APPLICATION OF BIOCHAR, LIME, AND COMPOST ON ACID SULPHATE SOIL FOR VEGETATIVE GROWTH OF SIAM MUTIARA LOCAL VARIETY RICE (*Oriza sativa L.*)

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ABSTRACT

More than 78 thousand hectares of acid sulfate soil in Barito Kuala Regency, South Kalimantan Province, Indonesia has been managed for agriculture purposed with the condition of high acidity, low nutrient availability and high iron poisoning in water of rice fields. Treatment combination of biochar, lime, and compost is amendment to improve the quality of acid sulfate soil for rice field to increase the rice production. The treatment of biochar as a soil enhancer with consideration of its organic-C which has good potential as a soil amendment. Meanwhile, compost as organic material will maintain soil reduce poisoning due to the solubility of metals. Lime will reduce soil acidity and dissolving soil cations thereby reducing metal toxicity in acid soils. The results showed that during vegetative period the water acidity of rice field reduces from 15th day after planting (dap) about pH 3.5, about pH 4.0 for 30th dap and continue increase about pH 4.5 on 45th dap. Continuing the increase of total of rice tiller each plot including their height to show the improvement performance of rice growth compared to control.

Keywords: Acid sulphate soil, Biochar, Compost, Vegetative period, Lime

INTRODUCTION

Barito Kuala Regency in South Kalimantan Province, Indonesia has a wide area of acid sulphate land, and more than 78,000 ha of acid sulfate land has been managed for agriculture (Alwi, 2014). Generally, the land is a tidal swamp land with high acidity and caused the low nutrient availability due to Fe poisoning in water and rice fields (Shamshuddin et al., 2016; Susilawati & Fahmi, 2013). To manage the acid sulphate soils for rice fields is a better choice considering preventing the soil from oxidizing process which results in soil acidification (Bhakari et al., 2013; Noor et al., 2019). Acid sulfate soils have characteristics when oxidized will lower the pH to very acid level and come to be negative effects for rice field are decreased availability of nutrients, increased the impact of toxic elements, and decrease in rice yields (Sulistiyani et al., 2014; Agustina et al., 2016).

Amendment of acid sulfate soils through soil ameliorants has been widely carried out (Goenadi, 2010). The soil amendment by utilizing biochar, compost, and lime. The treatment of biochar as a soil enhancer with consideration of its organic-C which has good potential as a soil amendment with the average soil water retention capacity is 21.13% (Anita & Cahyo, 2016; Beck et al., 2011).

Biochar that has been used in rice field does not disturb the C/N balance, is able to retain and the nutrients more available to plants. Meanwhile, soil amendment by using compost as organic material can maintain soil reduction conditions to reduce poisoning due to the availability of metals in the soil. Compost and microbial activity can release organic acids

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from the compost decomposition process which trap dissolved metals by increasing the availability of nutrients for rice field (Aryanto et al., 2015; Izar et al., 2011). Liming of acid soils is a common treatment in agriculture to reduce soil acidity and dissolving soil cations thereby reducing metal toxicity in acid soils (Shamshuddin et al., 2016; Quiroga et al., 2017; Pavlova et al., 2019).

Farmers on acid sulphate land in the Barito Kuala area commonly planted the rice local varieties of Siam Mutiara. This species is an indicator to show the result of the amendment of sulphate acid soil for rice fields to support the vegetative before entering generative period. The local name species variation is based on the shape of the grain, the taste of rice, or special characteristics received by the farmer where the height of local varieties of rice field at harvest ranges from 105-180 cm with low yields (Khairullah & William, 2005).

MATERIAL AND METHODS

Location and Material Preparation

The experimental plots were made by selecting community rice fields located in Belandean Village, Barito Kuala, and South Kalimantan Province by dividing 81 plots by 2.5 x 2.5 m each and grouping in three blocks. Each block consists of nine treatments by three replications with total 27 plots as illustrated in Figure 1. The construction of embankments in each plot aimed to avoid mixing the water in the plot with the surrounding water. The plot of rice field had been prepared to collect rainwater and managed the water level was not more than 15 cm above the ground.

