Establishment of Polyculturing System in a Paddy Rice Field Using Living Mulch
(リビングマルチを用いた水田の複作方式の確立)

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Modern agriculture increases crop productivity through chemical fertilizer application and mechanization, thus enables to produce lots of foods with less labor and high inputs of chemicals. Increased use of agro-chemicals and fertilizers cause environmental pollutions, human health problems and residual agro-chemicals in agricultural products. Safe food production and consumption is a major interest to consumers, thus the demand of production systems with low-input innovative agriculture or agrochemicals-free agricultures has been increased recently. Sustainable agriculture is one of the best ways to overcome these problems and many alternative approaches have been proposed. Polyculturing systems are one of that, such as mixed cropping and intercropping are widely practiced in upland fields. However, there is lack of establishment in the paddy field. The development of polyculturing system in paddy field becomes an important approach towards sustainability of cropping system in the Southeast Asia. This study was aimed to investigate the possibility for using floating aquatic plants as living mulch in paddy rice field for establishing a polyculturing system for Japan and Thailand.

The characteristics of living mulch were investigated in these two countries to introduce the polyculturing system for Japonica and Indica type varieties that are widely grown in these regions. *Spirodela polyrhiza*, common aquatic plants from tropical to temperate zone were used as inoculated plant in transplanted paddy rice field using seven Japanese cultivars in Japan. The yield of Aikoku, Akamai, Domannaka, Hanaechizen and Kichinkokumai increased 13-65% compared to un-inoculated control through the increment of panicle number. On the other hands, *S. polyrhiza* and *Lemna minor* were used as inoculated plants in Thailand for transplanting ten cultivars and direct seeded RD41, respectively. But there were no relations on the inoculation of aquatic plants on growth and yield of Thai rice cultivars. It might be affected by the environmental conditions.

To find out the appropriate inoculation methods of living mulch for constructing polyculturing system in paddy rice field, inoculation density and inoculation time of living mulch were investigated in transplanted Akamai field using *S. polyrhiza* as inoculating plant. Inoculation densities of living mulch were varied at 0, 25, 50, 75 and 100% coverage in the water surface at 7 days after transplanting (DAT) of rice. Inoculated density during 50 to 75% coverage increased rice yield around 10% compared to un-inoculated control. The effect of inoculation time of living mulch, varied at 0, 7, 14 and 21 DAT were evaluated. Rice yields of all inoculated plots were increased from 7 to 11% greater than un-inoculated control. The performance of polyculturing systems using 75% coverage at 7 DAT of *S. polyrhiza* and *Lemna aoukikusa* were compared with water hyacinth, rice bran, buckwheat hull, paper mulch, hand weeding and untreated control. Brown rice yields of living mulch plots increased by 10 to 11% to un-inoculated control. Number of weeds at maturing stage was less than rice bran and buckwheat hull plots. Living mulch had advantages on the costs and labor compared to hand weeding and paper mulch application. Thus, polyculturing system using living mulch was recommended as an ecofriendly and labor saving production systems.

The effects of living mulch were evaluated on agro-ecosystem in both laboratory and paddy field. Allelopathic activity of water culture extracts of *S. polyrhiza* and *L. aoukikusa* on germination of lettuce (*Lactuca sativa*), two weed species (false daisy (*Eclipta prostrata*) and barnyard grass (*Echinochloa crus-galli*)) and two rice cultivars (*Oryza sativa* L., cv. Akamai and Koshihikari). The germination of lettuce, false daisy and barnyard grass were delayed after incubation of both water culture extracts of aquatic plants. Final germination rates of all plants except lettuce were reduced by both extracts. Both of water culture extracts had no effect on germination of two rice cultivars. The shoot and root growths of two weed species were delayed by the both incubated extracts. These results indicated that water culture extracts of aquatic plants would have allelopathic substances, which delay germination and growth of weeds but not affected on rice germination. The effects of, *S. polyrhiza* living mulch was investigated on agro-ecosystem in Akamai rice filed. The total biomass in agro-ecosystem was increased after inoculation of living mulch. Although the light competition was not existed between rice and living mulch but the cumulative solar radiation (CSR) during rice growing period was reduced 18% in *S. polyrhiza* plot compared to no-inoculated control. There was a positive correlation between CSR and number of weeds at maturity, but correlation coefficient was the highest during 0-4 WAT and it was reduced in relation to the cumulative period was elongated. Number of weeds was reduced directly by sunlight-blocking from the floating mat of living mulch during the growing season. Cumulative CH_4 emission was decreased 36% in the *S. polyrhiza* plot compared to un-inoculated control. It might be related to the release of oxygen in the water and resulted to less reduced conditions in the soil and reduce activity of methane-producing microorganisms.

In conclusion, the benefits of polyculturing system using floating aquatic plants as living mulch could improve rice productivity, and reducing weeds and CH_4 emission. Living mulch can compensate for herbicide application and eventually reducing production costs of weed control by 4.1% of total cost in conventional production system. This system will have a possibility for producing premium rice, for example Akamai and Kichinkokumai in a rural area by conducting organic agriculture in Japan.