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SUMMARY OF DOCTORAL THESIS

Name: PROTIMA DHAR

Title: Studies on the Increase in Arsenic Concentration in Brown Rice Due to High Temperatures During the Ripening Period and Countermeasures for Reducing the Arsenic Concentration by Applying Soil Modifiers

(登熟期の高温による玄米ヒ素濃度の上昇ならびに種々の土壌改良資材施用によるその低減対策に関する研究)

Arsenic (As) is a non-essential, potentially ubiquitous metal, naturally occurring in the environment with a relatively low concentration. Rice, the primary dietary source of inorganic As, is more concentrated As in grain than other cereals, despite its high essential nutritional content like carbohydrates, protein, vitamins, and fiber. Increased air temperature would amplify the risk of increasing toxic inorganic As (iAs) accumulation in rice grain using multiyear statistical analysis. Considering the As toxic effect, many authentic mitigation techniques and tests have been followed to reduce As concentration in rice. However, the effect of high temperature on As accumulation in rice grain during the ripening period is not research experimentally. This thesis aimed to clarify the effect of high temperature during the ripening period on the elution of As in soil solution from soil solid phase and on the concentration of As species in brown rice using temperature-gradient chamber (TGC). Furthermore, it was verified whether the application of soil conditioner (silicate and iron) was effective in reducing the arsenic concentration in brown rice even at high temperatures.

This thesis gave some critical insights for conducting three experiments. The growing conditions in these experiments were common, and the cultivation and high-temperature treatment of rice were carried out as follows. Before transplanting Wagner pots were filled with 3-kg As-uncontaminated gray lowland paddy field soil and 2.8 g of a basal compound fertilizer used in every pot, which each pot contained N 14%, P_2O_5 14%, and K_2O 14%. Calcium silicate and converted furnace slag (CFS) were used as Si treatment and Fe treatment, respectively. Rice seedlings that were approx. 25 days old were transplanted to the Wagner pots and kept those with flooding conditions until harvest. One week after heading, all rice plants were moved into TGC for temperature-treatment, where the temperature treatment section separated, followed by ambient, mildly-high, moderately-high, and super-high temperature treatment to detect the temperature variation.

Air and soil temperature difference was observed in the TGC in the range of 2-3.2 °C compared to ambient temperature. The high temperature significantly increased the total As concentration in the soil solution during the ripening period. The concentrations of As in the soil solution during the middle ripening period (14-28 days after heading) were tended to be higher than those of the early ripening period (7 days after heading) and harvesting period (41 days after heading).

There was a significant negative correlation between the brown rice yield and the air and soil temperatures, and the increase in air and soil temperatures resulted in a decrease in the yield. The reduction in yield was significantly mitigated by applying calcium silicate and CFS. The concentration of As in the brown rice was significantly positively correlated with the air and soil temperature, and the concentration of As increased with increasing air and soil temperatures. When calcium silicate and CFS were applied, the concentration of As in brown rice was significantly lower at all temperature ranges, and those applications were effective in reducing the arsenic concentration

even at high temperatures. These results suggest that the application of soil modifiers including silicate and iron may help mitigate the decrease in yield and the increasing As concentration in brown rice even under high-temperature conditions.

* In addition, some of the figures, etc., have been omitted.