Responses in dry matter production of NERICA to soil moisture stress

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NERICAの乾物生産の土壌乾燥ストレスに対する反応

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Introduction

NERICA (new rice for Africa) developed by Africa Rice Centre (ARC) in West Africa has a reputation for high production under rainfed cultures. These genotypes have been widely adopted by farmers in West African countries and Uganda in East Africa while other countries such as Ethiopia, Kenya and Tanzania are conducting adaptability trials for selection and recommendations to farmers. Under Kenyan agro-ecological conditions, our preliminary adaptability trials of different NERICA lines showed that NERICA 1, 4 and 11 showed consistently higher yield. This study aimed to examine the dry matter production response to soil moisture stresses for these potential lines. Such response was further investigated based on the concept that dry matter is the product of water use (WU) and water use efficiency (WUE). Hence, a series of experiments were conducted under glasshouse and field conditions at Nagoya University from July to December 2006.

Materials and methods

Three selected NERICA genotypes (NERICA 1, 4 and 11) and IRAT 109 (*Oryza sativa*, japonica upland known to be tolerant to drought as control) were grown under glasshouse conditions. For pot experiment, the plants were grown in 6-litre pots filled with 5 kg air-dried alluvial sandy loam for 81 days. Each genotype was subjected to 3 soil moisture conditions; well-watered (30% soil moisture content, SMC) and two levels of droughted conditions (20 and 10% SMC). Another experiment was also conducted using root-box (25 cm x 2 cm x 40 cm, L x W x H) filled with 2.5 kg soil where each genotype was grown for 49 days. Plant growth was regularly recorded. Stomatal conductance, transpiration and photosynthesis were measured, and shoot and root samples were collected for further measurements. The experiment was laid out in a completely randomized design with 3 replications. For field experiment, seven NERICA lines (NERICA 1-7) were transplanted in the field plots under plastic house. The field had water gradient imposed through line sprinkler irrigation with PVC pipe set at one end perpendicular to the rows where each genotype was planted. The soil moisture content ranged from 40% to 20%. Plant growth was regularly recorded. Stomatal conductance, transpiration and photosynthesis were measured. Shoot and root samples were collected at maturity for further measurements.

Results and discussion

Soil moisture stress generally reduced dry matter productions in all genotypes examined in pot experiment (Fig. 1). In rootbox experiment, dry matter of IRAT 109 decreased with increasing drought stress while for NERICA varieties, dry matter generally decreased only from 30 to 20% SMC. Further reductions in soil moisture from 20 to 10% slightly reduced dry matter for NERICA 11 but promoted for NERICA 1 and 4 (Fig. 2.) Such trend with increased dry matter with increasing drought stress for NERICA 1 and 4 was also found in the field experiment (Fig. 3). In WU related trait, the total leaf area generally reduced by drought stress for all genotypes. From 30 to 20% SMC, NERICA tended to reduce more than IRAT 109 but from 20 to 10% SMC NERICA showed less reduction (40-50%) than IRAT 109 (74%) (Fig. 4). Furthermore, the total root length generally reduced by drought stress for all genotypes. From 30 to 20% SMC, NERICA tended to reduce more than IRAT 109 but further reductions in soil moisture from 20 to 10% showed that NERICA 1 and 4 had less reductions (8-17%) than IRAT 109 (26%) and NERICA 11 (32%) (Fig. 5). On the other hand, instantaneous WUE in pot experiment generally tended to increase for all genotypes especially from 30 to 20% SMC where NERICA 1 and NERICA 4 increased more than IRAT 109. Further reduction in soil moisture from 20 to 10% showed that WUE increased or maintained in NERICA 1 and 4 but decreased both in IRAT 109 (53%) and NERICA 11 (24%) (Fig. 6). The rootbox experiment showed almost the same trend with pot experiment (Fig. 6) except that IRAT 109 increased WUE from 20 to 10% SMC (Fig. 7). Such increase in WUE in NERICA 1 and 4 was also found in field experiment. These results imply that the maintenance of shoot dry matter production of NERICA 1 and 4 under drought maybe attributed to less reduction in WU and increase in WUE. This result is in partial agreement with the findings of Fujii et al. (2006) who showed high WUE for NERICA genotypes under low soil moisture conditions. Further analyses are being done to verify the above results using the actual water use of each genotype and the response of each root components to drought stress conditions.

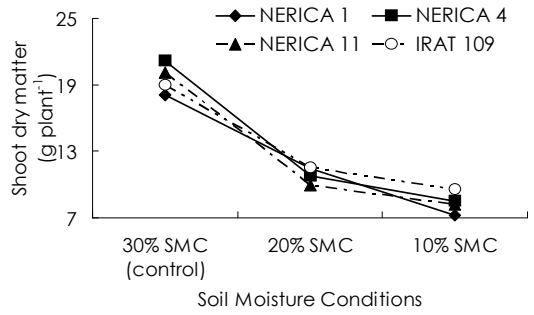

Fig 1. Shoot dry matter of selected NERICA lines and IRAT 109 under two levels of drought stress conditions in pot experiment.

