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The Use of Rice Husk Biochar and Flooding System on Rice Production in Central of Sulawesi Indonesia

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Abstract

The population growth rate is not in line with the rate of increase in food production, especially rice which is the staple food of 90% of the Indonesian people, to maintain food security in various government programs including PAJALE (Rice, corn and soybeans), through increased production through intensification or extensification. To increase land productivity, soil health must be improved using soil enhancers such as biochar. The source of biochar can come from plant residues such as rice husk. biochar can improve the physical, chemical and biological properties of the soil. Besides that, water management in the rice cultivation system is very important especially in certain phases of rice growth. This study aims to examine the use of Biochar doses and flooding systems on the efficiency of fertilizing and productivity of lowland rice plants. This study used a randomized block design, with a factorial pattern. The first factor consisted of 6 levels of treatment of biochar doses, 0, 1, 2, 3, 4, and 5 tons ha^{-1}. And the second factor consists of 2 levels, namely, (p1) continuous water flooding and (p2) intermittent water flooding, observed response parameters, plant height, concentration leaf, N,P, K, number of tillers, number of productive tillers, weight 1000 grain, and ton ha^{-1} production. The results showed that the setting of flooding and biohcar use had a positive effect in increasing the number of productive tillers at an average of 21 tillers, rice production by 22.31% from 4.44 tons ha^{-1} to 6.99 tons ha^{-1} harvested dry grain (HDG) 14% moisture content in the use of a dose of 3 tons ha^{-1} Biochar rice husk. Water flooding do not affect statistical production.

Keywords: Biochar; soil amendment; Water Supply; Rice Production.

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1. Introduction

Rice is a national strategic commodity whose production is continuously improved in order to meet national food needs. The rapid pace of population growth that is not balanced with the rate of increase in the standard area of paddy fields, as well as the increased conversion of productive paddy fields, and climate change have an impact on the intensification of drought and floods, increasing pest disturbance increasingly threatens national and local food security [1,2]. The fulfillment of national food needs must be in line with the rate of increase in population, including through increased land productivity (intensification) and expansion of rice cultivation area (extension). Efforts to increase agricultural production of food crops continue to be carried out by the government, among others, through the Pajale program (rice, maize and soybean) both through intensification and extensification by utilizing sub-optimal lands. Intensive tillage and the continuous use of inorganic fertilizers without the addition of organic matter makes unhealthy of soils [3,4] soil organic content continues to decrease, if the soil organic content is less than 2% then the plant will be difficult to grow well [2,5], besides that the quality of rice plants that use fertilizer chemistry without the use of organic matter will reduce the quality of rice plants [6] .One of the efforts made to increase rice production is to use organic materials and other agricultural wastes such as biochar that can function as soil ameliorants [7,8]. Biochar is charcoal from incomplete combustion with limited or no oxygen [9] basic materials can be sourced from agricultural waste, livestock plantations, forestry and households in the amount abundant, like rice husk. The potential of rice husk in 1 ha of rice fields with an average production of 7 tons^{-1} can produce agricultural waste around 1.54 tons per harvest season (22% of milled dry rice), this waste has the potential to pollute the environment if not further processed, as well as the potential improve soil fertility if treated properly, including as raw material for bokashi and biochar [9]. Benefits of biochar among others Biochar benefits can include nutrient retention, supply nutrients to decrease / increase pH according to soil pH conditions, Increase Organic Soil Organic C [8,10]) increased CEC, increased nutrient availability [10], increased P available [11] increasing the biomass of weight [12] efficiency of NPK fertilization [13] more stable when compared to the use of organic fertilizer or compost, can retain nutrients, supply nutrients to decrease / increase pH according to soil pH conditions, Increase Organic Soil Organic C [8] increased CEC, increased nutrient availability [10] increased P available [11] increasing the biomass weight of [12] efficiency of NPK fertilization [13] more stable when compared to the use of organic fertilizers or compost. Rice plants are basically not aquatic plants, but need enough water. Continuous flooding can inhibit root growth and absorb rice energy in forming aerenkhima. One of the cultivation systems developed is the system of rice cultivation by intermittent water supply. Special characteristics of intermittent irrigated rice cultivation with high use of organic fertilizer, from the research results reported that intermittent paddy cultivation method can increase soil biota activity, encourage root growth, and increase growth and production of rice plants [14] but water management aimed at seedling formation have not been widely reported, so it is important to try so that the use of biochar made from rice husks with good irrigation arrangements is an alternative to improve physical, chemical and biological soil quality which can ultimately support growth and lowland rice production, and reduce the use of inorganic fertilizers and improve the efficiency of lowland rice farming, so this research is important to carry out. Based on the description above, the problem formulated in this study is how is the effect of biochar and intermittent irrigation systems on productivity and efficiency of rice farming.

