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The Adaptation of Ciherang Rice Variety Roots to Various Levels of Low Nutrient Stress in Tidal Swamp Soils

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ABSTRACT

Rice cultivation in tidal land has many abiotic stresses. One of them is low nutrient stress. This research aims to determine and study the adaptation of rice roots to various levels of low nutrient stress in tidal swamp soil. These research was carried out from September 2016 to May 2017 at the Experimental Garden, Laboratory of Botany and Plant Physiology of Faculty of Agriculture of IBA University in Palembang, South Sumatra Province. These experiment used a Randomized Block Design with three replications and four low nutrient levels. The treatments are: N1 = 40% Fertilization dose (FD, N2 = 50% FD, N3 = 60% FD and N4 = 100% FD. The 100% FD is 300 kg urea. ha-1, 100 kg SP-36.ha-1 and 150 kg KCl.ha-1. These research used Ciherang rice varieties that planted in pots containing 12 kg of tidal swamp soil type B from Bunga Karang Village, Tanjung Lago District, Banyuasin Regency, South Sumatra Province, Indonesia. The results showed that low nutrient stress increased root length, root weight, root length density, root weight density, root weight ratio and number of tillers, but reduced crown weight and panicle weight per clump.

Keywords: nutrient deficiency stress, paddy, root adaptation, root stucture, tidal swamp soils

Adaptasi Perakaran Padi Varietas Ciherang Pada Berbagai Tingkatan Cekaman Hara Rendah Tanah Rawa Pasang Surut

ABSTRAK

Budidaya padi di lahan pasang surut memiliki banyak kendala atau cekaman abiotik. Salah satunya adalah cekaman hara rendah. Penelitian ini bertujuan untuk mengetahui dan mempelajari adaptasi perakaran padi pada berbagai level cekaman hara rendah tanah rawa pasang surut. Penelitian telah dilaksanakan pada bulan September 2016 sampai Mei 2017 di Kebun Percobaan, Laboratorium Botani dan Fisiologi Tumbuhan Fakultas Pertanian Universitas IBA, Palembang, Provinsi Sumatera Selatan. Percobaan menggunakan Rancangan Acak Kelompok dengan tiga ulangan, dan empat level hara rendah. Perlakuan tersebut adalah : N1 = 40% Dosis pemupukan (DP), N2 = 50% DP, N3 = 60% DP dan N4 = 100% DP. Dosis pemupukan 100% adalah 300 kg urea. ha-1, 100 kg SP-36.ha-1 dan 150 kg KCl.ha-1. Penelitian menggunakan padi varietas Ciherang yang ditanam dalam pot berisi 12 kg tanah rawa pasang surut tipe luapan B dari Desa Bunga Karang, Kecamatan Tanjung Lago, Kabupaten Banyuasin, Provinsi Sumatera Selatan, Indonesia. Hasil penelitian menunjukkan bahwa cekaman hara rendah meningkatkan panjang akar, bobot akar, kerapatan panjang akar, kerapatan bobot akar, nisbah bobot akar dan jumlah anakan, namun menurunkan bobot tajuk dan bobot malai per rumpun

Kata kunci : adaptasi perakaran, cekaman defisiensi hara, padi, struktur akar, tanah rawa pasang surut

INTRODUCTION

Rice cultivation in tidal land has various abiotic obstacles. One of them is low nutrient stress. This stress is due to low tidal land acidity (3.0-4.5) which causes nutrients be unavailable for plants. The leaching rate is also high and cause loss of nutrients. The unavailability of nutrients, especially nitrogen (N), phosphorus (P) and potassium (K) as macro nutrients, causes nutrient deficiency in plants and intolerant plants will be damaged.

Plant tolerance to low nutrients is related to the development of root systems [1], because plants depend on their root systems to absorb and get water and nutrients to survive in low nutrient environments. Root systems are complex and have been identified for their role in plant adaptation to low nutrient stress [2]. Roots are multicellular organs characterized by particular features such as gravitropic response, endogenous branching, root hairs and a protective root cap [3]. In low nutrient stress, roots will develop their morphology to increase nutrient uptake, which is measured in root length, root weight ratio and root length density [4]. Changes in root architecture, and induction of root-based transport systems allow plants to maintain optimal nutrient content in suboptimal enviroment [5].

