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Effect of Mixture of Water Hyacinth Compost and Rice Husk Biochar on the Improvement of Alluvial Soil Properties and the Growth of Red Ginger (*Zingiber Officinale* L.)

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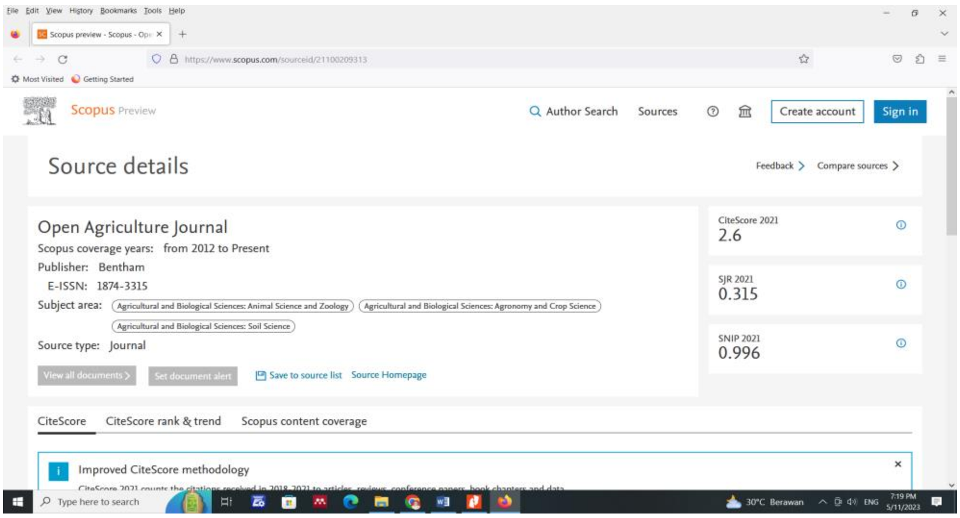

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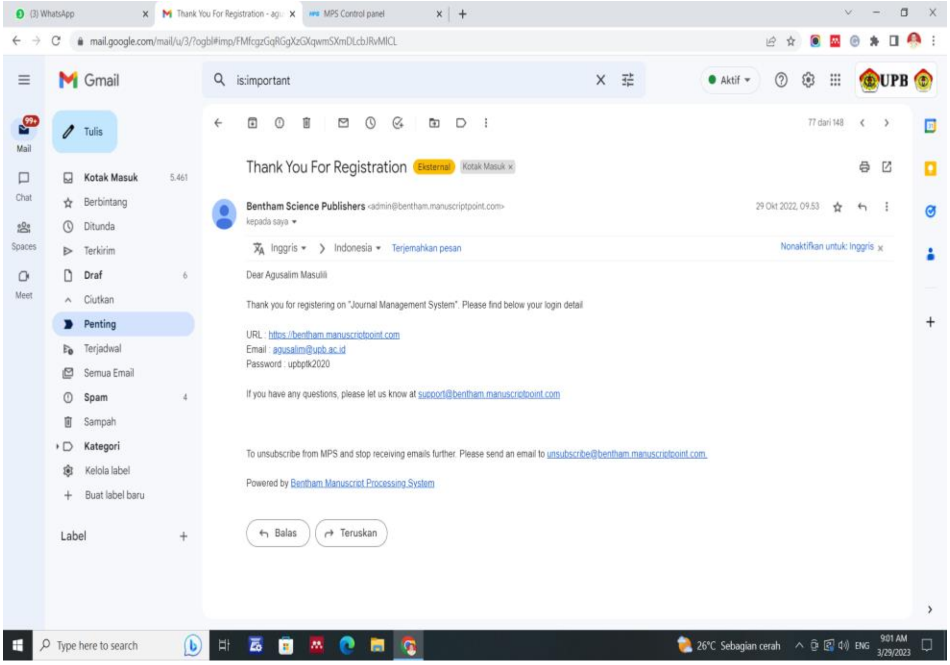

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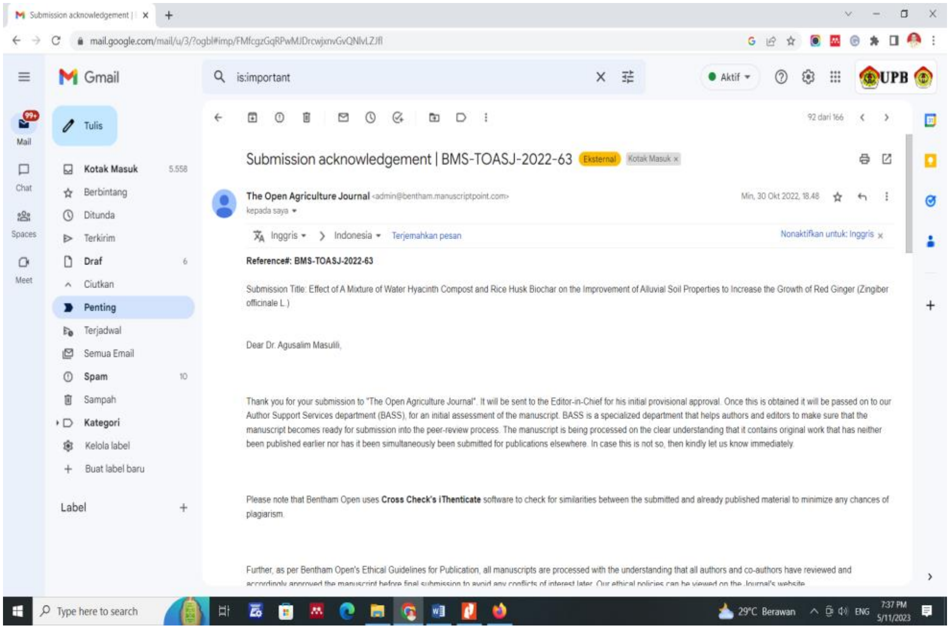

COVER LETTER
To Open Agriculture Journal

Dear Editor,

I would like to send an original article entitled: "Effect of A Mixture of Water Hyacinth Compost and Rice Husk Biochar on the Improvement of Alluvial Soil Properties to Increase the Growth of Red Ginger (Zingiber officinale L.)" for Open Agriculture Journal to consider. I confirm that this work is genuine and has not been published elsewhere, nor is it considered for publication elsewhere. We believe and hope that this manuscript is worthy of publication by Open Agriculture Journal. We are interested in publishing articles in this journal because it has an excellent reputation, so it is a matter of pride if published in Open Agriculture Journal. Here I attach the manuscript.

Thank you
Best regards,

Agusalim Masulili
Panca Bhakti University, Pontianak, West Kalimantan, Indonesia

Effect of A Mixture of Water Hyacinth Compost and Rice Husk Biochar on the Improvement of Alluvial Soil Properties to Increase the Growth of Red Ginger (*Zingiber officinale* L.)

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Abstract:

Background:

Alluvial is the potential soil for agricultural development. However, this soil having a physical soil can inhibit plant growth. One of the ways to improve the physical properties is through the application of soil reformers.

Objective:

This study aimed to know the optimum dose of a mixture of water hyacinth compost and rice husk biochar for improving alluvial soil properties to increase red ginger growth.

Methods:

This study was arranged in a completely randomized design (CRD) and four replications. The treatment was the doses of a mixture of water hyacinth compost and rice husk biochar (volume ratio of 2: 1), which consisted of six doses, namely: 0, 40, 60, 80, 100, and 120 g polybag^{-1}. Then each replication consisted of three samples. As many as 72 polybags were needed in this study. The observed physical properties of the soil were the bulk density (BD) and the soil pore space. The plant growth parameters included plant height, leaf numbers, tiller numbers, and fresh weight.

Results:

The results showed that applying a mixture of water hyacinth compost and rice husk biochar at a dose of 120 g polybag^{-1} caused the lowest BD and the most pore space in the soil. However, a dose of 80 g polybag^{-1} can provide maximum plant height, leaf numbers, tiller numbers, and fresh weight.

Conclusion:

The study findings show that mixing water hyacinth compost and rice husk biochar at 80 g polybag^{-1} is the optimum dose to support the maximum red ginger growth. However, we recommend that future research is needed to investigate the causes of decreasing BD and increasing soil pores.

Keywords: Bulk density, Soil pore, Red ginger, Alluvial, Water hyacinth, Rice husk biochar.

Running title: Alluvial soil properties in red ginger cultivation

1. INTRODUCTION

The red ginger plant (*Zingiber officinale* var. *rubrum*.) is one of the important medicinal plants and is widely used by the people of Indonesia. Jabborova et al. [1], ginger is important for maintaining health and is effective against some symptoms or diseases of headaches, nausea, vomiting, and motion sickness. In addition, ginger is associated with anti-tumorigenic and immunomodulatory effects as an anti-microbial, anti-viral agent, a powerful analgesic, and a stimulant that controls various diseases such as cholesterol and high blood pressure. Azizah et al. [2] stated that cultivation techniques and growing media determined the production standards of red ginger. A good growing medium for red ginger is loose and fertile soil. Hagner et al. [3], compost can improve ex-mining soils. Hafez et al. [4], the substance of humates and vermicompost can improve nutrition, plant growth, and water use efficiency. Research results by Perdigão et al. [5], tanning waste compost can increase nitrogen and ryegrass crop production on a laboratory scale.

One type of soil that has the potential for ginger development is alluvial soil which reaches an area of 15,111,870 km^2 or 10.29% of the total province of West Kalimantan. The soil type belongs to the immature group with slow profile development compared to mature soil and still resembles much of the parent material. Alluvial soil will be productive land for the development of red ginger plants if it can solve the problem. According to Yatno et al. [6], these soils belong to marginal soils and are high in clay. Hikmatullah and Al-Jabri [7], stated these soils are formed from deposits on flat to nearly flat slopes by fluvial or colluvial processes through water flow and gravitational forces causing physical, chemical, and mineralogical variations, as well as nutrient accumulation.

Yahya et al. [8] said that an important problem of alluvial soils was soil compaction, which causes obstacles to developing plant roots. It was related to the soil's high BD and low pore space. Widodo and Kusuma [9], the problem was associated with the low content of soil organic matter. Thus, efforts can be made to overcome alluvial soil problems to become a good growing medium by providing soil-improving treatment. One type of soil dressing that can be used is compost. The application was expected to improve the physical properties of the soil, including BD and soil pores. Cahyono et al. [10], compost contains organic compounds that can improve the chemical and physical properties of the soil, especially marginal soils. Widodo and Kusuma [9], compost can loosen the soil and enhance the pore space.