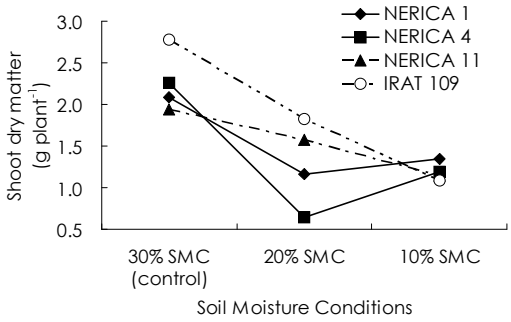

Fig 2. Shoot dry matter of selected NERICA lines and IRAT 109 under two levels of drought stress conditions in root box experiment.

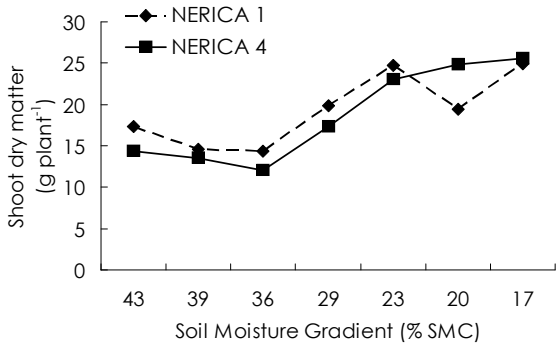

Fig 3. Shoot dry matter of NERICA 1 and 4 grown under increasing soil moisture deficit in field experiment.

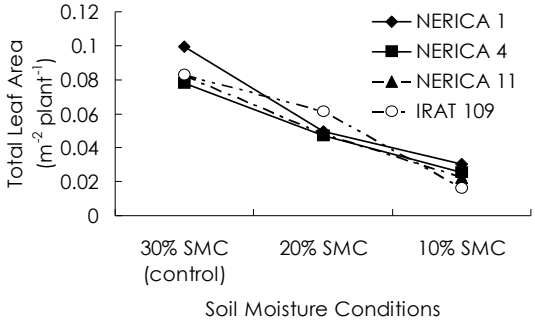

Fig 4. Total leaf area of selected NERICA lines and IRAT 109 under two levels of drought stress conditions in pot experiment.

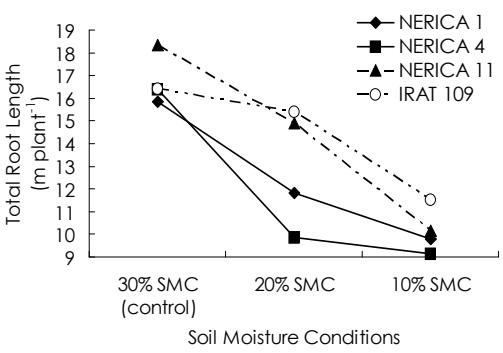

Fig 5. Total root length of selected NERICA lines and IRAT 109 under two levels of drought stress in root box experiment.

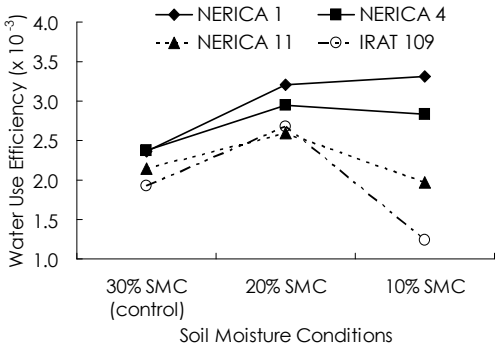

Fig 6. Instantaneous water use efficiency (photosynthetic rate/transpiration rate) of selected NERICA lines and IRAT 109 under two levels of drought stress in pot experiment.

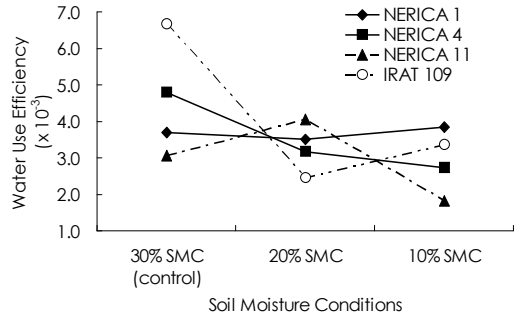

Fig 7. Instantaneous water use efficiency (photosynthetic rate/transpiration rate) of selected NERICA lines and IRAT 109 under two levels of drought stress in rootbox experiment.

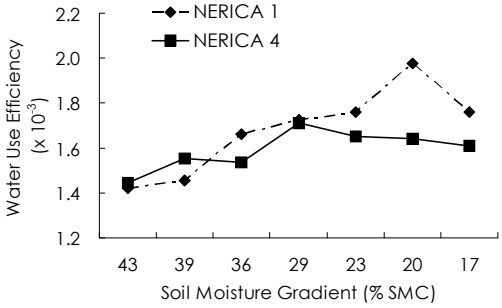

Fig 8. Instantaneous water use efficiency of NERICA 1 and 4 under decreasing soil moisture gradient in field experiment.

Reference

Fujii, M., Y. Miyamoto and S. Ishihara. 2006. Jpn. J. of Crop Sci. 75 (Extra 2). page 144-145