Effects of biochar and cow manure on soil chemical properties and peanut (*Arachis hypogaea* L.) yields in entisol

M Yunilasari¹, Sufardi² and Zaitun³

¹ Magister Student of Land Resources Conservation, Faculty of Agriculture, Universitas Syiah Kuala, Darussalam, Banda Aceh, 23111, Indonesia. E-mail: mira.yunilasari@gmail.com
² Department of Soil Science, Faculty of Agriculture, Universitas Syiah Kuala, Darussalam, Banda Aceh, 23111, Indonesia.
³ Department of Agrotechnology, Faculty of Agriculture, Universitas Syiah Kuala, Darussalam, Banda Aceh, 23111, Indonesia

E-mail: mira.yunilasari@gmail.com

**Abstract.** Availability of agricultural land is an important factor in ensuring food availability. Dryland such as Entisol has been used as an alternative for agricultural activities. Efforts to improve soil fertility on dryland can be done through the application of biochar and cow manure as soil amendments. This research was carried out on Entisol dryland located in the experimental site of The ACIAR Project, Universitas Syiah Kuala from April to September 2018. The study used a non-Factorial Randomized Block Design with 3 replications. The treatments were amendments of rice husk and cocopeat biochars, each was combined with cow manure. The doses used were 0 t ha⁻¹ and 10 t ha⁻¹ for each type of biochar, while cow manure was given at the doses of 0 t ha⁻¹; 10 t ha⁻¹; and 20 t ha⁻¹. After the application of biochar and cow manure, the experimental land was planted with peanuts. The results showed that the application of biochar and cow manure were able to increase soil pH, organic C, total N, C:N ratio, available-P, and exchangeable-K. Both types of soil amendments were also able to give a significant result on the weight of peanut seeds, and increase the potential yield of peanuts by 3.96 t ha⁻¹.

1. Introduction

Land conversions has made agricultural land narrower, reduced food production and impacted food security. The intensive farming system that was developed by the government to overcome these problems have led to a decline of agricultural land qualities. Thus, challenges arised to increase agricultural production which can outright cope with environmental changes by avoiding further land degradation [1].

To achieve the needs of agricultural products, especially food, can not only depend on efforts to increase productivity, but must be balanced by the expansion of new areas [2]. The use of dryland that has not been optimally cultivated so far could be an option for the expansion of new agricultural areas. There are various land orders developed on dryland, one of which is Entisol. It is the third largest after Inceptisol and Ultisol which covers 9.6% of Indonesia’s land area or around 18 million hectares [3].

Physically, Entisol has good drainage and aeration caused by the dominance of sand in the soil texture, but has a low organic matter content due to the ease of leaching. Entisol in Darussalam as the research
area is dominated by the sand fraction, and has soil fertility constraints such as low soil organic matter, total N, and water holding capacity.

Efforts to improve soil productivity and fertility have been carried out using chemical fertilizers and pesticides. This has caused environmental pollution due to the accumulation of nutrients derived from fertilizers and pesticides, both in the waters and groundwater. The land itself would be saturated and slowly damaged, and productivities would continue declined [4]. In overcoming this, several efforts have been made such as replacing chemicals with natural ingredients that can improve soil productivity, such as biochar and cow manure.

Biochar is a carbon-rich product that formed when biomass (such as wood, fertilizer, or agricultural waste) heated in a closed container with little or no air. Biochar can be used in improving agricultural productivity and environmental in several ways [5]. While manure is known as one of the organic materials that can improve soil structure and nutrient supply. Giving biochar and soil fertilizer is expected to improve soil properties in physical, chemical and biological [6].

Peanut (Arachis hypogaea L.) as the plant used in this research is one of the quite popular food in Indonesia. The need for peanut increases continuously along with population growth and food industry development. The very high national demand has not been able to be fulfilled by local farmers. It was reported that around 60% of our peanut consumptions still comes from imported products, especially from Vietnam and China [7].

