

Research article

Improvement of Soil Chemical Properties using Corn Cob Biochar (BTJ)

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Abstract

Corn waste is a solid waste that is still limited in use. One of the efforts that can be made to increase the use-value of maize waste is to convert it into biochar. Corn cobs are a component of corn that can be processed into biochar and can improve soil quality. This study aims to analyze the ability of corn waste biochar (in terms of chemical content and gas emissions) in improving soil quality. Primary data were collected by measuring C element using gravimetric method, N element using kjeldahl method, P element using oslen method, K ($\text{NH}_4\text{O AC pH 7}$), pH using potentiometric, and CO_2 emissions from biochar. Biochar is made by burning corn cobs at 500°C without oxygen for 2 hours. Chemical content measurement of corn cob biochar, known as biochar tongkol jagung (BTJ) and soil, was carried out for eight weeks. The chemical elements of the mixture of biochar and soil at week 8 include C-Organic (0.7%), Total N (0.1%), P_2O_5 (10.6 ppm), K_2O (0.28 me), pH (6.19), and CO_2 emissions (6.64 mg CO_2 /day).

Keywords : biochar; soil; C-organic; chemical contents

1. Introduction

Dryland is one of the critical lands that needs continuous improvement efforts. The preliminary research results on the pH and C-Organic characteristics of dry land in the Sidoarjo area show that the pH is relatively low in the range 5.5-6.1 and for the C-Organic content of 1.02-1.04%. One of the soil improvement efforts that can be done is by adding biomass. Biomass is usually used in compost or biogas. However, it will be more effective for dryland / agricultural land if the biomass is processed into biochar. Biochar is an organic material that has stable properties and can be used as a soil repairer. The use of biochar in agriculture is more effective because it can increase nutrient retention for plants compared to other organic matter and its long persistence in the soil. Biochar, which has high persistence ability, can reduce global warming (Nisa, 2010). Therefore, biomass use into biochar can be an alternative to reduce the rate of carbon emissions that can be released into the atmosphere.

One of the biomass that can be used as biochar is corn cobs. Corn cobs are one of the wastes that come from the processing of corn fruit. Maize production in Indonesia reached 19,612,435 tonnes (BPS, 2015). The large potential of waste generated can result in pollution if not treated properly. So far, corn cobs waste is usually used as animal feed and crafts.

Meanwhile, according to Iskandar (2017), corncob waste, if appropriately used, can also be a soil repairer (Iskandar, 2017). According to Jaili and Purwono in 2016, improving dry soil with a pH (5.7) and C-organic (3%) on agricultural land can be done by adding biochar. The agricultural sector is one of the sectors of plant cultivation that contributes to producing Greenhouse Gas (GHG) 14% on a global scale

and 7% (on a national scale) (Ariani et al., 2016). The addition of biochar to agricultural land can reduce the rate of CO₂ and N₂O emissions (Zhu et al., 2014). This shows that biochar can improve the pH, C-Organic, N, P, and K in the soil. Also, the addition of biochar can reduce CO₂ emissions resulting from the breakdown of organic matter in the soil. Therefore, this research will identify the effect of adding corncob biochar to dry soil on chemical content consisting of pH, C-Organic, N, P, K, and the resulting greenhouse gas (CO₂) emissions. In this study, it is expected that the quality of soil chemical characteristics will increase, and CO₂ emissions can be reduced by adding biochar to the soil.

