Summary of Doctoral Thesis

Enrollment year: 2017 y 4 m
UGAS Specialty: Plant Production
Name: NGUYEN THANH TUNG

Title	Comparison of soil fertility and the N, P and K balance in the paddy fields under conventional rice straw application versus cow dung compost application in mixed crop- livestock systems

After the rice harvest in Japan, rice straw (RS) is usually cut by combine harvester and incorporated into the soil to improve its fertility. In mixed crop–livestock systems, however, RS is collected and used as livestock feed, and cow dung compost (CDC) is then applied to the soil. This system utilizes the residual organic matter from both rice production and livestock husbandry to make each product. CDC application is also considered to improve the fertility of paddy soil. But, the nutrient input from CDC and the effect of CDC application on soil fertility vary among regions and/or soil types. We compared soil fertility between RS application (RS treatment, avg. 32 years) and RS removal plus CDC application (CDC treatment, avg. 21 years) in 79 paddy fields in Mamurogawa town, Yamagata Prefecture, a cold temperate region of Japan, and measured the nutrient contents in the applied RS and CDC. The total C content of RS was significantly higher than that of CDC, whereas the N, P, K, and Si contents of CDC were significantly higher than those of RS. However, there was no significant difference in paddy soil fertility—as measured by soil organic C, total N, CEC, available N, P, and Si, exchangeable K, Ca, and Mg, base saturation percentage, pH, and bulk density—between the treatments. The soil fertility of most fields was adequate by RS or CDC treatment. Thus, leaving RS in paddy fields or removing it and then adding CDC to the paddy fields has a similar effect in maintaining adequate soil fertility for single rice production or rice–livestock production systems

To clarify the result of higher nutrient input from CDC but non-significant difference in soil fertility between treatments, we investigated on the nutrients (N, P, and K) balance in the RS and CDC treatment. From 79 selected fields, we chose 10 pairs fields (RS treatment and CDC treatment are nearby) to conduct this research. We measured the nutrient inputs (organic matter, fertilizer, and N fixation in case of N) and the nutrient outputs (plant uptake and leaching) and calculated the nutrient balance of the pair fields. The result showed that: **(1) N balance**: The N fertilizer contributed the highest percentage to the total N input followed by organic matter and the lowest one was N fixation. The N fertilizer and N fixation in the RS treatment were non-significant difference with those in the CDC treatment. CDC contribute significantly higher N to the fields than RS, but the total N input was non-significant difference between treatments. The plant N uptake was higher in the CDC treatment, but the difference was not significant. Plant N uptake was the main output, accounting for 98% of total N output. The N leaching loss did not contribute significantly to the total output. The N balance was positive and non-significant difference between treatments. Therefore, non-significant differences in total N input, total N output, and N balance between treatments were the reason for non-significant difference in soil total N and available N of paddy field. **(2) P balance:** P input from CDC to the field was higher than that from RS, while fertilizer P in the CDC treatment was lower than that in the RS treatment. The higher amount of P input from CDC was depleted by the higher amount of

fertilizer P applied in the RS treatment, which lead to the same level of total P input between treatments. The plant P uptake was the main output, accounting for 99 % to the total P output. The P leaching loss was small and negligible. The difference in plant P uptake and P leaching between treatment was not significant, which lead to non-significant difference in total P output. Overall, the non-significant difference in soil available P between treatments come from non-significant difference in total P input, total P output, and P balance between treatments. **(3) K balance:** The contribution of organic matter in total K input was higher than that of fertilizer. The difference in K input from organic matter and chemical fertilizer between treatments was not significant, which resulted in non-significant difference in total K input to the paddy field. The plant K uptake was the main output, accounting for 90% of total K output. It was non-significant difference between treatments. The leaching loss was a significant amount and should be considered as a main output of K from the paddy field. The RS and CDC treatments resulted in the same level of K leaching loss. The total K output, therefore, was non-significant difference between treatments. Overall, the non-significant differences in total K input, total K output, and K balance were the reason for the non-significant difference in soil exchangeable K.

Aside from the main research on the nutrients balance, we also measured the nutrients (N, P, K, Si, Ca, and Mg) and total C concentration in the plow layer water and leaching water to understand the changing of nutrients and soluble C during cropping season and how they move through from paddy field in the RS and CDC treatments. We found that in plow layer water, the concentration of all of nutrients and C excepted for P increased after transplanting, reached to the peak, and then decreased after that. The plenty of input before and/or at transplanting by organic matter and fertilizer and poor rice plant uptake resulted in the higher concentration in the plow layer water at early growth stage. Plant nutrients uptake, emission, and soil adsorption can explain to the decrease in the nutrient concentration in plow layer water. The increasing in the concentration of K, Si, Ca, and Mg in leaching water may result in the sharply decreased in their concentration in the plow layer water. In case of N and C, the concentration in the plow layer water did not have relationship with the concentration in leaching water. P is a special nutrient, absorbed firmly in soil, so that there was few P existing in plow layer and leaching water. The concentration of N, P, K, and C in plow layer water and leaching water were similar in the RS and CDC treatments, and the concentration of Si, Ca, and Mg in plow layer water and leaching water were higher in the RS treatment than the CDC treatment.

Overall, the RS and CDC treatments resulted in the same level and at fertile level of soil fertility. The input of nutrients from CDC was higher than that from RS but the total input, total output of the CDC treatment was non-significant difference with that of the RS treatment. This led to non-significant difference in nutrients balance between treatments. Therefore, the non-significant difference in total nutrients input and output, and the nutrients balance were the reason for non-significant difference in soil fertility between treatments. The amount of fertilizer P in this area can be reduced especially in the CDC treatment. And, the removal of RS resulted in negative K balance if there is no CDC application. Although the N, P, and K balance were positive, total N and P, available N and P, and exchangeable K in soil did not increase for three years of the study duration in both the RS and CDC treatments.