This research expected could give information of the effects of biochar and cow manure addition and their interactions in Entisol, to improve soil chemical properties in appropriate doses to this type of dry land. And also expected to improve peanut productivity in hope can fulfilled its needed in Indonesia. In addition, it is also hoped can encourage natural materials uses in improving land quality, and reducing the use of non-organic materials that can cause pollution and damage to the environment.

2. Methods

This research was conducted in Entisoldryland soil located at ACIAR experimental site, UniversitasSyiahKuala. Soil and plant analysis were conducted in laboratory of BPTP Aceh and UniversitasSyiahKuala. This study was carried out for six months from April to September 2018.

The study was conducted on a trial plot measured 1.5 m x 1.5 m. The materials used were rice husk biochar, cocopeatbiochar, cow manure, peanut seeds from Bima variety, and also urea, KCl and ZA fertilizers. The tools used were biochar maker devices, thermocouple thermometer BARNANT 100, ground drill, and others laboratory instruments for analysis support.

The study used non-factorial Randomized Block Design, with 5% Duncan Multiple Range Test (DMRT) for further testing. The study consists of nine treatments, each was repeated three times so that 27 experimental units were obtained. The experimental arrangement can be seen in table 1.

Before applied by soil amendments, land was tillaged using tractor to improve its structure. Then experiment plots were formed in size 1.5 m x 1.5 m. Soil samples were taken for first analysis before application.

Biochar raw material used in this study were rice husk and cocopeat. Materials in dry condition were burned in combustion drum for about one hour. Temperature was measured using thermometer thermocouple BARNANT 100, and expected to reach 400-600°C. After combustion process was done, materials was removed from drum and immediately doused with water to prevent it from becoming ash. Wet biochar was dried in the sun for 3-5 days, then tested for water content. After dried, cocopeatbiochar was crushed so it had homogeneous size and reduced its high water content.

Biochars and cow manure were applied on soil several days before planting. Another soil samples were taken 45 days after planting (DAP) of peanut. Observed parameters were soil chemical properties such as soil pH, C organic (%), Total N(%), C:N ratio, available P (ppm), and exchangeable K (cmolkg⁻¹). Plant growth parameters were also observed as number of nodule, weight of seeds per plant (g), weight of 100 seeds (g), and estimated yields of peanut (tha⁻¹).
Table 1. Treatment combinations of biochar and cow manure at Entisolexperimental land

| Plots | Treatments                                      |
|-------|------------------------------------------------|
| A     | Biochar 0 t ha$^{-1}$ + cow manure 0 t ha$^{-1}$|
| B     | Rice husk biochar 10 t ha$^{-1}$ + cow manure 0 t ha$^{-1}$|
| C     | Cocopeatbiochar 10 t ha$^{-1}$ + cow manure 0 t ha$^{-1}$|
| D     | Biochar 0 t ha$^{-1}$ + cow manure 10 t ha$^{-1}$|
| E     | Rice husk biochar 10 t ha$^{-1}$ + cow manure 10 t ha$^{-1}$|
| F     | Cocopeatbiochar 10 t ha$^{-1}$ + cow manure 10 t ha$^{-1}$|
| G     | Biochar 0 t ha$^{-1}$ + cow manure 20 t ha$^{-1}$|
| H     | Rice husk biochar 10 t ha$^{-1}$ + cow manure 20 t ha$^{-1}$|
| I     | Cocopeatbiochar 10 t ha$^{-1}$ + cow manure 20 t ha$^{-1}$|

3. Results and discussion

3.1. Soil pH

The results of soil pH analysis did not show a significant difference between treatments. Based on the data in table 2, although the pH value was statically not significantly different, there was an increase in soil pH after the application of biochar and cow manure, where soil pH tended to be maintained in the neutral category. This is also mentioned in the Samira [8] study, which stated that biochar was able to maintain soil pH under optimal conditions for plant growth. In acid soils, biochar is known can increase soil pH significantly [9].

