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Growth and Yield of Rice Plant by the Applications of Sea Sand, Coconut and Banana Coir in Ustic Endoaquert

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ABSTRACT

The research aimed to study effect the application of sea sand (SS), coconut coir (CC), and banana coir (BC) on growth and yield of rice (*Oryza sativa* L.) in Ustic Endoaquert. The research was carried out in a fields using 3 × 3 × 3 factorial design. The SS factor consists of three treatment levels which were 0% SS, 25% SS, and 50% SS. Meanwhile, the CC and BC consist of three treatment levels, where each level were 0 Mg ha^{-1}, 10 Mg ha^{-1} and 20 Mg ha^{-1}. The application of coconut coir and banana coir did not have significant effect on plant height. On the other hand, the applications of sea sand and banana coir had significantly increased leaf length with the highest increasing percentage of 16.47% in SS application. The leaf numbers and tiller numbers were relatively unsimilar pattern. For leaf numbers only banana coir application had significant by increased of 65.52% and to tiller numbers only sea sand amount of 10.77%. Furthermore, the application of coconut coir and banana coir had significant for increasing a panicle numbers each ups to 29.53% and 29.05% compared to control. All ameliorant had significant effect to panicle length, but the best increasing was coconut coir with up to 46.49% in CC compared to sea sand and coconut coir applications and it was only coconut coir had significant increased the rice grain numbers.

Keywords: Banana coir, coconut coir, rice plant, sea sand, Vertisol

INTRODUCTION

The rate of population growth with a percentage of about 2% per year has resulted in increasing demand for rice. Until 2012, the national rice demand reached 34.055 million Mg and paddy production reached 68,956,292 Mg (BPS RI 2012) or equivalent to 37 million Mg of rice (Suswono 2012). Sudaryatno *et al*. (2010) predicted that the need of national rice in 2015 as many as 35,123,000 Mg and 37,021,000 Mg in 2020, or an average rate of rice consumption increasing 0.92% per year. Viewing statistics in 2012, it is apparently still a surplus as much as 3-4 million Mg of rice at this time. Although the current national rice need was adequate and surplus, but considering Indonesia's populations that were about 247 million and the increasing rate of population growth, it needs to be maintained and improved availability, one through the increasing productivity of paddy soil.

Rainfed Paddy soil (RPS) is ecosystems which water source are dominantly from irrigation and as fiSSt national rice sources which coverages 2.1 million ha (Toha and Pirngadi 2004). In Paguyaman, Gorontalo province, PS areas are dominantly classified as Vertisol soil that developed from lacustrine deposition materials (Hikmatullah *et al*. 2002; Prasetyo 2007; Nurdin 2011). From chemically aspect, Vertisol is classified as nutrient rich soil that has high nutrient sources (Deckers *et al.* 2001). However, the physical properties are limiting factor for the plant growth which are heavy clay texture, swelling and shrinking properties, lowest water infiltration, and slow drainage (Mukanda and Mapiki 2001). As a result, it has stunted plant growth and low yield. It is necessary to repair these properties by giving ameliorant materials.

Sand is one type of the ameliorant materials that can be applied to high clay soils. Ravina and Magier (1984); Narka and Wiyanti (1999) showed that application of the sand had significantly effect to decline COLE value, soil plasticity index, and soil permeability become large, but the water content availability was low. This is lines with statement of Kusnarta (2012) that sand can improving of aggregate and structure stability of Vertisol (*stability quotient*, SQ) way of declining clay function mecanisme in swelling-shriking processes. Besides, the application of sand amount 20% of weight has declining of COLE values. The Sea sand (SS) has using as medium of planting (Sari *et al.* 2006), but it has a NaCl contents caused some crops can grow normally (Kusnarta *et al.* 20012). Walter *et al.* (2000); Oliver and Smettem (2002); Al-Omran *et al*. (2004) has stated that the sandy soil texture is very influential on the status and distribution of water, so influincces the root system, root depth. Further Rajiman (2009) has stated that the sandy soil texture has influincess of nutrients and pH too.

However, paddy soil cultivation requires medium permeability with sufficient water content, so it needs another ameliorant to fix these properties, such as by using coconut coir and banana coir. Coconut coir (CC) has been used as water storage on farms (Subiyanto *et al.* 2003), while the banana coir (BC) is still relatively underused. Though BC absorption is relatively high when it is dried because it has pores that are interconnected (Indrawati 2009).

Applications of the three ameliorant materials were allegedly able to mutually improve soil physical and chemical properties of Vertisol under rice cultivation on RPS, so that productivity can be improved. This study aimed to determine the response of plant growth and yield components with SS, CC, and BC application in Ustic Endoaquert.

MATERIALS AND METHODS

Study Sites

The experiment was conducted in the green house of Mathematics and Natural Sciences Faculty of Gorontalo State University starting in April-August 2012. Meanwhile, the growing media was taken from the Vertisol with Ustic Endoaquert sub groups (Table 1).

Coconut and Banana Coir Preparation

Materials were obtained from the dried coconut husk that was surrounded the coconut shell inside. Coconut husk was peeled and separatly from coconut shell, and then a smooth outer skin was peeled again until remaining coconut coir (CC). Furthermore, CC was milled to 1 mm. Banana coir (BC) materials were obtained from dried banana bark. Banana bark was peeled and separated from the trunk up to 10 sheets of rods into the core of the BC. Furthermore, the banana peel was grounded into powder with a size of 0.05 mm. The CC and BC obtained were weighed according to the dosage of each treatment. Before application, the water absorption capacity (WAC) of CC and BC were tested through immersion. Immersion was used to determine the maximum WAC of the ameliorant material. Calculation of WAC followed the equation:

$$\text{WAC (\%)} = [\text{Pre Weight (w0)} / \text{Dry weight (w1)}] \times 100\%$$

Experimental Design

The study used a 3 × 3 × 3 factorial design. There were 3 factoSS in this study and each factor consisted of 3 dosages treatment and each treatment had 3 replications, so 81 plots experiments were obtained. Sea sand (SS) factors consisted of 0% SS (S_0), 25% SS (S_1), and 50% SS (S_2). Furthermore, the CC factor consisted of 0 Mg ha^{-1} CC (C_0), 10 Mg ha^{-1} CC (C_1), and 20 Mg ha^{-1} CC (C_2). While, the BC factors consisted of 0 Mg ha^{-1} BC (B_0), 10 Mg ha^{-1} BC (B_1), and 20 Mg ha^{-1} BC (B_2).

Table 1. Soil description and classification of Ustic Endoaquert.

Location	: Sidomukti village, Mootilango district, Gorontalo regency
Soil classification	
Taxonomy (USDA, 2010): Endoaquert Ustic	

PPT	: Eutric Grumusol
FAO/UNESCO	: Cambisol
Parent Material	: Lacustrine
Position Fisiografik	: Foot Slope, Depression
Topography	: Flat-Ramps; slopes <2%
Elevation	: 58 m sl
Drainage	: Poor
Groundwater Depth	: Shallow
Vegetation	: Rice (*Oryza sativa* L.)

Depth (cm)	Horizon	Descriptions
0-12	Apg1	Gray (10YR 5/1); clay loamy; massive structure; very sticky, plastic; smooth roots, a lot; clear flat.
12-31	Apg2	Gray (10YR 5/1); clays berliat; angular blocky structure, smooth, weak; very sticky, plastic; rusty brown (10YR 5/3), plain, smooth, clear, spots, sharp; rooting smooth, much; gradually average
31-53	Bwg1	Gray (10YR 5/1), clay; moderate, angular blocky structure, weak; very sticky, plastic; rooting smooth, slightly; frosted flat.
53-71/92	Bwg2	Gray (10YR 6/1), clay; angular blocky structure, rough, weak; very sticky, plastic; obviously choppy.
71/92-119	Bwssg	Dark gray (10YR 4/1), clay; moderate, angular blocky structure, moderate; very sticky, plastic; slikendside; rusty brown (10YR 5/3), plain, smooth, clear, tube, clear; frosted flat.
119-150	BCg1	Dark gray (10YR 4/1), clay; angular blocky structure, haSSh, strong; very sticky, plastic; rusty brown (10YR 5/3), plain, smooth, clear, tube, clear; clear flat.
150-200	BCg2	Dark gray (10YR 4/1), clay; very sticky, very friable; frosted flat.

Rice Planting and Maintainance

Before planting, a basicstarter fertilizer was weighed. Fertilizers used consisted of 125 kg Urea ha^{-1} which were given twice at ages 0 day after planting (DAP) and 60 DAP, respectively as much as 62.5 kg ha^{-1} each. Meanwhile, SP36 fertilizers in the amount of 100 kg ha^{-1} were given twice at age 0 DAP and 60 DAP, respectively as much as 50.0 kg ha^{-1} each, whereas KCl fertilizers in the amount of 50 kg ha^{-1} were given twice at ages 0 DAP and 60 DAP respectively as much as 25 kg ha^{-1} each.

A Ciherang rice seed variety that was used was tested its quality by soaking in saline solution, then planted in trays which were covered by leaves and soil media containing organic material with a ratio of 1:1 until 10 days. A day before planting, the planting medium was watered so that compounds which were toxic to rice seedlings moved down to the bottom of the pot. Rice seeds that had been 10 days aged were transferred into the plant growing media. Planting was done in the planting hole as deep as 8 cm. At planting time, it was followed by the application of basic fertilizers as much as half of the total dose of fertilizer. During the growth and development of plants, the maintenance performed was weeds clearing, watering at 30 DAP and 60 DAP, and subsequent fertilization at age 60 DAP. Harvesting was done when the plants had been aged less than 115 days after planting. Observations of plant growth components were plant height, leaf length, leaf number, and tiller numbers. Meanwhile, the observations of yield components were panicle length, panicle number, and rice grain numbers.

Statistical Analysis

Analyses of Variance (ANOVA) for factorials design were done to study the growth and yield response of rice plants due to application of ameliorant materials. If there was a significant effect, then it was continued by the least significant difference (LSD) test at 5% level.

RESULTS AND DISCUSSION

Soil Physical and Chemical Properties

Soil physical and chemical properties of the soil at a depth of 0-20 cm are presented in Table 2. Vertisol soil with an Ustic Endoaquert has clay loamy textures, slow of soil permeability and real of swelling and shrinking. Furthermore, the chemical properties of the soil indicates that the organic matter, total N, available P, and K can be exchanged are very low. Relatively rather acidic soil pH, cation exchange capacity and base saturation was high. Thus, based on the criterion of soil fertility status (Center for Soil Research 1983), the soil fertility was classified as moderate.

Table 2. Soil physical and chemical properties of Ustic Endoaquert.

Soil properties	Value	Criterion*
Texture:		
Sand	27	Clay loamy
Clay	35	
Silt	38	
Soil Permeability (cm hr^{-1})	1,59	Slow
Cole value	0,98	Real swell-shrinking
Water content availability	8,47	
C-Organic (%)	0,69	Very low
N-total (%)	0,06	Very low
C/N ratio	11,62	Moderate
Available-P, Bray 1 (mg P kg^{-1})	3,80	Very low
pH H_2O	6,48	Rather acid

NH4OAc 1 *N* pH 7 Extraction:		
K (cmol+ kg^{-1})	0,24	Very low
Ca (cmol+ kg^{-1})	14,90	High
Mg (cmol+ kg^{-1})	6,05	High
Na (cmol+ kg^{-1})	0,50	Moderate
CEC (cmol+kg^{-1})	30,93	High
Base saturation (%)	70,08	High
Extract KCl 1 *M*		
Al^{3+} (cmol+ kg^{-1})	0,00	
H^+ (cmol+ kg^{-1})	0,06	

* = Center for Soil Research (1983).

Growth Components of Rice Plant

The results of variance analysis for rice growth component on Ustic Endoaquert showed that coconut coir (CC) and banana coir (BC) had not significantly effect to plant high (Table 3), exceptly the sea sand (SS) had significant effect to plant high. The highest plant height was shown by the application of 20% SS and significant incrising plant high comparing other treatments. However, that plant height was still lower than normal and it was in aggreement with Supriatno *et al*. (2007), plant heigh of Ciherang varieties were ranged from 107-115 cm.

Table 3. The rice plant growth components by the application of sea sand, coconut coir and banana coir in Ustic Endoaquert.

Treatments	Plant height (cm)	Leaf length (cm)	Leaf number	Tiller number
Sea Sand				
0%	27.70a	20.64a	10.29^{ns}	12.07a
25%	30.97b	24.04b	14.18	13.37b
50%	30.23ab	23.01ab	14.04	13.29ab
Coconut Coir				
0 Mg ha^{-1}	29.57^{ns}	21.99^{ns}	11.88^{ns}	12.37^{ns}
10 Mg ha^{-1}	30.02	22.92	13.29	13.29
20 Mg ha^{-1}	29.32	22.78	13.33	13.07
Banana Coir				
0 Mg ha^{-1}	30.95^{ns}	23.89a	9.89a	12.56ns
10 Mg ha^{-1}	29.29	21.43b	16.37b	13.19
20 Mg ha^{-1}	28.65	22.37ab	12.26ab	13.00
Interaction	ns	ns	ns	ns
$LSD_{0.05}$	3.21	2.42	4.57	1.25

Number that followed by the same letter in the same column has not significant effect on the LSD level of 0.05, ns= not significant effect on the F level test 0.05.

The greatest increasing in plant height indicated that the application of 25% SS was able to increase plant height by 11.80%, while the lowest was shown on the application of 0 Mg ha^{-1} CC that was increased by 0.83% only. In the growth phase, especially plant height needs sufficient water availability. While, the application of 25% SS had not yet reducing water storages in soil, so the plant high was highest. On an application of 50% SS, the plant high was decreasing until 2.45%. Mishra *et al.* (2012) reporting that the water available significant decrease with increase of sand in mixture. Water shortages do not apparent at the beginning of the vegetative phase and it still can stimulate root development, but when this happens in the next vegetative phase, plant will be stunted (Sholeh and Riajaya 2000).

Water stress can reduce leaf area according to the speed of photosynthesis and allocation of assimilate from the canopy to the roots (Earl and Davis 2004). On the other hand, Berkelaar (2001) stated that aerobic soil conditions can make the plant roots get more oxygen, so the development is getting better, and in turn the plants will grow better and deliver optimal results. Furthermore, Yakup (2008) reported that plant height was significantly affected by soil water availability. In the water-saturated state, despite resistance by soil particles, no water can be absorbed by the soil except in certain plants such as paddy (Kasli and Effendi 2011).

Based on the test results of water absorption capacity (WAC) of both ameliorant showed that CC had a high WAC (71.77%), while BC was only 28.23%. Wuryaningsih *et al*. (2008) who conducted a study of growth *Anthurium andraeanum* in the pot by using coconut bulk media reported the physical properties were: a very high water content (1,314.41%), low-bulk density (0.09%), high total porosity (120.31%), and high pore water holding (116.6%). In addition, soil texture was classified as clay loamy (Table 2), so the soil puddling and flooding will become more easily dispersible and soil relatively compact (Isnaini and Suwarno 2005).

