Application of biochar and compost to changes in physical and chemical properties of soil and corn yield on dry land

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Abstract. The purpose of this study was to determine the effect of biochar and compost fertilizer and their interactions on changes in the physical and chemical properties of soil and corn products on dry land. This experiment uses a randomized block design with factorial patterns. The first factor, the biochar dose consisted of 4 levels, namely: 0; 5; 10; and 15 tons ha^{-1}. The second factor, compost dosage consisted of 2 levels: 0 tons ha^{-1} and 20 tons ha^{-1}. The highest dry corn seed per ha was obtained from the treatment of 10 tons ha^{-1} biochar which was 9.21 tons which increased 35.56% compared to dry corn seeds per ha which were obtained from the treatment without biochar which was 6.79 tons. The treatment of compost doses of 20 tons ha^{-1} gave the highest value of dry corn seeds per ha, which was 8.73 tons, an increase of 16.58% compared to the lowest yield, which was 7.49 tons in the treatment without compost. The interaction between the treatment of biochar and compost dosages had no significant effect on all observed variables, except for organic C, available P, available K, and very significant CEC effect.

1. Introduction

Corn (*Zea mays* L.) is a food that is very important for humans and livestock. Distribution of corn cultivation continues to expand in various countries in the world as well as in Indonesia because these plants have extensive adaptability in the tropics [1]. Dryland is used for farming activities with limited water use, which usually comes from rainwater. Physically dry land is not irrigated or does not get irrigation water so the main source of water is rainfall and a small portion comes from groundwater [2].

The use of fertilizers in the world continues to increase in accordance with the increase in the agricultural area, population growth, increase in the level of intensification and the increasingly diverse use of fertilizers as an effort to increase agricultural yields. Organic fertilizers are environmentally friendly fertilizers, have long-term effects that are good for soil fertility, and produce agricultural products that are safe for health. Giving organic fertilizer can quickly overcome nutrient deficiency, has no problem in nutrient washing and is able to provide nutrients quickly. The organic fertilizers have many advantages when compared to inorganic fertilizers, namely fertilizers that have more complete nutrients, both macronutrients and micronutrients and organic fertilizers contain organic acids [3].

Compost is a type of organic fertilizer that comes from agricultural waste, municipal waste, industrial waste which has a major contribution to improving the physical, chemical and biological

properties of the soil. This is because compost contains a lot of organic material. Organic matter is an important ingredient in fertilizing soil because it functions to stabilize soil aggregates. In addition, organic matter has a number of latent energies as heating plant residues above the soil surface, i.e. 4-5 kilos cal g^{-1} of dry matter [4].

Biochar bamboo has a very micro-porous structure, with adsorption efficiency around ten times higher than traditional wood biochar [5]. Biochar has higher stability characteristics for decomposition and is able to absorb ions well than other organic materials, due to its larger surface area, negative surface and density [6]. The effect of biochar as soil enhancers on plant productivity is highly dependent on the dose used. The results of the research in the field showed that the utilization of bamboo waste biochar with a dose of 10 tons ha^{-1} gave a significant influence on plant height and total wet weight of corn plants [7]. Furthermore, the results of research on biochar and compost showed that the giving of 10 tons of ha^{-1} biochar and 20 tons ha^{-1} cow manure compost could increase the growth and yield of bisi-2 hybrid maize plants [8-11].

Based on this, it is necessary to conduct research to increase the productivity of maize plants as well as to develop the utilization of biochar and compost widely, with various experiments on biochar dose levels in corn plants. This study aims to determine the effect of biochar and compost and their interactions on changes in the physical and chemical properties of soil and maize crops on dry land.

2. Materials and methods

The materials used in this study were corn seeds, compost cow manure, biochar, and pesticides, while the tools used were hand tractors, hoes, shovels, scratches, machetes, meters, raffia ropes, and stationery.

This experiment used a randomized block design with factorial patterns. The treatment consisted of two factors: the dose of biochar (B) and compost (C). The first factor, the dose of biochar (B) consists of 4 levels, namely: 0 tons ha^{-1} (B0), 5 tons ha^{-1} (B1), 10 tons ha^{-1} (B2), 15 tons ha^{-1} (B3). The second factor, the dosage of compost (C), consisted of 2 levels: 0 tons ha^{-1} (C0) and 20 tons ha^{-1} (C1). Thus there were 8 combination treatments and each treatment was repeated 3 times, so there were 24 trial plots.

