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Improvement of the chemical characteristics of Aceh entisol and maize yield due to the application of rice husk, biochar and manure

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Abstract

Entisols have known of containing low levels of clay and organic matter, therefore the water holding capacity is low. In order to increase soil fertility, the effort of adding organic amendments is required. One of the most possible method is applicating rice husk, biochar, and cow manure that is able to improve the soil structure to become more crumb and to increasee the ability to hold water. The study was conducted in the experimental garden of the Faculty of Agriculture, University Syiah Kuala, Banda Aceh, Indonesia. Analysis of soil chemical characteristics was conducted in Aceh BPTP laboratory. The study was conducted from May until September 2018. The research was designed using a Non-Factorial Randomized Block Design (RBD). The following treatments are R_1 (10 ton ha^{-1} rice husk), R_2 (10 ton ha^{-1} rice husk + N and K), R_3 (10 ton ha^{-1} rice husk + NPK), R_4 (Biochar 10 ton ha^{-1}), R_5 (Biochar 10 ton ha^{-1} + N and K), R_6 (Biochar 10 ton ha^{-1} + NPK), R_7 (cow manure 10 ton ha^{-1}), R_8 (cow manure 10 ton ha^{-1} + N and K), R_9 (cow manure 10 ton ha^{-1} + NPK), R_{10} (cow manure 20 ton ha^{-1}), R_{11} (cow manure 20 ton ha^{-1} + N and K) , R_{12} (20 ton ha^{-1} + NPK). The combination of biochar treatment 10 tons ha^{-1} + NPK influence the availablity of P in soil, the combination of cow manure treatment 20 tons ha^{-1} + N and K influence exchangeable potasium in soil, and the combination treatment of cow manure 10 tons ha^{-1} + N and K affects the potential yield of maize.

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Introduction

Entisols have a deep solum (> 90cm). Entisol have low levels of clay and organic matter, therefore the water holding capacity is low, the structure of crumbs to grains, this causes the soil to easily pass water and easily having percolation. Most of Entisols have a sandy texture and very shallow (thin). Entisols are abundant in alluvial areas or river sediments and coastal swamps, therefore these soils are often called alluvial soil.

Based on the chemical aspects of the soil at the test site, its acidity ranged between neutral to slightly alkaline (pH 7.20-8.60), total C and N organic content ranged between very low to low (0.74-1.54% C and 0.50-0.11% N) and the exchangeable Al content is very low. Total P and K content extracted using 25% HCL solution ranged between high to very high available P content. Exchangeable cations (Ca, Mg, K, and Na) vary from low to high but the amount of saturation and cation exchange is high however the CEC potential is low (<16cmol kgm^{-1}), since this soil is dominated by sand fractions. Based on the chemical characteristic above, the soil fertility at the site is limited due to lack of soil organic matter (soil C content <1.0%) as well as total N and low water binding capacity. Due to the low level of soil fertility in dry land, the efforts of increasing soil fertility is needed. To improve the physical and chemical characteristic of the soil, the organic amendments (as soil amenders) is applicated.

The use of organic material in the form of rice husk, cow manure, and biochar is potential to be used as soil amendments. Organic matter is known to have an important role in determining soil fertility, physically, chemically and biologically. Physically, organic matter plays a role in improving soil structure to become more crumb, increasing the ability to hold water thus the drainage is not excessive, and soil moisture and temperature become stable (Hanafiah, 2007).

Our present study is the continuation from the previous studies that have used soil ameliorants with initial doses that have not a significant effect, therefore it is necessary to increase the dose of soil ameliorants, It is expected that the physical and chemical properties of the soil as well as the yield of maize improved. This study aims to determine the effect of the addition of soil amendment to the chemical characteristics of the soil and the yield of maize.

Material and methods

Location and Time

The study was conducted in the experimental garden of the Faculty of Agriculture, University Syiah Kuala, Banda Aceh, Indonesia. Analysis of soil chemical properties was carried out in the Aceh BPTP laboratory. The study was conducted from May until September 2018. This research was the second cultivating season by using Bima Maize Cultivar.

The Process of Making Biochar

Biochar was originally made from the roasted rice husks. The rice husks were roasted inside a 244L drum for 60 minutes. The entire drum of rice husks were roasted evenly under the measeured temperature by *thermocouple thermometer-BARNANT 100*. To prevent the roasted rice husks for becoming ash, it was then poured with water slowly and evenly. Before the application, Biochar should be dried under the sunlight to reduce the water content after the making process.