Table 2. Effect of biochar and cow manure addition to soil pH in Entisol

| Treatments | Before planting | 45 DAP |
|------------|----------------|--------|
| A          | 7.17           | 7.24   |
| B          | 7.27           | 7.24   |
| C          | 7.09           | 7.18   |
| D          | 6.80           | 6.98   |
| E          | 6.97           | 7.15   |
| F          | 6.96           | 7.03   |
| G          | 6.89           | 7.29   |
| H          | 6.95           | 7.02   |
| I          | 6.70           | 7.36   |

In the addition of cocopeatbiochar 10 t ha$^{-1}$ combined with 20 t ha$^{-1}$ cow manure, the pH value increased by 9.8%, higher than other treatments.

3.2. Soil Organic C

After statistical analysis, the results showed that the soil organic C was not significantly different between treatments, although there were increases after application of biochar and cow manure. The highest increase of 0.4% was showed by 10 t ha$^{-1}$ rice husk biochar combined with 10 t ha$^{-1}$ cow manure application. Even though there were improvements, soil organic C contents were still included in very low category. Only treatment of rice husk biochar combined with cow manure 10 t ha$^{-1}$ has resulted more than 1% soil organic C content and raised it into low category, according to criteria of soil chemical properties by Soil Research Center[10].
Table 3. Effect of biochar and cow manure addition to soil organic C in Entisol

| Treatments | Before planting (%) | 45 DAP (%) |
|------------|---------------------|------------|
| A          | 0.70                | 0.76       |
| B          | 0.51                | 0.79       |
| C          | 0.59                | 0.75       |
| D          | 0.64                | 0.80       |
| E          | 0.64                | 1.05       |
| F          | 0.54                | 0.85       |
| G          | 0.62                | 0.84       |
| H          | 0.56                | 0.82       |
| I          | 0.65                | 0.89       |

The application of biochar can increase soil organic C content [11], although in some studies, the increases did not occur during the first planting period [12], [13], but increased in the second planting season [8]. This might explain why the soil organic C content was not significantly affected by treatments. It was possible that the applied biochar and cow manure have not perfectly decomposed yet, and the soil organic content was not yet available.

3.3. Soil N Total

The results of soil N total before and after peanut planting can be seen in Table 4. The increases of soil total N after application were very low, the highest only reached 0.03%. It was found at the addition of cocopeatbiochar combined with 20 t ha\(^{-1}\) of cow manure. The results also showed there were no significant differences between treatments.

Table 4. Effect of biochar and cow manure addition to soil N total in Entisol

| Treatments | Before planting (%) | 45 DAP (%) |
|------------|---------------------|------------|
| A          | 0.09                | 0.09       |
| B          | 0.07                | 0.09       |
| C          | 0.07                | 0.09       |
| D          | 0.08                | 0.11       |
| E          | 0.07                | 0.08       |
| F          | 0.08                | 0.10       |
| G          | 0.08                | 0.09       |
| H          | 0.08                | 0.09       |
| I          | 0.09                | 0.11       |

This was also reported by Gautama et al.[14], after the application of biochar and agricultural manure, soil pH, exchangeable potassium, and soil organic matter increased significantly, while total N and cation exchange capacity increased slightly, but without differences statistically. The low increase in total N could be caused by absorption by biochar and more effective nutrient uptake by plants. Considering soil samples wastaken at 45 DAP, where nutrient has maximally absorbed by plants, so that there were only a little left N nutrient in the soil.

