エアロビックライス生産システムにおける蒸散の冷却効果変動の定量化に向けて

Toward quantifying the dynamics of transpiration cooling in aerobic rice system

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Introduction

The declining freshwater resources are a threat to conventional systems of irrigated rice where rice fields are mostly flooded till few days to harvest. According to Tuong and Bouman (2003), some 22.5 Mha of irrigated rice will suffer various level of water scarcity by 2025. Improving rice water productivity due to imminent water scarcity is paramount to sustaining irrigated rice in the future through the development and adoption of water-saving technologies.

One of the promising water-saving technologies is aerobic rice system where high-yielding lowland rice is cultivated in unpuddled, non-flooded soils. However, this system has unstable yields despite the great water-saving potential. The change in agricultural practice has been shown to affect the local energy, water and carbon balances (Zhao et al, 2008) of agricultural fields. This could have potential influences on some key plant adaptive processes such as transpiration cooling. Transpiration cooling is the phenomenon of plant tissues maintaining their temperature below air temperature through the CO_2-H_2O pathway which is important for avoiding drought and high temperature related heat stress.

Water-saving technologies are bound to reduce transpiration cooling and soil/water evaporative cooling at the canopy and systems level (Julia and Dingkuhn,2013). Currently there is no information on the efficiency of transpiration cooling in aerobic rice. This needs to be quantified and the potential sterility risks evaluated. The objectives of this study are to 1) **quantify the diurnal variations of transpiration cooling in aerobic rice system** and 2) **identify the periods of maximum transpiration cooling and its relation to spikelet sterility**.

Materials and Methods

Plant materials: Two contrasting rice genotypes will be used in this study. The rice genotypes namely **Takanari** (lowland-adapted indica) and **IRAT109** (upland-adapted japonica) to be used have different root growth characteristics in aerobic conditions (Kato and Okami,2010) and hence transpiration cooling dynamics should differ.

Experimental design: Field and pot experiments (**Figure 1&2**) will be conducted in the summer (May-October) of 2019 and 2020 with aerobic and flooded water regimes. The threshold for irrigation in aerobic water regime will be -30kPa whiles 2-3 cm water depth will be maintained for flooded water regime. Soil water potentials of aerobic water regime will be monitored using porous-cup tensiometers at 10 cm depth.

Measurements: 1) Infrared imagery at different canopy heights will be measured using FLIR C2 thermal camera (FLIR Systems Inc.) to quantify transpiration cooling at canopy level. Transpiration cooling at rice panicle level will be measured using copper-constantan thermocouples, 2) panicle related parameters such as spikelet sterility and panicle exsertion will be measured on tagged panicles. Measurement periods will be at maximum tillering, panicle initiation, booting, 2 weeks pre-anthesis, anthesis, 2 weeks post-anthesis and grain filling periods.

Data analysis: Data from all experiments will be analysed by the generalized linear model procedure. Analysis of variance will be performed separately for each experiment in each year according to randomized block design to assess varietal differences. Differences between means will be compared using Fisher`s least-significant-difference (LSD) at 5% probability level.

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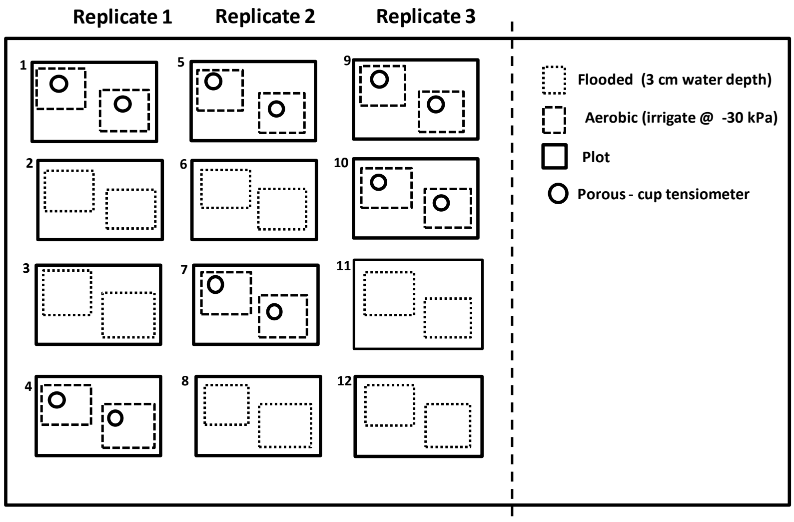

Figure 1. Experimental layout of pot study. Each plot will contain two pots per water × genotype treatment replicated three times.

Figure 2. Rice pot culture

Expected Results

The main target of this study is to assess the efficiency of transpiration cooling of high-yielding aerobic rice at the canopy and panicle scale. In addition, the difference in transpiration cooling of the contrasting genotypes will be evaluated and if there is any relationship between transpiration cooling and spikelet sterility in aerobic rice system.

References

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