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Innovation of Biofertilisers-Organic Based Nutrients Management and Water Saving Technology to Secure Rice Productivity s

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Introduction

The rice requirement is increasing continually as consequence of rapidly growing population in Indonesia. The Indonesian population is projected to reach 296 million in 2025, with the needs of 65.9 million tons of rice. Intensive cultivation of rice in a flooded systems (anaerobic) lowered soil biological forces function, and also inhibited the root system of rice plants to develop. Under anaerobic conditions, biodiversity in the soil become very limited due to the lack of oxygen. Only about 25% of the plant root system which able to develop well under these conditions. In contrast, under aerobic system the root system can grow up to 3-4 times larger than the waterlogged system (Simarmata and Yuwariah, 2009).

The intensive use of inorganic fertilizers has promoted the organic matter mineralization and lowered the soil organic carbon significantly. The result of various field studies indicated mostly of paddy soils in Indonesia has a low organic content (< 2%) and can be categorized as sick soils (Simarmata *et al*., 2012). System of organic based aerobic rice intensification (SOBARI, known as IPAT-BO in Indonesia), is an integrated `holistic production systems by focusing on the utilization of soil biology power and soil organic matter management, plant management, biofertlizers-organic based fertilizer management, and water management. The main focus of IPATBO is to restore soil health and increase rice production by using organic ameliorant and biofertilizers. The locally available of organic ameliorant (straw compost and rice husk biochar) are uses to remediate the soil health, to increase the fertilizers efficiency and crop rice productivity. Straw compost not only rich in energy (carbon) but also has the relative high nutrients contents, especially K and Si. The key success of rice cultivation depends on soil organic matter management for maintaining the carbon level in the soil. The rice straw is composted by using consortia of decomposer to accelerate the composting process, to control the potential pathogen in straw and to increase the straw compost quality. The rice husk which has high content of carbon and Si is converted to become rice husk biochar by burning it in absence or limited oxygen (Verheijen *et al*, 2010.

The application of straw compost and rice husk biochar combined with consortia of biofertilizers and water saving technology has a great prospect to remediate and improve the soil health and to increase the rice productivity in sustainable ways or to improve the nutrients availability in soils. The adoption of IPAT-BO with different rice varieties at various locations in Indonesia was able to produce 8-11 tons ha-^{1} of rice grain yield which means an increase in the average yield ranging from 50-150% compared with the anaerobic system. The condition is directly related to the increase in the root zone of up to 4-10 times, the number of tillers panicle up to 40-60 panicles clumps^{-1}, 25-35 cm panicle length and number of grain 200-300 grains panicle^{-1}

Material and Methods

The widely adopted of IPATBO technology in Demfarms at different areas in Indonesia is by incorporating 2-5 ton ha^{-1} composted rice straw using consortia of decomposer (consortia of *Streptomyces sp, Cytophaga sp, Bacillus sp*, and *Trichoderma sp*) and 500-1000 kg ha^{-1} of rice husk biochar during land preparation. Consortia of biofertilizers inoculangts (CBI) (consortia of *Azotobacter sp, Azosprillum sp, Pseudomonas sp and Bacillus sp*) was applied 200 g for seed treatment and 400 g for field application. Ten g of CBI was mixed carefully with 1 kg of rice seed) after the soaking the rice seeds) and 400 g inoculant was mix with 40 kg of compost and distributed evenly on the rice plots before the transplanting of rice seedling. Two single young seedlings (12–15 days) is planted with plant spacing about 30 x 35 cm in line about 5 cm distance from each others at point of planting cross section (Simarmata *et al*., 2011). The seedling is planted by slipping in sideways rather than plunging it into the soil vertically makes the shape of the transplanted seedling more like an L than like a J. The plot were fertilized with 100–150 kg N, 25-40 kg P_20_5 and 30 p- 50 kg of K_20 ha^{-1}. The inorganic fertilizers are divide in 3 steps; (1) 25% of N + 100 % of P fertilizers were applied shortly before rice planting, (2) 25 % of N + 50 % of K were applied at 21-28 days after transplanting (DAT) and (3) 50% of N and 50 % K were applied at 42 DAT. The water saving technology is adopted by using the water level indicator for watering the rice field. The rice fields are mostly maintained in a muddy condition. Maximum water level is 2-3 cm above the soil surface, which is provided from the time the rice plant reaches maximum vegetative stage up to panicles out. The water level is controlled by using measuring instrument water adequacy indicator or water level indicator, which is embedded in the paddy field at a depth of topsoil to several centimeters above the soil surface. The rice field is watered if the water level goes down to -5 cm or -10 cm. The flooding of rice field until 2-3 cm depth only done 1-2 days before each weeding to allow the removing of weeds the easily and during the flowering initiation until heading to stop the addition of tiller

