

Climate Change and Advancing Rice Production in Asia

Chair: Jun-Ichi Sakagami (Kagoshima University, Japan)

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2:00 PM - 2:20 PM

[S-01] Reduced Stomata Density and Size: The key to improve WUE in Climate-ready Rice

(Thailand)

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Rice is among the lowest water-use efficient crops. To produce a kg of polished rice, 2.5 tons of water on average is needed. Rice plants utilize most of the uptake water for evapotranspirational cooling via stomata. In order to develop water-used efficient rice, reducing stomatal density and size may help optimizing transpiration and photosynthetic assimilation. Climate-ready, Nutrient-dense rice is an integrative approach to develop new rice varieties of the future agriculture. By pyramiding genes/QTLs controlling broad-spectrum resistance to biotic and abiotic stresses into high nutritional rice background, we have generated series of rice ideotypes to mitigate the effects of climate change and to cope with double malnutrition in 2050.

By forward screening on a large-scale M_5 fast neutron mutagenized population, four stomatal model lines were identified expressing distinct stomata density (High vs Low Density = HD vs LD), and size (Big vs Small Sizes = BS vs SS). Gas exchange analysis revealed that the stomatal model lines were not different in photosynthetic assimilation (A) and chlorophyll fluorescence. In response to increasing $[CO_2]$, no difference in A from 100-600 ppm $[CO_2]$ for all stomatal model lines but beyond the peak, SS was more responsive to increasing $[CO_2]$ than any stomatal model lines. Nonetheless, HD had higher stomatal conductance (g_s) and g_{smax} than any stomatal model lines. All stomatal model lines were also similar in rhythmic stomatal responses to ten minutes dark/light transition cycles, except SS was more rapid than BS in the initial stomata closure.

The stomatal model mutants did not show any significant difference in response on a short term water stress. Long-term water stresses had less impact on leaf drying, F_v/F_m , grain yield, and harvest index in LD and SS. In the field, all stomatal model lines and JHN wt had similar WUE in well-water treatment. Nonetheless, LD showed the highest WUE and biomass/plant than any stomatal model lines in the long-term water-stress treatment.

In addition, three cycles of forward screening for recovery from drought stresses on 971 M_5 lines revealed three drought-selected mutants showing good recovery. Surprisingly, when compared to the stomatal model lines, all drought-selected mutants had lower stomatal density similar to LD. Comparison under well-water and water-stress revealed the three drought-selected mutants and LD gained better water-used efficiency and more drought tolerance than BS, HD, and SS. This is a conclusive evidence linking LD, WUE, and drought tolerance.

It is not clear the impact of altered stomatal traits on transpirational cooling under heat and drought

stresses. Our recent experiments on heat stress indicated that high stomata density (HD) were beneficial in high air temperature tolerance at reproductive stage while SS and LD accumulated higher canopy temperature than HD, BS, and JHN-wt. in a mild heat at 30°C. Nonetheless, SS and LD were cooler under water deficit.

Specific DNA markers associated with altered stomata traits were used for marker-assisted backcrossing to optimize high yielding, multiple resistance, grain quality, and water-use efficiency.