Growth, Phosphorus and Potassium Nutrition of Long- and Short-Age Rice (*Oryza sativa* L.) Varieties Under Limited Moisture Availability

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Abstract

Phosphorous (P) and potassium (K) are two important nutrients, and their availability in soils at native state to rice plants is limited. Moreover, the responses of short and long-age rice varieties to limited soil moisture availability are not kown, and under limited moisture availability the uptake of P and K to rice plants are further restricted. Therefore, a pot experiment was conducted to study the responses of short and long age rice varieties at P, K and moisture limited conditions. Two rice varieties; Bg 379-2 as a long duration (LD), and Bg 250 as a short duration (SD), two water treatments; continious flooding of pots until harvest (W1), and continuous flooding until flowering and then allowing the top soil of a pot to dry out gradually while the subsoil was kept moist through capilary action (W2) were tested with three replicates. Department of Agriculture recommended N, P and K fertilizer levels were applied. At physiological maturity of each variety plant height, productive and unproductive tillers, dry weight (DW) of shoot and roots, tissue P and K concentrations, available and solution P, and exchangable and soltion K concentrations in the soil were measured. Dry weight of both shoot and root were similar between moisture treatments, except for the increased shoot DW of SD at top soil drying condition. Rice varieties were more resonsive to P than K, and LD had adptations such as increase in root DW, solubility of P in the rhizosphere.

Key words: Moisture stress, Phosphorus, Potassium, Rice.

Introduction

Phosphorus (P) and potassium (K) are two important nutrients required by the rice plant (*Oryza sativa* L.). The amount of P removed by a rice crop at present is more than twice that removed 50 years ago. Uptake of 1.8 – 4.2 kg P ha^{-1} is required to produce one ton of grain (Dobrmenn *et al.*, 1996), and the net P removed through harvested grains is 0.5 to 0.9 Mt from irrigated rice fields in Asia (Dobrmenn *et al.*, 1998). Therefore, plant available and total P concentrations in soil have reduced, and the trend continues. Moreover, due to the lack of solubility and slow movement of P in soil, most of the P applied retained and fixed in top layers in the soil profile. Rice plants take up K in higher quantities from soil and the fraction removed from the soil is greater with the harvest than that of nitrogen (N) and P (Dissanayake *et al.*, 2011). However, a major problem in relation to K fertilizer application in rice cultivation under local conditions is that rice plant neither show positive response to added K fertilizer nor K deficiency symptoms when not applied in most instances while K applied through fertilisers leaches down and accumulates in the sub soil layers. Therefore, in a continuously cultivated lowland rice soil there is an inverse stratification of P and K in the soil profile. The responses of short and long age rice varieties for P and K fertility in flooded soils and under the water limited condtions are not known. Moreover, plant responses would also depend on their adaptability to these multiple limitations. Therefore, an experiment was designed to study the responses of short and long age rice varieties to P and K fertilizer application in a water limited conditions.

Materials and methods

A pot experiment was conducted at the Rice Research and Development Institute (RRDI), Ibbagamuwa, Sri Lanka. Soil columns with 100-cm tall 15-cm diameter, were filled with air-dried and sieved (3-mm mesh) lowland unfertilized rice soil collected from the RRDI

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(Endoaqualfs) with very low-P and K concentrations at its native stage (1.7 mg P kg^{-1} soil and 25.4 mg K kg^{-1} air dry soil). Experiment was arranged as a two factor factorial completely randomized design with three replicates.Two factors were rice varieties (requiring different time period for the physilogical maturity) and water manegemnet strategies. Two rice varieties were Bg 250 representing a short duration (SD) and Bg 379-2 representing long duration (LD). Two water management strategies; continuous flooding until harvest at the physiological maturity (W1), and top soil of a column was allowed to dry after flowering and bottom soil was kept moist by keeping the column in a water container (W2).

Nitrogen, P and K fertilizers were applied accoding to the Department of Agriculture recommendation (*i.e.* N 125 $kgha^{-1}$, P_2O_5 45 kg ha^{-1} and K_2O 35 $kgha^{-1}$) based on the surface area of the pots. There were two plants per pot. At maturity plant height, productive and unproductive tillers, above ground dry weight (DW) and root DW in three depths as top 15-cm, middle 30-cm and bottom 55-cm, shoot root ratio, tissue P and K concentrations, available and the solution P and exchangeable and the solution K concentrations in the soil were measured.

