



Tropentag 2012, Göttingen, Germany September 19-21, 2012

Conference on International Research on Food Security, Natural Resource
Management and Rural Development organised by:
Georg-August Universität Göttingen and University of Kassel-Witzenhausen

Application of straw compost and biofertilizers to remediate the soils health and to increase the productivity of paddy rice in Indonesia

Tualar Simarmata^a, Tien Turmuktini^b, Ania Citraresmini^c and Benny Joy^a

a Department of Soil Science, Faculty of Agriculture, Padjadjaran University, Jl. Raya Bandung Sumedang KM 21, Bandung 40900, Jawa Barat, Indonesia, Email : tualarsimarmata@yahoo.com;
tualar_simarmata@unpad.ac.id

b Faculty of Agriculture, Winaya Mukti University, Jl. Raya Bandung Sumedang, Bandung, Jawa Barat, Indonesia

c Centre for Application of Radiation and Isotope Technology, National Nuclear Energy Agency, Lebak Bulus Raya 49, Jakarta 12440, Indonesia

ABSTRACT

The intensive use of inorganic fertilizers and agrochemical products during the green revolution (in the early 1960s) has given a great impact on the decline of soil health and soil quality. Various field studies revealed that most of paddy soils in Indonesia has been exhausted, as indicated by a low organic content (<1.5 - 2%) and depletion of some essential nutrients, such as K and Si. This paddy soils can be categorized as sick or unhealthy paddy soils. Restoring the paddy soil health can be done by managing the straw and biofertilizers application combined with output-oriented integrated fertilizers management. The application of 2 – 5 ton ha⁻¹ of straw compost combined with 400 g ha⁻¹ of biofertilizers inoculant (consortia of non-symbiotic nitrogen fixers and phosphate solubilizing bacteria) gave a significant effect on increasing soil organic carbon, biodiversity of beneficial soil organism, the growth and yield of paddy rice significantly. In addition, the application of inorganic fertilizers can be reduced by at least 20% and the productivity of paddy rice is increased by at least 25%. Particularly, the supply of carbon, silica and potassium nutrients can be obtained from straw compost. Consequently, the remediation and preservation of soil health for sustainable rice cultivation is highly dependent on rice straw and biofertilizers management.

Key words : soil health, paddy soils, organic fertilizers, straw compost, biofertilizers

Introduction

The use of fertilizer N intensively in an increasing dose, has spurred intensive mineralization of soil organic matter resulting in lower content of C-organic. The results of various studies show that the content of C-organic soil in rice production farm centers is generally low (< 2%) and categorized as sick soil. The land has reached its saturation point (*leveling off*), causing a decline in soil quality and health (Simarmata, 2007).

Actually the main product of rice cultivation is organic fertilizer in the form of straw, in the amount of 1.2 – 1.5 fold of grain yield. Enhancing decomposition process and depressing pathogen contamination in this straw can be done by spraying a consortium of biological decomposers inoculant directly in the field (*direct composting*). The straw compost

will contribute to the carbon organic content in the soil which in turn will directly improve the energy source for beneficial microbes in the soil, especially the N-fixer microorganisms, P-solubilizers and fitohormon producers (Dobermann and Fairhurst, 2002).

In addition, straw compost is also a source of nutrients for N-fixation microbes and phosphate solubilizer. The utilization of this beneficial microbes in wetland rice cultivated with SOBARI (system of organic based aerobic rice intensification technology will create a favorable environment since the soil is not permanently submerged. The combination of composted straw and biofertilizers consortium is expected to increase the availability of nutrients, grain yield and to reduce the use of artificial fertilizers significantly (reducing the cost of fertilizer subsidies).

SOBARI is a holistic system of water, seed and inorganic fertilizer-saving rice cultivation which emphasizes the integration of the utilization of soils' biological forces, crop management, fertilizers and irrigation system. SOBARI is designed to support and optimize the growth and development of rice roots under aerobic conditions by water management.

Material and Methods

Field research was conducted in the Experimental Station and Training Centre for Agricultural Development (ESTCAD), Faculty of Agriculture Padjadjaran University, Jelekong district, Ciparay, Bandung regency, from April to August 2011 in the dry season, located about 600 m above sea level belong to the C-type of rainfall.

The treatments given was straw compost and biofertilizer at various level of doses. The combination dose of the straw compost (SC) and biofertilizer (BF), which was denoted as J treatment, was as follow: j_0 = control; j_1 = 400 g ha⁻¹ of BF; j_2 = 2.5 t ha⁻¹ of SC; j_3 = 2.5 t ha⁻¹ of SC + 400 g ha⁻¹ of BF; j_4 = 5.0 t ha⁻¹ of SC; j_5 = 5.0 t ha⁻¹ of SC + 400 g ha⁻¹ of BF; j_6 = 7.5 t ha⁻¹ of SC; and j_7 = 7.5 t ha⁻¹ of SC + 400 g ha⁻¹ of BF.

