Application of biochar to improve maize performance on volcanic and sediment soil based parent materials in dry land

A Krismawati1, Z Arifin1, C Hermanto1 and C Tafakresnanto2

1 East Java Assessment Institute for Agricultural Technology, Malang, Indonesia
2 Indonesian Center for Agricultural Land Resources Research and Development, Bogor, Indonesia

E mail: krismawati_amik@yahoo.com

Abstract. The study had been conducted in two dry land sites in East Java, where first site was in Situbondo District (volcanic soil), and the second in Sampang District (sediment soil) during the dry season I, 2018. The research was designed in RBD, 3 replicates, and 9 treatments, namely: A = FAF + 1,000 kg organic fertilizer ha⁻¹, B = FAF + 1,000 rice husk biochar ha⁻¹, C = FAF + 1,000 corn cob biochar ha⁻¹, D = FAF + 500 g biofertilizer ha⁻¹, E = RRIF, F = RRIF + 1,000 kg organic fertilizer ha⁻¹, G = RRIF + 1,000 kg biochar rice husk biochar ha⁻¹, H = RRIF + 1,000 kg corn cob biochar ha⁻¹, and I = RRIF + 500 g biofertilizer ha⁻¹. The results showed that the application of RRIF + 1,000 kg corn cob biochar ha⁻¹ in Situbondo District obtained dry seeds yield of corn 7.87 t ha⁻¹ (increased 36.16%), C-organic (increased 19.40%), soil CEC (increased 62.27%) from the RRIF and R/C ratio 2.28, while in Sampang District obtained of dry seeds yield of corn 7.63 t ha⁻¹ (increased 28.89%), C-organic (increased 46.51%), soil CEC (increased 22.98%) from the RRIF and R/C ratio 2.17.

1. Introduction

In general, dry land has low fertility level, particularly the eroded soil, so that it makes the tillage layer becomes thin and contains low organic matter, as well as low soil buffer capacity and leading to macronutrient deficiency. This condition is worsened by limited application of organic fertilizer, particularly on the annual crops. Besides that, in tropical area, the organic matter in the soil will quickly decrease naturally by 30 to 60% in 10 years [1].

Lack of organic matter may affect on P availability in the soil. However, both factors will affect on physical, chemical, and biological activities in the soil, besides climatic and topographic factors [2]. Organic matter will improve physical properties of the soil, for example, the change of color and structure of the soil which turns to dark and more loosen [3]. Organic matter will increase microorganism activities in the soil [4].

The government and community have made great efforts to increase land productivity. One of the efforts to improve soil quality is using soil conditioner. Today, the application of biochar (agricultural waste charcoal) has been developed as alternative soil conditioner. Biochar will be able to stand longer in the soil or has relative longer effect or relatively resistant to microorganism infestation, so that the decomposition process will run slowly [2].

At the beginning, the main concept of using soil conditioner is: (1) stabilizing soil aggregate to prevent erosion and pollution, (2) changing hydrophobic and hydrophilic properties, so that it can change soil capacity to retain water, and (3) increasing soil ability to hold nutrient by increasing Cation Exchange Capacity (CEC) [5]. The application of charcoal (biochar) on farming land is
intended to increase: (1) nutrient availability, (2) nutrient retention, and (3) water retention [6]. Charcoal is able to create better habitat for symbiotic microorganism, such as mycorrhiza, due to its ability to retain water and air, as well as to create neutral environment, particularly in acid soil [7].

Biochar as agricultural waste is the product of agricultural waste conversion through incomplete burning process (pyrolysis) under limited oxygen. Biochar has been proven effective in increasing pH and decreasing soil acidity, particularly in acid dry land, which mostly found in [8,9]. Besides that, the application of biochar may reduce the emission rate of CO₂ and N₂O [9,10], and contribute to carbon preservation (+ 52.8%), which means that biochar is able to store carbon quite longer and in great amount [7,10].

The decomposition process of biochar takes longer time from decades to centuries. The greater biochar in the soil, more C in the soil. Biochar is able to increase soil will store quality because it has high ability in holding water and nutrient. Furthermore, roles of the organic matter include: (1) maintaining soil moisture, (2) neutralizing toxicity of Al and Fe, (3) assisting in increasing nutrient availability, (4) buffering nutrient for plant, (5) stabilizing soil temperature, (6) improving organism activities, (7) improving soil structure, (8) increasing efficiency of the fertilizer application, and (9) decreasing erosion [11]. Materials are highly difficult to be decomposed require some processes such as incomplete burning (pyrolysis), and finally, it will produce charcoal that contains active carbon to be applied in the soil.

Objective of the research was to evaluate the effect of biochar application to improve maize performance on volcanic and sediment soil based parent materials in dry land.

2. Materials and methods
The research was conducted on two dry land areas. First area was in Situbondo District, which represents the volcanic land and the second is Sampang District representing the sediment soil. The research was performed during dry season I, from March to August 2018. The research was designed in Randomized Block Design (RBD), 3 replicates, and 9 treatments. The observed treatments were as follow:

A : Farmers Application of Fertilizer/FAF (200 kg Urea ha⁻¹ + 200 kg NPK ha⁻¹) + 1,000 kg organic fertilizer ha⁻¹
B : FAF + 1,000 kg rice husk biochar ha⁻¹
C : FAF + 1,000 kg corn cob biochar ha⁻¹
D : FAF + 500 g biofertilizer ha⁻¹
E : 250 kg Urea ha⁻¹ + 300 kg NPK ha⁻¹ (Recommended Rates of Inorganic Fertilizers/RRIF)
F : RRIF + 1,000 kg organic fertilizer ha⁻¹
G : RRIF + 1,000 kg rice husk biochar ha⁻¹
H : RRIF + 1,000 kg corn cob biochar ha⁻¹
I : RRIF + 500 g biofertilizer ha⁻¹

The research used plot of 30 m x 10 m, inter plot by a drainage channel with a width of 30 cm and a depth of 25 cm. The planted maize variety was hybrid HJ-21 with spacing 75 cm x 20 cm and 1 seed crop/hole. Organic fertilizer was disseminated evenly a day before planting on each plot in accordance with the observed treatment, while biofertilizer applied as seed treatment.

Corn cob and rice husk biochars were produced by pyrolysis device using horizontal drum, which was designed by University of Tribhuana Tungga Dewi, Malang. The burning temperature ranges from 250 to 300°C (300°C on average). The biochar resulted was dried under the sun. In order to obtain uniform shapes, the biochar was ground and sieved (the sieve size < 2 mm), and then analyzed in chemical laboratory, 2018. The analysis results are presented in Table 1.

The application of biochar was spreaded on the surface of the soil and then immersed during tillage. Biochar was disseminated in the morning before the wind blows hard. One third dose of Urea was each applied at 14, 28, and 42 DAP (Days After Planting), and NPK Phonska was applied during planting. Weeding, irrigation, and pest control were performed if necessary.
Table 1. Analysis results of the nutrient contents of rice husk biochar and corn cob biochars.

| Parameter         | Test result         |
|-------------------|---------------------|
|                   | Rice husk biochar   | Corn cob biochar |
| C-organic         | 0.91%               | 2.70%            |
| C/N-ratio         | 2.00%               | 2.70%            |
| pH                | 8.00%               | 8.50%            |
| Organic matter    | 1.58%               | 4.68%            |
| N-total content   | 0.58%               | 0.71%            |
| P_{2}O_{5} content| 0.30%               | 0.22%            |
| K_{2}O content    | 0.66%               | 1.68%            |
| Ca                | 0.72%               | 0.95%            |
| Mg                | 0.14%               | 0.20%            |
| Na                | 0.33%               | 1.56%            |
| CEC               | 6.62 cmol c kg^{-1}  | 15.28 cmol c kg^{-1} |

Measuring plant height was performed on 20 samples of plant from ground level to the highest leaf tip. Yield of grains was weighed for each treatment. Sample of the composite soil (chemical properties) was taken from the depth of 0 to 20 cm in 5 spots using drill of 1 inch size. Soil samples were missed and the composite was taken ± 0.5 kg to be analyzed in laboratory.

Data were analyzed statistically using SAS program over the observed variables using Analysis of Variance (ANOVA) with trust interval of 5% and Duncan’s test (DMRT = Duncan Multiple Range Test) at level 5% for the significant different effects of the variables [12, 13].

