Plasticity expression of root branching and deep rooting and its contribution to growth and yield of Upland New Rice for Africa (NERICA) under different soil moisture conditions

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Introduction

In rainfed upland rice ecosystem, soil moisture fluctuation (SMF) due to intermittent rainfall limits rice production. Root plasticity is a key trait that plays a crucial role in the plants’ ability to adapt to SMF stress. We previously showed that under moderate drought stress, NERICA 1 expressed root branching plasticity in a shallow soil layer while NERICA 4 expressed deep root plasticity (Menge et al., 2016). In this study, we hypothesized that the expression of plasticity in branching ability at shallow soil layer as well as deep root development of upland NERICA 1 and NERICA 4 respectively could be affected by the range of fluctuation in soil moisture. This study aimed to evaluate the functional roles of such root plasticity in the growth and yield of NERICA 1 and NERICA 4 in response to different ranges of SMF.

Materials and Methods

NERICA 1 and NERICA 4 were grown in a water-tight experimental bed under continuous well-watered (CWW) condition as control and two SMF conditions; wetter range SMF (WSMF); progressive drought to -50 kPa followed by re-watering and drier range SMF (DSMF); progressive drought to -80 kPa followed by re-watering. Those SMF conditions were initiated at 21 days after transplanting (DAT) and repeated until maturity stage. The experiment was arranged in randomized complete block design with four replications. Soil water potential was measured using a tensiometer (Daiki soil and moisture, Daiki Rika Kogyo Co., Japan) which was installed at 20 cm depth. Stomatal conductance and photosynthetic rate were measured using a portable photosynthesis analyzer (LI-6400, Li-COR Inc., USA). Shoot and root sampling were done at 98 DAT. Panicles were separated from straw and hand threshed to determine yield. Roots were sampled from 0 - 20 cm (shallow) and 20 - 40 cm (deep) soil layers using the round monolith method (Kang et al., 1994) and measured for nodal root length (NRL), lateral root length (LRL) and total length (TRL) using WinRHIZO (regent Instrument Inc).

Results and Discussion

NERICA 4 maintained its shoot dry weight and yield under both WSMF and DSMF conditions. This was attributed to significantly higher TRL in deep soil layer. On the other hand, NERICA 1 maintained its shoot dry weight and yield under WSMF but reduced under DSMF. This was due to significant increase in LRL especially in shallow soil layer. Furthermore, under DSMF, NERICA 1 had a significant reduction in harvest index, an indication of lower dry matter partitioning ability to the developing grain; resulting in a significant reduction in percentage filled grain ratio, thus low yield. The result showed that plasticity in root branching of NERICA 1 at shallow soil layer under WSMF and deep rooting in NERICA 4 under both WSMF and DSMF could contribute to sustaining growth and yield under the different soil moisture condition.

References