INCREASING RICE YIELD BY UTILIZING SUGARCANE WASTE AND LIQUID ORGANIC FERTILIZER

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ABSTRACT

Developing technology to support sustainable agriculture through environmentally sound approaches to enhance growth and yield of rice is needed. Utilization of agricultural waste products for further agricultural processes is a form of sustainability. Boiler ash is a waste as a result from combustion of bagasse generated in the sugar production process. It can be used as organic fertilizer, because it contains Silicon and other nutrients. The objective of this research was to examine the effect of boiler ash application and spraying frequency of Liquid Organic Fertilizer (LOF) Bacteria + LOF "Plus" on growth and rice yield. The experiment was conducted at Bener Village, Ngrampal sub-district, Sragen district, Indonesia, from November 2012 until February 2013. The experiment was arranged into Randomized Completely Block Design Split Plot with three replicates. The main plot was boiler ash application consisting of two treatments, ie., boiler ash 10 ton/ha and without boiler ash. Sub plot was spraying frequency of LOF Bacteria + LOF "Plus" consisting of five treatments, ie., spraying LOF Bacteria + LOF "Plus" two times, three times, four times, five times and.six times. The data were subjected to analysis of variance followed by Duncan's Multiple Range Test. The results showed that plants treated with boiler ash 10 ton/ha and sprayed with LOF bacteria + LOF "Plus"four times resulted in the highest growth and rice yield and the lowest number of un-productive panicles.

Keywords: *boiler ash, LOF bacteria, LOF "Plus", rice yield*

INTRODUCTION

One of the main concerns in Indonesian agricultural development has been boosting rice production. Implementation of green revolution technologies in rice-oriented on improving outcomes by relying on chemicals such as fertilizers and pesticides lead to continuous environmental degradation. This is partly demonstrated by the rapid soil nutrient depletion and disturbed the balance of nutrients in the soil (Deore *et al*., 2010; Padmini, 2010), Furthermore, intensive use of chemical pesticides leaves residue that contaminates soil, and causes the demise

of some soil decomposer organisms, resulting in disturbed biological soil equilibrium , pest and disease outbreak, and disrupted plant growth (BPTP, 2011). In addition, chemical residue disturbs the balance of nutrients in soil, reduces soil biodiversity, decreases soil fauna biomass, increases fluctuation of dominant soil fauna population groups and hampers decomposition processes of organic matters (Las *et al*., 2006; Tim sintesis Kebijakan, 2008; Hossaen *et al*, 2011). For rice cultivation usually farmer gives chemical fertilizers three times and the last application is conducted on three-weeks-old plants. At this time plants are still at the early tillering stage. **If the fertilizer is given after three-weeks-old plants, the leaves would be overlap to each other and the farmers do not have courage to give urea anymore because a lot of urea would be retained on the sidelines of the rice leaves causing physical damage (browning).** The department of Agriculture recommends that for rice cultivation urea should be given two or three times and the last application should be given when plants are 7 weeks after planting, when plants still require urea for the fruit filling. To produce high rice yield plants need nutrient intake on the active vegetative growth phase until the maximum tillering and the reproductive phase such as, booting, heading (panicle out) and anthesis (flowering).

Boosting rice production through environmentally friendly technology is needed to support sustainable agriculture. Utilization of waste products in organic plant cultivation is a form of sustainability, but the development of organic agriculture in Indonesia has not been encouraging. According to IFOAM (International Federation of Organic Agricultural Movement), Indonesia has utilized 40,000 ha (0.09 percent) agricultural land for organic farming. It will involve various synergistic programs to make Indonesia as one of the organic producers in the world. Based on the extensive use of land, Indonesia is the third country in Asia in developing organic agriculture after China and India. (IFOAM, *http://www.ifoam.org/about_ifoam/principles/index.html* accessed March 2013]. Most of the organic land is spread in Java. Utilization of agricultural waste, such as sugarcane waste as organic fertilizer is highly recommended. Boiler ash is combustion of bagasse generated in the sugar production process. The boiler ash contains elements of N, P, K and Silicon as well as some other micro nutrients that can increase the nutrient content in the soil when applied together with manure. Liquid fertilizer can be used to fulfill nutritional needs on vegetative growth phase and reproductive phase of plant. Liquid Organic Fertilizer spraying (LOF) as a supplementary fertilizer during tillering phase and the formation of flowers and grain filling is

needed. LOF "Bacteria" contains a variety of beneficial soil microbes for soil health, whereas LOF "Plus" besides containing nutrients and plant hormones also contains botanical pesticide that increasing plant resistance to pests.

