THE TOLERANCE LEVEL OF PADDY TO LOW NUTRIENT STRESS OF SWAMP LAND

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ABSTRACT

One of the growth constraints in swamp land is low nutrient stress, and the most efficient thing to do for cultivated is by using abiotic stress tolerant varieties. The efficiency could be measured from the reduction of nutrient input, therefore it is very important to know the tolerance level of paddy varieties to low nutrient stress of swamp land. This studi carried out nine months from September 2016 to May 2017. This study was conducted at the Experimental Station of the Faculty of Agriculture of IBA University in Palembang. The experiment was using Factorial Random Designs. The factors studied were paddy varieties: Ciherang, Indragiri, IPB 1R and IPB 6R, and low nutrient conditions: 40%, 50%, 60% and 100% of recommended doses using by farmer at swamp land (300 kg urea ha^{-1}, 100 kg SP-36 ha^{-1} and 150 kg KCl ha^{-1}). This experiment was carried out in pots (45 × 55 cm) containing 15 kg of type-B swamp lands from Bunga Karang Village, Tanjung Lago Subdistrict of Banyuasin Regency, South Sumatera Province. Plant media height was 50 cm. The result showed that at low nutrient stress, Indragiri variety was taller, and its number of productive tillers was higher than Ciherang, IPB 1R and IPB 6R. The rooting growth of IPB 6R and IPB 1R was higher than Ciherang and Indragiri. The tolerance level of plant to nutrient reduction is up to 50% reduction of nutrients. The giving of 40% recommended dosage caused plant growth and production barriers, but increases root component growth.

Keywords*:* low nutrient stress, paddy, swamp land, tolerance level

INTRODUCTION

The development of adaptive paddy varieties of suboptimal land such as swamp land needs information regarding the tolerance level of plants to abiotic stress of suboptimal land. Knowledge of this will help researchers in their development and farmers in their utilization. It is important that dissemination of technology innovation of wetland paddy cultivation can reach the target and expectation, that is increase of productivity and contribution of suboptimal land in achieving national food resilience and sufficiency from domestic production.

The most efficient approach in suboptimal land use for agriculture is by using abiotic stress tolerant varieties (Sobir, 2013). There are many constraints on paddy cultivation in swamplands, once is low nutrient stress, both macro and micro nutrients. It is because the characteristics of specific land, the influence of sea water intrusion, soil acidity and others. The influence of abiotic stress is one of the main limiting factors of growth, and production in the swamp (tidal) land.

Therefore, it is important to know the tolerance level of paddy to low nutrient stress of suboptimal land (Kesmayanti & Purwanto, 2017).

Low nutrient tolerant plants in nutrient utilization will have the ability to grow, develop and produce higher yields on nutrient deficiency than other plants (Presterl *et al.*, 2003). In order, to obtain tolerant plants to nutrient deficient stress, so identification and selection of a number of plant genotypes by comparing plants in nutrient deficiency and optimal nutrient conditions should be identified. The result would explain genetically the ability of nutrient use in sub-optimal and optimal conditions (Kant & Kafkafi, 2004). In nutrient-deficient conditions, tolerant plants will have higher photosynthesis, growth and production rates than intolerant plants (Lambers *et al.*, 2008). Research showed that the tolerant plants had better growth rate (Kesmayanti *et al.*, 2012a) which was reflected among others on net assimilation rate, relative growth rate, leaf area and plant weight (Kesmayanti, 2013).

In low-input farming systems, macro nutrient N,P,K becomes the most limiting element of growth and production. Thus, the cultivation of plant that are genetically tolerant and efficient in nutrient use is the most appropriate choice. This plant will tolerant to low nutrient, and has a tolerance mechanism by development of root system. The development of root will increase the area of absorption and the efficiency of water and nutrient uptake (Ramaekers *et al.*, 2010). The research results also show an increase in root growth plants that are tolerant to low nutrients (Kesmayanti, 2012b and Kesmayanti, 2013).

