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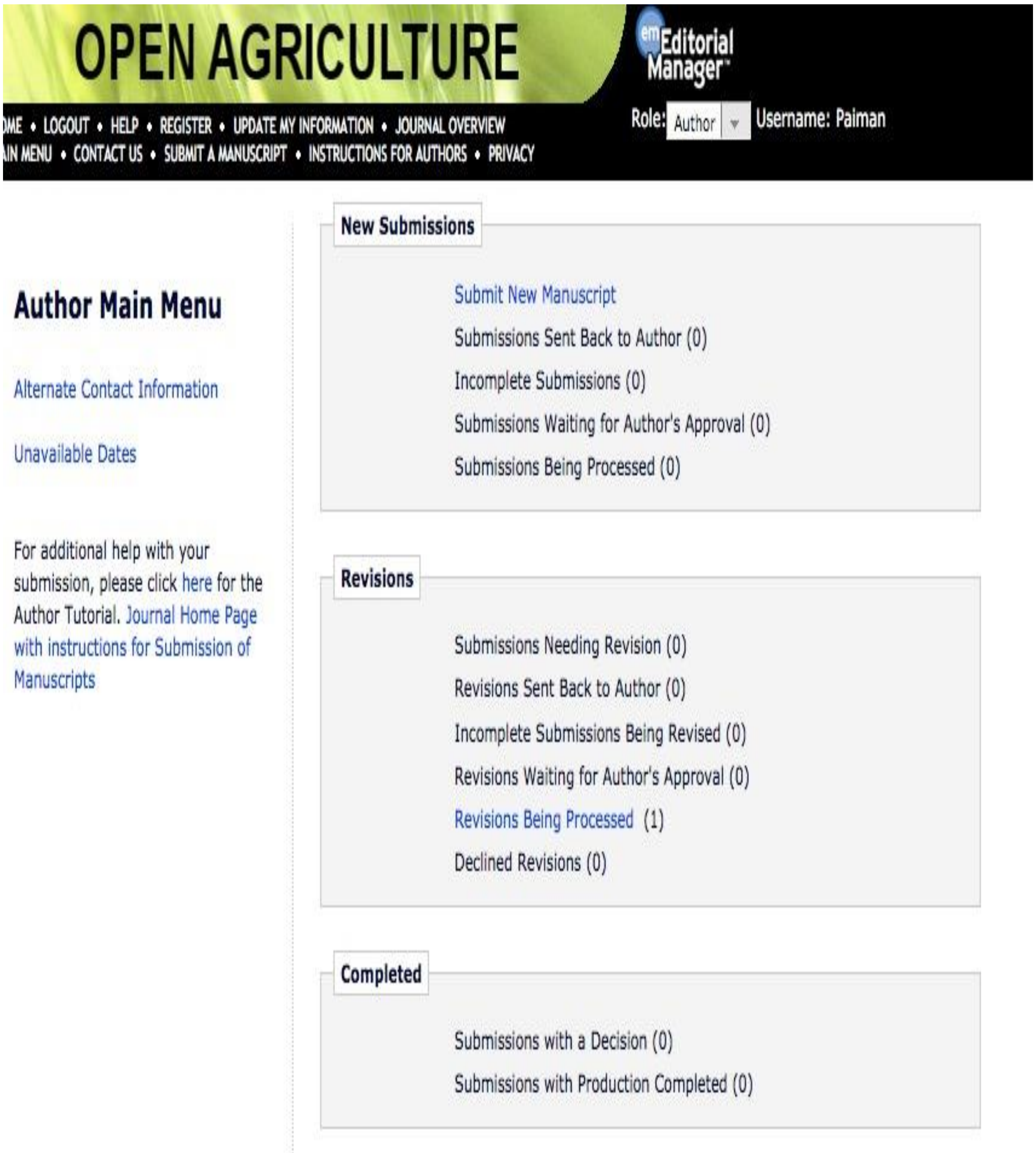

The First Manuscript for Submission

EFFECT OF SOIL WATER CONTENT AND HUSK RICE BIOCHAR ON RICE CULTIVATION IN POLYBAG

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ABSTRACT

Rice is the primary needs of daily for the majority of the people of Indonesia.The independent national food could be done by way of agricultural intensification. This research was conducted in Agroshop Garden, Faculty of Agriculture, Universitas PGRI Yogyakarta, Indonesia at March until July 2019. The aims of the research to know the effects of soil water content and husk rice biochar on growth and yield of rice. The research used polybag experiment in size of 40 x 40 cm. Soil weight put in polybag was 15 kg. The research consisted of two factors and arranged in the complete randomized design (CRD), replicated three times. The first factor was soil water content, which consisted of two kinds: field capacity and waterlogged. The second factor was the biochar dose, which consisted of four levels: 0; 75; 150; dan 225 g polybag^{-1}. The difference between average of the treatment was compared using DMRT at 5% significant levels. The results of the research showed that rice cultivation with flooded system better than field capacity on tillers number, panicle length, and harvest index. Biochar application was significant effect on tillers number, and leaf area. Interaction between flooded and biochar dosage of 0 or 75 g polybag^{-1} gives the highest dry weight of shoot, root and grain.

Keywords: Flooded; Field capacity; Biochar; Rice; Polybag

INTRODUCTION

Paddy is an annual crop that can grow well on soil types and soil water condition. Paddy is the crops producing rice to meet basic needs of food for half of the people who live in this world.

Many rice varieties can be cultivated, but in the principle of cultivation has the same method. There were different ways between rice cultivation on wet and dryland. One of the rice varieties suitable for planting in wetland, namely Ciherang.

According to Anonymous (2009), Ciherang variety is a new superior variety that is able adapt to the environment well to ensure better crop growth, high production, good quality, and taste of rice is delicious and fluffy so that in can be accepted by the market. Productivity potential of 6,0-8,5 tons ha^{-1} of dry unhulled rice and harvest age 116-125 days apter planting (DAP), resistant to brown planthopper pests biotype 2 or rather resistant to brown planthopper pests biotype 3, and resistant on bacterial leaf blight disease.

Cultivation of paddy in wet and dryland is commonly done by farmers but cultivation in polybag has not been done much. This method of cultivation can be done in the yard or home page. This cultivation can be done in urban areas using polybags. The advantage of this method is that it does not need to be flooded but is sufficiently watered so that in can save water. But there need to be further testing system with a water efficiency system, namely in field capacity in polybag.

At the juvenile of the crop growth, the need for water is still low because the size of habitus is still small so that the surface area of crop in carrying out evapotranspirations is still low. The highest water requirements for crop occur in the period of maximum vegetative growth. At the time the surface area of the crop reaches the highest level so that the greatest evapotranspitaions (Pinem at al., 2017). Water for crop serves to make up the body of the crop (70-90%), solvent and biochemical reaction medium, compound transport medium, giving turgor to cell division and enlargement, raw material for photosynthesis and keep the crop temperature constant.

The paddy crop including crop that are able to grow well on waterlogged land because they have the ability to oxidize blood rooting through parenchymal tissue which can diffuse oxygen to the root area. Oxygen from the leaf is flowed through the process of diffusion into the roots an stem through the cortex. The existence of this process, the paddy crop is able to meet the oxygen needs for root breathing even though it is flooded (Subari et al., 2012).

To increase the growth and yield of rice palnted in polybags can use biochar husk. According to Venheijen et al. (2010), biochar is choarchal or biomass that has been burned in an environment without or low in oxygen. Scientific agreement states that the administration of biochar to the soil is expected to be able to absorb carbon on a sustainable basis and can simultaneously improve soil function (current and future management), while avoiding the effect of short-term and long-term danage to the wider environment and good for human and animal health. Biochar as material or charcoal can be given to the soil.

Definition of biocahar depends on the creation and constituent materials of charcoal and is produced through an energy conversion process called pyrolysis, which is basically burning biomass in the absence of oxygen. Pyrolisis of biomass produces charcoal, oil and gas. The amount of material produced depends on the processing conditions. The differences in biochar and charcoal are biochar to be made used as soil amendments. Biochar can be produced from various biomass raw materials but is generally designed only as a product that can be used for soil improvement (McLaughlin et al., 2009).

iochar is a carbon-rich product obtained from biomass including wood, manure or leaf heated in closed container with less or whitout air available. Biochar was produced through thermal decomposition of organic matter with limited oxygen supply (O_2) and at relativety low temperatures (< 700°C) (Lehmann and Joseph, 2009).

Biochar is a product that is produced from biomass waste (agricultural awste) was heated without air or with very less air. The process of making charcoal is often called pyrolysis. The raw material that can be used for biochar production is biomass waste that is not utilized, namely rice husk, corn husk, brown fruit cacao, pecan shell, coffee skin, wood saws waste, leaf pulp of eucalyptus oil, wood branches such as residual coconut shell waste and other of the like (Widiastuti and Lantang, 2017).

Biochar products can be produced from the process or system of pyrolysis or grasification. Biochar was produced from the absence of oxygen by using heat from the outside, while with a grasification system only a small amount of biochar is produced. The basic ingredients used in pyrolysis can be various types and organic biomass. Biochar production process can be optimal if it takes place without oxygen (Gani, 2009).

Function of biochar are determined by two main properties, namely having a high affinity for nutrients and resistance in the soil. Biochar providing habitat for microbes in the soil but not consumed and can stay in the soil for hundreds or even thousands of years. Persistence of biochar in the long-term will not disturb the carbon-nitrogen balance in the soil, but can hold more water and nutrients for crop. Organic and inorganic fertilizer together with biochar can increase productivity and retention of nutrients for crops rooting (Gani, 2009).

The most dominant chemical component contained in the rice husk ash produced is SiO_2 by 72.28% and the compounds incandescent lost by 21.43%, while the percentage of compound content of CaO, Al_2O_3, and Fe_2O_3 classified are very low, respectively 0.65; 0.37; and 0.32% (Bakri, 2009).

