

# Upland Rice Growth Performance Grown under Different Planting Times and Biochar Applications at Zone D1 Oldeman Agroclimate in North Sumatra

Syarifa Mayly<sup>1</sup>, Abdul Rauf<sup>2</sup>, Chairani Hanum<sup>2</sup> and Hamidah Hanum<sup>2</sup>

<sup>1</sup>Doctoral Program of Agricultural Sciences, Faculty of Agriculture, Universitas Sumatera Utara, Padang Bulan, Medan 20155, Indonesia.

<sup>2</sup>Program Study of Agrotechnology, Faculty of Agriculture, Universitas Sumatera Utara, Padang Bulan, Medan 20155, Indonesia

**Keywords:** Biochar, Rice husk, Upland rice, Planting time, Oldeman agroclimate

**Abstract:** Upland rice yield is highly dependent on nutrients and water availability, temporal and spatial conditions of the climate and the length of planting time period. The effect of planting time and biochar application on upland rice yields varieties were investigated at Zone D Oldeman Agroclimate in North Sumatra. Five upland rice varieties (Batutegi, Inpago 4, Limboto, Situpatenggang, Situbagendit) were evaluated under four planting times and four biochar applications (no rice husk biochar, rice husk biochar, rice husk biochar + chicken manure, rice husk biochar + EM<sub>4</sub>). Results showed that biochar application increased plant growth and yield significantly. Application of rice husk biochar + chicken manure produced the highest mean of plant height, leaf chlorophyll content, total leaf area, yield per plot and harvest index, while ricehusk biochar + EM<sub>4</sub> produced the highest mean number of productive tiller per hill. The Planting time (15<sup>th</sup> Sept) period IV recorded the highest mean of all parameter excluding harvest index which the highest value were at period II. And Inpago 4, Limboto, Batutegi varieties showed the higher growth and yield performances among the four different planting times at zone D Oldeman Agroclimate.

## 1 INTRODUCTION

Upland rice is rice cultivation in dry land where all the water needs come from rainfall, so the yield is highly dependent on nutrients availability and water, temporal and spatial conditions of the climate and the length of planting time period. Variability in the amount and distribution of rainfall is in connection with upland rice cultivation is very dependent on the distribution of rainfall, the determination of the right planting time and in accordance with the rainfall pattern is very necessary (Alfons et al. 2010).

Sudrajat (2009) reported that there was a change in rainfall distribution patterns in North Sumatra Province of Indonesia from 1970-2008, which was the number of wet months decreases and the number of dry months increases. There were two zones that increased in the Oldeman classification in 2009, namely the E1 and E2 zones, therefore there were 8 zones: A1, B1, C1, D1, D2, E1, E2, and E3. North Sumatra Province of Indonesia is dominated by the

D1 climate type which is spread throughout the Regency / City. D1 climate type has 3-4 wet months in a row with less than two consecutive dry months. Climate change such as high and varied temperatures, rain patterns and extreme intensities such as floods and droughts will threaten the agricultural production system (Nelson, 2009).

Adaptation strategies are needed by plants to tackle climate change. Plant adaptation strategies include adjusting planting dates and varieties that are suitable and adaptive to the planting calendar, relocating crops and improving management practices needed to address climate change. According to Messina et al. (2009) that the final results of cultivars depend on the interaction between genotypes, responses to environmental conditions, and cultivation practices. Under the same conditions of cultivation practice, interaction between genotypes and environmental characteristics is the only determinant of the performance of varieties (Luquet et al. 2006).

One potential strategy for climate change mitigation is the biochar application that is used as an amendment. Biochar application as amendment can increase soil CEC, fertilize efficiency and reduce fertilizer requirements (Liang et al. 2006), improve plant growth and yield (Blackwell et al. 2009), increasing water holding capacity and water retention and reducing nutrient loss through leaching (Lehmann et al. 2009; Verheijen et al. 2010). The objectives of this study were to quantify the effect of planting time and biochar application on upland rice growth performance varieties which grown at Zone D Oldeman Agroclimate in North Sumatera, Indonesia.

## 2 MATERIALS AND METHODS

### 2.1 Description of the Experimental Site

The experiment research was conducted in BMKG Sampali Sampali station research field (the Indonesian Agency for Meteorology, Climatology and Geophysics) Deli Serdang District, North Sumatra of Indonesia from June 2014 to January 2015. Climate information was collected daily from BMKG Sampali Weather Stations.

