The sensitivity of CWSI, the crop water stress index, in rice under contrasting water regimes in greenhouse conditions
水稲栽培における異なる水管理下での水ストレス指標 CWSI の解析

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1. Introduction

Declining freshwater resource is a threat to conventional systems of irrigated rice where paddy fields are submerged till physiological maturity. Some 22.5 Mha of irrigated rice will suffer various level of water scarcity by 2025 [1] and hence improving rice water productivity is essential to sustaining irrigated rice in the future through water saving technologies.

One of the promising water-saving technologies is aerobic water regime where high-yielding lowland rice is cultivated in unpuddled, saturated soils. However, due to transient periods of soil moisture stress yields can be unstable. The crop water stress index (CWSI) developed by [2] is a valuable tool to monitor soil moisture stress since it is linearly related to plant temperature (Tc). The feasibility of CWSI in monitoring soil moisture stress and scheduling irrigation depends on the determination of Tc thresholds during which potential and null transpiration occurs respectively. Various approaches to determine those limits are well established [3] with the simplest empirical approach requiring air temperature (Ta) and vapor pressure deficit (VPD) derived from relative humidity (RH) to determine the potential and null Tc thresholds.

Currently there is limited information on the potential Tc thresholds in rice and its sensitivity to CWSI values in different water regimes. Hence in this study we 1) **derive the potential Tc thresholds in rice under greenhouse conditions** and 2) **evaluate the sensitivity of CWSI in rice using these thresholds under contrasting water regimes**.

2. Materials and Methods

Experimental design: Two rice genotypes namely **Takanari** (lowland-adapted indica) and **IRAT109** (upland-adapted japonica) were planted to Wagner pots (4.0L) (**Fig.1**) in the summer of 2019 in flooded (3-5 cm water depth) and aerobic water regime in a greenhouse with relative humidity of 52-75% and air temperature of 29/22°C (day/night). Porous-cup tensiometers were installed at 10 cm depth in aerobic water regime pots to facilitate irrigation when soil moisture tensions (SMT) were below -30kPa.

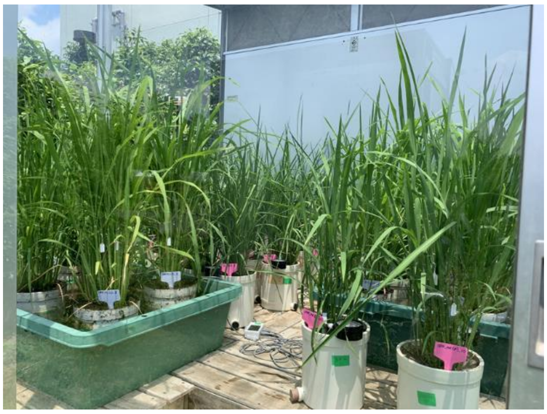

Fig.1 Rice experiment in greenhouse.

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Measurements: 1) To estimate Tc for CWSI, thermal images of rice plant canopies were captured at 70 and 75 days after sowing (DAS) using FLIR C2 thermal camera (FLIR Systems Inc.) concurrently with Ta and RH. CWSI was calculated following[2]:

$$CWSI = \frac{(Tc - Ta) - (Tc - Ta)ll}{(Tc - Ta)ul - (Tc - Ta)ll}$$

where (Tc-Ta)ul is temperature differential at null transpiration. (Tc-Ta)ll is temperature differential at potential transpiration.

Data analysis: The Tc values were extracted using a FLIR tools software. Tc-Ta differential was regressed on VPD to determine the potential Tc thresholds using data from flooded water regime. The temperature differential at null transpiration was set as 5°C [4]. Differences between CWSI in the water regimes were assessed using one-way analysis of variance (ANOVA). Significant differences were evaluated at 95% alpha level.

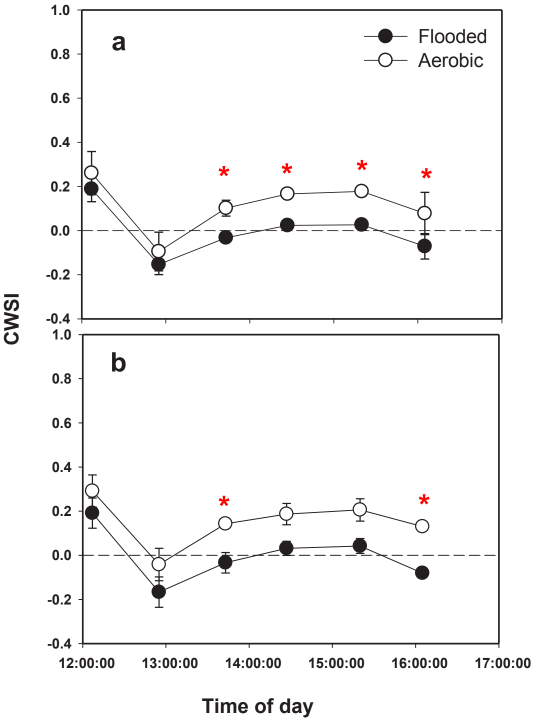

Fig.2 CWSI changes at 70 DAS for Takanari (a) and IRAT109 (b). Significant differences in red asterisk (*).

Table 1. Fitted parameters for potential transpiration threshold (Tc-Ta)ll = a + b*VPD

Genotype	**Slope (°CkPa^{-1})**	**Intercept (° C)**	**R^2**
	70 DAS		
Takanari	-4.49	7.59	0.78
IRAT109	-3.91	5.61	0.71
	75 DAS		
Takanari	-3.14	4.87	0.75
IRAT109	-3.11	5.69	0.78

3. Results and Discussions

The fitted parameters used to compute CWSI showed very high slope and intercept values (**Table 1**). This is remarkably high compared to those obtained in tree crops and some annual crops[5]. This could be attributed to hypoxia conditions during prolong inundation of rice which reduces its sensitivity to evaporative demand and therefore transpiration is at maximum. The CWSI was high briefly after solar noon (1200hrs) before reducing steeply. CWSI then diverged capturing the differences between flooded and aerobic water regimes (**Fig.2**). This could be due to a slower opening of stomata in the morning in rice[6]. The effect of genotype was apparent in the evolution of CWSI in the two different water regimes. Takanari's CWSI was significantly different in the water regimes except for one hour after solar noon whereas in the IRAT109 CWSI no significant differences were observed except around two time points in the day. The negative CWSI values are due to an underestimation of null transpiration temperature differential (that is, 5°C) used.

In conclusion, the sensitivity of CWSI in simulating the different water regimes was satisfactory and was also genotype dependent.