2. Methodology

This research was conducted from February to July 2020 in the Sidoarjo area with soil samples taken from the West Sidoarjo region. Soil characteristics that have low pH and chemical content (C-Organic) are need improvement. The following are the stages in this research:

a) Sampling of dry soil

Soil samples taken on untreated dry land were taken at a depth of 1-20 cm. According to research by Jaili and Purwono (2016), soils on dry land have low C-Organic (3%). Also, dry land has high levels of Al, Fe, and Mn compounds that can poison plants (Noor, 1996). The low level of dry soil fertility is caused by the low levels of C-Organic elements and plants' nutrients (Ningtyas, 2015). Therefore, this study using dry soil as a sample for soil quality improvement.

b) Measurement of soil characteristics on dry land

Soil characteristics testing is carried out to know the soil's chemical characteristics before the soil is incubated with BTJ. Soil characteristics measured in the form of elements C-Organic, N, P, K, and pH in the soil. Soil characteristics can be seen in Table 1. The principles of measuring the elements of C-Organic, N, P, K and pH in the soil can be seen in step 6.

c) Producing BTJ

The material used in this research is biochar from corn cobs waste (BTJ). Biochar is made from dry corn cobs waste from agricultural activities in Jombang. BTJ is made by burning corn cobs (1.5 kg) at 500 °C for 2 hours. The series of pyrolysis equipment is shown in Figure 1, and Biochar produced from corn cobs waste is shown in Figure 1.

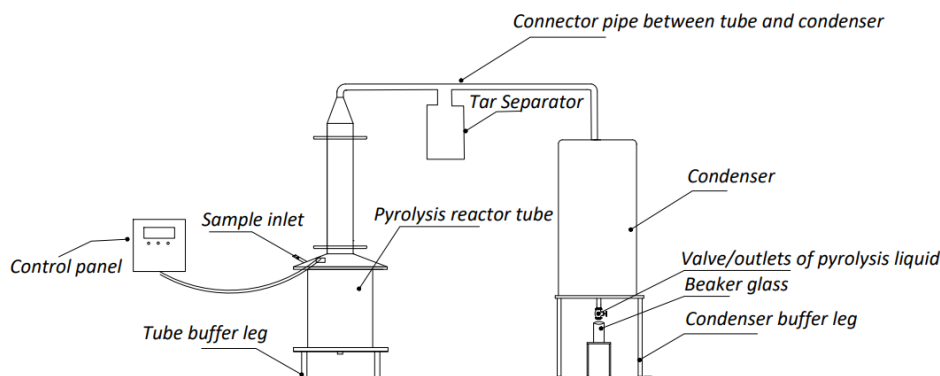


Figure 1. Pyrolysis equipment

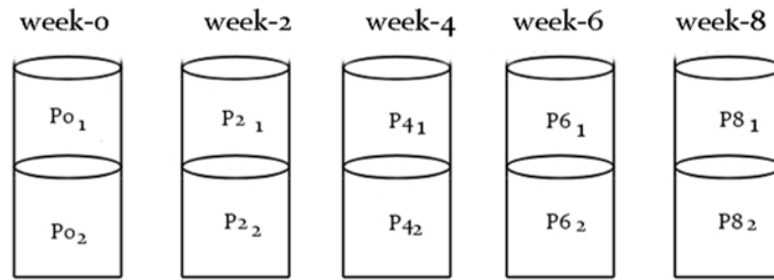
d) BTJ measurements

The BTJ test are carry to analyze its chemical analysis to improve soil quality. BTJ characters were interpreted according to PERMENTAN No. 7 of 2011 and the IBI standard. The main contents measured was C-Organic, N, P, K, and pH in BTJ that can be seen in step 6.

e) Soil incubation with BTJ

Soil incubation with BTJ in this study used a dose of 4 tons/ha. This refers to the statements of Lehmann (2006) and Agnesia (2015). offering biochar 0.4-8 ton/ha can increase production in plants. Based on the biochar dosage from 0.4 to 8 tonnes/ha, a dry soil sample weighing 2 kg was obtained and

placed in a closed container (jar) with 70 grams of biochar added. In this study, soil incubation with BTJ contained two samples every two weeks because it was intended as a duplo treatment. The soil incubation process can be seen in Figure 2.