Then, application of SS and BC had significant effect to leaf length (Table 3), exceptly the SS had not significant effect to leaf lenght. The largest increasing of leaf length was shown on SS application as much as 25% (16.47%) and it was significantly different with 0% SS application. It seems that application of 25% SS had not yet reducing water storages in soil, so the leaf length was highest. On an application of 50% SS, the leaf length was decreasing until 11.48%. Mishra *et al.* (2012) reporting that the water available significant decrease with increase of sand in mixture. While, the lowest was shown on the 0 Mg ha^{-1} CC (0.62%) and did not significantly different with 10 Mg ha^{-1} CC and 20 Mg ha^{-1} CC.

Fazeli *et al*. (2007) stated that the effect of a turn single of water availability will reduce growth. Furthermore, Kasli and Effendi (2011) stated that the effects of water shortages on some physiological processes of plants were seen in a slow accumulation of dry matter, decreasing leaf expansion rate, and limiting stomata closure photosynthesis. In addition, short-term leaves and leaf area in plants were thought to be influenced by the intensity of the light received in green house where the research took place. The present of trees around the green house allegedly indirectly affected the reception of light by the plant, eventhough the distance was about 6 feet from the green house. Anggarwulan *et al*. (2008) stated that light played an important role in the physiological processes of plants, especially photosynthesis, respiration, and transpiration. The plants required quite diverse intensity of light.

The application of SS and CC did not have significantly effect to leaf number, but had significant effect with BC (Table 3). Application of 10 Mg ha^{-1} BC had significantly increased to leaf numbers by 65.52% and it was significantly different with 0 Mg ha^{-1} BC application. This is presumably due to the ability of BC to maintain soil moisture and water availability. Indrawati (2009) stated that the stem of BC is a strong fiber and resistant to water. It also has pores that are interconnected, and when dry a material will be having absorption and high shelf.

The application of CC and BC did not have significantly effect to tiller number, but had significant effect with SS (Table 3). Application of 25% SS had significantly increased to tiller numbers by 10.77% and it was significantly different with 0% SS application. Indrawati (2009) stated that the growing media flooding as high as 5 cm was also associated in the formation of tiller numbers. This is in line with reports by Utomo and Rudi (2000) *in* Kasli and Effendi (2011) that the flooding up to approximately 3-5 cm above the ground was a condition that had been considered good for the formation of tillers and if in the high-growth phase the flooding increased more than 5 cm it would inhibit seedling establishment. The results are reinforced by reports Astuti (2010) that the tiller numbers produced from crops by flooding system more than the intermittent and kemalir system. However, in contrast with the results of Shi *et al.* (2002) that the maximum tillering growth phase, the highest tiller numbers were in on kemalir water management compared to intermittent and continuous flooding.

According to Sumardi *et al.* (2007) that water use efficiency for rice cultivation without flooding condition was much as 19.581%, while with flooding continuously its efficiency was as much as 10.907% only. In this study also showed that the higher the plant will be followed by a greater tiller numbers. This is in contrast with the results of Aldi *et al.* (2004); Hartati and Suwarto (2004); Rahayu and Harjoso (2010) that the tiller numbers showing contrary to the values of plant height, where the higher tiller numbers the plant high was turning.

Rahayu and Harjoso (2010) explained that according to the concept of source-sink, photosynthetic resulting plants will be distributed to all parts of the organ and a variety has the same capacity, so that when the distribution is much to the establishment of seedlings will be followed by low plant height, as well otherwise. Meanwhile, although it was not significantly affect to tiller numbers, but giving 10 Mg ha^{-1} CC and BC increased the tiller numbers eachs by 7.44% and 5.01% compared to control. This is related to the ability to absorb water of CC and BC is high, so that it will enough moisture and water availability. Ramesh *et al*. (2010) reported that combination application of soil and coconut coir as much as 4% showed changes in the nature of Catton black soil compactness better than control. In general, for all plant growth components based on the contributions of each ameliorant material can be prepared series as follows: SS > BC > CC.

Yield Components of Rice Plant

The analysis of variance for rice yield components on Ustic Endoaquert resulted that application of coconut coir (CC) and banana coir (BC) had significantly increased panicle numbers of rice plants, but sea sand (SS) had not significant effect to panicle numbers. It seems that the pattern of the percentage increase of the panicle numbers with CC and BC applications were relative similar, however the different between treatments increased the percentage figures. The application of 20 Mg ha^{-1} BC had significantly increased the panicle numbers by 29.47% compared to 20 Mg ha^{-1} BC and by 23.41% to control, but it had not significantly different with 0 Mg ha^{-1} BC application. This suggests that BC application is able to maintain the water availability due to the ability to absorb water is high. The BC rods quite strong and resistant to water, and has pores that are interconnected, and when dry a material will be having absorption and high shelf (Indrawati 2009). Meanwhile, although it was not significantly affect to panicle numbers, but giving 50% SS increased the tiller numbers by 19.36% compared to control.

Level of soil sand fraction was 27% with clay loamy textures, so that the application of 50% SS fraction in the soil could reduce weight to light, particularly the declining of COLE index. Sand texture is very influential on the status and distribution of water, so affecting the root system and root depth (Walter *et al.* 2000; Oliver and Smettem 2002). Thus, the plant root system is not disturbed due to the possibility of soil cracking is not the case anymore, so the process of water and nutrients absorption can be better. Along with these, Cepy and Wangiyana (2011) stated that the ground state is a very hard and difficult to penetrate dense root cause soil aggregates and limit the exploration of the roots, and the roots may even be damaged. If power is hampered exploration roots, it will reduce the total root surface area that can be connected directly to the ground.

Table 4. The rice yield components by the application of sea sand, coconut coir and banana coir inUstic Endoaquert

Treatments	Panicle numbers	Panicle length (cm)	Rice grain numbers
Sea Sand			
0%	2.48^{ns}	8.97b	8.64^{ns}
25%	2.59	7.35a	7.98
50%	2.96	8.28ab	9.07
Coconut Coir			
0 Mg ha^{-1}	2.59ab	6.41a	7.14a
10 Mg ha^{-1}	2.37a	8.80b	9.52b
20 Mg ha^{-1}	3.07b	9.39b	9.04ab
Banana Coir			
0 Mg ha^{-1}	2.52ab	7.33a	7.49^{ns}
10 Mg ha^{-1}	2.41a	9.49b	9.48
20 Mg ha^{-1}	3.11b	7.78a	8.72
Interaction	ns	ns	ns
$LSD_{0.05}$	0.63	1.24	2.05

Number that followed by the same letter in the same column has not significant effect on the LSD level of 0.05, ns= not significant effect on the F level test 0.05.

Then, application of 20 Mg ha^{-1} CC had significantly increased the panicle numbers by 29.54% compared to 10 Mg ha^{-1} CC, but it had not significantly different than the panicle numbers with application as much as 0 Mg ha^{-1} CC. This is presumably related to soil water availability. The WAC level of CC is high and will be able to absorb and retain water availability in the soil, so that more BC will be followed by the greater panicle numbers. This is consistent with the statement Dachban (2012) that the rice shortage water for 4 days in the generative period and the next 2 weeks was a period that was sensitive to water shortages. Furthermore, he said that the yield components showed the most dramatic decline was the panicle numbers.

In addition, the SS, CC and BC had significantly increased to panicle length. The application of as 10 Mg ha^{-1} BC had significantly increased panicle length by 29.47% compared to control (0 Mg ha^{-1} BC) and by 21.98% compared to 20 Mg ha^{-1} BC. This is presumably related to the water availability of each treatment. The research results by Dachban (2012) showed that the panicle length at breast level 3 mm, 2 mm and 1 mm had decreased long paniclesby 0.77%, 5.80%, 45.10% respectively, due to the reduction in yield because to lack of water. In fact, the research results by Astuti (2010) showed that the panicle length and rice grain numbers were not affected by irrigation, but each variety had panicle length and rice grain numbers per panicle significantly different according to the genetic. Meanwhile, 10 Mg ha^{-1} CC had significantly increased the rice grain numbers by 33.33% compared to control and did not have significantly different with 20 Mg ha^{-1} CC (Table 4). Apparently, the longer panicles will be relatively followed by a greater rice grain numbers. It is in line with the revelation Setiobudi *et al.* (2008) that the rice grain numbers was determined by the genetic properties of plants especially panicle length, tassel branch, and a differentiation rice grains.

CONCLUSION

The application of coconut coir and banana coir did not have significant effect on plant height. On the other hand, the applications of sea sand and banana coir had significantly increased leaf length with the highest increasing percentage of 16.47% in 25% SS application. The leaf numbers and tiller numbers were relatively unsimilar pattern. For leaf numbers only banana coir application had significant by increased of 65.52% and to tiller numbers only sea sand amount of 10.77%. Furthermore, the application of coconut coir and banana coir had significant for increasing a panicle numbers each ups to 29.53% and 29.05% compared to control. All ameliorant had significant effect to panicle length, but the best increasing was coconut coir with up to 46.49% in 20 Mg ha^{-1} CC compared to sea sand and coconut coir applications and it was only coconut coir had significant increased the rice grain numbers.

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Chapter in Book or Proceeding

Haselwandter K. 1997. Soil microorganisms, mycorrhiza and restoration ecology. In: KM Urbanska, NR Webb and PJ Edwards (eds). *Restoration Ecology and Sustainable Development*. Cambridge University Press, Cambridge, pp. 65-80.

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Book

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Nursyamsi D. 2008. Pelepasan kalium terfiksasi dengan penambahan asam oksalat dan kation untuk meningkatkan kalium tersedia bagi tanaman pada tanah-tanah yang didominasi mineral liat smektit. [Disertasi]. Institut Pertanian Bogor (in Indonesian).

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#24-13

Effect of Application of Sea Sand, Coconut and Banana Coir on Growth and Yield of Rice Planted at Ustic Endoaquert Soil taken from Paddy Rice Field

Growth and Yield of Rice Plant by the Applications of Sea Sand, Coconut and Banana Coir in Ustic Endoaquert

ABSTRACT

~~The~~ Research aimed to study effect of ~~the~~ application of sea sand (SS), coconut coir (CC), and banana coir (BC) on growth and yield of rice (*Oryza sativa* L.) planted at ~~in~~ Ustic Endoaquert. The ~~field~~ pot ~~research~~ experiment was carried out ~~in a fields~~ using ~~3 × 3 × 3~~ factorial design with 3 factors. The ~~SS~~ first factor was SS consisted of three ~~treatment~~ levels, i.e.: ~~which were~~ 0% ~~SS~~, 25% ~~SS~~, and 50% ~~SS~~. ~~Meanwhile, the~~ the second and the third factors were CC and BC, each consisted of three ~~treatment~~ levels, i.e.: ~~where each level were~~ 0 ~~Mg ha^-1^~~, 10 ~~Mg ha^-1^~~ and 20 Mg ha^{-1}. The application of coconut coir and banana coir did not have significant effect on plant height. On the other hand, the applications of sea sand and banana coir had significantly increased leaf length with the highest increasing percentage of 16.47% in SS application. The leaf numbers and tiller numbers were relatively unsimilar pattern. For leaf numbers only banana coir application had significant by increased of 65.52% and to tiller numbers only sea sand amount of 10.77%. Furthermore, the application of coconut coir and banana coir had significant for increasing a panicle numbers each ups to 29.53% and 29.05% compared to control. All ameliorant had significant effect to panicle length, but the best increasing was coconut coir with up to 46.49% in CC compared to sea sand and coconut coir applications and it was only coconut coir had significant increased the rice grain numbers.

ganti kesimpulan!

Keywords: Banana coir, coconut coir, rice plant, sea sand, Vertisol

INTRODUCTION

~~The~~ Rate of population growth, with a percentage of about 2% per year has resulted in increasing demand for rice consumption. Until 2012, ~~the~~ national rice demand reached 34.055 million Mg and paddy production reached 68,956,292 Mg (BPS RI 2012) or equivalent to 37 million Mg of rice (Suswono 2012). Sudaryatno *et al.* (2010) predicted that the need of national rice in 2015 as many as 35,123,000 Mg and 37,021,000 Mg in 2020, or an average rate of rice consumption increas~~ing~~ed 0.92% per year. Viewing statistics in 2012, it ~~is~~ was apparently ~~still~~ a surplus as much as 3-4 million Mg of rice at ~~this time~~ the year. Although the current national rice need was adequate and surplus, but considering Indonesia's populations that were about 247 million and the increasing rate of population growth, it ~~needs~~ needed to be maintained and improved ~~availability~~, one through the increasing productivity of paddy soil.

Paddy rice field ~~Rainfed Paddy~~ soil ~~(RPS)~~ is ecosystems which water source are dominantly from irrigation and as mainly ~~fiSSt~~ national rice sources which coverages 2.1 million ha (Toha and Pirngadi 2004). In Paguyaman, Gorontalo province, paddy rice field ~~PS~~ areas are dominantly classified as Vertisol~~s soil~~ that developed from lacustrine deposition materials (Hikmatullah *et al.* 2002; Prasetyo 2007; Nurdin 2011). From chemically aspect, Vertisol is classified as nutrient rich soil that has high nutrient sources (Deckers *et al.* 2001). However, the physical properties are limiting factor for ~~the~~ plant growth which are heavy clay texture, swelling and shrinking properties, lowest water infiltration, and slow drainage (Mukanda and Mapiki 2001). As a result, it frequently ~~has~~ stunted plant growth and low yield. It is necessary to repair these properties by giving ameliorant materials.

Sand is one type of the ameliorant materials that can be applied to high clay soils. Ravina and Magier (1984); Narka and Wiyanti (1999) showed that application of ~~the~~ sand had significantly effect to decline COLE value, soil plasticity index, and soil permeability become large, but the water content availability was low. This ~~is~~ was in lines with statement of Kusnarta (2012) that sand ~~can~~ could improv~~ing of~~ed aggregate and structure stability of Vertisol (*stability quotient*) ~~SQ)~~ way of declining clay function mecanisme in swelling-shriking processes. Besides, the application of sand about ~~amount~~ 20% of weight declined ~~has declining of~~ COLE values. The ~~Sea sand (SS) has using~~ was used as medium of planting (Sari *et al.* 2006), but it had a NaCl contents caused some crops ~~can~~ grow abnormally (Kusnarta *et al.* 20012). Walter *et al.* (2000); Oliver and Smettem (2002); Al-Omran *et al.* (2004) has stated that ~~the~~ sandy ~~soil~~ texture soil ~~is~~ was very influential on ~~the~~ status and distribution of water, so influincced ~~the~~ root system and root depth. Further Rajiman (2009) has stated that the sandy soil texture ~~has~~ influinced ~~of~~ nutrients on soil and pH too.

However, paddy soil cultivation requires medium permeability with sufficient water content, so it needs another ameliorant to fix these properties, such as by using coconut coir and banana coir. Coconut coir ~~(CC)~~ has been used as water storage on farms (Subiyanto *et al.* 2003), while the banana coir ~~(BC)~~ is still relatively not used yet ~~underused~~. Water ~~Though BC~~ absorption of banana coir ~~is~~ was relatively high when it ~~is~~ was dried because it ~~has~~ had pores that ~~are~~ were interconnected (Indrawati 2009).

