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Rice husk biochar application and the planting times effects on dry weight and water use efficiency of upland rice varieties

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Abstract. The objective of this study was to measure the effect of rice husk biochar application and the planting times on dry weight and water use efficiency of upland rice varieties at Zone D Oldeman Agroclimate in North Sumatra Indonesia. First factor as main plot was the planting times such as planting. Second factor as sub plot was upland rice varieties such as Batutegi, Inpago 4, Limboto, Situbagendit and Situpatenggang. Third factor as sub sub plot was type of rice husk biochar application such as no rice husk biochar (RHB), RHB, RHB + Chicken manure, RHB + EM4. Result showed that rice husk biochar (with chicken manure or EM4) increased upland rice dry weight (1-17%) and water use efficiency (17-25 %) in planting times of August and September and increased more higher in planting time of June and July about 17-25 %, 61-80 % respectively and rice husk biochar application decreased water use efficiency only in planting time of August. Batutegi and Inpago 4 varieties showed the highest dry weight and the highest value of water use efficiency were Inpago 4 and Limboto. Planting time of August or September showed the highest upland dry weight and water use efficiency.

1. Introduction

Rice is a staple food for the world's population. In 2013, total rice consumption were 3.23 billion people, total harvested area and world rice production were 159.97 million ha and 745.71 million tons [1]. There were three type ecosystems for rice cultivation according of water condition from rice environment such as upland, rainfed lowland and irrigated ecosystem which their percentage from global rice production about 4%, 19 % and 75 % respectively [2].

Kikuta et al. [3] reported that grain yield of upland rice varied according to rice environment and crop management strategies which availability of water was very important to produced highest grain yield. Production of upland rice were lower than paddy rice, because so many factors threaten production, among others droughts, like higher weed attack, lower soil fertility and lower input to the soil [4].

Biochar had the potential used as a soil amendment to improved soil quality and fertility and reduced greenhouse gas emissions. Corn cob biochar improved soil physical properties and water use efficiency by enhancing yield and plant physiology [5]. Under drought stress, biochar and gypsum



application improved WUE as compared to untreated plants [6]. The objective of this study was to assess the impact of planting time, upland varieties and rice husk biochar application on dry weight and water use efficiency parameters.

2. Materials and Methods

2.1. Experimental design

The experiment were conducted at Sampali Weather Station Research Field (Indonesia Agency of Meteorology, Climatology and Geophysics) Deli Serdang District North Sumatra Indonesia from June 2014 to January 2015. This study used split split plot design with three factors and two replications. First factor as main plot were the planting time of June, July, August, September. Second factor as sub plot were upland rice varieties such as Batutegi, Inpago 4, Limboto, Situbagendit and Situpatenggang. Third factor as sub sub plot were type of rice husk biochar applications such as no rice husk biochar (RHB), RHB, RHB + Chicken manure, RHB + EM4. Biochar material was from rice husk from rice mill at Serdang Bedagai District which had pyrolysis process for 6-8 hours at temperature 300-350°C. Five upland varieties were get from Indonesia Rice Research Sukamandi West Java, Indonesia.

2.2. Field management, data collection and statistical analysis of data

The size of the plot was 2 m x 2 m. Seed was sown 5 seeds per hole with spacing 0.2 m x 0.2 m at depth of 3-5 cm and after 2 week the plant were thinned to 2 plant per hill. The doses of rice husk biochar were 20 tons/ha except the treatment of rice husk biochar + chicken manure which contain 10 ton/ha rice husk biochar + 10 tons/ha chicken manure. The dose of EM₄ was 2 ml/L water. The parameter were measured at 1, 2 and 3 months after planting. Dry weight were measured from destructive sample which the part of plant have been dried in an oven at 70°C until the plant weight was stable. Water use efficiency (WUE) was measured after harvest, used the formula by Howell [7].

$$\text{Water use efficiency} = \frac{\text{crop product}}{\text{Eta during planting season}} \quad (1)$$

Note: Crop product was the yield of upland rice (kg/plot)

Eta was the actual evapotranspiration which get from Thornwaite empirical approach (m³/plot)

The statistical analysis of the data obtained as a result of the study was conducted according to the ANOVA and Duncan Multiple Range Test tests at 95% confidence interval.

3. Results and Discussions

In this study, different planting time, rice husk biochar and upland varieties had significant effects on dry weight at 1, 2, 3 month after planting (MAP) and water use efficiency (WUE). Mean values of dry weight and WUE in responses to different planting times factors can be seen in table 1.