Financial analysis on farming operation was performed to find out its properness. Farming analysis used the economic analysis calculation with R/C-ratio (Revenue Cost ratio) or ratio between revenue and cost. Analysis tool for R/C-ratio [14] with equation as follows:

\[
R/C \text{ ratio} = \frac{NPT}{BT}
\]

In which, \( R/C \) = Revenue and Cost Ratio
\( NPT \) = Total production value (IDR ha^{-1})
\( BT \) = Total cost value (IDR ha^{-1})

If,
\( R/C > 1 \): Feasible to be developed
\( R/C = 1 \): Break even
\( R/C < 1 \): Not feasible to be developed

3. Results and discussion

3.1. Soil characteristics at study site

Based on chemical properties as presented in Table 2, the two dry land had areas had clayey volcanic soil in Situbondo District and silty clay sediment soil in Sampang Distric. The soil pH ranged from slightly acid to acid with pH H_{2}O values of 5.4 to 6.1. The soil these this area was considered very low soil fertility, indicated by very low C-organic (0.67 to 0.86%), as well as N-total < 1%. The soils containeds 2.19 and 18.01 ppm P_{2}O_{5} Bray 1. The facts showed that dry land had unbalanced nutrients, which might affect on low productivity of maize. Cation Exchange Capacity (CEC) values were 10.18 and 17.18 cmol, kg^{-1}. 
Table 2. Soil analysis results before the research performed at Situbondo and Sampang Districts.

| Soil Chemical Properties | Situbondo District | Sampang District |
|--------------------------|--------------------|------------------|
| pH (H₂O)                | 5.4                | 6.1              |
| C-organic (%)           | 0.67               | 0.86             |
| N-total (%)             | 0.08               | 0.13             |
| C/N ratio               | 8                  | 7                |
| P₂O₅ Bray 1 (ppm)       | 2.19               | 18.01            |
| K (me 100 g⁻¹)          | 0.32               | 0.25             |
| Na (me 100 g⁻¹)         | 0.38               | 0.39             |
| Ca (me 100 g⁻¹)         | 5.90               | 9.18             |
| Mg (me 100 g⁻¹)         | 0.60               | 2.18             |
| CEC (me 100 g⁻¹)        | 10.18              | 17.80            |
| Number of Bases (NB)    | 7.20               | 11.99            |
| Base Saturation (SB)    | 71                 | 67               |
| Sand (%)                | 50                 | 4                |
| Dust (%)                | 30                 | 55               |
| Clay (%)                | 20                 | 41               |
| Texture                 | Clay               | Silty Clay       |

The dominant parent material in Sampang soil was sediment with characteristics of Ca > Mg > Na (9.18 > 2.18 > 0.39 me 100 g⁻¹), K was low (0.25 me 100 g⁻¹), silty clay texture (clay = 41 > 50%), red soil (Mediteran) - black (Grumusol). The dominant parent material in Situbondo soil was volcanic with characteristics of Ca > Mg > Na (5.90 > 0.60 > 0.38 me 100 g⁻¹), K was low (0.32 me 100 g⁻¹), clay texture (clay = 50%), > 50%), brown (Latosol) - black (Andisol).

Optimal availability of P ranges in neutral pH 6.5 to 7.0, and optimal K ranges in pH 6.5 to 7.2. Low pH does not due to Al or Fe activities, but the increase H⁺ ion that derived from organic acids such as oxalate, fulfat, citric, and malat that derived from decomposition yield of organic material [15, 16].

Table 3. Soil analysis results on C-organic and CEC contents after the research in Situbondo and Sampang Districts.

| Treatments | Test Parameter | Situbondo District | Sampang District |
|------------|----------------|--------------------|------------------|
|            | Before       | After             | Increased (%)    | Before       | After             | Increased (%)    |
| B          | 0.78         | 16.42             | 14.64            | 1.42         | 65.12             |
| C          | 0.67         | 0.90              | 34.32            | 0.86         | 1.40              | 62.79            |
| G          | 0.76         | 13.43             | 12.67            | 1.20         | 39.53             |
| H          | 0.80         | 19.40             | 18.60            | 1.26         | 46.51             |
| B          | 11.51        | 6.57              | 18.05            | 18.50        | 3.93              |
| C          | 10.18        | 12.47             | 22.50            | 20.16        | 13.26             |
| G          | (cmol c)     | 14.89             | 46.27            | 18.69        | 5.00              |
| H          | kg⁻¹         | 16.52             | 62.27            | 21.89        | 22.98             |

Low organic material causes low soil buffer capacity was well, and macronutrient deficiency. Lack of organic material will affect on P availability in the soil. Both factors will affect on physical, chemical, and biological activities in the soil, Besides climatic and topographic factors.

Table 3 presents low organic material in the soil as indicated by low C-organic values of 0.67% and 0.86% in both (Situbondo and Sampang District soils) therefore adding biochar was highly
required. In general, C-organic increases following the application of biochar. Application of 1,000 kg ha\(^{-1}\) increased soil C-organic contents by 13.43 and 34.42% (in Situbondo and Sampang District areas). Adding organic material will increase C-organic in the soil. The proper time of applying of organic material into might increase its nutrient, so that the organic material probably experienced mineralization process. More organic materials are applied, will cause better effects [17]. Crop may not grow optimally, if it has lack of nutrient [18]. Suggested that organic material could improve physical properties of the soil, such as turning the soil color to be darker and loose structure [3]. Organic material may increase microorganism activities in the soil. However, biochar is applied to improve dry land productivity, whereas biochar has higher pH and ability to retain nutrient so that nutrient is available for plant [6,9,19].

P in available form (P Bray 1) was very low in Situbondo soil, but sufficient in Sampang. The easiest way to provide available P. P is supplementing with TSP fertilizer or SP-36. However we should try an alternative of using P total, which is still under fixed condition to be released in available form by utilizing bacteria or alike.

P plays its role in forming cell, so that if the plant absorbs less P, its growth will be inhibited. Maximum P is available under pH 6 to 7 [20]. Biochar may increase P availability in alkaline soil due to P reactivity increases and forms compound that could not dissolved with Ca [21]. It is different from other organic materials in the soil, in which biochar is stronger in absorbing P [22].

Biochar is able to increase pH of the soil. It meaning that biochar could neutralize the soil pH [23]. Suggested that application of 5% biochar could neutralize pH of the soil. pH value of the charcoal depends on temperature of the pyrolysis and age of the charcoal material used ranges 11 in fresh condition (has not decayed/rotten) under pyrolysis temperature of higher than 450-500°C. When has been decayed exposed longer, and treated under the charcoal pH ranges 5-8 [24, 25].

Higher Ca cation content in the soil causes gher, its pH to base. The decreasing pH in relation with the application of biochar in basice soils soil is caused by the decreasing concentration of alkali metal oxides (for example, Ca\(^{2+}\), Mg\(^{2+}\) and K\(^{+}\)) due to ash of the biochar is base, while this research did not use the biochar ash [25]. Most of cation Ca\(^{2+}\), Mg\(^{2+}\) and K\(^{+}\) in the soil, which contained in biochar are not tied by electrostatic force, but exist as dissolved salt, therefore they are easily provided and absorbed by the plant [26]. The amount of dissolved P correlates with the released Ca and Mg, and it proves that P was previously bond by Ca and Mg [27].

Table 3 showed low CEC values of 10.18 and 17.80 cmol c kg\(^{-1}\) in Situbondo and Sampang District soils. In general, CEC increases following the application of biochar. Application of 1,000 kg ha\(^{-1}\) biochar increased soil CEC 6.57 to 62.27% and 3.93 to 22.98% in Situbondo and Sampang District.

The increase in the soil CEC value following the application of biochar is due to the formation of carboxylic group as a result of abiotic oxidation on exterior surface of the biochar particle [22]. This was the reason of the increase CEC following the application of biochar. CEC of the soil is standard to measure how good the nutrient is bound by the soil, so that it can retain the nutrient as a result of leaching process in the ground as well as loss of the soil surface. If the soil properties relating to nutrient retention can be improved, it means that the provided nutrient will be available for the plant [28]. Biochar is able to increase capacity in retaining water, and CEC providing nutrients to improve nutrient absorption, so that the soil fertility will increase as well [29].