2. Material and method

2.1 Design Experiment

This research was carried out in the lowland Farms (swamp) land of Lelean Nono village, Baolan District, Tolitoli Regency, Central Sulawesi. In March to July 2018. This research used factorial randomized block design. The first factor is the water management of two levels, P1 (continuous flooding) P2 (intermittent flooding until the end of vegetative growth) the second factor is biochar dose consisting of 6 levels, P0 without Biochar, P1 Biochar dosage 1 ton ha^{-1}, P2 Biochar dosage 2 tons ha^{-1}, P3 Biochar dosage 3 tons ha^{-1}, P4 Biochar dosage 4 tons ha^{-1}, P5 Biochar dosage 5 tons ha^{-1}. 12 treatment combinations were obtained with three replications, so that 36 treatment plots needed measuring 3 X 4 meters with a spacing of 30 x 30 cm, each treatment plot consisted of 133 plants, sample plant plots as each plant observation was 12.

2.2 Methodology

(1) Land Preparation

The land is treated using a tractor if it is left inundated to kill weeds and toxic poisons on the ground for 7 days, then put in a hoe (hand tractors cannot be used) and then dried until the soil is moist (shredded). The prepared land is further divided into 3 blocks according to the replication based on the sun's direction of the diversity of the previous rice plant growth, each block consists of 6 plots, with the same size each, which is 3m x 4m. Each plot was given 1 ton ha-1 cow dung compost and biochar according to treatment, then flooded until soil conditions were scrambled for 1 week before planting.

Figure 1: Land after planting

(2) Seed selection and seedbed

Seeds that are pithy are selected by soaking the seeds in a bucket of salt water (comparing to 1 liter of 125 g of salt) the floating seeds are separated from the seeds that sink. The seeds to be used are sinking seeds, then the sinking seeds are taken and washed with water until clean from salt solution, then air dried, then soaked for 24 hours, then dried again and re-aerated for 24 hours. The seed is planted in the nursery box filled with soil mixed with cow dung compost and rice husk biochar in a ratio of 1: 1: 1, the height of the nursery is 4 cm, the seed is sown in the nursery, then covered with thin soil.

(3) Planting

Planting is carried out after the seeds are 10 days after seedlings, by planting 1 seed perforated planting and shallow planted as deep as 2 cm in the form of horizontal roots (L-form), at a designated place using a tick.

(4) Water management

Flooding is carried out according to treatment. For comparison (P1), continuous flooding as high as 5-10 cm until before harvest. While the treatment (P2) intermittent flooding (5 dry days and 10 days of submergence) is given at the beginning of planting left to recede alone, submergence is continued when the plant is 6 DAP, and the flooding is 2-5 cm. The frying interval is carried out until the plants are 55 DAP, then the land is flooded until before harvest (90 DAP) and dried until harvest.

(5) **Harvest**

Harvesting is done when the plants are 116 days after planting or when the rice plants have yellowed more than 90% in one plant family and the flag leaves have begun to dry.

2.3 Date Collection and Analysis

Response variables observed in this experiment:

(1) Growth parameters

1. Plant height, measured from the ground surface to the longest leaf tip, measuring plant height is measured when the plants are 15, 30.45, and 60 day after planting (DAP).
2. The number of tillers formed is calculated by counting all the tillers formed, counted when the plants are 15, 30.45, and 60 DAP
3. Number of productive tillers, calculated by counting all productive tillers done before harvest
4. Concentrations of plant N, P and K nutrients are measured when the plant is 45 DAP (maximum vegetative growth)

(2) Production parameters

1. Weight of 1000 grains of pithy rice weighed by means of samples taken randomly in each group that has weighed dry weight and then weighed
2. Production of tons of ha-1 MPD, by weighing the results of milled dry tiles with a standard moisture

content of 14% . $$\text{Production} = \frac{Area\ Ha}{Tile\ area}\ x\ Tile\ production \quad ....(1)$$

Data in the research were recorded and classified using Microsoft Office Excel 2010. Tested parameters used a variance analysis test (ANOVA). If there was a single effect or interaction between treatments, we applied the Tukey advanced test (HSD 5%).