3.4. Soil C:N Ratio

C:N ratio was obtained from comparison between soil organic C with soil total N. Highest ratio increasing of 54.38% was found at addition of rice husk biochar 10 t ha\(^{-1}\) combined with cow manure 10 t ha\(^{-1}\).
Table 5. Effect of biochar and cow manure additions to soil C:N ratio in Entisol

| Treatments | Before planting | 45 DAP |
|------------|----------------|--------|
| A          | 7.64           | 8.33   |
| B          | 8.58           | 8.99   |
| C          | 8.65           | 8.55   |
| D          | 7.75           | 7.64   |
| E          | 8.77           | 13.54  |
| F          | 6.64           | 8.76   |
| G          | 7.37           | 9.77   |
| H          | 7.39           | 9.14   |
| I          | 7.46           | 7.77   |

Table 5 showed that most of the soil C:N ratio increased after addition of biochar and cow manure, except for the additions of cocopeat biochar without cow manure and 10 t ha\(^{-1}\) cow manure without biochar. In both treatments there were slight decreases of 1.14-1.46% in the value of the ratio. Although there were increases of the soil C:N ratio value, but statistically it did not show a significant difference between treatments.

The increase of the C:N ratio value indicates that the soil mineral decomposition by macro and microorganisms after addition is slower. The ability of biochar to remain in the soil for a very long time is maintained with this slow decomposition rate. However, the value of the C:N ratio was still included in the low-moderate category based on soil chemical assessment criteria, which means the rate of decomposition of the mineral soil is still quite fast.

The highest ratio of C:N was obtained from the addition of 10 t ha\(^{-1}\) rice husk biochar combined with 10 t ha\(^{-1}\) cow manure, while the lowest ratio of C:N was obtained from the addition of 10 t ha\(^{-1}\) cow manure without biochar. These mean that the increases of the soil C:N ratio were better with the additions of biochars, compared to the treatment without biochar.

3.5. Soil Available-P

The results of the analysis did not show a significant difference between the treatment of available P content of the soil. But as seen in Table 6, there was an increase in the available P content of soil after the application of biochar and manure in a 45 DAP soil analysis.

Table 6. Effect of biochar and cow manure additions to soil available-P in Entisol

| Treatments | Before planting (ppm) | 45 DAP (ppm) |
|------------|-----------------------|--------------|
| A          | 31.54                 | 36.49        |
| B          | 34.64                 | 38.47        |
| C          | 29.82                 | 35.30        |
| D          | 28.79                 | 39.57        |
| E          | 26.43                 | 40.15        |
| F          | 39.42                 | 46.61        |
| G          | 28.86                 | 37.98        |
| H          | 35.64                 | 40.31        |
| I          | 29.42                 | 41.17        |

The highest value was produced by the application of cocopeat biochar 10 t ha\(^{-1}\) combined with 10 t ha\(^{-1}\) cow manure. The biggest increase of 51.93% was in the treatment of 10 t ha\(^{-1}\) rice husk biochar combined with 10 t ha\(^{-1}\) cow manure, while the lowest increase was in the treatment of rice husk biochar 10 t ha\(^{-1}\) without cow manure.
Biochar as a soil amendment can significantly increase the soil available-P content [15]; [16]. In addition, the addition of P from chemical fertilizers or cow manure can cause accumulation of P content in the soil and enrich the topsoil [17].

3.6. Soil exchangeable-K
From all observed parameters of soil chemical characteristics, the soil exchangeable-K content was the only result that gave a significant difference between treatments. Biochar and cow manure additions has given a very significant effect on soil exchangeable-K, with the highest values obtained from the treatment of cocopeatbiochar combined with 10 t ha\(^{-1}\) cow manure.