Where:

$P_{0_1}, P_{2_1}, P_{4_1}, P_{6_1}, P_{8_1}$: Treatment carried in week-0, 2, 4, 6, 8 on 1st sample

$P_{0_2}, P_{2_2}, P_{4_2}, P_{6_2}, P_{8_2}$: Treatment carried in week -0, 2, 4, 6, 8 on 2nd sample

Figure 2. Soil incubation

f) Measurement of elements of C-Organic, N, P, K, pH and CO₂ emissions

Testing of C-Organic, N, P, K and CO₂ emissions was carried out at weeks 0, 2, 4, 6, and 8 after incubation referring to previous research conducted by Ningtyas (2015). It aims to analyze changes in chemical elements in soil incubation. Biochar was applied to the soil with an incubation period of 8 weeks.

a. Measurement of the C-Organic element using the Walkey-Black method

The principle of measuring the C-Organic element is by adding 1 N K₂Cr₂O₇ compound, 20 ml H₂SO₄, 5 ml H₃PO₄, and 1 ml diphenylamine indicator, FeSO₄ titration. This measurement uses glassware (erlenmeyer), pipette, burette, and statif (BPT, 2005).

b. Measurement of element N using the Kjeldahl method

The principle of measuring the element N by adding an N catalyst, concentrated H₂SO₄ compounds, NaOH-Na₂S₂O₃, methyl red, and HCl titration. This measurement uses glassware (erlenmeyer), pipette, burette, and statif (Sudarmadji et al., 2007).

c. Measurement of the element P using the Oslen method

A spectrophotometer measured the principle of measuring the element P using olsen extract, phosphate dye reagent, and the solution's absorbance at a wavelength of 693 nm. (Sulaeman et al., 2005).

d. Measurement of element K using NH₄O AC pH 7

The principle of measuring the element K uses a soil filtrate flame photometer at saturated 1 N NH₄OAc (BPT, 2005).

e. Soil pH measurements using the glass electrode method

The principle of measuring pH using an electrode. At the end of this electrode, a bulb functions as a place for the exchange of positive ions (H⁺). The ion exchange that occurs causes a difference in potential difference between the two electrodes, so that the potentiometer reading will be positive or negative (Desmira et al., 2018).

f. Measurement of CO₂ emission using verstraete modification and HCL titration

The principle of measuring CO₂ emissions in soil incubation in biofilm bottles containing KOH compounds for 7 days and titrated with HCL compounds (Nasution et al., 2015).

3. Result and discussion

3.1 Soil characteristic

Based on the Government Regulation of the Republic of Indonesia Number 150 of 2000, the soil characteristics in this study (Table 1.) are included in the standard criteria for soil damage in dry land

because they contain a pH of 5.85 (4.5-8.5). In addition, the C-Organic content of 1.02% in the soil is classified as low (Table 1). This is comparable to Jaili and Purwono (2016) research, where soil in dryland contains 3% C-Organic and a pH of 5.7.

Table 1. Result of soil characteristic

No	Parameter of Chemical test	Unit	Result	Soil standard criteria
1	pH		5.85	4.5-8.5*
2	C-Organic	%	1.02	≤15**
3	N	%	0.105	
4	P	Ppm	18	
5	K	Me	0.12	

Source :

* : Republic of Indonesia Government Regulation Number 150 of 2000

** : Regulation of the Minister of Agriculture of the Republic of Indonesia Number 70 / PERMENTAN/SR.140 / 10/2011

3.2 BTJ Characteristic

The burning of corn cobs waste at a temperature of 500 °C produces BTJ, which has a chemical content consisting of elements C, N, P, K, and pH (Table 2.). Table 2 shows that BTJ has a very high C-Organic (53.2%). BTJ has a very high C-Rrganik. According to Sarwono (2016) and Xiao et al. (2014), high C element in biochar is due to fossil combustion containing carbon and as a storage for element C in soil biochar in the land. The chemical elements in biochar meet the provisions of PERMENTAN No. 7 of 2011 and IBI standards except the degree of acidity of biochar (pH 10.21). The biochar's pH is alkaline (pH 10.21) due to the burning temperature of the corn cobs at 500 °C. This study's results are comparable to that of Steiner, 2006, the ash content in biochar is generally alkaline. According to Narzari et al., (2015), the higher the pyrolysis temperature, the higher the biochar's pH (the pH of biochar is increasingly alkaline). The increase in pH is due to the separation of alkaline salts from organic compounds due to increased pyrolysis temperature. This increase in temperature will cause the C content in biochar to increase and the O and H elements in the biochar to decrease.