One of the materials that can potentially be composted is water hyacinth. These plants can absorb heavy metals and have a very high growth speed. This growing speed caused water hyacinths to be considered a weed or nuisance plant. In large quantities, water hyacinths will have negative impacts in the form of disturbances in the use of water, namely accelerating silting of irrigation canals, enlarging evapotranspiration, making it difficult to transport water, and reducing fishery products. To minimize the negative impact, water hyacinths can be used as compost. Research results by Birnadi et al. [11] showed that water hyacinth compost significantly influenced the increase in the peanuts' growth. Mashavira et al. [12] use water hyacinth compost can increase the growth rate and yield of healthy tomatoes. Water hyacinth compost has the potential to be a source of nutrients, increasing soil organic matter, soil particle aggregation, porosity, water holding capacity, cation exchange capacity, pH, and soil microorganisms [13].

Adding rice husk biochar can increase the role of water hyacinth compost in improving the soil's physical properties, especially BD and pore space. Beusch [14], adding rice husk biochar to the soil contributes to soil fertility, where rice husk biochar can improve the soil's physical, chemical, and biological properties. Karthik et al. [15], biochar can increase soil pores and lower BD. In line with this, Glaser et al. [16] also suggested that biochar could increase soil productivity. According to Nyasapoh [17], biochar application can improve water use efficiency.

So far, many studies have related compost and rice husk biochar to improve soil properties and plant growth. However, further research was still needed to use water hyacinth compost mixed with biochar to improve the properties of BD and soil pores. In addition, research on improving the physical properties of alluvial soils could increase red ginger growth. Therefore, based on the background and literature review above, this study aimed to know the optimum dose of a mixture of water hyacinth compost and rice husk biochar for improving alluvial soil properties to increase red ginger growth.

2. MATERIALS AND METHODS

2.1. Study Area

The study was done in March - June 2021. The research location was at the Faculty of Agriculture, Panca Bhakti University, Pontianak, Indonesia. Topographic contours were flat, with an average soil surface height of 1 m above sea level (ASL). The average temperature and humidity of the air were 27.6 ºC and 82.8%. The location of the study was at 2°05' North Latitude – 3°05' South Latitude and 108°30'–144°10' East Longitude.

2.2. Experiment Design

The study was arranged in a CRD and four replications. The treatment was a mixture of water hyacinth compost and rice husk biochar (volume ratio of 2: 1), which consisted of six doses: 0, 40, 60, 80, 100, and 120 g $polybag^{-1}$. Each replication consisted of three samples, so 72 polybags were needed.

2.3. Research Procedures

In this study, an alluvial type of soil was used. The soil sample was taken from a depth of 20 cm. The soil was dredged for one week and cleared of dirt, root residues, wood, and twigs. The soil was crushed to a size of about 0.2 cm. Then the soil was put into a polybag of 40 × 40 cm with a weight of 8 kg. The plant material was local red ginger from Poring Village, Pinoh District, Melawi Regency, West Kalimantan Province, Indonesia.

The compost material was made from water hyacinth growing in the farmers' land primary channels. Water hyacinths were taken from all parts of the plant and chopped to a size of 1–2 cm. The dose of composting was 10 kg of water hyacinth, 5 kg of rice bran, 5 kg of goat manure, and 5 L water, then mixed and stirred. Next, the compost was watered with a solution of Tricogreen 6 tablespoons and stirred again until evenly mixed. Then it was tightly covered with a plastic tarp and stored in a place protected from direct sunlight. The material was allowed to stand for four weeks and stirred once weekly.

Rice husk biochar was made from rice milling waste and was produced by pyrolysis. Next, the water hyacinth compost was mixed with the rice husk biochar in a volume ratio of 2:1. Then, the dosage level of treatment was incubated into the polybag for one week before. Then the red ginger seedlings were planted. Dolomite lime was used as a soil amelioration material. NPK Mutiara fertilizer (16:16:16) was used as the basic fertilizer.

2.4. Parameters

The parameters observed in the study were the soil's physical properties and red ginger growth. Specifically, observation of alluvial soil properties were BI and soil pores. BD was measured by the clod method described by Blake & Harke. Soil pores were total pores calculated from the moisture content of the soil (v/v) at a matrix potential of 0 kPa. In addition, observations of red ginger growth were carried out 90 days after planting (DAP), including plant height, leaf numbers, tiller numbers, and fresh weight of the plant.

2.5. Statistical Analysis

The data were analyzed using analysis of variance (ANOVA) at 5% significance levels [18] with IBM SPSS Statistic 23. In addition, the treatment means were compared using least significance different (LSD) at 5% significance levels.

3. RESULTS

3.1. Changes in BD and Soil Pores

A mixture of water hyacinth compost and rice husk biochar had the potential to improve the physical properties of alluvial soils. The higher dose of a mixture of water hyacinth compost and rice husk biochar caused a decrease in BD but increased soil pore at 90 days after treatment (DAT). The results of the LSD test at 5% significant levels on BD and soil pores at 90 DAP are shown in Table **1**.

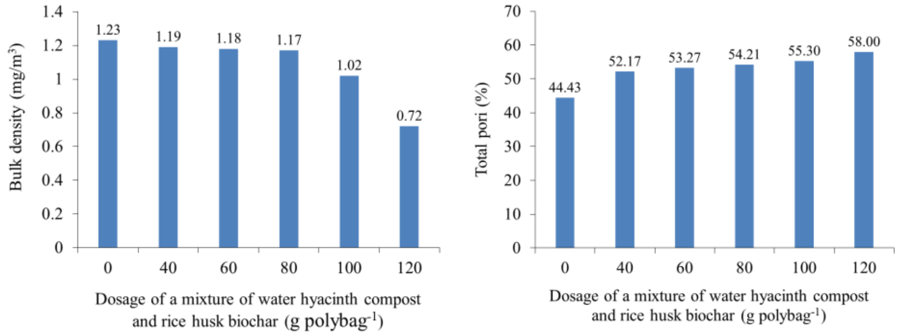
Table 1. Effect of mixing water hyacinth compost with rice husk biochar on BD and soil pores.

Mixed of water hyacinth compost and rice husk biochar (g polybag^{-1})	**BD (mg m^{-3})**	**Total pores (%)**
0	1.23 d	44.43 a
40	1.19 c	52.17 b
60	1.18 bc	53.27 b
80	1.17 b	54.21 c
100	1.02 a	55.30 cd
120	0.72 a	58.00 d

Remarks: The numbers followed by the same letter in the column show no difference based on the LSD test at 5% significant levels.

Table **1** shows that the lowest BD obtained at doses of 100 and 120 g polybag^{-1} did not significantly different, but significantly different from doses of 0-80 g polybag^{-1}. The total pore also increased in the dose of water hyacinth compost and the rice husk biochar. The highest total pores were achieved at a mixture of water hyacinth compost and rice husk biochar at a dose of 120 g polybag^{-1}. It was not significantly different from the dose of 100 g polybag^{-1} but significantly different from the dose of 0-80 g polybag^{-1}. It suggests that improving soil physical properties with BD indicators and alluvial soil pores can be made by increasing the mixture of water hyacinth compost and rice husk biochar.

Changes in BD and total pores at various dose treatments of water hyacinth compost and rice husk biochar at 90 DAT can be seen in Fig. **1**.



(a) (b)

Fig. (1). Effect of a mixture of water hyacinth compost and rice husk biochar on BD (a) and total soil pores (b).

Fig. **1a** shows that the highest BD was obtained on the 0 g polybag^{-1} (as control) and decreased further when the treatment dose of a mixture of water hyacinth compost and rice husk biochar was increased. The lowest decrease in BD at the dose treatment was 120 g polybag^{-1}. Fig. **1b** shows an increase in the dose of a mixture of water hyacinth compost and rice husk biochar caused the increase in total soil pore. Again, the lowest total soil pores were obtained at 0 g polybag^{-1} and the highest at a dose of 120 g polybag^{-1}.

3.2. Growth of Red Ginger Plants

Changes in soil fertility have a good effect on the growth of red ginger plants. The results of the LSD test at 5% significant levels on plant height, leaf numbers, tiller numbers, and fresh weight of plant at 90 DAP can be seen in Table **2**.

Table 2. Effect of a mixture of water hyacinth compost with rice husk biochar on the growth of red ginger plants.

Mixed of water hyacinth compost and rice husk biochar (g polybag^{-1})	Plant height (cm)	Leaf numbers (strands)	Tiller numbers (stem)	Fresh weight of plant (g)
0	52,63 a	54,92 a	7,50 a	128,84 a
40	49,67 a	62,33 a	6,92 a	128,06 a
60	48,31 a	59,42 a	7,25 a	145,66 a
80	56,80 b	97,08 b	11,42 b	267,47 b
100	46,52 a	54,08 a	7,17 a	150,11 a
120	48,05 a	58,08 a	7,42 a	154,77 a

Remarks: The numbers followed by the same letter in the column show no difference based on the LSD test at 5% significant levels.

Table **2** shows that the dose treatment of a mixture of water hyacinth compost and rice husk biochar significantly influenced all observed growth parameters. Furthermore, the highest values for plant height, leaf number, tiller numbers, and fresh weight of plants were obtained at a dose treatment of 80 g polybag^{-1}, in stark contrast to the control doses of 40, 60, 100, and 120 g polybag^{-1}.

For more details, the effect of a mixture of water hyacinth compost with rice husk biochar on the red ginger growth at 90 DAP can be seen in Fig. **2**.

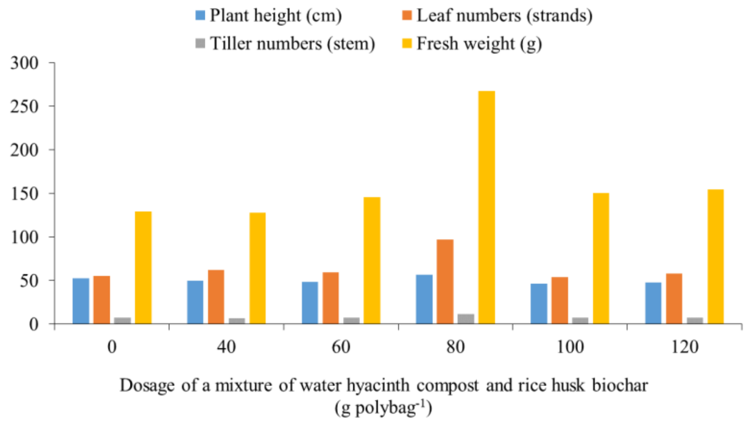


Fig. (2). Growth of red ginger plants on various doses of a mixture of water hyacinth compost and rice husk biochar.

Fig. **2** shows that the highest red ginger growth was obtained at a dose of 80 g polybag^{-1}. However, when the treatment dose was increased to 100 or 120 g polybag^{-1}, there was a decrease in plant growth. Therefore, it indicates that inhibition of red ginger growth could occur in a mixed dose of water hyacinth compost with rice husk biochar after a dose of 80 g polybag^{-1}.