This paper discusses rice tolerance and adaptation to low nutrient stresses that are focused and limited to nitrogen, phosphorus and potassium nutrients. According to [6], symptoms of N deficiency are stunted growth and stunted lateral shoots, also leaves chlorosis. The P deficiency causes stunted plant and root growth, thin stems, dark green, purple and red leaves and distorted shape. The K deficiency causes stunted growth, shorter stem segments, weak stems, roots not developing properly, and necrosis.

In rice plants, the symptoms of N deficiency varies and depend on their growth phase. If N deficiency is in the initial growth phase, so the leaves will be chlorosis, the stem is short and thin, and have little tillers. If N deficiency continues until the harvest phase, make the amount of grain per panicle is only a little. The P deficiency causes dwarf plants, dark green and leaves longer than normal. The number of tillers and grain per panicle is a little. Mild K deficiency causes dwarf plants, dark green leaves, and little tillers. Severe deficiency of K causes yellowish-orange leaves that start from old leaves in the top. Necrosis occurs in the leaves and the size and weight of grain is reduced. This research aims to determine and study the adaptation of Ciherang rice roots to various levels of low nutrient stress in tidal swamp soils.

MATERIALS AND METHOD

These research was carried out from September 2016 to May 2017 at Experimental Garden, Botanical and Plant Physiology Laboratory of Agriculture Faculty of IBA University, in Palembang, South Sumatera Province. The experiment used Randomized Block Design with three replications, consisted of four treatmentsof nutrient levels. Those treatment was: N1 = 40% fertilizer dosage (FD), N2 = 50% FD, N3 = 60% FD and N4 = 100% FD. The 100% FD is 300 kg urea. ha^{-1}, 100 kg SP-36.ha^{-1} and 150 kg KCl.ha^{-1}.

Research used Ciherang rice variety that planted in pots (55 cm x 45 cm) containing 12 kg of tidal soil (overflow type B) from Bunga Karang Village, Tanjung Lago Sub-district of Banyuasin Regency, South Sumatera Province, Indonesia. Plant media height was 50 cm, that mixed by 5 ton.ha^{-1} of chicken manure and 2 ton.ha^{-1} of lime dolomite. Two weeks before planting, the media was flooded with 5-7 cm of water and it was replaced daily to reduce the effects of toxic elements. Two days before planting the water level was reduced to 2-3 cm. Seedlings were planted after two weeks of nursery. Each pot was planted with one plant.

Nitrogen fertilizer given three times: 50% at 7 day after plant (DAP), 25% at 20 DAP and 25% at 40 DAP. Phosphorus and potassium fertilizer given twice: 50% at planting and 50% at 20 DAP. The dosage of 100% FD was 300 kg urea. $ha^{-1,}$ 100 kg SP-36.ha^{-1} and 150 kg KCl. ha^{-1}. The dosage of 60% FD was 180 kg urea.ha^{-1}, 60 kg SP-36.ha^{-1} and 90 kg KCl. ha^{-1}. The dosage of 50% FD was 150 kg urea.ha^{-1}, 50 kg SP-36.ha^{-1} and 75 kg KCl. ha^{-1}. The dosage of 40% FD was 120 kg urea.ha^{-1}, 40 kg SP-36.ha^{-1} and 60 kg KCl. ha^{-1}. The parameters was root length, root weight, root lenth density, root weight density, root weight ratio, canopy weight, root canopy ratio, number of tiller, panicle weight per hill. Data were analyzed using analysis of variance (ANOVA), followed by a tukey test $p<0.05$ if significant.

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RESULTS AND DISCUSSION

Root Length

Root length was significantly affected by nutrient levels. Rice root length at the lowest nutrient level (40% FD) were the longest and not different with optimal nutrient (100% FD) in the tukey test 0,05 (Table 1 and Figure 1).

