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Water Saving and Organic Fertilizers Based Technology to Remediate the Health of Paddy Soils and to Increase Rice Productivity in Indonesia

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Introduction

Rice is one of the most important grains in Indonesia since this crop is the staple food for the majority people. The rate of rice consumption is about 139 kg rice per capita per annum and it belong to the highest in the world compared with Japan, Malaysia and Thailand are only about 45 kg, 80 kg and 90 kg per capita per year, respectively (Suryana, 2008). Paddy rice cultivation largely depends on irrigation and its consuming about 3000 – 5000 L of water to produce 1 kg of grain or it requires 15000 – 30.000 m^3/ha of water to produce 5 ton of grain yield/ha (Nielsen, 2004, Simarmata, 2009). The increasing scarcity of water threatens the sustainability of the irrigated rice production system. The task becomes more difficult due to the global climate change. Therefore, it is need more efficient use of water in rice production. Several strategies are being pursued to reduce rice water requirement, such as alternate wetting and drying (Bouman *et al*., 2002, Yang, 2004, Ho, 2004, Anthofer**,** . 2004., Uphoff, 2004)

The intensively high inputs of artificial fertilizers and other agrochemical products application has decreased the organic content in soil significantly. The result of various field studies indicated mostly of paddy soils in Indonesia has a low organic content (< 2%) and based on soil health indicator, it can be categorized as sick soils (Simarmata, 2009). Since 2006 we have developed system of organic based aerobic rice intensification system (SOBARI) to promote the soil biological activity (soil organisms) and to provide a favorable condition for rice roots growth. This technology is a holistic rice production system by using and integrating the soil biological power, plant, fertilizers and water management to remediate the soils health of paddy soils and to increase the rice producvtivity in sustainable ways.

Material and Methods

A research has been conducted at demonstration plots (demo area) from year of 2007 to 2010 in different areas and provinces of Indonesia. SOBARI is widely adopted by incorporating the rice straw or straw compost during land preparation. Young seedlings (12 – 15 days) are planted with plant space about 25 x 30 cm, or 30 x 30 cm or 30 x 35 cm. A single seedling is planted in twin methods (two single seedlings are planted in line about 5 cm distance from each other at point of planting cross section. The seedling is planted by slipping in sideways rather than plunging it into the soil vertically and it makes the shape of the transplanted seedling more like an L than like a J. With an L shape, it is easier for the tip of the root to resume its growth downward into the soil.

Water application or irrigation is required to regulate the soil moisture under the field capacity to muddy conditions until the beginning of grain ripening stage. The water regulation is necessary to allow rice roots growing properly and to stimulate the growing of soil organisms and as well as its biodiversity. One or two days before weeding (manually or mechanically), the rice field is irrigated with 1- 2 cm depth or a thin layer to allow the removing of weeds easily and to improve the soil aeration.

The application straw compost combined with inorganic fertilizers (called as organic based fertilizers) are widely adopted in SOBARI. The fertilizers application of SOBARI are divided in 3 steps, as follows: (1) basic fertilizer is applied shortly before transplanting, consisted of 2 – 4 ton/ha straw compost combined with 50 kg urea, 50 kg SP-36 and 25 kg KCl or 50 kg urea and 100 kg NPK, (2) 100 kg urea applied at 18 – 21 days after transplanting or after weeding, and (3) 50 – 100 kg urea and 25 – 50 kg KCl per hectare or 50 kg urea and 50 - 100 kg NPK are applied at 35 – 38 days after transplanting. Leaf Color Chart (LCC) can be used to monitor the nutrient conditions and to determine the N rate

Results and Discussion

The field results of SOBARI from several Provinces or districts in Indonesia are summarized in Table 1. As shown in Table 1, adoption of SOBARI with various rice varieties under different planting season in several provinces of Indonesia are fairly easily to achieve 40 – 60 fertile tiller plant and contains about 150 – 250 grains per panicle. The average yield was ranged from 8 to 10 ton grain yield per hectare (about 50 – 100% higher than traditional flooded paddy rice).