3. Result and discussion

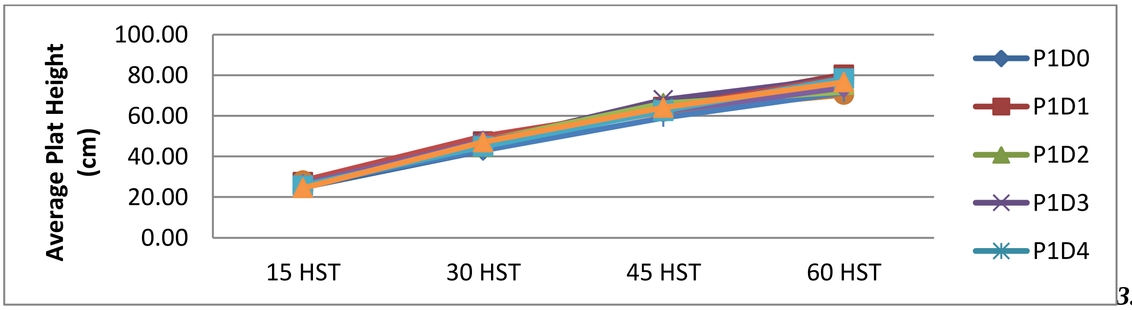
3.1 Site Location Characteristics

The chemical and phisical properties of soil and the husk biochar are shown in Table 1

Table 1: The chemical and physical properties of Soils and the husk biochar

No	Parameter	Content		Unit
		Soil	Biochar	
1	pH H_20 (1:25)	5,05	7,75	
2	Water content	-	4,72	%
3	Sand	4,0	-	%
4	Dash	65,4	-	%
5	Loam	30,6	-	g cm^3
6	Bulk Densiy	1,01	-	%
7	C – Organic	4.01	8,86	%
8	N – Total	0,49	0,44	-
9	CEC	24,07	19,25	cmol (+) mg^{-1}
10	Al-Ec	0,76	-	cmol (+) mg^{-1}
11	H-Ec	0,23	-	%
12	P_2O_5 (Bray 1)	3,20	0,014	Mg/100g
13	P_2O_5 (HCL 25%)	41,78		Mg/100g
14	K_2O (HCL 25%)	3,61		cmol (+) mg^{-1}
15	Calsium (Ca)	3,00	3,04	cmol (+) mg^{-1}
16	Potassium (K)	0,80	3,61	cmol (+) mg^{-1}
17	Natrium (Na)	0,40	0,27	%

Source : Primary data at Analysis in the Untad Soil Science Laboratory



3.2

Plant height (cm)

Figure 3: The average height of rice plants of flooding system and application of rice husk biochar dosage

There are not significant between intermittent and flooding treatment statistically, but visually, the height of paddy plants are higher on the flooding than intermittent system. This is show that the flooding system and biochars are not influences the elongation of height plant of paddy . The elongation stem of paddy plant more effectivines by genetic factor than environmental factor in these research [15]. Say that the elongation stem on flooding system were the escape strategy of paddy to did of aerobicaly metebolism and CO_2 fixations. .

3.2 Number of Tillers

The effect of flooding and biobhar on number of tillers was shown on Table 2.

Table 2: Average Number of tillers given by biochar and flooding system

Average number of tillers							
15 DAP							
Treatments	D0	D1	D2	D3	D4	D5	Average
P1	9,06	12,67	10,36	11,47	11,64	13,73	11,49a
P2	9,72	13,78	12,61	14,06	12,47	17,36	13,33a
Average	9,39a	13,22b	11,49ab	12,76ab	12,06ab	15,55b	
HSD 5 % = 3,31							
30 DAP							
Treatments	D0	D1	D2	D3	D4	D5	Average
P1	24,30a A	27,34a A	21,93a A	26,41a A	23,39a A	20,35a A	23,95
P2	21,19a A	22,80ab A	24,40ab A	24,86ab A	28,53b A	25,02ab A	24,47
Average	22,74	25,07	23,17	25,63	25,96	22,68	
HSD 5% = 7,25							
45 DAP							
Treatment	D0	D1	D2	D3	D4	D5	Average
P1	23,22a A	26,61ab A	24,42ab A	23,89ab A	28,06b A	22,69ab A	24,81
P2	22,83a A	24,89ab A	24,81ab A	29,16b A	28,17b A	26,50ab A	26,06
Average	23,03	25,75	24,61	26,53	28,11	24,60	
BNJ = 5,1							
60 DAP							
Treatment	D0	D1	D2	D3	D4	D5	average
P1	23,61	24,70	25,39	26,89	27,33	25,64	25,59a
P2	23,92	26,44	26,53	28,69	26,56	27,11	26,54b
Average	23,76a	25,57b	25,96b	27,79c	26,95c	26,37bc	
HSD Flooding system = 0,47 HSD Dosage of Biochar = 1,57							