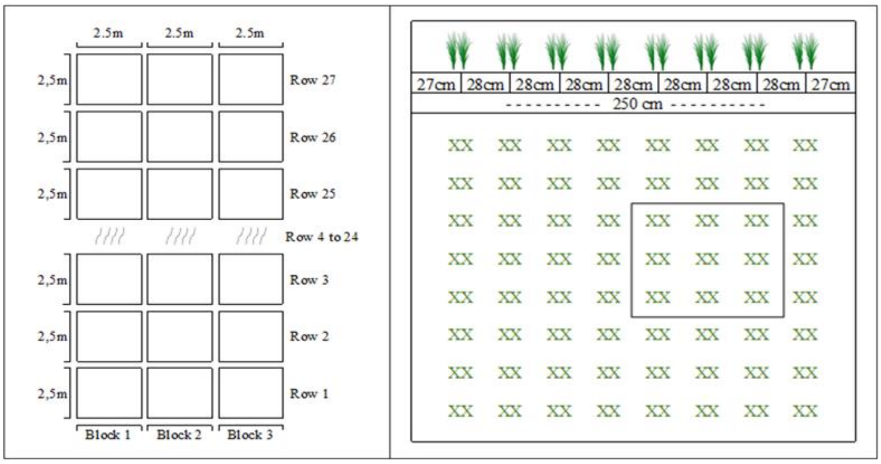

Figure 1. Experimental design layout (left) and rice tiller planting position (right)

Materials used in the treatment were biochar, lime, and compost. Biochar was obtained from burnt and crushed coconut shells obtained from the surrounding community. Compost was obtained from pruning local grass species during clearing and mixed with rice straw with the same composition through a composting process commonly carried out by the surrounding community. Lime was purchased from agricultural shops around the research site. The treatment materials in the form of mixture of biochar, lime and compost that has been determined is given to the experimental plot of land. Each experimental plot was assigned according to its plot code by sprinkling it onto the experimental plot and incubated for 14 days. The sizes and experimental plots are presented in Table 1.

Table 1. Code and quantity of the treatments

Biochar	Lime	Compost		
		c_0 (0.0 t ha^{-1})	c_3 (3.0 t ha^{-1})	c_6 (6.0 t ha^{-1})
b_0 (0.0 t ha^{-1})	m_0 (0.0 t ha^{-1})	$b_0m_0c_0$	$b_0m_0c_3$	$b_0m_0c_6$
	m_1 (1.0 t ha^{-1})	$b_0m_1c_0$	$b_0m_1c_3$	$b_0m_1c_6$
	m_2 (2.0 t ha^{-1})	$b_0m_2c_0$	$b_0m_2c_3$	$b_0m_2c_6$
b_6 (6.0 t ha^{-1})	m_0	$b_6m_0c_0$	$b_6m_0c_3$	$b_6m_0c_6$
	m_1	$b_6m_1c_0$	$b_6m_1c_3$	$b_6m_1c_6$
	m_2	$b_6m_2c_0$	$b_6m_2c_3$	$b_6m_2c_6$
b_{12} (12.0 t ha^{-1})	m_0	$b_{12}m_0c_0$	$b_{12}m_0c_3$	$b_{12}m_0c_6$
	m_1	$b_{12}m_1c_0$	$b_{12}m_1c_3$	$b_{12}m_1c_6$
	m_2	$b_{12}m_2c_0$	$b_{12}m_2c_3$	$b_{12}m_2c_6$

Each experimental plot used 128 rice tillers divided into 64 planting points where one planting point is planted with two rice tillers with the age is 105 days after seedling and the height average is 25 cm. The total rice tillers needed for the 81 experimental plots were 10,368 rice tillers. Rice tiller planting position as mentioned in Figure 1.

Sampling and Analysis Data

Sampling for soil analysis was taken before and after treatment on parameters of water field rice pH, available-P, NH4, organic-C, and exchangeable-K. Sampling for water field rice pH every plot on days 15, 30, and 45 after planting. To see the effect to the rice plant, we sampled total of rice tiller and height of rice tiller also on days 15, 30 and 45 dap.

Statistical analysis was conducted with SAS (Statistical Analysis System) to see how the effect of single treatment and its combination used F test of 5 % and test of significant different of Duncan's Multiple Range Test (DMRT). Figure 2 shows the illustration of vegetative and generative period.

