

## 学位論文要旨 Dissertation Abstract

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学位論文題目 : Effects of double-row transplanting systems in a rice field  
Title of dissertation on micrometeorological properties and rice production  
(水田の微気象学的特性とコメの生産に及ぼす複列移植の効果)

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Over the last ten years, rice production in Indonesia has been lower than its consumption. This condition is depressed by global warming, which has been reported to decrease rice production in Indonesia. Therefore, sustainable rice production under climate change conditions is a critical food security issue in Indonesia. Over the past decade, the Indonesian government has been recommending double-row transplanting systems, i.e., *Jajar Legowo* (JL) and *Jejer Manten* (JM), to increase rice production. JM has not been promoted nationally, unlike JL, which has been promoted since 2013. These systems have been reported to obtain higher yields of Indica rice cultivars than the standard tile (TL) system, primarily due to the border effect. However, scientific investigations of the border effect in these systems remain limited. Scientific evidence is needed to support the promotion of JM and JL.

Field experiments were conducted to observe the growth and production of rice during the summer seasons in 2022 and 2023 by transplanting Nikomaru (a Japonica rice cultivar) in an experimental field at Ehime University, Japan. The planting densities were 16.00, 19.03 and 21.33 hills  $m^{-2}$ , for TL, JM and JL, respectively. At the same place during the summer season of 2023, field experiments were conducted to observe micrometeorological properties of a rice field, such as such as the ratio of the

single-leaf area that contributes to absorbing and emitting solar radiation ( $F_l$ ), intercepted photosynthetically active radiation ( $PAR_{int}$ ) and photosynthetic rates by the canopy ( $P_{canopy}$ ). This study addresses whether double-row transplanting systems can increase rice yield and alter the micrometeorological conditions of a rice field.

The study found that JM obtained the highest yield, followed by JL and TL. Higher plant competition for light in JM and JL caused a lower tiller number and above-ground biomass ( $W_t$ ) per hill than in TL. However, due to denser plants, JM and JL obtained a higher number of tillers,  $W_t$ , leaf area index (LAI) and sink capacity per unit area than TL. Moreover, JM obtained the highest sink filling rate, followed by JL and TL. Additionally, JM obtained the highest normalized difference vegetation index (NDVI), followed by JL and TL. NDVI during flag leaf extension to milking stage was highly correlated to the sink filling rate and yield. The synergistic effect of higher sink capacity and sink filling rate, supported by higher NDVI, led to higher yields in JM and JL than in TL.

This study found that JM and JL obtained a lower  $F_l$  than TL due to a denser canopy. However, the wide space in JM and JL caused the border effect, indicated by a higher  $PAR_{int}$  and  $P_{canopy}$  in JM and JL than in TL. Due to border effects in a dense canopy in JM and JL, the higher  $P_{canopy}$  supported the higher sink capacity resulting in the higher sink filling rate in JM and JL than in TL. The synergistic effect of higher sink capacity and sink filling rate, supported by higher  $P_{canopy}$ , led to higher yields in JM and JL than in TL. Comparing JM and JL, JM obtained border effect efficiently due to a higher  $PAR_{int}$  and  $P_{canopy}$  in JM than in JL. The symmetric planting pattern in JM is more advantageous for the canopy in intercepting solar radiation. JM has a wide space not only between the rows but also between the columns, so the possibility of competition for light is lower in JM than in JL.

This study suggests that JM is the best transplanting system for increasing rice yield by increasing planting density and sink filling rate. This finding suggests that applying JM and JL to other varieties of Japonica rice may also be beneficial. The findings of this study also suggest that the Indonesian government should prioritize promoting JM similarly to the nationwide promotion of JL.