Table 1. Mean values of dry weight and WUE as affected by different planting times

Planting Time	Dry Weight at 1 MAP	Dry Weight at 2 MAP	Dry Weight at 3 MAP	Dry Weight at harvest	Water Use Efficiency (m ³ /plot)
W1 (June)	34.39 a	53.20 b	80.13 b	140.68 a	0.54 ns
W2 (July)	30.83 b	56.29 b	80.12 b	119.93 b	0.75 ns
W3 (August)	7.69 c	16.18 c	112.19 a	125.26 b	0.75 ns
W4 (September)	5.70 c	83.54 a	101.38 ab	116.51 b	0.80 ns

*means in the same columns are not significantly different at the P= 0.05 level

Ns = not significant

As shown in Table 1, the highest value of dry weight at 1 MAP and after harvest were the planting time of June and the highest value of dry weight at 2, 3 MAP were the planting time of September. The planting times had no significant differences to WUE. And WUE increased linearly start from planting time of June to September. The highest and lowest value of WUE found at planting time of September and June, respectively.

Means value of dry weight and WUE as effect of upland rice varieties factors can be seen in table 2. As shown in table 2, Batutegi variety constantly showed the highest dry weight from 1 MAP to harvest. Inpago 4 variety showed the highest value of dry weight and WUE at harvest.

Table 2. Mean values of dry weight and WUE as affected by upland rice varieties

Varieties	Dry Weight at 1 MAP	Dry Weight at 2 MAP	Dry Weight at 3 MAP	Dry Weight at harvest	Water Use Efficiency (m ³ /plot)
V1 (Batutegi)	23.77 a	54.35 a	105.40 a	132.17 ab	0.70 bc
V2 (Inpago 4)	17.78 b	54.22 a	91.98 bc	134.61 a	0.80 a
V3 (Limboto)	20.47 ab	57.68 a	91.72 b	122.86 c	0.77 ab
V4 (Situbagendit)	19.46 ab	47.07 b	85.88 c	112.12 d	0.66 c
V5 (Situpatenggang)	16.78 b	48.19 b	89.31 bc	127.16 bc	0.63 c

*means in the same columns are not significantly different at the P= 0.05 level

Rice husk biochar application effect on dry weight and WUE can be seen in table 3. As shown in table 2, Batutegi variety constantly showed the highest dry weight from 1 MAP to harvest. Inpago 4 variety showed the highest value of dry weight and WUE at harvest. Rice husk biochar application showed the higher value of dry weight compared no rice husk biochar application almost for all time of observation except at harvest observation. Rice husk biochar application only and rice husk biochar + chicken manure showed the highest value of dry weight at 1, 2 MAP and rice husk biochar + EM4 showed the highest dry weight value at harvest observation. While for WUE, the highest value found from rice husk biochar + chicken manure or EM4 application.

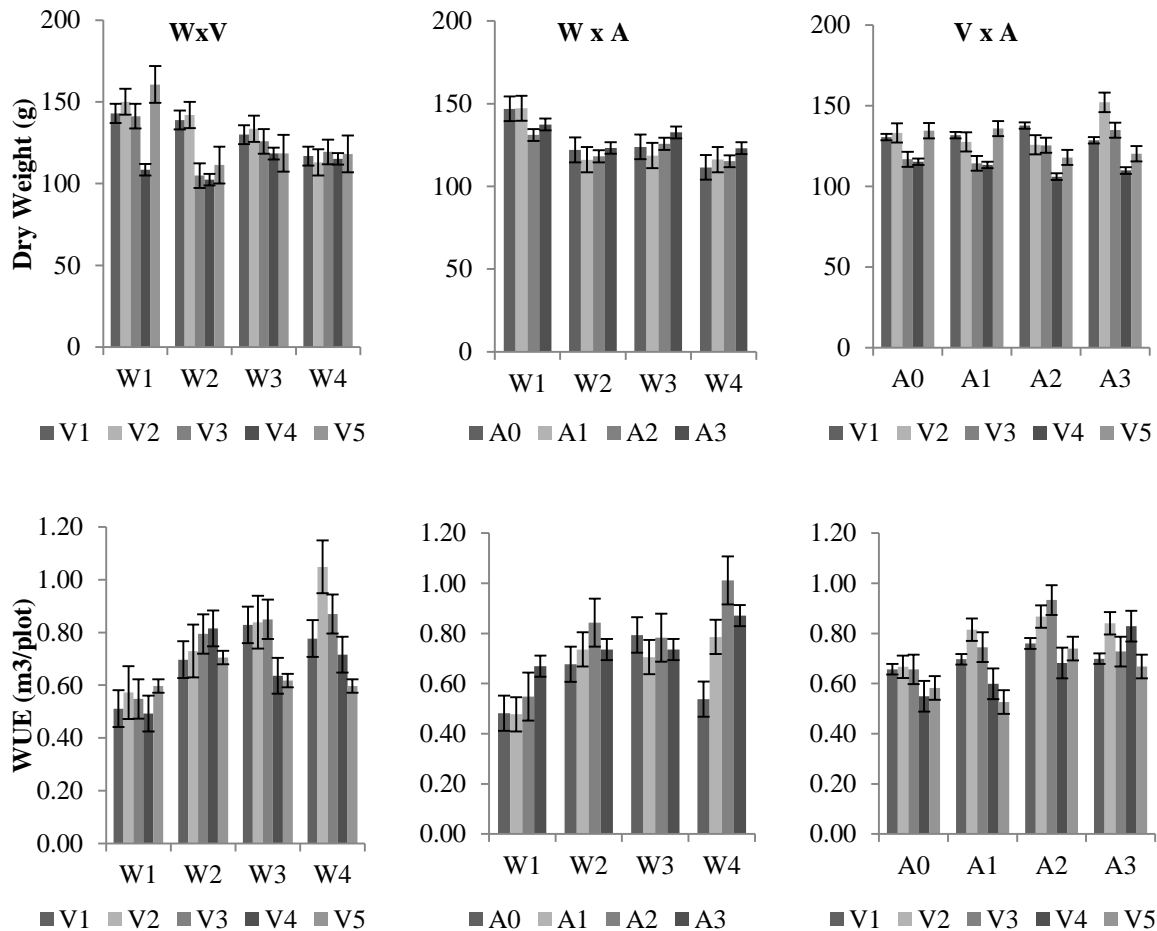
Table 3 Mean values of dry weight and WUE as affected by rice husk biochar application

