(Format No. 13)

SUMMARY OF DOCTORAL THESIS

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Title: ASSESSMENT OF EFFECTS OF SILICON APPLICATION AND IMPROVED WATER MANAGEMENT ON RICE PRODUCTION IN INDONESIA

インドネシアの米生産におけるケイ酸施用と水管理改善の効果の評価

Various innovations have been made in rice production systems in Indonesia to increase the productivity. However, the rice production has fluctuated and stagnated over the past decade. Among those innovations, silicon (Si) application has not been appreciated in Indonesia because it was not an essential nutrient and also due to limited study about role of Si for rice plant in Indonesia. About water management, mostly Indonesian farmers employ continuous flooding in rice cultivation with assumption that continuous flooding could produce high yield. However, this water management is no longer suitable due to water shortage in some rice production area. This study is to assess effects of Si application and appropriate water management on improving rice productivity in Indonesia. Field surveys and rice cultivation experiments were conducted in three major rice producing provinces, namely Lampung, West Java and East Java province. Based on this present condition, this study was conducted.

Filed surveys were conducted in West Java and Lampung province in order to examine the soil available Si content in relation with blast infection of rice categorizing two types of sawah: Bs+ (site which has blast disease occurrence) and Bs- (site which has no blast disease occurrence). The result showed that soil available Si in West Java (300 – 960 mg SiO_2kg^{-1}) was higher than in Lampung (61 – 188 mg SiO_2kg^{-1}) as an effect of different parent material. West Java province, has parent material that is dominated by tuffaceous sandstone and volcanic rock. Soils developed from tuffaceous parent materials are known to contain higher Si than other parent material. Although West Java had higher soil available Si, it still experienced severer rice blast disease. This might be due to high rainfall and excessive N fertilizer application in West Java. Silicon content in rice leaves from West Java was ranged from 2.7 – 8.0% or equal to 57.8 – 171.2 g SiO_2kg^{-1}. Revealed that Bs- sites had higher Si content in rice leaves than Bs+ sites which is in agreement with many previous researches that stated Si accumulation in rice plant could improve plant resistant on blast disease. Comparison of several extraction methods for assessing soil available Si, showed that 0.01M HCl extraction gave significant correlation ($p<0.01$; $r=0.66$) with Si content in rice leaves, which indicated that the 0.01M HCl method was better assessing SiO_2 availability in studied soils.

A field experiment was conducted in Sukabumi, West Java to evaluate the effect of Si application on blast disease infection, plant morphology and stomata formation of rice. The results demonstrate that Si application showed significant effect on suppressing leaf ($p < 0.01$) and neck blast disease ($p < 0.05$) attack on Ciherang rice variety although the soil in study site had soil available Si of 426.54 $mgSiO_2kg^{-1}$ which is above critical level. The results confirmed that Si application have potential to improve rice growth and yield through the improvement of resistance to blast infection and increment of stomata density significantly ($p < 0.01$) in Indonesia although they did not result in the yield increment in the present study.

On the water management method, intermittent irrigation (IT) water management significantly increased the yield during dry season (direct seeding) compared to continuous flooding (CF) water management. IT also tended to be higher in the yield than AR although it was not statistically different. The yield increase was attributed to better grain filling status shown in the 1000-grains weight. IT demonstrated a better root growth compared to continuous flooding (CF) and Aerobic Rice (AR), which exhibited possibility to improve lodging resistance, and shoot growth and decreased blast disease infection. Moreover, leaf Si content in IT and AR was higher than that of CF, which could promote higher photosynthetic rate as Si in leaf takes role to stimulate photosynthesis through improving light interception and the translocation of photo-assimilated carbon to the panicle in rice. In this experiment also, Si application clearly improved plant resistance to both leaf and neck blast infection ($p< 0.01$) and increased stomata density ($p< 0.01$) in all water treatments.

In wet season (transplanting) also, IT showed significantly increases yield comparing with CF. Better root growth performance with IT could lead to enhance growth (shoot weight and plant height) and yield, and Si uptake which affected on improving resistances to lodging and blast infection. Regarding to brown rice grain quality, IT management significantly increased micronutrients (Cu, Mn, and Zn) contents. Meanwhile Si application, obviously exhibited the beneficial effect on improving plant resistance to blast infection. Although, the Si application did not result in the higher yield in this experiment, it exhibited potential improving rice plant growth and production in Central Java region.

Practicing Si application combined with intermittent irrigation could be a promising method to improve rice production. Moreover, Si application could be an alternative method which environmentally friendly instead of fungicide application that has been commonly practice for blast disease control. Therefore, these methods should be considered as practical options for improving our rice production in Indonesia. It is necessary to develop a governmental program in order to extend these methods to the farmers.