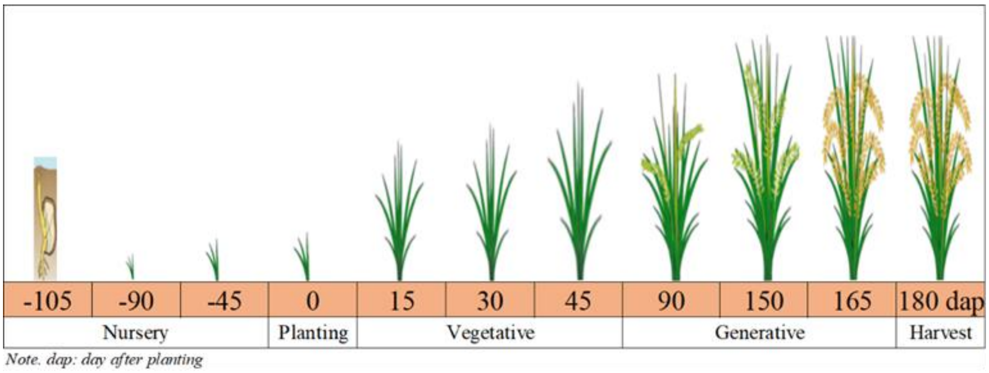

Figure 2. Illustration of Generative Period of Local Rice Species

RESULT AND DISCUSSION

Soil NPK Analysis Result

Soil sampling on every treatment to analysis pH, NH4, organic-C, and exchangeable-K presented in in Figure 3. The availability of Phosphor (P-available) show increase after treatment although not show the different for all treatment. The highest among the treatment is 10.89 ppm on the combination of $b_{12}m_1c_3$. For NH4 the highest is 83.26 ppm on the combination of b12m0c6 and K-exchangeable is 0.9 on combination of $b_{12}m_2c_6$.

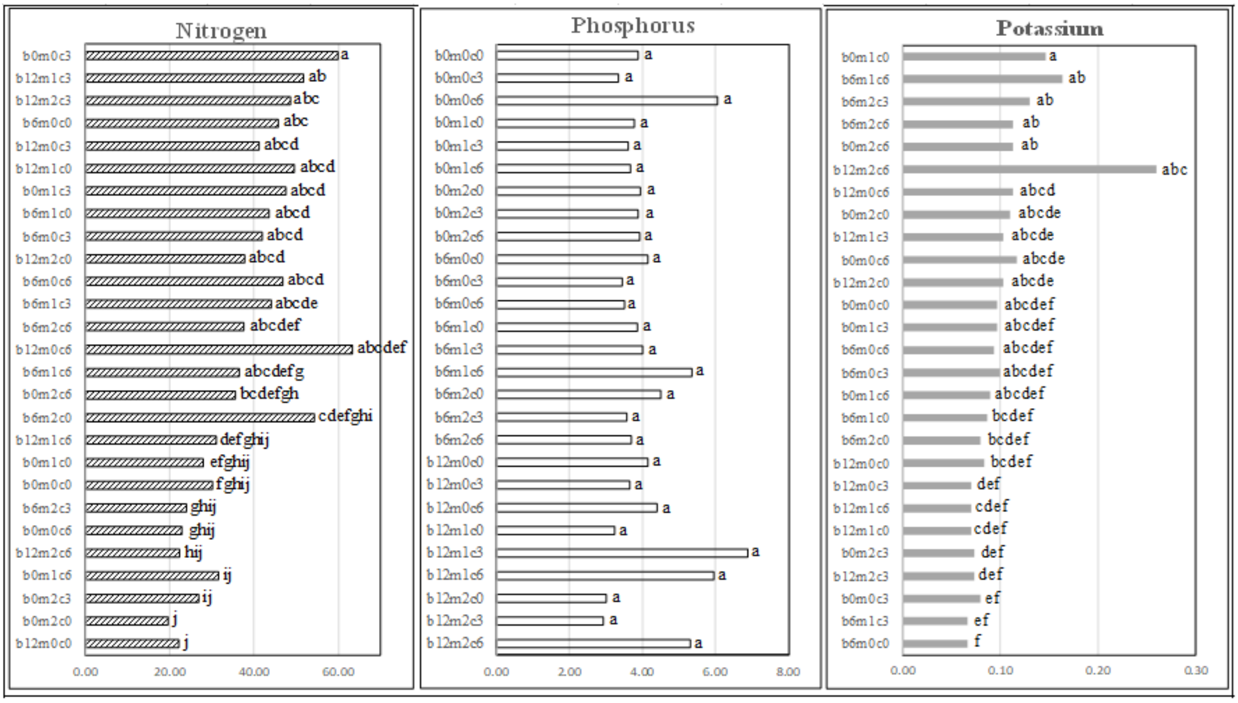

Figure 3. Graphic Data of Nitrogen, Phosphor and Kalium After Treatment. The different lowercase letter indicated the different values

Water pH of Rice Field Analysis Result

Water sampling was carried out on each plot. The results obtained were calculated on average as shown in Figure 4. All treatments showed that the pH mostly average between 3.0 to 3.5 on 15th day. Then increase mostly pH between 3.5 to 4.0 on 30th and continue to increase on the 45th with the pH between 4.0 to 5.0 as detail in Figure 4.