The variables observed were the physical properties of soil, soil chemistry, growth, and yield of corn plants, which included moisture content, weight volume, porosity, pH, organic C, N-total, available P, K-available, CEC, plant height, the yield of dry corn seeds per ha.

3. Results

Significance of the effect of the treatment of doses of biochar (B) and compost (C) and interaction (BxC) on the observed variables is presented in Table 1. Based on Table 1, the dose treatment of biochar (B) had a significant effect ($P<0.05$) to very significant ($P<0.01$) in all observed variables except bulk density, porosity, N, and P had no significant effect ($P> 0.05$). The treatment of compost doses (C) had no significant effect ($P> 0.05$) on all variables variables observed except for P-available and K-available, plant height, and the yield of dry corn seeds per ha, which had a very significant effect ($P<0.01$). The interaction between biochar and compost (BxC) dosage treatments had no significant effect ($P>0.05$) on all observed variables, except for organic C, P-available, K-available, and CEC, which had very significant effect ($P < 0.01$). The average of all variables was observed because the effect of biochar doses from bamboo and compost can be seen in Table 2.

Table 1. The significance of the effects of biochar and compost and their interactions on all observed variables.

No	Variable	Treatment		
		Biochar (B)	Compost (C)	Interaction (B x C)
1.	Water content (%)	*	ns	ns
2.	Bulk density (g m^{-3})	ns	ns	ns
3.	Porosity (%)	ns	ns	ns
4.	pH	**	ns	ns
5.	C-organic (%)	**	ns	**
6.	N-total (%)	ns	ns	ns
7.	P-available (ppm)	ns	**	**
8.	K-available (ppm)	**	**	**
9.	CEC (me/100g)	**	ns	**
10	Plant height (cm)	**	**	ns
11	The yield of dry corn seeds per ha (ton)	**	**	ns

* = significant effect, ** = very significant effect, ns = not significant effect

Table 2. The average of all variables observed due to the effect of doses of biochar from bamboo and compost.

Treatment	Bamboo Biochar (B)				Compost (C)	
	B0 (0 ton ha^{-1})	B1 (5 ton ha^{-1})	B2 (10 ton ha^{-1})	B3 (15 ton ha^{-1})	C0 (0 ton ha^{-1})	C1 (20 ton ha^{-1})
Water content (%)	7.71 b	9.03 ab	9.46 a	10.00 a	8.62 a	9.48 a
Bulk density (g m-3)	0.96 a	0.91 ab	0.90 ab	0.87 b	0.92 a	0.90 a
Porosity (%)	63.95 b	65.53 ab	66.19 ab	67.08 a	65.28 a	66.09 a
pH	6.63 ab	6.74 a	6.71 a	6.55 b	6.65 a	6.66 a
C-Organic (%)	4.01 a	3.83 a	3.82 a	3.39 b	3.69 a	3.83 a
N-total (%)	0.16 a	0.16 a	0.17 a	0.18 a	0.17 a	0.16 a
P-available (ppm)	35.52 b	37.65 b	46.89 a	39.45 ab	31.77 b	47.98 a
K-available (ppm)	592.18 d	836.24 c	978.88 b	1036.44 b	772.19 b	949.67 a
CEC (me/100g)	18.70 ab	16.84 b	12.16 c	19.71 a	16.62 a	17.09 a
Plant height (cm)	275.98 b	279.33 b	302.72 a	301.58 a	281.01 b	298.80 a
The weight of corn dried seeds per ha (ton)	6.79 b	7.66 b	9.21 a	8.79 a	7.49 b	8.73 a

Description: The average value followed by the same letter in the same treatment and row, means that it is not significantly different from the LSD 5% test level

4. Discussion

The results of this study indicate that the highest yield of dry corn seeds per ha was obtained from the treatment of 10 tons ha^{-1} biochar dose of 9.21 tons which increased by 35.56% compared to without biochar which was 6.79 tons.

The high yield of dried corn seeds per ha in the treatment of 10 tons of ha^{-1} biochar is caused by changes in the physical and chemical properties of biochar in the soil which can improve soil properties and yields of corn plants. The nature of biochar which has a porous structure with a larger surface area causes the soil to have the ability to retain nutrients and water in the soil. This is in line with the results of the pre-experimental soil analysis which when compared with the results of the analysis after treatment, showed a change in the improvement of soil physical properties and soil chemistry for the better (Table 2).

