Roots Bioassay of Upland Rice Varieties on Several Soil Moisture Gradients

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Abstract
Water availability is a major factor affecting rice production especially in upland. The Production of upland rice is low because of the low of water availability in upland. Roots play an important role in upland rice adaptation to drought conditions. This study aimed to identify the characteristic of upland rice variety root development under soil moisture gradients. This study use randomized factorial design consisting of 2 factors and 3 replicate. Factor I : 12 upland rice variety, ie: Silumut, Batutegi, Limboto, Situpatenggang, Situbagendit, Towuti, Cirata, Danau Gaung, Gajah Mungkur, Inpago 4, Inpago 5, Inpago 6. Factor II : gradien of soil moisture level, ie: 20 %, 40 %, 60 %, 80 % field capacity. The Result of research indicate all the upland rice variety were classified tolerance based on relative value of root leght. The highest root lenght and the heaviest root dry matter were generally from combination uplandrice varieties with 60 & 80 % field capacity except Inpago 4 and Situbagendit showed the highest root lenght at 20 % field capacity and combination The heaviest root dry matter at 40 % were Inpago 4 and Jatiluhur generally from characteristic of root gro field capacity.
Key words : root lenght, root dry matter, relative value, upland rice, tolerance.

Introduction

Upland rice is one important plant in upland area. National production of upland rice was 2.4 million tonnes that was still lower compared with lowland rice which reached 54.4 million tons (Puslitbang Tanaman Pangan, 2007). Upland rice production can be improved by expansion the new upland rice planted area, increased the yield per hectare, and the reduction of yield losses due to biotic and abiotic stresses (Las *et al*, 2008).

The important subject to increase rice production was formed the plant material with resistance to drought. There are two main mechanisms of plant resistance to drought which plants avoid drought (Drought avoidance) and (2) plants tolerate drought (Drought tolerance). The ability of plants to avoid from the drought is a strategy that is more relevant to avoid drought and improve the appearance of the plant before the survivability of drought-formed (Serraj *et al*., 2009) while the drought tolerance is more important for plants to survive the severe drought. The ability of plants to avoid drought is mainly concerned with the characteristics of roots like as deep root, root thin and ability to penetrate deep roots (Kamoshita *et al*., 2002, Kato *et al*., 2006, Nguyen *et al*., 2004; Subere *et al*., 2009; Zhang *et al*. 2001).

Materials and Methods

This study was conducted in green house of agriculture faculty Methodist University. This study used a randomized factorial design with two factors and 3 replications. The first experiment consisted 12 upland rice varieties were Silumut, Batutegi, Limboto, Situpatenggang, Situbagendit, Towuti, Cirata, Danau Gaung, Gajah Mungkur, Inpago 4, Inpago 5, Inpago 6. All the upland rice varieties derived from ICRR Sukamandi, expect Si Lumut was a local Sumatera varieties. The second experiment consisted four level of soil moisture gradient were namely 20%, 40%, 60%, 80% of field capacity.

Soil used in this study collected from BMKG Sampali Medan field research. Soil sample was taken for physical and chemical properties analysis. The amount of water added determined by gravimetri methods. Soil dried for a week, and then sieved with 2 mesh for cleared the debris and dirt. Then soil was weight five kg and put in polybag.

Rice seeds are soaked in a mixture of 2 g Dithane M 45 and 0,1 g Curater 2G. Upland rice varieties grown by 5 seed per polybag and the water added at 80% field capacity until two weeks after planting. Soil moisture gradient treatment began at two weeks after planting, according to treatment of 20%, 40%, 60%, 80% of field capacity. At the age of 30 HST, plant roots are removed and measured development include root length, and root dry weight.