① Soil description and classification were presented at Table 1

application

Applications of the three ameliorant materials were allegedly able to mutually improve soil physical and chemical properties of Vertisol under rice cultivation ~~on RPS~~ in paddy rice field, so that its productivity ~~can~~ could be improved. This ~~study~~ research aimed to ~~determine~~ study ~~the response of plant growth and yield components with SS, CC, and BC application in~~ the effect of sea sand, coconut coir and banana coir on growth and yield of rice planted at Soil taken from Paddy Rice field Ustic Endoaquert.

MATERIALS AND METHODS

Study Sites

The experiment was conducted in the green house of Mathematics and Natural Sciences Faculty of Gorontalo State University starting in April-August 2012. Meanwhile, the growing media was ~~taken from the Vertisol with~~ Ustic Endoaquert ~~sub groups (Table 1).~~ Soil taken from ... Subdistrict, ... District, Gorontalo Province ①

Coconut and Banana Coir Preparation

Materials were obtained from ~~the~~ dried coconut husk that was surrounded ~~the~~ coconut shell inside. Coconut husk was peeled and ~~separatly~~ separated from coconut shell, ~~and~~ then, a smooth outer skin was peeled again until remaining coconut coir (CC). Furthermore, the CC was milled to 1 mm. Banana coir (BC) materials were obtained from dried banana bark. Banana bark was peeled and separated from ~~the~~ trunk up to 10 sheets of rods into ~~the~~ core of the BC. Furthermore, the banana peel was grounded into powder with a size of 0.05 mm. The CC and BC obtained were weighed according to ~~the~~ dosage of each treatment. Before application, ~~the~~ water absorption capacity (WAC) of CC and BC were tested through immersion. Immersion was used to determine ~~the~~ maximum WAC of the ameliorant material. Calculation of WAC followed the equation:

$$WAC\ (\%) = [\text{Pre Weight } (w0) / \text{Dry weight } (w1)] \times 100\%$$

Experimental Design

The study used a ~~3 × 3 × 3~~ factorial design ~~. There were~~ with 3 factors of ameliorants, ~~in this study and~~ where each factor consisted of 3 dosages ~~treatment and each treatment~~ of ameliorants and each had 3 replications, ~~so~~ 81 plots experiments were obtained. Sea sand ~~(SS)~~ factors consisted of 0% ~~SS~~ (S_0), 25% ~~SS~~ (S_1), and 50% ~~SS~~ (S_2), ~~Furthermore, the~~ CC factor consisted of 0 ~~Mg ha^{-1} CC~~ (C_0), 10 ~~Mg ha^{-1} CC~~ (C_1), and 20 Mg ha^{-1} ~~CC~~ (C_2), ~~While~~ while, the BC factors consisted of 0 ~~Mg ha^{-1} BC~~ (B_0), 10 ~~Mg ha^{-1} BC~~ (B_1), and 20 Mg ha^{-1} BC (B_2).

Table 1. Soil description and classification of ~~Ustic Endoaquert.~~ the experiment site

Location	: Sidomukti Village, Mootilango Subdistrict, Gorontalo ~~regency~~ District.
Soil classification	
Taxonomy (USDA, 2010): Endoaquert Ustic	

PPT	: Eutric Grumusol
FAO/UNESCO	: Cambisol
Parent Material	: Lacustrine
Position Fisiografik	: Foot Slope, Depression
Topography	: Flat-Ramps; slopes <2%
Elevation	: 58 m sl
Drainage	: Poor
Groundwater Depth	: Shallow
Vegetation	: Rice (*Oryza sativa* L.)

Depth (cm)	Horizon	Descriptions
0-12	Apg1	Gray (10YR 5/1); clay loamy; massive structure; very sticky, plastic; smooth roots, a lot; clear flat.
12-31	Apg2	Gray (10YR 5/1); clays berliat; angular blocky structure, smooth, weak; very sticky, plastic; rusty brown (10YR 5/3), plain, smooth, clear, spots, sharp; rooting smooth, much; gradually average
31-53	Bwg1	Gray (10YR 5/1), clay; moderate, angular blocky structure, weak; very sticky, plastic; rooting smooth, slightly; frosted flat.
53-71/92	Bwg2	Gray (10YR 6/1), clay; angular blocky structure, rough, weak; very sticky, plastic; obviously choppy.
71/92-119	Bwssg	Dark gray (10YR 4/1), clay; moderate, angular blocky structure, moderate; very sticky, plastic; slikendside; rusty brown (10YR 5/3), plain, smooth, clear, tube, clear; frosted flat.
119-150	BCg1	Dark gray (10YR 4/1), clay; angular blocky structure, haSSh, strong; very sticky, plastic; rusty brown (10YR 5/3), plain, smooth, clear, tube, clear; clear flat.
150-200	BCg2	Dark gray (10YR 4/1), clay; very sticky, very friable; frosted flat.

(2)

Its

Rice Planting and Maintainance

Before planting, ~~a~~ basic~~starter~~ fertilizers ~~was~~ were weighed and applied to the soils. ~~Fertilizers used consisted of 125~~ ~~kg~~ 125 kg Urea ha^{-1} ~~which~~ were given twice at ages 0 day after planting (DAP) and 60 DAP, each respectively as much as 62.5 kg ha^{-1} ~~each~~. Meanwhile, SP36 ~~fertilizers in the amount of~~ 100 kg ha^{-1} were given twice at age 0 DAP and 60 DAP, each respectively as much as 50.0 kg ha^{-1} ~~each~~, whereas KCl ~~fertilizers in the amount of~~ 50 kg ha^{-1} were given twice ~~at ages 0 DAP and~~ 60 DAP, each respectively as much as 25 kg ha^{-1} ~~each.~~

~~A~~ Ciherang rice seed variety ~~that was used~~ was tested its quality by soaking in saline solution, then planted in trays which were covered by leaves and soil media containing organic material with a ratio of 1:1 until 10 days. A day before planting, the planting medium was watered so that compounds ~~which were~~ toxic to rice seedlings were moved down to the bottom of the pot. Rice seeds ~~that had been~~ 10 days aged were transferred into ~~the~~ plant growing media. Planting was done in ~~the~~ planting hole as deep as 8 cm. ~~At planting time, it~~

How did you irrigate the soil ...? Why is until flooding water content of field capacity ...

and applying basic fertilizers

and ~~was~~ followed by ~~the~~ application of basic fertilizers, ~~as much as half of the total dose of fertilizer~~. During ~~the~~ growth and development ~~of~~ plants, the maintenance performed was weeds clearing, watering at 30 DAP and 60 DAP, a~~nd subsequent fertilization at age 60 DAP~~. Harvesting was done when ~~the~~ plants ~~had been~~ aged less than 115 days after from planting. Observations of plant growth components were plant height, leaf length, leaf number, and tiller numbers. Meanwhile, the observations of yield components were panicle length, panicle number, and rice grain numbers.

Statistical Analysis

Analyses of Variance (ANOVA) for factorials design were done to study the growth and yield response of rice plants due to application of ameliorant materials. If there was a significant effect, then it was continued by the least significant difference (LSD) test at 5% level.

RESULTS AND DISCUSSION

~~Soil Physical and Chemical Properties~~

depth

(2) pinda ke hal-4

Initial ~~S~~oil ~~physical and chemical~~ properties of the soil at ~~a depth of~~ 0-20 cm are presented in Table 2. The soil ~~Vertisol soil with an Ustic Endoaquert~~ had clay loamy textures, slow of soil permeability and real of swelling and shrinking. Furthermore, the soil chemical properties ~~of the soil~~ indicated that ~~the~~ soil organic matter, total N, available P, and K ~~can be~~ exchanged were ~~are~~ very low. Relatively rather acidic soil pH, cation exchange capacity and base saturation were ~~was~~ high. Thus, based on ~~the~~ criterion of ~~soil fertility status~~ (Center for Soil Research 1983), the soil fertility status was classified as moderate.

Table 2. Initial ~~Soil physical and chemical~~ properties of Ustic Endoaquert at 0-20 cm depth.

Soil properties	Value	Criterion*
Texture:		
Sand	27	Clay loamy
Clay	35	
Silt	38	
Soil Permeability (cm hr^{-1})	1,59	Slow
Cole value	0,98	Real swell-shrinking
Water content availability	8,47	?
C-Organic (%)	0,69	Very low
N-total (%)	0,06	Very low
C/N ratio	11,62	Moderate
Available-P, Bray 1 (mg P kg^{-1})	3,80	Very low
pH H_2O	6,48	Rather acid ?

NH4OAc 1 *N* pH 7 Extraction:		
K (cmol+ kg^{-1})	0,24	Very low
Ca (cmol+ kg^{-1})	14,90	High
Mg (cmol+ kg^{-1})	6,05	High
Na (cmol+ kg^{-1})	0,50	Moderate
CEC (cmol+kg^{-1})	30,93	High
Base saturation (%)	70,08	High
Extract KCl 1 *M*		
Al^{3+} (cmol+ kg^{-1})	0,00	
H^{+} (cmol+ kg^{-1})	0,06	

* = Center for Soil Research (1983).

Growth Components of Rice Plant

The results of variance analysis for rice growth component ~~on~~ planted as Ustic Endoaquert showed that ~~coconut coir~~ (CC) ~~and banana coir~~ (BC) ~~had~~ did not significantly effect to plant high (Table 3), while ~~exceptly the sea sand (SS) had~~ significant effect ed to plant high. The highest plant height was shown at ~~by the~~ application of 20% SS ~~and~~ which significant increased ~~incrising~~ plant high comparing other treatments. However, the ~~that~~ plant height was still lower than normal growth as reported by ~~and it was in aggreement with~~ Supriatno *et al.* (2007), that plant heigh of Ciherang varieties were ranged from 107-115 cm.

Table 3. The rice ~~plant~~ growth components at ~~by the~~ application of sea sand, coconut coir and banana coir at ~~in~~ Ustic Endoaquert Soils. How about other variable ...?

Treatments	Plant height (cm)	Leaf length (cm)	Leaf number	Tiller number
Sea Sand				
0%	27.70a	20.64a	10.29^{ns}	12.07a
25%	30.97b	24.04b	14.18	13.37b
50%	30.23ab	23.01ab	14.04	13.29ab
Coconut Coir				
0 Mg ha^{-1}	29.57^{ns}	21.99^{ns}	11.88^{ns}	12.37^{ns}
10 Mg ha^{-1}	30.02	22.92	13.29	13.29
20 Mg ha^{-1}	29.32	22.78	13.33	13.07
Banana Coir				
0 Mg ha^{-1}	30.95^{ns}	23.89a	9.89a	12.56ns
10 Mg ha^{-1}	29.29	21.43b	16.37b	13.19
20 Mg ha^{-1}	28.65	22.37ab	12.26ab	13.00
Interaction	ns	ns	ns	ns
$LSD_{0.05}$	3.21	2.42	4.57	1.25

Number that followed by ~~the~~ same letter in ~~the~~ same column did ~~has~~ not significant effect at ~~on the~~ LSD level of 0.05, ns= not significant effect on the F level test 0.05.

The highest ~~greatest~~ increase ~~ing in~~ of plant height was indicated at ~~that the~~ application of 25% SS which ~~was able to~~ increased plant height by 11.80%, while the lowest one was shown at ~~on the~~ application of 10 Mg ha^{-1} CC which ~~that was~~ increased it by 0.83% only. At ~~the~~ growth phase, especially plant height needs sufficient water availability. ~~While, the~~ Application of 25% SS had ~~not yet~~ reduc~~ing~~ed water storages in soil, so ~~the plant high was~~ highest. it did not effect on water availability but could increase ~~On an~~ At application of 50% SS, the plant high ~~was~~ decreas~~ing~~ed until 2.45%. ~~Mishra *et al.*~~ (2012) report~~ing~~ed that ~~the~~ water available significantly decreased with increase of sand in mixture. Water shortages do not apparent at the beginning of ~~the~~ vegetative phase and it still can stimulate root development, but ~~when this happens in~~ at ~~the~~ next vegetative phase, plant will be stunted (Sholeh and Riajaya 2000).

Water stress can reduce leaf area according to the speed of photosynthesis and allocation of assimilate from the canopy to the roots (Earl and Davis 2004). On the other hand, Berkelaar (2001) stated that aerobic soil conditions can make the plant roots get more oxygen, so the development is getting better, and in turn the plants will grow better and deliver optimal results. Furthermore, Yakup (2008) reported that plant height was significantly affected by soil water availability. In the water-saturated state, despite resistance by soil particles, no water ~~can~~ could be absorbed by the soil except in certain plants such as paddy (Kasli and Effendi 2011).

~~Based on the~~ Test results of ~~water absorption capacity (~~WAC~~)~~ of both ameliorant showed that CC had a high WAC (71.77%), while BC was only 28.23%. Wuryaningsih *et al.* (2008) who conducted a study of growth *Anthurium andraeanum* in ~~the~~ pot by using coconut bulk media reported ~~the~~ that its physical properties were: a very high water content (1,314.41%), low-bulk density (0.09%), high total porosity (120.31%), and high pore water holding (116.6%). In addition, soil texture was classified as clay loamy (Table 2), so the soil puddling and flooding ~~will~~ would become more easily dispersible and soil was relatively compact (Isnaini and Suwarno 2005).

~~Then,~~ application of SS and BC had significant effect to leaf length (Table 3), ~~exceptly~~ while the SS ~~had not~~ did not have significant effect to leaf lenght. The largest increas~~ing~~e of leaf length was shown ~~on~~ at SS application as much as 25% (16.47%) and it was significantly different with ~~0% SS application~~ control. It seems that application of 25% SS had ~~not yet~~ reduc~~ing~~ed water storages in soil, but it also increase root porosity so the leaf length was highest. ~~On an~~ At application of 50% SS, the leaf length ~~was~~ decreas~~ing~~ed until 11.48%. Mishra *et al.* (2012) reporting that ~~the~~ water available ~~significant~~ decreased significantly with increase of sand in mixture. ~~While,~~ The lowest leaf length was shown ~~on~~ at the 0 Mg ha^{-1} CC (0.62%) and ~~did not~~ it was not significantly different with 10 Mg ha^{-1} CC and 20 Mg ha^{-1} CC.

Fazeli *et al.* (2007) stated that ~~the~~ effect of a turn single of water availability ~~will~~ would reduce growth. Furthermore, Kasli and Effendi (2011) stated that ~~the~~ effects of water shortages on some physiological processes of plants were seen in a slow accumulation of dry matter, decreasing leaf expansion rate, and limiting stomata closure photosynthesis. In addition, short-term leaves and leaf area in plants were thought to be influenced by the intensity of the light received in green house where the research took place. The present of trees around the green house allegedly indirectly affected the reception of light by the plant, eventhough the distance was about 6 feet from the green house. Anggarwulan *et al.* (2008) stated that light played an important role in the physiological processes of plants, especially photosynthesis, respiration, and transpiration. The plants required quite diverse intensity of light.

