc</sup>	113.6 <sup>c</sup>
Rice husk biochar residue 5 t ha <sup>-1</sup>	4.2 <sup>bc</sup>	18.4 <sup>c</sup>	80.8 <sup>abc</sup>
Cocopeat biochar residue 0 t ha <sup>-1</sup>	2.9 <sup>ab</sup>	12.6 <sup>ab</sup>	64.6 <sup>ab</sup>
Cocopeat biochar residue 2.5 t ha <sup>-1</sup>	4.4 <sup>c</sup>	17.0 <sup>bc</sup>	107.6 <sup>c</sup>
Cocopeat biochar residue 5 t ha <sup>-1</sup>	2.0 <sup>a</sup>	10.3 <sup>a</sup>	51.2 <sup>a</sup>
<b>Cow Manure Residue</b>			
Cow manure residue 0 t ha <sup>-1</sup>	3.81	16.2	84.2
Cow manure residue 2.5 t ha <sup>-1</sup>	3.69	15.8	91.6
Cow manure residue 5 t ha <sup>-1</sup>	3.48	14.5	81.7

Note: Letters in superscript indicate differences at 5% level

Biochar residue significantly affected the root nodules number (Table 3). The highest of root nodules number was founded in rice husk biochar residue 2.5 t ha<sup>-1</sup> (113.6 g), but not different from the treatment of cocopeat biochar residue 2.5 t ha<sup>-1</sup> (107.6 g). The cow manure residue did not cause a significant on the root nodules number.

Biochar residues significantly affected root dry weight, plants dry weight, and root nodules number indicated that biochar residues, both rice husk, and cocopeat biochar residue, could stimulate plant growth and plant roots. This was due to that biochar can improve air and water circulation in the soil [6], improve soil water retention capacity and soil structure [7], and bind N, Ca, K, Mg [8].

The result of the statistic analysis showed that the cow manure residue not significant effect on root dry weight, plant dry weight, and root nodule number (Table 3). This was due to (1) low manure application (0, 2.5, and 5 t ha<sup>-1</sup>), so it was insufficient to increase growth and peanut yield, although it was combined with biochar residues; and (2) its application in the first growing season. Based on the information in peanut research, the manure 10 t ha<sup>-1</sup> application gave good results. The cow manure 10 t ha<sup>-1</sup> application could produce the highest peanut dried pods (19.91 kW ha<sup>-1</sup>) and dry weight of 100 seeds (64,844 g) [9], plant height, and the number of filled pods [10].

### 3.3 Peanut Production

Rice husk biochar residues and cocopeat biochar residues did not significantly affect pod weight, total pods, and a total of filled pods (Table 4). The highest pod weight, total pods, and total of filled pods per plant tend to be highest in the treatment without biochar residue (biochar residue 0 t ha<sup>-1</sup>).

Cow manure residues have no significant effect on pod weight, total pods, and a total of filled pods (Table 4). The highest pods weight, pods total, and total of filled pods per plant tend to be highest in the treatment without residual manure (0 t ha<sup>-1</sup> cow manure residue).

**Table 4.** Effects of biochar residue and cow manure residues on peanut pods

Treatments	Pods weight (g plant <sup>-1</sup> )	Pods total (plant <sup>-1</sup> )	Filled pods (total plant <sup>-1</sup> )
<b>Biochar Residue</b>			
Rice husk biochar residue 0 t ha <sup>-1</sup>	90.37	40	37
Rice husk biochar residue 2.5 t ha <sup>-1</sup>	78.89	35	33
Rice husk biochar residue 5 t ha <sup>-1</sup>	83.52	37	35
Cocopeat biochar residue 0 t ha <sup>-1</sup>	80.19	37	36
Cocopeat biochar residue 2.5 t ha <sup>-1</sup>	84.63	37	36
Cocopeat biochar residue 5 t ha <sup>-1</sup>	79.81	37	34
<b>Cow Manure Residue</b>			
Cow manure residue 0 t ha <sup>-1</sup>	83.70	38	36
Cow manure residue 2.5 t ha <sup>-1</sup>	81.48	36	34
Cow manure residue 5 t ha <sup>-1</sup>	83.52	37	35

Rice husk biochar residues and cocopeat biochar residues in the second planting season did not have a significant effect on peanut pods. It is suspected that biochar requires a long time to affect plant yields, especially peanut pods. The application of sawdust biochar also showed no significant difference in the pods of peanut plants [11].