Design of the Experiment

The research was designed using a Non-Factorial Randomized Block Design (RBD) with 3 replications consisting of 36 plots and 12 treatments. The following treatments are : R_1 (10 ton ha^{-1} rice husk), R_2 (10 ton ha^{-1} rice husk + N and K), R_3 (10 ton ha^{-1} rice husk + NPK), R_4 (Biochar 10 ton ha^{-1}), R_5 (Biochar 10 ton ha^{-1} + N and K), R_6 (Biochar 10 ton ha^{-1} + NPK), R_7 (cow manure 10 ton ha^{-1}), R_8 (cow manure 10 ton ha^{-1} + N and K), R_9 (cow manure 10 ton ha^{-1} + NPK), R_{10} (cow manure 20 ton ha^{-1}), R_{11} (cow manure 20 ton ha^{-1} + N and K) , R_{12} (20 ton ha^{-1} + NPK).

The Application of Organic Materials

The treatments was applied to each plot 2 weeks before planting. NPK fertilizer was applicated at a dose of 375 kg ha^{-1}, Urea 420 kg ha^{-1}, KCl 300 kg ha^{-1}. Soil samples for the chemical characteristics were collected in a

composite manner, with a soil drill. Chemical response variables observed including the availability of P and the exchangeable K. The observed plant response variable is the potential yield in tons ha^{-1}.

Soil Samples Collection

The soil samples were collected as Composite by collecting soil samples from certain decided points which represented the condition of land. Each composite was collected 0–20cm depth using ground drill.

Soil Chemical Characteristics

The following soil chemical characteristics analyzed were the availability of P-value and Exchangeable Potassium. P-value was calculated using Bray II method, where the soil sample was extracted using NH_4F dan HCl. The reacted P with molybdate acid would appear as blue color and therefore the P could be measured spectrometrically where as the exhangeable. Meanwhile the exchangeable Potassium was analyzed using NH_4Oac 1 N pH 7 method. The following tests were conducted in BPTP Laboratory Aceh.

Data Analysis

The observational data were analyzed statistically by the F test (analysis of variance). If the treatment has a significant effect, further analysis is carried out by using the Duncan's New Multiple Range Test (DNMRT) test at the level of 5%.

Results and discussion

Soil Chemical Characteristics

Fertilizer is one of the factors that determine the yield of maize to achieve optimal results. This nutrient input can be obtained from inorganic fertilizers (N, P and K) and organic fertilizers. Fertilization aims to feed the plants to grow and develop with sufficient and balanced soil chemical elements. The results of the observations showed that the application of rice husk, biochar and cow manure as soil ameliorant, which was applied to each plot at the appropriate dosage of treatment could increase the available P, exchangeable K and increase the potential yield of maize. The results of the observations of available P, exchangeable K and the potential yield of maize are presented in Fig. 1, Fig. 2 and Fig 3.

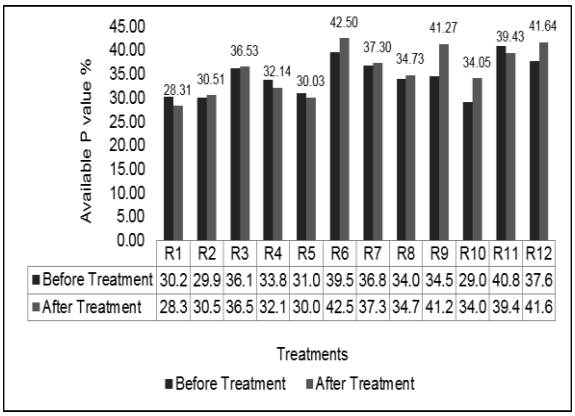

Fig. 1. Average comparison of available P values due to the treatment of rice husk, biochar, and cow manure.

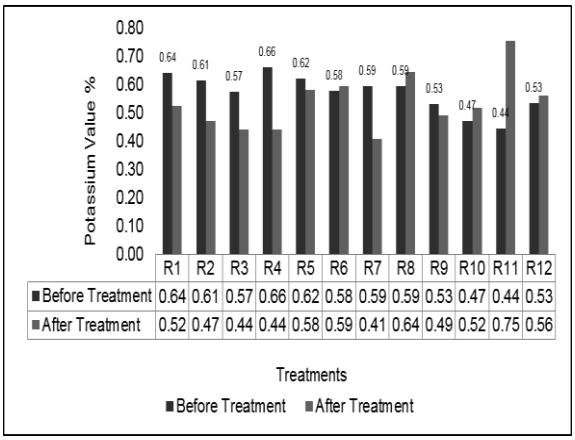

Fig. 2. Average comparison of The Exchangeable Potassium values due to the application of rice husks, biochar, and cow manure.

Fig. 1 demonstrates the combination of the treatment of the addition of 10ton ha^{-1} biochar with NPK could increase the P-value availability at the Entisols, and could also be seen in Fig. 1, the treatment combination followed by NPK fertilizer (R_3, R_6, R_9, and R_{12}) have higher value compared to the previous condition before the addition of soil amendment treatment. In general, the available P-value found at the study site is very high since Biochar is one of the prospective agricultural waste management efforts to encourage the optimization of suboptimal and degraded lands (Neneng, 2014). Moreover, Xu *et al.* (2013) clarified the reason why P could affected by the Biochar application is because it was influenced by the soil pH, Fe, and Al alteration.