Notice : The numbers marked by the same lowercase letters in the same row and capital letters in the same column are not significantly different according to the HSD test at 5% level.

P1 = Continuous flooding , P2 = intermittent flooding, D0 = without the use of rice husk biochar,

D1 = Dosage 1 Ton ha^{-1} D2 = Dosage 2 Ton ha^{-1} D3 = Dosage 3 Ton ha^{-1} D4 = v4 Ton ha^{-1} D5 = v5 Ton ha^{-1}

The aerobic and anaerobic condition on paddy field will affected on the growth and develop of roots of rice plants. On the flooding condition paddy will be formed aerenchima to get of oxigen from air. The formation of aerenchima will affect formation the number of tiller. The use of biochar (3 tons ha^{-1}) affects the number of tillers. This is an indirect impact of improving the condition of wetland soils, biochar can improve physical properties [16,17], chemistry of soil [8,18], and soil biology [10]. so that it can effect and increase the number of tillers.

3.3 Concentrations of N, P, and K nutrients in plant tissue

The results showed that the treatment of biochar and intermittent water regulation had an effect on increasing the concentration of N, K, but no significant on P concentration in the leaves tissue on aged 45 DAP. Data on the concentration of N, P, and K leaves of rice plants aged 45 DAP are shown in Table 2

Table 2: Average percentage of N, P, and K concentrations of leaves of rice plants that were given biochar and flooding system, date where taken on 45 DAP

Concentration of N (%) Plant tissue							
Treatments	D0	D1	D2	D3	D4	D5	Average
	2,48a	3,16b	3,24b	3,34b	2,57a	3,83c	
P1	A	B	A	A	A	A	3,10
	2,34a	2,87a	3,60c	3,91d	3,39b	3,78cd	
P2	A	A	B	B	B	A	3,31
Average	2,41	3,01	3,42	3,63	2,98	3,80	
HSD 5% = 0,19							

Percentage concentration of K (%)							
Treatments	D0	D1	D2	D3	D4	D5	Average
	1,11a	2,64b	1,67ab	1,55ab	2,44b	2,07ab	
P1	A	A	A	A	A	A	1,91
	1,74ab	2,16b	1,28ab	1,89ab	2,53b	1,07a	
P2	A	A	A	A	A	A	1,78
Average	1,43	2,40	1,48	1,72	2,49	1,57	
HSD 5 % = 1,06							

The application of rice husk bicohar and intermittent flooding can increase the nutrient concentration of N in 45 DAP rice plants. The ability of Biochar to high water holding capacity [16], can keep nutrients N and make it more available to plants. Biochar application can neutralize soil pH [18], there by stimulating the process of N mineralization and nitrification [16] which causes plant uptake to increase. Biochar increases the N needed for plant assimilation through a mechanism of increasing retention and reducing N leaching. Application of biochar Rice husk, and intermittent flooding significantly increased uptake of K nutrient in paddy rice plants at aged of 45 DAP. This increase was caused by used of biochar which had a high K level of 3.61 Cmol mg-1, so that it was able to increase the exchange rate K which had an impact on high K nutrient uptake. In line with [19] which states that biochar can meet the needs of potassium for the vegetative growth of corn plants so that it has the potential to replace the use of potassium fertilizer.