Results and Discussion

Field rice yield of SOBARI ("IPATBO") adoption from 2007 – 2013 with various rice variety under different planting season in several provinces of Indonesia increased relative easily the average rice productivities from 4–6 ton ha^{-1} to 6-10 ton ha^{-1} of grain yield (about 50–150% higher than control or flooded paddy rice). The latest field results as reported` by Ministry of Research and Technology during 2014-2015 at different location in Indonesia are presented in Table 1.

Table 1. Field rice grain yield of SOBARI ("IPATBO') technology of various rice variety at different location in Indonesia

Year	Farmer Group	Location	Varietas	Rice yield (ton ha^{-1})	
				control	IPAT-BO
2014	Kento Situru,	Bau-Bau	Sidenuk	3	9
	Suko Tani	Lumajang	Hibrida DG I	6	11.2
	Sri Utomo	Magetan	Inpari 4	6	12.4
	Karya Tani	Ponoroga	Pandan Wangi	6	9,1
	Soreang	Bandung	Mira I	7	11,4
	Tani Rejo 3	Karang Anyar	Sidenuk	7	10,1
2015	Tenko Situru	Bau-Bau	Sidenuk	3	9,2
	PP Kerja	Boyolali	Sidenuk	7	11,5
	Madiun (Polresta)	Madiun	Sidenuk	4,2	10,1

Note : control is rice cultivation under permanent flooding

The higher obtained rice yield was also contributed of the panting methods (Table 2) and the water management (Table).

Table 2. The rice grain yield in respond to planting methods (Kantikowati *et al*., 2014)

Planting Methods	Rice grain yield	
	ton ha-1	increment
Tegel (square)	4,98 a	
Legowo	5,67 b	13,8 %
IPATBO (twin seedling)	6,63 c	33,31 %

Table 3. Rice grain yield in respond to water management (Antralina *et al*., 2015)

Water Level	Grain Yield(ton ha^{-1})	increment
m_o = flooded permanently	8.78	-
m_1 = irrigated if water level -5 cm below soil surface	11.63	
m2= irrigated if water level -10 cm below soil surface	9.80	
m_3 = irrigated if water level -15 cm below soil surface	10.78	

The twin seedling planting methods of IPATBO increased the number of productive tillers that has 150-250 grains per panicle. In general, the highest grain yield is obtained by irrigated the rice field if the water level goes down maximum at -5 cm below surface. The field study revealed that the application of 2 ton ha^{-1} of straw compost and 500 – 1000 kg rice biochar combined with biofertlizers incerased the soils health status from sicks soils to become fairly healthy soils (Table 4)

Table 4. Soil health status of Ciparay lowland before and after comchar application.

	Before Treatments			After Remediation		
Parameter	Value	Score	Criteria	Value	Scor	Criteria
pH (H_2O)	6.5	4	Medium	6.5	4	Medium
N total (%)	0.2	1	Low	1.8	5	High
P_2O_5 (mg/100 g)	20.82	3	Low	22.52	4	High
K_2O (mg/100 g)	12.55	1	Low	38.2	2	Medium
C-organik (%)	2.21	2	Medium	2,47	2	Medium
Total scor		2,2	Sick		3.4	Moderately health

Conclusions and Outlook

SOBARI ("IPAT-BO") as biofertilizer-organic-based nutrients managements for a sustainable rice cultivation combined with (1) application of 2-5 ton rice straw ha^{-1}, 500 – 1000 kg ha^{-1} of biochar and 400 – 600 g of consortia biofertlizers inoculants, (2) water saving technology using water level indicator and (3) empowering soil biology activity is enable to increase rice productivity by at least 25-50%, increased water irigarion effsiency by 35%, reduce the inorganik fertilizers by 25%, imrpove the soil health status from sick to become moderately health

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