Utilization of rice husk into biochar is one of the innovations that can be applied to farmers to overcome problems in agriculture such as reducing soil acidity, increasing productivity of food crop and storing carbon stocks to overcome problems of global invironmental (Widiastuti and Lantang, 2017). The ulitization of biochar as soil enhancers in the first planting season has resulted in good soil physical properties for the second planting season which directly yields positive results for growth and yield of rice crop. Apllication of biochar dose of 10 tons ha^{-1} can increase the yield of rice in the form of grain bay 13.5% compared to control, which 5.11 menjadi 5.80 tons ha^{-1} (Waty et al., 2014).

The combination of rice straw compost (60%) and biochar (40%) was able to cause differences in the real responces and the highest results achieved in the response of soil C-organic content, phosphate solvent bacteria population, P available, and dry weiht of grain. Treatment interaction of 2 tons ha^{-1} rice straw-biochar and NPK fertilizer able to reduce fertilizer use by up to 40% of recommendations (300 kgs ha^{-1} urea; 100 kgs ha^{-1} SP-36; 100 kgs ha^{-1} KCl) on the highest dry weight of grain (Noviani et al., 2018).

The application of biochar dose of 8 tons ha^{-1} can give a significant effect on plant height, leaf number, leaf area, and weight of mustard crop (Musnoi, 2017). Combination of rice straw husk (1 tons ha^{-1}) and biochar rice husk (1 ton ha^{-1}) together the use of chemical fertilizer is possible to increase the weight of grain per panicle for better yield than just giving chemical fertilizer (Thavanesan dan Seran, 2018). There was 52% reduction in land emission (N_2O)

Biochar is able to increase the availability of water in the soil. The highest percentage of available water pore is given by application of coconut shell biochar at 21.55% followed by rice husk biochar and the lowest on wood biochar. The highest available water pore is application of biochar at 45 tons ha^{-1} and the lowest followed by biochar dose of 30 and 15 tons ha^{-1} (Khoiriyah and Widianto, 2016).

The application of biochar dose of 15 tons ha^{-1} with smoothness level of 60 mesh on alkaline soil can reduce pH to 5.19%, increase C-organic 34.94%, CEC 32.92% and P available 277.08%. Thus the rice husk biochar has the potential to be used as soil conditioner for inceptisol soil (Salawati et al, 2016). The use of 70% rice husk biochar (7,5 tons ha^{-1}) + 25 % straw compost (2,5 tons ha^{-1}) produced 29 tiller number, grain yield as much 8.23 tons ha^{-1} and able to provide soil nutrient in ultisol soil with increasing pH, N, P, K, Ca, Mg and S (Herman and Resigia, 2018).

MATERIALS AND METHODS

Time and place

This research was carried out in February – juny 2019 in Agrshop Garden, Faculty of Agriculture, Universitas PGRI Yogyakarta.

Experimental design

The research consisted of two factors and arranged in the completely randomized design (CRD) with replicated three times. The first factor was the soil water content which consisted of two types: field capacity and flooded. The second factor was the dose of biochar which consisted of four levels: 0; 75; 150, and 225 g polybag^{-1}.

Research method

The composition of planting media with ratio of sedimen (alluvial) and cow manure is 10:1 or 15 kgs of soil weght compared 1.5 kgs cow manure. Planting media of 15 kgs was put into a polybag, add SP-36 fertilizer and mixed evenly. Biochar was mixed suitable with each treatment, namely 0; 14; 28; and 42 tons ha^{-1} atau 0; 75; 150; and 225 g polibag^{-1}.

Rice seed nursery of Ciherang was carried out on germination plastic tub in size of 25 x 30 x 10 cm (length x width x height) that has been filled with soil media. Ciherang rice seeds are spread on the soil surface of the soil media and covered with less soil. Nursery media watered to field capacity. The seeds will germinate about 4 days after seedling.

Watering is needed to maintain soil moisture. Seedling after 10 HSS are ready to transferred to the planting to soil media in polybag. Rice seedlings were planted into soil in 3 cm deep. Each polybag was planted by 3 planting hole with equilateral triangle planting system. Each planting hole was planted by two seedlings with 25 x 25 plant spacing.

Water application into polybag was carried out with watering suitable the treatment. Field capacity was maintained through bulk watering. Application of water in flooded treatment as 5 cm from soil surface in a polybag. Urea fertilizer (46%) was given as much as 10 g polybags twice, namely age of 14 and 42 DAP. Anticipation of the attack of Walang Sangit was used Temin pesticides. Weeds that grow on the soil surface in polybags are weeded by revoking it.

Observations on growth dan yield of rice covers growth component, namely tiller, number, leaf area, dry weight of shoot, dry weight of root. The yield component covers, namely panicle length, dry weight of grain and harvest index.

Statistic analysis

The data of soil temperature and weed propagules were analyzed using analysis of variance (ANOVA) at the 5% significant levels [17]. The difference between the average of the treatment was compared using Duncan's new multiple range test (DMRT) at 5% significant levels.

RESULTS AND DISCUSSION

Tillers number, leaf area, panicle length and harvest index

Based on analysis of variance on tillers number, leaf area, panicle length and harvest index showed that no significant interaction between soil water content and biochar. Treatment of soil water content has a significant effect on tillers number, panicle length, and harvest index. Biochar treatment has a significant effect on tillers number and leaf area (Appendix 1). Test comparation between treatments based on DMRTat 5% significant levels on tillers number, leaf area, panicle length, and harvest index in Table 1.

Paddy was planted in waterlogged soil has tillers number, panicle length, and harvest index more high than on the soil in field capacity. Ciherang rice is more suitable to grow in excess water conditions to form more tillers number. According to Subari et al. (2012), paddy rice including crop that are able to grow well on waterlogged soil because they have the ability to oxidize root areas through parenchymal tissue that can be praised for oxygen to the rizhosfer. Oxygen from the leaf is flowed through the process of diffusion into the roots and stem through the cortex. The existence of this process, the paddy crop is able to meet the oxygen needs for root breathing even though waterlogged soil.

Paddy growth in the field capacity treatment was not optimal because of the frequent lack of water due to delayed watering. Air deficit in rhizosfer will effect all aspects of crop growth including physiological and biochemical processes. Further water shortages will cause some stomatal to close and inhibit the entry of CO_2, and further inhibit photosynthesis. Low carbohydrates formed will affect the decrease in growth and yiels of crop. Water is raw material fo photosynthesis, solvent and biochemical reaction medium, compound transport medium, give turgor to cells for cell devision and enlargement, and keep the crop temperature constant. Water deficit causes the biochemical processes in the crop's body to be disrupted.

The amount of water available in the soil will cause crop cell turgor pressure to be more awake so that cell activity in photosynthesis is better and more carbohydrates are produced. Carbohydrates are used as an energy source for crop cell division in the form of tillers number, panicle length and harvest index.

Table 1. Effect of soil water content on tillers number, leaf area, panicle length and harvest index per polybag

Treatment	Tillers number (stem)	Leaf area (dm^2)	Panicle lenght (cm)	Harvest index
Soil water content				
Field capacity	39.17 b	73.42 a	18.74 b	0.29 b
Waterlogged soil	45.75 a	73.68 a	21.91 a	0.35 a
Biochar dose (g polibag^{-1})				
0	51.08 p	76.76 p	19.87 p	0.31 p
75	41.50 q	83.27 p	20.43 p	0.32 p
150	39.00 q	73.79 p	20.45 p	0.32 p
225	39.92 q	60.37 q	20.53 p	0.32 p

Remarks: Number in the same column followed by the same characters are not significantly different based on DMRT at 5% significant levels.

Without application of biochar (0 g polibag^{-1}) in the soil gives more tillers number. The application of biochar to the soil actually causes a decrease the tillers number. Growth of tiller inhibit with the application of biochar. This is different from the occurrence of observations on the leaf area of crop. The application of biochar in dose of 225 g polibag^{-1} significant caused in declining of leaf area. The biochar application exceed the optimal limit causes growth of leaf area to narrow.

Dry weight of soot, root, and grain

Analysis of variance on dry weight of soot, root, and grain showed that significant interaction between soil water content and biochar (Appendix 1). Test comparation between treatments based on DMRTat 5% significant levels on dry weight of soot, root, and grain in table 2.

Paddy crop grown in waterlogged soils and biochar dose of 0 and 75 g polibag^{-1} (Table 2) produced dry weight of shoot, root and grain higher than other treatment combination. Dry weight of shoot, root and grain began to decline in the treatment of waterlogged soil after biochar dose of g polibag^{-1}. Paddy rice that grow on the field capacity and biochar dose of 0; 14; 28 or 42 ton ha^{-1} have lower dry weight of shoot. The lower dry weight of shoot, root and grain produced by paddy brice planted in the field capacity combined with the application of biochar dose of 0; 14; 28 or 42 ton ha^{-1}.