### 2.2 Experimental Design

The experimental design was arranged in a split plot arrangement with two replications. The treatments included the four planting date and four biochar application. Four planting date treatments included 15<sup>th</sup> June, 15<sup>th</sup> July, 15<sup>th</sup> August, 15<sup>th</sup> September respectively, were applied as main plots while five varieties of upland rice included Batutegi, Inpago 4, Limboto, Situpatenggang, Situbagendit were considered as subplots and four biochar application which include no rice husk biochar, rice husk biochar, rice husk biochar + chicken manure, rice husk biochar + EM<sub>4</sub> were considered as sub subplots.

### 2.3 Plant Material and Cropping Period

Five upland rice varieties from Indonesian Rice Research Sukamandi, West Java were selected for this study.

### 2.4 Field Management, Data Collection, and Data Analysis

The field tillage included clearing, breaking soil with hoe, bedding, compacting and smoothing the beds. The bed size was 2 x 2 m with one meter distance between blocks and 0,5 meter distance between plots. The rate of biochar treatment were 0; 20 tons/ha rice husk biochar; 10 tons/ha rice husk biochar + 10 tons/ha chicken manure; 20 tons/ha rice husk biochar + 2 ml EM<sub>4</sub>. Rice husk biochar treatment were applied two days before sowing. Upland rice variety used for this research was Inpago 4 with spacing 0,2m x 0,2 m, sowing 5 seeds per hole at a depth of 3–5 cm and then thinned to 2 plants per hill at 2 weeks after planting..

The parameters were collected at 1, 2, and 3 months after planting (MAP) included plant height (cm) which recorded on five randomly plants by measuring the height from the ground to the tip of the panicle, leaf chlorophyll contents (LCC) was measured with a SPAD-502 portable chlorophyll meter (Minolta, Tokyo, Japan). All chlorophyll meter readings were taken midway between the stalk and the tip of the leaf. Total leaf area = TLA (cm<sup>2</sup>) was measured with CI-202 portable area meter (CID, Inc USA). All leaf from destructive sample were measured with this device. The data were analyzed by using ANOVA with F test at the level of 95 % and then followed by DMR test if the values were significant at the level of probability.

## 3 RESULTS AND DISCUSSION

The effect of rice husk biochar application on plant height, leaf chlorophyll content and total leaf area 12 month after planting can be seen in Figure 1. Significant differences were found among the planting time factor for all upland rice growth parameter. Among the planting time, cropping period IV (September – January) recorded highest plant height, leaf chlorophyll content and total leaf area (110.48 cm, 39.39 and 214.71 cm<sup>2</sup>). Planting Time IV showed significant mean difference with other planting times for all growth upland rice parameter 12 month after planting but there was not significant difference with planting time period I for plant height and period III for total leaf area parameter. There was a significant difference (P<0,05) among upland rice varieties for all growth parameters. Inpago 4 and Batutegi showed the highest mean for all growth of upland

rice varieties. Some upland rice varieties only showed the highest mean for growth parameter like Limboto variety for plant height and leaf chlorophyll content parameter, Situbagendit variety for leaf chlorophyll content and total area parameter and Situpatenggang variety for plant height parameter. There were significant differences among rice husk biochar application for plant height parameter and no significant difference for leaf chlorophyll content and total area leaf. Rice husk biochar + chicken manure produced significant highest mean plant height (109.77 cm) than no rice husk biochar (97.21 cm), rice husk biochar (102.25 cm) and rice husk biochar + EM<sub>4</sub>. For leaf chlorophyll content and total leaf area parameter, rice husk biochar + chicken manure showed the highest mean and no rice husk biochar showed the lowest mean of those parameter.

there were no no significant interactions among the planting time x biochar, varieties vs biochar, planting time x varieties x biochar. Combination Batutegi variety at cropping period I showed the highest plant height were not showed significant difference with combination Inpago 4 and Situpatenggang with cropping period I, combination all upland rice varieties with cropping period IV exclude Situbagendit varieties. Combination upland rice varieties such as Inpago 4, Limboto, Situbagendit with cropping period IV showed the highest leaf chlorophyll content 12 month after planting. Combination Batutegi variety with cropping period I, combination all upland rice varieties with cropping period IV, combination all upland rice varieties with cropping period III exclude Situbagendit variety showed the highest total leaf area parameter.