So, it is very important to conduct this research to determine the tolerance level of paddy to low nutrient stress of swamp land. This research result could be use as the basic treatment for identified and selection a number of paddy varieties to low nutrient stress of swamp land. This knowlegde of low nutrient tolerants paddy varieties would be very useful in the selection of adaptive varieties that will be cultivated on low nutrient condition of swamp land

MATERIALS AND METHODS

These research was conducted in September 2016 until May 2017, located in Experimental Station, Botanical and Plant Physiology Laboratory of Faculty of Agriculture IBA University, in Palembang. Studied using Factorial Random Block Design, three replications. The first factor was paddy varieties (Ciherang, Indragiri, IPB 1R and IPB 6R). The second was low nutrient conditions: 40%, 50%, 60% and 100% recommended doses (300 kg urea ha^{-1}, 100 kg SP-36 ha^{-1} and 150 kg KCl ha^{-1}). These experiment was conducted in pots (55×45 cm) containing 15 kg of type B swamp land soil from Bunga Karang Village, Tanjung Lago Sub-district of Banyuasin Regency, South Sumatera Province.

Plant media height was 50 cm, that before used 5 ton ha^{-1} of chicken manure and 2 ton ha^{-1} of lime dolomite was mixed. The pots were arranged on a planting table in a plastic roofed house and walled. Two weeks before planting, media was flooded with water 5 - 7 cm. It was replaced daily to reduce the effects of toxic elements. Two days before planting the waters height reduced to 2 - 3 cm. Seedlings were planted after two weeks of nursery. Each pot was planted with one plant with a depth of 5 - 10 cm. Nitrogen fertilizer given three times: 50% at 7 dap, 25% at 20 dap and 25% at 40 dap. Phosphorus and potassium given twice: 50% at planting and 50% at 20 dap. Dosage of 100% N,P,K fertilizer given based on recommended dosage. N1 = 300 kg urea ha^{-1}, P1

= 100 kg SP-36 ha^{-1} and K1 = 150 kg KCl ha^{-1}. The dosage of 60% NPK was N2 = 180 kg urea ha^{-1}, P2 = 60 kg SP-36 ha^{-1} and K2 = 90 kg KCl ha^{-1}. The dosage of 50% NPK was N3 = 150 kg urea ha^{-1}, P3 = 50 kg SP-36 ha^{-1}, K3 = 75 kg KCl ha^{-1}. The dosage of 40% NPK was N4 = 120 kg urea ha^{-1}, P4 = 40 kg SP-36 ha^{-1}, and K4 = 60 kg KCl ha^{-1}. The growth characters observed were plant height, number of productive tiller, canopy weight, panicle weight per hill, root weight, root-shoot ratio, and root length.

RESULTS AND DISCUSSION

Results

Plant Height

The interaction of varieties and low nutrient stress had significant effect on plant height. The highest is Indragiri 100% nutrient, that isnot different to IPB-1R-at all nutrient levels and Indragiri-50%. But significantly different from all other treatment interactions (Table 1). There was a decrease of plant height of all varieties at low nutrient stress. The highest percentage of decrease was measured at 40% nutrient: 8.68% in Ciherang, 7.90% in Indragiri, 4.47% in IPB 1R and 4.38% in IPB 6R (Figure 1).

Tabel 1. Plant height (cm), number of productive tillers, canopy weight (g) and panicle weight per hill of paddy Ciherang, Indragiri, IPB-1R and IPB-6R varieties on low nutrient stress of swamp land