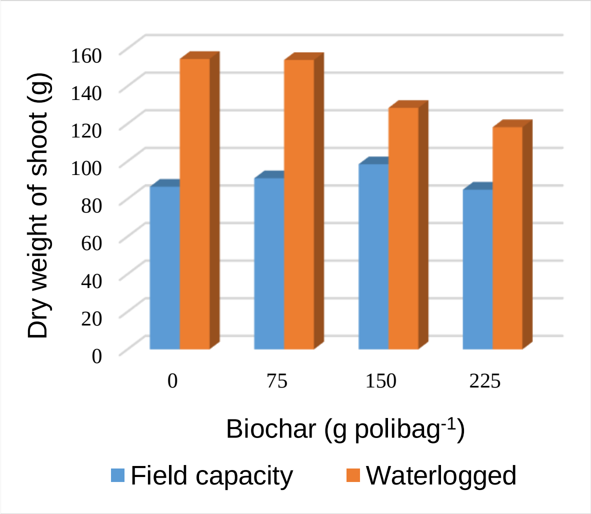
Table 2. The effect of treatment interaction between soil water conten and biochar on dry weight of shoot, root, grain per polybag

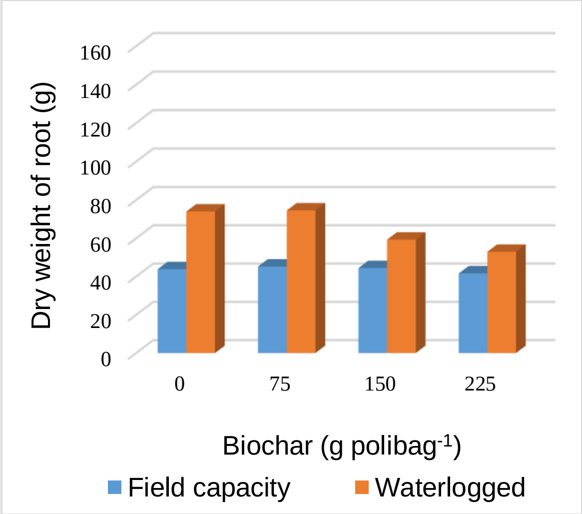
Treatment combination	Dry weight of shoot (g)	Dry weight of root (g)	Dry weight of grain (g)
$A_1 + B_0$	86.49 d	43.82 cd	49.82 c
$A_1 + B_1$	90.99 d	45.23 cd	57.03 c
$A_1 + B_2$	98.43 d	44.44 cd	58.94 c
$A_1 + B_3$	84.92 cd	41.63 d	52.59 c
$A_2 + B_0$	154.45 a	74.00 a	123.10 a
$A_2 + B_1$	153.90 a	74.54 a	124.09 a
$A_2 + B_2$	128.42 b	59.31 b	100.19 b
$A_2 + B_3$	118.17 bc	52.94 bc	88.85 b

Remarks: Number in the same column followed by the same characters are not significantly different based on DMRT at 5% significant levels, A_1 = Field capacity, A2 = Soil water content, $B_0 = 0$; $B_1 = 75$; $B_2 = 150$; and $B_3 = 225$ g polibag^{-1}

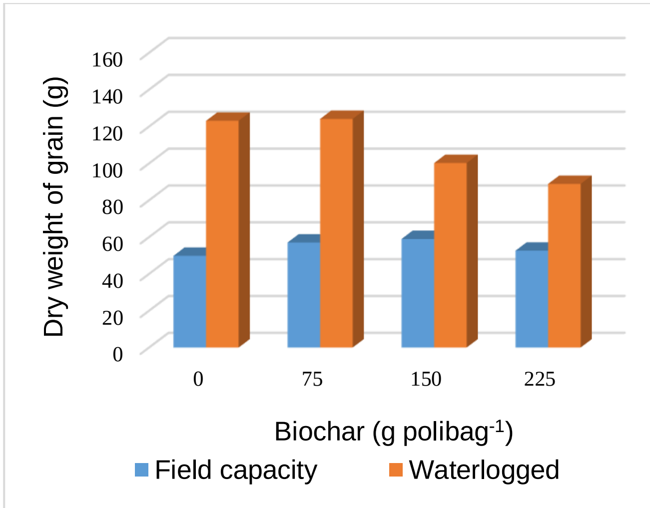
Soil nutrient absorption process can run well if there is enough water in the soil. Crop cell turgor pressure can be maintained if water available in the soil. Photosynthesis can run well and produce maximum carbohydrates if the water needs for crop fulfilled. Carbohydrates are used as an energy source to arrange tissue of stem, leaf and root as a results of dry weight of shoot and root formed. Some of the remaining carbohydrates are stored in the body of crop on the stem, leaf and root then it will be moved to seeds filling when moving to the generative phase. It is evident that paddy crop that grow on waterlogged soil produce higher dry weight of grain in biochar dose of 0 and 75 g polibag^{-1}. The biochar application more 75 g polibag^{-1} on waterlogged soil causes a decrease dry weight of shoot, root and grain.

For more details the effect of the treatment interaction between soil water content and biochar can be seen in Figure 1.





a. Dry weight of shoot **b. Dry weight of root**



c. Dry weight of grain

Figure 1. Treatment interaction between soil water conten and biocharon dry weight of shoot, root and grain

The effect of soil water conten and biochar on root density of paddy crop showed that in Figure 2. Based on Figure 2 appears that the root growth was very tight in paddy crop that grow on waterlogged soil and application of biochar dose of 0 and 75 g polibag^{-1} than other treatment combination. Hight root density will also affect the dry weight of root crop. Root are crop organs that are directly related to the soil. The more surface area of roots in the soil causes the greater absorption of soil nutrient. Nutrient needed by crop to support biochemical processes in the crop's body. Root density affects the ability of crop to absorb nutrients in the soil to support overall crop growth. Based on Figure 2 showed that root length no significant difference, because the longitudinal growth of the root is pressed from the size of the polybag that not too big.

a. Field capacity

Biochar 0 g polybag^{-1}

Biochar 75 g polybag^{-1}

Biochar 150 g polybag^{-1}

Biochar 225 g polybag^{-1}

b. Waterlogged

Biochar 0 g polybag^{-1} | Biochar 75 g polybag^{-1} | Biochar 150 g polybag^{-1} | Biocah 225 g polybag^{-1}

Figure 2.The effect of soil water content and biochar on root density of paddy crop

CONCLUSION

Based on the results and discussion, then take some concluding from this research is given below:

1. Rice cultivation with floogged soil better than field capacity on tillers number, panicle length, and harvest index.
2. Biochar application was significant effect on tillers number, and leaf area.
3. Interaction between flogged soil and biochar dose of 0 or 75 g polybag^{-1} gives the highest dry weight of shoot, root and grain.

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APPENDIX

Appendix 1. The results of analysis of variance on tillers number, leaf area, dry weight of shoot and root, panicle long, dry weight of grain, and harvest index

Source of variation	Degree of freedom	Means square of				F table 5%
		X_1	X_2	X_3	X_4	
Treatment	7	122.94 *	278.93 ns	2,496.7 *	546.1 *	3.49
Water	1	260.04 *	0.40 ns	14,128.5 *	2,751.8 *	4.49
Biochar	3	186.06 ns	557.07 *	535.5 ns	215.0 ns	3.24
Interaction	3	14.12 ns	93.64 *	580.7 *	142.0 *	3.24
Error	16	12.43	100.91	169.8	28.9	
Coeficient variation (%)		8.23	13.66	11.38	9.87	

Continue of Appendix 1

Source of variation	Degree of freedom	Means square of			F table 5%
		Y_1	Y_2	Y_3	
Treatment	7	8.8552 *	2,954.57 *	0.00297 *	3.49
Water	1	60.2934 *	17,796.71 *	0.02007 *	4.49
Biochar	3	0.5633 ns	452.46 ns	0.00013 ns	3.24
Interaction	3	0.0011 ns	509.30 *	0.00012 ns	3.24
Error	16	2.0816 ns	98.10	0.00067	
Coeficient variation (%)		7.10	12.10	8.12	

Remaks: * = Significant at the 0.05 level, ns = Non significant at the 0.05 level, X_1 = Tillers number, X_2 = Leaf area, X_3 = Dry weight of shoot, X_4 = Dry weight of root, Y_1 = Panicle lenght, Y_2 = Dry weight of grain, and Y_3 = Harvest index.

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Correspondence History

Correspondence Date ▲▼	Letter ▲▼	Recipient ▲▼	Revision ▲▼
Nov 12, 2019	Author Submits Revision Confirmation	Paiman Paiman, PhD	1
Nov 12, 2019	PDF Built and Requires Approval	Paiman Paiman, PhD	1
Oct 19, 2019	Editor Decision - Revise	Paiman Paiman, PhD	0
Sep 09, 2019	Author Notice of Manuscript Number	Paiman Paiman, PhD	0
Sep 06, 2019	Author Submits New Manuscript Confirmation	Paiman Paiman, PhD	0
Sep 06, 2019	PDF Built and Requires Approval	Paiman Paiman, PhD	0

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3. Editor Decision - Revise: 19 Oktober 2019

Reviewers' Comennts and Response to Reviewers' comments

Reviewers' comments:

No	Reviewers Comments	Authors Response
	Reviewer #1:	
1	You have have not mentioned anything about biochar (self prepared or purchased), please write it clearly with relevant information.	We have been added about biochar in the sub-heading in second paragraph in materials and methods
2	No need to mention your statistical method in abstract.	We have been deleted
3	Generally significant level is report as 95% not 5%, or simply report the the p value 0.05.	We used p value 0.05 level
4	Application of biochar significantly affects the number of tillers and leaf area- at what does or all doses ?	Without application of biochar was given higher tillers number than the others treatment. Biochar doses of 14 tons/ha produce the wider leaf area.
5	how do you explain the data in table 1, only number of tillers shows significantly affected, if others were not sensitive to changes, what was the rationale behind considering them.	In Table 1 showed that tillers number and leaf area were significantly affected by biochar application, but panicle length and harvest index were not. We have been explained it in the first paragraph of result & discussion.
6	please move alphabets to superscript (if already not there in original files)	Yes, we already move alphabets to superscript alphabets to superscript in original files.
	Reviewer #2: Author studied how water content and bio-char amendment improve rise production. Paper could be interesting for the reader of open agriculture, but I still have some major issues with these paper and those can be clarified before paper would accepted.	
1	- First of all, language is very rough and I suggest proof reading with native English speaker.	Thank you for the suggestion. We have done
2	- Introduction must be rewritten in more concise way. There are 6 paragraphs only	• We have been revise the introduction.