Result of statistical analysis, based on the analysis of variance, the interaction of the three factors of biochar, lime, and compost which is presented in Table 2. The result is not different value for pH of rice field water on sampling of 15th, 30th and 45th after planting. The three result of water pH, total and height rice tiller mentioned in Table 2.

Table 2. Result of Statistical Analysis of pH, Total and Height of Rice Tiller

Source of Diversity		Day After Planting		
Combination	Parameter	15^{th}	30^{th}	45^{th}
Biochar + Lime + Compost	pH of Rice Field Water	0.0383	0.4040	0.6470
	Total of Rice Tiller	0.4778	0.4182 *	0.0356 *
	Height of Rice Tiller	0.8303	0.6371	0.4770

*Note: * means significant difference*

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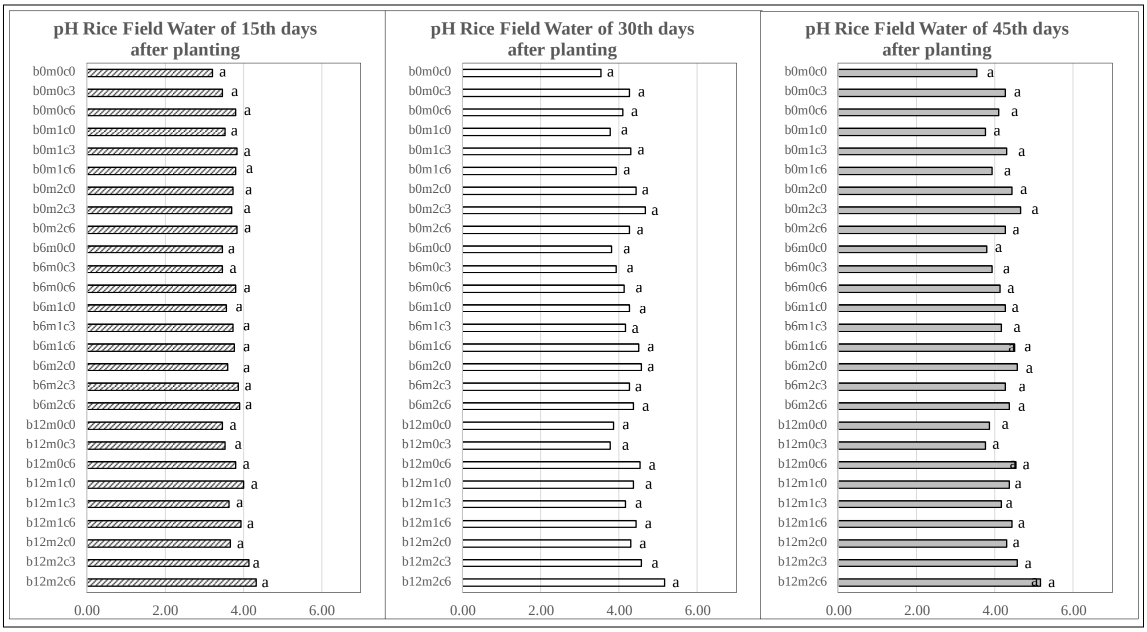

Figure 4. Graphic of Rice Field Water pH Result on 15th, 30th, and 45th days after planting. The same lowercase letter indicated the same values.

Total Rice Tiller Analysis Result

The treatment of applying a combination of biochar, lime, and compost with a predetermined dose in each plot resulted increase in the number of tillers. In the treatment of plots without biochar, lime, and compost, the average number of tillers was 6 rice tillers during the vegetative period of 15th dap, and eight rice tillers on 30th dap, and 19 rice tiller on 45th dap where detail in Figure 5. Total rice tiller increase compares if we compared 30th dap to 15th dap and compared 45th dap to 15th dap or 30th dap. Based on the analysis of variance as mentioned on Table 2, the interaction of three factors of biochar, lime and compost showed no difference on the total of rice tiller on 15th dap but showed a significant difference on 30th and 45th dap.