Inorganic fertilizer was applied at the following doses: p_1 = 100%; p_2 = 90%, p_3 = 80%, p_4 = 70%; and p_5 = 60% from the recommended level (doses of recommendation are : 300 kg ha⁻¹ urea; 100 kg ha⁻¹ SP-36; 100 kg ha⁻¹ KCl).

Fourteen days old of seedlings (14 DAP) were transplanted in the twin system (TS). Two single seedlings was planted in 5 cm distance at the planting space of 30 cm x 35 cm. Straw compost was applied shortly before land cultivation (one week before planting of seedling). The water condition was maintain at muddy condition (water level about 0 -1 cm). Paddy fields were reirrigated up to 1 cm height when the water level goes down about -10 cm below soil surface. Special designed plastic pipe (diameter 4 inch and 30 cm length) was used to monitor the water levels on the plots.

Results and Discussion

Table 1 indicated that the application of straw compost + biofertilizer at various doses and inorganic fertilizers (N, P, and K) at various percentages of the recommended dose resulted in various yield responses. The application of 5 t ha⁻¹ straw compost + 400 g ha⁻¹ biofertilizer along with 80% dose of N, P, and K fertilizers provided the highest yield (7.20 kg plot⁻¹ which was equivalent to 6.65 t ha⁻¹). This suggests that the application of 5 t ha⁻¹ straw compost + 400 g ha⁻¹ biofertilizer could substitute 20% of N, P, and K fertilizers and increase yield.

In addition, the application of straw compost + biofertilizer combined with inorganic fertilizer significantly influenced C-organic, and soil CEC (Table 2). C-organic was increased at the application of straw compost, consequently a source of energy for biological activities in the soil will be provided (Singh and Purohit, 2011). This condition, in turn, would affect the physical and chemical activities of the soil and, thus, indirectly increase the nutrient availability as can be seen from soil CEC.

Soil and crop health would be affected eventually by the application of straw compost, and this bring into the suggestion that the application of straw compost: (1) serves as a substance or agent to restore soil health and soil quality that is cost effective and easily available; (2) serves as a complete source of nutrients with optimum composition for the growth and yield of rice plants, (3) serves as an organic fertilizer to reduce the use of inorganic fertilizers by 50% and of potassium and silica fertilizers by 100% (Savant, et al., 1997); (4) serves as a source of energy and nutrients for beneficial organisms in soil, which acts as a natural fertilizer biorektor and plant in soil; and (5) has a residual effect on soil quality improvement and productivity enhancement in a sustainable manner (Simarmata, 2011).

Tabel 1. The average yield per plot as a respon of the interaction of organic fertilizer (straw compost + biofertilizer) and inorganic fertilizers (N, P and K) treatments.

Doses of straw compost (sc) + biofertilizer (bf) (J)	NPK fertilizer (P)				
	Grain yield (kg/10.5 m ²)				
	P ₁ (100%)	P ₂ (90%)	P ₃ (80%)	P ₄ (70%)	P ₅ (60%)
j ₀ = Control	6.59 b (e)	6.48 d (d)	6.35 c (c)	6.07 b (b)	5.99 b (a)
j ₁ = 400 g ha ⁻¹ BF	6.77 d (e)	6.44 c (d)	5.87 a (b)	6.21 c (c)	5.59 a (a)
j ₂ = 2.5 t ha ⁻¹ SC	6.82 e (e)	6.18 a (c)	6.40 d (d)	5.91 a (b)	5.57 a (a)
j ₃ = 2.5 t ha ⁻¹ SC + 400 g ha ⁻¹ BF	6.66 c (d)	6.24 b (b)	6.17 b (a)	6.49 g (c)	6.17 d (a)
j ₄ = 5.0 t ha ⁻¹ SC	6.29 a (c)	6.63 e (e)	6.48 e (d)	6.24 d (b)	6.12 c (a)
j ₅ = 5.0 t ha ⁻¹ SC + 400 g ha ⁻¹ BF	6.83 e (c)	6.62 e (b)	7.20 f (d)	6.36 e (a)	6.63 f (b)
j ₆ = 7.5 t ha ⁻¹ SC	6.88 f (e)	6.61 e (d)	6.32 c (a)	6.45 f (c)	6.41 e (b)
j ₇ = 7.5 t ha ⁻¹ SC + 400 g ha ⁻¹ BF	6.88 f (c)	6.90 f (c)	6.99 f (d)	6.56 h (b)	5.99 b (a)

Notes: The average number marked by the same letters in parentheses in the horizontal direction indicates the response to the treatments was not significantly different according to Duncans' multiple range test at 5% level.

Table 2. Average-soil organic C (%) and CEC as a respon of the interaction of organic fertilizers (straw compost + biofertilizer) and inorganic fertilizers (N, P, K) treatments.