4. DISCUSSION

4.1. Changes in BD and Soil Pores

Organic amendments to the soil will undergo a further decomposition process and produce organic acids. Furthermore, the resulting organic substance will affect the soil's physical, chemical, and biological properties. In line with this, the study results in Table **1** show that the higher dose of the mixture of water hyacinth compost and rice husk biochar has a good impact on improving BD and soil pores. Adding organic matter to the soil will influence the formation of soil granulation due to the presence of organic matter that can produce organic acids to form clay-organic complexes. The formation of soil aggregation impacted decreasing BD and increasing soil pores. The treatment showed an inverse relationship between BD and soil pores, where BD decreased, so total pores increased and vice versa.

Soil aggregation is closely related to BD and soil pores. In connection with Cincotta et al. [19], soil aggregation was related to organic matter content and would affect BD and soil pores. Furthermore, research supported by D'Hose et al. [20] showed that biochar mixed with compost improved the soil's chemical properties. Reinforced by Zhang et al. [21], humic substances played an important role in the formation and stability of soil aggregates. Based on research by Šimanský et al. [22] also played a role in soil structure. Humic acids can improve soil properties [23]. The humic substance is a component of organic matter of the most active humus fraction and can interact with soil particles through binding with its active group. This compound has a functional group that can bond with soil minerals. The reaction between soil minerals and humic materials will encourage the occurrence of aggregation and the formation of stable aggregates. Thus, applying soil reformers as a mixture of water hyacinth compost and biochar will affect the content and stability of organic C in the soil aggregate, and further will affect the increase in soil pores.

4.2. Growth of Red Ginger Plants

Water hyacinth compost and rice husk biochar in alluvial soils, including a certain amount of organic soil dressing, can increase plant growth due to improving the soil's chemical, physical, and biological properties. The study results in Table **2** show a decrease in soil BD, and an increase in soil pores occurred with an increase in the dose of a mixture of hyacinth compost and rice husk biochar. The best results were obtained at a dose treatment of 120 g polybag^{-1}. However, the red ginger growth was best achieved at a dose of 80 g polybag^{-1} and decreased when the treatment dose was increased. It indicates that too high a dose can inhibit red ginger growth. This phenomenon hints that aspects of soil fertility to support red ginger growth require a balance between various soil properties, both physical and chemical soil.

Various studies have found that organic reformers improve soil quality and increase plant growth. Cahyono et al. [10] showed that compost could improve acidic soil properties. Frimpong et al. [24], N-rich compost mixture + C+ biochar-rich compost can enhance soil quality, including CEC and soil pH. Organic amendments could improve soil fertility, carbon sequestration, and crop productivity [25]. Using organic amendments can increase crop yields and reduce inorganic fertilizers by up to 50% [26]. Applying a mixture of water hyacinth compost and rice husk biochar affected soil properties (physical, chemical, and biological).

CONCLUSIONS AND RECOMMENDATION

Based on the results of research and discussion, it can be concluded that applying a mixture of water hyacinth compost and rice husk biochar at a dose of 120 g polybag^{-1} caused the lowest BD and the most pore space in the soil. However, a dose of 80 g polybag^{-1} can provide maximum plant height, leaf numbers, tiller numbers, and fresh weight. Therefore, the study findings show that mixing water hyacinth compost and rice husk biochar at 80 g polybag^{-1} is the optimum dose to support the maximum red ginger growth. However, we recommend that future research is needed to investigate the causes of decreasing BD and increasing soil pores.

LIST OF ABBREVIATIONS

ANOVA	=	Analysis of Variance
ASL	=	Above Sea Level
BD	=	Bulk Density
CRD	=	Completely Randomized Design
DAP	=	Days After Planting
DAT	=	Days After Treatment
LSD	=	Least Significance Different
NPK	=	Nitrogen, Phosphate, and Kalium

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

HUMAN AND ANIMAL RIGHTS

No humans or animals were used in this research.

CONSENT FOR PUBLICATION

Not applicable.

AVAILABILITY OF DATA AND MATERIALS

Not applicable.

FUNDING

Not applicable.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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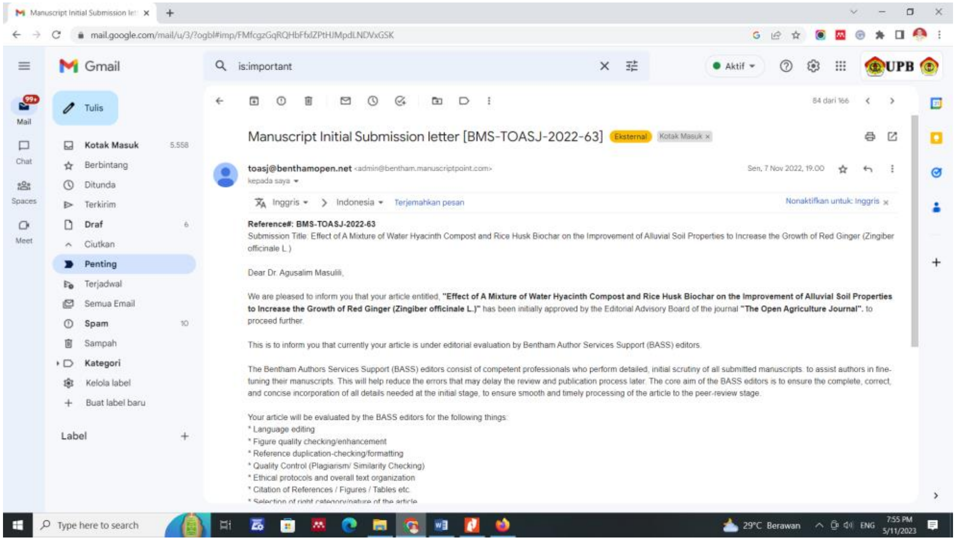
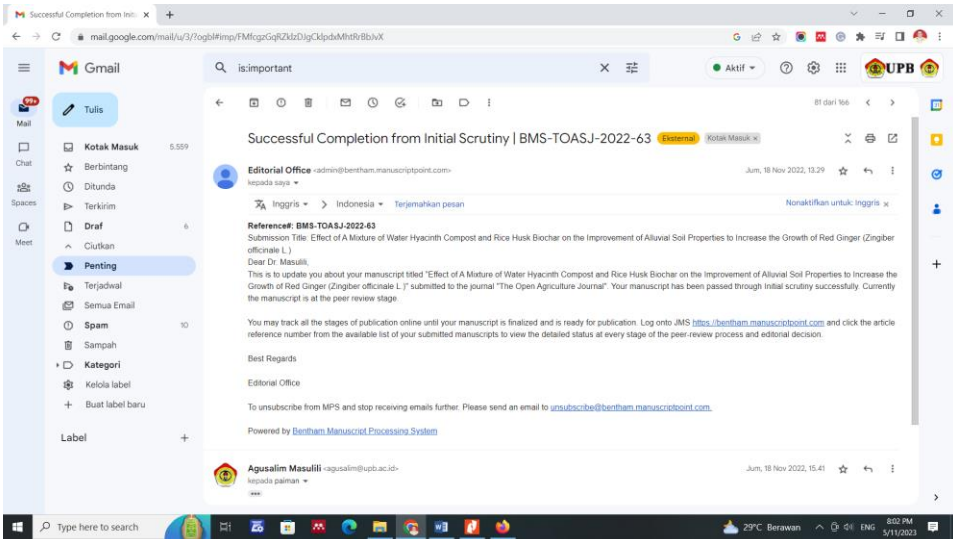
5. Email pemberiathuan, dalam evaluasi 7 November 2022



6. Email Successful Completion Initial scrutiny, 18 November 2022



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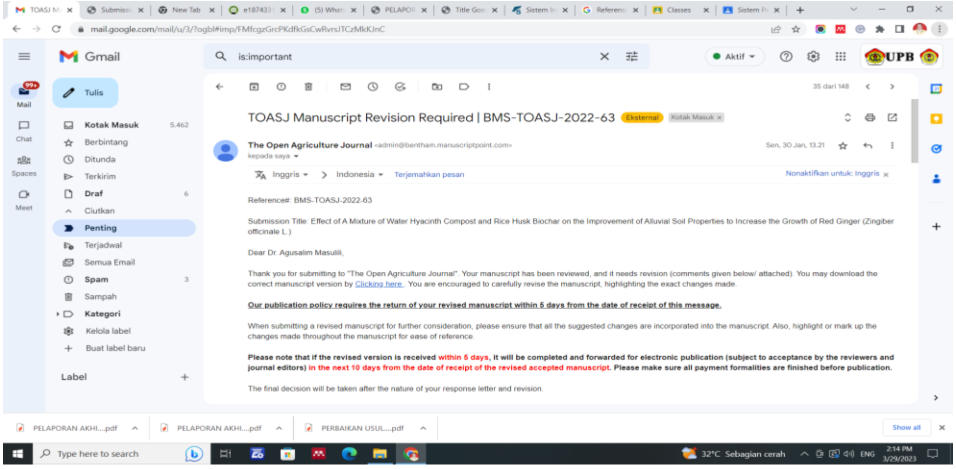
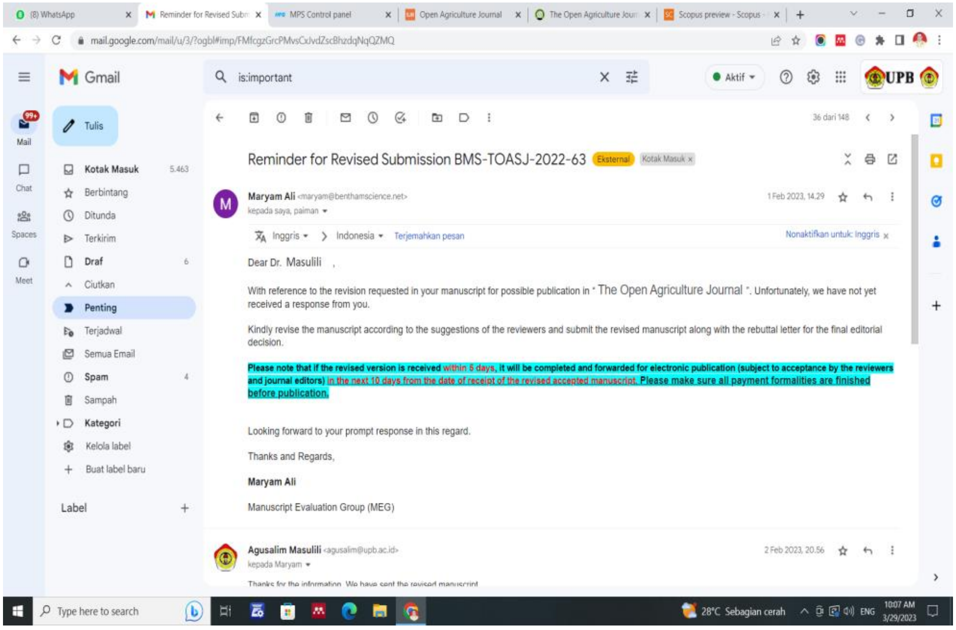


8. Reminder for revised, 1 Februari 2023



i. *Effect of A Mixture of Water Hyacinth Compost and Rice Husk Biochar on the Improvement of Alluvial Soil Properties to Increase the Growth of Red Ginger (Zingiber officinale L.)*

Effect of Mixture of Water Hyacinth Compost and Rice Husk Biochar on the Improvement of Alluvial Soil Properties and the Growth of Red Ginger (Zingiber officinale L.)

