Utilization of biochar for reducing NPK fertilization in corn 
(*Zea mays L.*) growth on ultisol

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**Abstract.** Reducing fertilization for increasing production is a tricky thing, but utilization of biochar expected to be a solution. This research aimed to find the best biochar for reducing fertilizer of Nitrogen, Phosphorus, and Potassium in corn growth on Ultisol. This research was conducted using a Non Factorial Randomized Block Design with a level of treatment that were 100% NPK (2 gram), 75% NPK (1.5 gram) plus corn cobs biochar 100 gram, 75% NPK (1.5 gram) plus corn skin biochar 100 gram, 75% NPK (1.5 gram) plus paddy husk biochar 100 gram, 75% NPK (1.5 gram) plus paddy straw biochar 100 gram, 50% NPK (1 gram) plus corn cob biochar 100 gram, 50% NPK (1 gram) plus corn skin biochar 100%, 50% NPK (1 gram) plus paddy husk biochar 100 gram, 50% NPK (1 gram) plus paddy straw biochar 100 gram, all treatments with 3 replications. The result showed that reducing fertilization NPK down to 50% not significant effect for NPK nutrient uptake on corn and the best biochar for reducing NPK was biochar Husk and straw.

1. **Introduction**
Corn plants are one type of grain food crop from the grass family. Corn production from year to year in Sumatera Utara is increasing, along with the increasing population. The highest production in Sumatera Utara was found in Karo (456,649 tons), while the lowest was in Nias Barat (60 tons). Whereas in Sumatera Utara in 2009 it produced 1,166,548 tons, in 2010 it increased to 1,377,718 tons [1]. One effort to increase the production and productivity of corn plants is by fertilizing and application of biochar as a source of soil organic. In many types of organic and inorganic fertilizers on the market, fertilization is one of the activities that are closely related to plant growth and production. NPK fertilizer is a compound fertilizer made by mixing fertilizer elements, namely N, P, and K. To reduce fertilizer costs, compound fertilizers are often used as an alternative to single fertilizer use. Nutrient requirements for one type of plant depend on the age of the plant, type of plant and climate [2]. NPK fertilizer application carried out every planting season, resulting in a high accumulation of N, P, and K in the soil. The high accumulation of nutrients in the soil resulted in low nutrients availability in the soil. With the low N, P and K elements available to plants in the soil, efforts need to be made to increase the availability of N, P, and K in the soil. One effort to increase the availability of nutrients in the soil is by using biochar [3].
Biochar is a black charcoal as a result of the biomass combustion process in a state of limited or no oxygen. Biochar is also an organic matter that has a stable nature and can be used as a soil conditioner on dry land. The selection of biochar raw matters was based on the product of abundant and wasteful crop residues [4]. For now, the production of biomass, which is very abundant and underutilized is paddy husk. Husk from paddy milling waste reaches 20-23% of the grain. Production of Milled Dry Grain (MDG) reached 71.29 million tons; hence the amount of husk produced in Indonesia was around 16.39 million tons [1].

Biochar application can increase the uptake of nitrogen, phosphorus, and potassium. The presence of plant nutrients, surface area, and high natural absorption of biochar and the capacity of biochar to act as a medium for microorganisms are identified as the main reasons for biochar as an ingredient to improve physical properties [5]. Biochar can improve the chemical, physical and biological properties of the soil. N fertilizer leaching can be significantly reduced by biochar application to the planting media. Biochar is more effective in suppressing nutrients for its availability to plants than other organic matters such as leaves, compost, or manure. Biochar also holds P, which cannot be retained by ordinary soil organic matter; biochar also provides an excellent growing medium for various soil microbes [6]. Increasing of price fertilizer N, P, K makes the farmer has many difficulties for growing their corn plant, hence the aim of this research to reduces utilization of fertilizer by using biochar application.