Planting Time	Dry Weight at 1 MAP	Dry Weight at 2 MAP	Dry Weight at 3 MAP	Dry Weight at harvest	Water Use Efficiency (m ³ /plot)
A0 (No biochar)	17.63 b	47.48 b	87.84	126.07 ab	0.62 c
A1(RHB)	22.53 a	54.44 ab	93.26	124.58 b	0.68 bc
A2 (RHB+CM)	19.90 ab	55.61 a	95.92	122.59 b	0.80 a
A3 (RHB + EM4)	18.56 b	51.67 b	96.81	129.14 a	0.75 ab

*means in the same columns are not significantly different at the P= 0.05 level

There were significant interaction for two factors among the planting time, upland rice varieties and rice husk biochar application for dry weight and WUE at harvest, except interaction upland rice varieties with rice husk biochar which had no significant difference for WUE. The effect of interaction two factor between biochar application on dry weight and WUE parameter at harvest time with upland rice varieties, the planting time can be seen in figure 1. As shown in Figure 1 (W x V), in planting time of June (W1), Situpatenggang and Inpago 4 showed the highest dry weight at harvest and had significant differences with other combination planting time with upland rice varieties. Interaction between planting time with rice husk biochar (W x A) showed that the highest dry weight at harvest found from combination rice husk biochar in planting time of June and had no significant difference with combination rice husk biochar +EM4 and no biochar with planting time of June. Combination

Inpago 4 with rice husk biochar + EM4 (V x A interaction) showed the highest dry weight at harvest and had significant differences with other varieties and rice husk biochar combinations.



Notes: W x V : Interaction Planting times with Upland rice varieties; W x A : interaction planting times with rice husk biochar; V x A : Interaction upland rice varieties with rice husk biochar. Planting Time included W1= Planting Time of June, W2 = Planting time of July, W3 = Planting time of August, W4= Planting time of September. Upland rice variety included V₁ = Batutegi, V₂ = Inpago 4, V₃ = Limboto, V₄= Situbagendit, V₅ = Situpatenggang. Biochar Application included A₀= No biochar, A₁ = Rice Husk Biochar, A₂ = Rice Husk Biochar+ Chicken Manure, A₃= Rice Husk Biochar + EM₄

Figure 1. Effect of Interaction Two Factor between Planting Time, Upland Rice Variety and Biochar Application on Dry Weight and WUE parameters at Harvest Observation

Interaction two factor between planting time with varieties (w x V) showed significant differences to WUE which combination Inpago 4 and Limboto with planting time of September showed the highest WUE and had significant difference with others combination. Combination rice husk biochar with chicken manure or EM₄ in planting time of September showed the highest WUE and had significant difference with others combination.

Rice husk biochar (with chicken manure or EM₄) increased upland rice dry weight (1-17%) and water use efficiency (17-25%) in planting times of August and September and increased more higher in planting time of June and July about 17-25%, 61-80% respectively. Biochar addition can increased dry weight and WUE, its similarity with the research result that reported by [8]; [6]. WUE can be used as an adaptive trait to encountered drought environment. WUE showed the crop availability to produce

biomass per unit of water transpired. Brunn et al [9] reported that biochar can increased water retention due improved density of Danish sandy soil and root penetration.

4. Conclusion

Rice husk biochar addition with chicken manure or EM4 can improved water use efficiency in planting time period which have less water compared with no biochar addition. Inpago 4 variety had the good performance of dry weight and water use efficiency compared another upland rice varieties in all of planting period of cultivation. The planting time of August or September were a favourable environment for upland rice cultivation at Zone D Oldeman Agroclimate in North Sumatra, Indonesia.

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