3.2. Analysis result of the physical properties on soil
At the end of the research, 9 soil samples of the soil were taken, on the 9 treatments, in Situbondo and Sampang District, in order to find out the soil physical properties of the research at locations. The analysis results of the physical properties are presented in Table 4.

Table 4 shows that in Sampang District soil, the content weight (CW) along with the applications of biochar are lower, on average, even though they are very small. It also occurred during the fertilizer application in Situbondo District. Content Weight (CW) of soil will affect other physical properties such as soil porosity and water retention (pF).
Table 4. Analysis results on soil physical properties of the research sites located in Situbondo and Sampang District, in dry season I, 2018.

| Treatments | Cont-ent weight (CW) g cm⁻³ | Saturated hydraulic con-ductivity (SHC) cm jam⁻¹ | Mass Diameter Ratio (MDR) mm | pF (cm³ cm⁻³) | Pori (%) |
|------------|----------------------------|---------------------------------------------|----------------------------|--------------|---------|
|            |                            |                                             |                            | 0  | 2  | 2.5 | 4.2 | Macro | Micro | Meso |
| Situbondo District |
| A          | 1.19                       | 21.3                                        | 0.71                        | 0.525 | 0.282 | 0.267 | 0.138 | 26   | 13    | 14   |
| B          | 1.30                       | 34.5                                        | 0.78                        | 0.475 | 0.297 | 0.276 | 0.139 | 20   | 14    | 14   |
| C          | 1.38                       | 32.3                                        | 0.57                        | 0.468 | 0.313 | 0.292 | 0.148 | 18   | 14    | 15   |
| D          | 1.29                       | 38.0                                        | 0.36                        | 0.486 | 0.266 | 0.256 | 0.127 | 23   | 13    | 13   |
| E          | 1.38                       | 13.7                                        | 0.56                        | 0.507 | 0.321 | 0.301 | 0.152 | 21   | 15    | 15   |
| F          | 1.16                       | 16.2                                        | 0.52                        | 0.540 | 0.265 | 0.252 | 0.141 | 29   | 11    | 14   |
| G          | 1.29                       | 16.4                                        | 0.84                        | 0.498 | 0.289 | 0.274 | 0.177 | 22   | 10    | 18   |
| H          | 1.15                       | 32.6                                        | 0.55                        | 0.490 | 0.263 | 0.247 | 0.126 | 24   | 12    | 13   |
| I          | 1.08                       | 18.0                                        | 0.80                        | 0.479 | 0.280 | 0.263 | 0.148 | 22   | 11    | 15   |
| Sampang District |
| A          | 1.28                       | 1.7                                         | 2.01                        | 0.501 | 0.352 | 0.335 | 0.201 | 17   | 13    | 20   |
| B          | 1.41                       | 0.1                                         | 3.75                        | 0.489 | 0.393 | 0.476 | 0.230 | 11   | 15    | 23   |
| C          | 1.50                       | 0.3                                         | 3.65                        | 0.476 | 0.403 | 0.393 | 0.247 | 8    | 15    | 25   |
| D          | 1.47                       | 0.1                                         | 2.01                        | 0.491 | 0.384 | 0.372 | 0.234 | 12   | 13    | 24   |
| E          | 1.31                       | 1.2                                         | 3.00                        | 0.717 | 0.362 | 0.334 | 0.198 | 38   | 14    | 20   |
| F          | 1.39                       | 0.2                                         | 2.79                        | 0.701 | 0.394 | 0.372 | 0.234 | 33   | 14    | 23   |
| G          | 1.42                       | 0.2                                         | 4.18                        | 0.650 | 0.384 | 0.366 | 0.266 | 28   | 13    | 24   |
| H          | 1.42                       | 0.4                                         | 4.76                        | 0.480 | 0.378 | 0.358 | 0.223 | 12   | 14    | 22   |
| I          | 1.50                       | 0.1                                         | 3.82                        | 0.503 | 0.410 | 0.400 | 0.250 | 10   | 15    | 25   |

Soil density and ability of the roots to permeate water has closely related to Content Weight. More research have shown physical properties improvement of the soil as a result of the application of organic soil conditioner, for example, increasing percentage of soil particle in aggregate form increasing percentage of big and steady aggregate, as well as decreasing percentage of the smaller aggregate, and reducing the Content Weight (CW), increasing the aggregate stability, and reducing penetration resistance of the soil [30 – 35].

Table 4 presents that the adding of biochar in treatment by code B, C, G, and H, both in Sampang and Situbondo Regencies tend to increase for macro and meso pores. The increase biochar, which has not optimal yet, is caused by shorter incubation period and quality of the biochar. Several researches showed that the effect of biochar application on physical properties of the soil took longer than the chemical properties. Biochar effectiveness highly depends on chemical and physical properties of the biochar, which are determined by type of the raw material (soft wood, hard wood, rice hull, and etc.), as well as the carbonization method (type of burning tool, temperature), and the biochar forms (solid, powder, active carbon) [7]. Suggested the application of 7 criteria to assess quality of the biochar for soil conditioner, which include (1) pH, (2) volatile content, (3) ash level, (4) capacity to retain water, (5) BD (Bulk Density), (6) pore volume, and (7) specific surface area [36].

Total porosity is comparison between percentages of pore space in the soil against soil volume. Soil pore is unfilled part of the soil (filled with air and water). Soil pore is divided into macro pore and micro pore. Macro pore is filled with air or gravitation water (water which is easily removed due to gravity), and micro pore is filled with capillary water or air. Organic material, such as manure or biomass as organic soil conditioner that play as aggregate stabilizer due to those materials may play as microaggregate, mesoaggregate, and mesoaggregate stabilizers. Its position and composition highly determine formation, distribution, and stability of the aggregate [37, 38].

Position of the organic matter as soil conditioner may locate: (1) between clay domain in microaggregate, (2) between microaggregates, but within mesoaggregate, (3) between mesoaggregates
in macroaggregate, and (4) between macroaggregate [30, 36]. The increasing size and stability of the aggregate will have positive effect on physical properties, such as increasing water retention capacity and amount of the available water, increasing macro and meso pores, increasing total porosity, improving soil aeration, as well as increasing soil permeability and infiltration. Besides that, improvement of the soil aggregation may decrease soil sensitivity to erosion [31, 39].

Macro pore increased almost 3 fold using crooked tobacco biochar compost combination in mediteran. Macro pore increased 21 to 24% using rise husk biochar combination or corn cob biochar dung combination in lithosol. However, the macro pore decreased 21% using single use of dung with in regosol [40].

Table 4 shows the effect of biochar application on treatment by codes B, C, G, and H toward pF level in Situbondo and Sampang District. It presents water moisture in the soil under diverse pressure starting from pF 0, 2, 2.5 and 4.2. Under pF 0, the entire pores are filled with water. Macro pore, which is filled with air will be substituted and forced to be filled with water. Average moisture under saturated condition is ± 50%. Some of them have higher moisture due to the organic matter maybe higher and may have higher ability to retain water. On pF 2.54 water of gravity (water, which easily loss due to gravity) has been loss. Such condition is socalled field capacity. In this condition, the moisture is the most optimal for plant to be applied by biochar on treatment in Sampang District, while the treatment without biochar, average moisture is lower. It showed that biochar could increase soil ability to retain moisture.

pF 4.2 is usually so-called as permanent wilting point. Macro and micro pores have no longer contained water. The plant is unable to absorb water anymore. Under permanent wilting point, it showed that the application of biochar, inSitubondo District, on the treatment B = 0.23, C = 0.25, G = 0.24, and H = 0.22, while without biochar, the moisture is lower, on average. It showed that biochar could increas soil ability to retain moisture. It also occurred on area of the research in Situbondo District. Average ability to retain moisture in Sampang District is higher than in Situbondo District, due to soil texture in Sampang District is finer (silty clay), meanwhile soil texture in Situbondo District. is more rough, such as clay.

Charcoal is able to create better habitat for symbiotic microorganism, such as mycorrhiza, due to its ability to retain water and air, as well as to create neutral environment, particularly in acid soil [10]. In Table 4, it shows that the application of biochar on treatment by codes B, C, G, and H (Situbondo and Sampang District) against SHJ. The table presents that SHJ on area of the research in Situbondo District is higher than in Sampang. It is due to area of the research in Sampang has silty clay soil. It causes the water flow is retained longer, so that it has small permeability SHJ. In both areas of the research (Situbondo and Sampang District), SHJ increase along with the application of biochar. It is due to biochar is able to improve structure, increase porosity, cavity in the soil, and increase content weight (BI).