Doses of straw compost (sc) + biofertilizer (bf)	Dose of NPK fertilizer from the recommended dose (P)									
	C-organic (%)					CEC (me 100 g ⁻¹)				
	p ₁ (100%)	p ₂ (90%)	p ₃ (80%)	p ₄ (70%)	p ₅ (60%)	p ₁ (100%)	p ₂ (90%)	p ₃ (80%)	p ₄ (70%)	p ₅ (60%)
j ₀ (control)	2.21 abc (bc)	2.04 a (ab)	1.80 ab (ab)	2.56 bc (c)	1.71 a (a)	25.56 b (a)	26.01 bc (a)	26.08 ab (a)	24.29 a (a)	25.27 ab (a)
j ₁ = 400 g ha ⁻¹ BF	1.93 a (a)	2.47 a (bc)	1.69 a (a)	2.14 ab (ab)	2.88 d (c)	25.71 b (a)	28.25 c (b)	24.57 a (a)	24.62 a (a)	25.14 ab (a)
j ₂ = 2.5 t ha ⁻¹ SC	2.07 ab (a)	2.45 a (ab)	2.26 bc (ab)	2.74 c (b)	2.31 bc (ab)	23.43 ab (a)	25.92 bc (ab)	24.58 a (ab)	26.06 ab (b)	24.78 ab (ab)
j ₃ = 2.5 t ha ⁻¹ SC + 400 g ha ⁻¹ BF	2.66 c (c)	2.50 a (bc)	2.08 abc (ab)	1.97 a (a)	2.29 bc (abc)	24.83 b (ab)	23.24 a (a)	24.56 a (ab)	26.63 ab (b)	25.14 ab (ab)
j ₄ = 5.0 t ha ⁻¹ SC	2.45 bc (a)	2.16 a (a)	2.42 c (a)	2.34 abc (a)	2.02 ab (a)	22.10 a (a)	24.83 ab (b)	23.58 a (ab)	24.41 a (ab)	24.32 ab (ab)
j ₅ = 5.0 t ha ⁻¹ SC + 400 g ha ⁻¹ BF	2.41 abc (ab)	2.27 a (ab)	1.94 abc (a)	2.56 bc (b)	2.68 cd (b)	24.46 ab (a)	25.83 bc (ab)	27.22 bc (b)	26.77 ab (ab)	25.88 b (ab)
j ₆ = 7.5 t ha ⁻¹ SC	2.05 ab (a)	2.30 a (a)	2.25 bc (a)	2.47 bc (a)	2.30 bc (a)	25.79 b (bc)	24.55 ab (ab)	28.66 c (d)	27.47 b (cd)	22.76 a (a)
j ₇ = 7.5 t ha ⁻¹ SC + 400 g ha ⁻¹ BF	2.51 bc (a)	2.11 a (a)	2.25 bc (a)	2.29 abc (a)	2.57 cd (a)	24.04 ab (a)	26.44 bc (ab)	27.56 bc (b)	25.72 ab (ab)	26.87 b (b)

Notes: The average number followed by the same letters in parentheses in the horizontal direction indicates the response to the treatments was not significantly different according to Duncans' multiple range test at 5% level.

Conclusions and Outlook

- Interaction between the application of organic fertilizers (straw compost + biofertilizer) and inorganic fertilizers (N, P, and K) affects yield, the content of C-organic, and soil CEC.
- The application dose of 5 t ha⁻¹ straw compost + 400 g ha⁻¹ biofertilizer and 80% N, P, K fertilizers can substitute 20% inorganic N, P, K fertilizers and can increase the yield by 13.3%, i.e., 7.20 kg plot⁻¹ or equivalent to 6.65 t ha⁻¹.

References

- Dobermann, A., and T.H. Fairhurst, 2002. Rice Straw Management . Better Crops International. Vol. 16, Special Supplement, May 2002
- Savant, N.K., G.H. Snyder, dan L.E. Datnoff. 1997. Silicon management and sustainable rice production. Dalam Advances in Agronomy, Vol. 58. Academic Press, Inc.
- Simarmata, T. 2007. Peningkatan Produktivitas Padi Melalui Teknologi Intensifikasi Padi Secara Aerob Terkendali. Makalah Diskusi Ilmiah Tanggal 21 Mei 2007, Fakultas Pertanian Universitas Padjadjaran, Jatinangor.
- Simarmata.T, Benny Joy and Ten Turmuktini.2011. Management of Water Saving and Organic Based Fertilizers Technology for Remediation and Maintaining the Health of Paddy Soils and to Increase the Sustainability of Rice Productvity in Indonesia. Call paper on Sustainable Agriculture and Food Security: Challenge and Opportunities, 27 – 28 September 2011, University of Padjadjaran Bandung – Indonesia.
- Singh, T and S.S. Purohit. 2011. Biofertilizers Technology. Agrobios (India). ISBN. 13:978-81-7754-382-7.