	speak about bio-char importance and how it effects on rice production. Author must reduce this part with most important information. Only one paragraph about effect of soil water content and poly bags.	• We have been reduced this part of paragraph were not important information. • We have been added reference in paragraph of 2 to 7 in the introduction that correlated with soil water content
3	- there is no information about research aim, objective or hypothesis. It must be mentioned in end of introduction part.	We have been added the information about research aim, objective or hypothesis in the end paragraph of introduction.
4	- in M&M, how different measurement has been done should be mentioned with appropriate references. Which software is used for statistical analysis should be mentioned with appropriate reference.	• We have done revise with appropriate reference in sub-heading of data observed in the materials and methods. • We have been mentioned in subheading of statistical analysis in M&M that related to the software
5	- improve the quality of figures, are very blurry.	We have been improve the quality of figures to become clearly in Figure 1, 2, 3 and 4.
6	- results and discussion part also need improvement with some more link with previous studies.	We have revise and improve the results and discussion part.
7	- Conclusion is very short and very generic. Must be rewritten with some more unique information of these study.	The conclusions has been rewritten with more unique information.
	Reviewer #4:	
1	Abstract 1. Mention the wt of the soil or applied ration of the biochar. 2. In the abstract must need to monition the scientific name of the crop. 3. What is the hypothesis of the experiment? 4. Is it practical?	Abstract 1. Types of soil water content, and applied ration of the biochar have wrote in the abstract 2. We have done in the abstract. 3. The hypothesis of the experiment has been written in the end of introduction. 4. Yes. It is experimental research.
2	Introduction: 1. Varietal description should be in the M & M. 2. Need to revise the introduction per the journal standard or avoid methodology in the introduction.	Introduction: 1. We have been added varietal description in nurseries and seedlings of the M&M. 2. We have been done revise the introduction per the journal standard

	3. Avoid the repetition in the introduction. 4. Need to make it more informative clearly.	and avoid methodology in the introduction. 3. We have erased the repetition 4. We have rewrite more informative.
3	M & M: 1. Location environmental and year of the experiment is not clearly cited. 2. What was the chemical composition of the biochar at the time of application, it is not clear. 3. Experiment was conducted in the playhouse or in open? 4. Need to revise methodology more clearly to the audience.	M & M 1. We have been added location environmental and year of the experiment in first paragraph of M & M. 2. We have been added chemical composition of the biochar in second paragraph of M & M. 3. The research was conducted in playhouse. 4. We have revised it.
4	Result and discussion: 1. What is the new in the result? 2. After applying the biochar, it will affect the soil fertility temporary. Need to have a look again. May give proper justification. 3. Need to discuss the field capacity and water separately. 4. It can be in two subheadings: water and crop performance.	Result and discussion: 1. The new in the results showed that the application of biochar will be more beneficial if placed in the soil waterlogged. 2. We have been gave the proper justification in eighth paragraph of result and discussion. 3. We have been added about the discuss field capacity and water in the second pargaraph. 4. We have been added water and crop performance in sub-heading in the end paragraph in result and discussion
	Reviewer #5:	
	1. The present form of manuscript " The effect of soil water content and rice husk biochar on rice cultivation in polybags" has a draft quality rather and is untidy, very carelessly written. English is poor and chaotic. 2. Every section of manuscript needs improvement. Abstract is poorly written it needs to be rewritten and should contain introduction aim hypothesis aim result and conclusion rather than writing the name of statical test.	1. We have been revised the draft quality and English writing. 2. Every section in manuscript have done the improvement. The abstract has been rewritten and contain introduction, aims, hypothesis, result and conclusion. 3. Introduction have been revised. Connective link between soil water content, biochar and polybag cultivation have been explanatory with clearly in the introduction.

	3. Introduction section is like assay about biochar. Connective link is missing between biochar soil water content and polybag cultivation. 4. Also the concluding part of introduction is missing at the end of introduction. Author should make the introduction section crisp and to the point related to research. 5. Material method section should be in more detain there is no information of pyrolysis temperature of biochar and its poly aromatic content also software use for statical analysis is missing. 6. Similarly result and discussion also need improvement and require more justification of statement. 7. Top of all English is very poor it should be proofread by native English speaker.	4. We have been added the concluding part of introduction at the end of the introduction. We also have been made the introduction section crisp and to the point related to research. 5. In materials & methods section, we have been added the information of pyrolysis temperature of biochar and its polycyclic aromatic hydrocarbons content in second paragraph. Also software use for statistical analysis was wrote in the end of paragraph. 6. The result and discussion have been rewritten with the improvement and require more justification of statement. 7. We have been done to proofread by native English speaker.

4. Authors Submits Revision Confirmation: 12 November 2019

THE EFFECT OF SOIL WATER CONTENT AND RICE HUSK BIOCHAR ON RICE CULTIVATION IN POLYBAG

ABSTRACT

Rice (*Oryza sativa* L.) production is important in the national food of Indonesia. The growth and yield of rice can be increased by the soil water supply and biochar application into the soil in a polybag. Water is a unique material resource that plays a vital role in agriculture. Biochar is a carbon-rich product obtained from biomass and can hold water and nutrients more available to plants. The biochar used in this study was made from materials of rice husk. This study aims to determine the effect of soil water content and biochar application in the soil on the growth and yield of rice in the polybag. This experiment was arranged in the completely randomized design (CRD) with factorial, replicated three times. The first factor is soil water content consisted of two types i.e.: field capacity and soil waterlogging. The second factor is the biochar application consisted of four doses i.e.: 0; 14; 28; and 42 tons/ha. The results of the research showed that rice cultivation with soil waterlogging is better than field capacity on the tillers number, panicle length, and harvest index. Without biochar application was given higher tillers number, but biochar dose of 14 tons/ha produce the wider leaf area. There was significant interaction between soil water content and biochar application on the dry weight of root, shoot, and grains. The treatment

combination of the soil waterlogging and biochar dose of 14 tons/ha were more effective to increase the growth and yield of rice in a polybag.

Keywords: *field capacity, soil waterlogging, rice husk biochar, rice cultivation, polybag*

INTRODUCTION

The rice (*Oryza sativa* L.) production is important in the national food of Indonesia. The conversion of the agricultural field to non-agricultural which is increasingly difficult to control around urban areas causes the rice field to be more narrow. As a result, the ability of the agricultural field to support national food needs is decreasing. The one way that can be taken to get around the narrowness of the agricultural field is by rice cultivation in the polybag (Humaerah, 2013). The rice cultivation with polybags in an around urban area has been done by the farmer. Water supply can be done through watering.

Water is a unique material resource that plays a vital role in nature and in agriculture (Mbah, 2012). The knowledge about the soil water content at the field capacity or the soil waterlogging is very important for assessing plant water requirements, irrigation scheduling, and predicting crop responses to irrigation. Field capacity is the amount of water remaining in the soil after all gravitational water has drained. The remaining water is held in micropores via attractive 'capillary' forces or surface tension between water and solids (Elkheir, 2016). The definition of soil waterlogging is considered to the condition where the soil is fully saturated with water. In soil waterlogging, the diffusion of gases through soil pores is strongly inhibited by their water content that it fails to match the needs of growing roots (Morales-Olmedo et al., 2015). Ciherang variety was well planted in the lowland irrigated rice field up to 500 m above sea levels Anonymous (2009).

At the beginning of plant growth, the need for water is low because the size of the habitus is small, so that the surface area of plants in conducting evapotranspiration is low. Water requirements for plants are highest in periods of maximum vegetative growth. At that time the plant surface area reached the highest level so that the largest evapotranspiration (Pinem & Ichwan, 2017). Water-wise rice production is now a primary concern that ensures the saving of a considerable amount of freshwater volume as well as overcoming water shortage for rice production. The reducing water input from a traditional practice to water-wise rice cultivation sustains rice production without affecting plant and soil parameters (Jahan, 2018).

For the dry season, the system of rice intensification (SRI) and 80% SRI produced higher yields of 9.68 tons/ha and 11.45 tons/ha and saved 26% and 35% of water, respectively compared to the continuously flooded (CF) (8.69 tons/ha). The yield advantage of the 80% SRI and SRI over the CF was less during the wet season with 6.01 tons/ha and 5.99 tons/ha of production, and water savings of 30% and 14%, respectively compared to the CF (5.64 tons/ha). The 50% SRI had the lowest yield of all for both seasons, 7.48 tons/ha and 4.99 tons/ha for the dry and wet seasons, respectively. Statistically, the 80% SRI treatment outperformed all other treatments over the two seasons with an additional yield of 1.57 tons/ha and 33% (345 mm) water savings compared to the CF (Materu et al., 2018).

Treatment of alternative wet and dry (AWD) significantly decreased plant height, tillers number, panicles number, filled grains, yield, and harvest index but increased unfilled grains compared to the other treatment. Treatment of saturated to 1 cm flooding saved 45% of water use than in the treatment of the flooding at 5 cm depth, and showed higher water use efficiency (WUE) but produced rice yield similar to saturated to 1 cm flooding and flooding at 1-3 cm depth treatments. The saturated to 1 cm flooding water could easily be implemented in rice cultivation by the farmers which might not affect rice production, plant and soil characters (Khairi et al., 2015).

The reduction in water consumption was greater than the reduction in grain yield in the case of drying soil 10% below saturation before re-flooding. The reduction in water consumption was less than the reduction in grain yield in the case of drying soil 30% below saturation before re-flooding. The increase in water use was greater than the increase in grain yield in the case of maintaining soil moisture at 100% of saturation before reflooding (Hamoud, 2018).

Continuous watering can cause the soil in the polybags to become denser. To anticipate these to be added soil conditioner. According to Hilber et al. (2012), biochar is increasingly promoted as a beneficial soil conditioner. However, it may contain residues of polycyclic aromatic hydrocarbons (PAHs) as a result of its production by pyrolysis. According to Milla et al. (2013), the partially burned rice husk (husk biochar) enhances the water holding capacity.

Biochar is charcoal or biomass that has been burned (pyrolysis) in environmental conditions without or low oxygen. The scientific agreement states that giving biochar to the soil is expected to absorb carbon sustainably and can simultaneously improve soil function (current and future management) while avoiding the effects of damage in the short and long term for the wider environment and for both human and animal health (Verheijen, 2009). Biochar can be produced from a variety of biomass feedstock but is generally designed only as a product that can be used for soil improvement (McLaughlin et al., 2009).