Root Legth Density

Variable root length density would provide an information about the density of the plant roots spreads in the soil. From the experiment got that look like the root length parameter, the root length density at the lowest nutrient was also highest and not different with optimal nutrientin the tukey test 0,05 (Table 1 and Figure 1).

Root system responses contribute to plant adaptation to low-fertility soils [7]. These include the ability of roots to increase the volume of soil explored and surface area for the uptake of nutrients. These system are related to root elongation rate, lateral root production, root hair characteristics, root length density, and root ability to penetrate soil [8]. Plants that are able to modify and develop their root structure in low nutrient stress, will be able to survive, grow and develop and reproduce in limited nutrient conditions [9]

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Table 1. Root length (RL) and root length density (RLD) of rice in four nutrient levels

Level of nutrient	RL (cm)	RLD ($cm.kg^{-1}$)
40% FD	42,58 b	3,55 b
50% FD	32,57 a	2,71 a
60% FD	32,67 a	2,72 a
100% FD	33,42 ab	2,78 ab

Remarks: Means with the same letter in the same column are not significantly different at tukey test p<0,05.

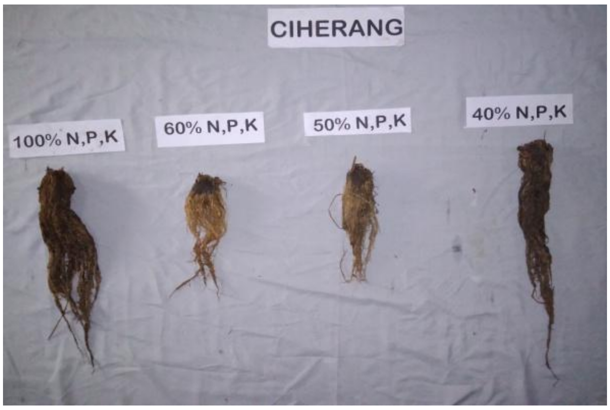

Figure 1. Rice root stuctures in four levels of nutrients

Root Weight

The heaviest roots measured in plants that got the lowest nutrients (40% FD), which is not significantly different from optimal nutrients (100% FD) in tukey test 0,05 (Tabel 2). Figure 1 shows the root structure at 40% and 100% FD, longer and greater than 50% and 60% FD. This makes the roots heavier.

Root Weight Density

Root weight density is the ratio of root weight to the volume of soil, which will inform about the density of the root distribution in the soil. Plants that received the lowest nutrient treatment (40% FD) had the highest root weight density and were not significantly different from 100% FD (Table 2 and Figure 1.

The increase of root weight, root weight density and root weight ratio at low nutrient stresses because, under stress conditions the plants will increase theirs tolerance in order to survive. This tolerance was related to the phenomenon of changes in the root structure: formation more of adventitious root which able to survive longer in suboptimal soil, the basal roots are more oriented horizontally, lateral roots are more and more spread, and increasing of root hair and root lenght. It makes root larger and heavier [1][10][9].

Table 2. Root weight (RW) and root weight density (RWD) of rice in four nutrient levels

Level of nutrient	RW (g)	RWD g.kg^{-1})
40% FD	117,50 b	9,79 b
50% FD	58,33 a	4,86 a
60% FD	59,17 a	4,93 a
100% FD	66,67a	5,56 ab

Remarks: Means with the same letter in the same column are not significantly different at tukey test p<0,05

Root Weight Ratio

Root weight ratio explains root efficiency in supporting the formation of total plant biomass. The results showed that root weight ratio was not significantly affected by the several levels of nutrients. The means shows the root weight ratio in the 40% FD highest (Table 3).

Root Canopy Ratio

The root canopy ratio is not affected by the treatment. The means show an increase in root canopy ratio in reducing nutrient given (Table 3). This is because nutrient reduction encourages plant adaptation to low nutrients by modifying and developing their root structure.