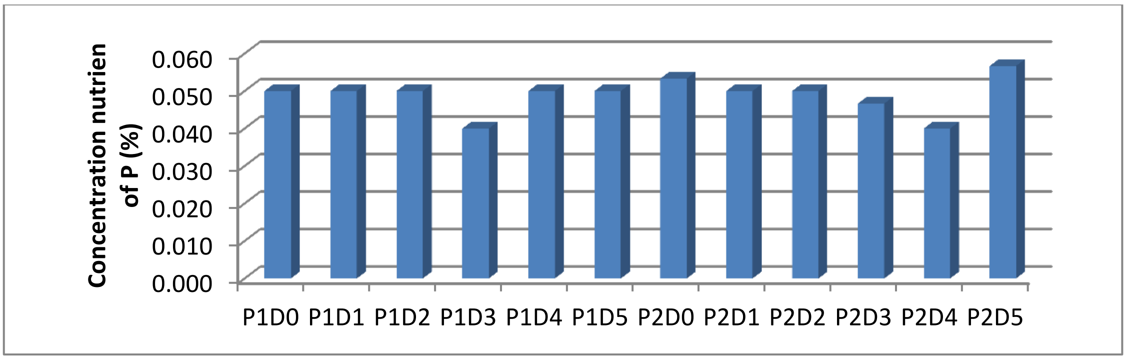


Figure 4: P nutrient concentration of 45 DAP. Lowland rice plant tissue of flooding system and application of rice husk biochar dosage

Biochar application and flooding had no effect on the uptake of P in rice plant tissue, this was caused due to the high total P content on soils (41.78 mg 100g-1). So that the application of biochar does not affect the P uptake of plant tissue.

3.4 1000 seed weight (g)

The results of the study show that the use of biochars can increase of the weight of 1000 grains of rice. The average of dried weight of 1000 grains due to application of biochar in flooding systems presented in Table 3.

Table 3: Average weight of 1000 grains (g) of rice that were given biochar and Management water flooding

Treatment	D0	D1	D2	D3	D4	D5	Average
P2	26,40	27,82	28,43	28,69	28,34	28,60	28,05a
P2	26,78	27,41	27,62	29,00	28,60	28,81	28,04a
Average	26,59a	27,62b	28,03bc	28,85c	28,47bc	28,71c	

HSD 5% the use of biochar = 0,64

HSD 5% Flooding System = 0,61

Application of biochar up to dose of 3 tons ha^{-1} can to increase the weight of 1000 grains of rice, but the water management does not significant statistically.. The result was no interaction and this is probably caused by water management that provide growth space for plant roots, aerobic and anaerobic microbial respiration cause oxidation reduction, changes in reduction and oxidation reactions due to water management and application of biochar rice husk synergize for plant growth which can ultimately increase the weight of grain content.

3.5 Production

The results of the study that the use of biochar and water management can increase rice production. The data of Production are presented in Table 4.

Table 4: Average production (ton ha^{-1}) of rice in the flooding system and application of various doses of biochar rice husk, water content of 14%

Treatments	D0	D1	D2	D3	D4	D5	Average
P1	4,55	5,21	6,13	6,69	6,64	6,50	5,95a
P2	4,34	6,53	6,98	7,29	6,59	6,94	6,45b
Average	4,44a	5,87b	6,56c	6,99c	6,62c	6,72c	

HSD 5% the use of biochar = 0,48

HSD 5% flooding= 0,16

Production of paddy were palnated in lowland with continuous flooding, or on wetland had lose when compared to intermittent system, this is in line with research [20], which reports that production paddy is higher in lowland rice where the intervals water intermittent flooding. The condition of flooding will affect the condition of nutrients in the soil, the flooding will make a condition of reduction and there are some changes in chemical physics in the soil including the reduction in the value of oxidation reduction (redox) of several nutrients [21]. Reduction in the value of redox potential is generally toxic to plants [22]. Continuous flooding causes aerobic microorganisms to be disrupted due to the absence of oxygen so that the rate of decomposition of organic matter becomes slow [2]. The Application of rice husk biochar aims to improve soil structure that is longer and more stable[10]. Biochar is able to neutralize soil pH [17,18,23], changes in pH affect nutrient availability which ultimately affects paddy rice production.

4. Conclusions

1. Intermittent flooding and application of biochar rice husk together can increase the number of tillers at the age of 30 and 45 DAP, the number of productive tillers, nutrient concentrations of N, K, weight of 1000 grains and the production of Mekongga varieties of rice.
2. The use of a biochar dose of 3 t. ha^{-1} on conventional cultivation can increase production up from 4.44 t.ha^{-1} to 6.99 t.ha^{-1}
3. Intermittent flooding is able to increase production of rice from 5.95 t.ha^{-1} to 6.45 t.ha^{-1}

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5. Conflicts of Interest

Authors have declare no conflict of interest exist.

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