Paddy Varieties	Nutrient deficiency				Average
	100%	60%	50%	40%	
			Plant height		
Ciherang	132.5 b	130.83 ab	127.17 ab	121.00 a	127.88 a
Indragiri	156 d	138.83 bc	145.5 cd	143.67 c	146.00 c
IPB-1R	154.67 d	153.33 d	149.75 cd	147.75 cd	151.38 d
IPB-6R	137.08 bc	132.25 b	131.52 ab	131.08 ab	132.98 b
Average	145.06 b	138.81 a	138.49 a	135.88 a	
			Number of productive tillers		
Ciherang	13.58 b	9.00 a	9.92 ab	10.08 ab	10.65 a
Indragiri	27.08 d	20.58 c	18.67 c	19.92 c	21.56 c
IPB-1R	12.88 b	12.83 b	12.75 b	11.50 ab	12.49 b
IPB-6R	14.08 b	11.67 ab	12.25 ab	9.92 ab	11.98 ab
Average	13.58 b	9.00 a	9.92 a	10.08 a	
			Canopy weight		
Ciherang	216.30 ab	152.13 a	162.13 a	143.80 a	168.59 a
Indragiri	303.80 b	215.47 ab	217.13 ab	197.13 a	233.38 d
IPB-1R	221.30 ab	179.63 a	197.13 a	178.80 a	194.22 bc
IPB-6R	232.97 ab	208.80 a	217.13 ab	164.63 a	205.88 c
Average	243.59 c	189.01 a	198.38 b	171.09 a	
			Panicle weight per hill		
Ciherang	51.44 ab	43.78 ab	43.11 a	34.94 a	43.32 a
Indragiri	56.03 b	44.61 ab	43.11 a	39.19 a	45.74 ab
IPB-1R	54.78 b	48.94 ab	48.53 ab	47.28 ab	49.88 b
IPB-6R	56.44 b	49.36 ab	52.53 b	41.86 ab	50.05 b
Average	54.67 c	46.67 b	46.82 b	40.82 a	

Remarks: Numbers followed by the same letter on the same parameter are not significantly different ($P<0.05$)

Number of Productive Tillers

The interaction of varieties and low nutrient stress had significant effect on the number of productive tillers. Number of productive tillers of Indragiri variety on optimal and lower nutrient more and significantly different with Ciherang, IPB 1R and IPB 6R. Number of productive tillers at 60%, 50% and 40% are not different, but different and fewer than 100% (Table 1). There was a decrease in the number of productive tillers at low nutrient stress condition (Figure 1).