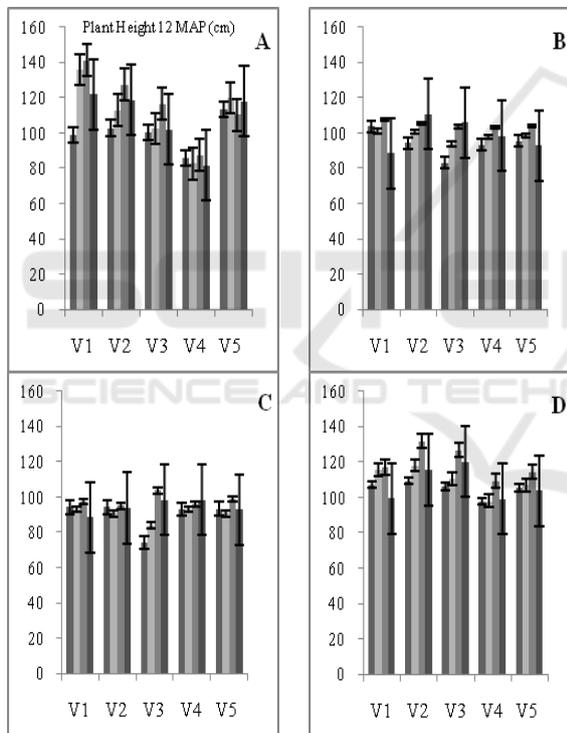


Figure 1: Effect of Planting Time, Upland Rice Variety and Biochar Application on Plant Height (cm) 12 MAP. Planting Time included A= Planting Time (Cropping) Period I, B = Period II, C = Period III, D= Period IV. Upland rice variety included V<sub>1</sub>=Batutegi, V<sub>2</sub>= Inpago 4, V<sub>3</sub>= Limboto, V<sub>4</sub>= Situbagendit, V<sub>5</sub>=Situpatenggang. Biochar Application included A<sub>0</sub>= No biochar, A<sub>1</sub>= Rice Husk Biochar, A<sub>2</sub>= Rice Husk Biochar+ Chicken Manure, A<sub>3</sub>= Rice Husk Biochar + EM<sub>4</sub>.

There were significant interactions among the planting times and the varieties for all growth upland rice parameter 12 month after planting but

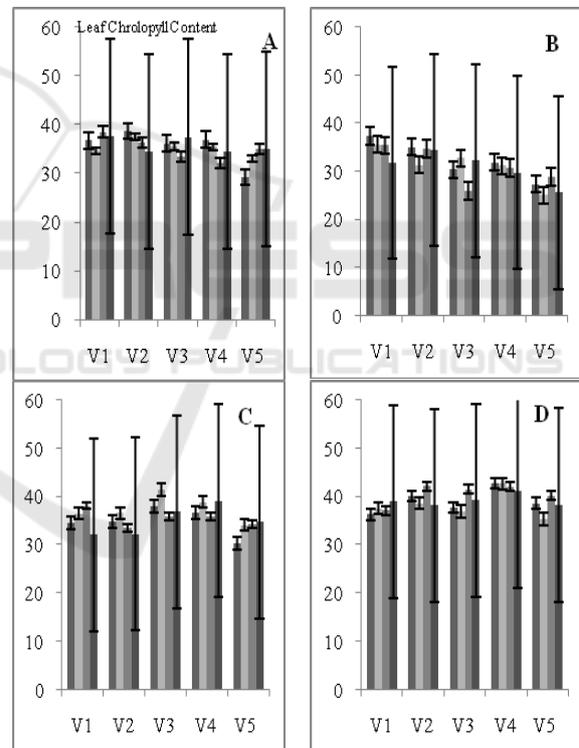


Figure 2: Effect of Planting Time, Upland Rice Variety and Biochar Application on Leaf Chlorophyll Content 12 MAP.