The addition of cocopeatbiochar combined with each doses of cow manure has given the highest result compared to other treatments, and has increased the soil exchangeable-K content to 466.04%.

| Treatments | Before planting (cmol kg\(^{-1}\)) | 45 DAP (cmol kg\(^{-1}\)) |
|------------|-----------------------------------|---------------------------|
| A          | 0.35                              | 0.26 \(a\)               |
| B          | 0.42                              | 0.54 \(ab\)              |
| C          | 0.30                              | 1.51 \(c\)               |
| D          | 0.38                              | 0.71 \(ab\)              |
| E          | 0.32                              | 0.89 \(b\)               |
| F          | 0.35                              | 2.00 \(c\)               |
| G          | 0.35                              | 0.60 \(ab\)              |
| H          | 0.38                              | 0.71 \(ab\)              |
| I          | 0.31                              | 1.50 \(c\)               |

Note: Letters in superscript indicate significant differences according to DMRT at 5%

From Table 13 it can be seen that the two types of biochar have given the best results when combined with 10 t ha\(^{-1}\) cow manure. Higher dose of cow manure has not given further increasing to soil exchangeable-K. The decrease in soil exchangeable-K content only occurred in the control treatment, which is assumed that the nutrients in the soil have been absorbed by the plants.

The addition of biochar increased CEC, the availability of P and K, thereby increasing plant growth [18]. In addition, biochar improves soil chemical properties such as pH, percentage of soil organic C, CEC and exchangeable alkaline cations such as Ca\(^{2+}\), Mg\(^{2+}\), K\(^{+}\) [15]. Based on Habieb [13] it was found that cocopeatbiochar contained potassium of 2.87% while rice husk biochar had no potassium content. This could explain the high content of soil exchangeable-K in the treatment with cocopeatbiochar compared to rice husk biochar.

3.7. Weight of peanut seed
The additions of biochar and cow manure has given significantly different results on weight of seed per plant between treatments. The combination of 10 t ha\(^{-1}\) rice husk biochar along with 20 t ha\(^{-1}\) cow manure has given the highest yield on weight of seed per plant. The application of biochar along with other fertilizers is known to increase crop production [19].

There are also significant differences between treatments to the weights of 100 seeds. Based on Table 8, the weight of 100 seeds ranges from 26.97 grams to 43.60 grams. The heaviest weight was obtained from the addition of 10 t ha\(^{-1}\) cow manure without biochar, while the lowest weight was obtained from the treatment with 20 t ha\(^{-1}\) cow manure also without the addition of biochar.
Table 8. Effect of biochar and cow manure addition to weight of peanut seeds in Entisol

| Treatments | Weight of seeds per plant (g) | Weight of 100 seeds (g) |
|------------|-------------------------------|------------------------|
| A          | 33.71<sup>bc</sup>            | 31.99<sup>ab</sup>     |
| B          | 40.68<sup>c</sup>             | 39.42<sup>bc</sup>     |
| C          | 38.67<sup>c</sup>             | 40.00<sup>bc</sup>     |
| D          | 41.04<sup>c</sup>             | 43.60<sup>c</sup>      |
| E          | 39.32<sup>c</sup>             | 38.85<sup>bc</sup>     |
| F          | 22.54<sup>ab</sup>            | 35.60<sup>abc</sup>    |
| G          | 16.31<sup>a</sup>             | 26.97<sup>a</sup>      |
| H          | 41.89<sup>c</sup>             | 39.86<sup>cbe</sup>    |
| I          | 35.83<sup>bc</sup>            | 31.87<sup>ab</sup>     |

Note: Letters in superscript indicate significant differences according to DMRT at 5%

3.8. Numbers of root nodules and peanut estimated yields

Root nodules are the result of the root response of peanut plants to Rhizobium bacterial infections [20]. Rice husk biochar is known to have a larger pore space compared to cocopeatbiochar, so it is better at improving soil structure and aeration. This can create a better place for macro and microorganisms, including the Rhizobium bacteria. Increasing the number of these bacteria in the soil can form more root nodules, and is expected to increase N fixation for plants.

The number of root nodules did not show significant results between treatments. The highest number of root nodules was obtained by treatment with 10 t ha<sup>-1</sup> rice husk biochar combined with 10 t ha<sup>-1</sup> cow manure. The combination of rice husk biochar and cow manure with higher doses did not increase the number of root nodules.

