Characterization of Tolerant Upland Rice to Drought on Rooting and Physiology System

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Abstract

This study aims to determine the efficiency of water use between cultivars and identify the root system, drought-tolerant upland rice physiology. Implemented in plastic house in North Aceh, in January 2015 until May 2015. Using a split plot design (Split-plot) with three replications, and two factors: The first factor is drought stress (C) consisting of 4 levels of field capacity is : C1: 20% (300 ml / day), C2: 40% (600 ml / day), C3: 60% (900 ml / day) and the C4: 80% (1200 ml / day). The second factor is the 10 varieties of upland rice varieties consists of 3 groups (the result of screening with PEG 6000), namely (tolerant varieties) consists of Inpago 9, Inpago 4, Inpago 8. (moderate varieties) which consists of Inpago 5, Situ Bangendit, Inpago7, Towuti, and (sensitive varieties) which consists of Inpari 6 JATE, Inpari 33 and Sintanur. Materials used are topsoil, manure, Phonska + Urea compound fertilizer dose (300 kg / ha + Urea 200 kg / ha), polybags size 40 cm x 50 cm. The tools used include: Soil pH and DM 15 Mouisture Tester, Digital Thermometer, Chlorophyll Meter SPAD, Spectrophotometer, meter, digital scales, label, signage and all the tools that support research. Drought stress causes decreased root weight, root crown ratio, proline content of leaves and total leaf chlorophyll, but led to increased root length. Results of the study showed avoidance mechanism varieties tolerant to drought stress in different ways varieties Inpago 4 through increasing root length, root weight, root crown ratio and the amount of leaf proline. Ciapus varieties through an increase in the amount of chlorophyll. Moderate varieties Inpago 7, situbangendit unidentified able to adapt to the conditions of drought stress on field capacity 20% and 40% on content of proline and root length. Susceptible Inpari varieties 6 jete and Inpari 33 gave the highest content of chlorophyll and proline.

Keywords: Upland Rice, Varieties, *Drought,* ***Root, Chlorophyll, Proline***

1. Introduction

Rice is the staple food for three billion people in Asia, where more than 90 percent of the world's population produces and consumes rice (Li and Xu, 2007). Serious threat faced in rice cultivation is the declining availability of water due to uncertain rainfall. Drought is the most important risk factor in determining the rainfed rice production (Pandey *et al*. 2007). Indonesia is also facing unavoidable climate change due to global warming and will have broad impact on many aspects of life, including the agricultural sector. Changes in rainfall patterns and rising temperatures lead to decreased agricultural production, flooding and drought caused crop acreage increasing experiencing puso (Sumaini *et al*, 2011). Drought is also a challenge for the development of drought-tolerant rice varieties (Zhao *et al*., 2008). The use of tolerant cultivars is the most promising strategy to minimize the effect of water deficit on growth and productivity of upland rice during the dry season (Kumar *et al*., 2008).

Strategy selection for specific genotypes suitable areas are needed to reduce the high risk in the face when conditions are not optimal climate change (Tardieu and Hammer, 2012). To anticipate these conditions, the development of upland rice production in rainfed field need to get serious attention given the low levels of genetic diversity and the limited adoption of improved varieties in farmers' fields which is one of the major problems in upland rice breeding programs are centralized. Nevertheless, it is still most likely be done in order to find the character of upland rice adaptive based on its typology environment. Loffler et al, 2005 .; Chapman, 2008; Chauhan *et al*., 2013 stated that environmental characterization that integrate weather, soil, crop, and management factors using simulation models of plants to identify environmental and characteristic patterns of stress (frequency and intensity) are necessary and useful in the strategy of breeding that targets the development of improved varieties that are tolerant against drought stress. Root system and physiology become important character in the drought conditions in which the ability of the roots to form roots and root penetration canopy height ratio is a component of the essential nature of the roots are related to Drought avoidace (Yamauchi et al. 1996; Samson et al., 2002). Physiological responses as well as one of the indicators that are important for plants to maintain turgor pressure lowering osmotic potential as a mechanism of tolerance to drought stress is the ability to accumulate dissolved compounds, especially proline and total leaf chlorophyll (Girousse at al, 1996; Szabadoz and Savoure 2009).

Upland rice varieties are a source of genetic material that can be used to study varieties that have drought stress tolerance characters. Nazirah et al (2014) reported some varieties have high levels of tolerance to drought stress upland rice and paddy rice, and there are three groups of varieties that are tolerant based on morphological characters they are Inpago 9, Inpago 4 and Inpago 8, furthermore, varieties in moderate group such as Inpago 5, situbangendit, Inpago 7 and Towuti while sensitive groups varieties are Inpari 6 jete, Inpari 33 and Sintanur.
This study aims to determine the efficiency of water use between cultivars and identify the character of rooting, physiological drought-tolerant upland rice.