Results and Discussion

Growth of Root Lenght and Root Dry Matter

Research result showed significant variation for interaction between upland rice varieties and soil moisture gradient on root lenght and root dry matter. The average of root lenght can be seen at Table 1. The highest value of root lenght was 43,67 cm from combination of Inpago 6 and 60 % field capacity, which had significantly different with all other treatment combinations except with combination of Inpago 4 and 20 % field capacity. While the shortest value of root lenght was combination of Situbagendit and 20 % field capacity. In general, the highest root length comes from combination of each varieties with 60 % field capacity (Danau Gaung, Inpago 6, Limboto, Towuti) and 80% field capacity (Batutegi, Inpago 5, Jati Luhur, Situpatenggang). Only Inpago 4 and Situbagendit showed the highest root lenght at combination with 20 % field capacity.

Table 1. Root Lenght of Upland Rice Varieties at 30 days After Planting on Several Soil Moisture Gradient

Varietas	Root Lenght (cm)				Average V
	K_1 (20% FC)	K_2 (40% FC)	K_3 (60% FC)	K_4 (80% FC)	
V_1 (Batutegi)	24.33 c-h	23.17 c-h	25.00 c-h	26.00 c-f	24.63
V_2 (Danau Gaung)	20.50 c-h	28.00 bc	27.83 cd	25.17 c-g	25.38
V_3 (Gajah Mungkur)	20.17 c-h	22.33 c-h	27.00 cde	24.33 c-h	23.46
V_4 (Inpago 4)	38.17 ab	25.00 c-h	22.50 c-h	25.83 c-f	27.88
V_5 (Inpago 5)	18.83 c-h	19.17 c-h	18.67 c-h	20.83 c-h	19.38
V_6 (Inpago 6)	21.50 gh	19.33 d-h	43.67 a	27.83 fgh	28.08
V_7 (Jatiluhur)	19.83 c-h	20.00 c-h	22.83 c-h	24.17 c-h	21.71
V_8 (Limboto)	15.00 c-h	17.67 c-h	18.00 c-h	15.83 cd	16.63
V_9 (Silumut)	17.00 e-h	23.67 c-h	18.17 c-h	23.50 c-h	20.58
V_{10} (Situbagendit)	23.83 c-h	16.00 fgh	14.83 h	21.67 c-h	19.08
V_{11} (Situpatenggang)	26.33 c-h	24.83 c-h	23.00 c-h	27.17 c-h	25.33
V_{12} (Towuti)	16.50 fgh	21.00 c-h	21.50 c-h	21.00 c-h	20.00
Average K	21.83	21.68	23.58	23.61	

Note : Data in the same column followed by the common letters are not significantly different at the P= 0.05 level according to the Duncan's Multiple Range Test

Understanding the root functional traits is needed for plant strategies to increase crop productivity under different drought conditions. Root traits associated with maintaining plant productivity under drought include small fine root diameters, long specific root length, and considerable root length density, especially at depths in soil with available water. Screening of root traits at early stages in plant development can proxy traits at mature stages but verification is needed on a case by case basis that traits are linked to increased crop productivity under drought (Comas *et al.*, 2013).

Upland rice has a deeper root in direct sowing system than transplanting rice in field rice. Cultivation method affected root system. Rice rooting has limited absorb water at a depth of more than 60 cm below the soil surface (Tuong *et al.,* 2002), upland rice in direct sowing system has a deeper root system than the root system of transplanting rice in rice field.

The average of root dry matter can be seen at Table 2. The heaviest value of root dry matter was 0,33 g from combination of Limboto and 80 % field capacity, which had significantly different with all other treatment combinations. While the lightest value of root matter was combination of Inpago 5 and 20 % field capacity. In general, the heaviest root dry matter comes from combination of each varieties with 60 % field capacity (Batutegi, Danau Gaung, Gajah Mungkur, Towuti) and 80% field capacity (Inpago 5, Inpago 6, Limboto, Si Lumut, Situbagendit , Situpatenggang). Only Inpago 4 and Jatiluhur showed the heaviest root lenght at combination with 40 % field capacity.

Suralta *et al*, (2010) research results found that utilization of CSSLs could precisely reveal that root plastic development in response to transient soil moisture stresses contributed to the maintenance of shoot dry matter production. The root system can improve the distribution of roots in the soil (Siopongco *et al*., 2005) and absorb water more efficiently under conditions of limited water. Root systems have a positive contribution to the production of dry matter through the addition of a total length of roots and water absorption, especially in mild water stress conditions.