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Abstract:

Background:

Alluvial is the potential soil for agricultural development. However, this soil having a physical soil can inhibit plant growth. One of the ways to improve the physical properties is through the application of soil reformers.

Objective:

This study aimed to know the optimum dose of a mixture of water hyacinth compost and rice husk biochar for improving alluvial soil properties to increase red ginger growth.

Methods:

This study was arranged in a completely randomized design (CRD) and four replications. The treatment was the doses of a mixture of water hyacinth compost and rice husk biochar (volume ratio of 2: 1), which consisted of six doses, namely: 0, 40, 60, 80, 100, and 120 g polybag^{-1}. Then each replication consisted of three samples. As many as 72 polybags were needed in this study. The observed physical properties of the soil were the bulk density (BD) and the soil pore space. The plant growth parameters included plant height, leaf numbers, tiller numbers, and fresh weight.

Results:

The results showed that applying a mixture of water hyacinth compost and rice husk biochar at a dose of 120 g polybag^{-1} caused the lowest BD and the most pore space in the soil. However, a dose of 80 g polybag^{-1} can provide maximum plant height, leaf numbers, tiller numbers, and fresh weight.

Conclusion:

The study findings show that mixing water hyacinth compost and rice husk biochar at 80 g polybag^{-1} is the optimum dose to support the maximum red ginger growth. However, we recommend that future research is needed to investigate the causes of decreasing BD and increasing soil pores.

Keywords: Bulk density, Soil pore, Red ginger, Alluvial, Water hyacinth, Rice husk biochar.

Running title: Alluvial soil properties in red ginger cultivation

5. INTRODUCTION

The red ginger plant (*Zingiber officinale* var. *rubrum*.) is one of the important medicinal plants and is widely used by the people of Indonesia. Jabborova et al. [1], ginger is important for maintaining health and is effective against some symptoms or diseases of headaches, nausea, vomiting, and motion sickness. In addition, ginger is associated with anti-tumorigenic and immunomodulatory effects as an anti-microbial, anti-viral agent, a powerful analgesic, and a stimulant that controls various diseases such as cholesterol and high blood pressure. Azizah et al. [2] stated that cultivation techniques and growing media determined the production standards of red ginger. A good growing medium for red ginger is loose and fertile soil. Hagner et al. [3], compost can improve ex-mining soils. Hafez et al. [4], the substance of humates and vermicompost can improve nutrition, plant growth, and water use efficiency. Research results by Perdigão et al. [5], tanning waste compost can increase nitrogen and ryegrass crop production on a laboratory scale.

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One type of soil that has the potential for ginger development is alluvial soil which reaches an area of 15,111,870 km^2 or 10.29% of the total province of West Kalimantan. The soil type belongs to the immature group with slow profile development compared to mature soil and still resembles much of the parent material. Alluvial soil will be productive land for the development of red ginger plants if it can solve the problem. According to Yatno et al. [6], these soils belong to marginal soils and are high in clay. Hikmatullah and Al-Jabri [7], stated these soils are formed from deposits on flat to nearly flat slopes by fluvial or colluvial processes through water flow and gravitational forces causing physical, chemical, and mineralogical variations, as well as nutrient accumulation.

Yahya et al. [8] said that an important problem of alluvial soils was soil compaction, which causes obstacles to developing plant roots. It was related to the soil's high BD and low pore space. Widodo and Kusuma [9], the problem was associated with the low content of soil organic matter. Thus, efforts can be made to overcome alluvial soil problems to become a good growing medium by providing soil-improving treatment. One type of soil dressing that can be used is

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compost. The application was expected to improve the physical properties of the soil, including BD and soil pores. Cahyono et al. [10], compost contains organic compounds that can improve the chemical and physical properties of the soil, especially marginal soils. Widodo and Kusuma [9], compost can loosen the soil and enhance the pore space.

One of the materials that can potentially be composted is water hyacinth. These plants can absorb heavy metals and have a very high growth speed. This growing speed caused water hyacinths to be considered a weed or nuisance plant. In large quantities, water hyacinths will have negative impacts in the form of disturbances in the use of water, namely accelerating silting of irrigation canals, enlarging evapotranspiration, making it difficult to transport water, and reducing fishery products. To minimize the negative impact, water hyacinths can be used as compost. Research results by Birnadi et al. [11] showed that water hyacinth compost significantly influenced the increase in the peanuts' growth. Mashavira et al. [12] use water hyacinth compost can increase the growth rate and yield of healthy tomatoes. Water hyacinth compost has the potential to be a source of nutrients, increasing soil organic matter, soil particle aggregation, porosity, water holding capacity, cation exchange capacity, pH, and soil microorganisms [13].

Adding rice husk biochar can increase the role of water hyacinth compost in improving the soil's physical properties, especially BD and pore space. Beusch [14], adding rice husk biochar to the soil contributes to soil fertility, where rice husk biochar can improve the soil's physical, chemical, and biological properties. Karthik et al. [15], biochar can increase soil pores and lower BD. In line with this, Glaser et al. [16] also suggested that biochar could increase soil productivity. According to Nyasapoh [17], biochar application can improve water use efficiency.

So far, many studies have related compost and rice husk biochar to improve soil properties and plant growth. However, further research was still needed to use water hyacinth compost mixed with biochar to improve the properties of BD and soil pores. In addition, research on improving the physical properties of alluvial soils could increase red ginger growth. Therefore, based on the background and literature review above, this study aimed to know the optimum dose of a mixture of water hyacinth compost and rice husk biochar for improving alluvial soil properties to increase red ginger growth.

6. MATERIALS AND METHODS

6.1. Study Area

The study was done in March - June 2021. The research location was at the Faculty of Agriculture, Panca Bhakti University, Pontianak, Indonesia. Topographic contours were flat, with an average soil surface height of 1 m above sea level (ASL). The average temperature and humidity of the air were 27.6 ºC and 82.8%. The location of the study was at 2°05' North Latitude – 3°05' South Latitude and 108°30'–144°10' East Longitude.

6.2. Experiment Design

The study was arranged in a CRD and four replications. The treatment was a mixture of water hyacinth compost and rice husk biochar (2: 1, v/v), which consisted of six doses: 0, 40, 60, 80, 100, and 120 g polybag^{-1}. Each replication consisted of three samples, so 72 polybags were needed.

6.3. Research Procedures

In this study, an alluvial type of soil was used. The soil sample was taken from a depth of 20 cm. The soil was dredged for one week and cleared of dirt, root residues, wood, and twigs. The soil was crushed to a size of about 0.2 cm. Then the soil was put into a polybag of 40 × 40 cm with a weight of 8 kg. The plant material was local red ginger from Poring Village, Pinoh District, Melawi Regency, West Kalimantan Province, Indonesia.

The compost material was made from water hyacinth growing in the farmers' land primary channels. Water hyacinths were taken from all parts of the plant and chopped to a size of 1–2 cm and than 10 kg of water hyacinth, 5 kg of rice bran, 5 kg of goat manure, and 5 L water were mixed well. Next, the compost was watered with a solution of Tricogreen 6 tablespoons and stirred again until evenly mixed. Then it was tightly covered with a plastic tarp and stored in a place protected from direct sunlight. The material was allowed to stand for four weeks for incubation and stirred once weekly.

Rice husk biochar was made from rice milling waste and was produced by pyrolysis. Next, the water hyacinth compost was mixed with the rice husk biochar in a 2:1 (v/v). Then, the dosage level of treatment was incubated into the polybag for one week before why???. Then the red ginger seedlings were planted. Dolomite powder (liming agent) was used as a soil amelioration material (amount???). NPK Mutiara fertilizer (16:16:16) was used for the basal fertilization. (amount???).

6.4. Parameters

The parameters observed in the study were the soil's physical properties and red ginger growth. Specifically, observation of alluvial soil properties were BI and soil pores. BD was measured by the clod method described by Blake & Harke(???). Soil pores were total pores calculated from the moisture content of the soil (v/v) at a matrix potential of 0 kPa. In addition, observations of red ginger growth were carried out 90 days after planting (DAP), including plant height, leaf numbers, tiller numbers, and fresh weight of the plant.

6.5. Statistical Analysis

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The data were analyzed using analysis of variance (ANOVA) at 5% significance levels [18] with IBM SPSS Statistic 23. The treatment means were compared using least significance different (LSD) at thesignificance level (α: 0.05).

7. RESULTS

7.1. Changes in Bulk Densityand Soil Pores

A mixture of water hyacinth compost and rice husk biochar had the potential to improve the physical properties of alluvial soils. The higher dose of a mixture of water hyacinth compost and rice husk biochar caused a decrease in BD but increased soil pore at 90 DAP (Table 1).

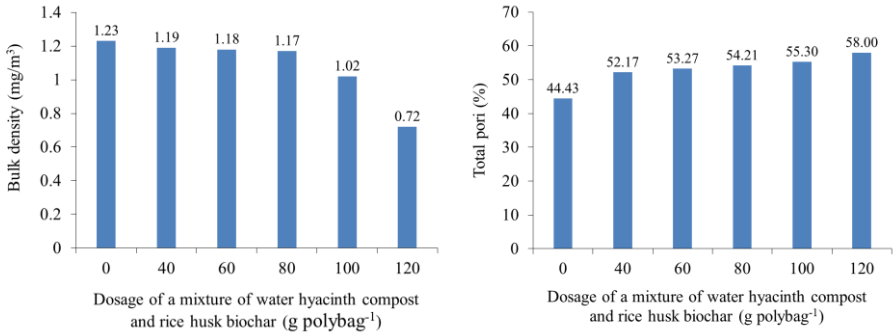
Table 1. Effect of mixing water hyacinth compost with rice husk biochar on BD and soil pores.

Mixed of water hyacinth compost and rice husk biochar (g polybag^{-1})	**Bulk Density (mg m^{-3})**	**Total porosity (%)**
0	1.23 d	44.43 a
40	1.19 c	52.17 b
60	1.18 bc	53.27 b
80	1.17 b	54.21 c
100	1.02 a	55.30 cd
120	0.72 a	58.00 d

Values are the mean of four replicates (n= 4). Different letters in the same column are significantly different according to the Duncan's Multiple Range Test.