The weight of peanuts is influenced by the seeds number and pods formed in the soil. Peanut plants need organic material to provide elements of potassium, calcium, phosphorus, and nitrogen, which dissolve easily in the soil in helping to develop the pods [12]. At the same time, biochar generally contains carbon compounds (C) which are very high, it adds C in the soil, but it does not add other nutrients significantly [13].

Rice husk biochar residue and cocopeat biochar residue did not significantly affect the seeds per plant weight, but significantly affected the 100 seeds weight. In the 100 seeds weight parameter, the rice husk biochar residue 2.5 t ha<sup>-1</sup> treatment produced the highest weight of 100 seeds (40.52 g). Cow manure residue has no significant effect on the seeds per plant weight and the 100 seeds weight.

In the first planting season, the peanut was not significantly affected in term of seed weight per plant and 100 seeds weight [5], while in the second planting season showed significant in weight of 100 seeds with those treated with rice husk biochar and cocopeat biochar residues.. The difference shows that the rice husk biochar residue and cocopeat biochar residue application can increase peanut production in the second planting season.

When compared to the weight of 100 Bima peanut seeds, which is 30-40 g in general, this study found that the weight of 100 Bima peanut seeds planted in the study site was a bit higher. It provides a piece of evidence that the application of various types of biochar and manure with various dosage levels indicate a heavier weight of 32.37 - 40.52 g. The application of various types of biochar and manure with various levels increase the weight of 100 varieties of peanut Bima variety.

**Table 5.** Effects of biochar residue and cow manure residues on peanut seeds

Treatments	Seed weight (g plant <sup>-1</sup> )	Weight of 100 seeds (g)
<b>Biochar Residue</b>		
Rice husk biochar residue 0 t ha <sup>-1</sup>	30.87	39.83 <sup>b</sup>
Rice husk biochar residue 2.5 t ha <sup>-1</sup>	24.51	40.52 <sup>b</sup>
Rice husk biochar residue 5 t ha <sup>-1</sup>	25.00	37.10 <sup>ab</sup>
Cocopeat biochar residue 0 t ha <sup>-1</sup>	24.84	37.81 <sup>ab</sup>
Cocopeat biochar residue 2.5 t ha <sup>-1</sup>	29.53	38.76 <sup>ab</sup>
Cocopeat biochar residue 5 t ha <sup>-1</sup>	24.15	32.37 <sup>a</sup>
<b>Cow Manure Residue</b>		
Cow manure residue 0 t ha <sup>-1</sup>	26.42	38.79
Cow manure residue 2.5 t ha <sup>-1</sup>	26.77	38.65
Cow manure residue 5 t ha <sup>-1</sup>	26.26	35.76

Note: Letters in superscript indicate differences at 5% level

#### 4. Conclusion

Rice husk biochar residue and cocopeat biochar residue not significant effect on soil chemical properties, plant height 15 and 30 DAP, peanut pods, and seed weight per plant, but had a positive effect on plant height 45 DAP, branches number 15, 30, 40 DAP, root dry weight, plant dry weight, root nodules number, and 100 seeds weight. The best residual dosage of rice husk biochar and cocopeat biochar was 2.5 t ha<sup>-1</sup>.

The application of cow manure residue did not significantly affect soil chemical properties, plant height 15, 30 and 45 DAP, the number of branches 30, 45 DAP, root dry weight, plant dry weight, root nodules number, peanut pods, seed weight per plant, and 100 seeds weight. Nevertheless, it had a positive effect on branches number 15 DAP. The best dosage of cow manure residue was 2.5 t ha<sup>-1</sup>

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