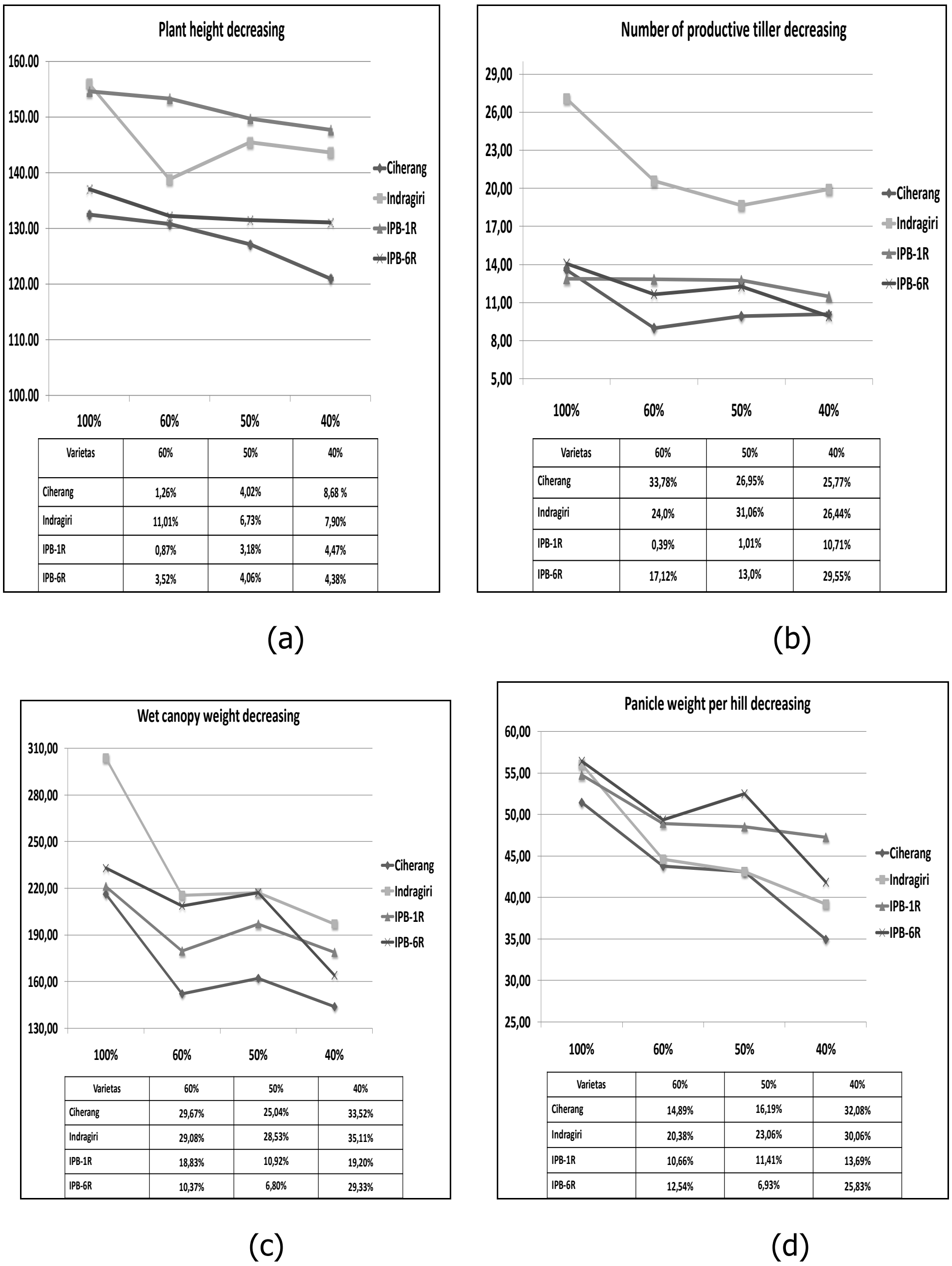


Figure 1. The decreasing of : a. plant height, b. number of productive tiller, c. canopy weight, d. panicle weight per hill of paddy Ciherang, Indragiri, IPB-1R and IPB- 6R varieties on low nutrient stress of swamp land

Canopy Weight

The interaction of varieties and low nutrient stress had significant effect on the weight of the canopy. The highest optimum varieties of Indragiri-nutrient canopy varieties were not significantly different with IPB-1R and IPB 6R-nutrient at optimal and Indragiri-60% and 50% low. The higher of wet canopy is on optimum nutrients (Table 1). There is a decrease of canopy weight in the low nutrient stress condition (Figure 1).

Panicle Weight per Hill

The interaction of varieties and low nutrient stress significantly was affected the panicle weight per hill. The weight of panicles per hill of IPB-6R and IPB-1R varieties on the optimum nutrient is highest and relatively not different to low nutrients, also to Indragiri and Ciherang in optimum and 60% of nutrient. Optimal nutrient conditions yielded the highest average panicle weight per hill, and differed significantly with panicle weight per hill at low nutrient stress (Table 1). There was a decrease of panicle weight per hill at low nutrient stress condition (Figure 1).

Root Weight

Root weights were influenced by the interaction of varieties and low nutrient stress. The varieties of IPB-6R and IPB-1R have the highest average root weight. At low nutrient stress (40% N,P,K) the plant has highest average of root weight and is significantly different from other nutrient deficiency treatments (Table 2). There was an increase of the average root weight at low nutrient conditions (Figure 2).

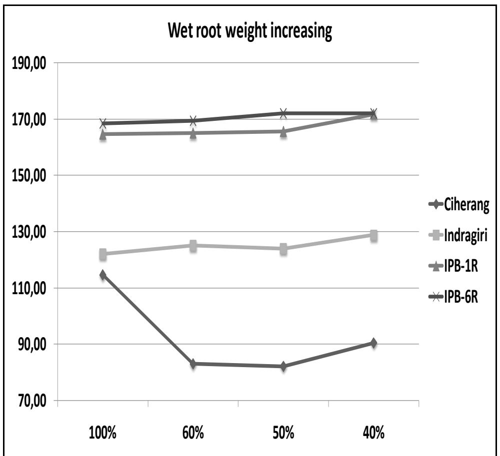
Tabel 2. Root weight (g), root lenght (cm), and root-shoot ratio of paddy Ciherang, Indragiri, IPB-1R and IPB- 6R varieties on low nutrient stress of swamp land