2. Materials and methods
This research was conducted at Screen House and analysed in the Laboratory of Chemistry and Soil Fertility and the Research and Technology Laboratory, Faculty of Agriculture, Universitas Sumatera Utara – Medan, which was started from May to July 2018. The materials used in this research were corn skin, corn cob, paddy husk and paddy straw as raw material for biochar, soil as a planting medium, NPK fertilizer as treatment, corn seeds as indicator plants, other chemicals for analysis, and labels as a marker of treatment. The tools used in this research were pyrolysis drum as a tool for making biochar, hoes to take soil samples, burlap as a container for taking biochar raw materials, polybags as a container for planting, analytical scales to weigh materials, pH meters to measure soil pH, and some additional equipment for analysis purposes.

This research was conducted using a Non Factorial Randomized Block Design (RBD) with a level of treatment that was (B1) 100% NPK 2 gram, (B2) 75% NPK 1.5 gram plus corn cobs biochar 100 gram, (B3) 75% NPK 1.5 gram plus corn skin biochar 100 gram, (B4) 75% NPK 1.5 gram plus paddy husk biochar 100 gram, (B5) 75% NPK 1.5 gram + paddy straw biochar 100 gram, (B6) 50% NPK 1 gram plus corn cob biochar 100 gram, (B7) 50% NPK 1 gram plus corn skin biochar 100%, (B8) 50% NPK 1 gram plus paddy husk biochar 100 gram, (B9) 50% NPK 1 gram plus paddy straw biochar 100 gram with 3 replications. The data analysis method used polynomial orthogonal contrast for grouping tests at the level of 5%.

3. Results and discussion

3.1. Soil pH

Based on Table 1 and Table 2 could be seen that the application of biochar increases soil pH significantly compared without the biochar. The highest pH increase in the treatment of a 50% reduction in NPK dose with rice husk biochar was 6.23 on the 75% NPK fertilizer dosage with corn cob biochar. The increase in pH through the application of biochar because that biochar has an alkaline reaction with the presence of ash and has a liming effect, and the high alkali material in biochar is caused by many cations hence the base saturation becomes high and increase the pH [7] [8]. Based on Table 2, known that differences in fertilizer dosage do not significantly increase soil pH, this is because fertilizers are not chemicals for increasing pH but could be decrease pH with oxides and the derivative reactions produced [9].

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1. International Conference on Agriculture, Environment and Food Security (AEFS) 2019. IOP Conf. Series: Earth and Environmental Science 454 (2020) 012149. doi:10.1088/1755-1315/454/1/012149
Table 1. The average of soil pH with the application of several types of biochar in corn (*Zea mays* L.)

| Treatment                                      | Dosage                      | pH   |
|------------------------------------------------|-----------------------------|------|
| B1 (100% NPK)                                  | 2 g/polybag                 | 5.60 |
| B2 (75% NPK + corn cob biochar)                 | (1.5 g+100 g)/polybag       | 6.23 |
| B3 (75% NPK + corn skin biochar)                | (1.5 g+100 g)/polybag       | 6.06 |
| B4 (75% NPK + husk biochar)                     | (1.5 g+100 g)/polybag       | 5.33 |
| B5 (75% NPK + straw biochar)                    | (1.5 g+100 g)/polybag       | 6.13 |
| B6 (50% NPK + corn cob biochar)                 | (1 g+100 g)/polybag         | 6.10 |
| B7 (50% NPK + corn skin biochar)                | (1 g+100 g)/polybag         | 5.76 |
| B8 (50% NPK + husk biochar)                     | (1 g+100 g)/polybag         | 6.23 |
| B9 (50% NPK + straw biochar)                    | (1 g+100 g)/polybag         | 6.20 |

Table 2. Contras Test of Soil pH with the application of several types of biochar in corn (*Zea mays* L.)

| Treatment                                      | Dosage                      | pH   |
|------------------------------------------------|-----------------------------|------|
| B1 vs B2B3B4B5B6B7B8B9                        | *                           |      |
| B2B3B4B5 vs B6B7B8B9                          | tn                          |      |
| B2 vs B3B4B5                                  | tn                          |      |
| B4 vs B5                                      | *                           |      |
| B6 vs B7B8B9                                  | tn                          |      |
| B7 vs B8B9                                    | tn                          |      |
| B8 vs B9                                      | tn                          |      |