The application of SS and CC did not have significant~~ly~~ effect to leaf number, but had significant effect ~~with~~ to BC (Table 3). Application of 10 Mg ha^{-1} BC had significant~~ly~~ increase~~d~~ to leaf numbers by 65.52% and it was significant~~ly~~ different with ~~0 Mg ha^{-1} BC application~~ control. This ~~is~~ was presumably due to the ability of BC to maintain soil moisture and water availability. Indrawati (2009) stated that the stem of BC ~~is~~ was a strong fiber and resistant to water. It also ha~~s~~d pores that ~~are~~ were interconnected, and when dry a material ~~will~~ would be having absorption and high shelf.

The application of CC and BC did not have significant~~ly~~ effect to tiller number, but application of had significant effect ~~with SS~~ to it (Table 3). Application of 25% SS ~~had~~ significantly increased ~~to~~ tiller numbers by 10.77% an~~d it was significantly different with 0% SS application~~. Indrawati (2009) stated that the growing media flooding as high as 5 cm was also associated ~~in the~~ with formation of tiller numbers. This ~~is~~ was in line with reports ~~by~~ of Utomo and Rudi (2000) *in* Kasli and Effendi (2011) that the flooding up to approximately 3-5 cm above ~~the ground~~ soil surface was a condition that ~~had been~~ considered as good for ~~the~~ formation of tillers and ~~if in the high growth~~ at foll phase the flooding ~~increased more than 5 cm it~~ would inhibit seedling establishment. The results ~~are~~ were reinforced by reports Astuti (2010) that the tiller numbers were produced from crops by flooding system more than ~~the~~ by intermittent and kemalir system. However, in contrast with ~~the~~ results of Shi *et al.* (2002) that the maximum tillering growth phase, the highest tiller numbers were in on kemalir water management compared to intermittent and continuous flooding.

~~According to~~ Sumardi *et al.* (2007) reported that water use efficiency for rice cultivation without flooding condition was much as 19.581%, while with flooding continuously, its efficiency was as much as 10.907% only. In this study also showed that the higher the plant ~~will~~ would be followed by a greater tiller numbers. This ~~is~~ was in contrast with the results of Aldi *et al.* (2004); Hartati and Suwarto (2004); Rahayu and Harjoso (2010) who reported that the tiller numbers showed contrary to ~~the~~ values of plant height, where the higher tiller numbers was the plant high ~~was turning~~ lower

Rahayu and Harjoso (2010) explained that according to the concept of source-sink, photosynthetic resulting plants will be distributed to all parts of the organ and a variety has the same capacity, so that when the distribution is much to the establishment of seedlings will be followed by low plant height, as well otherwise. ??? tidal Meanwhile, although it was not significantly affect to tiller numbers, but ~~giving~~ application of 10 Mg ha^{-1} CC and BC increased ~~the~~ tiller numbers eachs by 7.44% and 5.01% compared to control. This ~~is~~ was related to ~~the~~ ability to absorb water of CC and BC ~~is~~ were high, so that ~~it will~~ they would enough moisture and water availability. Ramesh *et al.* (2010) reported that combination ~~application~~ of soil and coconut coir as much as 4% showed changes in the nature of Catton black soil ??? compactness better than control. ~~In general, for all~~ plant growth ~~components based on the~~ contributions of ~~each~~ ameliorant effects ~~material can be prepared series as follows: SS > BC > CC.~~ was in order of SS > BC > CC

Yield Components of Rice Plant

~~The~~ analysis of variance for rice yield components ~~on Ustic Endoaquert~~ resulted that application of ~~coconut coir~~ (CC) ~~and banana coir~~ (BC) had significantly increased to panicle numbers ~~of rice plants~~, but application of ~~sea sand (SS) had not~~ did not have significant effect to panicle numbers. It seems that ~~the pattern of the~~ percentage increase of ~~the~~ panicle numbers with CC and BC applications were relative similar, however ~~the~~ the different between treatments was increased ~~the~~ of percentage figures. ~~The~~ application of 20 Mg ha^{-1} BC ~~had~~ significantly increased ~~the~~ panicle numbers by 29.47% compared to 20 Mg ha^{-1} BC and by 23.41% compared to control, ~~but it had not significantly different with 0 Mg ha^{-1} BC application~~. This suggested that BC application ~~is~~ was able to maintain ~~the~~ water availability due to ~~the~~ ability to absorb water ~~is~~ was high. The BC ~~rods~~ was quite strong and resistant to water, and had pores that ~~are~~ were interconnected, and when dry a material ~~will~~ would be having absorption and high shelf (Indrawati 2009). Meanwhile, although it was not significant~~ly~~ e~~affect~~ffect to panicle numbers, but ~~giving~~ application of 50% SS increased ~~the~~ tiller numbers by 19.36% compared to control.

~~Level of~~ Soil sand fraction was ~~27% with~~ clay loamy textures, so that ~~the~~ application of 50% SS ~~fraction in~~ to the soil could reduce weight to light fraction, particularly ~~the declining~~ declined ~~of~~ COLE index. Sand texture ~~is very influential~~ effected on ~~the~~ status and distribution of water, so affecting ~~the~~ root system and root depth (Walter *et al.* 2000; Oliver and Smettem 2002). Thus, the plant root system ~~is~~ was not disturbed due to the possibility of soil cracking ~~is~~ was not ~~the case~~ anymore, so the process of water and nutrients absorption ~~can~~ could be better. Along with these, Cepy and Wangiyana (2011) stated that the ground state ~~is a very~~ hard and difficult to penetrate dense root cause soil aggregates and limit the exploration of the roots, and the roots may even be damaged. If power is hampered exploration roots, it will reduce the total root surface area that can be connected directly to the ground. TIDAK NYAMB

Table 4. The rice yield components ~~by the~~ at application of sea sand, coconut coir and banana coir planted at ~~in~~ Ustic Endoaquert

Treatments	Panicle numbers	Panicle length (cm)	Rice grain numbers (unit
Sea Sand			
0%	2.48^{ns}	8.97b	8.64^{ns}
25%	2.59	7.35a	7.98
50%	2.96	8.28ab	9.07
Coconut Coir			
0 Mg ha^{-1}	2.59ab	6.41a	7.14a
10 Mg ha^{-1}	2.37a	8.80b	9.52b
20 Mg ha^{-1}	3.07b	9.39b	9.04ab
Banana Coir			
0 Mg ha^{-1}	2.52ab	7.33a	7.49^{ns}
10 Mg ha^{-1}	2.41a	9.49b	9.48
20 Mg ha^{-1}	3.11b	7.78a	8.72
Interaction	ns	ns	ns
$LSD_{0.05}$	0.63	1.24	2.05

Number that followed by the same letter in the same column has not significant effect on the LSD level of 0.05, ns= not significant effect on the F level test 0.05.

~~Then~~ Application of 20 Mg ha^{-1} CC ~~had~~ significantly increased ~~the~~ panicle numbers by 29.54% compared to 10 Mg ha^{-1} CC. ~~but it had not significantly different than the panicle numbers with application as much as 0 Mg ha^{-1} CC~~. This ~~is~~ was presumably related to soil water availability. The WAC level of CC ~~is~~ was high and ~~will~~ would be able to absorb and retain water availability in the soil, so that more BC ~~will~~ would be followed by the greater panicle numbers. This was ~~is~~ consistent with ~~the~~ statement of Dachban (2012) that ~~the~~ rice shortaged water for 4 days ~~in the~~ at generative period and ~~the next~~ following 2 weeks was a period ~~that was~~ sensitive to water shortages. ~~Furthermore, he said that the yield components showed the most dramatic decline was the panicle numbers.~~

In addition, the SS, CC and BC application ~~had~~ significantly increased ~~to~~ panicle length. The application of ~~as~~ 10 Mg ha^{-1} BC ~~had~~ significantly increased panicle length by 29.47% compared to control ~~(0 Mg ha^{-1} BC)~~ and by 21.98% compared to 20 Mg ha^{-1} BC. This ~~is~~ was presumably related to ~~the~~ water availability of each treatment. The research ~~results~~ conducted by Dachban (2012) showed that the panicle length at ~~breast~~ level of 3 mm, 2 mm and 1 mm ~~had~~ decreased long panicles by 0.77%, 5.80%, 45.10% respectively, due to ~~the~~ reduction ~~in~~ of plant yield because of ~~to lack~~ of water. In fact, ~~the research results by~~ Astuti (2010) ~~showed~~ reported that ~~the~~ panicle length and rice grain numbers were not affected by irrigation, but each variety had panicle length and rice grain numbers per panicle significant~~ly~~ different ~~according~~ due to the genetic. Meanwhile, 10 Mg ha^{-1} CC ~~had~~ significantly increased ~~the~~ rice grain numbers by 33.33% compared to control ~~and~~ but did not have significant~~ly~~ different with 20 Mg ha^{-1} CC (Table 4). Apparently, ~~the~~ longer panicles ~~will~~ would be relatively followed by a greater rice grain numbers. It ~~is~~ was in line with ~~the revelation~~ Setiobudi *et al.* (2008) that the rice grain numbers was determined by ~~the~~ genetic properties of plants especially panicle length, tassel branch, and a differentiation rice grains.

CONCLUSION

~~The application of coconut coir and banana coir did not have significant effect on plant height. On the other hand, the~~ Applications of sea sand and banana coir ~~had~~ significantly increased leaf length where ~~with~~ the highest increas~~ing~~ percentage of 16.47% was acheived at ~~in~~ 25% SS application. ~~The~~ Their effect on leaf numbers and tiller numbers were relatively not ~~un~~similar pattern where ~~For~~ leaf numbers only by banana coir application ~~had significant by~~ increased about ~~of~~ 65.52%, while ~~and to~~ tiller numbers only increased sea sand application ~~amount of~~ about 10.77%. Furthermore, the application of coconut coir and banana coir ~~had~~ significant ~~for~~ increased ~~a~~ panicle numbers each ups to 29.53% and 29.05% compared to control. All ameliorant ~~had~~ significant increased ~~effect to~~ panicle length, but the best one ~~increasing~~ was coconut coir which could increase up to 46.49% at ~~in~~ 20 Mg ha^{-1} CC compared to sea sand and coconut coir applications ~~and it was~~ only coconut coir ~~had~~ significantly increased ~~the~~ rice grain numbers.

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Effect of application sea sand, coconut and banana coir on growth and yield of rice planted at Ustic Endoaquert soil taken from paddy rice field

Nurdin

ABSTRACT

Research aimed to study effect of application of sea sand (SS), coconut coir (CC) and banana coir (BC) on growth and yield of rice (*Oryza sativa* L.) planted at Ustic Endoaquert. The pot experiment was carried out using factorial design with 3 factors. The first factor was SS consisted of three levels i.e.: 0%, 25%, and 50%. The second and third factors were CC and BC, each consisted of three levels i.e.: 0, 10, and 20 Mg ha^{-1}. Application of sea sand and banana coir significantly increased leaf length where the highest increase percentage of 16.47% was achieved at 25% SS application. Their effect on leaf numbers and tiller numbers were relatively not similar pattern where leaf number only increased about 65.52% by banana coir application, while tiller numbers only increased about 10.77% by sea sand application. Furthermore, the application of coconut coir and banana coir significantly increased panicle numbers each ups t0 29.53% and 29.05% compared to control. All ameliorant significantly increased panicle number, but the best was coconut coir with could increased up to 46.49% at 20 Mg ha^{-1} CC compared to sea sand and banana coir application. Only coconut coir significantly increased the rice grain numbers.

Keywords: Banana coir, coconut coir, rice plant, sea sand, Vertisol

INTRODUCTION

Rate of population growth with a percentage of about 2% per year has resulted in increasing demand for rice consumption. Until 2012, national rice demand reached 34.055 million Mg and paddy production reached 68,956,293 Mg (BPS RI 2012) or equivalent to 37 Million Mg of rice (Suswono 2012). Sudaryatno *et al*. (2010) predicted that the need of national rice in 2015 as many as 35,123,000 Mg and 37,021,000 Mg in 2020, or an average rate of rice consumption increased 0.92% per year. Viewing statistics in 2012, it was apparently a surplus as much as 3-4 million Mg of rice at the year. Although the current national rice need was adequate and surplus, but considering Indonesia's populations that were about 247 million and the increasing rate of population growth, it needed to be maintained and improved, one through the increasing productivity of paddy soil.

Paddy rice field soil is ecosystem which water source are dominantly from irrigation and as mainly national rice sources which coverage 2.1 million ha (Toha and Pirngadi 2004). In Paguyaman, Gorontalo Province paddy rice field areas are dominantly classified as Vertisols that developed from lacustrine deposition materials (Hikmatullah *et al.* 2002; Prasetyo 2007; Nurdin 2011). From chemically aspect, Vertisol is classified as nutrient rich soil that has high nutrient sources (Deckers *et al.* 2001). However, the physical properties are limiting factor for plant growth which are heavy clay texture, swelling and shrinking properties, lowest water infiltration, and slow drainage (Mukanda and Mapiki 2001). As a result, it frequently has stunted has plat growth and low yield. It is necessary to repair these properties by giving ameliorant materials.

Sand is one type of the ameliorant materials that can be applied to high clay soils. Ravina and Magier (1984); Narka and Wiyanti (1999) showed that application of sand had significantly effect to decline COLE value, soil plasticity index, and soil permeability become large, but the water content availability was low. This was in line with statement of Kusnarta (2012) that sand could improve aggregate and structure stability of Vertisol (*stability quotient*), way of declinine clay function mechanism in swelling-shirking processes. Besides, the application of sand about 20% of weight declined COLE values. The SS was used as medium of planting (Sari *et at.* 2006), but it had NaCl contents caused some crops grew abnormally (Kusnarta *et al*. 20140. Walter *et al*. (2000); Oliver and Smetten (2002); Al-Omran *et al.* (2004) has stated sandy texture soil was very influential on status and distribution of water, so influenced root system and root depth. Further Rajiman (2009) has stated that the sandy texture soil influenced on soil nutrient and pH too.

However, paddy soil cultivation requires medium permeability with sufficient water content, so it needs another ameliorant to fix these properties, such as by using coconut coir and banana coir. Coconut coir been used as water storage on farms (Subiyanto *et al*. 2003). While, the banana coir is still relatively not used yet. Water absorption of banana coir was relatively high when it was dried because it had pores that were interconnected (Indrawati 2009).

Applications of the three ameliorant were allegedly able to mutually improve soil physical and chemical properties of Vertisol under rice cultivation in paddy rice field, so that its productivity could be improved. This research aimed to study the effect of application sea sand, coconut coir and banana coir on growth and yield of rice planted Ustic Endoaquert soil taken from paddy rice field.

MATERIAL AND METHODS

Study Site

The experiment was conducted in the green house of Mathematics and Natural Science Faculty of Gorontalo State University starting in April-August 2012. Meanwhile, the growing media was Ustic Endoaquert Soil taken from Mootilango Sub district, Gorontalo District, Gorontalo Province. Soil description and classification as presented at Table 1.