2. Research Methodology

The experiment was conducted in a plastic house in North Aceh, in January 2015 until May 2015. The study design was split plot design with three replications, with two factors: The first factor is drought stress (C) consisting of 4 levels field capacity, namely: C1: 20% (300 ml / day), C2: 40% (600 ml / day), C3: 60% (900 ml / day) and the C4: 80% (1200 ml / day). The second factor is the 10 varieties of upland rice varieties consists of 3 groups (a result of screening with PEG 6000), namely (tolerant varieties) consists of Inpago 9, Inpago 4, Inpago 8. (moderate varieties) which consists of Inpago 5, Situ Bangendit, Inpago7, Towuti, and (susceptible varieties) which consists of Inpari 6 JATE, Inpari 33 and Sintanur. Materials used are topsoil, fertilizer, compound fertilizer Phonska + Urea (300 kg / ha + Urea 200 kg / ha), seed varieties of upland rice (screening results in previous trials) polybag size 40 cm x 50 cm. The tools used include: Soil pH and DM 15 Mouisture Tester, Digital Thermometer, Chlorophyll Meter SPAD, Spectrophotometer, meter, digital scales, label, signage and all the tools that support research.

3. Data analysis procedures

The experimental data were analyzed using analysis of variance at the level of the test $\alpha = 0.05$ and further analysis using test Duncan's Multiple Range Test (DMRT). Data is processed using SAS statistical program Windows version (Version 9.1).

4. Work Procedures

4.1 Soil preparation

Top soil land is wind dried and pulverized. Soil is sieved with a 3 mm sieve, and then soil is inserted into 10 kg per polybag. Land used in this project is previously analyzed its physical and chemical properties in the laboratory. The initial step before the study is to determine the condition of field capacity by using the gravimetric method. This method is done by spraying water on medium until saturated, and left until the water stops dripping from the polybag. Planting medium are first wind dried and pulverized and sieved by 2 mm size sieve. Smooth soil is later mixed with cow manure at a dose of 10 tonnes per ha, compound fertilizer Phonska + Urea (300 kg / ha + Urea 200 kg / ha). Finally the media is inserted into a poly bag with the size of 35 cm x 40 cm.

4.2 Plant Material Preparation

For uniformity of germination, seeds are heated in the oven for 72 hours at a temperature of 43 0C. After roasting process, seeds are weighed as much as 35 g of each of the varieties of rice seeds then soaked in a mixture of Dithan M 45 as much as 2 g / l and Curater 2G as much as 0.1 grams.

Dithan M 45 is necessary to prevent late blight. While 2G Curater needed to prevent pests found in the soil such as worms and bedbug ground. The mixture of seed treatment plus enough water then put rice seed and soaked for 24 hours. 5-6 seeds that have undergone treatment are inserted in the soil as deep as 2-3 cm per polybag.

4.3 Thinning

Thinning is done taking 2 MST then later select one left one homogeneous and the best growth plant per polybag.

4.4 Maintenance

Maintenance of the plant includes the eradication of pests and diseases is done by using baycarb insecticide with a concentration of 0.5 to 1 l / ha. Frequency of spray is conducted in accordance with the state of pests and diseases. Weeds growing in polybags are revoked intensively.

4.5 Watering

Watering is given every morning as much as 4 mm / day prior to the drought treatment. Treatment drought

4.6 Drought Treatment

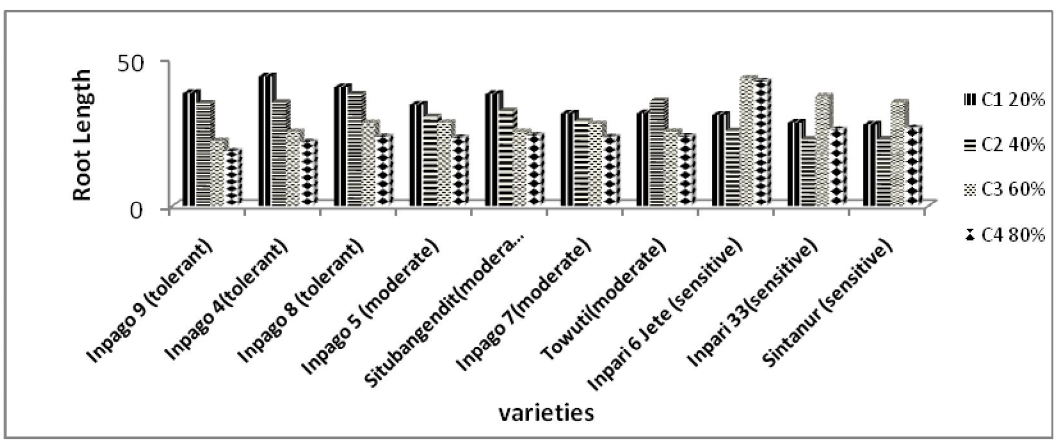
Drought treatment began at 4 weeks of plant age to harvest by providing water by gravimetric method. To monitor water level, densitometers is used and the amount of groundwater is controlled in accordance with the treatments. Water in each treatment plot was added in accordance of water lost.