Table 3: Root weight ratio (RWR) and root canopy ratio (RCR) of rice in four nutrient levels

Level of nutrient	RWR	RCR
40% FD	0,34	0,67
50% FD	0,27	0,37
60% FD	0,27	0,39
100% FD	0,27	0,32

Canopy Weight

Canopy weight was significantly affected by treatment. Plant canopy weight in optimal nutrient (100% FD) was highest and not significantly different with 40% and 50% FD at tukey test 0.05 (Table 4). The comparison of plant morphology between the four levels of nutrients provided can be see in Figure 2.

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Table 4: Canopy weight (CW) of rice in four nutrient levels

Level of nutrient	CW (g)
40% FD	180,00 ab
50% FD	158,33 ab
60% FD	146,67 a
100% FD	212,50 b

Remarks: Means with the same letter in the same column are not significantly different at tukey test p<0,05

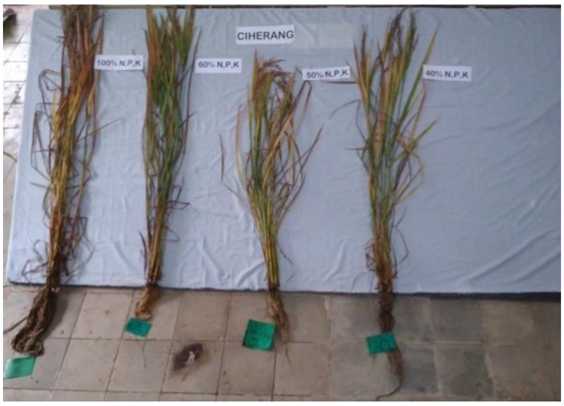

Figure 2. Morphology of rice and number of tiller in four levels of nutrients

Root architectural traits, including the root number, root length, orientation and branching of several root classes are contribute to the superior performance of plant growth and yield of crops grown on low-fertility soils [11]. Plants that are able to modify and develop their root structure in low nutrient stresses will be able to survive, grow and develop and reproduce in limited nutrient conditions. The ability of plant adaptation to soil with low fertility will be seen in the recovery speed at low nutrient stresses that will be seen in the morphology of the plant [9].

Number of Tiller

The number of tillers in rice plants is very dependent on plant growth. Plants with better growth will produce more tiller. Analysis of variance show the number of tillers are not affected by treatment. The research results report the number of tillers highest at 1000% FD, followed by 60%, 50% and 40% FD (Table 5). This condition is also seen in Figure 2.

Panicle Weight Per Clump

As the number of tillers, panicle formation in rice plants is very dependent on plant growth. If plant growth is better, so it will produce more panicles. Analysis of variance showed the panicle weight per clump not affected by treatment of four levels nutrients given. The results showed the highest panicle weight per clump are in optimal nutrient (100% FD) (Table 5).

Table 5. Number of tiller (NT) and panicles weight per clump (PWC) of rice in four nutrient levels

Level of nutrient	NT ($tiller.hill^{-1}$)	PWC
40% FD	9,08	30,42
50% FD	8,75	38,75
60% FD	10,50	39,58
100% FD	13,33	47,08

Plant root adaptive growth in response to low availability of macro- and micronutrients depends on a wide range of variables such as nutrient forms, availability, concentration, localization and nutrient behaviour in soil, as well as the nutrient status of the plant [10]. In its evolution and development, roots help plants in various processes such as: absorption of water and nutrients, support for the establishment of plants, and as an organ of storage [12[,[13]. Therefore the root structure that develops well will greatly encourage the growth and production of a plant. It makes plant growth and produce better [9]. However, above all those things, root is the most important organ in determining the level of growth and production of plants, because root is the organ that absorbs water and nutrients for the plants metabolism.

CONCLUSION

In low nutrient stress of tidal land, root length, root weight, root length density, root weight density, root weight ratio and number of tillers of Ciherang rice variety increased, but canopy weight and panicle weight per clump decreased. In giving 40% of nutrients, the lenght and weight of rice root increase more than 50%, 60% and 100% nutrient given. This occurs because the mechanism of rice root adaptation to survive from low nutrient stress of tidal swamp soils.

Although, the development of root structure is important in plant tolerance to low nutrients, but for the best plant growth and production, sufficient nutrients are still needed.

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