Screening some promising rice cultivars for rooting ability in low management condition

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Abstract

Rainfall reduction in West Africa adversely affects water supply for rainfed rice production. There is a need to improve water use efficiency by rice varietal rooting ability in order to mitigate water stress. Therefore, the rooting ability of some interspecific (O. sativa (V11) × O. Glaberrima (V12)) rice cultivars named NERICAs (V1, V2, V3, V4, V5, V6, V7, V8, V9 and V10) was assessed compared to their parents under two rates (0 kg ha⁻¹ (N0) and 30 kg ha⁻¹ (N1)) of nitrogen-N in a split-plot design. Profile method of root study was used. Highest root densities (1700 m⁻²) were observed for cultivars V1-NERICA 1 and V2-NERICA 2 with 0 kg N ha⁻¹ compared to that of 30 kg N ha⁻¹, meanwhile, the highest overall mean value of root density (4000/m²) was observed for N1 (30 kg N ha⁻¹) especially in the top soil (0-20 cm). The cultivar-V11 (O. sativa) has the highest root density in the topsoil indifferently to N-rates while NERICA 2 (V2), 4 (V4) and 8 (V8) have similar characters in subsoil 20-40 cm and 40-60 cm likewise for the parent O. Glaberrima (V12) in 40-60 cm depth. Varietal difference of rooting ability was under different management options and NERICA 1 and 2 was recommended for drought mitigation under limited N-supplying condition while NERICA 4 and 8 are for low-N supplying condition.

Key words: NERICA rice cultivar, root density, drought, nitrogen, soil.

Introduction

Annual rainfall reduction in West Africa (CNRS, 2000) is a threat of rainfed rice (Oryza sativa L.) production that account for 80% of rice cultivated surface (Audebert et al., 1999). Enhancing water use efficiency by morphological traits as root development can improve rice production in the sub-region. Thus, varietal difference in rooting ability was assessed under low input management condition and identify some cultivars for drought stress mitigation in small farmers’ fields. The aim was to identify cultivars some presuming drought tolerant NERICA cultivars that can develop highest root density for the improvement of water use efficient under no- and/or low-nitrogen fertilizer effect.

Material and methods

Study area

The study was carried out in 2006 in southern Benin (6° 28’ N, 2° 21’ E, 15 m elevation) at Abomey-Calavi. The experiment was laid out on the summit of the plateau landscape with a slope of about 0-2%. Three years of fallow dominated by Imperata cylindrica preceded the experiment under a bimodal rainfall pattern with a short dry season from July to August. The soil was Acrisols free of morphological constraints such as gravels and hardpan.
Experiment layout

Ten interspecific rice cultivars considered as New Rice for Africa (NERICA) released by Africa Rice Center after crossing O. glaberrima and O. sativa from Africa and Asia respectively, was used for the trial. The rooting ability of NERICAs was assessed compared with that of their parent O. sativa (V11) and O. glaberrima (V12) using NERICA 1 (V1) to NERICA 10 (V10) in successive order. Two rates of nitrogen, N0 (0 kg N ha\(^{-1}\)) and N1 (30 kg N ha\(^{-1}\)) were combined with 50 kg k ha\(^{-1}\) and 50 kg P ha\(^{-1}\) as basal fertilizers respectively according to the fertilizer treatments in a split-plot design. The land was previously ploughed using a hand-held hoe before laying out 15 m\(^2\) (3 x 5 m) plots. In the first week of June, rice varieties were seeded sown at the rate of three grains per hill at 20 x 20 cm spacing.

Data collection

At rice flowering period, destructive sampling was done for root study. Two opposite profiles (70 × 70 cm) were done in each plot (treatment) for root study as described by Tardieu et Manichon (1986) using a grid of 60 × 30 cm in dimension including cells of 5 × 5 cm. The observation was done within the 60 cm depth. The number of root impact was counted in each cell (25 cm\(^2\)) of the grid that was placed twice from zero to 60 cm depth.

Statistical analysis

Counted data were transformed by root square method before processing analyse of variance to generate mean values of root density for each cultivar and for 0-20 cm, 20-40 cm and 40-60 cm depths respectively. GenStat discovery was used for these purposes.

Results

There is no significant effect of nitrogen rate on root density contrasting with variety and depth effects as well as for their interactions. But nitrogen has significant interaction with each of these factors whereas no significant effect is observed for the full factors interaction (Table 1).

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GM (Numb.m\(^{-2}\)) 1516; CV(%) 20

Highest root densities are observed for NERICA 1 (V1) and NERICA 2 (V2) with no nitrogen fertilizer (0 kg N ha\(^{-1}\)) while significant highest densities occurred for NERICA 6 (V8), NERICA 10, O. sativa (V11) and O. glaberrima (V12) when 30 kg N ha\(^{-1}\) was applied (Figure 1).

Figure 2 shows that the highest significant root density as observed under 30 kg N ha\(^{-1}\) occurred especially in the topsoil (0-20 cm).

However, highest root density was observed for NERICA 2 (V2), NERICA 4 and NERICA 8 in subsoil (20-40 cm and 40-60 cm). Similar observation was done for V12 (the parent O. glabberima from Africa) in 40-60 cm (Figure 3).

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Figure 1: Root density mean values of rice varieties according to N-fertilizer levels

Figure 2: Effect of N-levels on root density in 0-20 cm, 20-40 cm and 40-60 cm of soil depth (bars are standard errors)
Figure 3: Varieties root density each soil depth (0-20 cm (a), 20-40 cm (b), 40-60 cm (c)) in the profile

Discussion

Oryza glaberrima as the parent of NERICA cultivars originated from Africa, was found to have deepest rooting ability in the studied agroecology. This genotype has probably significant influence in the rooting ability of NERICA 2, NERICA 4 and NERICA 8 which have consistently developed highest root density in the subsoil (20-60 cm). Furthermore, the varietal difference observed under N-rates could be explained by nitrogen effect in root ramification (Kouamé et al., 2013) which could be also dependant on cultivars. The highest root density recorded for NERICA 2, NERICA 4 and NERICA 8 can justify their high potential for soil exploration, thereby, improving their water use efficiency in drought-prone area. But, in soil deficient in nitrogen, NERICA 1 and NERICA 2 are recommendable for this purpose.
Conclusion and recommendation

Our study showed a varietal difference in rooting ability on Acrisols under low nitrogen management condition. Among the NERICAs tested, those who are likely to be more influenced by *O. glaberrima* genotype are the recommendable in limited water supplying condition.

In mid-season drought-prone area of West Africa, NERICA2, NERICA 4 and NERICA 8 are recommended for upland rice cropping, meanwhile, in N-deficient condition NERICA 1 and 2 are preferred for this.

References