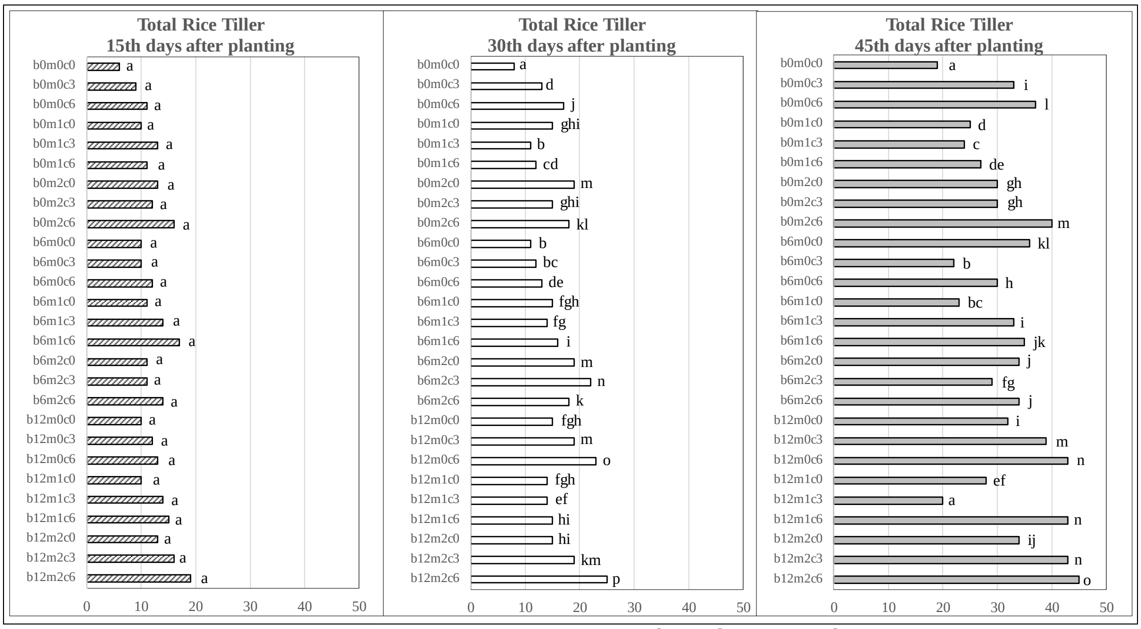

Figure 5. Graphic of total of rice tiller during 15th, 30th, and 45th day after planting. The same lowercase letter indicated the same values and the different lowercase letter, and the different lowercase letter is different values.

Height of Rice Tiller Analysis Result

The rice tiller height average increases each plot during the vegetative period. In the treatment of plots without biochar, lime and compost, the average plant height was 25 on 15th, was 52 on 30th and 64 on 45th dap as graphics in Figure 6. Based on the analysis of variance, the interaction of the three factors giving biochar + lime + compost showed not different on 15th, 30th and 45th days after planting.