Coconut and Banana Coir Preparation

Materials were obtained from dried coconut husk that was surounded coconut shell inside. Coconut husk was peeled and separated from coconut shell, then, a smooth outer skin was peeled again until remaining coconut coir (CC). Furthermore, CC was milled to 1 mm. Banana coir (BC) materials were obtained from dried banana bark. Banana bark was peeled and separated from trunk up to 10 sheets of rods into core of the BC. Furthermore, the banana peel was grounded into powder with a size of 0.05 mm. The CC and BC obtained were weighed according to dosage of each treatment. Before application, water absorption capacities (WAC) of CC anci BC were tested through immersion. Immersion was used to determine maximum WAC of the ameliorant material. Calculation of WAC followed the equation:

$$WAC\ (\%) = [\text{Pre Weight } (w0)/\text{Dry weight } (w1)] \times 100\%$$

Experimental Design

The used factorial design with 3 factors of ameliorant, where each factor consisted of 3 dosages of ameliorant and each had 3 replications, so 81 pot experiments were obtained. Sea sand factors consisted of 0% (S0), 25% (S1), and 50% (S2). CC factor consisted of 0 (C0), 10 (C1), and 20 Mg ha^{-1} CC (C2). While, the BC factors consisted of 0 (B0), 10 (B1), and 20 Mg ha^{-1} BC (B2).

Table 1. Soil description and classification of the Experiment Site

Location	:	Sidomukti Village, Mootilango Subdistrict, Gorontalo District, Gorontalo Province
Soil classification		
Taxonomy (USDA 2010)	:	Ustic Endoaquert
PPT System	:	Eutric Cambisol
FAO-UNESCO System	:	Cambisol
Parent material	:	Lacustrine
Position physiographic	:	Foot slope, Depression
Topography	:	Flat-Ramps, slopes <2%
Elevation	:	58 m sl
Drainage	:	Poor
Ground water depth	:	Shallow
Vegetation	:	Rice (*Oryza sativa* L.)

Depth (cm)	Horizon	Descriptions
0-12	Apg1	Gray (10YR 5/1); clay loamy; massive structure; very sticky, plastic; smooth roots, a lot; clear flat.
12-31	Apg2	Gray (10YR 5/1); clays; angular blocky structure, smooth, Weak; very sticky, plastic; rusty brown (10YR 5/3), plain, smooth, clear, spots, sharp; rooting smooth, much; gradually average
31-53	Bwg1	Gray (10YR 5/l); clay; moderate, angular blocky structure, weak; very sticky, plastic; rooting smooth, slightly; frosted flat.
53-71/92	Bwg2	Gray (10YR 6/l); clay; angular blocky structure, rough, weak; very sticky, plastic; obviously choppy.
71/92-119	Bwssg	Dark gray (10YR 4/1); clay moderate, angular blocky structure, moderate; very sticky, plastic; slickenside; rusty brown (10YR 5/3), plain, smooth, clear, tube, clear; frosted flat.
119-150	BCg1	Dark gray (10YR 4/1); clay; angular blocky structure, harsh, strong; very sticky, plastic; rusty brown (10YR 5/3),

		plain, smooth, clear, tube, clear; clear flat.
150-200	BCg2	Dark gray (10YR 4/1); clay, very sticky, very friable; frosted flat.

Initial properties of the soil at 0-20 cm depth are presented in Table 2. The soil had clay loamy textures, slow of soil permeability, and real of swelling and shrinking. Furthermore, the soil chemical properties indicated that the soil organic matter, total N, available P, and K exchanged were low. Relatively neutral of soil pH, cation exchange capacity and base saturation were high. Thus, based on criterion of Center for Soil Research (1983) the soil fertility status was classified as moderate.

Table 2. Initial soil properties of Ustic Endoaquert at 0-20 cm Depth

Soil Properties	Values	Criterion*
Texture:		
Sand (%)	27	Clay Loamy
Clay (%)	35	
Silt (%)	38	
Soil permeability (cm hour^{-1})	1.59	Slow
COLE value	0.98	Real swell-shrinking
Water content availability	8.47	
C-organic (%)	0.69	Very low
Total N (%)	0.06	Very low
C/N ratio	11.62	Moderate
Available-P, Bray 1 (mg P kg^{-1})	3.80	Very low
pH H_2O	6.48	slightly acid
NH_4OAo 1 *N* pH 7 Extraction:		
K(cmol+ kg^{-1})	0.24	Very low
Ca (cmol+ kg^{-1})	14.90	High
Mg (cmol+ kg^{-1})	6.05	High
Na (cmol+ kg^{-1})	0.50	Moderate
CEC (cmol+kg^{-1})	30.93	High
Base saturation (%)	70.08	High
Extract KCI 1 *M*:		
Al^{3+} (cmol+ kg^{-1})	0.00	
H^{+} (cmol+ kg^{-1})	0.06	

*Center for Soil Research (1983).

Planting Rice and Its Maintenance

Before planting, basic fertilizers were weighted and applied to the soils. Urea 125 kg ha^{-1} were given twice at ages 0 days after planting (DAP) and 60 DAP, each as much as 62.5 kg ha^{-1} respectively. Meanwhile, SP36 100 kg ha^{-1} were given twice at ages 0 days after planting (DAP) and 60 DAP, each as much as 50.0 kg ha^{-1} respectively, whereas KCl 50 kg ha^{-1} were given twice at ages 0 days after planting (DAP) and 60 DAP, each as much as 25.0 kg ha^{-1} respectively.

Ciherang rice seed variety was tested its quality by soaking in saline solution, then planted in trays which were covered by leaves and soil media containing arganic material with a ratio of 1:1 until 10 days. A day before planting, the planting medium was watered so that toxic compounds to the rice seedling were moved down to the bottom of the pot. Rice seeds 10 days aged were transferred into plant growing media. Planting was done in planting hole as deep as 8 cm and followed by application of basic fertilizers. During plant growth and development, the maintenance performed was weed cleaning, watering is done every 7 DAP to end the grain filling phase until flooding water content of filed capacity. Adding second basic fertilizers at 60 DAP. Harvesting was done when plant ageless than 115 days after from planting. Observation of plant growth components were plant height, leaf length, leaf number and tiller number. Meanwhile, the observations of yield components were panicle length, panicle number, and rice grain number.

Statistical Analysis

Analyses of Variance (ANOVA) for factorials design were done to study the growth and yield response of rice plants due to application of ameliorant materials. If there was a significant effect, then it was continued by the least significant difference (LSD) test at 5% level.

RESULT AND DISCUSSION

Growth Components of Rice Plant

The results of variance analysis for rice growth component planted at Ustic Endoaquert showed that CC and BC did not significantly effect to plant high (Table 3), while the SS significantly affected to plant high. The highest plant height was shown at application of 20% SS which significantly increased plant height compared other treatments. However, the plant height still lower than normal growth as reported by Supriatno *et al.* (2007), that plant height of Ciherang varieties were ranged from 107-115 cm.

Table 3. The rice plant growth components at application of sea sand, coconut coir and banana coir planted at Ustic Endoaquert soil

Treatments	Plant Height (cm)	Leaf length (cm)	Leaf number	Tiller number
Sea sand				
0%	27.74a	20.64a	10.29^{ns}	12.07a
25%	3097b	24.04b	14.18	13.37b
50%	30.23ab	23.01ab	14.04	13.29ab
Coconut coir				
0 Mg ha^{-1}	29.57^{ns}	21.99^{ns}	11.88^{ns}	12.37^{ns}
10 Mg ha^{-1}	30.02	22.92	13.29	13.29
20 Mg ha^{-1}	29.32	22.78	13.33	13.07
Banana coir				
0 Mg ha^{-1}	30.95^{ns}	23.89a	9.89a	12.56^{ns}
10 Mg ha^{-1}	29.29	21.43b	16.37b	13.19

20 Mg ha^{-1}	28.65	22.37ab	12.26ab	13.00
Interaction	ns	ns	ns	ns
$LSD_{0.05}$	3.21	2.42	4.57	1.25

Number that following by same latter in same column did not significantly effect at LSD level of 0.05; ns=not significant effect at F level test 0.05

The highest increase of plant height was indicated at application of 25% SS which increased plant height by 11.80%, while the lowest one was shown at application of 10 Mg ha^{-1} CC which increased it by 0.83% only. At growth phase, especially plat height needs sufficient water availability. Application of 25% SS had not yet reduced water storage in soil, so it did not effect on water availability, but could increase plant height. At application of 50% SS, the plant high decreased until 2.45%. Mishra *et al.* (2012) reported that water available significantly decreased with increase of sand in mixture. Water shortages do not apparent at the beginning of vegetative phase and it still can stimulate root development, but at next vegetative phase, plant will be stunted (Sholeh and Riajaya 2000).

Furthermore, Yakup (2008) reported that plant height was significantly affected by soil water availability. In the water-saturated state, despite resistance by soil particles, no water could be absorbed by the soil except in certain plants such as paddy (Kasli and Efendi 2011).

Test results of WAC of both ameliorant showed that CC had a high WAC (71.77%), while BC was only 28.23%. Wuryaningsih *et al*. (2008) who conducted a study of growth *Anthurium andraeanum* in pot by using coconut bulk media reported that its physical properties were: a very high water content (1,314.41%), low-bulk density (0.09%), high total porosity (120.31%), and high pores water holding (116.6%). In additional, soil texture was classified as clay loamy (Table 2), so the soil puddling and flooding would become more easily dispersible and soil was relatively compact (Isnaini and Suwarno 2005).

Then, application of SS and BC had significant effect to leaf length (Table 3), while the application CC did not have significant effect to leaf length. The largest increase of leaf length was shown at SS application as much as 25% (16.47%) and it was significantly different with control. It seems that application of 25% SS had not yet reduced water storages in soil but it might increase soil pores, so the leaf length was highest. An application of 50% SS, the leaf length decreased until 11.48%. Mishra *et al.* (2012) reporting that the available decreased significantly with increase of sand in mixture. The lowest leaf length was shown at the 0 Mg ha^{-1} CC (0.62%) and it was not significant different with 10 Mg ha^{-1} CC and 20 Mg ha^{-1} CC.

Fazeli *et al*. (2007) stated that effect of a turn single of water availability would reduce growth. Furthermore, Kasli and Effendi (2011) stated that effects of water shortages on some physiological processes of plants were seen in a slow accumulation of dry matter, decreasing leaf expansion rate, and limiting stomata closure photosynthesis. In addition, short-term leaves and leaf area in plants were thought to be influenced by the intensity of the light received in green house where the research took place. The present of trees around the green house allegedly indirectly affected the reception of light by the plant, even though the distance was about 6 feet from the green house. Anggarwulan *et al.* (2008) stated that light played an important role in the physiological processes of plants, especially photosynthesis, respiration, and transpiration. The plants required quite diverse intensity of light.

The application of SS and CC did not have significant effect to leaf number, but had significant effect to BC (Table 3). Application of 10 Mg ha^{-1} BC had significant increase to leaf number by 65.52% and it was significant different with control. This was presumably due to the ability of BC to maintain soil moisture and water availability. Indrawati (2009) stated that the stem of BC was strong fiber and resistant to water. It also had pores that were interconnected, and when dry a material would be having absorption and high shelf.

The application of CC and BC did not have significant effect to tiller number, but application of SS had significant effect to it (Table 3). Application of 25% SS increased significantly tiller numbers by l0.77%. Indrawati (2009) stated that the flooding growing media as high as 5 cm was also associated with formation of tiller numbers. This was in line with reports of Utomo and Rudi, (2000) *in* Kaseli and Effendi (2011) that the flooding up to approximately 3-5 cm above soil surface condition that considered as good for formation of tillers and at foll phase the flooding would inhibit seedling establishment. The results were reinforced by reports Astuti (2010) that the tiller number were produced from crops by flooding system more than by intermittent and kemalir system. However, in contrast with results of Shi *et al*. (2002) that the maximum tillering growth phase, the highest tiller numbers were in on kemalir water management compared to intermittent and continuous flooding.

Sumardi *et al*. (2007) that water use efficiency for rice cultivation without flooding condition were much as 19.581%, while with continuously flooding its efficiency was as much as 70.907% only. In this study also showed that the higher the plant would be followed by a greater tiller numbers. This was in contrast with the result of Aldi *et al*. (2004); Hartati and Suwarto (2004); Rahayu and Harjoso (2010) who reported that tiller number showed contrary to values of plant height, where the higher tiller number was the lower plant high.

Although it was not significant effect to tiller numbers, but application of 10 Mg ha^{-1} CC and BC increased tiller number each by 7.44% and 5.04% compared to control. This was related to ability to absorb water of CC and BC was high, so that they would enough moisture and water availability. Ramesh *et al.* (2010) reported that combination of soil and coconut coir as much as 4%

showed changes in the nature of Catton black soil compactness better that control. Contribution of ameliorant effect to plant growth was in order of SS > BC > CC.

Yield Components of Rice Plant

Analysis of variance for rice yield component resulted that application of CC and BC had significant increase to panicle numbers, but application of SS did not have significant effect to panicle numbers. It seems that percentage of panicle numbers with CC and BC application were relative similar. However, its different between treatments was increase of percentage figures. Application of 20 Mg ha^{-1} BC significantly increased panicle number by 20.47% compared to 10 Mg ha^{-1} BC and by 23.4l compared to control. This suggested that BC application was able to maintain water availability due to ability to absorb was high. The BC was quite strong and resistant to water and had pores that where interconnected and when dry a material would be having absorption and high shelf (Indrawati 2009). Meanwhile, although it was not significant effect to panicle numbers, but application of 50% SS increased tiller numbers by 19.36% compared to control.

Soil sand fraction was clay loamy textures, so that application of 50% SS to the soil could reduce weight to light fraction, particularly declined COLE index. Sand textures effected on status and distribution of water, so affecting root system and root depth (Walter *et al*. 2000; Oliver and Smettem 2002). Thus, the plant root system was not disturbed due to the possibility of soil cracking was not anymore, so the process of water and nutrients absorption could be better.

Table 4. The rice yield component at application of sea sand, coconut coir and banana coir planted at Ustic Endoaquert soil

Treatments	Panicle number	Panicle length (cm)	Rice grain number
Sea sand			
0%	2.48ns	8.97b	8.64ns
25%	2.59	7.35a	7.98
50%	2.96	8.28ab	9.07
Coconut coir			
0 Mg ha^{-1}	2.59ab	6.41a	7.14a
10 Mg ha^{-1}	2.37a	8.80b	9.52b
20 Mg ha^{-1}	3.07b	9.39b	9.04ab
Banana coir			
0 Mg ha^{-1}	2.52ab	7.33a	7.49ns
10 Mg ha^{-1}	2.41a	9.49b	9.48
20 Mg ha^{-1}	3.11b	7.78a	8.72
Interaction	ns	ns	ns
$LSD_{0.05}$	0.63	1.24	2.05

Number that following by same latter in same column did not significantly effect at LSD level of 0.05; ns=not significant effect at F level test 0.05

Application of 20 Mg ha^{-1} CC significantly increased panicle numbers by 29.54% compared to 10 Mg ha^{-1} CC. This was presumably related to soil water availability. The WAC level of CC was high and would be able to absorb and retain water availability in the soil, so that more CC would be followed by the greater panicle numbers. This was consistent with statement of Dachban (2012) that rice storage water for 4 days at generative periods and following 2 weeks was a sensitive periods to water storages.