Description: (**) Very Significant; (*) Significant; (tn) not significant

1) Criteria according to the assessment of the properties of the Soil Research Center (1983) and Medan BPP staff (1982)

3.2. *N Nutrient uptake*

Based on Table 3 could be seen that the reduction of NPK fertilizer dosage using biochar was not significantly effect in N plant uptake compared to 100% NPK without biochar, down to 50% reduction in NPK dosage, this showed that the application of biochar was effective to increase the availability of nitrogen in the soil although in low dosages by increasing soil pH, and increased microbial growth played a role in increasing the availability of N, P and K nutrients, giving biochar effective in holding N leaching and evaporation and manipulating the presence in the soil and could be absorbed by plants [10].

Table 3. The average of N nutrient uptake with the application of several types of biochar on corn (*Zea mays* L.)

| Treatments                                      | Dosage                      | Mg/tan |
|------------------------------------------------|-----------------------------|--------|
| B1 (100% NPK)                                  | 2 g/polybag                 | 1.29   |
| B2 (75% NPK + corn cob biochar)                 | (1.5 g+100 g)/polybag       | 0.85   |
| B3 (75% NPK + corn skin biochar)                | (1.5 g+100 g)/polybag       | 1.08   |
| B4 (75% NPK + paddy husk biochar)               | (1.5 g+100 g)/polybag       | 1.23   |
| B5 (75% NPK + paddy straw biochar)              | (1.5 g+100 g)/polybag       | 1.10   |
| B6 (50% NPK + corn cob biochar)                 | (1 g+100 g)/polybag         | 0.84   |
| B7 (50% NPK + corn skin biochar)                | (1 g+100 g)/polybag         | 0.82   |
| B8 (50% NPK + paddy husk biochar)               | (1 g+100 g)/polybag         | 1.18   |
| B8 (50% NPK + paddy straw biochar)              | (1 g+100 g)/polybag         | 1.15   |
3.3. **P Nutrient Uptake**

Based on Table 4 and Table 5, it can be seen that reducing the NPK dose by utilizing biochar has the same effect as giving 100% NPK without using biochar in increasing P nutrient uptake. It showed that the application of NPK could be reduced down to 50% by using biochar and it was proven that biochar is effective and efficient for increasing soil P uptake. Most fertilizers applied on poor soil organic carbon are ineffective and increasing of organic carbon by application biochar made large of the soil surface, firmly bound to the sorption complex. The presence of biochar increases the cation exchange capacity so that it retains the nutrients supplied and provides them for plants [8].

**Table 4.** The average of P nutrient uptake and contrast with the application of several types of biochar on corn (Zea mays L.)

| Treatment                        | Dosage                  | mg/tan |
|----------------------------------|-------------------------|--------|
| B1 (100% NPK)                    | 2 g/polybag             | 0.139  |
| B2 (75% NPK + corn cob biochar)  | (1.5 g+100 g)/polybag  | 0.075  |
| B3 (75% NPK + corn skin biochar) | (1.5 g+100 g)/polybag  | 0.096  |
| B4 (75% NPK + paddy husk biochar)| (1.5 g+100 g)/polybag  | 0.140  |
| B5 (75% NPK + paddy straw biochar)| (1.5 g+100 g)/polybag | 0.114  |
| B6 (50% NPK + corn cob biochar)  | (1 g+100 g)/polybag    | 0.098  |
| B7 (50% NPK + corn skin biochar) | (1 g+100 g)/polybag    | 0.091  |
| B8 (50% NPK + paddy husk biochar)| (1 g+100 g)/polybag    | 0.156  |
| B8 (50% NPK + paddy straw biochar)| (1 g+100 g)/polybag    | 0.138  |