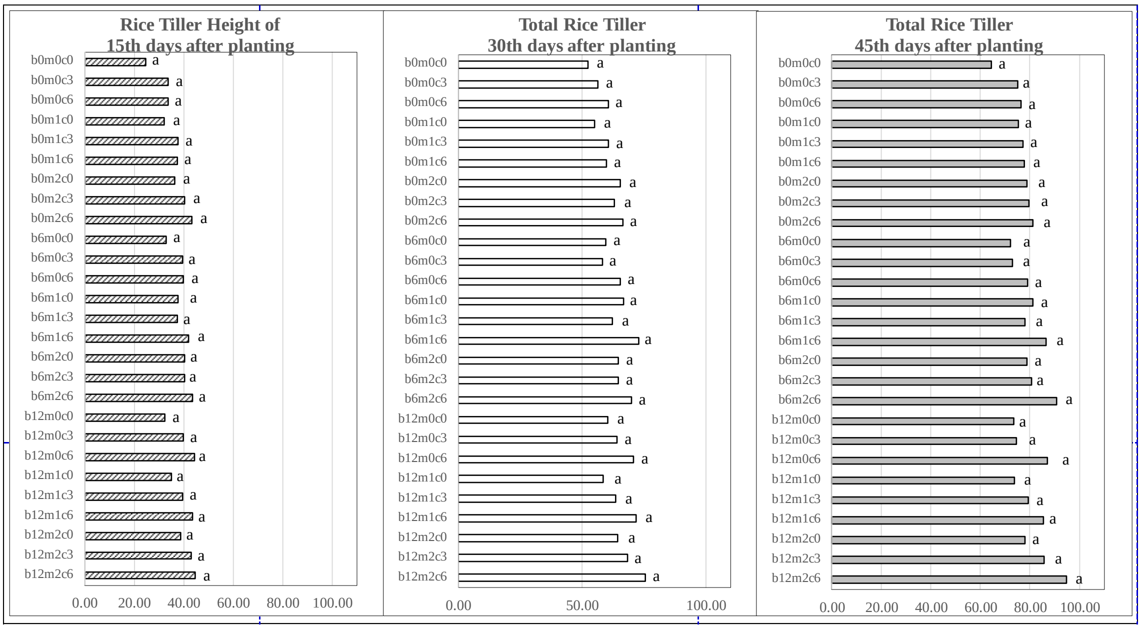

Figure 6. Graphic of the Increasing of Rice Tiller Height during 15th, 30th, and 45th Day after Planting. The same lowercase letter indicated the same values

DISCUSSION

Soil Amendment for Generative Period

Soil characteristics that support rice growth especially in acid sulphate soil is the availability of nutrients needed by plants in sufficient and balanced quantities to grow optimally, resulting in optimal productivity as well (Kurnia, 2005). Applying biochar, lime, and compost to acid sulphate soils improves the condition of microorganisms, accelerates increasing the pH and produces more rice tillers. The net yield of these two processes depending on the specific conditions (soil and biological characteristics of the plant) can be a decrease and an increase in the number of tillers. Adding compost to rice plants stimulates microbes into the soil. The microbes contained in fertilizers increase plant growth either by supplying essential nutrients or increasing nutrient availability to plant roots (Shazana et al., 2014)

Reduce the Soil Acidity after Treatment

Treatment biochar, lime and compost increase the pH water of rice field. Increasing the pH affected reducing the poisoning of Fe. The critical limit of Fe concentration in soil solution that causes iron poisoning is around 100 ppm at pH 3.7 (Aidi, 2013; Sahrawat, 2005). The concentration of Fe in the nutrient solution is less than 250 ppm showed symptoms of poisoning and decreased plant growth (De Dorlodot et al., 2005). The critical limit of Fe stress that can still be tolerated by rice plants is 250-500 mg kg-1 (Amnal, 2009). Fe toxicity is also influenced by the status of plant nutrients such as P and K (Suhartini & Makarim, 2009).

The Treatment Effect to Total and Height of Rice Tiller

The addition of biochar, lime and compost to the acid sulphate soil increases the availability of N, P, and cation exchange capacity (CEC) which in turn increases crop yields which as early indicated by increasing in the number of rice tillers (Dariah et al., 2015; Saleh, 2017; Suryana, 2011). Biochar has high stability characteristics (Hidayat & Nursyamsi, 2015) functions as a soil enhancer, increases plant growth and supplies a number of useful nutrients and improves soil physical and biological properties (Hadjar, 2010).

Differences in genetic composition are one of the factors that cause various plant appearances, including plant height (Donggulo et.al, 2017). Rice plant height can be used as one of the growth parameters (Paramita & Surahman, 2018; Syahri., 2013). Rice tillers are plants consisting of one stem, roots, and leaves that can produce flowers (Wibowo, 2010). Rice tillers that live and grow strong are saplings that are expected to be able to produce maximum grain. The number of vegetative tillers and productive tillers is very dependent on the rice variety used, variety is one of the main technologies that can increase rice productivity and farmers' opinions (Koesrini et.al, 2015). The number of rice tillers can be classified as moderate to high, the criteria for the number of productive tillers are moderate, ranging from 5-9, while high is around 10-19 (IRRI, 2013).

CONCLUSION

The combination of biochar, lime, and compost improved the soil quality to support rice growth with indicator better performance during vegetative period. Reducing water acidity affected more nutrient availability to more total and height of rice tiller. The performance of rice growth can be continued to investigate on generative period after better performance in vegetative period to see the consistency of soil amendment.

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