Biochar is a carbon-rich product obtained from biomass, including wood, manure or leaves that are heated in closed containers (containers) with little or no air available. Biochar is produced by thermal decomposition of organic material with a limited supply of oxygen (O_2) and at relatively low temperatures (< 700°C) (Lehmann & Joseph, 2012). Biochar is a product produced from biomass waste (agricultural waste) that is heated without air or with very little air. The process of making charcoal is often called pyrolysis. The raw materials that can be used to make biochar are biomass waste that is not utilized, namely: rice husks, corncobs, cocoa pods, hazelnut shells, coffee skins, wood sawdust, eucalyptus oil leaves, wood branches such as the waste of animal feed residues, coconut shell, and the like (Widiastuti & Lantang, 2017).

The benefits of biochar are determined by two main properties, which are a high affinity for nutrients and persistence in the soil. Biochar provides habitat for microbes in the soil, but it is not consumed and can live in the soil in hundreds or even thousands of years. Biochar persistence in a long time will not upset the carbon-nitrogen balance in the soil but can hold water and nutrients more available to plants. Organic and inorganic fertilizers with biochar can increase productivity, as well as nutrient retention and availability for plant roots (Gani, 2009).

Utilization of rice husk into biochar is one of the innovations that can be applied to farmers to overcome problems in agriculture, such as reducing the level of soil acidity, increasing crop productivity, and storing carbon stocks to overcome global environmental problems (Widiastuti & Lantang, 2017). Utilization of biochar as a soil enhancer in the first planting season has produced good soil physical properties for the second planting season which directly gives positive results for the growth and yield of lowland rice. The application of biochar dose of 10 tons/ha can increase rice yield in the form of grain by 13.5% compared to the control of 5.11 tons/ha to 5.80 tons/ha (Waty et al., 2014).

The use of a biochar dose of 8 tons/ha can give a significant increase in effect on plant height, the number of leaves, leaf area and weight of mustard plants (Musnoi et al., 2017). The combination of rice straw (10 tons/ha) and biochar rice husk (10 tons/ha) together with the use of chemical fertilizers is possible to increase the weight of grains/panicle for better results compared to only the application of chemical fertilizers (Thavanesan & Seran, 2018).

Biochar is able to increase the availability of water in the soil. The highest available pore for water was found in the coconut shell biochar by 21.55% and followed by biochar and the lowest was in wood biochar. The highest percentage of available pore water was found in the administration of biochar doses of 45 tons/ha and the lowest was followed by biochar doses of 30 and 15 tons/ha (Khoiriyah et al., 2016). The interaction between the biochar dose of 15 tons/ha with 60 mesh particle size can reduce the soil pH by 5.19% (from 7.7 to 7.3) and increase the soil CEC by 32.92% (from 16.37 to 22.25 $cmol^+/kg$). And also improve the soil C-organic by 33.94% (from 1.09% to 1.46%), and enhance the soil available phosphor by 277.08% (from 12.61 ppm to 47.55 ppm) (Salawati et al., 2016).

The use 75% of biochar (7.5 tons/ha) + 25% straw compost (2.5 tons/ha) produces 29 tillers, 8.23 tons/ha of rice production and is able to provide nutrients in the ultisol soil with increasing pH, N, P, K, Ca, Mg, and S (Herman & Resigia, 2018). Biochar significantly affected the following yield components: the number of tillers, percentage of the productive tillers, number of grains/panicle, panicle density, percentage of filled grain, and weight of 1,000 grains (Lakitan et al., 2018).

The objective of these works here was to study aims to determine the effect of soil water content and the biochar application in the soil on growth and yield of rice in the polybags. Therefore it is expected that the soil waterlogging and the biochar dose of 14 tons/ha could be given the higher growth and yield of rice in the polybag cultivation.

MATERIALS AND METHODS

Experiment area

The study was conducted at April to September 2019 in the greenhouse of Agroshop garden, Faculty of Agriculture, Universitas PGRI Yogyakarta having an elevation of 118 m mean sea level (MSL) in the position 70 33’ LS – 8 12’ LS and 110 00’ BT – 110 50’.

Production and application of biochar

This biochar used in this study made from materials of rice husk. The biochar characterization was done using simple pyrolysis apparatus made from the modified drum as a biochar reactor, fresh rice husk from rice milling put in the reactor. Starting burning from the bottom of the reactor for 5 hours with the average temperature of 225 ^oC in the reactor and after 5 hours will change to biochar.

During the pyrolytic production of biochar, polycyclic aromatic hydrocarbons (PAHs) can form and are present on the surface of biochar. The pyrolysis process is the key factor responsible for the yield of PAHs in biochar. Slow pyrolysis and longer residence time result in lower PAHs yields than the fast pyrolysis and shorter residence time. Temperature is also another significant determinant affecting the formation and yield of PAHs. Low molecular weight PAHs are usually formed at low temperatures (< 500 °C) whereas the high molecular weight PAHs commonly appear under high temperatures (> 500 °C). Analytical methods for the extraction of PAHs from biochar mainly include Soxhlet extraction and accelerated solvent extraction (Wang et al., 2017). Rice husk biochar had higher concentrations of PAHs (64.65 mg/kg) than wood biochar (9.56 mg/kg), and both soil types contained quantifiable levels of PAHs. However, soil that had contained biochar for 3 years had significantly higher levels of PAHs (1.95 mg/kg) compared to unamended soil (1.13 mg/kg) (Quilliam et al., 2013).

The chemical content of biochar was not analysis by the researchers. The researchers used the results of data analysis chemical by Bakri (2009), that the most dominant chemical component contained in the rice husk ash produced SiO_2 (72.28%), and incandescent lost compounds (21.43%), while the percentage of CaO (0.65%), Al_2O_3 (0.37%), and Fe_2O_3 (0.32%) compounds were classified as very low.

The biochar needed (g/polybag) for each treatment can be calculated. The formula used to calculate the soil dry weight per hectare (kg/ha) = soil area of one ha (m^2) x soil tillage depth (m) x soil bulk density of alluvial (kg/m^3). If it is known that the soil area of one hectare is 10,000 m^2, soil tillage depth of 0.2 m, and bulk density of 1.4 kg/m^3, then the soil dry weight per hectare is 2,800,000 kg/ha. The doses of biochar application consisted of four levels i.e: 0; 14; 28 dan 42 tons/ha (or 0; 1,400; 28,000; and 42,000 kg/ha). If known the dry weight per polybag is 15 kg/polybag and the soil dry weight per hectare is 2,800,000 kg/ha, so the doses of biochar application per polybag (kg/polybag) can be calculated by the following formula = $\frac{\text{Soil dry weight per polybag (kg/polybag) x doses of biochar (kg/ha)}}{\text{Soil dry weight per hectare (kg/ha)}}$. Based on this formula, so the doses of biochar application for each treatment i.e.: 0; 0.075; 0.150; and 0.225 kg/polybag, respectively, and it was the same of 0; 75; 150; and 225 g/polybag.

Experiment design

This experiment was arranged in a completely randomized design (CRD) with factorial, repeated three times. The first factor is that soil water content consisted of two types of soil conditions: field capacity and soil waterlogging. The second factor that the application of biochar consisted of four doses: 0; 14; 28; and 42 tons/ha (or 0; 75; 150; and 225 g/polybag). This research consisted of eight treatment combinations and repeated three times and each repetition consisted of three samples so that it was needed 72 polybags.

Soil media preparation

The soil dry weight of 15 kg was added 25 g of TSP fertilizer and dose of biochar application according to the treatment and then mixed evenly. The soil media mixture put in a polybag. The size of the polybag was a diameter of 40 cm and a height of 30 cm. The filling of soil media mixture was conducted on the 72 polybags. According to Humaerah (2013), the diameter of the pot affects the number of panicles produced by rice plants. The diameter of 40 cm produces more panicles than the diameter of 30 cm.

Ciherang variety

The yield rice production could be increased by the use of superior rice variety. Ciherang is a new superior variety that can adapt to the environment well to ensure better plant growth, high production, and good quality as well as delicious and fluffier rice flavors so that it can be accepted by the market.

Ciherang variety has an age of 116 to 125 days, plant habitus of erect, plant height of 107 to 115 cm, productive tillers of 14 to 17 stems, the average and potential of rice yield were 6.0 and 8.5 tons/ha, resistant to brown planthopper biotype 2 and 3, resistant to bacterial leaf pests strains III and IV. Ciherang was suitable to be planted in the lowland irrigated rice field (Anonymous, 2009).

Nurseries and seedlings

The rice variety used is Ciherang. The rice seedlings were carried out in the plastic germination tub in size of 25 cm x 30 cm x 10 cm (length x width x height) that have been filled with soil media. The seeds are spread out on the surface of soil media. Then, seeds covered slightly with soil. The soil media is watered until to field capacity. The seeds will germinate about 4 days after sowing.

Planting and plant spacing

Before planting, the soil media in the polybag is watered until field capacity. Then, the seedlings after 10 days after planting (DAP) are ready to be transplanted in the soil media in polybags. The plant number per polybag consisted of three clumps. Each polybag is planted in three holes and one hole is planted two seedlings. The planting system is the equilateral triangle model. The plant spacing between holes in the polybag is 25 cm x 25 cm.

Soil water content

The treatment of field capacity and soil waterlogging was begun from planting to 30 days. After that, there is no different treatment in watering the polybag. For the soil waterlogging treatment, the high waterlogging as high as 3 cm from the soil media surface in the polybag. A decrease of the water volume in polybags is added by watering. For the field capacity treatment, the soil moisture is maintained through watering the soil media in the polybag.