Permeability (SHJ) is the fast and slow rate of water seeping into the soil through both macro and micro pores both horizontally and vertically. Slow or fast rate of soil permeability can be influenced by the amount of soil porosity, where the greater the porosity of the soil, the greater the rate of soil permeability, so that the movement of water and certain substances moves faster. The permeability value increases with the greater the porous soil. In drier soils, some of the pores are filled with air which blocks water flow [41].

Moreover, Table 4 shows that the application of biochar on treatment by codes B, C, G, and H (Situbondo and Sampang District) against MDR (soil structure). It shows that MDR in Sampang District is higher than 2, which indicates that the MDR is very stable. MDR in Situbondo ranges 0.36 to 0.86, it indicates that MDR is less stable. In the treatment by the application of biochar with code B, C, G, and H (Situbondo and Sampang District), MDR values are higher, on average. It means that the application of biochar may increase the aggregate stability in which it functions as cementing from fraction 2 of the soil.

Structure is defined as primary granular aggregation to be secondary granular that is restricted to each other by a natural space divider. It can be said that structure is a field term to describe soil
aggregation. Aggregate stability affects the soil resistance to strike of the rainfall. The stronger binding force among soil particles, the soil will be more difficult to be affected by any disturbing forces that derived from strike of the rainfall or water flow. The increase size and stability of the aggregate will positively affect on other physical properties of the soil, for example, increasing retention capacity of the water and amount of the available water, increasing macro and meso pores, increasing total porosity, improving soil aeration, as well as increasing soil permeability and infiltration. Besides that, soil aggregation improvement may decrease soil sensitivity to erosion [32, 39].

3.3. Corn growth

3.3.1. Plant height. The application of corn cob biochar 1,000 kg ha⁻¹ combined with 250 kg Urea ha⁻¹ + 300 kg NPK ha⁻¹ at 21, 42, and 63 DAP in Situbondo and Sampang District higher than rice husk biochar (Table 5). Results of DMRT test by level 5% at 63 DAP, fertilizer application of H = (250 kg Urea ha⁻¹ + 300 kg NPK ha⁻¹ + 1,000 kg corn cob biochar ha⁻¹) showed the highest growth, 251.38 cm (Situbondo District), which significantly different with other treatment. Results of DMRT test by level 5% at 63 DAP, fertilizer application of H = (250 kg Urea ha⁻¹ + 300 kg NPK ha⁻¹ + 1,000 kg corn cob biochar ha⁻¹) showed the highest growth, but not different from treatment B, C, and G (Sampang District).

The application of corn cob biochar 1,000 kg ha⁻¹ combined with 250 kg Urea ha⁻¹ + 300 kg NPK ha⁻¹ at 21, 42, and 63 DAP in Situbondo and Sampang District higher than rice husk biochar (Table 5). Results of DMRT test by level 5% at 63 DAP, fertilizer application of H = (250 kg Urea ha⁻¹ + 300 kg NPK ha⁻¹ + 1,000 kg corn cob biochar ha⁻¹) showed the highest growth, 251.38 cm (Situbondo District), which significantly different with other treatment. Results of DMRT test by level 5% at 63 DAP, fertilizer application of H = (250 kg Urea ha⁻¹ + 300 kg NPK ha⁻¹ + 1,000 kg corn cob biochar ha⁻¹) showed the highest growth, but not different from treatment B, C, and G (Sampang District).

| Treatments | Situbondo District | Plant Heigh (cm) | Sampang District |
|------------|--------------------|------------------|------------------|
|            | 21 DAP(⁵) | 42 DAP(⁵) | 63 DAP(⁵) | 21 DAP(⁵) | 42 DAP(⁵) | 63 DAP(⁵) |
| A          | 28.54 ab  | 104.66 a    | 170.59 a    | 21.58 a  | 125.33 b | 168.00 a   |
| B          | 27.74 a   | 118.77 cd   | 219.20 bc   | 24.78 a  | 95.78 a  | 195.51 bc  |
| C          | 29.46 abcd | 121.43 cd   | 227.32 bc   | 25.19 a  | 134.95 b | 210.83 c   |
| D          | 29.10 abcd| 114.73 bc   | 194.61 ab   | 24.11 a  | 95.00 a  | 170.09 a   |
| E          | 31.03 cd  | 109.96 ab   | 166.19 a    | 21.59 a  | 88.07 a  | 184.47 ab  |
| F          | 30.45 bcd | 106.90 a    | 199.97 ab   | 22.10 a  | 123.21 b | 178.53 ab  |
| G          | 29.04 abc | 124.70 de   | 223.93 bc   | 26.08 a  | 98.09 a  | 206.51 c   |
| H          | 31.10 d   | 129.51 e    | 251.38 d    | 26.58 a  | 147.50 b | 214.09 c   |
| I          | 30.53 bcd | 110.78 ab   | 166.19 a    | 23.93 a  | 93.82 a  | 182.88 ab  |
| CV         | 5.03      | 4.46         | 4.80         | 14.69    | 13.16    | 6.52        |

Note: The numbers followed by the same letter in the same column are not significantly different from the DMRT at the 5%; ns = non significant; s = significant.

The application of biochar, made of corn cob biochar and rice husk biochar has increased height of plant at 63 DAP, which is significantly higher than without biochar application. The application of biochar made of cacao shell will increase plant height at 90 DAP, which is significantly higher than biochar from rice husk biochar. During the first and third planting seasons, there was no different effect of biochar types. Both types of biochar are able to support rice growth during three planting seasons in the ricefield, where the soil has further decomposition [42].
Suggested that plant height of maize has significant effect and positive correlation with numbers of leaf and numbers of seed per ear with \( r = 0.484 \) and \( r = 0.592 \). It showed that the higher the plant, the greater numbers of leaf and seeds per ear will be produced. Besides that, height of the maize plant has positive correlation with strong relation against seed weight and dry weight of maize with \( r = 0.721 \) and \( r = 0.700 \). It is presumed that the correlation is due to plant height may affect numbers of leaf, seed weight and dry weight of maize, due to leaf is the place where photosynthesis takes place, so that the higher photosynthetic process will increase yield of the plant [43].

The application of biochar from coconut shell tends to make the plant grows higher than without biochar application. The increase tendency of the maize height as a result of biochar is caused by ability of the biochar to retain nutrients due to positive (+) and negative (-) charges, so that the nutrients will be prevented from leaching process and it can be utilized by the plant [44, 45, 46].

3.3.2. Stem diameter. Results for analysis of variance showed that the application of fertilizer 250 kg Urea ha\(^{-1}\) + 300 kg NPK ha\(^{-1}\) + 1,000 kg corn cob biochar ha\(^{-1}\) at 21, 42, and 63 DAP have resulted stem diameter 0.46 cm, 2.11 cm, 2.74 cm (Situbondo District), and 0.39 cm, 2.10 cm, 2.44 cm (Sampang District) (Table 6).

Results for analysis of variance showed that the application of fertilizer 250 kg Urea ha\(^{-1}\) + 300 kg NPK Phonska ha\(^{-1}\) + 1,000 kg corn cob biochar ha\(^{-1}\) at 21, 42, and 63 DAP have resulted stem diameter 0.46 cm, 2.11 cm, 2.74 cm (Situbondo District), and 0.39 cm, 2.10 cm, dan 2.44 cm (Sampang District) (Table 6).