Paddy Varieties	Nutrient deficiency				Average
	100%	60%	50%	40%	
			Root weight		
Ciherang	114.63 ab	82.97 a	82.13 a	90.47 a	92.55 a
Indragiri	122.13 abc	125.13 abc	123.97 abc	128.80 abc	125.01 b
IPB-1R	164.63 bc	165.03 bc	165.63 bc	171.80 bc	166.77 c
IPB-6R	168.47 bc	169.47 bc	172.13 bc	172.23 bc	170.55 c
Average	142.47	135.65	135.97	140.80	
			Root lenght		
Ciherang	39.23 a	37.23 a	33.80 a	40.40 a	37.665 a
Indragiri	34.65 a	38.81 a	39.98 a	42.50 ab	38.985 a
IPB-1R	42.10 ab	40.86 a	42.06 ab	47.00 b	43.005 b
IPB-6R	44.90 b	47.06 b	46.56 b	50.66 b	47.295 c
Average	40.22 a	40.99 a	40.60 a	45.14 b	
			Root-shoot ratio		
Ciherang	0.53 ab	0.55 ab	0.51 ab	0.63 ab	0.55 a
Indragiri	0.40 a	0.58 ab	0.57ab	0.65 ab	0.55 a
IPB-1R	0.74 b	0.92 bc	0.84 bc	0.96 bc	0.87 b
IPB-6R	0.72 b	0.81 bc	0.79 bc	1.05 c	0.84 b
Average	0.60 a	0.71 a	0.68 a	0.82 b	

Remarks: Numbers followed by the same letter on the same parameter are not significantly different (P<0.05)

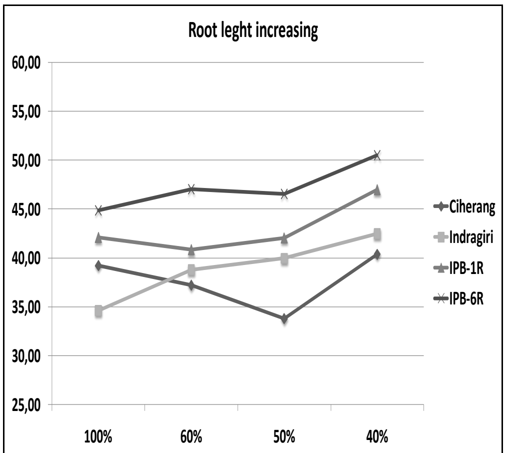
Root Lenght

Root length was affected by the interaction of varieties and low nutrient stress. The IPB-6R variety has the longest root which is not significantly different from IPB-1R, but different from Ciherang and Indragiri. At low nutrient stress (40% N,P,K) the plant has the highest average of root length and significantly different from other nutrient deficiency treatments (Table 2). There was an increase of root length at low nutrient conditions (Figure 2).



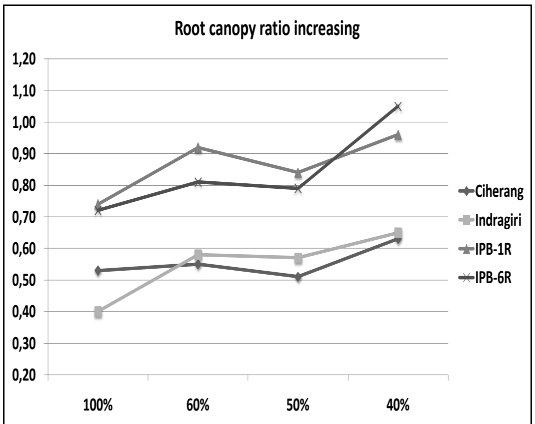
Varietas	60%	50%	40%
Ciherang	-27,62%	-28,35%	-21,08%
Indragiri	2,46%	1,51%	5,46%
IPB-1R	0,24%	0,61%	4,36%
IPB-6R	0,59%	2,17%	2,17%

(a)



Varietas	60%	50%	40%
Ciherang	-4,79%	-3,65%	8,08%
Indragiri	12,01%	15,38%	22,66%
IPB-1R	-2,95%	-0,1%	11,64%
IPB-6R	4,81	3,70%	12,83%

(b)



Varietas	60%	50%	40%
Ciherang	2,91%	-4,41%	18,71%
Indragiri	29,67%	42,02%	62,53%
IPB-1R	29,08%	12,94%	29,16%
IPB-6R	18,83%	9,63%	44,59%