5. Result and Discussion

5.1 Root Length (cm)

Water stress treatment given cause variations in each group of varieties and describes the ability to reach the water in the deeper layers by extending root crop which is a mechanism in the face of drought stress. Figure 1 shows a group of tolerant varieties root length was seen in 20% of field capacity (C1). A group of moderate length varieties of the highest root varieties Inpago 5, situbangendit and Inpago 7 also the longest at 20% field capacity while at 40% field capacity (C2) while the longest susceptible varieties Inpari 6 jete at 60% field capacity (C3). Differences in root systems of tolerant, moderate and sensitive upland rice shows variation of root length character. Tolerant varieties showed the longest roots in water conditions in a state of water deficit of 20% field capacity (C1) while sensitive groups adapted to the conditions of excess water at field capacity of 60% (C3). Growda et al (2011) states in addition to the differences in the status of water in farming systems also occur differences in root growth and adaptation to drought. 4 Inpago varieties of tolerean group had the longest roots are 44.33 cm compared with varieties of other groups. Suprihatno et al, 2011 stated the advantages of varieties Inpago 4 adatif in unfavorable environmental conditions. In addition, one form of adaptation to drought is the root of the elongation of roots and root expansion (Fukai and Cooper 1995; Serraj et al. 2004).

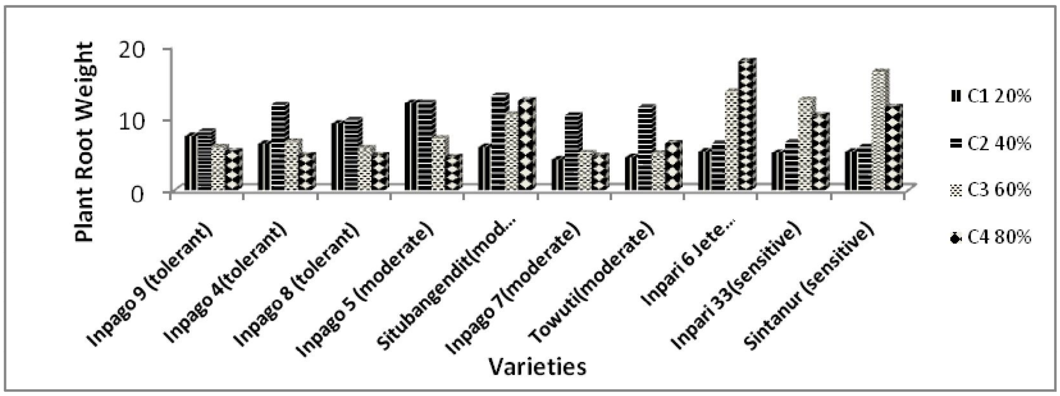
Figure 1: Effect of Length of Root Due to Water stress on the Upland Rice Variety



5.2 Plant Root Weight

Figure 2. Weight of roots in three groups showed tolerant varieties group and the moderate group had the highest root weight at 40% field capacity (C2) and the lowest for the two groups of tolerant and moderate varieties Inpago 5 and Inpago 7 looks at field capacity of 80% (C4). For susceptible groups varieties Inpari 6 jete is seen the highest dry weight at 80% field capacity (C4) Inpari 33 and Sintanur best at 60% field capacity (C3) and the lowest was at 20% field capacity (C1). Results showed tolerant varieties and moderate varieties were given excessive water conditions at 80% field capacity (C4) will lower root dry weight but in the best condition sensitive groups on field capacity of 80% (C4) and a 60% field capacity (C3). Group tolerant varieties Inpago 4 and followed by moderate situbangendit varieties have good vigor on the ground layer that root dry weight increased even though the water situation is in the state of deficit. Asch et al (2005) reported the varieties that are relatively tolerant will enhance root growth greater in drought conditions so that the ability to form branching and root hairs better on-tolerant varieties compared to varieties susceptible (Serraj et al 2004) reported that roots response to drought stress will increase the depth of the roots and the achievement of broader development of roots.