Biochar is very important to improve the ability of soil to store carbon, increase soil fertility, and maintain the balance of soil ecosystems, increase plant growth and yield by providing and maintaining nutrients [12,13].

The treatment of compost doses of 20 tons ha^{-1} gives the highest value of dry corn seed yield per ha, which is 8.73 tons, increasing by 16.58% compared to without compost, which is 7.49 tons. The high yield of dry corn seeds per ha is thought to be due to the nature of compost which can improve the physical and chemical properties of soil, this condition can be seen from the decrease in soil volume weight or soil compaction, increased soil porosity, soil water content, pH, organic C, P-available, K-available, and land CEC when compared to without compost treatment (Table 2). The compost can improve soil structure, improve porosity, enhance soil binding capacity to nutrients and water, help the weathering process of mineral materials, and increase the activity of microorganisms in the soil [14].

The weight of corn dried seeds at the treatment dose of biochar on changes in physical and chemical properties of soil and yields of maize on dry land was supported by a real correlation in the observed variables such as soil moisture content (r = 0.89**), weight of soil volume (r = -0.89**), porosity (r = 0.89**), organic C (r = -0.63*), N-total (r = 0.62*), P-available (r = 0.87**), K-available (r = 0.94**).

The results of the regression analysis of biochar doses with dry corn seed weight showed a quadratic relationship with the regression line equation: $Y = 6.659 + 0.3444X - 0.0129X^2$ with a coefficient of determination (R^2) of 57.30% (Figure 1). From the results of the regression analysis, the optimum dose was 13.35 tons ha^{-1}, with dry corn seed weight per hectare maximum of 8.96 tons. Based on the results of the regression analysis showed that the higher the increasing dose of biochar to optimum, then decreased when it exceeds the optimum dose. The results showed that the treatment of compost doses of 20 tons ha-1 (C1) gave the highest value of dry corn seed weight of 8.73 tons, increased by 16.58% compared to the lowest yield of 7.49 tons in the treatment without doses of compost fertilizer 0 tons ha^{-1} (C0).

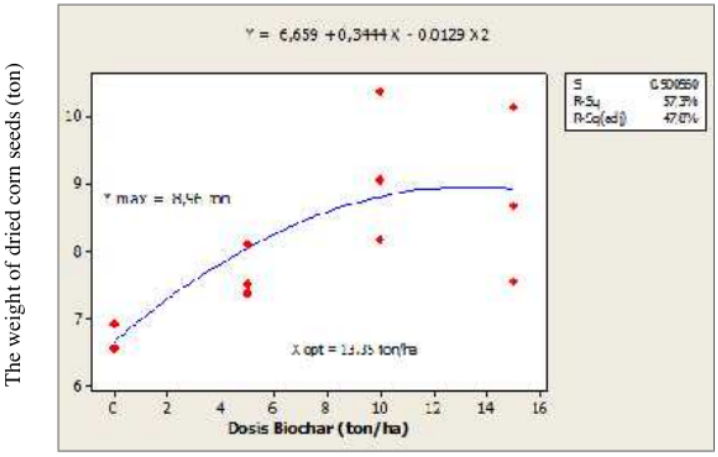

Figure 1. Relationship between the dose of biochar and the weight of dried corn seeds.

5. Conclusion

The interaction of doses of biochar and compost had no significant effect on all observed variables, except for organic C, available P, available K, and CEC having a very significant effect. The treatment of biochar doses had a significant effect on all variables observed except the weight of soil volume, porosity, N, and P had no significant effect. The treatment of compost doses has no significant effect on soil properties variables observed except for total N-and P-available soils which are very real, whereas compost doses have a significant effect on all plant variables observed.

The highest dry corn seed weight per ha was obtained from the treatment of 10 tons ha^{-1} biochar which was 9.21 tons which increased by 35.56% compared to the lowest dry corn seed weight per ha obtained from the treatment without biochar which was 6.79 tons.

The treatment of compost doses of 20 tons ha^{-1} gives the highest value of dry corn seed weight per ha, which is 8.73 tons, increasing by 16.58% compared to the lowest yield of dry corn seed per ha, which is 7.49 tons in the treatment without compost. The results of the regression analysis showed that the optimum dose was 13.35 tons ha^{-1}, with the weight of dry corn seeds per ha of maximum of 8.96 tons.

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