Table 2. Chemical content in BTJ

Parameter of Chemical content	Biochar in 500 °C	Agriculture ministry regulation No.7 (2011)	IBI standard (2015)
C-Organic(%)	53,2	>15	>20
N Total (%)	0,12	-	-
P ₂ O ₅ (%)	0,57	-	-
K ₂ O(%)	2,31	-	-
Ph	10,21	4-9	6-10

3.3 C-organic content in soil incubation with BTJ

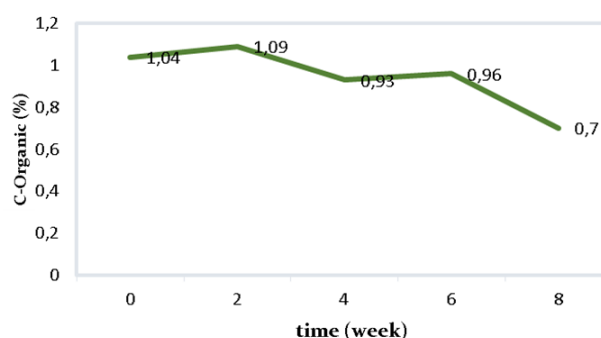


Figure 3. Concentration of C-Organic (%) in soil incubation with BTJ

Figure 3. shows that the C-Organic element in soil incubation with BTJ increased organic carbon at week two due to the addition of BTJ. This is in line with the research results by Wilhelm et al. (2004) and Gokila and Baskar (2015) that increasement in organic carbon content is due to the addition and decomposition of organic matter in the soil. At week 8, organic C elements in soil incubation with BTJ decreased. The decrease in organic carbon elements in the soil is due to the decomposition of organic compounds by microbes releasing CO₂ gas (Subowo, 2010).

3.4 Nitrogen content in soil incubation with BTJ

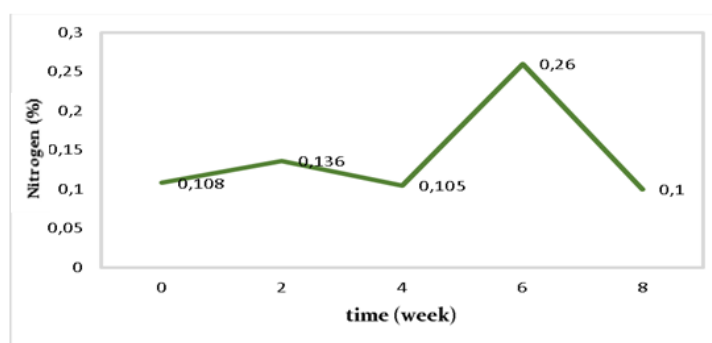


Figure 4. Concentration of N total (%) in soil incubation with BTJ

The concentration of the total element N in soil incubation with BTJ increased at week 6 (Figure 4). This is due to the increased activity of nitrifying bacteria in breaking down ammonium into nitrate. According to Widowati et al. (2012), the addition of biochar in the soil can increase the efficiency of nitrogen concentration. At week 8, the Total N concentration decreased due to soil microbes' improved organic decomposition process. According to Steiner et al., in 2008, the positive impact of the addition of biochar in the soil would increase soil fertility by increasing soil microorganisms' activity. Based on the results of research by Widowati and Asnah (2014) on the soil incubation process with biochar, microorganisms break down organic material into nitrate compounds, and nitrate compounds decrease due to evaporation and dissolving water washing.