In addition, the SS, CC and BC significantly increased panicle length. Application of 10 Mg ha^{-1} BC significantly increased panicle length by 29.47% compared to control and by 21.8% compared to 20 Mg ha^{-1} BC. This was presumably related to soil water availability of each treatment. The research conducted by Dachban (2012) showed that the panicle length at level of 3 mm, 2 mm, and 1 mm decreased long panicle length by 0.77%, 5.80%, and 45.10% respectively, due to reduction of plant yields because of water. In fact, Astuti (2010) reported that panicle length and rice grain numbers were not affected by irrigation, but each variety had panicle length and rice grain numbers per panicle significant different due to the genetic. Meanwhile, 10 Mg ha^{-1} CC significantly increased rice grain numbers by 33.33% compared to control but did not have significant different with 20 Mg ha^{-1} CC (Table 4). Apparently, long panicles would be relatively followed by a greater rice grain numbers. It was in line with Setiobudi *et al.* (2008) that the rice grain numbers was determined by genetic properties of plants especially panicle length, tassel branch, and a diifferentiation rice grains.

CONCLUSION

Application of sea sand and banana coir significantly increased leaf length where the highest increase percentage of 16.47% was achieved at 25% SS application. Their effect on leaf numbers and tiller numbers were relatively not similar pattern where leaf number only increased about 65.52% by banana coir application, while tiller numbers only increased about 10.77% by sea sand application. Furthermore, the application of coconut coir and banana coir significantly increased panicle numbers each ups t0 29.53% and 29.05% compared to control. All ameliorant significantly increased panicle number, but the best was coconut coir with could increased up to 46.49% at 20 Mg ha^{-1} CC compared to sea sand and banana coir application. Only coconut coir significantly increased the rice grain numbers.

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Effect application of sea sand, coconut and banana coir on the growth and yield of rice planted at Ustic Endoaquert soil

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ABSTRACT

The research was aimed to study effect application of sea sand (SS), coconut coir (CC) and banana coir (BC) on the growth and yield of rice (*Oryza sativa* L.) planted at Ustic Endoaquert soil. The pot experiment was carried out using a factorial design with 3 factors. The first factor was SS consisted of three levels i.e.: 0%, 25%, and 50%. The second and third factors were CC and BC, each consisted of three levels i.e.: 0, 10, and 20 Mg ha^{-1}. Application of SS and BC significantly increased leaf length where the highest increasing percentage was 16.47% which was achieved at 25% SS application. Their effect on leaf numbers and tiller numbers were relatively not similar pattern where leaf number only increased about 65.52% by BC application, while tiller numbers only increased about 10.77% by SS application. Furthermore, the application of CC and BC significantly increased panicle numbers to 29.53% and 29.05%, respectively compared to control. All ameliorants significantly increased panicle numbers, but the best was CC with the increasing up to 46.49% at 20 Mg ha^{-1} CC compared to SS or BC application. However, only coconut coir significantly increased the rice grain numbers.

***Keywords*:** Banana coir, coconut coir, rice plant, sea sand, vertisol

INTRODUCTION

Rate of population growth with a percentage of about 2% per year has resulted in increasing demand for rice consumption. Until 2012, national rice demand reached 34.055 million Mg and paddy production reached 68,956,293 Mg (BPS RI 2012) or equivalent to 37 million Mg of rice (Suswono 2012). Sudaryatno *et al*. (2010) predicted that the need of national rice in 2015 as many as 35,123,000 Mg and 37,021,000 Mg in 2020, or an average rate of rice consumption increased 0.92% per year. Viewing statistics in 2012, it was apparently a surplus as much as 3-4 million Mg of rice at the year. Although the current national rice needed was adequate and surplus, but considering Indonesia's populations that were about 247 million and the increasing rate of population growth, the rice production was needed to be maintained and improved, one through the increasing productivity of paddy soil.

Paddy rice field soil is an ecosystem which water source are dominantly from irrigation and as mainly national rice sources which coverage 2.1 million ha (Toha and Pirngadi 2004). In Paguyaman, Gorontalo Province paddy rice field areas are dominantly classified as Vertisols that developed from lacustrine deposition materials (Hikmatullah *et al*. 2002; Prasetyo 2007; Nurdin 2011). From chemically aspect, Vertisol is classified as nutrient rich soil that has high nutrient sources (Deckers *et al*. 2001). However, the physical properties are limiting factor for plant growth which are heavy clay texture, swelling and shrinking properties, lowest water infiltration, and slow drainage (Mukanda and Mapiki 2001). As a result, it frequently has stunted plant growth and low yields. It is necessary to repair these properties by giving ameliorant materials.

Sand is one type of the ameliorant materials that can be applied to high clay soils. Ravina and Magier (1984); Narka and Wiyanti (1999) showed that application of sand had significantly effect to decline COLE value and soil plasticity index, while soil permeability became large, but the water content availability was low. This was in line with statement of Kusnarta (2012) that sand could improve aggregate and structure stability of Vertisol (*stability quotient*), way of declining clay function mechanism in swelling-shirking processes. Besides, the application of sand about 20% of weight declined COLE values. The SS was used as planting media (Sari *et at.* 2006), but it had high NaCl contents that caused some crops grew abnormally (Kusnarta *et al*. 2014). Walter *et al*. (2000); Oliver and Smetten (2002); Al-Omran *et al.* (2004) has stated sandy texture soil was very influential on status and distribution of water, so it influenced root system and root depth. Further Rajiman (2009) has stated that the sandy texture soil influenced on soil nutrient and pH too.

However, paddy soil cultivation requires medium permeability with sufficient water content, so it needs another ameliorant to fix these properties, such as by using CC and BC. CC has been used as water storage on farms (Subiyanto *et al*. 2003). While, the banana coir is still relatively not used yet. Water absorption of banana coir was relatively high when it was dried because it had pores that were interconnected (Indrawati 2009).

Applications of the three ameliorant were allegedly able to mutually improve soil physical and chemical properties of Vertisol under rice cultivation in paddy rice field, so that its productivity could be improved. This research was aimed to study the effect application of sea sand, coconut coir and banana coir on the growth and yield of rice planted at Ustic Endoaquert soil taken from paddy rice field.

MATERIALS AND METHODS

Study Site

The experiment was conducted in the green house of Mathematics and Natural Science Faculty of Gorontalo State University starting in April-August 2012. Meanwhile, the growing media was Ustic Endoaquert Soil taken from Mootilango Sub district, Gorontalo District, Gorontalo Province. Soil description and classification are presented in Table 1.

Coconut and Banana Coir Preparation

Materials were obtained from dried coconut husk that surounded coconut shell inside. Coconut husk was peeled and separated from coconut shell, then, a smooth outer skin was peeled again until remaining coconut coir (CC). Furthermore, CC was milled to 1 mm. Banana coir (BC) materials were obtained from dried banana bark. Banana bark was peeled and separated from trunk up to 10 sheets of rods into core of the BC. Furthermore, the banana peel was grounded into powder with a size of 0.05 mm. The CC and BC obtained were weighed according to dosage of each treatment. Before application, water absorption capacities (WAC) of CC and BC were tested through immersion. Immersion was used to determine maximum WAC of the ameliorant material. Calculation of WAC followed the equation:

WAC (%) = [Pre Weight (w0)/Dry weight (w1)] x 100%

Experimental Designs

A factorial design with 3 factors of ameliorant was used, where each factor consisted of 3 dosages of ameliorant and each had 3 replications, so 81 pot experiments were obtained. Sea sand (SS) factors consisted of 0% (S0), 25% (S1), and 50% (S2). CC factor consisted of 0 (C0), 10 (C1), and 20 Mg ha^{-1} CC (C2). While, the BC factors consisted of 0 (B0), 10 (B1), and 20 (B2) Mg ha^{-1} BC.

Initial properties of the soil at 0-20 cm depth are presented in Table 2. The soil had clay loamy textures, slow of soil permeability, and real of swelling and shrinking. Furthermore, the soil chemical properties indicated that the soil organic matter, total N, available P, and K exchanged were low. Relatively neutral of soil pH, cation exchange capacity and base saturation were high. Thus, based on criterion of Center for Soil Research (1983) the soil fertility status was classified as moderate.

Planting Rice and Its Maintenance

Before planting, basic fertilizers were weighted and applied to the soils. Urea 125 kg ha^{-1} were given twice at ages 0 days after planting (DAP) and 60 DAP, each as much as 62.5 kg ha^{-1}, respectively. Meanwhile, SP36 100 kg ha^{-1} were given twice at ages 0 days after planting (DAP) and 60 DAP, each as much as 50.0 kg ha^{-1}, respectively, whereas KCl 50 kg ha^{-1} were given twice at ages 0 days after planting (DAP) and 60 DAP, each as much as 25.0 kg ha^{-1}, respectively.

Ciherang rice seed variety was tested its quality by soaking in saline solution, then planted in trays which were covered by leaves and soil media containing organic material with a ratio of 1:1 until 10 days. A day before planting, the planting medium was watered so that toxic compounds to the rice seedling were moved down to the bottom of the pot. Rice seeds 10 days aged were transferred into plant growing media. Planting was done in planting hole as deep as 8 cm and followed by application of basic fertilizers. During plant growth and development, the maintenance performed was weed cleaning, watering was done every 7 DAP to end the grain filling phase until flooding, water content was filed capacity. Additication of second basic fertilizers were at 60 DAP. Harvesting was done when plant age was less than 115 days after planting. Observation of plant growth components were plant height, leaf length, leaf number and tiller number. Meanwhile, the observations of yield components were panicle length, panicle number, and rice grain number.

Statistical Analysis

Analyses of Variance (ANOVA) for factorials design were done to study the growth and yield response of rice plants due to application of ameliorant materials. If there was a significant effect, then it was continued by the least significant difference (LSD) test at 5% level.

RESULTS AND DISCUSSION

Growth Components of Rice Plant

The results of variance analysis for rice growth component planted at Ustic Endoaquert showed that CC and BC did not significantly effect to plant high (Table 3), while the SS significantly affected to plant high. The highest plant height was shown at application of 20% SS which significantly increased plant height compared other treatments. However,

Table 1. Soil description and classification of the Experiment Site

Location		: Sidomukti Village, Mootilango Subdistrict, Gorontalo District, Gorontalo Province
Soil classification		
Taxonomy (USDA 2010)		: Ustic Endoaquert
PPT System		: Eutric Cambisol
FAO-UNESCO System		: Cambisol
Parent material		: Lacustrine
Position physiographic		: Foot slope, Depression
Topography		: Flat-Ramps, slopes <2%
Elevation		: 58 m sl
Drainage		: Poor
Ground water depth		: Shallow
Vegetation		: Rice (*Oryza sativa* L.)
Depth (cm)	**Horizon**	**Descriptions**
0-12	Apg1	Gray (10YR 5/1); clay loamy; massive structure; very sticky, plastic; smooth roots, a lot; clear flat.
12-31	Apg2	Gray (10YR 5/1); clays; angular blocky structure, smooth, Weak; very sticky, plastic; rusty brown (10YR 5/3), plain, smooth, clear, spots, sharp; rooting smooth, much; gradually average
31-53	Bwg1	Gray (10YR 5/l); clay; moderate, angular blocky structure, weak; very sticky, plastic; rooting smooth, slightly; frosted flat.
53-71/92	Bwg2	Gray (10YR 6/l); clay; angular blocky structure, rough, weak; very sticky, plastic; obviously choppy.
71/92-119	Bwssg	Dark gray (10YR 4/1); clay moderate, angular blocky structure, moderate; very sticky, plastic; slickenside; rusty brown (10YR 5/3), plain, smooth, clear, tube, clear; frosted flat.
119-150	BCg1	Dark gray (10YR 4/1); clay; angular blocky structure, harsh, strong; very sticky, plastic; rusty brown (10YR 5/3), plain, smooth, clear, tube, clear; clear flat.
150-200	BCg2	Dark gray (10YR 4/1); clay, very sticky, very friable; frosted flat.

Table 2. Initial soil properties of Ustic Endoaquert at 0-20 cm Depth

Soil Properties	Values	Criterion*
Texture:		
Sand (%)	27	
Clay (%)	35	Clay Loamy
Silt (%)	38	
Soil permeability (cm $hour^{-1}$)	1.59	Slow
COLE value	0.98	Real swell-shrinking
Water content availability	8.47	
C-organic (%)	0.69	Very low
Total N (%)	0.06	Very low
C/N ratio	11.62	Moderate
Available-P, Bray 1 (mg P kg^{-1})	3.80	Very low
pH H_2O	6.48	slightly acid
NH_4OAo 1 *N* pH 7 Extraction:		
K(cmol+ kg^{-l})	0.24	Very low
Ca (cmol+ kg^{-l})	14.90	High
Mg (cmol+ kg^{-1})	6.05	High
Na (cmol+ kg^{-1})	0.50	Moderate
CEC (cmol+kg^{-1})	30.93	High
Base saturation (%)	70.08	High
Extract KCI 1 *M*:		
Al^{3+} (cmol+ kg^{-l})	0.00	
H^+ (cmol+ kg^{-l})	0.06	

*Center for Soil Research (1983).

the plant height still lower than normal growth as reported by Supriatno *et al.* (2007), that plant height of Ciherang varieties were ranged from 107-115 cm.

The highest increasing of plant height was indicated at application of 25% SS which increased plant height by 11.80%, while the lowest one was shown at application of 10 Mg ha^{-1} CC which only increased by 0.83%. At growth phase, especially plant height it needed sufficient water availability. Application of 25% SS had not yet reduced water storage in soil, so it did not effect on water availability, but it could increase plant height. At application of 50% SS, the plant height decreased until 2.45%. Mishra *et al.* (2012) reported that water available significantly decreased with the increasing of sand in mixture. Water shortages did not apparent at the beginning of vegetative phase and it still could stimulate root development, but at next vegetative phase, plant would be stunted (Sholeh and Riajaya 2000).

Furthermore, Yakup (2008) reported that plant height was significantly affected by soil water availability. In the water-saturated state, despite resistance by soil particles, no water could be absorbed by the soil except in certain plants such as paddy (Kasli and Efendi 2011).

Test results of WAC of both ameliorant showed that CC had a high WAC (71.77%), while BC was only 28.23%. Wuryaningsih *et al.* (2008) who conducted a study of growth *Anthurium andraeanum* in pot by using coconut bulk media reported that its physical properties were: a very high water content (1,314.41%), low-bulk density (0.09%), high total porosity (120.31%), and high pores water holding (116.6%). In additional, soil texture was classified as clay loamy (Table 2), so the soil puddling and flooding would become more easily dispersible and soil was relatively compact (Isnaini and Suwarno 2005).

Unlike the application of CC, the application of SS and BC had significant effect to leaf length (Table 3). The largest increasing of leaf length was shown at SS application as much as 25% (16.47%) and it was significantly different with control. It seems that application of 25% SS had not yet reduced water storages in soil but it might increase soil pores, so the leaf length was the highest. With the application of 50% SS, the leaf length decreased

Table 3. The rice plant growth components with the application of sea sand, coconut coir and banana coir planted at Ustic Endoaquert soil.

