論文内容の要旨

論文題目　Assessment of the System of Rice Intensification (SRI) Techniques under the Temperate Climatic Condition in Japan
（温帯日本におけるイネ強化法（SRI）の評価）

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The System of Rice Intensification (SRI) involves the adoption of certain changes in management practices for rice cultivation that create a better growing environment for the rice crop. Use of the intermittent irrigation with alternate wet and dry intervals (AWD) and single transplanting of the younger seedlings at wider spacing are regarded as the key factors in SRI for better crop growth and productivity.

Field experiments were conducted in Chiba, Japan during the two consecutive rice growing seasons (May-September) of 2008-09 to observe the effects of SRI components on rice crop performance, field environment, water savings, and water-wise rice production. The effects of irrigation method, age of seedling and spacing were evaluated during 2008 rice-season with 8 treatment combinations in a Split-split plot design (S-SPD). AWDI at 10 days intervals and continuous flooding throughout the cropping season were the two main plot factors while the effects of age of seedlings (14 and 21 days) and plant spacing (30x30 cm^2 and 30x18 cm^2) were evaluated as sub and sub-sub plot factors, respectively. The experiment results revealed that the SRI management with the proposed AWDI can save a significant amount of irrigation water (29%) without reduced grain yield (7.41t/h compared with 7.37t/ha from normal planting with ordinary water management).

Water productivity also observed to be significantly higher in all combinations of practices in AWDI plots: 1.74 g/liter with SRI management and AWDI as compared to 1.23

g/liter in normal planting with ordinary water management. In addition, the research outcomes showed a role of AWDI in minimizing pest and disease incidence, shortening the rice crop cycle, and also improving plant stand until harvest. Synergistic effects of younger seedlings and wider spacing were seen in tillering ability, panicle length, and number of filled grains that ultimately led to higher productivity with better grain quality.

Field experiment with the complete sets of SRI practices was carried out in Randomized Complete Block Design (RCBD) during 2009 rice growing season at the same field. SRI (with 8 days old seedlings) and Conventional (with 22 days old seedlings) practices were the first factor (cultivation method), while Organic and Inorganic managements were evaluated as second factor (management method) in the field experiments. The highest yield was observed with the conventional method with inorganic management (6.84t/h) that was at par with the Organic SRI (6.59t/h) followed by Organic Conventional (6.48t/h). It was recorded as 5.92t/h in Inorganic SRI management. Overall, the effects of SRI components were positive and significant on per plant basis however, it was not differed significantly in terms of grain yield per unit area.

Development of healthy and vigorous roots, increased stem diameter, greater productive leaf area, longer panicles, greater number of filled grains, development of plants tolerant to insect-pest and disease, and reduced plant lodging percentage were some notable achievements with SRI management. Water savings and water-wise rice production are other important issues that are likely to draw the attention of rice researcher and farm communities to adopt SRI under water scarce condition. However, still, comparatively better grain yields when using conventional management method underscore a need for further investigations in defining an appropriate combination of practices for SRI management considering local soil properties, prevailing climate, and critical watering stages in rice crop management.

Above all, the followings are the key lessons during the course of two years' experimentation.

- Soil aeration is very important operation in the intermittent plot. As the soil surface becomes hard as a result of alternate wet and dry intervals, it is imperative to make them loose through weeding or hoeing practices. It has been appeared as an utmost practice even if herbicides were applied to the intermittent plot.

- Panicle length and number of grains/filled grains were largely attributed to the use of single seedling at wider spacing. Despite of having fewer effective tillers or panicles per unit area, satisfactory yield in SRI plots were merely due to better panicle and grain characteristics. It has been possible due to the development of a large number of white and functional roots, greater leaf area with dark green foliage (productive leaf surface), and healthy and vigorous plant with thicker stem and longer roots. Normal seedlings that were transplanted singly at wider spacing also possessed longer panicles as well. So potential of single transplanting with the different seedlings' age should be further explored.

- SRI components appeared to be highly responsive to agri-input especially with the application of organic fertilizers. The application of as much as organic manures, and soil aeration together can provide the better results than the inorganic fertilizers alone.

Weeding requirements can be reduced by using just a single dose of pre-emergence herbicides after transplanting or by maintaining a shallow standing water depth for the first 15-20 days or more after crop establishment when crop canopies completely shade the land, and subsequently maintaining the alternate wetting and drying period or by creating a saturated but un-flooded soil regime until maturity.

- Intermittent irrigation with alternate wetting and drying intervals appeared to be a good practice for pest and disease management, water savings and water productivity.

- Due to its lodging tolerance effects, SRI practices with AWDI appeared to be a better practice in wind affected areas (especially during maturation).

- Organic rice farming under SRI and Conventional management was profitable than the conventional rice farming. Though the grain yield was comparatively lower in Organic SRI along with the increased labor inputs for weed management, but provides higher net return per unit area and was associated with the price premium for organically produced rice.

Overall, based on the field experiment in Chiba, Japan, it can be concluded that in certain areas and under the right conditions, use of intermittent irrigation with AWD schedule is a promising method in irrigated rice cultivation with dual benefits of resource saving and productive. The increased productivity of water and its resource-saving aspects are likely to be the critical factors that will make farmers and other stakeholders adopt AWDI in water-scarce environments, becoming increasingly common. In the meantime, use of baby seedlings (8 to 14 days after sowing) and single transplanting at wider spacing (30x30 cm^2) was proved to be significant with respect to the panicle and grain characteristics, among others.

SRI components showed positive effects on crop performance and environment. For grain yield, SRI effects was positive and significant on per plant basis; but appeared to be non significant while accounting per unit area. And the associated benefits (water-wise rice production, resource savings and environment-friendly cultivation) could be much greater than those achieved with the conventional methods of rice cultivation. No extraordinary high yields and increased labor costs while using Organic SRI may limit its adoption however, the associated benefits has demonstrated the scope of SRI practices as a promising technique of sustainable rice farming over conventional method even in the temperate climatic condition. Indeed, once farmers learn that they can reduce their seed requirement, water requirement, production costs, and perhaps labor requirements, while maintaining yields, SRI methods are poised to become more widely adopted