3.4 Phospor content in soil incubation with BTJ

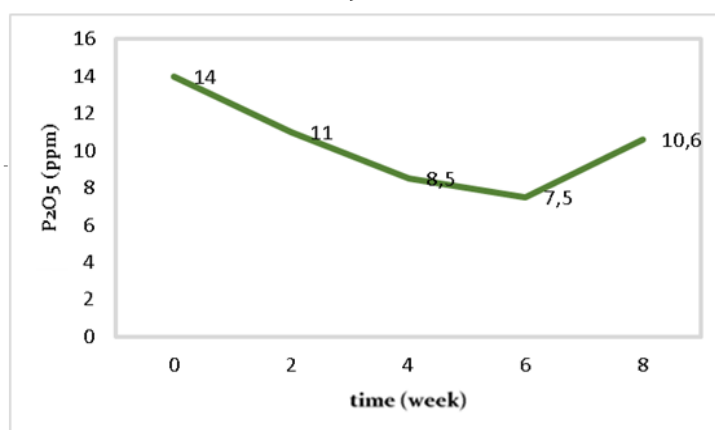


Figure 5. Concentration of P₂O₅ (ppm) in soil incubation with BTJ

From week 0 to week 6, the P concentration decreased as P₂O₅ (Figure 5). The research results by Afrida et al. (2014) show that the addition of biochar results in the degradation of organic material into organic acids that can react with Al, Fe, and Ca metals to add a C source to the phosphorus solubilizing bacteria. This increases the evaporation of inorganic P elements and the organic P content

in the soil. According to Citraresmini and Taufik (2016), the low P element in the soil is due to P elements' adsorption by colloids and metal elements. At week 8 there was an increase in phosphorus in the soil due to the mineralization process rate through the release of P-organic and P-inorganic into the soil solution (Afrida et al., 2014). The increase in P elements in the soil will increase the soil's nutrients, thereby improving soil fertility and accelerating plant growth (Noviani et al., 2018).

3.5 Potassium content in soil incubation with BTJ

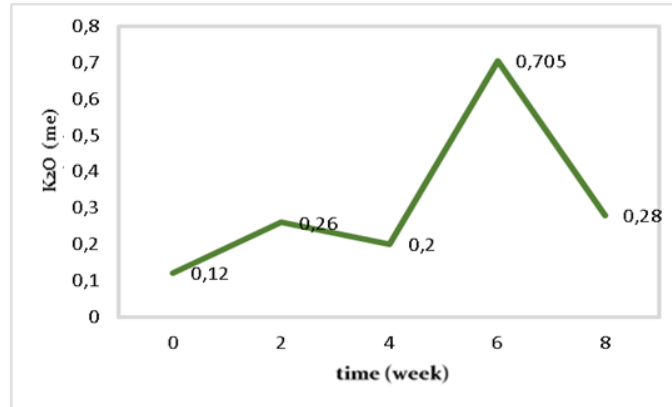


Figure 6. Concentration of K₂O (me) in soil incubation with BTJ

Figure 6. shows that the K₂O compound in the soil increased until week 6 due to soil incubation activity with BTJ. The results of this study are similar to those of Agnesia's (2014) study. The more biochar added to the soil, the greater the K element in the soil. According to Widowati and Asnah (2014), biochar contains dissolved and leached K elements from soil that has been incubated with biochar. There was a K₂O decrease in the soil because due to water washing in the soil at the 8th week.