Table 6. The effect of fertilizer application on stem diameter at 21, 42, and 63 DAP on dry land, Dry Season I, 2018, Situbondo and Sampang District.

| Treatments | Stem Diameters (cm) |
|------------|---------------------|
|            | Situbondo District   | Sampang District  |
|            | 21 DAP\(^{(m)}\) | 42 DAP\(^{(s)}\) | 63 DAP\(^{(s)}\) | 21 DAP\(^{(m)}\) | 42 DAP\(^{(s)}\) | 63 DAP\(^{(s)}\) |
| A          | 0.37 a              | 1.56 b             | 2.05 ab           | 0.29 a              | 1.64 a              | 1.95 a              |
| B          | 0.44 a              | 1.85 e             | 2.42 d            | 0.39 a              | 1.90 d              | 2.30 d              |
| C          | 0.40 a              | 1.92 ef            | 2.54 de           | 0.37 a              | 2.04 e              | 2.37 de             |
| D          | 0.43 a              | 1.64 c             | 2.54 c            | 0.33 a              | 1.84 cd             | 2.05 b              |
| E          | 0.41 a              | 1.38 a             | 2.13 bc           | 0.25 a              | 1.74 b              | 1.88 a              |
| F          | 0.43 a              | 1.45 a             | 1.96 a            | 0.31 a              | 1.86 d              | 2.17 c              |
| G          | 0.42 a              | 1.95 f             | 2.62 ef           | 0.35 a              | 2.05 e              | 2.42 e              |
| H          | 0.46 a              | 2.11 g             | 2.74 f            | 0.39 a              | 2.10 e              | 2.44 e              |
| I          | 0.39 a              | 1.72 d             | 2.16 bc           | 0.33 a              | 1.78 bc             | 2.06 b              |
| CV (%)     | 9.47                | 3.50               | 4.80              | 14.78               | 2.63                | 2.36                |

Note : The numbers followed by the same letter in the same column are not significantly different from the DMRT at the 5%; ns = non significant; s = significant.

Results of DMRT test by level 5% at 42 DAP, the application of 250 kg Urea ha\(^{-1}\) + 300 kg NPK ha\(^{-1}\) + 1,000 kg corn cob biochar ha\(^{-1}\) resulted the greatest stem diameter (Situbondo District), and significantly different with other treatments, whereas in Sampang District, stem diameter, even though it is insignificantly different with C and G, but it is significantly different with treatment B.

Stem enlargement does not only depend on nutrient supply, which is absorbed by the plant, but also the genetic factor. Stem enlargement is caused by some factors, for example, the external factors include nutrients which play in water by transporting the nutrient from the ground, and internal factors include types and varieties of the plant, most of the excellent vegetative phase is shown by the plant height [47].

Fertilizer application of \( \frac{1}{4} \) NPK standard + organic standard and \( \frac{1}{2} \) NPK standard + organic standard are still able to provide nutrients for vegetative growth, such as stem diameter, but by entering the reproductive phase, the need for nutrients will increase [48].
3.3.3. Yield component (weight of 100 seeds, weight per cob, and dry seeds yield of corn). Results for analysis of variance showed that the application of biochar from rice husk biochar as well as corn cob biochar have produced higher weight of 100 seeds and weight per cob, even it is statistically insignificant and has significant effect on dry seeds yield of corn in Situbondo District. Results for analysis of variance showed that the application of biochar from rice husk biochar as well as corn cob biochar have significant effect on weight of 100 seeds, weight per cob, and dry seeds yield of corn in Sampang District (Table 7).

The highest weight of 100 seeds was obtained by the application of fertilizer $H = (250$ kg Urea ha$^{-1} + 300$ kg NPK ha$^{-1} + 1,000$ kg corn cob biochar ha$^{-1}$) 48.14 g, higher than other treatments even it is statistically non significant (Situbondo District). The highest weight of 100 seeds was obtained by the treatment of $H = (250$ kg Urea ha$^{-1} + 300$ kg NPK ha$^{-1} + 1,000$ kg corn cob biochar ha$^{-1}$) 36.85 g even though it did not show significant difference with fertilizer application of C, D, E, and F or increase 4.91% in comparison with the recommended dose of chemical fertilizer (treatment B) 35.23 g (Sampang District).

Table 7. The effect of fertilizer on weight of 100 seeds, weight per cob, and dry seeds yield of corn with moisture level 14%, Dry Season I, 2018, Situbondo and Sampang District.

| Treatments | Situbondo District | | | Sampang District | | |
| --- | --- | --- | --- | --- | --- | --- |
| | Weight of 100 seeds (grams$^{(a)}$) | Weight per cob (grams$^{(a)}$) | Dry seeds yield of corn (tons/ha)$^{(a)}$ | Weight of 100 seeds (grams$^{(a)}$) | Weight per cob (grams$^{(a)}$) | Dry seeds yield of corn (tons/ha)$^{(a)}$ |
| A | 43.54 a | 226.54 a | 5.26 a | 30.79 ab | 187.10 a | 5.25 a |
| B | 45.84 a | 240.19 a | 7.16 e | 32.55 abc | 208.01 b | 6.43 d |
| C | 46.03 a | 249.55 a | 7.34 e | 34.39 bcd | 217.30 b | 6.84 e |
| D | 43.97 a | 241.86 a | 5.40 a | 30.67 ab | 206.86 b | 5.26 ab |
| E | 43.46 a | 239.35 a | 5.78 b | 32.59 abc | 199.53 ab | 5.92 c |
| F | 44.42 a | 258.08 a | 6.71 c | 30.18 a | 206.38 b | 6.25 d |
| G | 46.77 a | 262.73 a | 7.64 f | 35.95 cd | 216.63 b | 7.48 f |
| H | 48.14 a | 267.36 a | 7.87 f | 36.85 d | 246.57 c | 7.63 f |
| I | 44.26 a | 243.36 a | 6.32 c | 34.03 abcd | 210.21 b | 5.45 b |
| CV (%) | 7.36 | 8.15 | 3.00 | 7.02 | 5.72 | 2.20 |

Note: The numbers followed by the same letter in the same column are not significantly different from the DMRT at the 5%; ns = non significant; s = significant.

Dry weight of 100 seeds describes size and full grain as indicator of seed quality. Higher dry weight of 100 seeds means that the seeds have high quality. Ear formation and seed filling describe the function of photosynthate, which is translocated for reproductive organs development. Moreover, the increasing dry weight of seed relates to the extent of photosynthate translocation to the seeds, the increasing nutrient status in the soil and better rooting system of the plant to absorb nutrients from the ground. High photosynthate translocation to the reproductive organs makes the ear formation and seed filling has run well and the formed seeds produce full grain and bigger size that depend on development of the photosynthetic organs and the environmental supports [49].

The application of Empty Recemus of Palm Oil (ECPO) 50 g polybag$^{-1}$ may increase ear weight of sweet corn without cornhusk and show significantly difference in comparison with no application of biochar ECPO, as well as the application of mycorrhiza 15 g plant$^{-1}$ show the increase of ear weight without cornhusk and has significantly difference in comparison without the application of mycorrhiza, but insignificantly difference with the application of mycorrhiza by dose 10 g plant$^{-1}$. The combination of biochar ECPO 37.5 g polybag$^{-1}$ and mycorrhiza 15 g plant$^{-1}$ showed the highest weight of cob without cornhusk in comparison with other combination and significantly different than without the application of ECPO and mycorrhiza [50].

Results for analysis of variance showed that dose combination between biochar and NPK have significant effect on yield of harvest. Yield of harvest showed that treatment combination between
biochar 2 t ha⁻¹ and NPK 180 kg ha⁻¹ produced higher yield of harvest, but insignificantly difference with the application of biochar 0 t ha⁻¹ and 180 kg ha⁻¹. The results showed that the biochar application along with reduction 40% inorganic fertilizer produce the same yield, on average, in comparison with no application of biochar and without reducing dose of inorganic fertilizer. Adding 2 t ha⁻¹ biochar and 45% dose of inorganic fertilizer will also produce higher yield than without biochar and dose of NPK 100%. Based on the combination yield of biochar 4 t ha⁻¹ and NPK 180 kg ha⁻¹ showed the increase of harvest yield, 12%, in comparison with the application of biochar 0 t ha⁻¹ with dose of NPK 300 kg ha⁻¹. It is due to biochar is able to increase absorption of the plant to NPK. The higher absorption of the plant, the yield will be optimal [51].

Adding organic matter in the soil will be able to increase development of microorganism in the soil. Biochar plays the role as habitat for the growth of useful microorganism. Biochar has micro pores that can be used as habitat for microorganism, which may reduce competition among microorganism, so that biological activities will increase. Higher activity of the microorganism in the soil may increase nutrient availability in the soil, so that the plant will be able to absorb nutrient and increase production of the plant [52].

Weight of seed per plant and yield of grains per hectare are significantly affected by dose of fertilizer application. Adding N 225 kg ha⁻¹ will increase weight of seeds per plant and yield of seeds reach 8.9 t ha⁻¹ and become 12.7 t ha⁻¹. P is useful for seed formation and it could stimulate the root growth, which plays important role in absorbing water and nutrient. P is required since early growth, both in vegetative and generative phases [53, 54].