Based on field experiences, the SOBARI method may reduce the water irrigation use by at least 30 % - 50 %. The management soil organic matter, application of organic fertilizers and biofertilizers are need to increase nutrients availability and biological activity in soils. **SOBARI**

is focusing on the application of rice straw compost as a main source of organic fertilizer. Briefly, nutrient content of every 5 ton rice straw is equal to 50 kg N, 10 kg P_2O_5 and 120 kg K_20. Straw is also an important source of nutrients such as zinc (Zn) and silicon (Si) (Dobermann.and Fairhurst. 2002; Simarmata, 2009). Application of 2 – 4 t of straw compost (5 – 10 ton of straw) increase the soil health, the rice yield and reduces the inorganic fertilizers by at least 25%. It has increased the organic carbon content, nutrient availability (N, P, K, Ca, Mg, S, Si and micronutrients), cation exchange capacity (CEC), and soil biodiversity significantly.

Table 1: Unmilled Rice Yield Summary of SOBARI in Different Provinces and Districts in Indonesia (Planting Season 2007 – 2009) with various rice variety

Location	Yield (t/ha	Control (t/ha)	Increment (%)
SOBARI Experimental Field and Demo Plot of Agriculture Faculty of Padjadjaran University Bandung	6 – 12	4 – 7	50 –150%
Demo Plot in Research Institute for Rice of Indonesia, harvested on July 2008	7 – 10	-	-
West Java (Bandung, Garut, Sumedang, Bogor, Bekasih, Subang, etc.)	6 - 11	4 – 6	50 –100 %
Banten (Serang, Lebak)	6 – 10	4 – 6	50 –100 %
East Java (Tulung Agung, Jombang, Madiun, Blitar, Mojokerto, Nganjuk, etc.)	6 – 10	4 - 6	50 –100 %
Central Java (Sragen, Sukoharjo, Wonogiri, Karang Anyar, Purworejo, Magelang, Semarang, etc.)	6 - 10	4 - 6	50 –80%
Nort Sumatera (Sergei, Tebing Tinggi, Tapanuli, etc)	5 – 10	3 - 7	50 –100 %
South Sulawesi (Gowa, Luwu, etc.) conducted by Famer Groups in 16	6 – 10	3 – 6	50-200%
North Sulawesi (Minsel, Minut, etc.) conducted by Famer Groups	6 – 10	3 – 7	50 –200 %
Nusa Tenggara (Kupang, Ende, Bajawa, Nagekeo, Rote Ndao) conducted by Famer Groups with	6 - 10	2 – 6	50 –300 %
West Kalimantan (2 ha)	8,9	-	100%

It is expected that the degraded health of paddy soils can be restored or remediated by application of rice straw (5 – 10 ton/ha) or straw compost (2 – 4 ton/ha) within 6 season (about 3 years), respectively. Consequently, the sustainability of soil health and rice productivity is highly correlated with straw or soil organic matter and integrated organic based fertilizers management. The use of straw as agent for remediating or restoring the soil health and quality has some benefits such as follows: (1) in situ directly available and relative cheap, (2) source of complete nutrients to reduce the inorganic fertilizers use and (3) to promote the eco-friendly sustainable rice cultivation.

Conclusions and Outlook

The conclusions and suggestions can be summarized as follows:

1. SOBARI is a holistic of water saving and inorganic fertilizers reducing technology focusing on soil biological power, soil organic matter and organic based integrated fertilizers management for improving, maintaining the soil health and to increase rice productivities in sustainable ways.
2. SOBARI combined with the application of 2 – 4 ton/ha straw compost can reduce the water irrigation at least 30 - 50%, and inorganic fertilizers by at least 25%, improve the soil health, and increase the rice yield about 50% - 100% compared with traditionally flooding rice cultivation.
3. The degraded health of paddy soils can be restored or remediated by application of 2 - 4 ton straw compost or 5 – 10 ton rice straw within 6 seasons (3 years), respectively.
4. The health of paddy soils and sustainability of rice production in Indonesia are highly depend on the rice straw or soil organic matter and integrated organic based fertilizer management.

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