The results of the analysis showed that the addition of biochar and cow manure provided a significant difference in the potential yield between treatments. Based on Table 9 it is known that the combination of 10 t ha<sup>-1</sup> rice husk biochar and 20 t ha<sup>-1</sup> cow manure obtained the highest yield of 3.96 t ha<sup>-1</sup>. These results are much higher compared to farmer yields which are only 1.7 t ha<sup>-1</sup> for Bima peanut variety.

Biochar residues in soil are known to increase the yield potential of plants compared to soils without biochar[21]; [22]. While the application of cow manure together with other fertilizers is also known to be able to significantly increase crop yields [11].

Table 9. Effect of biochar and cow manure to root nodules and peanut yields in Entisol

| Treatments | Number of Root Nodules (Numbers) | Estimated Yields (t ha<sup>-1</sup>) |
|------------|---------------------------------|--------------------------------------|
| A          | 74.67                           | 3.18<sup>bc</sup>                    |
| B          | 112.33                          | 3.84<sup>c</sup>                     |
| C          | 71.00                           | 3.65<sup>c</sup>                     |
| D          | 80.00                           | 3.88<sup>c</sup>                     |
| E          | 132.33                          | 3.71<sup>c</sup>                     |
| F          | 64.33                           | 2.13<sup>abc</sup>                   |
| G          | 75.33                           | 1.54<sup>a</sup>                     |
| H          | 51.00                           | 3.96<sup>c</sup>                     |
| I          | 45.67                           | 3.38<sup>bc</sup>                    |

Note: Letters in superscript indicate significant differences according to DMRT at 5%

4. Conclusion and recommendation

The results showed that the application of biochar and cow manure can increase soil pH by 9.8%, soil organic C by 0.4%; total N 0.03%; C:N ratio by 54.38%; soil available-P by 51.93% and soil exchangeable-
K by 466.04%. The two types of soil amendments were also able to give a significant difference on the weight of peanut seeds, so that could increase the yield potential of peanuts by 3.96 t ha\(^{-1}\).

Research on the content of cocopeat/biochar needs to be done considering its ability to increase soil exchangeable-K very significantly. In addition, it is necessary to observe nutrient uptake by plants, to see the effect of high P and K content on the possibility of excess absorption of these nutrients by plants. Further research to determine the effect of long-term biochar residues as organic soil amendments, and its effect on soil fertility also needs to be done.

5. Acknowledgments
This research was funded by the Australian Centre for International Agriculture Research (ACIAR) – SCMN/2012/103 “Improving Soil and Water Management and Crop Productivity of Dryland Agriculture System of Aceh and New South Wales”.