The lowest BD obtained at doses of 100 and 120 g polybag^{-1} did not significantly different, but significantly different from doses of 0-80 g polybag^{-1}. The total pore also increased in the dose of water hyacinth compost and the rice husk biochar. The highest total pores were achieved at a mixture of water hyacinth compost and rice husk biochar at a dose of 120 g polybag^{-1}. It was not significantly different from the dose of 100 g polybag^{-1} but significantly different from the dose of 0-80 g polybag^{-1}. It suggests that improving soil physical properties with BD indicators and alluvial soil pores can be made by increasing the mixture of water hyacinth compost and rice husk biochar.

Changes in BD and total pores at various dose treatments of water hyacinth compost and rice husk biochar at 90 DAT can be seen in Fig. **1**.



(a) (b)

Fig. (1). Effect of a mixture of water hyacinth compost and rice husk biochar on BD (a) and total soil pores (b).

Fig. **1a** shows that the highest BD was obtained on the 0 g polybag^{-1} (as control) and decreased further when the treatment dose of a mixture of water hyacinth compost and rice husk biochar was increased. The lowest decrease in BD at the dose treatment was 120 g polybag^{-1}. Fig. **1b** shows an increase in the dose of a mixture of water hyacinth compost and rice husk biochar caused the increase in total soil pore. Again, the lowest total soil pores were obtained at 0 g polybag^{-1} and the highest at a dose of 120 g polybag^{-1}.

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7.2. Growth of Red Ginger Plants

Changes in soil fertility have a good effect on the growth of red ginger plants. The results of the LSD test at 5% significant levels on plant height, leaf numbers, tiller numbers, and fresh weight of plant at 90 DAP can be seen in Table **2**.

Table 2. Effect of a mixture of water hyacinth compost with rice husk biochar on the growth of red ginger plants.

Mixed of water hyacinth compost and rice husk biochar (g polybag^{-1})	Plant height (cm)	Leaf numbers (strands)	Sproud??? Tiller numbers (stem)	Fresh weight of plant (g)
0	52,63 a	54,92 a	7,50 a	128,84 a
40	49,67 a	62,33 a	6,92 a	128,06 a
60	48,31 a	59,42 a	7,25 a	145,66 a
80	56,80 b	97,08 b	11,42 b	267,47 b
100	46,52 a	54,08 a	7,17 a	150,11 a
120	48,05 a	58,08 a	7,42 a	154,77 a

Remarks: The numbers followed by the same letter in the column show no difference based on the LSD test at 5% significant levels.

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Table **2** shows that the dose treatment of a mixture of water hyacinth compost and rice husk biochar significantly influenced all observed growth parameters. Furthermore, the highest values for plant height, leaf number, tiller numbers, and fresh weight of plants were obtained at a dose treatment of 80 g polybag^{-1}, in stark contrast to the control doses of 40, 60, 100, and 120 g polybag^{-1}.

For more details, the effect of a mixture of water hyacinth compost with rice husk biochar on the red ginger growth at 90 DAP can be seen in Fig. **2**.

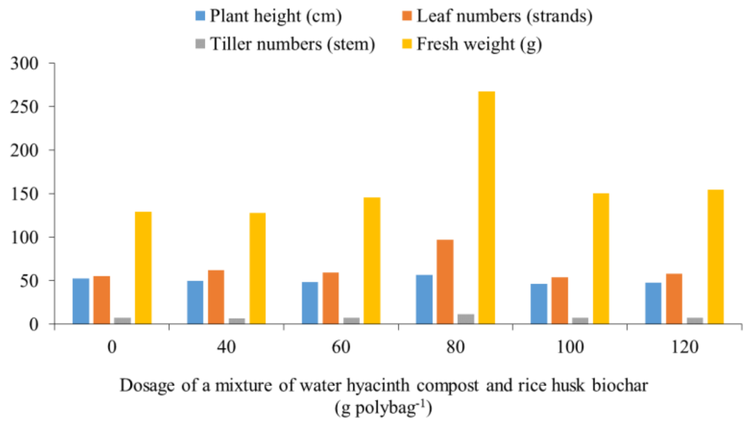

Fig. (2). Growth of red ginger plants on various doses of a mixture of water hyacinth compost and rice husk biochar.

Fig. **2** shows that the highest red ginger growth was obtained at a dose of 80 g polybag^{-1}. However, when the treatment dose was increased to 100 or 120 g polybag^{-1}, there was a decrease in plant growth. Therefore, it indicates that inhibition of red ginger growth could occur in a mixed dose of water hyacinth compost with rice husk biochar after a dose of 80 g polybag^{-1}.

8. DISCUSSION

8.1. Changes in BD and Soil Pores

Organic amendments to the soil will undergo a further decomposition process and produce organic acids. Furthermore, the resulting organic substance will affect the soil's physical, chemical, and biological properties. In line with this, the study results in Table **1** show that the higher dose of the mixture of water hyacinth compost and rice husk biochar has a good impact on improving BD and soil pores. Adding organic matter to the soil will influence the formation of soil granulation due to the presence of organic matter that can produce organic acids to form clay-organic complexes.

The formation of soil aggregation impacted decreasing BD and increasing soil pores. The treatment showed an inverse relationship between BD and soil pores, where BD decreased, so total pores increased and vice versa.

Soil aggregation is closely related to BD and soil pores. In connection with Cincotta et al. [19], soil aggregation was related to organic matter content and would affect BD and soil pores. Furthermore, research supported by D'Hose et al. [20] showed that biochar mixed with compost improved the soil's chemical properties. Reinforced by Zhang et al. [21], humic substances played an important role in the formation and stability of soil aggregates. Based on research by Šimanský et al. [22] also played a role in soil structure. Humic acids can improve soil properties [23]. The humic substance is a component of organic matter of the most active humus fraction and can interact with soil particles through binding with its active group. This compound has a functional group that can bond with soil minerals. The reaction between soil minerals and humic materials will encourage the occurrence of aggregation and the formation of stable aggregates. Thus, applying soil reformers as a mixture of water hyacinth compost and biochar will affect the content and stability of organic C in the soil aggregate, and further will affect the increase in soil pores.

8.2. Growth of Red Ginger Plants

Water hyacinth compost and rice husk biochar in alluvial soils, including a certain amount of organic soil dressing, can increase plant growth due to improving the soil's chemical, physical, and biological properties. The study results in Table 2 show a decrease in soil BD, and an increase in soil pores occurred with an increase in the dose of a mixture of hyacinth compost and rice husk biochar. The best results were obtained at a dose treatment of 120 g polybag^{-1}. However, the red ginger growth was best achieved at a dose of 80 g polybag^{-1} and decreased when the treatment dose was increased. It indicates that too high a dose can inhibit red ginger growth. This phenomenon hints that aspects of soil fertility to support red ginger growth require a balance between various soil properties, both physical and chemical soil.

Various studies have found that organic reformers improve soil quality and caused an increase in plant growth. Cahyono et al. [10] showed that compost could improve acidic soil properties. Frimpong et al. [24], N-rich compost mixture + C+ biochar-rich compost can enhance soil quality, including cation exchange capasity and soil pH. Organic amendments could improve soil fertility, carbon sequestration, and crop productivity [25]. Using organic amendments can increase crop yields and reduce inorganic fertilizers by up to 50% [26]. Applying a mixture of water hyacinth compost and rice husk biochar affected soil properties (physical, chemical, and biological).

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CONCLUSIONS AND RECOMMENDATION

Based on the results of research and discussion, it can be concluded that applying a mixture of water hyacinth compost and rice husk biochar at a dose of 120 g polybag^{-1} caused the lowest BD and the most pore space in the soil. However, a dose of 80 g polybag^{-1} can provide maximum plant height, leaf numbers, tiller numbers, and fresh weight. Therefore, the study findings show that mixing water hyacinth compost and rice husk biochar at 80 g polybag^{-1} is the optimum dose to support the maximum red ginger growth. However, we recommend that future research is needed to investigate the causes of decreasing BD and increasing soil pores.

LIST OF ABBREVIATIONS

ANOVA	=	Analysis of Variance
ASL	=	Above Sea Level
BD	=	Bulk Density
CRD	=	Completely Randomized Design
DAP	=	Days After Planting
DAT	=	Days After Treatment
LSD	=	Least Significance Different
NPK	=	Nitrogen, Phosphate, and Kalium

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

HUMAN AND ANIMAL RIGHTS

No humans or animals were used in this research.

CONSENT FOR PUBLICATION

Not applicable.

AVAILABILITY OF DATA AND MATERIALS

Not applicable.

FUNDING

Not applicable.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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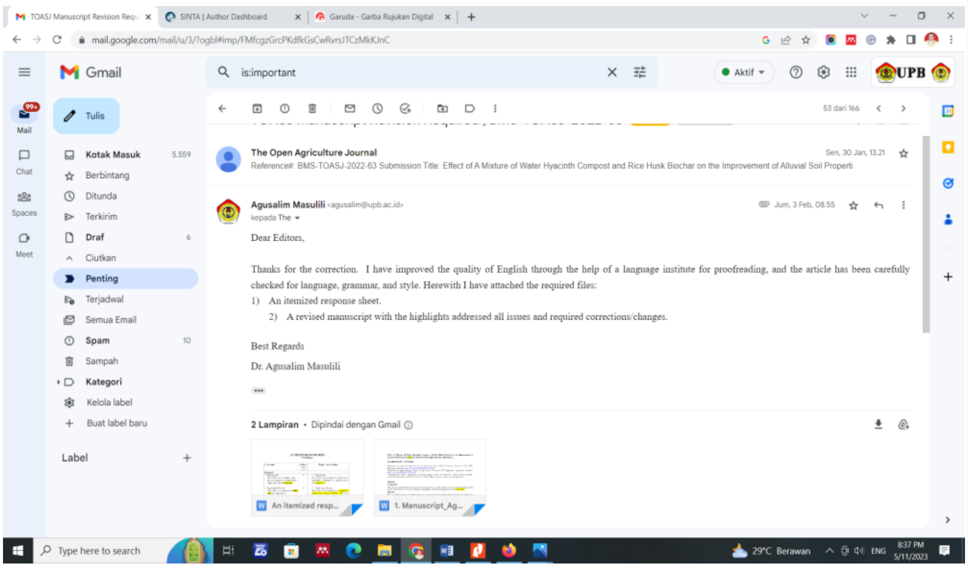

Effect of Mixture of Water Hyacinth Compost and Rice Husk Biochar on the Improvement of Alluvial Soil Properties and the Growth of Red Ginger (*Zingiber officinale* L.)

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Abstract:

Background:

Alluvial is the potential soil for agricultural development. However, this soil having a physical soil can inhibit plant growth. One of the ways to improve the physical properties is through the application of soil amendments.

Objective:

This study aimed to know the optimum dose of a mixture of water hyacinth compost and rice husk biochar for improving alluvial soil properties and the growth of red ginger.

