

(Format No. 3)

SUMMARY OF DOCTORAL THESIS

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Title: **STAY-GREEN IN RICE (*Oryza sativa* L.) GROWN IN DROUGHT-PRONE AREAS CHARACTERIZED BY DESICCATED SOILS**

(乾燥土壌下で発現する旱魃地帯栽培イネ(*Oryza sativa* L.)の緑葉維持能力)

Drought is the predominant environmental factor affecting rice production in rain-fed areas of Southeast Asia such as Vietnam. Overcoming the effect of drought on rice yield and yield stability by investigating the secondary traits related to drought resistance has been one of the objectives of rice breeding programs. Stay-green is regarded as one of the effective drought resistant mechanisms in some crops such as sorghum when the drought occurs in the terminal growth stage. However in rice (*Oryza sativa* L.) the existence and the effectiveness of stay-green trait for the production are unknown.

The first investigation was to determine whether the stay-green trait exists in rice cultivars of drought-prone areas. Twenty-four cultivars mainly from Japan and Vietnam were grown in pots of 0.08 m in diameter and 1.00 m deep. At heading, irrigation was terminated to half of the pots and continued to the remaining pots. Every four days, the leaf green color with a chlorophyll meter (SPAD), the green leaf area (GLA) and the fraction of transpirable soil water (FTSW) for the grain-filling period were measured. A maintenance capacity of SPAD value and GLA under desiccated soils was evaluated by determining the ratio of integrated SPAD value or GLA over observed days or FTSWs in desiccated (D) plants compared to irrigated (I) plants ($SPAD_{D/I}$ or $GLA_{D/I}$, respectively). The $SPAD_{D/I}$ and $GLA_{D/I}$ in 24 cultivars showed diverse frequency distributions. Cultivars belonging to higher ranges of the distribution in $SPAD_{D/I}$ and $GLA_{D/I}$ tended to show higher ratios of plant dry weight at harvest in D compared to I plants. Poor relationships in $SPAD_{D/I}$ or $GLA_{D/I}$ between the grain-filling and the seedling periods under desiccated soils were observed, and hence the maintenance

capacity of green leaves in the grain-filling period would differ from that in the seedling period. These results suggested that stay-green as a capacity maintaining green leaves and benefiting matter production under desiccated soils exists in rice cultivars of drought-prone areas.

The next research was to clear whether the trait could be effective for rice production in large soil volume cultivation conditions, and what factors contribute to the trait. Five cultivars of japonica and indica, which showed differences in their capacity to maintain green leaves (+ and -) in a previous trial were grown in pots of 1 m depth of 31-L volume. When water was withheld from pots at heading, SPAD value, GLA and leaf conductance (C_L) in (+) cultivars were higher than in (-) cultivars under similar conditions of soil desiccation. The net assimilation rate and water use efficiency in the (+) cultivars showed a tendency to be higher than in the (-) cultivars, while grain weight in one of the (+) cultivars was not higher because of sterility. Removal of the panicle at heading increased the maintenance of green leaves in all cultivars even under reduced nitrogen top-dressing. Nitrogen absorption after anthesis in (+) cultivars was higher and retranslocation from straw to grains was smaller than that in (-) cultivars. Vietnam (+) cultivars grown in larger pots of 130-L showed superior maintenance of green leaves, leaf conductance and dry-matter increase under the post-anthesis drought. These results suggest that the stay-green trait contributes to rice production under post-anthesis drought conditions through higher water use efficiency due to the maintenance of assimilation and higher retention capacity of nitrogen in the rice straw.

The third investigation focused on if the capacity to stay green in the terminal growth stage is related to root performance in Vietnam rain-fed rice cultivars. Three Vietnam cultivars that showed different ability in stay-green trait in the first experiment were grown under flood conditions in 130-L volume pots. Irrigation was withheld from half of the pots at the anthesis period, while the flood condition was maintained in the remaining pots. The SPAD value, GLA and C_L decreased after heading while trends of the decrease by soil desiccation differed among cultivars. The cultivar, which showed higher maintenance of the SPAD value, GLA and C_L under desiccated soils had significantly denser roots in the surface soil layer at harvest. The water absorption rate per soil volume and per root length of almost all soil layers in the cultivar was maintained longer and higher in desiccated soils. The SPAD value and GLA of detached

leaves in the cultivar incubated under dark and humid conditions were maintained significantly longer, and hence the maintenance of green leaves comes from the leaf properties. These results suggest that in stay-green rice cultivars the properties keeping green leaves contribute to a delay in the suppression of assimilate processes and maintain the water absorption function of the roots by maintaining the assimilate supply to roots.

From the results, it is concluded that stay-green trait exists in rice of drought-prone areas and the trait gives benefit on rice production under desiccated soils in the post-anthesis period. To improve the drought resistance in rice, diversity of the stay-green observed in the research is expected to be use as materials for breeding by mapping quantitative trait loci (QTLs).