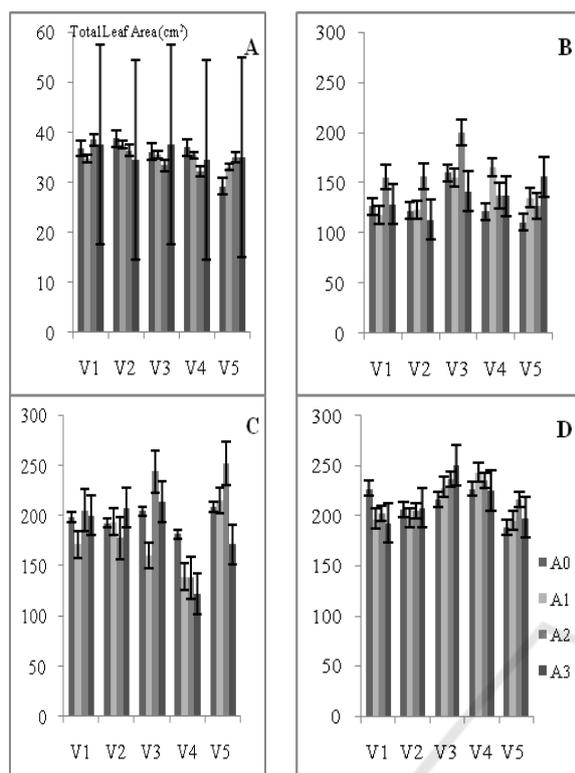


Figure 3 : Effect of Planting Time, Upland Rice Variety and Biochar Application on Total Leaf Area (cm<sup>2</sup>) 12 MAP.

Planting time of period I showed the lowest growth and yield of upland rice. From four planting times, it appear that only the planting period I recorded total crop evapotranspiration higher than total rainfall. It showed that there was a lack of water during the period of plant growth (drought). Drought stress in upland rice causes yield loss and decreases in harvest index (Yue et al., 2006). The reduction in upland rice yield was due to drought stress depends on stress level (Matsumoto et al. 2014; Lafitte et al., 2004; Farooq et al., 2010) and the period of stress (Mannan et al., 2012; Bernier et al., 2007). Heinemann et al., (2007) showed that mild drought stress there was a reduction in upland rice yield of <30%, where as in severe drought stresses the reduction in upland rice yield reached 50%. Sarvestani et al. (2008) stated that water stress at the vegetative stage significantly reduced plant height of all cultivars.

Inpago 4, Limboto and Batutegi varieties showed the best growth performance. It assumed that environment were more suitable for Inpago 4, Limboto and Batutegi varieties. This upland rice growth characteristics was vary and influenced by the expression of genetic characteristics and environmental conditions. This is consistent with the

description of the upland rice varieties where the varieties of Batutegi, Inpago 4 and Limboto had plant height > 110 cm -134 cm, and these varieties had a large number of tillers, namely > 13-18 tillers (BPTP Central Java, 2014).

Batutegi, Inpago 4, Limboto, and Situbagendit varieties show the highest amount of chlorophyll. Study by Shrestha et al. (2012) showed that genotype selection and environmental conditions are more important factors limiting crop yields compared to nitrogen applications. The N content of leaves allocated in the chloroplast is around 80%, and only 50% is invested in photosynthetic proteins and only 0.5-1.5% is allocated in chlorophyll which depends on the environment of plant and species growth. And the amount of leaf N content allocated to chlorophyll-protein complexes increases with decreasing radiation and is observed in many species (Evans and Poorter, 2001).

Application of rice husk biochar + chicken manure showed the highest vegetative growth compared to other types of biochar applications. Rice husk biochar consists of very light materials with porous microstructure and specific gravity 0.150 g cm<sup>3</sup> (Haefele et al., 2009). Addition of fertilizer and biochar give positive results for plant growth. The addition of large biomass production is obtained from the application of fertilizer and rice husk biochar on Ultisol soil. Rice husk biochar application in kale increases the number of leaves, leaf width, leaf length, number of branches, root size, wet weight plant and chlorophyll content (Milla et al., 2013). Mixing biochar with other soil amendments such as manure, compost or lime before application to the soil can increase efficiency by reducing the number of applications needed. Since biochar has been proven to absorb nutrients and protect them from leaching (Major, 2009; Major et al., 2009; Novak et al., 2009), mixing with biochar can improve the efficiency of manure or other amendment applications.

#### 4 CONCLUSIONS

Rice husk biochar application with chicken manure or EM<sub>4</sub> showed a significant increase in all parameters of crop growth upland rice in Zone D Oldeman Agroclimate. Treatment application of rice husk biochar + chicken manure was found to be the optimum application type in this research, which no had significant differences in leaf chlorophyll content and total leaf area parameter. Upland rice varieties showed significant differences in all parameter

which Inpago 4, Limboto and Batutegi recorded the highest mean among different planting time compared with other varieties. Planting time period IV recorded the highest growth and yield performances, and it mean that the period IV was a favourable environment to upland rice grown in Zone D Oldeman Agroclimate.

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