**Table 5.** Contrast test of P nutrient uptake with the application of several types of biochar on corn (Zea mays L.)

| Contrast Test                      | p-value |
|------------------------------------|---------|
| B1 vs B2B3B4B5B6B7B8B9             | tn      |
| B2B3B4B5 vs B6B7B8B9               | tn      |
| B2 vs B3B4B5                       | *       |
| B4 vs B5                           | tn      |
| B6 vs B7B8B9                       | tn      |
| B7 vs B8B9                         | *       |
| B8 vs B9                           | tn      |

3.4. **K Nutrient Uptake**

**Table 6.** The average of K nutrient uptake with the application of several types of biochar on corn (Zea mays L.)

| Treatments                        | Dosage                  | Mg/tan |
|-----------------------------------|-------------------------|--------|
| B1 (100% NPK)                     | 2 g/polybag             | 3.09   |
| B2 (75% NPK + corn cob biochar)   | (1.5 g+100 g)/polybag  | 2.70   |
| B3 (75% NPK + corn skin biochar)  | (1.5 g+100 g)/polybag  | 2.86   |
| B4 (75% NPK + paddy husk biochar) | (1.5 g+100 g)/polybag  | 3.11   |
| B5 (75% NPK + paddy straw biochar)| (1.5 g+100 g)/polybag  | 3.23   |
| B6 (50% NPK + corn cob biochar)   | (1 g+100 g)/polybag    | 2.75   |
| B7 (50% NPK + corn skin biochar)  | (1 g+100 g)/polybag    | 2.94   |
| B8 (50% NPK + paddy husk biochar) | (1 g+100 g)/polybag    | 3.85   |
| B9 (50% NPK + paddy straw biochar)| (1 g+100 g)/polybag    | 3.93   |
The reduction of NPK fertilizer dosage using biochar has the same effect as NPK fertilization of 100% dosage on N uptake, even higher up to 50% dosage NPK fertilizer reduction treatment. The highest K uptake was found in the treatment of 50% NPK reduction with rice husk or straw 3.85 mg/plant and 3.93 mg/plant respectively. Biochar is a material that is rich in potassium, hence the provision of biochar can supply soil potassium, the biochar pores make the potassium given to experience oxidation and so its availability increases for plants [8].

3.5. Plant height
Reducing the NPK dose down to 50% with biochar added have not a significant effect on reducing plant growth. Even at a 50% dose of NPK and the addition of biochar corn husk can increase the height of corn plants up to 129 cm (Table 7). It is because biochar application was able to increase nutrient availability and to make fertilizer effective in the soil, biochar was able to retain nutrients due to increased cation exchange capacity in the soil [10]. Biochar has a high surface area and rich in an aromatic chain and porous clusters, hence the oxidation process on the surface of the biochar increases and positively correlates with high organic matter of the carboxylic group and also increases microbial activity and produces organic acids [10].

Table 7. The plant height with the application of several types of biochar on corn (Zea mays L.)

| Treatment                 | Dosage                  | Cm  |
|---------------------------|-------------------------|-----|
| B1 (100% NPK)             | 2 g/polybag             | 117.40 |
| B2 (75% NPK + corn cob biochar) | (1.5 g+100 g)/polybag | 113.77 |
| B3 (75% NPK + corn skin biochar) | (1.5 g+100 g)/polybag | 129.55 |
| B4 (75% NPK + paddy husk biochar) | (1.5 g+100 g)/polybag | 115.43 |
| B5 (75% NPK + paddy straw biochar) | (1.5 g+100 g)/polybag | 93.43 |
| B6 (50% NPK + corn cob biochar) | (1 g+100 g)/polybag | 115.17 |
| B7 (50% NPK + corn skin biochar) | (1 g+100 g)/polybag | 115.70 |
| B8 (50% NPK + paddy husk biochar) | (1 g+100 g)/polybag | 103.87 |
| B8 (50% NPK + paddy straw biochar) | (1 g+100 g)/polybag | 97.67 |

4. Conclusion
Application biochar can reduce NPK fertilization and increase the growth of corn, the best biochar in reducing NPK fertilization is biochar husk and rice straw, that can reduce NPK fertilization down to 50%.

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