Table 2. Root Dry Matter of Upland Rice Varieties at 30 Days After Planting on Several Soil Moisture Gradient

Varieties	Root Dry Matter (g)				Average V
	K_1 (20% FC)	K_2(40% FC)	K_3(60% FC)	K_4(80% FC)	
V_1 (Batutegi)	0.08 i	0.20 d	0.22 c	0.20 d	0.18
V_2 (Danau Gaung)	0.08 i	0.23 c	0.28 b	0.20 d	0.20
V_3 (Gajah Mungkur)	0.15 f	0.12 g	0.20 d	0.17 e	0.16
V_4 (Inpago 4)	0.23 c	0.27 b	0.23 c	0.20 d	0.23
V_5 (Inpago 5)	0.07 i	0.13 g	0.13 g	0.22 c	0.14
V_6 (Inpago 6)	0.10 h	0.08 i	0.13 g	0.17 e	0.12
V_7 (Jatiluhur)	0.08 i	0.18 e	0.15 f	0.17 e	0.15
V_8 (Limboto)	0.15 f	0.15 f	0.12 g	0.33 a	0.19
V_9 (Silumut)	0.08 i	0.17 e	0.13 g	0.27 b	0.16
V_{10} (Situbagendit)	0.08 i	0.17 e	0.10 h	0.23 c	0.15
V_{11} (Situpatenggang)	0.25 c	0.27 b	0.27 b	0.28 b	0.27
V_{12} (Towuti)	0.08 i	0.17 e	0.27 b	0.23 c	0.19
Average K	0.12	0.18	0.19	0.22	

Note : Data in the same column followed by the common letters are not significantly different at the P= 0.05 level according to the Duncan's Multiple Range Test

Relative Value of Root Lenght

Based on vegetative growth of upland rice varieties in several soil moisture gradient, the optimum growth achieved at 80 % field capacity water application and its defined as the normal condition, furher growth at 20 % field capacity level defined as the stress condition. Tolerance classification of upland rice varieties based on relative value of Root lenght can be seen in Table 3.

All of upland rice varieties used in this study had relative value of root lenght above 50 %, and there were two varieties like Inpago 4 and Situbagendit which had relative value above 100 %. Based on relative value of root lenght, varieties can be classified tolerance if its value above 50 %, and sensitive if its value below 50 %.

Table 3. Tolerance Classification of Upland Rice Varieties at 30 Days After Planting Based on Relative Value of Root Lenght

Varieties	Root lenght (cm)		Relative value (%)	Criteria
	20% Field Capacity Stress Condition	80% Field capacity Normal Condition		
V_1 (Batutegi)	24.33	26.00	0.94	Tolerance
V_2 (Danau Gaung)	20.50	25.17	0.81	Tolerance
V_3 (Gajah Mungkur)	20.17	24.33	0.83	Tolerance
V_4 (Inpago 4)	38.17	25.83	1.48	Tolerance
V_5 (Inpago 5)	18.83	20.83	0.90	Tolerance
V_6 (Inpago 6)	21.50	27.83	0.77	Tolerance
V_7 (Jatiluhur)	19.83	24.17	0.82	Tolerance
V_8 (Limboto)	15.00	15.83	0.95	Tolerance
V_9 (Silumut)	17.00	23.50	0.72	Tolerance
V_{10} (Situbagendit)	23.83	21.67	1.10	Tolerance
V_{11} (Situpatenggang)	26.33	27.17	0.97	Tolerance
V_{12} (Towuti)	16.50	21.00	0.79	Tolerance

Conclusions

All the upland rice variety were classified tolerance based on relative value of root leght. The highest root lenght and the heaviest root dry matter were generally from combination uplandrice varieties with 60 & 80 % field capacity except Inpago 4 and Situbagendit showed the highest root lenght at 20 % field capacity and combination The heaviest root dry matter at 40 %were Inpago 4 and Jatiluhur generally from characteristic of root gro field capacity.

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