Treatments	Plant Height (cm)	Leaf length (cm)	Leaf number	Tiller number
Sea sand				
0%	27.74a	20.64a	10.29^{ns}	12.07a
25%	3097b	24.04b	14.18	13.37b
50%	30.23ab	23.01ab	14.04	13.29ab
Coconut coir				
0 Mg ha^{-1}	29.57^{ns}	21.99^{ns}	11.88^{ns}	12.37^{ns}
10 Mg ha^{-1}	30.02	22.92	13.29	13.29
20 Mg ha^{-1}	29.32	22.78	13.33	13.07
Banana coir				
0 Mg ha^{-1}	30.95^{ns}	23.89a	9.89a	$l2.56^{ns}$
10 Mg ha^{-1}	29.29	21.43b	16.37b	13.19
20 Mg ha^{-1}	28.65	22.37ab	12.26ab	13.00
Interaction	ns	ns	ns	ns
$LSD_{0.05}$	3.21	2.42	4.57	1.25

Note: Number that following by same latter in same column did not significantly different at LSD level of 0.05; ns=not significant effect at F level test 0.05

until 11.48%. Mishra *et al.* (2012) reporting that the water available decreased significantly with increasing sand in mixture. The lowest leaf length was shown at the 0 Mg ha^{-1} CC (0.62%) and it was not significantly different with 10 and 20 Mg ha^{-1} CC.

Fazeli *et al.* (2007) stated that effect of a turn single of water availability would reduce growth. Furthermore, Kasli and Effendi (2011) stated that effects of water shortages on some physiological processes of plants were seen in a slow accumulation of dry matter, decreasing leaf expansion rate, and limiting stomata closure photosynthesis. In addition, short-term leaves and leaf area in plants were thought to be influenced by the intensity of the light received in green house where the research took place. The present of trees around the green house allegedly indirectly affected the reception of light by the plant, even though the distance was about 6 feet from the green house. Anggarwulan *et al.* (2008) stated that light played an important role in the physiological processes of plants, especially photosynthesis, respiration, and transpiration. The plants required quite diverse intensity of light.

The applications of SS and CC did not have significantly effect to leaf number, but BC had significantly effect (Table 3). Application of 10 Mg ha^{-1} BC had significantly increased leaf number by 65.52% and it was significantly different with control. This was presumably due to the ability of BC to maintain soil moisture and water availability. Indrawati (2009) stated that the stem of BC was strong fiber and resistant to water. It also had pores that were interconnected, and when dry a material would be having absorption and high shelf.

The application of CC and BC did not have significant effect to tiller number, but application of SS had significant effect to it (Table 3). Application of 25% SS increased significantly tiller numbers by l0.77%. Indrawati (2009) stated that the flooding growing media as high as 5 cm was also associated with the formation of tiller numbers. This was in line with reports of Utomo and Rudi, (2000) in Kaseli and Effendi (2011) that the flooding up to approximately 3-5 cm above soil surface condition that considered as good for formation of tillers and at foll phase the flooding would inhibit seedling establishment. The results were reinforced by reports Astuti (2010) that the tiller numbers produced from crops by flooding system were more than by intermittent and kemalir systems. However, in contrast with results of Shi *et al.* (2002) that at the maximum tillering growth phase, the highest tiller numbers were in kemalir water management compared to intermittent and continuous floodings.

Sumardi *et al.* (2007) that water use efficiency for rice cultivation without flooding condition were as much as 19.581%, while with continuously flooding its efficiency was as much as 70.907% only. In this study also showed that the higher the plant would be followed by a greater tiller numbers. This was in contrast with the result of Aldi *et al*. (2004); Hartati and Suwarta (2004); Rahayu and Harjoso (2010) who reported that tiller number showed contrary to values of plant height, where the higher tiller number was the lower plant high.

Although it had not significant effect to tiller numbers, but application of 10 Mg ha^{-1} CC and BC increased tiller number by 7.44% and 5.04%, respectively compared to control. This was related a to high ability to absorb water of CC and BC, so that they would enough moisture and water availability. Ramesh *et al.* (2010) reported that combination of soil and coconut coir as much as 4% showed changes in the nature of Catton black soil compactness better that control. Contribution of ameliorant effect to plant growth was in order of SS > BC > CC.

Yield Components of Rice Plant

Analysis of variance for rice yield component resulted that application of CC and BC had significantly increased panicle numbers, but application of SS did not have significantly effect to panicle numbers. It seems that percentage of panicle numbers with CC and BC application were relative similar. However, the different between treatments were increasing of percentage figures. Application of 20 Mg ha^{-1} BC significantly increased panicle number by 20.47% compared to 10 Mg ha^{-1} BC and by 23.4l compared to control. This suggested that BC application was able to maintain water availability due a to high ability to absorb water. The BC was quite strong and resistant to water and had pores that where interconnected and when dry, a material would be having absorption and high shelf (Indrawati 2009). Meanwhile, although it had not significantly effect to panicle numbers, but application of 50% SS increased tiller numbers by 19.36% compared to control.

Soil sand fraction was clay loamy textures, so that application of 50% SS to the soil could reduce weight to light fraction, particularly declined COLE index. Sand textures affected status and distribution of water, so affecting root system and root depth (Walter *et al*. 2000; Oliver and Smettem 2002). Thus, the plant root system was not disturbed due to lock of the possibility of soil cracking, so the process of water and nutrients absorption could be better.

Application of 20 Mg ha^{-1} CC significantly increased panicle numbers by 29.54% compared to 10 Mg ha^{-1} CC. This was presumably related to soil water availability. The WAC level of CC was high and would be able to absorb and retain water availability in the soil, so that more CC would be followed by the greater panicle numbers. This was consistent with statement of Dachban (2012) that rice storage water for 4 days at generative periods and following 2 weeks was a sensitive periods to water storages.

In addition, the SS, CC and BC significantly increased panicle length. Application of 10 Mg ha^{-1} BC significantly increased panicle length by 29.47% compared to control and by 21.8% compared to 20 Mg ha^{-1} BC. This was presumably related to soil water availability of each treatment. The research conducted by Dachban (2012) showed that the panicle length at level of 3 mm, 2 mm, and 1 mm decreased long panicle length by 0.77%, 5.80%, and 45.10% respectively, due to reduction of plant yields because of water. In fact, Astuti (2010) reported that panicle length and rice grain numbers were not affected by irrigation, but each variety had panicle length and rice grain numbers per panicle significantly different due to the genetic. Meanwhile, 10 Mg ha^{-1} CC significantly increased rice grain numbers by 33.33% compared to control but did not have significantly different with 20 Mg ha^{-1} CC (Table 4). Apparently, long panicles would be relatively followed by a greater rice grain numbers. It was in line with Setiobudi *et al.* (2008) that the rice grain numbers was determined by genetic properties of plants especially panicle length, tassel branch, and a differentiation rice grains.

CONCLUSIONS

Application of sea sand and banana coir significantly increased leaf length where the highest increasing percentage of 16.47% was achieved at 25% SS application. Their effect on leaf numbers and tiller numbers were relatively not similar pattern where leaf number only increased about 65.52% by banana coir application, while tiller numbers only increased about 10.77% by sea sand application. Furthermore, the application of coconut coir and banana coir significantly increased panicle numbers up to 29.53% and 29.05%, respectively compared to control. All ameliorants significantly increased panicle numbers, but the best was coconut coir that could increase up to 46.49% at 20 Mg ha^{-1} CC compared to sea sand and banana coir application. Only coconut coir significantly increased the rice grain numbers.

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Table 4. The rice yield component at application of sea sand, coconut coir and banana coir planted at Ustic Endoaquert soil

Treatments	Panicle number	Panicle length (cm)	Rice grain number
Sea sand			
0%	2.48ns	8.97b	8.64ns
25%	2.59	7.35a	7.98
50%	2.96	8.28ab	9.07
Coconut coir			
0 Mg ha^{-1}	2.59ab	6.41a	7.14a
10 Mg ha^{-1}	2.37a	8.80b	9.52b
20 Mg ha^{-1}	3.07b	9.39b	9.04ab
Banana coir			
0 Mg ha^{-1}	2.52ab	7.33a	7.49ns
10 Mg ha^{-1}	2.41a	9.49b	9.48
20 Mg ha^{-1}	3.11b	7.78a	8.72
Interaction	ns	ns	ns
$LSD_{0.05}$	0.63	1.24	2.05

Note: Number that following by same latter in same column did not significantly effect at LSD level of 0.05; ns=not significant effect at F level test 0.05

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Effect Application of Sea Sand, Coconut and Banana Coir on the Growth and Yield of Rice Planted at Ustic Endoaquert Soil

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ABSTRACT

The research was aimed to study effect application of sea sand (SS), coconut coir (CC) and banana coir (BC) on the growth and yield of rice (*Oryza sativa* L.) planted at Ustic Endoaquert soil. The pot experiment was carried out using a factorial design with 3 factors. The first factor was SS consisted of three levels i.e.: 0%, 25%, and 50%. The second and third factors were CC and BC, each consisted of three levels i.e.: 0, 10, and 20 Mg ha^{-1}. Application of SS and BC significantly increased leaf length where the highest increasing percentage was 16.47% which was achieved at 25% SS application. Their effect on leaf numbers and tiller numbers were relatively not similar pattern where leaf number only increased about 65.52% by BC application, while tiller numbers only increased about 10.77% by SS application. Furthermore, the application of CC and BC significantly increased panicle numbers to 29.53% and 29.05%, respectively compared to control. All ameliorants significantly increased panicle numbers, but the best was CC with the increasing up to 46.49% at 20 Mg ha^{-1} CC compared to SS or BC application. However, only coconut coir significantly increased the rice grain numbers.

Keywords: Banana coir, coconut coir, rice plant, sea sand, vertisol

INTRODUCTION

Rate of population growth with a percentage of about 2% per year has resulted in increasing demand for rice consumption. Until 2012, national rice demand reached 34.055 million Mg and paddy production reached 68,956,293 Mg (BPS RI 2012) or equivalent to 37 million Mg of rice (Suswono 2012). Sudaryatno *et al*. (2010) predicted that the need of national rice in 2015 as many as 35,123,000 Mg and 37,021,000 Mg in 2020, or an average rate of rice consumption increased 0.92% per year. Viewing statistics in 2012, it was apparently a surplus as much as 3-4 million Mg of rice at the year. Although the current national rice needed was adequate and surplus, but considering Indonesia's populations that were about 247 million and the increasing rate of population growth, the rice production was needed to be maintained and improved, one through the increasing productivity of paddy soil.

Paddy rice field soil is an ecosystem which water source are dominantly from irrigation and as mainly national rice sources which coverage 2.1 million ha (Toha and Pirngadi 2004). In Paguyaman, Gorontalo Province paddy rice field areas are dominantly classified as Vertisols that developed from lacustrine deposition materials (Hikmatullah *et al*. 2002; Prasetyo 2007; Nurdin 2011). From chemically aspect, Vertisol is classified as nutrient rich soil that has high nutrient sources (Deckers *et al*. 2001). However, the physical properties are limiting factor for plant growth which are heavy clay texture, swelling and shrinking properties, lowest water infiltration, and slow drainage (Mukanda and Mapiki 2001). As a result, it frequently has stunted plant growth and low yields. It is necessary to repair these properties by giving ameliorant materials.

Sand is one type of the ameliorant materials that can be applied to high clay soils. Ravina and Magier (1984); Narka and Wiyanti (1999) showed that application of sand had significantly effect to decline COLE value and soil plasticity index, while soil permeability became large, but the water content availability was low. This was in line with statement of Kusnarta (2012) that sand could improve aggregate and structure stability of Vertisol (*stability quotient*), way of declining clay function mechanism in swelling-shirking processes. Besides, the application of sand about 20% of weight declined COLE values. The SS was used as planting media (Sari *et at.* 2006), but it had high NaCl contents that caused some crops grew abnormally (Kusnarta *et al*. 2014). Walter *et al*. (2000); Oliver and Smetten (2002); Al-Omran *et al.* (2004) has stated sandy texture soil was very influential on status and distribution of water, so it influenced root system and root depth. Further Rajiman (2009) has stated that the sandy texture soil influenced on soil nutrient and pH too.

However, paddy soil cultivation requires medium permeability with sufficient water content, so it needs another ameliorant to fix these properties, such as by using CC and BC. CC has been used as water storage on farms (Subiyanto *et al*. 2003). While, the banana coir is still relatively not used yet. Water absorption of banana coir was relatively high when it was dried because it had pores that were interconnected (Indrawati 2009).

Applications of the three ameliorant were allegedly able to mutually improve soil physical and chemical properties of Vertisol under rice cultivation in paddy rice field, so that its productivity could be improved. This research was aimed to study the effect application of sea sand, coconut coir and banana coir on the growth and yield of rice planted at Ustic Endoaquert soil taken from paddy rice field.

MATERIALS AND METHODS

Study Site

The experiment was conducted in the green house of Mathematics and Natural Science Faculty of Gorontalo State University starting in April-August 2012. Meanwhile, the growing media was Ustic Endoaquert Soil taken from Mootilango Sub district, Gorontalo District, Gorontalo Province. Soil description and classification are presented in Table 1.

Coconut and Banana Coir Preparation

Materials were obtained from dried coconut husk that surounded coconut shell inside. Coconut husk was peeled and separated from coconut shell, then, a smooth outer skin was peeled again until remaining coconut coir (CC). Furthermore, CC was milled to 1 mm. Banana coir (BC) materials were obtained from dried banana bark. Banana bark was peeled and separated from trunk up to 10 sheets of rods into core of the BC. Furthermore, the banana peel was grounded into powder with a size of 0.05 mm. The CC and BC obtained were weighed according to dosage of each treatment. Before application, water absorption capacities (WAC) of CC and BC were tested through immersion. Immersion was used to determine maximum WAC of the ameliorant material. Calculation of WAC followed the equation:

$$\text{WAC (\%)} = [\text{Pre Weight } (w0)/\text{Dry weight } (w1)] \times 100\%$$

Experimental Designs

A factorial design with 3 factors of ameliorant was used, where each factor consisted of 3 dosages of ameliorant and each had 3 replications, so 81 pot experiments were obtained. Sea sand (SS) factors consisted of 0% (S0), 25% (S1), and 50% (S2). CC factor consisted of 0 (C0), 10 (C1), and 20 Mg ha^{-1} CC (C2). While, the BC factors consisted of 0 (B0), 10 (B1), and 20 (B2) Mg ha^{-1} BC.

Initial properties of the soil at 0-20 cm depth are presented in Table 2. The soil had clay loamy textures, slow of soil permeability, and real of swelling and shrinking. Furthermore, the soil chemical properties indicated that the soil organic matter, total N, available P, and K exchanged were low. Relatively neutral of soil pH, cation exchange capacity and base saturation were high. Thus, based on criterion of Center for Soil Research (1983) the soil fertility status was classified as moderate.

Planting Rice and Its Maintenance

Before planting, basic fertilizers were weighted and applied to the soils. Urea 125 kg ha^{-1} were given twice at ages 0 days after planting (DAP) and 60 DAP, each as much as 62.5 kg ha^{-1}, respectively. Meanwhile, SP36 100 kg ha^{-1} were given twice at ages 0 days after planting (DAP) and 60 DAP, each as much as 50.0 kg ha^{-1}, respectively, whereas KCl 50 kg ha^{-1} were given twice at ages 0 days after planting (DAP) and 60 DAP, each as much as 25.0 kg ha^{-1}, respectively.