Treatment without biochar showed lower maize yields than with biochar. The application of biochar 2 t ha⁻¹ and 4 t ha⁻¹ was able to reduce fertilizer dose by up to 45%. Yields of biochar treatments 2 t ha⁻¹ and NPK180 kg ha⁻¹ were 12.75 t ha⁻¹ an increased 0.7% from the application of biochar 0 t ha⁻¹ and NPK 300 kg ha⁻¹ with yields of 12.66 t ha⁻¹. Meanwhile, yield of harvest from the treatment of 4 t ha⁻¹ and NPK 180 kg ha⁻¹ was 14.20 t ha⁻¹ and increased of 12.16% from the 0 t ha⁻¹ and NPK 300 kg ha⁻¹ [55].

3.4. Analysis on corn farming per hectare in Situbondo and Sampang District, dry season I, 2008

Profit rate and efficient farming are indicator of success in farming or properness of the farming technology that being managed. In order to determine the profitable dose of fertilizer, input – output analysis was conducted by an assumption that the calculated production cost is cost for providing production means and fertilizer application and harvest cost, whereas miscellaneous costs are assumed equal for all treatments. Financial analysis of maize farming is presented in Table 8 and 9.

Selling price of grain is IDR 3,500 kg⁻¹. In this analysis, change or additional cost are calculated as a result of different fertilizer application, farming cost, and output value due to different fertilizer application. Net income (profit) is calculated by reducing the sale value of grain yield and fertilizer cost, as well as harvest cost, and other farming costs (labor costs and cost of production facilities), so that profit of the fertilizer application can be calculated.

Results of financial analysis on maize farming in Situbondo District over fertilizer treatment of H = (250 kg Urea ha⁻¹ + 300 kg NPK ha⁻¹ + 1,000 kg corn cob biochar ha⁻¹), and the highest yield of dry seeds yield of corn and the highest net income (profit) is IDR 15,486,000 by R/C-ratio = 2.28. The lowest fertilizer application is inorganic and organic fertilizer A = (200 kg Urea ha⁻¹ + 200 kg NPK ha⁻¹ + 1,000 kg organic fertilizer ha⁻¹) produced dry seeds yield of corn and net income (profit) is IDR 8,660,000,- by R/C-ratio = 1.89. Results of financial analysis on maize farming in Sampang District over fertilizer treatment of H = (250 kg Urea ha⁻¹ + 300 kg NPK ha⁻¹ + 1,000 kg corn cob biochar ha⁻¹), and the highest dry seeds yield of corn and the highest net income (profit) is IDR 14,421,000,- by R/C-ratio = 2.17. The lowest fertilizer application is inorganic and organic fertilizer A = (200 kg Urea ha⁻¹ + 200 kg NPK ha⁻¹ + 1,000 kg organic fertilizer ha⁻¹) produced dry seeds yield of corn and net income (profit) is IDR 8,445,000,- by R/C-ratio = 1.87.
Table 8. Financial analysis on farming by the fertilizer application on yield of maize over the area one (1,0) hectare, Situbondo District, Dry Season I, 2018 (x IDR.000).

| Activity                  | A  | B  | C  | D  | E  | F  | G  | H  | I  |
|---------------------------|----|----|----|----|----|----|----|----|----|
|                           | Unit | Price (IDR) | Unit | Price (IDR) | Unit | Price (IDR) | Unit | Price (IDR) | Unit | Price (IDR) | Unit | Price (IDR) | Unit | Price (IDR) |
| A. Labor (WWD)            |     |       |     |       |     |       |     |       |     |       |     |       |     |       |
| 1. Tillage                | 10  | 1,000 | 10  | 1,000 | 10  | 1,000 | 10  | 1,000 | 10  | 1,000 | 10  | 1,000 | 10  | 1,000 |
| 2. Planting               | 22  | 1,320 | 22  | 1,320 | 22  | 1,320 | 22  | 1,320 | 22  | 1,320 | 22  | 1,320 | 22  | 1,320 |
| 3. Fertilization          | 8   | 480  | 8   | 480  | 8   | 480  | 8   | 480  | 8   | 480  | 8   | 480  | 8   | 480  |
| 4. Weeding and Filling    | 20  | 1,200 | 20  | 1,200 | 20  | 1,200 | 20  | 1,200 | 20  | 1,200 | 20  | 1,200 | 20  | 1,200 |
| 5. Spraying               | 4   | 240  | 4   | 240  | 4   | 240  | 4   | 240  | 4   | 240  | 4   | 240  | 4   | 240  |
| 6. Irrigation             | 8   | 480  | 8   | 480  | 8   | 480  | 8   | 480  | 8   | 480  | 8   | 480  | 8   | 480  |
| 7. Pruning                | 22  | 1,320 | 22  | 1,320 | 22  | 1,320 | 22  | 1,320 | 22  | 1,320 | 22  | 1,320 | 22  | 1,320 |
| 8. Harvest                | 1,050 | 1,432 | 1,050 | 1,432 | 1,050 | 1,432 | 1,050 | 1,432 | 1,050 | 1,432 | 1,050 | 1,432 | 1,050 | 1,432 |
| 9. Post Harvest           | 12  | 720  | 12  | 720  | 12  | 720  | 12  | 720  | 12  | 720  | 12  | 720  | 12  | 720  |
| Total Labor               | 6,970 | 7,532 | 7,532 | 7,188 | 7,532 | 7,188 | 7,532 | 7,188 |
| B. Production Facility    |     |       |     |       |     |       |     |       |     |       |     |       |     |       |
| 1. Seed (kg)              | 25  | 1,125 | 25  | 1,125 | 25  | 1,125 | 25  | 1,125 | 25  | 1,125 | 25  | 1,125 | 25  | 1,125 |
| 2. Fertilizer (kg):       |     |       |     |       |     |       |     |       |     |       |     |       |     |       |
| 3. Urea                   | 200 | 360  | 200 | 360  | 200 | 360  | 200 | 360  | 200 | 360  | 200 | 360  | 200 | 360  |
| 4. NPK Phoska             | 200 | 460  | 200 | 460  | 200 | 460  | 200 | 460  | 200 | 460  | 200 | 460  | 200 | 460  |
| 5. Organic Fertilizer     | 1,000 | 500  | 1,000 | 500  | 1,000 | 500  | 1,000 | 500  |
| 6. Biofertilizer (Sachet) | 10  | 60   |     |       | 10  | 60   |     |       |
| 7. Biochar                | 1,000 | 2,000 | 1,000 | 2,000 | 1,000 | 2,000 | 1,000 | 2,000 |
| 8. Insecticide            | 5   | 300  | 5   | 300  | 5   | 300  | 5   | 300  |
| Total Means of Production | 2,745 | 4,245 | 4,245 | 2,000 | 2,745 | 4,245 | 2,000 | 4,245 |
| Total Cost Production     | 9,715 | 11,777 | 11,633 | 9,305 | 9,715 | 11,777 | 11,633 | 9,305 |
| Dry seeds yield of corn   | 5.25 | 7.16  | 7.34  | 5.40  | 5.25 | 7.16  | 7.34  | 5.40  |
| Grain gross income        | 18,375 | 25,600 | 25,600 | 18,900 | 18,375 | 25,600 | 25,600 | 18,900 |
| Net income (IDR)          | 8,660 | 14,057 | 14,057 | 9,595 | 8,660 | 14,057 | 14,057 | 9,595 |
| R/C ratio                 | 1.89 | 2.13  | 2.21  | 2.03  | 1.89 | 2.13  | 2.21  | 2.03  |

Notes: Price : Urea = IDR 1,800,-/kg; NPK = IDR 2,300,-/kg; Organic Fertilizer = IDR 500,-/kg; Biofertilizer = IDR 6,000,-/sachet; Biochar = IDR 2,000,-/kg; Selling price of grain is IDR 3,500,-/kg in Situbondo District in July 2018; It is assumed that the production cost is equal except fertilizer and harvest costs; Net income is total sale value minus fertilizer cost, labor costs, production facility costs, and harvest cost (IDR 200,-/kg).
### Table 9. Financial analysis on farming by the fertilizer application on yield of maize over the area one (1.0) hectare, Sampang District, Dry Season I, 2018 (x IDR,000).  