Methods:

This study was arranged in a completely randomized design (CRD) with four replications. The treatment consisted of a mixture of water hyacinth compost and rice husk biochar (volume ratio of 2:1), which consisted of six doses: 0, 40, 60, 80, 100, and 120 g polybag^{-1}. Then each replication consisted of three samples. As many as 72 polybags were needed in this study. The observed physical properties of the soil were the bulk density (BD) and the soil pore space. The plant growth parameters included plant height, leaf numbers, tiller numbers, and fresh weight.

Results:

The results showed that applying a mixture of water hyacinth compost and rice husk biochar at a dose of 120 g polybag^{-1} caused the lowest BD and the most pore space in the soil. However, a dose of 80 g polybag^{-1} can provide maximum plant height, leaf numbers, tiller numbers, and fresh weight.

Conclusion:

The study findings show that mixing water hyacinth compost and rice husk biochar at 80 g polybag^{-1} is the optimum dose to support the maximum red ginger growth. However, we recommend that future research is needed to investigate the causes of decreasing BD and increasing soil pores.

Keywords: Bulk density, Soil pore, Red ginger, Alluvial, Water hyacinth, Rice husk biochar.

Running title: Alluvial soil properties in red ginger cultivation

9. INTRODUCTION

The red ginger plant (*Zingiber officinale* var. *rubrum*.) is one of the important medicinal plants and is widely used by the people of Indonesia. Jabborova et al. [1], ginger is important for maintaining health and is effective against some symptoms or diseases of headaches, nausea, vomiting, and motion sickness. In addition, ginger is associated with anti-tumorigenic and immunomodulatory effects as an anti-microbial, anti-viral agent, a powerful analgesic, and a stimulant that controls various diseases such as cholesterol and high blood pressure. Azizah et al. [2] stated that cultivation techniques and growing media determined the production standards of red ginger. A good growing medium for red ginger is loose and fertile soil. Hagner et al. [3] explained that compost could improve ex-mining soils. Hafez et al. [4] added that the substance of humates and vermicompost can improve nutrition, plant growth, and water use efficiency. Research results by Perdigão et al. [5] stated that tanning waste compost could increase nitrogen and ryegrass crop production on a laboratory scale.

One type of soil that has the potential for ginger development is alluvial soil which reaches an area of 15,111,870 km^2 or 10.29% of the total province of West Kalimantan. The soil type belongs to the immature group with slow profile development compared to mature soil and still resembles much of the parent material. Alluvial soil will be productive land for the development of red ginger plants if it can solve the problem. According to Yatno et al. [6], these soils belong to marginal soils and are high in clay. Hikmatullah and Al-Jabri [7], stated these soils are formed from deposits on flat to nearly flat slopes by fluvial or colluvial processes through water flow and gravitational forces causing physical, chemical, and mineralogical variations, as well as nutrient accumulation.

Yahya et al. [8] argued that an important problem of alluvial soils was soil compaction, which causes obstacles to developing plant roots. It was related to the soil's high BD and low pore space. Widodo and Kusuma [9], the problem was associated with the low content of soil organic matter. Thus, efforts can be made to overcome alluvial soil problems to become a good growing medium by providing soil-improving treatment. One type of soil dressing that can be used is compost. The application was expected to improve the physical properties of the soil, including BD and soil pores. Cahyono et al. [10] stated that compost contains organic compounds that can improve the chemical and physical properties of the soil, especially marginal soils. Widodo and Kusuma [9], compost can loosen the soil and enhance the pore space.

One of the materials that can potentially be composted is water hyacinth. These plants can absorb heavy metals and have a very high growth speed. This growing speed caused water hyacinths to be considered a weed or nuisance plant. In large quantities, water hyacinths will have negative impacts in the form of disturbances in the use of water, namely accelerating silting of irrigation canals, enlarging evapotranspiration, making it difficult to transport water, and reducing fishery products. To minimize the negative impact, water hyacinths can be used as compost. Research results by Birnadi et al. [11] stated that water hyacinth compost significantly influenced the increase in the peanuts' growth. Mashavira et al. [12] said that using water hyacinth compost could increase the growth rate and yield of healthy tomatoes. Water hyacinth compost has the potential to be a source of nutrients, increasing soil organic matter, soil particle aggregation, porosity, water holding capacity, cation exchange capacity, pH, and soil microorganisms [13].

Adding rice husk biochar can increase the role of water hyacinth compost in improving the soil's physical properties, especially BD and pore space. Beusch [14] stated that adding rice husk biochar to the soil contributes to soil fertility, where rice husk biochar can improve the soil's physical, chemical, and biological properties. Karthik et al. [15] said biochar could increase soil pores and lower BD. In line with this, Glaser et al. [16] also suggested that biochar could increase soil productivity. According to Nyasapoh [17], biochar application can improve water use efficiency.

So far, many studies have related compost and rice husk biochar to improve soil properties and plant growth. However, further research was still needed to use water hyacinth compost mixed with biochar to improve the properties of BD and soil pores. In addition, research on improving the physical properties of alluvial soils could increase red ginger growth. Therefore, based on the background and literature review above, this study aimed to know the optimum dose of a mixture of water hyacinth compost and rice husk biochar for improving alluvial soil properties and the growth of red ginger.

10. MATERIALS AND METHODS

10.1. Study Site

The study was done in March - June 2021. The research location was the Faculty of Agriculture, Panca Bhakti University, Pontianak, Indonesia. Topographic contours were flat, with an average soil surface height of 1 m above sea level (ASL). The average temperature and humidity of the air were 27.6 ºC and 82.8%. The location of the study was at 2º05' North Latitude – 3°05' South Latitude and 108°30'–144°10' East Longitude.

10.2. Experiment Design

The study was arranged in a completely randomized design (CRD) with four replications. The treatment was a mixture of water hyacinth compost and rice husk biochar (volume ratio of 2:1, v/v), which consisted of six doses: 0, 40, 60, 80, 100, and 120 g polybag^{-1}. Each replication consisted of three samples, so 72 polybags were needed.

10.3. Research Procedures

In this study, an alluvial type of soil was used. The soil sample was taken from a depth of 20 cm. The soil was dried for a week and cleared of dirt, root residues, wood, and twigs. The soil was crushed to a size of about 0.2 cm. Then the soil was put into a polybag (plastic pot) of 40 × 40 cm with a weight of 8 kg. The plant material was local red ginger from Poring Village, Pinoh District, Melawi Regency, West Kalimantan Province, Indonesia.

The compost material was from water hyacinth growing in the farmers' land primary channels. Water hyacinths were taken from all parts of the plant and chopped to a size of 1–2 cm. And then, 10 kg of water hyacinth, 5 kg of rice bran, 5 kg of goat manure, and 5 L water were mixed well. Next, the compost was watered with a solution of Tricogreen 6 tablespoons and stirred again until evenly mixed. Then it was tightly covered with a plastic tarp and stored in a place protected from direct sunlight. The material was allowed to stand for four weeks for incubation and stirred once weekly.

Rice husk biochar was made from rice milling waste and was produced by pyrolysis. Next, the water hyacinth compost was mixed with the rice husk biochar in a volume ratio of 2:1 (v/v). Then, the dosage level of treatment was incubated into the polybag for a week before for the stability of soil organic matter. Then the red ginger seedlings were planted. Dolomite powder (liming agent) was used as a soil amelioration material 7.7 g polybag^{-1}. NPK Mutiara fertilizer (16:16:16) was used for basal fertilization 1.2 g polybag^{-1}.

10.4. Parameters

The parameters observed in the study were the soil's physical properties and red ginger growth. Specifically, the observation of alluvial soil properties was BD and soil porosity. BD was measured by the clod method described by Blake & Harke. Soil pores were total pores calculated from the moisture content of the soil (v/v) at a matrix potential of 0 kPa. In addition, observations of red ginger growth were carried out 90 days after planting (DAP), including plant height, leaf numbers, tiller numbers, and fresh weight of the plant.

10.5. Statistical Analysis

The data were analyzed using analysis of variance (ANOVA) at the significance levels (∝: 0.05) [18] with IBM SPSS Statistic 23. In addition, the treatment means were compared using the least significance difference (LSD) at the significance levels (∝: 0.05).

11. RESULTS

11.1. Changes in Bulk Density and Soil Pores

A mixture of water hyacinth compost and rice husk biochar could improve the physical properties of alluvial soils. The higher dose of a mixture of water hyacinth compost and rice husk biochar caused a decrease in BD but increased soil pore at 90 days after treatment (DAT). The results of the $LSD_{\propto: 0.05}$ on BD and soil porosity at 90 DAP (Table 1).

Table 1. Effect of mixing water hyacinth compost with rice husk biochar on Bulk Density and soil pores.

Mixed of water hyacinth compost and rice husk biochar (g polybag^{-1})	**Bulk Density (mg m^{-3})**	**Total porosity (%)**
0	1.23 d	44.43 a
40	1.19 c	52.17 b
60	1.18 bc	53.27 bc
80	1.17 b	54.21 bc
100	1.02 a	55.30 cd
120	0.72 a	58.00 d
$LSD_{\propto: 0.05}$	0.02	2.75

Remarks: Values are the mean of four replicates (n= 4). Different letters in the same column are significantly different according to the LSD at the significant levels (∝: 0.05).

Table **1** shows that the lowest BD obtained at doses of 100 and 120 g polybag^{-1} did not significantly different, but significantly different from doses of 0-80 g polybag^{-1}. The total pore also increased in the dose of water hyacinth compost and the rice husk biochar. The highest total pores were achieved at a mixture of water hyacinth compost and rice husk biochar at a dose of 120 g polybag^{-1}. It was not significantly different from the dose of 100 g polybag^{-1} but significantly different from the dose of 0-80 g polybag^{-1}. It suggests that improving soil physical properties with BD indicators and alluvial soil pores can be made by increasing the mixture of water hyacinth compost and rice husk biochar.

Changes in BD and total pores at various dose treatments of water hyacinth compost and rice husk biochar at 90 DAT can be seen in Fig. **1**.

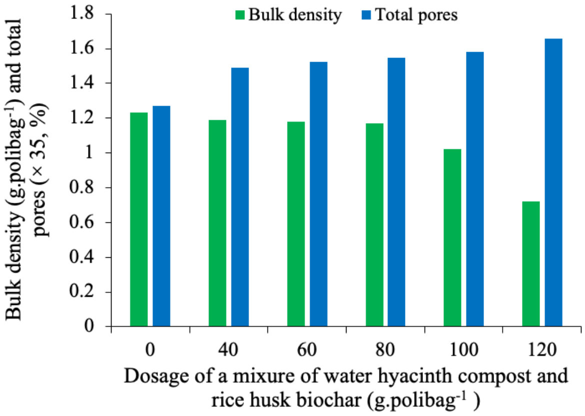

Fig. (1). Effect of a mixture of water hyacinth compost and rice husk biochar on bulk density and total soil porosity.