MATERIAL AND METHODS

The experiment was conducted in November 2012 until February 2013 at Bener Village, Ngrampal, Sragen Regency. The rice variety planted was Mekongga. The experiment design was Randomized Completely Block Design Split Plot with three replicates and each plot size was 6 m x 10 m. The Main Plot was the use of boiler ash that consists of two treatments, i.e., 10 ton/ha boiler ash and without boiler ash. The Sub Plot was the application frequency of combination of LOF Bacteria and LOF“Plus” that consists of five treatments ie., spraying LOF Bacteria + LOF “Plus” two times, three times, four times, five times and.six times.

Plant growth parameters observed were number of leaves, plant dry weight and number of tillers, whereas yield components measured were number of panicles/hill, length of panicles, number of grain/panicles, number of un-productive tillers, weight of grains per hill, per plot and per hectare. The data were subjected to analyze of variance to determine the variability and the influence of each factor of both the main plot and the subplot were analyze using DMRT (Duncan's Multiple Range Test) on the significant level of 5%.

RESULTS

Plant Growth Components

There were no interaction between the application of boiler ash and LOF Bacteria + LOF “Plus” spraying frequency on the plant growth components. Number of leaves of 42, 49, and 56 days old plants in rice plots treated with 10 tons/ha boiler ash was significantly higher than that in rice plots without fly ash. Number of leaves were higher in plants sprayed 4 times with LOF bacteria + LOF “Plus” than those sprayed two times, three times or six times, although it was not significantly different from those treated with 5 times spraying (Table 1).

Table 1. The effect of boiler ash application and LOF Bacteria + LOF "Plus" spraying frequency on number of leaves

Treatment		Number of leaves				
		28 days	35 days	42 days	49 days	56 days
Boiler ash	Without Boiler ash	50,69 q	59,80 q	83,29 q	103,61 p	93,78 q
	Boiler ash 10 ton/ha	54,03 p	64,28 p	90,21 p	105,17 p	98,99 p
LOF Bacteria & LOF "Plus"	2 times spraying	52,83 a	60,26 a	76,81 b	97,32 c	93,89 c
	3 times spraying	53,76 a	61,06 a	77,21 b	103,95 b	99,27 b
	4 times spraying	52,83 a	60,70 a	81,95 a	106,42 a	104,09 a
	5 times spraying	51,83 a	61,33 a	80,11 a	106,96 a	103,60 a
	6 times spraying	51,90 a	61,23 a	80,48 a	103,93 b	101,12 b
Interactions		-	-	-	-	-

Note: Numbers followed by same alphabet in the same column shows no significant difference in Duncan's Multiple Range Test analysis at the 95% level of confidence. (-) no interaction

Table 2 shows that plant dry weight in rice plots treated with 10 tons/ha fly boiler ash was significantly higher than those without fly ash application. The plant dry weight in rice plots treated with five times LOF Bacteria + LOF "Plus" spraying was higher than those sprayed two times or three times, although it was not significantly different from those treated with four times or six times spraying.

Table 2. The effect of boiler ash application and LOF bacteria + LOF "Plus" spraying frequency on plant dry weight

Treatment		Plant dry weight (g)				
		28 days	35 days	42 days	49 days	56 days
Fly boiler ash	Without Fly ash	24,90 q	34,19 q	45,12 q	59,61 q	70,54 q
	Boiler ash 10 ton/ha	35,90 p	41,21 p	57,19 p	67,45 p	63,90 p
Bacteria & LOF "Plus"	2 times spraying	26,31 b	36,76 b	48,28 b	54,82 b	52,13 c
	3 times spraying	26,65 b	36,33 b	50,42 b	61,95 ab	66,16 b
	4 times spraying	30,32 ab	37,28 b	51,02 ab	65,55 a	70,16 ab
	5 times spraying	35,51 a	37,58 b	54,20 a	67,87 a	76,43 a
	6 times spraying	31,39 ab	40,67 a	50,88 b	62,36 ab	67,47 b
Interactions		-	-	-	-	-

Note: Numbers followed by same alphabet in the same column shows no significant difference in Duncan's Multiple Range Test analysis at the 95% level of confidence. (-) no interaction

Table 3. The effect of boiler ash application and LOF bacteria + LOF "Plus" spraying frequency on number of tillers