(c)

Figure 2. The increasing of: a. wet root weight, b. root leght, c. root-shoot ratio of paddy Ciherang, Indragiri, IPB-1R and IPB- 6R varieties on low nutrient stress of swamp land

Root-Shoot Ratio

The root-shoot ratio was influenced by the interaction of varieties and low nutrient stress. In low nutrient stress, IPB-6R has the highest root-shoot ratio and is not significantly different from IPB-1R, but higher than Indragiri and Ciherang. At low nutrient stress (40% N,P,K) the plant has highest average of root-shoot ratio and significantly different from other nutrient deficiency treatments (Table 2). There was an increase root-shoot ratio at low nutrient conditions (Figure 2).

Discussion

These research showed that plant had decrease of top-growth in low nutrient stress, such as: plant height, number of productive tiller, and canopy weight. These also caused a decrease in panicle weight per hill (Table 1 & Figure 1). It showed that the reduction of N, P and K nutrient have caused decrease in growth rate and production of some paddy varieties. It was because the reduction of nutrients make the plants suffer and grow in nutrient deficiency condition, that causes metabolic and growth constraints.

For their optimal growth, plants need N 2 - 5% of their dry weight. It make N becomes the most important nutrient for plants (Marschner, 1995). Nitrogen deficiency causes the leaves be smaller and fewer, also the stems be shorter and smaller. This is because N is important in cell formation and division (Mengel & Kirkby, 2001). Nitrogen deficiency will inhibit cell division and elongation, since N elements are important in synthesis of protein, amino acids, nucleic acids, DNA, RNA and enzymes (Taiz & Zeiger, 2002). The study results show that 1/3 of the NO_2- absorbed plants will be converted to N-organic (Morikawa *et al.*, 2005). The barriers to cell division and elongation will inhibit plant growth and development as reflected in obstacles the increase in the number and extent of leaves, increased height, and the formation of branching and budding (Lambers *et al.*, 2008).

Besides N, P is also very important for plants. Phosphorus influences from germination, cell forming and division up to flowering, fertilization and filling of seeds, acceleration of maturation, as well as an increase in the quantity and quality of results. it is because P is the part of a number of plant metabolism components. The limitation of P cause growth restrictions, development and production of crops (Sanchez, 2007).

Beside N and P, K is an essential nutrient for plants. Potassium plays a role in regulating movement or open-close stomata, fiber formation and cell wall synthesis, the addition of dry weight of plants and as a cation carrier photosynthesis. However, one of the most important roles of K is as an enzyme activator, hence K deficiency will also inhibit various metabolic processes and plant growth (Mengel, 2007).

The average of rooting variables on nutrient reductions was increase. It observed in root weight, root length, and root-shoot ratio. The result showed that on low nutrient stress (40% of nutrient intake) the plant root grower more than other nutrinet condition (Table 2 & Figure 2). It was because the plant will develop their roots to increase nutrient uptake, if planted in nutrient deficiency conditions (Gerloff, 1987). The morphological adaptations include root elongation, increased number of small diameter roots, increasing number and length of root hair (Marschner, 1995). In nutrient deficiency conditions, rooting will grow elongated, diffuse and form branches to absorb nutrients. The root-shoot ratio will also increase. These have led the root as an indicator of the ability of plant adaptation in nutrient deficiency conditions (Lambers *et al.*, 2003; Lamon, 2003; Miller & Cramer, 2005).

The result also showed that in low nutrient condition, IPB-1R and IPB-6R always show the root growth better than Ciherang and Indragiri. But, for the top growth and yield Indragiri is relatively better than others.

CONCLUSION

At low nutrient stress, Indragiri variety was taller, and its number of productive tillers was higher than Ciherang, IPB 1R and IPB 6R. The development of rooting of IPB 6R and IPB 1R was higher than Ciherang and Indragiri varieties. The limit tolerance of Ciherang, Indragiri, IPB 1R and IPB 6R to nutrient reduction is up to 50% reduction of nutrients. The giving of 40% recommended dosage caused growth in canopy and production barriers, but increases root component growth.

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