| Activity                  | A          | B          | C          | D          | E          | F          | G          | H          | I          |
|---------------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                           | Unit       | Proc. Unit | Unit       | Proc. Unit | Unit       | Proc. Unit | Unit       | Proc. Unit | Unit       |
| 1. Tillage                | 14         | 1,050      | 14         | 1,050      | 14         | 1,050      | 14         | 1,050      | 14         |
| 2. Planting               | 20         | 1,000      | 20         | 1,000      | 20         | 1,000      | 20         | 1,000      | 20         |
| 3. Fertilization          | 6          | 450        | 6          | 450        | 6          | 450        | 6          | 450        | 6          |
| 4. Weeding and Filling    | 20         | 1,000      | 20         | 1,000      | 20         | 1,000      | 20         | 1,000      | 20         |
| 5. Spraying               | 4          | 300        | 4          | 300        | 4          | 300        | 4          | 300        | 4          |
| 6. Irrigation             | 8          | 600        | 8          | 600        | 8          | 600        | 8          | 600        | 8          |
| 7. Pruning                | 6          | 450        | 6          | 450        | 6          | 450        | 6          | 450        | 6          |
| 8. Harvest                | 1,560      | 1,929      | 2,052      | 1,578      | 1,776      | 1,875      | 2,248      | 2,289      | 1,635      |
| 9. Post Harvest           | 8          | 600        | 8          | 600        | 8          | 600        | 8          | 600        | 8          |
| Total Labor               | 5,510      | 7,579      | 7,502      | 7,026      | 7,226      | 7,325      | 7,696      | 7,739      | 7,085      |
| 1. Seed (kg)              | 25         | 1,125      | 25         | 1,125      | 25         | 1,125      | 25         | 1,125      | 25         |
| 2. Fertilizer (kg):       |            |            |            |            |            |            |            |            |            |
| 1. Urea                   | 200        | 360        | 200        | 360        | 200        | 360        | 200        | 360        | 200        |
| 4. NPK                    | 200        | 460        | 200        | 460        | 200        | 460        | 200        | 460        | 200        |
| 5. Organic Fertilizer     | 1,000      | 500        | 1,000      | 500        | 1,000      | 500        | 1,000      | 500        | 1,000      |
| 6. Biofertilizer (Sachet) |            | 10         | 60         | 10         | 60         | 10         | 60         | 10         | 60         |
| 7. Biochar                | 1,000      | 2,000      | 1,000      | 2,000      | 1,000      | 2,000      | 1,000      | 2,000      | 1,000      |
| 8. Insecticide            | 4          | 280        | 4          | 280        | 4          | 280        | 4          | 280        | 4          |
| Total Means of Production | 2,745      | 4,225      | 4,225      | 4,225      | 2,505      | 2,655      | 3,065      | 4,545      | 4,545      |
| Total Cost Production (IDR)| 9,755      | 11,604     | 11,727     | 9,333      | 9,991      | 10,390     | 12,243     | 12,284     | 9,710      |
| Dry seeds yield of corn (tons/ha) | 5.20 | 6.43 | 6.84 | 5.26 | 5.92 | 6.25 | 7.48 | 7.63 | 5.45 |
| Gain gross income (IDR)   | 18,200     | 22,505     | 22,680     | 18,410     | 20,720     | 21,875     | 26,180     | 26,705     | 19,075     |
| Net income (IDR)          | 8,445      | 10,901     | 10,953     | 9,077      | 10,297     | 11,455     | 13,937     | 14,421     | 9,365      |
| Ratio: Biofertilizer/Urea | 1.87       | 1.64       | 1.51       | 1.97       | 2.07       | 2.11       | 2.14       | 2.07       | 1.96       |

Notes: Price: Urea = IDR 1,800,-/kg; NPK = IDR 2,300,--/kg; Organic Fertilizer = IDR 5,000,-/kg; Biofertilizer = IDR 6,000,-/sachet; Biochar = IDR 2,000,-/kg; Selling price of grain is IDR 3,500,-/kg in Sampang District in July 2018; It is assumed that the production cost is equal except fertilizer and harvest costs; Net income is total sale value minus fertilizer cost, labor costs, production facility costs, and harvest cost (IDR 300,-/kg).
The amount of gross income depends on amount of the yield (grains) multiplied grain price per kg minus the production costs (labor costs and cost of production facilities. In general, the technology of fertilizer application using biochar, both from rice husk biochar, is prospecting and should be developed. It can be seen from R/C-ratio, which is higher than 1 (>1). It showed that the fertilizer application technology, which is introduced to the farmers, is economically worth it and good enough. R/C ratio or B/C ratio is profitable if R/C ratio or B/C ratio is higher than one. R/C ratio or B/C ratio > 1 means that the business has run sufficiently [14]. It can be said that from farming operation side, technology that applying soil conditioner of biochar, from maize ear and rice hull, is worth to be developed.

The profit and cost aspect in farming operation is important to be considered, whereas the maize farmers usually have limited cost and low productivity. It is expected that each farming technology can be adopted by the farmer. Therefore, in order to be easily adopted by the farmers, such technology should be easily applicable and profitable [56].

4. Conclusions
The results showed that the application of RRIF + 1,000 kg corn cob biochar ha\(^{-1}\) in Situbondo District obtained yields of dry seeds yield of corn 7.87 t ha\(^{-1}\) (increased of 36.16%), C-organic (increased of 19.40%), soil CEC (increased of 62.27%), obtained the highest profit of IDR 15,486, or increased of 42.21% from the RRIF and R/C ratio 2.28.

The results showed that the application of RRIF + 1,000 kg corn cob biochar ha\(^{-1}\) in Sampang District obtained yields of dry seeds of corn 7.63 t ha\(^{-1}\) (increased of 28.89%), C-organic (increased of 46.51%), soil CEC (increased of 22.98%), obtained the highest profit of IDR 14,421,000 or increased of 25.60% from the RRIF and R/C ratio 2.17.