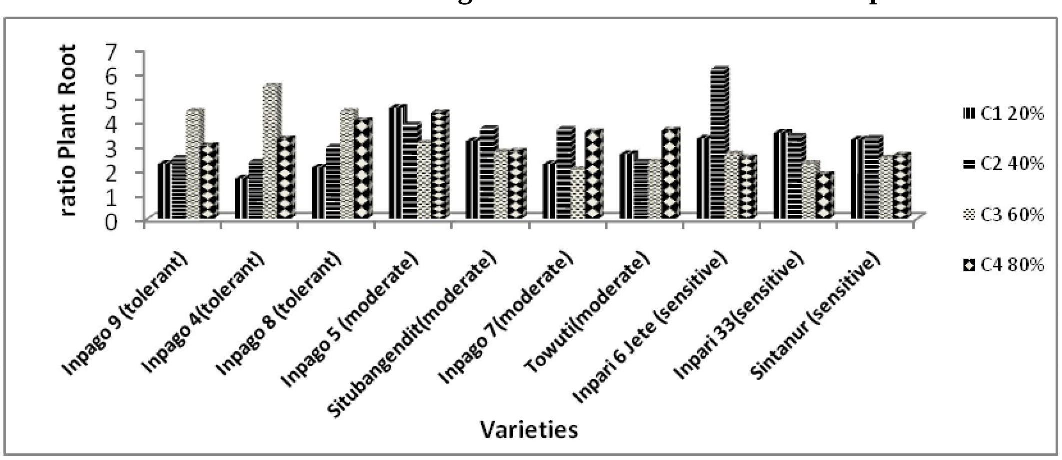
Figure 2: The Effect of Plant Root Weight Due to Water Stress on Upland Rice Varieties



5.4 Ratio Plant Root

Figure 3. Drought stress caused a decrease in crown root ratio, at the tolerant group varieties of 20% of field capacity (C1) shows the lowest root crown ratio. A decline in moderate group varieties occurred in 60% of field capacity (C3) susceptible group varieties on 20% field capacity (C1), a decrease in crown root ratio and an increase in 40% field capacity (C2) and 20% (C1). This shows the increasing growth of the upper part of the plant (canopy) and vice versa stunted root growth, thus causing the value ratio higher and vice versa crown root ratio lower value indicates greater root growth than the canopy. Saragih, (2010) Stated that the inpago 4 varieties are very adaptive to bad environment such as water shortages during cultivation time so it will not interfere with the formation and growth of rice.

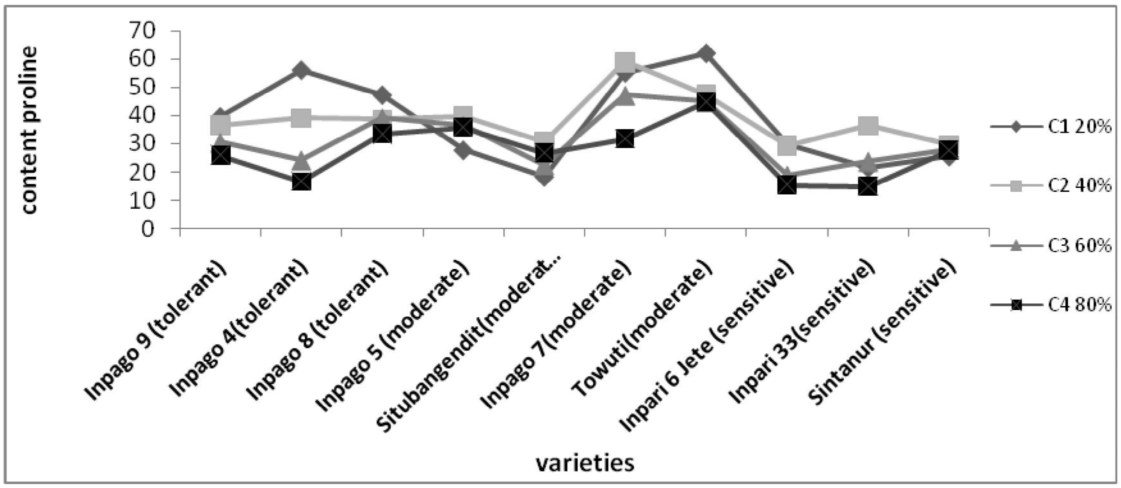
Figure 3: The Effect of Plant Root Heading Ratio Due to Water stress on Upland Rice Varieties