Ciherang rice seed variety was tested its quality by soaking in saline solution, then planted in trays which were covered by leaves and soil media containing organic material with a ratio of 1:1 until 10 days. A day before planting, the planting medium was watered so that toxic compounds to the rice seedling were moved down to the bottom of the pot. Rice seeds 10 days aged were transferred into plant growing media. Planting was done in planting hole as deep as 8 cm and followed by application of basic fertilizers. During plant growth and development, the maintenance performed was weed cleaning, watering was done every 7 DAP to end the grain filling phase until flooding, water content was filed capacity. Additication of second basic fertilizers were at 60 DAP. Harvesting was done when plant age was less than 115 days after planting. Observation of plant growth components were plant height, leaf length, leaf number and tiller number. Meanwhile, the observations of yield components were panicle length, panicle number, and rice grain number.

Statistical Analysis

Analyses of Variance (ANOVA) for factorials design were done to study the growth and yield response of rice plants due to application of ameliorant materials. If there was a significant effect, then it was continued by the least significant difference (LSD) test at 5% level.

RESULTS AND DISCUSSION

Growth Components of Rice Plant

The results of variance analysis for rice growth component planted at Ustic Endoaquert showed that CC and BC did not significantly effect to plant high (Table 3), while the SS significantly affected to plant high. The highest plant height was shown at application of 20% SS which significantly increased plant height compared other treatments. However,

Table 1. Soil description and classification of the Experiment Site.

Location	:	Sidomukti Village, Mootilango Subdistrict, Gorontalo District, Gorontalo Province
Soil classification		
Taxonomy (USDA 2010)	:	Ustic Endoaquert
PPT System	:	Eutric Cambisol
FAO-UNESCO System	:	Cambisol
Parent material	:	Lacustrine
Position physiographic	:	Foot slope, Depression
Topography	:	Flat-Ramps, slopes <2%
Elevation	:	58 m sl
Drainage	:	Poor
Ground water depth	:	Shallow
Vegetation	:	Rice (*Oryza sativa* L.)

Depth (cm)	Horizon	Descriptions
0-12	Apg1	Gray (10YR 5/1); clay loamy; massive structure; very sticky, plastic; smooth roots, a lot; clear flat.
12-31	Apg2	Gray (10YR 5/1); clays; angular blocky structure, smooth, Weak; very sticky, plastic; rusty brown (10YR 5/3), plain, smooth, clear, spots, sharp; rooting smooth, much; gradually average
31-53	Bwg1	Gray (10YR 5/l); clay; moderate, angular blocky structure, weak; very sticky, plastic; rooting smooth, slightly; frosted flat.
53-71/92	Bwg2	Gray (10YR 6/l); clay; angular blocky structure, rough, weak; very sticky, plastic; obviously choppy.
71/92-119	Bwssg	Dark gray (10YR 4/1); clay moderate, angular blocky structure, moderate; very sticky, plastic; slickenside; rusty brown (10YR 5/3), plain, smooth, clear, tube, clear; frosted flat.
119-150	BCg1	Dark gray (10YR 4/1); clay; angular blocky structure, harsh, strong; very sticky, plastic; rusty brown (10YR 5/3), plain, smooth, clear, tube, clear; clear flat.
150-200	BCg2	Dark gray (10YR 4/1); clay, very sticky, very friable; frosted flat.

Table 2. Initial soil properties of ustic endoaquert at 0-20 cm depth.

Soil Properties	Values	Criterion*
Texture:		
Sand (%)	27	Clay Loamy
Clay (%)	35	
Silt (%)	38	
Soil permeability (cm hour^{-1})	1.59	Slow
COLE value	0.98	Real swell-shrinking
Water content availability	8.47	
C-organic (%)	0.69	Very low
Total N (%)	0.06	Very low
C/N ratio	11.62	Moderate
Available-P, Bray 1 (mg P kg^{-1})	3.80	Very low
pH H_2O	6.48	slightly acid
NH_4OAo 1 *N* pH 7 Extraction:		
K(cmol+ kg^{-1})	0.24	Very low
Ca (cmol+ kg^{-1})	14.90	High
Mg (cmol+ kg^{-1})	6.05	High
Na (cmol+ kg^{-1})	0.50	Moderate
CEC (cmol+kg^{-1})	30.93	High
Base saturation (%)	70.08	High
Extract KCI 1 *M*:		
Al^{3+} (cmol+ kg^{-1})	0.00	
H^+ (cmol+ kg^{-1})	0.06	

*Center for Soil Research (1983).

the plant height still lower than normal growth as reported by Supriatno *et al.* (2007), that plant height of Ciherang varieties were ranged from 107-115 cm.

The highest increasing of plant height was indicated at application of 25% SS which increased plant height by 11.80%, while the lowest one was shown at application of 10 Mg ha^{-1} CC which only increased by 0.83%. At growth phase, especially plant height it needed sufficient water availability. Application of 25% SS had not yet reduced water storage in soil, so it did not effect on water availability, but it could increase plant height. At application of 50% SS, the plant height decreased until 2.45%. Mishra *et al.* (2012) reported that water available significantly decreased with the increasing of sand in mixture. Water shortages did not apparent at the beginning of vegetative phase and it still could stimulate root development, but at next vegetative phase, plant would be stunted (Sholeh and Riajaya 2000).

Furthermore, Yakup (2008) reported that plant height was significantly affected by soil water availability. In the water-saturated state, despite resistance by soil particles, no water could be absorbed by the soil except in certain plants such as paddy (Kasli and Efendi 2011).

Test results of WAC of both ameliorant showed that CC had a high WAC (71.77%), while BC was only 28.23%. Wuryaningsih *et al.* (2008) who conducted a study of growth *Anthurium andraeanum* in pot by using coconut bulk media reported that its physical properties were: a very high water content (1,314.41%), low-bulk density (0.09%), high total porosity (120.31%), and high pores water holding (116.6%). In additional, soil texture was classified as clay loamy (Table 2), so the soil puddling and flooding would become more easily dispersible and soil was relatively compact (Isnaini and Suwarno 2005).

Unlike the application of CC, the application of SS and BC had significant effect to leaf length (Table 3). The largest increasing of leaf length was shown at SS application as much as 25% (16.47%) and it was significantly different with control. It seems that application of 25% SS had not yet reduced water storages in soil but it might increase soil pores, so the leaf length was the highest. With the application of 50% SS, the leaf length decreased

Table 3. The rice plant growth components with the application of sea sand, coconut coir and banana coir planted at Ustic Endoaquert soil.

Treatments	Plant Height (cm)	Leaf length (cm)	Leaf number	Tiller number
Sea sand				
0%	27.74a	20.64a	10.29^{ns}	12.07a
25%	3097b	24.04b	14.18	13.37b
50%	30.23ab	23.01ab	14.04	13.29ab
Coconut coir				
0 Mg ha^{-1}	29.57^{ns}	21.99^{ns}	11.88^{ns}	12.37^{ns}
10 Mg ha^{-1}	30.02	22.92	13.29	13.29
20 Mg ha^{-1}	29.32	22.78	13.33	13.07
Banana coir				
0 Mg ha^{-1}	30.95^{ns}	23.89a	9.89a	$l2.56^{ns}$
10 Mg ha^{-1}	29.29	21.43b	16.37b	13.19
20 Mg ha^{-1}	28.65	22.37ab	12.26ab	13.00
Interaction	ns	ns	ns	ns
$LSD_{0.05}$	3.21	2.42	4.57	1.25

Note: Number that following by same latter in same column did not significantly different at LSD level of 0.05; ns=not significant effect at F level test 0.05.

until 11.48%. Mishra *et al.* (2012) reporting that the water available decreased significantly with increasing sand in mixture. The lowest leaf length was shown at the 0 Mg ha^{-1} CC (0.62%) and it was not significantly different with 10 and 20 Mg ha^{-1} CC.

Fazeli *et al.* (2007) stated that effect of a turn single of water availability would reduce growth. Furthermore, Kasli and Effendi (2011) stated that effects of water shortages on some physiological processes of plants were seen in a slow accumulation of dry matter, decreasing leaf expansion rate, and limiting stomata closure photosynthesis. In addition, short-term leaves and leaf area in plants were thought to be influenced by the intensity of the light received in green house where the research took place. The present of trees around the green house allegedly indirectly affected the reception of light by the plant, even though the distance was about 6 feet from the green house. Anggarwulan *et al.* (2008) stated that light played an important role in the physiological processes of plants, especially photosynthesis, respiration, and transpiration. The plants required quite diverse intensity of light.

The applications of SS and CC did not have significantly effect to leaf number, but BC had significantly effect (Table 3). Application of 10 Mg ha^{-1} BC had significantly increased leaf number by 65.52% and it was significantly different with control. This was presumably due to the ability of BC to maintain soil moisture and water availability. Indrawati (2009) stated that the stem of BC was strong fiber and resistant to water. It also had pores that were interconnected, and when dry a material would be having absorption and high shelf.

The application of CC and BC did not have significant effect to tiller number, but application of SS had significant effect to it (Table 3). Application of 25% SS increased significantly tiller numbers by l0.77%. Indrawati (2009) stated that the flooding growing media as high as 5 cm was also associated with the formation of tiller numbers. This was in line with reports of Utomo and Rudi, (2000) in Kaseli and Effendi (2011) that the flooding up to approximately 3-5 cm above soil surface condition that considered as good for formation of tillers and at foll phase the flooding would inhibit seedling establishment. The results were reinforced by reports Astuti (2010) that the tiller numbers produced from crops by flooding system were more than by intermittent and kemalir systems. However, in contrast with results of Shi *et al*. (2002) that at the maximum tillering growth phase, the highest tiller numbers were in kemalir water management compared to intermittent and continuous floodings.

Sumardi *et al*. (2007) that water use efficiency for rice cultivation without flooding condition were as much as 19.581%, while with continuously flooding its efficiency was as much as 70.907% only. In this study also showed that the higher the plant would be followed by a greater tiller numbers. This was in contrast with the result of Aldi *et al*. (2004); Hartati and Suwarta (2004); Rahayu and Harjoso (2010) who reported that tiller number showed contrary to values of plant height, where the higher tiller number was the lower plant high.

Although it had not significant effect to tiller numbers, but application of 10 Mg ha^{-1} CC and BC increased tiller number by 7.44% and 5.04%, respectively compared to control. This was related a to high ability to absorb water of CC and BC, so that they would enough moisture and water availability. Ramesh *et al.* (2010) reported that combination of soil and coconut coir as much as 4% showed changes in the nature of Catton black soil compactness better that control. Contribution of ameliorant effect to plant growth was in order of SS > BC > CC.

Yield Components of Rice Plant

Analysis of variance for rice yield component resulted that application of CC and BC had significantly increased panicle numbers, but application of SS did not have significantly effect to panicle numbers. It seems that percentage of panicle numbers with CC and BC application were relative similar. However, the different between treatments were increasing of percentage figures. Application of 20 Mg ha^{-1} BC significantly increased panicle number by 20.47% compared to 10 Mg ha^{-1} BC and by 23.4l compared to control. This suggested that BC application was able to maintain water availability due a to high ability to absorb water. The BC was quite strong and resistant to water and had pores that where interconnected and when dry, a material would be having absorption and high shelf (Indrawati 2009). Meanwhile, although it had not significantly effect to panicle numbers, but application of 50% SS increased tiller numbers by 19.36% compared to control.

Soil sand fraction was clay loamy textures, so that application of 50% SS to the soil could reduce weight to light fraction, particularly declined COLE index. Sand textures affected status and distribution of water, so affecting root system and root depth (Walter *et al*. 2000; Oliver and Smettem 2002). Thus, the plant root system was not disturbed due to lock of the possibility of soil cracking, so the process of water and nutrients absorption could be better.

Application of 20 Mg ha^{-1} CC significantly increased panicle numbers by 29.54% compared to 10 Mg ha^{-1} CC. This was presumably related to soil water availability. The WAC level of CC was high and would be able to absorb and retain water availability in the soil, so that more CC would be followed by the greater panicle numbers. This was consistent with statement of Dachban (2012) that rice storage water for 4 days at generative periods and following 2 weeks was a sensitive periods to water storages.

In addition, the SS, CC and BC significantly increased panicle length. Application of 10 Mg ha^{-1}

Table 4. The rice yield component at application of sea sand, coconut coir and banana coir planted at Ustic Endoaquert soil.

Treatments	Panicle number	Panicle length (cm)	Rice grain number
Sea sand			
0%	2.48ns	8.97b	8.64ns
25%	2.59	7.35a	7.98
50%	2.96	8.28ab	9.07
Coconut coir			
0 Mg ha^{-1}	2.59ab	6.41a	7.14a
10 Mg ha^{-1}	2.37a	8.80b	9.52b
20 Mg ha^{-1}	3.07b	9.39b	9.04ab
Banana coir			
0 Mg ha^{-1}	2.52ab	7.33a	7.49ns
10 Mg ha^{-1}	2.41a	9.49b	9.48
20 Mg ha^{-1}	3.11b	7.78a	8.72
Interaction	ns	ns	ns
$LSD_{0.05}$	0.63	1.24	2.05

Note: Number that following by same latter in same column did not significantly effect at LSD level of 0.05; ns=not significant effect at F level test 0.05.

BC significantly increased panicle length by 29.47% compared to control and by 21.8% compared to 20 Mg ha^{-1} BC. This was presumably related to soil water availability of each treatment. The research conducted by Dachban (2012) showed that the panicle length at level of 3 mm, 2 mm, and 1 mm decreased long panicle length by 0.77%, 5.80%, and 45.10% respectively, due to reduction of plant yields because of water. In fact, Astuti (2010) reported that panicle length and rice grain numbers were not affected by irrigation, but each variety had panicle length and rice grain numbers per panicle significantly different due to the genetic. Meanwhile, 10 Mg ha^{-1} CC significantly increased rice grain numbers by 33.33% compared to control but did not have significantly different with 20 Mg ha^{-1} CC (Table 4). Apparently, long panicles would be relatively followed by a greater rice grain numbers. It was in line with Setiobudi *et al.* (2008) that the rice grain numbers was determined by genetic properties of plants especially panicle length, tassel branch, and a differentiation rice grains.

CONCLUSIONS

Application of sea sand and banana coir significantly increased leaf length where the highest increasing percentage of 16.47% was achieved at 25% SS application. Their effect on leaf numbers and tiller numbers were relatively not similar pattern where leaf number only increased about 65.52% by banana coir application, while tiller numbers only increased about 10.77% by sea sand application. Furthermore, the application of coconut coir and banana coir significantly increased panicle numbers up to 29.53% and 29.05%, respectively compared to control. All ameliorants significantly increased panicle numbers, but the best was coconut coir that could increase up to 46.49% at 20 Mg ha^{-1} CC compared to sea sand and banana coir application. Only coconut coir significantly increased the rice grain numbers.

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