Observation parameters

Observations on the growth and yield of rice consisted of the tillers' number (stem), leaf area (dm^2/clumps), dry weight of shoot (g/clumps), root (g/clumps), grains (tons/ha), panicle length (cm), and harvest index. The leaf area was measured with a portable pallet leaf area meter CI-202. The dry weight of roots, shoots, and grains was measured by the digital analytical balance ACIS AD-i Series. The panicle length (cm) was measured using a ruler. The harvest index was measured with the formula: a ratio of economic yield (grain dry weight) and biological yield (the dry weight of grains, leaves, stem, roots). The dry weight grains per hectare (tons/ha) was measured by the formula = the dry weight grains per clumps (g) * the plant number per hectare (clumps). The plant number per hectare with a plant spacing of 25 x 25 cm^2 is 160,000 clumps.

Statistical analysis

Data of observations were analyzed by analysis of variance (ANOVA) at P-value 0.05 (Gomez and Gomez, 1984). The analysis of data has used the software of IBM SPSS Statistics 23. To determine the differences between treatments was used Duncan's new multiple range tests (DMRT) at P-value 0.05.

RESULTS AND DISCUSSION

Tiller number, leaf area, panicle length, and harvest index

The results of the analysis of variance on the tiller number, leaf area, panicle length, and harvest index showed no significant interaction occurred between the treatment of soil water content and biochar application. The treatment of soil water content significantly affected on the tiller number, panicle length, and harvest index. The biochar application was significantly affected by the tiller number and leaf area. Comparative test between the average of treatments based on

DMRT at P-value 0.05 on the tiller number, leaf area, panicle length, and harvest index in Table 1.

Table 1. The Effect of Soil Water Content and biochar application on the Tillers Number, Leaf Area, Panicle Length and Harvest Index

Treatment	Tiller number (stem/clumps)	Leaf area (dm^2/clumps)	Panicle length (cm)	Harvest index
Soil water content				
Field capacity	13.06 b	24.47 a	18.74 b	0.29 b
Soil waterlogging	15.15 a	24.36 a	21.91 a	0.35 a
Doses of biochar (g/polybag)				
0	17.03 p	25.59 p	19.87 p	0.31 p
14	13.80 q	27.76 p	20.43 p	0.32 p
28	13.00 q	24.59 p	20.45 p	0.32 p
42	13.31 q	20.12 q	20.53 p	0.32 p
Interaction between treatment	(-)	(-)	(-)	(-)

Remarks: Number in the same column followed by the same characters are not significantly different based on DMRT at P-value 0.05. (-) = No interaction between the soil water content and biochar application

The water affect

The soil water content significantly affected the tiller number, panicle length, and harvest index, but no significant effect on the leaf area. The rice planted in soil waterlogging has a higher tiller number, panicle length and harvest index compared to in the field capacity. The Ciherang variety is more suitable to grow in soil waterlogging to form the higher tiller number. The water content in the field capacity was not enough for the growth of Ciherang variety. The Ciherang variety requires excess water conditions for growth. According to Subari et al. (2012), the rice plants are able to grow well in the soil waterlogging, because it has the ability to oxidize its root area through a network of parenchyma that can diffuse oxygen to the root area. Oxygen from the leaf is flowed through a process of diffusion to the roots and stems through the cortex. The existence of this process, the rice plant is able to meet the needs of oxygen for root respiration even in the soil waterlogging conditions.

The occurrence of water deficit at the reproductive stage affects rice grain quality, but it could not be stated that the water stress improves or decreases rice grain quality (head rice ratio, amylose content, protein content, and gel consistency). Soil water deficit has significant implications on rice grain quality (Bleoussi et al, 2016). The rice growth in the field capacity is not optimal, because water shortages often occur due to watering delays. Soil water content in the root zone will affect all aspects of plant growth including the physiological and biochemical processes. The water will further cause part of the stomata to close and inhibit the entry of CO_2 and further inhibit the photosynthesis process. The low carbohydrate formed will affect the decrease in the growth and yield of rice.

Water is a raw material for photosynthesis, solvents and biochemical reaction media, transport medium compounds, provide turgor for cells for cell division and enlargement and maintain plant temperature to be constant. The water causes biochemical processes in the body of the plant to be disrupted. The water content available in the soil will cause the pressure of plant cell turgor to be more maintained so that cell activity in the process of photosynthesis is better and carbohydrates are produced more. Carbohydrates are used as an energy source for the division of plant cells informing the tiller number, panicle length, and harvest index.

The biochar application

The biochar application significantly affected the tiller number, and leaf area, but not significantly affected on the panicle length, and harvest index. Without the application of biochar a (0 tons/ha) to the soil, it would give a higher tiller number. The biochar application into the soil actually causes a decrease in the tiller number. The tiller number was inhibited by biochar application. This is different from the occur in the observation of the leaf area. The biochar application was not a significant difference in the leaf area between biochar doses of 0, 14, and 28 tons/ha. However, the biochar dose of 42 tons/ha resulted in decreased leaf area. The biochar application exceeds the optimal limit causing the narrower leaf area.

The application of biochar decreased soil bulk density, soil strength, exchangeable Al, and soluble Fe and increased porosity, available soil water content, C-organic, soil pH, P-available, CEC, exchangeable K, and Ca (Masulili et al., 2014). The biochar application more than optimal limit actually causes the shoots, roots, and grain to decrease. The biochar application of 14 tons/ha in the soil waterlogging is the optimal dose. The biochar application could have functioned as a soil amendment and improve the soil’s physical properties such as increasing soil pH. The increase of soil pH results in a favorable environment for root’s rice development. The pH value near-neutral conditions result in the optimum availability of nutrients that facilitate higher phosphate absorption in addition to other nutrients. Phosphate element is highly needed for roots development as the nutrient source for a plant that substitutes inorganic fertilizer role and can be categorized as a chemical function, although this function has not yet properly implemented by the biochar.

The dry weight of shoots, roots, and grains

Analysis of variance on the dry weight of shoots, roots, and grains showed a significant interaction between the soil water content and biochar application. Comparative test results between treatment interactions based on DMRT at P-value 0.05 on the dry weight of shoots, roots, and grains (Table 2).

Table 2. The Effect of Treatment Interactions between Soil Water Content and Biochar Application on the Dry Weight of Shoots, Roots, and Grains

Combination of treatment	Shoot dry weight (g/clumps)	Root dry weight (g/clumps)	Grains dry weight (tons/ha)
$A_1 + B_0$	28.83 d	14.61 cd	2.66 c
$A_1 + B_1$	30.33 d	15.08 cd	3.04 c
$A_1 + B_2$	32.81 d	14.81 cd	3.14 c
$A_1 + B_3$	28.31 cd	13.88 d	2.80 c
$A_2 + B_0$	51.48 a	24.67 a	6.57 a
$A_2 + B_1$	51.30 a	24.85 a	6.62 a
$A_2 + B_2$	42.81 b	19.77 b	5.34 b
$A_2 + B_3$	39.39 bc	17.65 bc	4.74 b
Interaction between treatment	(+)	(+)	(+)

Remarks: Number in the same column followed by the same characters are not significantly different based on DMRT at P-value 0.05, A_1 = Field capacity, A_2 = Soil waterlogging,

B_0 = 0; B_1 = 14; B_2 = 28; and B_3 = 42 tons/ha. (+) = Significant interaction between the soil water content and biochar application

The combination treatment between the soil water content and biochar application was significant on the dry weight of shoots, roots, and grain. The rice plants growing in the soil waterlogging combined with the biochar doses of 0 and 14 tons/ha give a higher dry weight of shoots, roots, and grain than in biochar doses of 28, and 42 tons/ha (Table 2). The dry weight of shoots, roots, and grains are lower growth and yield by rice plants in the soil of field capacity with the biochar application doses of 0; 14; 28; or 42 tons/ha. The biochar application in the field capacity can not increase the growth and yield of rice.

The nutrient absorption process can occur well if the Ciherang grows in the soil waterlogging. The turgor pressure of plant cells can be maintained properly if the water is available in the soil. The process of photosynthesis can occur smoothly and produce maximum carbohydrates if the water needs enough for rice plants in the soil. Carbohydrates are used as an energy source to arrange the dry weight of stem, leaf, and root tissue. Some of the remaining carbohydrates stored in the body of rice plants in the leaves, stems, and roots, then are transferred to the seeds filling when it changes to the generative phase.

Figures 1, 2, and 3 showed that the effect of the interaction between the soil water content and the biochar application on the dry weight of shoots, roots, and grains. Based on Figure 1, 2, and 3 showed that the treatment of soil waterlogging was combined with without the biochar application and biochar application doses of 14 tons/ha could be given the higher growth and yield of rice than the biochar application doses of 28 and 42 tons/ha on the dry weight of shoots, roots, and grains. The interaction between field capacity and all doses of biochar given the lower dry weight of shoots, roots, and grains.