5.5 Number of Leaf Proline

Increased accumulation of proline as a result of drought, especially in the treatment of 20% field capacity (C1), increasing crop proline is a mechanism to deal with drought stress conditions. Increased proline not only occur in groups of tolerant varieties, but also on some groups of moderate varieties, a decrease in the accumulation of proline at 80% field capacity (C4). Figure 4. This identifies that a more tolerant varieties accumulate proline compared to susceptible varieties when exposed to drought stress. 4 Inpago varieties of groups and varieties tolerant Towuti moderate group has a good potential to adapt to conditions of water shortages and identified resistant to drought. Accumulation plant proline is a mechanism when facing drought stress, proline subsequent role in maintaining osmotic pressure (osmotic adjustment). Osmotic adjustment increase resilience to drought resistance by maintaining plants turgor, but increased concentration of proline in plant cells requires considerable energy. According to Fukai and Cooper (1995) is described as a source of N for formation of proline especially from the leaf protein degradation. Bohnert and Jensen (1996) suggest that the accumulation of proline can function as osmotic adjusmen and store carbon and nitrogen, in the event of drought stress.

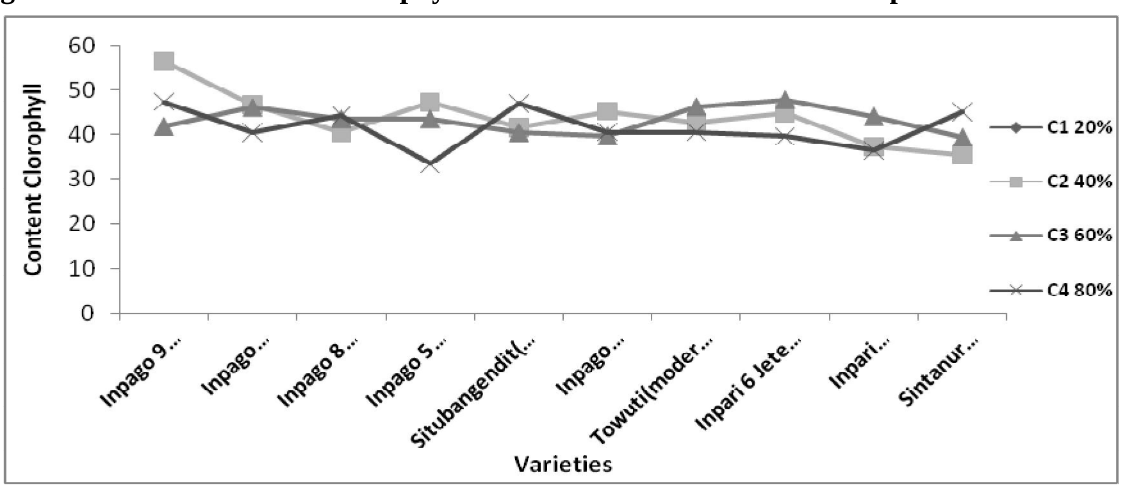
Figure 4: The Effect of Proline content Due to Water Stress on Upland Rice Varieties



5.6 content chlorophyll

Pictures 5. Water drought caused a decrease in chlorophyll content. Chlorophyll is the main component of chloroplasts for photosynthesis and chlorophyll content relatively associated with photosynthesis. The results showed a decrease in chlorophyll content in water conditions 20% (C1) which is a symptom of oxidative caused by pigment photooxidation and the oxidative caused by pigment fotooksidatif and degradation of chlorophyll (Verma et al, 2004; Farooq et al. 2009). Most chlorophyll can be found in Ciapus varieties on 40% field capacity (C2) and the lowest at 5 Inpago varieties on 80% field capacity (C4). Ciapus varieties are new varieties (VUB) iand adapt well in the highlands and had a green leafy character.

Figure 5: The Effect of leaf chlorophyll content Due to Water Stress on Upland Rice Varieties



Conclusion

1. Water stress causes decreased in root weight, root crown ratio, proline content of leaves and total leaf chlorophyll. But led to increased root length.
2. Tolerant variety show avoidance mechanisms to drought stress in different ways varieties Inpago 4 through increasing root length, root weight, root crown ratio and the amount of leaf proline. Ciapus varieties through an increase in the amount of chlorophyll.
3. Moderate variety Inpago 7, situbangendit is identified to be able to adapt to the conditions of drought stress on field capacity 20% and 40% on content of proline and root length
4. Sensitive variety Inpari 6 jete and Inpari 33 gave the highest content of chlorophyll and proline

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