Treatment		Number of tillers				
		28 days	35 days	42 days	49 days	56 days
Boiler ash	Without Boiler ash	10,86 p	12,05 p	15,60 q	18,80 q	17,00 q
	Boiler ash 10 ton/ha	10,72 p	13,08 p	17,28 p	21,17 p	19,33 p
LOF Bacteria & LOF "Plus"	2 times spraying	10,73 a	12,40 b	13,75 c	17,66 b	15,75 b
	3 times spraying	10,66 a	12,30 b	16,11 b	18,74 b	18,41 a
	4 times spraying	10,90 a	12,63 ab	16,65 ab	21,38 ab	19,33 a
	5 times spraying	10,80 a	12,83 a	18,23 a	22,79 a	18,22 a
	6 times spraying	10,86 a	12,36 b	16,86 ab	22,88 a	16,11 b
Interactions		-	-	-	-	-

Note: Numbers followed by same alphabet in the same column shows no significant difference in Duncan's Multiple Range Test analysis at the 95% level of confidence. (-) no interaction

Table 3 shows that the number of tillers of 42, 49, and 56 days old plants in rice plots treated with 10 tons/ha boiler ash was significantly higher than those without fly ash application. The number of tillers of 35, 42 and 49 days old plants in rice plots treated with 5 times LOF bacteria + LOF "Plus" spraying was higher than those sprayed two times or three times although it was not significantly different from plots sprayed four times. The number of tillers of 56 days old plants in rice plots treated with two times or six times LOF bacteria + LOF "Plus" spraying was lower than those sprayed three times, four times or five times.

Yield components

Table 4 shows that yield components, including number of panicles/hill, length of panicles, number of grain/panicles in rice plots treated with 10 tons/ha boiler ash was significantly higher than those without boiler ash application. Furthermore, boiler ash application reduced number of un-productive tillers. Number of panicles/hill, length of panicles and number of grain/panicles in 5 times LOF Bacteria + LOF "Plus" spraying were significantly higher than rice plots treated with those in plots sprayed two times, but were not significantly different from those in plots treated with 3,4 dan 6 times LOF spraying. Rice plots treated with 5 times LOF Bacteria + LOF "Plus" spraying produced the lowest number of un-productive tillers.

Table 4. The effect of boiler ash application and LOF bacteria + LOF "Plus" spraying frequency on yield components

Treatment		Yield components			
		Number of panicles/hill	Length of panicles (cm)	Number of grain/panicles	Unproductive tillers (%)
Fly boiler ash	Without Fly ash	11,31 q	24,72 q	142,58 q	18,74 p
	Fly boiler ash 10 ton/ha	13,13 p	25,60 p	162,13 p	16,22 q
Bacteria & LOF "Plus"	2 times spraying	11,04 b	24,60 b	142,80 c	17,79 a
	3 times spraying	11,83 ab	25,23 ab	149,03 bc	18,69 a
	4 times spraying	12,43 ab	25,30 ab	159,67 ab	17,21 a
	5 times spraying	13,39 a	25,77 a	167,00 a	14,92 b
	6 times spraying	11,98 ab	24,93 ab	153,30 b	18,79 a
Interactions		-	-	-	-

Note: Numbers followed by same alphabet in the same column shows no significant difference in Duncan's Multiple Range Test analysis at the 95% level of confidence. (-) no interaction

Table 5. The effect of boiler ash application and LOF bacteria + LOF "Plus" spraying frequency on grain weight

		Weight of 1000 grains (g)	Weight of grains per hill (g)	Weight of grains per plot (g)	Weight of grains per hectare (ton)
Boiler ash	Without boiler ash	27,09 p	29,98 q	12,55 q	6,27 q
	Boiler ash 10 ton/ha	26,51 p	32,61 p	13,76 p	6,88 p
LOF Bacteria & LOF "Plus"	2 times spraying	26,83 a	29,74 a	12,79 b	6,40 b
	3 times spraying	26,80 a	29,85 b	12,75 b	6,44 b
	4 times spraying	26,40 a	31,65 ab	12,97 ab	6,58 ab
	5 times spraying	27,19 a	34,00 a	13,87 a	6,94 a
	6 times spraying	26,90 a	31,23 b	13,19 ab	6,65 ab
Interactions		-	-	-	-

Note: Numbers followed by same alphabet in the same column shows no significant difference in Duncan's Multiple Range Test analysis at the 95% level of confidence. (-) no interaction

Weight of grains per hill, per plot and per hectare in rice plots treated with 10 tons/ha boiler ash was significantly higher than those without boiler ash application. The weight of 1000 grains was not affected significantly by treatment of 10 tons/ha boiler ash and LOF Bacteria + LOF "Plus" spraying frequency. The weight of grains per hill, per plot and per hectare in rice plots treated with 5 times LOF Bacteria + LOF "Plus" spraying were significantly higher than those sprayed two times

or three times, but was not significantly different from those treated with 4 or 6 times LOF spraying (Table 5).