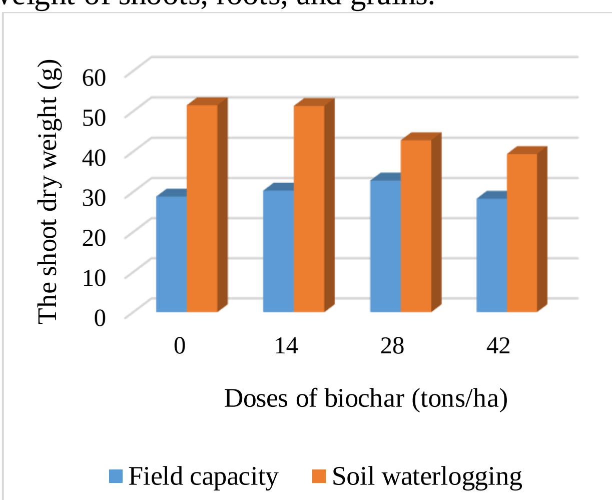


Figure 1. The Interaction between Soil Water Content and Biochar Application on the Shoots Dry Weight

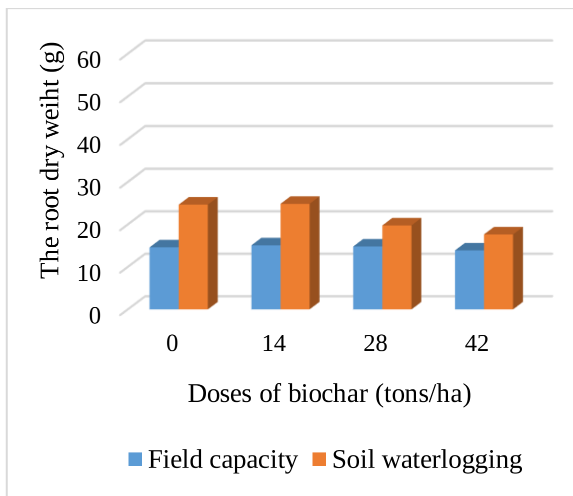


Figure 2. The Interaction between Soil Water Content and Biochar Application on the Roots Dry Weight

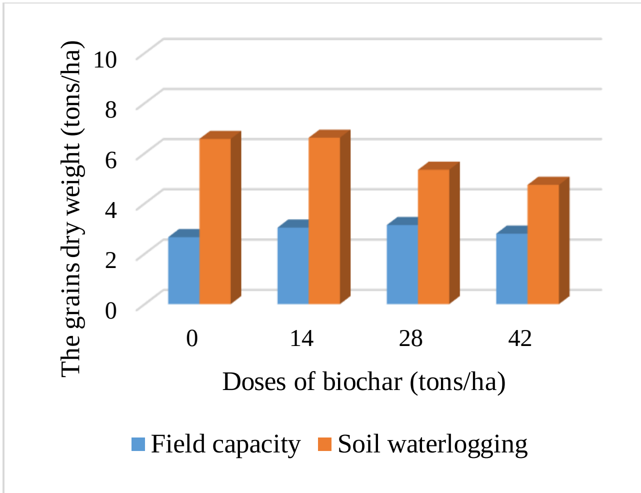


Figure 3. Interaction between Soil Water Content and Biochar Application on the Grains Dry Weight

Water and crop performance

The effect of soil water content on the shoot performance can be seen in Figure 4 follows. Based on Figure 4 shows that shoot performance was very different on the plant height. This rice that grows in the soil waterlogging has a higher plant than growth in the field capacity. The rice leaves appear greener when flowering in the soil waterlogging than rice that in the field capacity. The rice plant flower faster on the soil waterlogging than in field capacity.

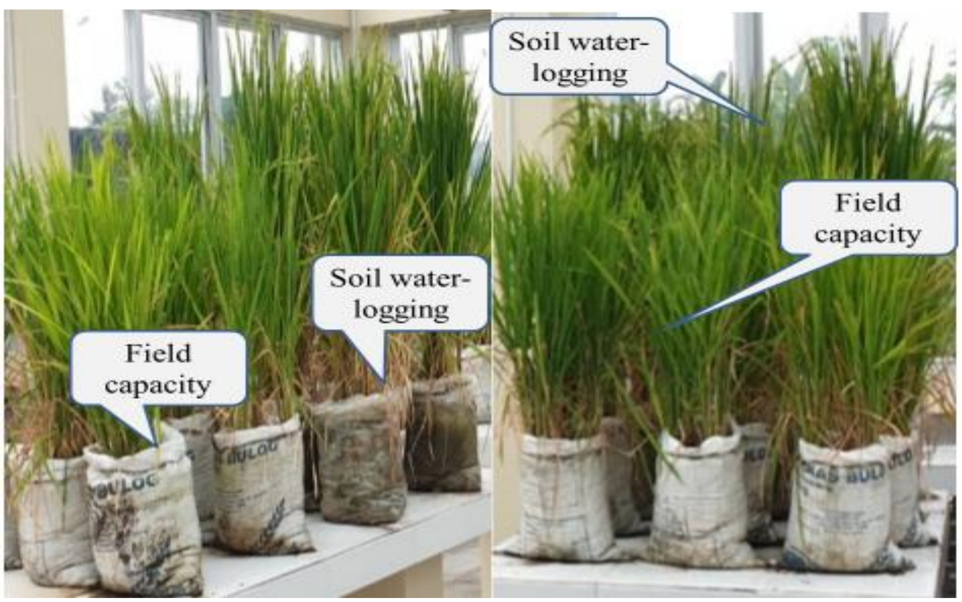


Figure 4. The Effect of Soil Water Content on the Plant Height and Greenish Leaves Performance

The effect of soil water content on the performance of root rice can be seen in Figure 5 follows. Based on Figure 5 showed that the root performance is very dense in the rice plants that grow in the soil waterlogging than in the field capacity. The noticeable denser root occurs at biochar application of 0 or 14 tons/ha. The root density correlated with the dry weight of roots and then support to growth and yield of rice plants. There did not appear to be different on the root length between the rice plant that growth in the soil waterlogging and field capacity. The root is an important organ for plants. The root rice is a plant organ that directly related to the soil. Root density of rice affects the ability of rice plants to absorb nutrients in the soil to support overall growth. Nutrients are needed by rice plants to support biochemical processes in plants.

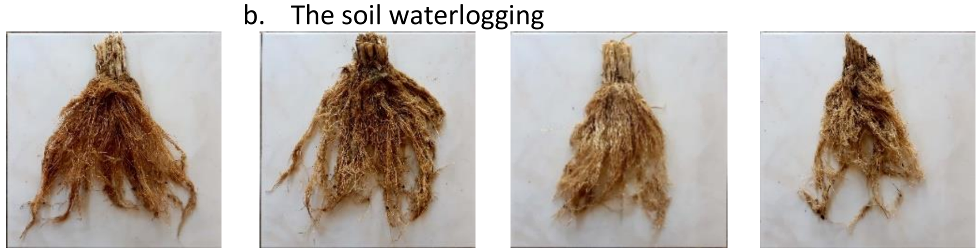
a. The field capacity

Biochar application (tons/ha)

0 14 28 42

b. The soil waterlogging

Biochar application (tons/ha)



0 14 28 42

Figure 5. The Effect of Soil Water Content on the Root of Rice Performance in the four doses of biochar application

CONCLUSION

Based on the results of the analysis and discussion can be concluded that rice cultivation with soil waterlogging is better than field capacity on the tillers number, panicle length, and harvest index. Without biochar application was given higher tillers number, but biochar dose of 14 tons/ha produce the wider leaf area. There was significant interaction between soil water content and biochar application on the dry weight of root, shoot, and grains. The treatment combination of the soil waterlogging and biochar dose of 14 tons/ha were more effective to increase the growth and yield of rice in a polybag. The rice cultivation in polybags through water supply can be done in around the urban areas.