Therefore, the addition of rice husk biochar could causes a significant increase in phosphorus (P) availability in the soil (Bu *et al*., 2019).

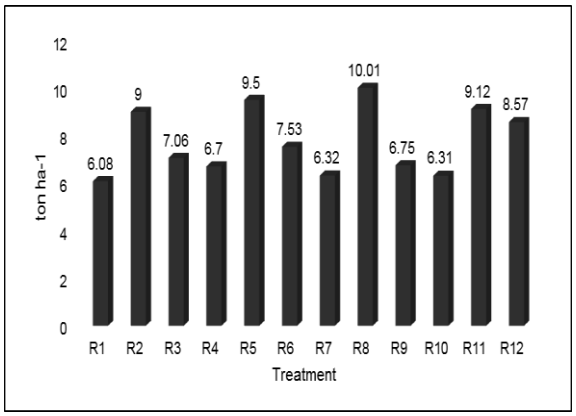

Fig. 3. Potential yield of maize per hectare due to rice husk, biochar, and cow manure application.

Fig. 2 shows that there was an increase in the exchangeable potassium value simultaneously in the addition of 20 tons ha^{-1} cow manure doses combined with N, K fertilizer. The highest exchangeable potassium value is found in the treatment combination (R_{11}) with a value of 0.75 cmol kg^{-1}. The addition of coconut husk biochar combined with several doses of cow manure can increase the exchangeable potassium value of the soil up to 460.04% (Yunilasari, 2019). It can also be seen in the treatment of increasing the rice husks dose with several fertilizer combinations (R_1, R_2, R_3) has not been able to increase the exchangeable potassium value, this is presumably because the organic material of rice husk has not completely weathered, therefore it has not given any reaction to increase the high exchangeable potassium value.

The combination of NPK + cow manure treatment significantly increased the exchangeable potassium levels compared to other treatments. The increase in exchangeable potassium seemed to be sharper, followed by application of 20 tons ha^{-1} cow manure (Sarno, 2009). The size of the potassium content in the soil is also because the potassium nutrients in the soil are more stable than nitrogen, and are faster mobile than the phosphorus nutrients so that it is easily moved by rain water, the temperature can accelerate the release and weathering of minerals in potassium leaching (Yuwono, 2012).

The Potential Yield of Maize per Hectare

Fig. 3 shows that the yield of maize has a very significant effect due to the addition of soil amendments. The application of soil amendment in the form of biochar, rice husk, and cow manure + NPK fertilizer at some level has a very significant effect on yield of maize.

The results of observation in Fig. 3 show the potential yield of maize with the highest value found in the combination of cow manure 10 tons ha^{-1} + N and K (R_8) with a value of 10.01 tons ha^{-1} and the lowest value is found in the combination of R_1 treatment of 6.08 tons ha^{-1}. In this study the highest value in the R_8 treatment combination was also supported by the P-available parameter with a value of 34.73% and the exchangeable potassium parameter with a value of 0.64 cmol kg^{-1}.

The treatment without P (NK + cow manure) gave a higher contribution to the diameter of the cobs, with a larger diameter of the cobs it would have an effect on more maize kernels, so the potential yields were higher (Heniyati, 2019). The treatment of organic fertilizer + inorganic fertilizer was able to increase the weight of cobs per plant by 170.18 g per plant or the weight of cobs without club per plant by 162.76 g per plant. It is suspected that the research soil has sufficient element of P, especially after being applicated with cow manure (Hayati *et al*., 2011).

The application of cow manure gives a very real effect on P-Total and P Available. This is because organic matter is a source of elements N, P and S, thus the increasing soil organic matter will increase P-Total itself. The increase in P may be caused by improved soil conditions mainly related to the increase in soil pH due to cow manure (Fikdalillah *et al*., 2016). The P element is very powerful to accelerate the flowering and harvesting of plants, especially for grain and fruit-producing plants. Moreover, P can also stimulate the growth of plant roots to be longer and more so that it can increase the absorption of other nutrients in the soil (Subroto and Awang, 2005).

In this case, even though the Biochar treatment is not present as the highest yield resulting treatment, Biochar remain hold the role of supporting growth and yield component as well as mentioned by Carter *et al.* (2013) from their previous experiment of Biochar application to letuce in first planting season, continued to second season resulting increase of yield 10–20%.

Conclusion

The addition of soil amendments with several NPK fertilizer combinations affects several soil chemical parameters such as P – availability and exchangeable potassium in Entisol. The highest P – availability could be obtained by the application of 10 tons ha^{-1} rice husk biochar + NPK. Whereas, the exchangeable potassium could be obtained by the application of 20 tons ha^{-1} cow manure + N and K. However, according to the parameters of maize potential yield, the best combination treatment to increase highest number of production could be obtained by the application of 10 tons ha^{-1} cow manure + N and K.

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