References
[1] Barrow C J 2012 Biochar: potential for countering land degradation and for improving agriculture. *Elsevier Appl. Geo.* 34 21-28
[2] Rutung S E, Suryani D, Subardja, Sukarman K, Nugroho, Suparto, Hikmatullah, Mulyani A, Tafakrensanto C, Sulaeman Y, Subandiono R E, Wahyunto, Ponidi, Prasodjo N, Suryana U, Hidayat H, Priyono A and Supriatna W 2015. *Indonesian Agricultural Land Resources: Area, Distribution, and Potential Availability* (Jakarta: IAARD Press)
[3] Utomo M, Sudarsono, Rusman B, Sabrina T, Lumbanraja J and Wawan 2016 *Soil Science, Fundamentals of Management* (Jakarta, Indonesia: Prenada Media Group)
[4] Utami SNH and Handayani S 2003 Chemical properties of Entisol in organic farming systems *J. Ilmu Pertanian* 10(2) 63 – 69
[5] Lehmann J and Joseph S 2009 *Biochar for Environmental Management: Science, Technology and Implementation* (New York: Routledge)
[6] Sukartono WH, Utomo, Kusuma Z and Nugroho WH 2011 Soil fertility status, nutrient uptake and maize (*Zea mays* L.) yield following biochar and cattle manure application on sandy soils of Lombok, Indonesia *J. of Tropical Agr.* 49(1-2) 47-52
[7] Soesanto L and Rahayuni R F 2013 *Diseases Due to Bacteria, Viruses, Nematodes and Nutrient deficiency* (Yogyakarta: Graha Ilmu)
[8] Samira D, Sufardi, Zaitun, Chairunna and Ghani A 2013 *Improving soil chemical properties by NPK fertilizer application and residual rice husk biochar effect on irrigation paddy field* The 3rd Annual International Conference Universitas Syiah Kuala In conjunction with The 2nd International Conference on Multidisciplinary Research (Banda Aceh: Universitas Syiah Kuala)
[9] Chintala R J, Mollinedo T E, Schumacher DD, Malo and Julson J L 2014 Effect of biochar on chemical properties of acidic soil. *J. Archives of Agronomy and Soil Sci.* 20(3) 393-404
[10] Balai Penelitian Tanah 2009 *Chemical Analysis of Soil, Plants, Water and Fertilizers* (Bogor: Departemen Pertanian)
[11] Novak JM, Busscher W J, Laird D L, Ahmedna M, Watts D W and Niandou M A S 2009. Impact of biochar amendment on fertility of a southeaster coastal plain soil. *Soil Sci.* 174 (2) 105-112.
[12] Sufardi 2012 *Introduction to Plant Nutrition* Universitas Syiah Kuala (Banda Aceh: CV. Bina Nanggroe)
[13] Habieb M, Zaitun and Sufardi 2018 The effect of biochar and cow manure to increase soil fertility in Entisol Darussalam *Int. J. of Agronomy and Agrc. Research.* 13 (2) 1-7
[14] Gautama D K, Bajracharya RM and BK Sitaula 2017 Effects of biochar and farm yard manure on soil properties and crop growth in an agroforestry system in the Himalaya *Canadian Centre of Sci. and Education J. Sust. Agrc. Research.* 6 (4)
[15] Pandit N R, Mulder J, Hale S E, Zimmerman A R, Pandit B H and Cornelissen G 2018 Multi-year double cropping biochar field trials in Nepal: finding the optimal biochar dose through agronomic trials and cost-benefit analysis *Elsevier J. Sci. of the Tot Env.* 637-638 1333-41

[16] Singh C, Tiwari S, Gupta V K and Singh J S 2018 The effect of rice husk biochar on soil nutrient status, microbial biomass and paddy productivity of nutrient poor agriculture soils *Elsevier J. CATENA* 171 485-493

[17] Fei L, Zhao M, Chen X and Shi Y 2011 Effects of phosphorus accumulation in soil with the utilization ages of the vegetable greenhouses in the suburb of Shenyang *Elsevier J. Procedia Env. Sci.* 8 16-20

[18] Nguyen B T, Trinh N N, Le C M T, Nguyen T T, Tran T V, Thai B V and Le T V 2018 The interactive effects of biochar and cow manure on rice growth and selected properties of salt-affected soil *Archives of Agronomy and Soil Sci.* 64 1744-58

[19] Rurangwa E, Vanlauwe B and Giller K E 2017 Benefits of inoculation, P fertilizer and manure on yields of common bean and soybean also increase yield of subsequent maize *Elsevier J. Agr. Ecosystems and Env.* 261 219-229

[20] Hasnunidah N and Suwandi T 2016 *Plant Physiology* (Yogyakarta: Innosain)

[21] Waty R 2013 *Effect of NPK Fertilization and Biochar Residues on Soil Physics, Paddy (Oryza sativa L.) Growth and Yield at Second Planting Season* Thesis (Banda Aceh: Universitas Syiah Kuala)

[22] Mawardiana 2013 *Effect of Biochar Residues and NPK Fertilization on Nitrogen Dynamic, Soil Chemical Properties and Paddy (Oryza sativa L.) Yield at Third Planting Season.* Thesis (Banda Aceh: Universitas Syiah Kuala)