DISCUSSION

Application of boiler ash 10 ton/ha increased plant growth (number of leaves, plant dry weight and number of tillers) and yield (number of panicles, panicle length, grain weight per hill, per plot and per hectare). Increased growth and yield of rice is affected by the content of macro- and micro-nutrient in the boiler ash, as the main source of nutrients for plant growth and metabolism. Nutrient serves as a constituent in the morphology of organic structure of plants, the source of energy as well as activator and enzyme cofactor. Boiler ash contains 71% SiO_2, 2.4% P_2O_5 elements, 9% K_2O, 4% CaO and some micronutrients (2.3% Na_2O, 3.1% Al_2O_3, 3.7% Fe_2O_3 and 3.2% MgO) (Yukamgo & Yowono, 2007). The function of boiler ash as nutrient provider will increase when it is applied together with organic fertilizer. The results showed that the application of boiler ash was not only increase the number of tillers and panicles but also reduced the number of un-productive tillers. A great number of leaves and tillers that overlap to each other could decrease photosynthesis because shaded leaves competing for light resulted in un-productive tillers. Silicon content in boiler ash increases the mechanical strength of plant tissue, so that the leaves grow stronger and upright. The leaves do not shade to each other, therefore, photosynthesis occurs effectively. Silicon in leaves helps translocation of carbon as the results of photosynthesis (Roesmarkam & Yowono, 2002).

The utilization of LOF from agricultural waste and biological agent increased the growth and rice yield. LOF Bacteria and LOF "Plus" spraying supported the vitality of the plant. Appropriate LOF spraying frequency produced thick and erect leaves, so the sunlight is able to penetrate most of the leaf surface that help the photosynthesis process and maximum assimilates can be translocated into the grains. The results showed that five times LOF Bacterial + LOF "Plus" spraying produced better growth and yield than two or three times LOF Bacterial + LOF "Plus" spraying, although it was not significantly different from four or six times LOF Bacterial + LOF "Plus" spraying. Liquid Organic Fertilizer Spraying (LOF) function as a supplementary fertilizer on tillering phase and the formation of flowers and grain filling.

The biological agent is formulated into liquid bacteria fertilizer that contains 1) major microbes as provider of N, P, K elements through biosynthetic, bio enzymatic and fixation so

they are available to plants; 2) secondary microbes that produce a food source for the proliferation of all microbes in the biotic associations; 3) create ideal soil conditions for development of all microbes (Ngrembakatingkir.blogspot.com. 2011). The role of bacteria in LOF is to decompose large molecules of organic matters into small molecules. During the decomposition *Bacillus* sp. produces enzyme protease; Lactic acid bacteria decompose sugars become lactic acid, format acid, ethanol, and CO2; yeast helps to change sugars into ethyl alcohol and CO2. Yeast is used for the fermentation process (Kosit, 2011). Fungi may increase the uptake and efficiency of micronutrients like Zn, Cu, Fe and Mg (Suresh *et al*., 2011). The LOF "Plus" contains various macro and micro nutrients, growth hormone and botanical pesticide that will be able to meet most of the nutrients required for plant growth and development. The chemical analysis of LOF "Plus" at Integrated Research and Testing Laboratory (LPPT), Universitas Gadjah Mada, Yogyakarta, Indonesia showed that the macronutrient contents were 0,07 percent nitrogen, 0,023 percent phosphorus and 0,138 percent potassium, the micronutrient contents were 1.51 ppm Zn, 2,10 ppm Mn, 26,87 ppm Fe, 157,59 ppm Mg, and IAA plant hormones was 0,07 ppm.

CONCLUSION

Use of mixture of LOF "Bacteria + Plus" and boiler ash application can improve plant growth and rice yield. Additional application of mixture of "Bacteria + Plus" to boiler ash application significantly reduced number of un-productive tillers.

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