

## 論文の内容の要旨

論文題目 Mechanism of Greenhouse Gases Emission from Paddy Field with Environmentally Sustainable Rice Growing Method  
(温室効果ガス排出から見た環境保全的稲作法のメカニズム)

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About Ninety percent of rice production and consumption takes place in Asian countries. Not only the consumption of rice in Asian countries is higher but also rice is inter-connected with feast and festival. The quality of rice taste varies with location, topography, cultivation system, irrigation facilities. Especially, lowland rice is considered as good quality in taste and have higher demand in the market. But because of untimely precipitation, drought, deforestation, urbanization leading to lowering the water resources can cause rice production fluctuating. After the green revolution, the per capita rice consumption is increased in Asia from 85 kg to 103 kg and at the same time global per capita rice consumption is increased from 50 to 65 kg (Mohanty, S. 2013). On one hand, the increased in rice consumption along with population increment is challenging the sustainable rice production. On the other hand, climate change is also hindering the rice production and its adaptability. To overcome these issues, several mechanisms were developed not only to increase rice production but also to ensure the

sustainability from viewpoints of environment, economic and social. Some of the mechanisms developed to cope with climate change and limited resources were AWD (alternative wetting and drying) irrigation, development of drought tolerance rice cultivars, and newly disseminating processes, synergy for the both climate and production system, SRI (System of Rice Intensification) methods. In this study, from the viewpoints of mechanism of GHGs (Greenhouse Gases), the consecutive experiments were performed starting from the lysimeter environment to real farmer's paddy field, adopting one of SRI key elements with irrigation application in Chiba prefecture and Fukushima prefecture, Japan from 2013~2015 in rice growing seasons.

In this study, one of the main objectives is to understand the rice plant development under SRI and non-SRI method. Second objective is to investigate the soil layer condition of paddy field under the different water treatment and final one is to understand mechanism of GHGs emission with respect to soil layer in depth-wise condition.

The method in this study is experimental based. Data collections are adopted in various ways. The soil pH and ORP are recorded manually in situ condition. The soil moisture (soil water content), temperature are measured for every sixty minutes by sensors throughout the experiment. The gas data are also collected by closed chamber method and transferred in air tight bial in situ conditions. The laboratory experiments are conducted to analyse the GHG by gas chromatography and post-harvest measurements are conducted for rice plant height, tiller, leaves, grain yields and total biomass by dismantling and oven drying processes. The data recording and computing process are done using excel and graphical/statistical analysis tool R.

For the first objective, we found that on rice plant development under the SRI method and non-SRI method, the structural development of rice plant in the flooding plot is significantly greater than the SRI plot. Young single seedlings are used in both plots, and there is no difference in grain yield. Dry root weight is greater in the flooding plot but no difference is observed for root length. The difference in result is because the same number of rice seedlings are transplanted in both plots. In order to further understand the structural development in SRI and non-SRI methods, we investigated the SRI method by seedling densities and it is found that the grain yield is significantly higher for transplantation treatment with three and four seedlings rather than one seedling, validating the farmer's confidence in their way of applying the SRI method suggesting that farmers can transplant more than one seedling in lowland areas. In the farmer's field, It is found that by same methodology applied in lysimeter environment, the grain yield (14% moisture level) is also insignificant difference, indicating the value 55.54 gms./hill in SRI method and 59.81 gms./hill in local method. It suggests that SRI method and non-SRI method near our study area, the rice yields do not differ between two methods.

For the second study, the soil layer condition in growing and non-growing seasons, it is found that the soil moistures are fluctuating with same pattern of ponding depth (water availability in paddy field) and the temperatures also have similar trend with the average temperature obtained from meteorological agency. The soil ORP (Oxygen Reduction Potential) is measured in lysimeter experiment at different depths, shows positive for depth at 20 cm. We supposed that lower depth should be more reducing in nature of paddy field soil. Henceforth, it is also validated in real farmer's field in Iwaki-shi, Fukushima, measuring ORP at 5 cm, 10 cm, 15, 20, and 30 cm depths, in two paddy fields (Paddy

field A is with intermittent irrigation and B is Iwaki-Shi local method). It is found that 30 cm depth showed similar results as lysimeter experiment. It is found that up to 20cm depth, ORP is negative and 30 cm depth is not responsible for the GHGs emission.

For the final objective, to investigate mechanism of GHG emission with respect to soil layer conditions in depth-wise, the higher correlation between methane flux and ORP value at 10 cm and 15 cm is found with lysimeter environment, reducing the 50% methane in comparison between SRI and non-SRI methods. In case of paddy field, intermittent irrigation method (Paddy field A) has shown higher correlation among methane flux and ORP at 15, 20, and 30 cm depths, while in local method (Paddy field B) it shows negative correlation at the depth of 5, 10, 15, and 20 cm. It indicates that different phenomenon is observed in GHG emission in intermittent irrigation method and continuous flooding method.

Finally, the SRI method is now spreading in more than 50 countries in all over the world. In case of Japan, still the SRI method is on the process of adoption and have less practices in farm level. Other factor for slow adoption of SRI method is that Japanese rice already have higher yield among the Asian countries, so from the viewpoints of Japanese farmer's, they think SRI method is not very important to adopt. The results achieved from our experiment, suggests that intermittent irrigation method (One of SRI key elements) have importance to contribute reduction in GHG emission from rice farming in Japan.

Key words: Mechanism, GHGs, Environmentally sustainable, SRI, Lysimeter, paddy field