Fig. **1** shows that the highest BD was obtained on the 0 g polybag^{-1} (as control) and decreased further when the treatment dose of a mixture of water hyacinth compost and rice husk biochar was increased. The lowest decrease in BD at the dose treatment was 120 g polybag^{-1}. Fig. **1** shows that an increase in the dose of a mixture of water hyacinth compost and rice husk biochar caused an increase in total soil porosity. Again, the lowest total soil pores were obtained at 0 g polybag^{-1} and the highest at a dose of 120 g polybag^{-1}.

11.2. Growth of Red Ginger Plants

Changes in soil fertility have a good effect on the growth of red ginger plants. The results of the $LSD_{\propto: 0.05}$ on plant height, leaf numbers, tiller numbers, and fresh weight of plant at 90 DAP can be seen in Table **2**.

Table 2. Effect of a mixture of water hyacinth compost with rice husk biochar on the growth of red ginger plants.

Mixed of water hyacinth compost and rice husk biochar (g polybag^{-1})	**Plant height (cm)**	**Leaf numbers (sheets)**	**Tiller numbers (sproud)**	**Fresh weight of plant (g)**
0	44.63 a	54.92 a	7.50 a	128.84 a
40	49.67 a	62.33 a	6.92 a	128.06 a
60	48.31 a	59.42 a	7.25 a	145.66 a
80	56.80 b	97.08 b	11.42 b	267.47 b
100	46.52 a	54.08 a	7.17 a	150.11 a
120	48.05 a	58.08 a	7.42 a	154.77 a
$LSD_{\propto: 0.05}$	6.45	23.52	2.24	84.40

Remarks: Values are the mean of four replicates (n= 4). Different letters in the same column are significantly different according to the LSD at the significant levels (∝: 0.05).

Table **2** shows that the dose treatment of a mixture of water hyacinth compost and rice husk biochar significantly influenced all observed growth parameters. Furthermore, the highest values for plant height, leaf number, tiller numbers, and fresh weight of plants were obtained at a dose treatment of 80 g polybag^{-1}, in stark contrast to the control doses of 40, 60, 100, and 120 g polybag^{-1}.

For more details, the effect of a mixture of water hyacinth compost with rice husk biochar on the red ginger growth at 90 DAP can be seen in Fig. **2**.

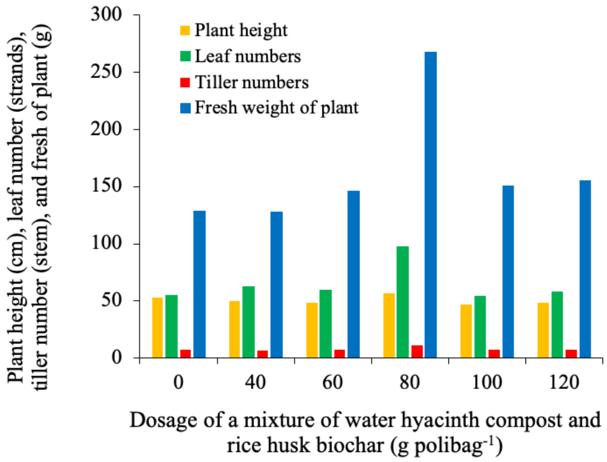

Fig. (2). Growth of red ginger plants on various doses of a mixture of water hyacinth compost and rice husk biochar.

Fig. **2** shows that all parameters' observations of red ginger growth were highest at a dose of 80 g polybag^{-1}. However, when the treatment dose was increased to 100 or 120 g polybag^{-1}, there was a decrease in plant growth. Therefore, it indicates that inhibition of red ginger growth could occur in a mixed dose of water hyacinth compost with rice husk biochar after a dose of 80 g polybag^{-1}.

12. DISCUSSION

12.1. Changes in Bulk Density and Soil Pores

Organic amendments to the soil will undergo a further decomposition process and produce organic acids. Furthermore, the resulting organic substance will affect the soil's physical, chemical, and biological properties. In line with this, the study results (Table **1**) showed that the higher dose of the mixture of water hyacinth compost and rice husk biochar has a good impact on improving BD and soil pores. Adding organic matter to the soil will influence the formation of soil granulation due to the presence of organic matter that can produce organic acids to form clay-organic complexes. The formation of soil aggregation impacted decreasing BD and increasing soil pores. The treatment showed an inverse relationship between BD and soil pores, where BD decreased, so total pores increased and vice versa.

Soil aggregation is closely related to BD and soil pores. In connection with Cincotta et al. [19], soil aggregation was related to organic matter content and would affect BD and soil pores. Furthermore, research supported by D'Hose et al. [20] showed that biochar mixed with compost improved the soil's chemical properties. Reinforced by Zhang et al. [21], humic substances played an important role in the formation and stability of soil aggregates. Based on research by Šimanský et al. [22] also played a role in soil structure. Humic acids can improve soil properties [23]. The humic substance is a component of organic matter of the most active humus fraction and can interact with soil particles by binding with its active group. This compound has a functional group that can bond with soil minerals. The reaction between soil minerals and humic materials will encourage aggregation and the formation of stable aggregates. Thus, applying soil reformers as a mixture of water hyacinth compost and biochar will affect the content and stability of organic C in the soil aggregate and will further affect the increase in soil pores.

12.2. Growth of Red Ginger Plants

Water hyacinth compost and rice husk biochar in alluvial soils, including a certain amount of organic soil dressing, can increase plant growth due to improving the soil's chemical, physical, and biological properties. The study results (Table **2**) showed that a decrease in soil BD and an increase in soil pores occurred with an increase in the dose of a mixture of hyacinth compost and rice husk biochar. The best results were obtained at a dose treatment of 120 g polybag^{-1}. However, the red ginger growth was best achieved at a dose of 80 g polybag^{-1} and decreased when the treatment dose was increased. It indicates that too high a dose can inhibit red ginger growth. This phenomenon hints that aspects of soil fertility to support red ginger growth require a balance between various soil properties, both physical and chemical soil.

Various studies have found that organic reformers improve soil quality and cause an increase in plant growth. Cahyono et al. [10] showed that compost could improve acidic soil properties. Frimpong et al. [24], N-rich compost mixture + carbon + biochar-rich compost can enhance soil quality, including cation exchange capacity and soil pH. Organic amendments could improve soil fertility, carbon sequestration, and crop productivity [25]. Then, using organic amendments can increase crop yields and reduce inorganic fertilizers by up to 50% [26]. Applying a mixture of water hyacinth compost and rice husk biochar affected soil properties (physical, chemical, and biological).

CONCLUSIONS AND RECOMMENDATION

Based on the results of research and discussion, it can be concluded that applying a mixture of water hyacinth compost and rice husk biochar at a dose of 120 g polybag^{-1} caused the lowest BD and the most pore space in the soil. However, a dose of 80 g polybag^{-1} can provide maximum plant height, leaf numbers, tiller numbers, and fresh weight. Therefore, the study findings show that mixing water hyacinth compost and rice husk biochar at 80 g polybag^{-1} is the optimum dose to support the maximum red ginger growth. However, we recommend that future research is needed to investigate the causes of decreasing BD and increasing soil pores.

LIST OF ABBREVIATIONS

ANOVA	=	Analysis of Variance
ASL	=	Above Sea Level
BD	=	Bulk Density
CRD	=	Completely Randomized Design
DAP	=	Days After Planting
DAT	=	Days After Treatment
LSD	=	Least Significance Different
NPK	=	Nitrogen, Phosphate, and Kalium

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

HUMAN AND ANIMAL RIGHTS

No humans or animals were used in this research.

CONSENT FOR PUBLICATION

Not applicable.

AVAILABILITY OF DATA AND MATERIALS

Not applicable.

FUNDING

Not applicable.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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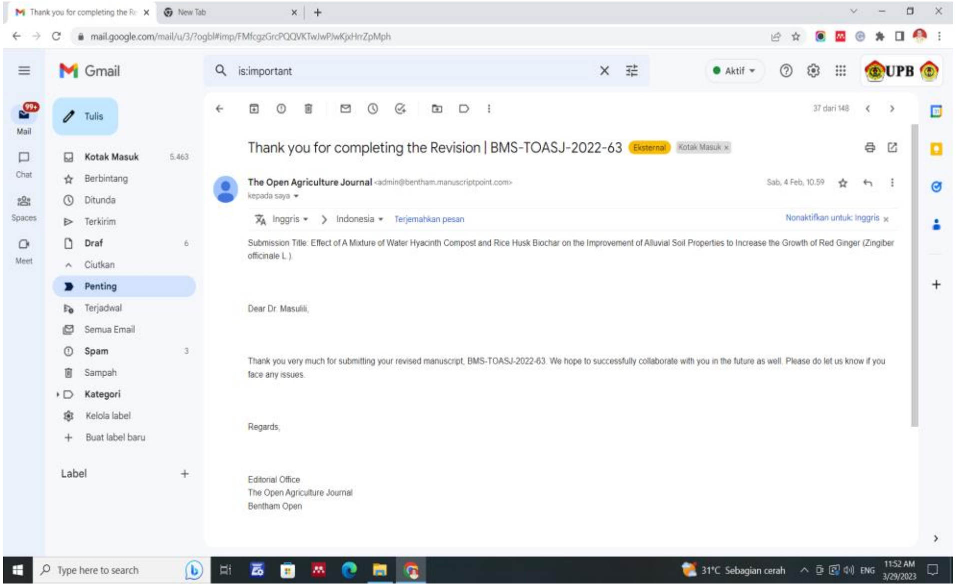
AN ITEMIZED RESPONSE SHEET
To Referees

Comments	**Addres-sed** Y/N	**Reply / Action taken**
<u>Referee 1:</u>		
1. Background: One of the ways to improve the physical properties is through the application of soil ~~reformers~~.	Y	1. Background: One of the ways to improve the physical properties is through the application of soil amandents.
2. Experiment Design: The study was arranged in a ~~CRD and~~ four replications.	Y	2. Experiment Design:

		The study was arranged in a completely randomized design (CRD) with four replications.
3. Table 1. Giving LSD value will be useful. You can add LSD value, LSD:? Readers could see LSD value, so himself can evaluate significance among them.	Y	3. Table 1. In Table 1 we have added the LSD 5% of BD and total pores are 0.02 and 2.75, respectively.
4. Table 2. Giving LSD value will be useful. You can add LSD value, LSD:? Readers could see LSD value, so himself can evaluate significance among them.	Y	4. Table 2. In Table 2 we have added LSD 5% of plant height, leaf numbers, tiller numbers, and fresh wight of plant are 6.45, 23.52, 2.24, and 84.40, respectively.
5. Research Procedures In this study, an alluvial type of soil was used. The soil sample was taken from a depth of 20 cm. The soil was ~~dredged~~ for ~~one~~ week and cleared of dirt, root residues, wood, and twigs.	Y	5. Research Procedures In this study, an alluvial type of soil was used. The soil sample was taken from a depth of 20 cm. The soil was dried for a week and cleared of dirt, root residues, wood, and twigs.
6. References Some references in this list were used in the text of manuscript. It is main problem. They have to corrected!	N	6. References References [13] have been cited in the fourth paragraph of the last sentence in the introduction. References [18] have been cited in the subheading section of statistical analysis. Reference [22] has been cited in the subheading of Changes in BD and Soil Pores in the second paragraph. References [25] and [26] have been cited in the subheading of Growth of Red Ginger Plants in the last paragraph.
Referee 2:		
I pointed out some minor corrections in general. However, there are important corrections to be made in the references section.	Y	Thank you. Incorrect references are fixed.
Referee 3:		
1. A few parameters (bulk density, total pores, plant height, tiller numbers, and FW) were discussed in the study. Why did not you discuss more physical parameters (macro and micropores, permeability, total efficiency, etc.) and chemical parameters (total C	N	1. We did not observe macro and micropores, permeability, total efficiency, etc.) and chemical parameters (total C and N, current P, extractable K, CEC, etc.

and N, current P, extractable K, CEC, etc.)?		
2. The same data is never given in both tables and graphs.	Y	2. The data is not displayed in tables and graphs, as it is not the parameters section we observed, as we explained in no. 1. In the future, we will continue this research by thoroughly observing the physical and chemical properties of the soil.
3. In fact, you did this very well in your previous paper (Masulili, A., Utomo, W. H., & Syechfani, M. S. (2010). Rice husk biochar for rice-based cropping system in acid soil 1. The characteristics of rice husk biochar and its influence on the properties of acid sulfate soils and rice growth in West Kalimantan, Indonesia. Journal of Agricultural Science, 2(1), 39.	Y	3. We would like to thank you for your appreciation of our previous papers. However, in this study, the only focus of observation is BI and total pores which have been the main limiting factors for the development of red ginger saplings on alluvial soils.
4. I recommend that you consider the suggestions and opinions made in the main text.	Y	4. We thank you for the input. In the future, the characteristics of the soil as a whole will be continued and set forth in the scientific article of the next section.
Referee 4:		
1. INTRODUCTION The section needs to be checked for correct English usage such as the 4th paragraph (showed, use) lacked any consistency of tense.	Y	Thanks you. We have changed the word "use" to use of
2. MATERIALS AND METHODS The word "area" should be changed to "site" The word "CRD" is first mentioned and should be given its full name.	Y	We have changed the word area to site → study site. The word "CRD" we have written its full name: completely randomized design (CRD)
3. RESULTS The data from Figure 2 should be done with statistical analysis. And finally all data observed in the text should be assessed comprehensively.	Y	Thanks for the suggestion. Figure 2 is only used to clarify the parameters who have been analyzed with statistics. All the data observed in the text have been comprehensively discussed in paragraph before discussion.

10. Email bukti revisi diterima, 4 Februari 2023



Thank you for completing the Revision | BMS-TOASJ-2022-63

The Open Agriculture Journal <admin@bentham.manuscriptpoint.com>

Sab, 4 Feb, 10.59

Submission Title: Effect of A Mixture of Water Hyacinth Compost and Rice Husk Biochar on the Improvement of Alluvial Soil Properties to Increase the Growth of Red Ginger (Zingiber officinale L.)

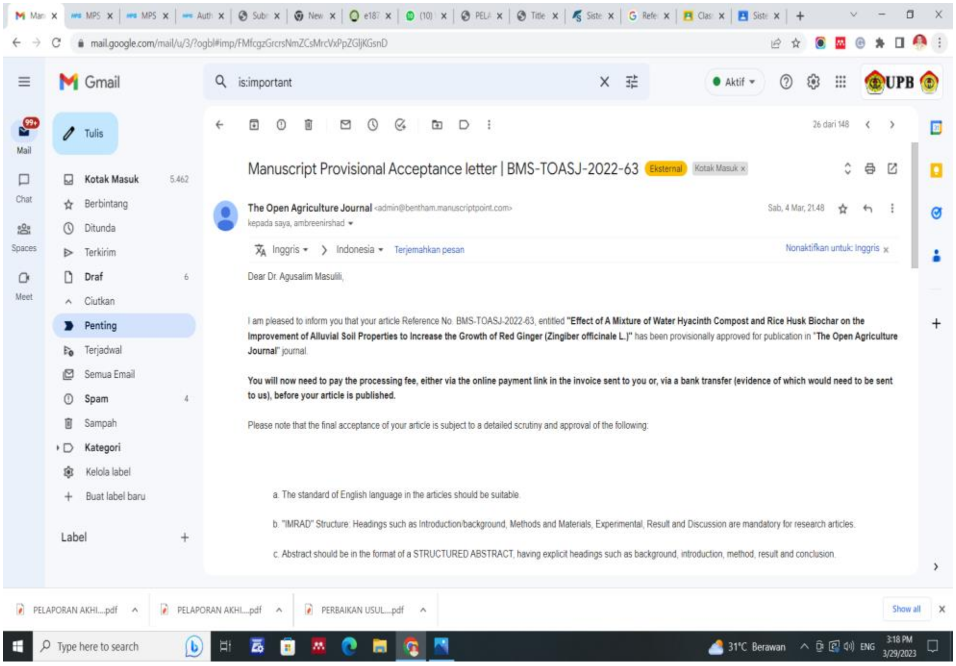
Dear Dr. Masulili,

Thank you very much for submitting your revised manuscript, BMS-TOASJ-2022-63. We hope to successfully collaborate with you in the future as well. Please do let us know if you face any issues.

Regards,

Editorial Office
The Open Agriculture Journal
Bentham Open

11. Email Manuscript Provisional Acceptance letter, 4 Maret 2023.



Manuscript Provisional Acceptance letter | BMS-TOASJ-2022-63

The Open Agriculture Journal <admin@bentham.manuscriptpoint.com>

Sab, 4 Mar, 21.48

Dear Dr. Agusalim Masulili,

I am pleased to inform you that your article Reference No. BMS-TOASJ-2022-63, entitled **"Effect of A Mixture of Water Hyacinth Compost and Rice Husk Biochar on the Improvement of Alluvial Soil Properties to Increase the Growth of Red Ginger (Zingiber officinale L.)"** has been provisionally approved for publication in "**The Open Agriculture Journal**" journal.

You will now need to pay the processing fee, either via the online payment link in the invoice sent to you or, via a bank transfer (evidence of which would need to be sent to us), before your article is published.

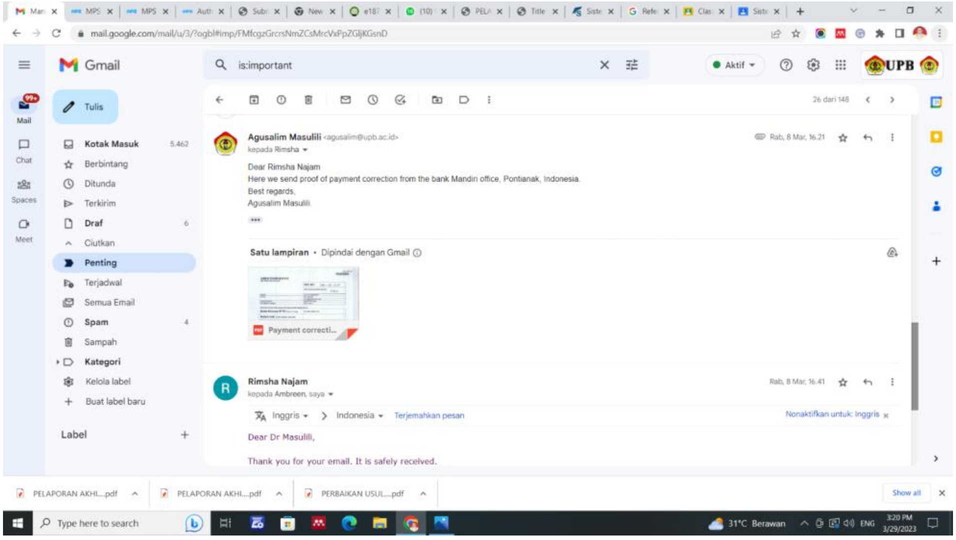
Please note that the final acceptance of your article is subject to a detailed scrutiny and approval of the following:

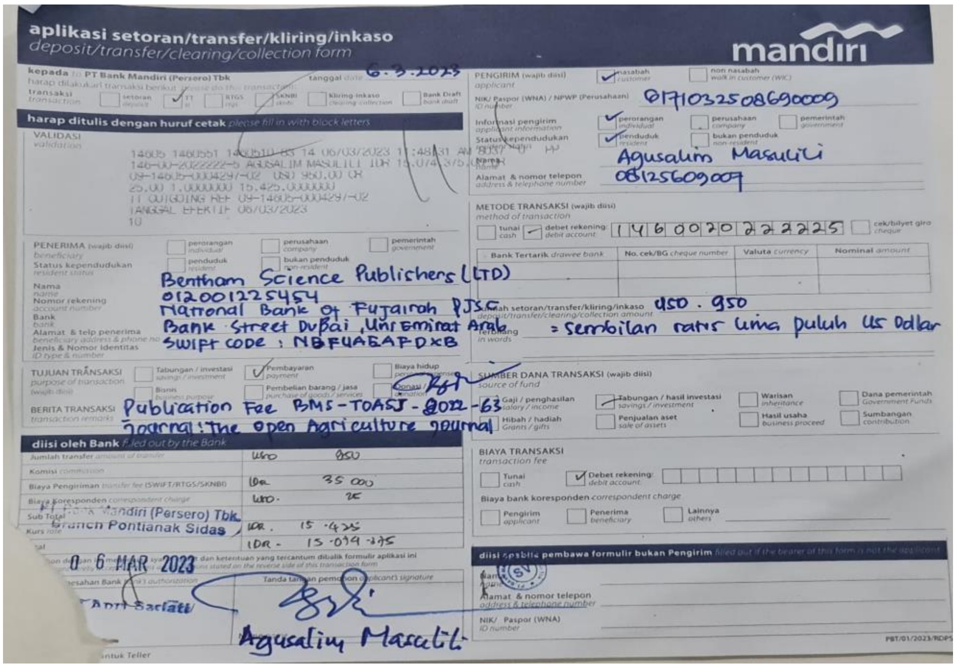
a. The standard of English language in the articles should be suitable.

b. "IMRAD" Structure: Headings such as Introduction/background, Methods and Materials, Experimental, Result and Discussion are mandatory for research articles.

c. Abstract should be in the format of a STRUCTURED ABSTRACT, having explicit headings such as background, introduction, method, result and conclusion.

12. Email bukti pembayaran





13. Pulish, 11 Mei 2025

URL = https://openagriculturejournal.com/VOLUME/17/ELOCATOR/e187433152303270/FULLTEXT/