3.6 pH in soil incubation with BTJ

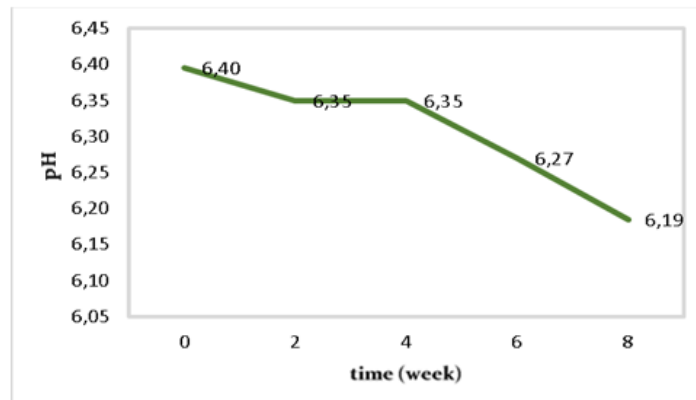


Figure 7. pH at the time of incubation of the soil week 0 to 8

Organic material in the soil will decompose into acidic compounds (Sujana et al., 2014), which will make the pH decrease until week 8 (Figure 7). This is in line with Agnesia's (2014) research that soil pH is decreasing due to biochar's addition due to the decomposition of organic material in the soil. According to Darman (2006), this is due to the amphoteric nature of biochar having carboxyl groups as acids and amino groups as bases (depending on soil conditions) positively and negatively charged. At fourth week, the pH increases due to the process of methanogenesis bacteria breaking down acetic acid compounds into CH₄ gas (Cahyaningtyas et al., 2012).

3.4 CO₂ emissions resulting from soil incubation with BTJ

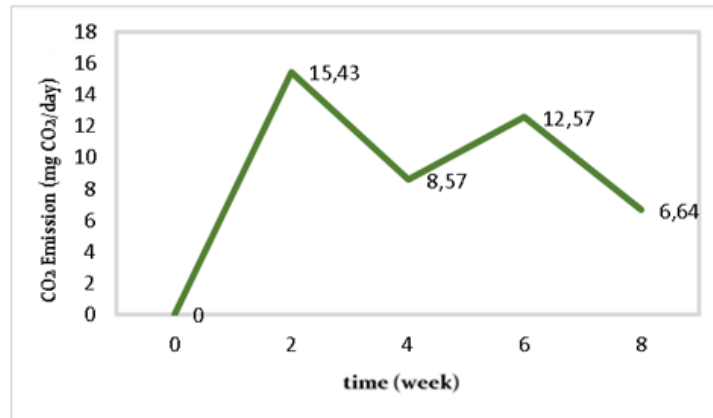


Figure 8. CO₂ emission(mg CO₂/day) at the time of soil incubation with BTJ

Biochar contains high organic carbon material (Gaskin et al., 2008). The addition of BTJ in the soil causes an increase in CO₂ gas from the decomposition of organic material by microbes. This is a factor causing the increase in CO₂ gas in week 2. At weeks 4 and 8, there is a decrease in CO₂ emissions (Figure 8). This is because biochar is a compound that is difficult to oxidize into CO₂ gas and good carbon storage in the soil to reduce global warming (Sarwono, 2016). When C-Organic decreases, CO₂ gas also decreases through the process of organic degradation in the soil. According to Lubna and Emenda (2013), C-Organic's content in the soil is decreasing because C-Organic as a food substrate is continuously in the metabolism of soil bacteria and produces carbon dioxide gas every day. The longer the activity of decomposing C-Organic by microbes occurs, the less C-Organic in the soil so that the CO₂ gas produced is also smaller.

4. Conclusion

The characteristics of BTJ meet the parameters of C-Organic content in improving soil quality (PERMENTAN No.7 Year 2011 and IBI Standards 2015). After mixing BTJ in dry land for eight weeks, it was seen that the chemical elements of the soil had changed for the better. These changes can be seen in several parameters, including C-Organic (0.7%), Total N (0.1%), P₂O₅ (10.6 ppm), K₂O (0.28 me), pH (6.19), and emissions. CO₂ (6.64 mg CO₂/day). Changes in soil chemical elements have not yet been seen to be significant. This is because BTJ takes a long time to degrade with the soil completely.

One of the impacts of the addition of BTJ to the soil is to increase soil fertility through increased activity of soil microorganisms. Therefore it is necessary to have a comprehensive microbial test to determine its effect on soil respiration. The drawback of this study is that it does not carry out total microbial testing. In addition, the observation time of BTJ application on the soil can be further extended (observation time 16 weeks) and increase the variation of biochar doses to obtain significant changes in soil chemical elements.

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