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学 位 論 文 要 旨
Dissertation Abstract

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学位論文題目：
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Study on micrometeorological environment and the modeling in rice paddy fields
（水田における微気象環境とそのモデル化に関する研究）

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Rice (*Oryza sativa* L.) is an important crop worldwide, and paddy fields are dominant land use form. With the predicted global warming, the effects of climate change on rice yield and quality have become major concerns. We studied micrometeorological environment and the modeling in rice paddy fields.

The effects of micrometeorological conditions and vegetational factors, such as the growth stage and the canopy resistance (r_c) on the energy budget in the rice paddy field were assessed. The r_c model was developed by the function of solar radiation (*St*) and the vapor pressure deficit (VPD). Under higher *St*, r_c was influenced by VPD more, and it meant stomatal aperture became sensible to VPD. It showed that r_c was not directly related to Bowen ratio (*Bo*), which meant that r_c did not account for the energy partitioning directly. Therefore, critical canopy resistance (r_{cc}), defined as the canopy resistance when *Bo* was zero, was applied to standardize r_c. It demonstrated that r_c - r_{cc} accounted for the energy partitioning directly.

In order to mitigate the high temperature damage on rice growth, water ponding experiments were conducted to decrease leaf temperature (T_l) and panicle temperature (T_p) in two rice paddy fields. An experimental plot was set from July 8 to September 8 within the first conventionally water managed paddy field (cultivar Akitakomachi), and the other experimental plot was set within the second conventionally water managed paddy field (cultivar Nikomaru) from September 9 to 30, and water ponding was conducted in both plots every day. T_l and T_p T_l and T_p in the water ponding plot ($T_{l(WP)}$, $T_{p(WP)}$) and conventionally water managed paddy field ($T_{l(Con)}$, $T_{p(Con)}$) were measured every two or three hours during daytime in every 10 cm canopy layer every day. Based on the measured results, water ponding decreased T_l and T_p consistently during daytime as a whole. In the first experimental paddy field, $T_{l(WP)}$ was 4.3 ℃ lower than $T_{l(Con)}$, and $T_{p(WP)}$ was 5.5 ℃ lower than $T_{p(Con)}$ at largest. Under large *St*, high air temperature (T_a=32.77 ℃), low relative humidity (*RH*) and wind speed (*u*) conditions, $T_{p(WP)}$ was controlled to be 26.4 ℃, which meant that $T_{p(WP)}$ was 6.37 ℃ lower than T_a, while $T_{p(Con)}$ was 30.8 ℃ at 10:40 on

August 19. In the second experimental paddy field, $T_{l(WP)}$ was 3.6 ℃ lower than $T_{l(Con)}$, and $T_{p(WP)}$ was 3.4 ℃ lower than $T_{p(Con)}$ at largest. Under larger *St*, higher T_a and lower *RH* conditions, water ponding was more effective to decrease T_l and T_p, thus mitigating the high temperature damage.

To continuously monitor T_p to understand the growth impairment caused by heat stress in rice, we developed three-layer model, which consists of upper and lower rice canopy layers and water surface layer for predicting panicle temperature. In this model, the upper and lower canopy resistances were obtained by stomatal conductance and leaf area of each layer. T_p was predicted by solving radiation and heat balance equations of the panicle with modelled upper canopy temperature (T_{c1}) and lower canopy temperature (T_{c2}), in which the inclination factors of leaves and panicles (F_1, F_2 and F_p), the aerodynamic resistance between the panicle and atmosphere (r_{ap}), the panicle resistance for transpiration (r_p), air temperature and humidity at the panicle's height (T_{ac1} and e_{ac1}) were included. F_1, F_2 and F_p were decided by fitting the calculated transmissivity of downward solar radiation (TDSR) to the measured TDSR. The relationships between u and r_{ap}, between days after heading and r_p were parameterized. T_{ac1} and e_{ac1} were calculated from the resistances of the pathways of sensible and latent heat fluxes according to the Ohm's law. The better agreements between measured and calculated T_{c1}, T_{c2} and T_p have indicated the three-layer model is a more reliable tool compared with one-layer or two-layer models to predict T_p.