References
[1] Suriadikarta D A, Trihatini, Setyorini and Hartatik W 2000 Teknologi pengelolaan bahan organik tanah dalam Di dalam: Teknologi Pengelolaan Lahan Kering Menuju Pertanian Produktif dan Ramah Lingkungan (in Bahasa) (Bogor: Pusat Penelitian dan Pengembangan Tanah dan Agroklimat) pp 183–238
[2] Tang J, Zhu W, Kookana R and Katayama A. 2013. Characteristics of biochar and its application in remediation of contaminated soil. *Journal of Bioscience and Bioengineering* 116 653-659
[3] Vaccari, F 2011 Biochar as a strategy to sequester carbon and increase yield in durum wheat *European Journal of Agronomy* 34 231 – 238
[4] Lehmann J 2011 Biochar effects on soil Biota-Review *Soil Biology and Biochemistry* 43 1812-1836
[5] Arsyad S 2000 *Soil and Water Conservation, Institute for Information Resources* (Bogor Agricultural University: IPB Press)
[6] Glaser B, Lehmann J and Zech W 2002 Ameliorating physical and chemical properties of highly weather soils in the tropic charcoal, A review *Biology and Fertility of Soils* 35 219–230
[7] Ogawa M 2006 *Carbon sequestration by carbonization of biomass and forestation three case studies* pp 133 – 146
[8] Nurida N L, Dariah and Rachman A 2013 Soil quality improvement with agricultural waste biochar soil repairer *Journal of Soil and Climate* 37 69–78
[9] Zhu O, Peng X, Huang T, Xie Z and Holden N M 2014 Effect of biochar addition on maize growth and nitrogen use efficiency in Acid Red Soil *Pedosphere* 24 690-708
[10] Knoblauch, Maanfat C A A, Pfeiffer E M and Haefele S M 2010 Impact of black carbon on trace gas production and turnover in soils *Soil Biol. Biochem.* 32 1337–1342
[11] Harahap E M 2000 Making organic acids for fertilizer Workshop on developing entrepreneurship cultivation through teaching materials Department of Soil Science FP-USU
[12] Gomez A K and Gomez A 1993 Statistical Procedures for Agricultural Research 2nd Edition Los Banos
[13] Sastrosupadi A 2005 Practical Experiment Design in Agriculture Kanisius Yogyakarta p 243
[14] Soekartawi and Soeharjo A 2011 Farming science and research for smallholder development (Jakarta: UI Press)
[15] Mullen M D 1999 Transformation of other elements In Principles and Applications Soil Microbiology (New Jersey: Prentice-Hall)
[16] Nyakpa M Y, Lubis A M, Pulung, Munawar A G, Hong G B and Hakim N 1988 Soil Fertility (Lampung: Lampung University)
[17] Sutedjo and Mulyani S 2002 Fertilizers and Fertilization Methods (Jakarta: Rineka Cipta)
[18] Iskandar D 2003 Effect of fertilizer dosage N P on growth and production of sweet corn in dry land Proceedings of the Technology Conference for the Country 2 1-5
[19] Nurida N L, Dariah A and Sutono S 2015 An alternative soil repairer to increase productivity and soybean crops on acid dry land Journal of Soil and Climate 39 99 –109
[20] Poerwanto R 2003 Cultivation of fruits: the process of flowering and fertilization (Bogor: IPB Press) p 44
[21] De Luca T H, Derek M, MacKenzie J and Gundale M J 2009 Biochar effects on soil nutrient transformation United Kingdom: Earthscan Publisher p 251 – 270
[22] Cheng C H, Lehmann J, Thie J E, Burton S D and Engelhard M H 2006 Oxidation of black carbon through biotic and abiotic processes Organic Geochemistry 37 1477–1488
[23] Tambunan S, Siswanto B and Handayanto E 2014 Effect of application of fresh organic matter and biochar on the availability of P in the soil in dry land in South Malang Journal of Land and Land Resources 1 85–92
[24] Siringoringo H H and Siregar C A 2011 Effect of charcoal application on early growth of Michelia Montana Blume and changes in soil fertility properties in Latosol Soil types Conservation and Rehabilitation Research and Development Center, Bogor
[25] Steiner C, Teixeira W G, Lehmann J, Nehls T, de Macedo J L V, Blum, W E H and Zech W 2007 Long term effects of manure, charcoal and mineral fertilization on crop product and fertility on a highly weathered central Amazonian upland soil Plant and Soil 291 275–290
[26] Nurida N L 2014 The potential use of biochar for dry land rehabilitation in Indonesia Journal of Land Resources Special edition Characteristics and Variations of Agricultural Land Resources pp 57-68
[27] Kpomblekou A and Tabatabai M A 1994 Effect of organic acids on release of phosphorus from phosphate rocks Soil Sci. 15 442-453
[28] Sohi S, Lopez-Capel E, Krull E and Bol R 2009 Biochar, climate change and soil: A review to guide future research CSIRO Land and Water Science Report 05/09
[29] Lehman J and Joseph S 2009 Biochar for Environmental Management (United Kingdom: Earthscan Publisher) pp 127 – 143
[30] Suwardjo, Adimihardja A and Abujamin S 1989 The use of crop residue mulch to minimize tillage frequency Soil and Fertilizer Research Coverage 8 31-37
[31] Oades J M 1990 Association of colloids in soil aggregates Soil Colloids and their Association in Aggregates ed De Boodt M F, Hayes M H D and Herbillon A (New York: Plenum Press) pp 463-483
[32] Kurnia U 1996 Study of land rehabilitation methods to increase and conserve soil productivity Postgraduate Dissertation IPB Bogor.
[33] Tang J, Zhu W, Kookana R and Katayama A 2013 Characteristics of biochar and its application in remediation of contaminated soil Journal of Bioscience and Bioengineering 116 633-659
[34] Lu, Sakagamu G K, Tanaka H and Hamada R 1998 Role of organic matter in stabilization of stable aggregates in soil under different type of landuse Soil Sci Plant Nutr. 44 147-155
[35] Purnomo J, Mulyadi, Amien I and Suwardjo H 1992 Effect of various green matter of legume plants on damaged soil productivity Soil and Fertilizer Research Coverage 10 61-64
[36] Kuwagaki H and Tamura K 1990 Aptitude of wood charcoal to a soil improvement and other non fuel use In Technical report on the research development of the new uses of charcoal and pyrolineigious acid, technical research association for multiuse of carbonized material pp 27-44
[37] Emmerson W W and Greenland D J 1990 Soil aggregates formation and stability Soil Coloid and Their Assosiation in Agregate ed De Boodt M F, Hayes M H D and Herbillon A (New York: Plenum Press) pp 485-512
[38] Beare M H, Cabrera M I, Hendrik P F and Coleman D C 1994 Aggregate protected and unprotected organic matter pool in convensional and no tillage soils Soil Sci. Soc. Am. J. 58 786-795
[39] Emmerson W W and Greenland D J 1990 Soil aggregates formation and stability Soil Coloid and Their Assosiation in Agregate ed De Boodt M F, Hayes M H D and Herbillon A (New York: Plenum Press) pp 485-512
[40] Widowati, Sutoyo, Iskandar T and Karamina H 2017 Characterization of biochar combination with organic fertilizer: the effects on physical properties of some soil types Journal Bioscience Research 14 955–965
[41] Bintoro A, Wijayanto D and Isrun Soil physical characteristics of several land uses in Beka Village, Marawola Sub District, Sigi District Journal Agrotekbi 5 423–430
[42] Nurida N L, Sutono and Muchtar 2017 Utilization of biochar of cacao pods and rice husks to increase lowland rice productivity in ultisol Lampung Journal of the Assessment and Development of Agricultural Technology 20 69–80
[43] Aisyah A, Suastika I W and Retno S Effect of application of several sulfur fertilizers on residue, uptake and production of maize at Molisoli Jonggol, Bogor Journal of Land and Land Resources 2 93–101
[44] Apzani W, Sudantha I M and Fauzi M T 2015 Application of stimulator biocompost Trichoderma spp. And coconut shell biochar for growth and yield of maize (Zea mays L.) in kerosene fielding Journal Agrotechnology 9 21–35
[45] Syaikhu A H, Hariyono B and Suprayogo D 2016 Test the benefits of biochar and soil amendment to improve the physical properties of sandy soil and its impact on sugarcane growth and production Journal of Land and Land Resources 3 345-357
[46] Yunita O I 2012Potential Nutrients for Nitrogen, Phosphorus and Potassium in Sandy Soil using Biochar and Manure for Maize (Zea mays L.) Essay Mataram University
[47] Ramli 2014 Utilization of biochar of cacao pods and rice husks to increase lowland rice productivity in Ultisol Lampung Journal of the Assessment and Development of Agricultural Technology 20 69–80
[48] Erselia I, Respatie D W and Rogomulyo R 2017 Effect of dosage combination of NPK fertilizer and natural organic fertilizer enriched with functional microbes on growth and yield of maize (Zea mays L.) Journal of Regional Development Agribusiness 3 27–35
[49] Rahni N M 2012 The effect of PGPR phytohormones on the growth and yield of corn (Zea mays L.) Journal of Regional Development Agribusiness 3 27–35
[50] Tarigan A D and Nelvia 2020 Effect of biochar application of Oil Palm Empty Bunches (OPEB) and Mycorrhiza on growth and yield of sweet corn (Zea mays sachrrata L.) in Ultisol Soil Journal Agrotekbi 12 23–37
[51] Verdiana M A, Sebayang M T and Sumarmi T 2016 Effect of various doses of rice husk biochar and NPK fertilizer on growth and yield of corn Journal of Plant Production 4 611–616
[52] Widowati 2010 Production and application of biochar/charcoal in affecting soil and crops Dissertation of the Faculty of Agriculture Brawijaya University p 162
[53] Chan K Y, Van Zwieten L, Meszaros I, Downie A and Joseph S 2007 Agronomic values of greenwaste biochar as a soil amende ment Australian Journal of Soil Research 45 629 – 634

[54] Wahyudin A, Nurmala T and Rahmawati R D 2015 Effect of dosage of phosphorus and liquid organic fertilizers on growth and yield of green beans (Vigna radiate L.) on Jatinangor Ultisols Journal Kultivar 14 16–22

[55] Bakri 2003 The effect of Oil Palm Empty Bunches (OPEB) biochar and Mycorrhiza on growth and yield of sweet corn (Zea mays sacharrata L.) in Ultisol soil Journal Agroekotek 12(1) 23–37

[56] Budianto J 2000 Acceptability of agricultural technology for consumers Food Crops Research Symposium IV Food Crops Research Center Bogor pp 12-13