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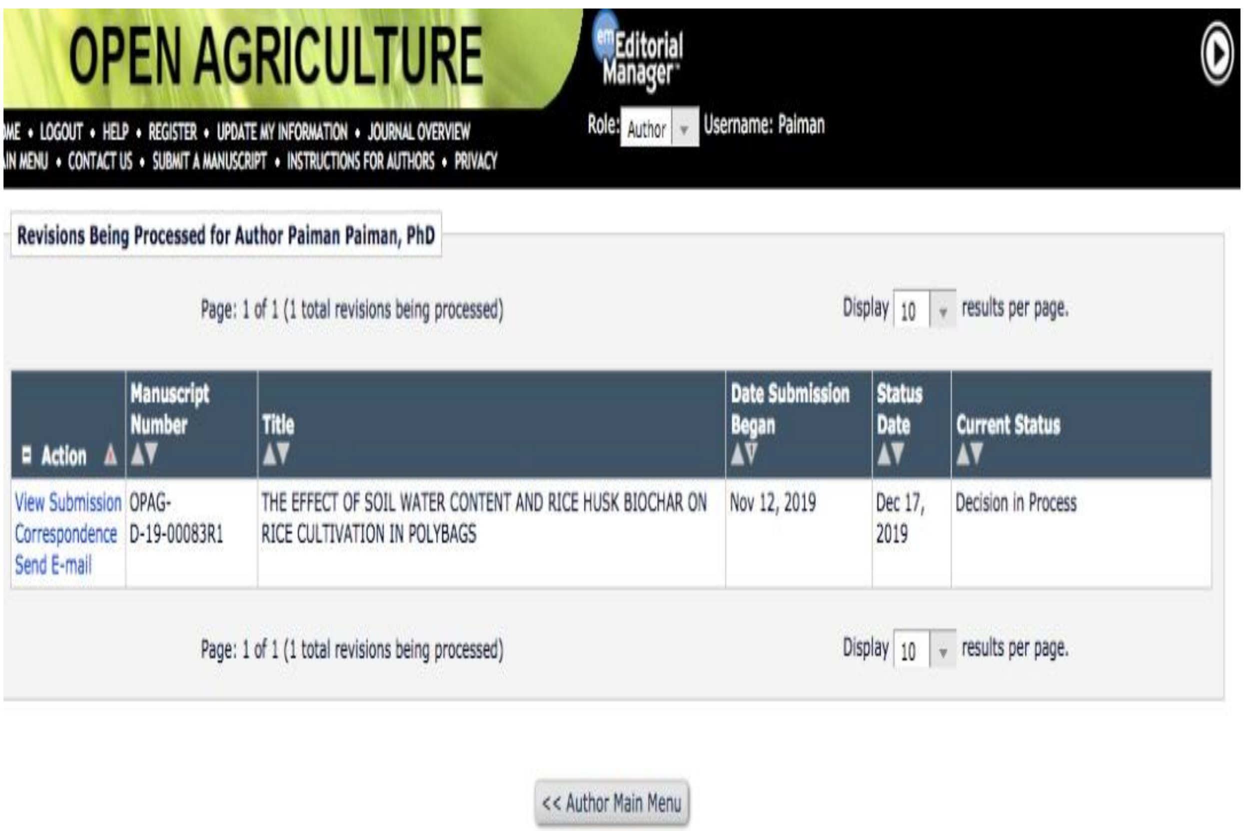
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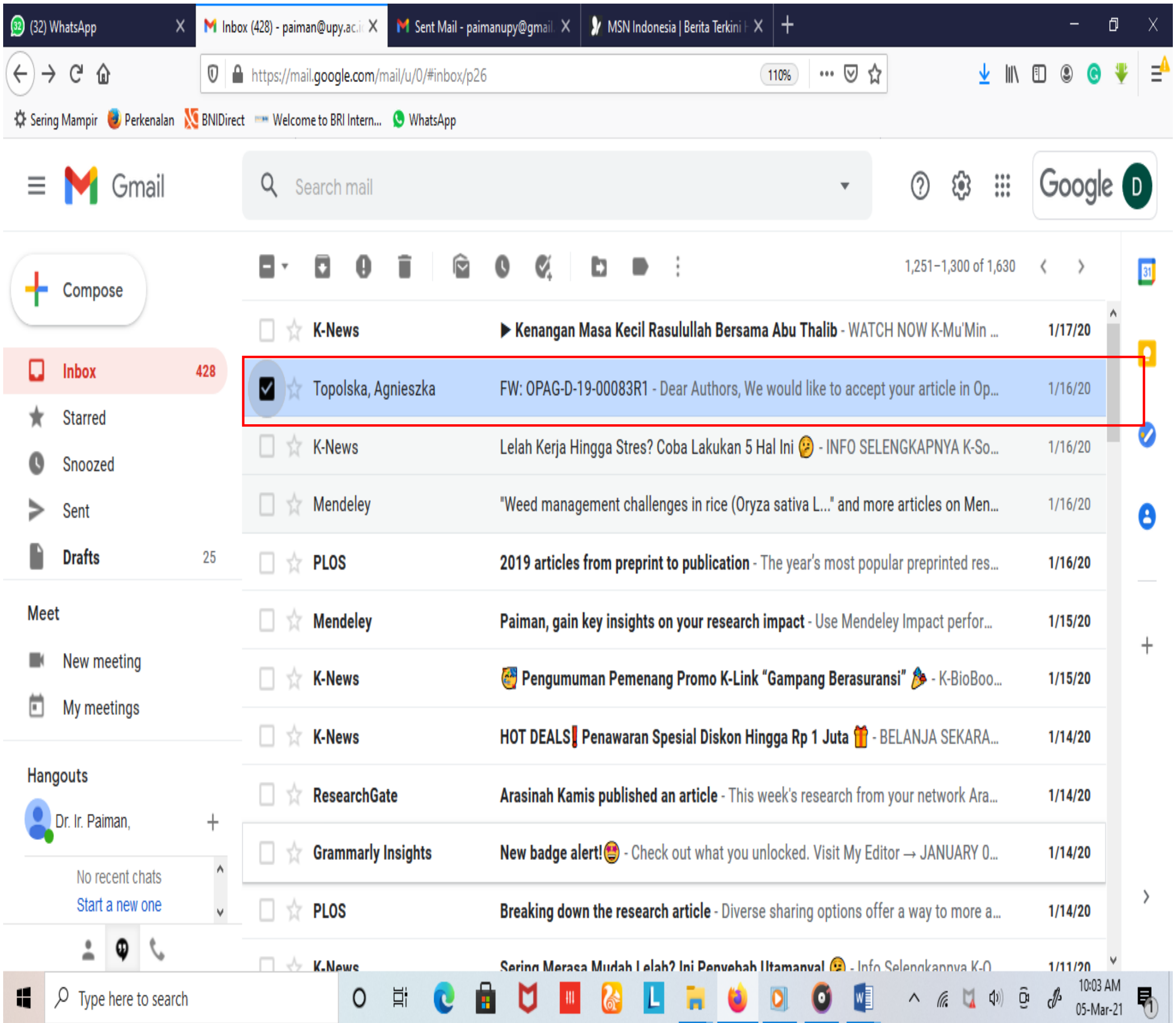

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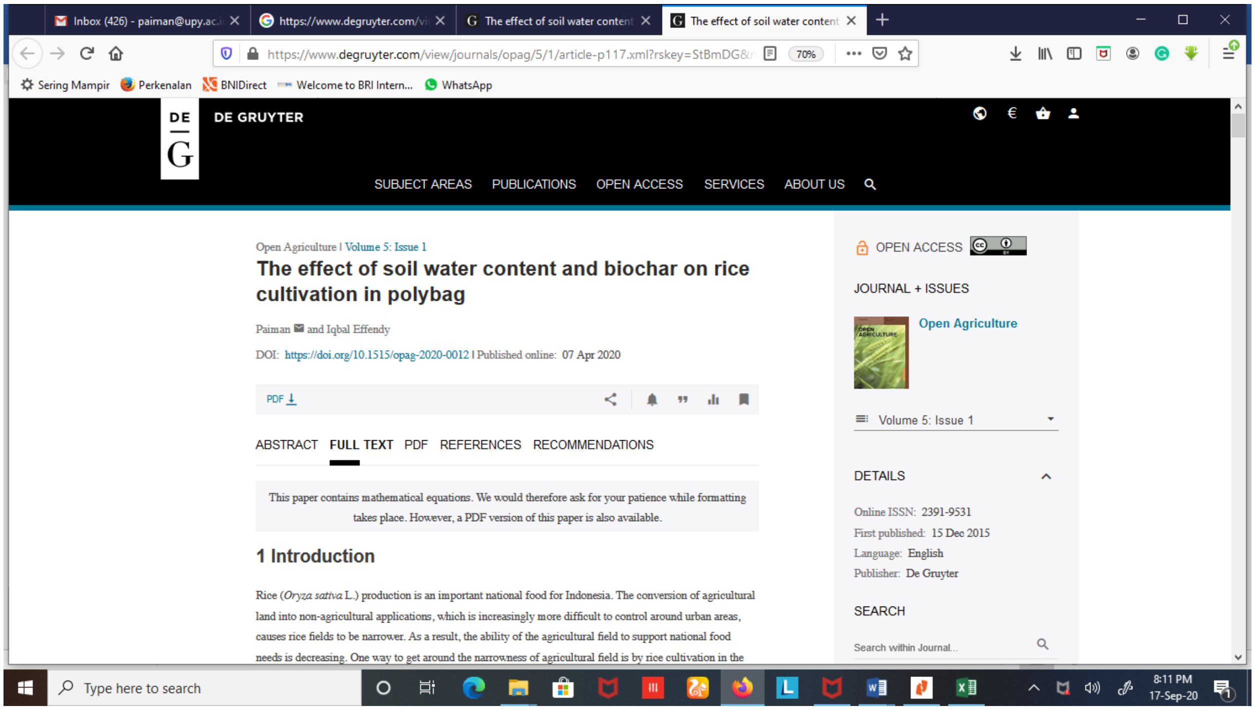

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1 Introduction

Rice (*Oryza sativa* L.) production is an important national food for Indonesia. The conversion of agricultural land into non-agricultural applications, which is increasingly more difficult to control around urban areas, causes rice fields to be narrower. As a result, the ability of the agricultural field to support national food needs is decreasing. One way to get around the narrowness of agricultural field is by rice cultivation in the

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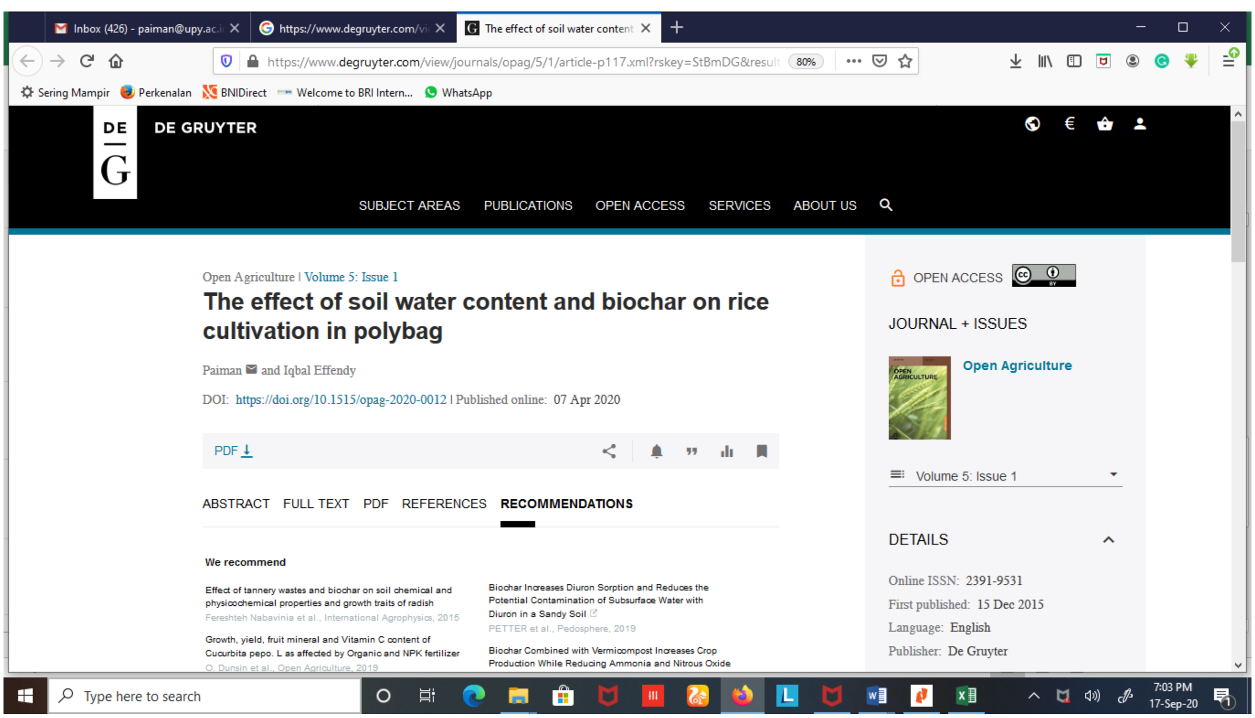

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