APPLICATION OF STRAW COMPOST AND BIOFERTILIZERS TO REMEDIATE THE SOILS HEALTH AND TO INCREASE THE PRODUCTIVITY OF PADDY RICE IN INDONESIA

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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 bio-fertilizers 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).

The actual 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.

Materials & 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 denotated as J treatment, was as follow: jo = control; j1 = 400 g ha-1 of BF; j2 = 2.5 t ha-1 of SC; j3 = 2.5 t ha-1 of SC + 400 g ha-1 of BF; j4 = 5.0 t ha-1 of SC; j5 = SC 5.0 t ha-1 + 400 g ha-1 of BF; j6 = 7.5 t ha-1 SC; and j7 = 7.5 t ha-1 of SC + 400 g ha-1 of BF.

Inorganic fertilizer was applied at the following doses: p1 = 100%; p2 = 90%, p3 = 80%, p4 = 70%; and p5 = 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 & Discussion

Table 1 indicated that the appication of straw compost + bio-fertilizer 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 bio-fertilizer could substitute 20% of N, P, and K fertilizers and increase yield.

In addition, the application of straw compost + bio-feritlizer 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).

Conclusions

- The results of the study revealed that the interaction between the administration of organic fertilizers (straw compost + bio-fertilizer) 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 bio-fertilizer 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.

Straw Composting

Seedling

Water Management in SOBARI system

Water Gauges

Harvesting

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 m2)				
	P1 (100%)	P2 (90%)	P3 (80%)	P4 (70%)	P5 (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.

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Poster presented at Tropentag 2012
September 19 - 21, 2012 | Göttingen, Germany
International Research on Food Security,
Natural Resource Management and Rural Development