Results and Discussion

When comparing varieties, root DW of LD in all three depths were higher than that of SD irrespective of water treatnments (Fig.1). Eventhough the above ground DW of LD was similar between two moisture treatments, the above ground DW of SD under top soil drying condition was greater than that under continuously flooded condition.

Shoot root ratio of LD was lesser (2.7) under reduced water availability than that under continiously flooded conditions (3.4). Maximum shoot root ratio of 5.5 was observed in SD at reduced water availabilty indicating

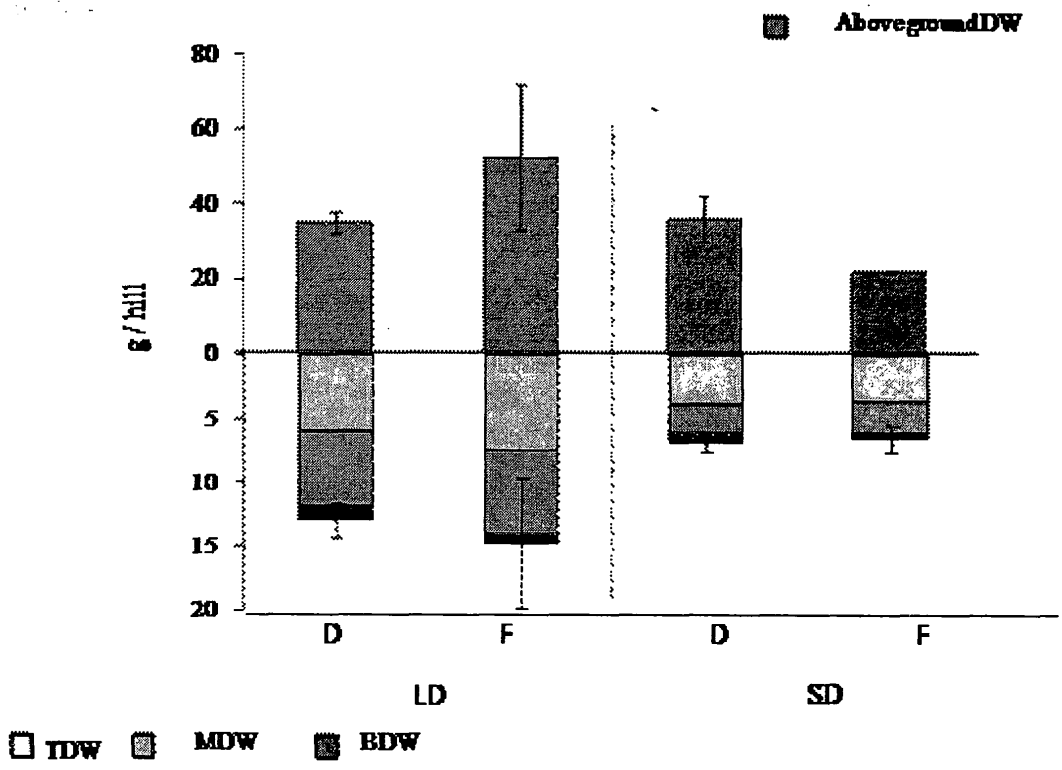

Figure 1. Above ground DW, and root DW (top 15-cm (TDW), middle 30-cm (MDW) and bottom 55-cm (BDW), of long (LD) and short (SD) aged rice varieties under continiously flooded (F) and reduced water availability (D).

that the shoot growth was enhanced relative to that in roots. The results suggested as LD has a higher root DW, reflecting a higher root length it would possess for efficient P and K uptake than SD.

Plant avaialble P concentration in the top 15 cm soil layer was higher at reduced water avaialbility than that under continuously flooded condition, irrespective of the variety (data not shown). Moreover, plant avaialble P concentration in the top 15 cm soil layer of the LD variety was higher (9.6 mg P kg^{-1}) than that observed in SD (4.0 mg P kg^{-1}) under water limited conditions, suggesting the ability of LD to increase the solubility of P in the rhizosphere. However, such a change in K in soil and in plant uptake were not observed. Therefore, rice varieties were more responsive to P than K, and Bg 379-2 had greater adptations such as increased root DW and solubility of P in the rhizosphere.

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