学位論文内容の要旨

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学位論文題名

The microbial dynamics in natural farming rice paddy

（自然農法水田における土壌微生物ダイナミクス）

Natural farming in a rice paddy is an alternative agricultural system to grow food instead of conventional farming, which is highly supported by microbial functions rather than utilization of various types of fertilizer. The degree in biological nitrogen fixation (BNF) and the utility of incorporated rice straw often controls the successfulness of the natural farming. However, a natural farming rice paddy, in addition to highly rely on microorganism activities, weeds are one of the major issues that affect the rice yields. In this study, ^{15}N abundance was used to understand the BNF between natural and conventional farming rice paddies. I also compared the microbial community in Hokkaido with that in Taiwan. Also, inter-tillage (remove weeds) and no-tillage (not disturb the weeds) systems were compared to clarify whether disturbance impacted microbial dynamics. A rice straw decomposition experiment with incubation pots was also conducted to investigate the relationship between rice straw decomposition rates, and the incorporation of different C to N ratio of plant residues.

1. Identifying microbial communities in conventional farming (CF) and “natural farming” (NF) paddy fields in Hokkaido university

In 2018, root zone (rhizosphere) of rice and surface soil were sampled in a natural farm and a conventionally managed farm (farms with the use of chemical fertilizer). The soils were analyzed using a next generation sequencer Ion Chef and PGM (to identify the variety of whole bacteria). I found two bacterial families with the ability to conduct BNF. First, I found that NF rice/weed root has higher ratio of *Rhizobiales* than CF. *Rhizobiales* might be more sensetive to chemical fertilizer. *Rhodospirillales* accounted for a smaller ratio in both NF and CF. Previous studies found that most of the BNF activity in soils are conducted by *Alphaproteobacteria*, including *Rhizobiales* and *Rhodospirillales*. *Rhizobiales* are symbiotic with plant root and *Rhodospirillales* often appear in water. I observed that *Proteobacteria* was competing with *Crenarchaeota*, the relative abundance of *Chloroflexi* was higher

in Hokkaido soils than Taiwan soils.

2. **Inter–tillage during natural farming rice paddy production negatively impacted the microbial abundances in soils but not on diversities**

   Natural farming systems aim to maintain biodiversity, but it remains unclear whether the inter-tillage impact soil microbes in rice paddies. Thus, this study aimed to understand to what extent "five-times inter-tillage" treatment (5T) influences on soil bacterial abundance and community structures compared with no-tillage (NT), under a natural farming rice paddy system. Soils were sampled at rice proximity, soil surface and 10 cm depth in a natural farming rice paddy, during the early to late vegetative phase (June to July), in Hokkaido, Japan. The 16S rRNA community structures and abundance were analyzed by next generation sequencing (NGS) and quantitative PCR, respectively. I observed NT had significantly higher bacterial abundances at the soil surface than 5T. However, there was no clear differences between 5T and NT, regarding the bacterial community structures, including their diversity indices.

3. **The fluctuation on microbial abundance during the decomposition of rice straw with different weed residues**

   Carbon to nitrogen (C/N) ratio is regarded as a critical index to evaluate in what extent the incorporated organic matter influence soil microbes whether conduct mineralization or immobilization, in other words, the nutrients such as inorganic nitrogen and carbon release to soil or stock in microbes. In this study, I sampled two most predominated and different C/N ration weeds which are clover and *Rumex* around natural farming rice paddy after harvested in early October. The objective of the study was to investigate whether the surrounding weeds can improve soil microbial activities. We hypothesized that incorporated weeds would increase bacteria and fungi abundance and lead to a higher rice straw decomposition rate. As a result, the rice straw decomposition rate was significantly influenced over time instead of by different treatments not influenced by the treatments in the current study. Nonetheless, I found *Rumex* treatment had relatively higher F : B ratio among four treatments; Clover treatment had largest ammonium and nitrate concentration. The accumulative C released from rice straw is associated with F : B ratio and soil respiration. Higher F:B ratio lead to lower soil respiration and higher accumulative C released from rice straw.