【Workshop 2】Crop Production under Heat Stress

Canopy Micrometeorological Model for Climate Change Impact Study

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Projected global warming is expected to increase the occurrence of heat-induced spikelet sterility (HISS) of rice (*Oryza sativa* L.). Previous chamber experiments have shown that HISS can occur where temperature at the flowering time exceeds the threshold temperature of around 35 °C (Kim *et al*., 2001). In fact, severe rice HISS occurred in the Yangtze Valley of China during the summer of 2003 (Wang *et al*., 2004). While, no serious yield losses have been reported in Australia where the daily maximum temperature sometimes reaches over 40 °C during the rice flowering season (Angus 1997). One of the reasons of the inconsistency is expected as heat avoidance by the evaporative cooling of rice panicle/canopy evapotranspiration. However, organ temperature such as panicle by evaporative cooling and plant heat balance has not been quantified among various climatic conditions so far.

A heat balance model was developed to simulate panicle temperature under field condition. The model includes two sub-models: First is canopy microclimate sub-model, which estimates canopy (leaf) temperature, water temperature, and air temperature and humidity inside canopy by solving the heat balance between the atmosphere and canopy. Second is the panicle temperature sub-model, which calculates panicle temperature from the heat and radiation budgets of panicle in the canopy microclimate. The model was parameterized by observation data of micrometeorology and evapotranspiration conductance at paddy rice fields, and validated using panicle temperature measured by very thin thermocouples and infrared thermometer.

We applied the model to micrometeorological measurement data in irrigated rice paddy fields in the middle Yangtze Valley, China, in 2006. Daily maximum air temperature was 35 °C and panicle temperature was estimated as 38 °C, higher by about 3 °C than the air temperature above canopy. This attributed to the high humidity (daily minimum 67%) and low wind speed (less than 1 m/s in average), which retarded evapotranspiration and canopy/panicle temperatures were easy to elevate. While, the air temperature above canopy in Reverina, Australia reached 42 °C in summer 2005. When applied the model, daily panicle temperature was estimated as 32 to 35 °C, which was lower by 3 to 7 °C than daily air temperature. This attributed to the extremely low humidity (15 to 40%) and high wind speed (2 to 4 m/s), which stimulated evaporative cooling by canopy and panicle evapotranspiration. It is suggested that extremely dry and windy climatic condition in Reverina, Australia should be the key factor for stable rice production under extremely hot environment during flowering season.

This analysis strongly suggests that we must use the panicle temperature instead of the air temperature, as a measure variable for the climate change impact study especially on rice sterility. So many chamber and field experiments addressed to the rice sterility-temperature issues have been conducted and plenty of precious data have been accumulated at various climatic zones in the world. Those data can be analyzed on an equal footing with each other, using the panicle temperature instead of the air temperature by canopy micrometeorological model.