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The Stock and Flowpaths of Organic Carbon in the Irrigated Rice Field from Imogiri Bantul D.I Yogyakarta Indonesia

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ABSTRACT

Soil organic carbon determines the quality, productivity and the sustainability of agricultural systems. Organic matter input and output are the processes that lead to the system's sustainability from the perspective of organic carbon balance. Soil and crop management systems influence the return of organic carbon to the irrigated rice field. This study aimed to evaluate the recovery of soil organic carbon of irrigated rice fields treated with organic and conventional managemet systems. The study was conducted at Imogiri Bantul D.I. Yogyakarta Indonesia, to evaluate carbon dynamics (organic carbon inputs and losses) in irrigated rice fields under organic and conventional rice management systems. The organic rice management system in this study is defined as eliminating the use of agrochemical materials that are poisoning the environment and relying on the use of organic materials, while conventional rice systems are defined as relying on the use of agrochemical materials. The results showed that the Mentik Wangi organic rice produced 11.227 t.ha-1, while the conventional rice system produced 11.877 t.ha-1 dry biomass. The return of organic carbon were derived from organic fertilizer, rice stump and rice roots, while the carbon loss were caused by straw and grain removals. In the organic rice system, the total carbon input (recycled) was 7.161 t.ha-1, while the output (removal) was 6.194 t.ha-1, implying a sustainable system with a greather input than the output. On the contrary, in the conventional rice system, the total carbon input was 4.946 t.ha-1, while the loss was 6.931 t.ha-1, implying carbon deficits which my lead to unsustainability.

Keywords: *Organic carbon, irrigated rice field, organic rice system, conventional rice system*

INTRODUCTION

Carbon determines sustainability to crop productivity and cropping systems. Maintenance of organic carbon are regulated by the quality and quantity of organic material returned to the soil (Manna, et al., 2003). Organic matter is the center of transformation and nutrient-biomass flow. This conditions are related to input and output of materials, which in turn will determine the quality and further sustainability of the farming system.

Agricultural practices affect to the return and content of soil organic carbon (Tian, et al., 2013 ; West dan Post, 2002). The remains of plants and animals are sources of soil organic matter, with the main components of organic carbon. Organic carbon is important in processes in the soil and positively correlated with fertility rates (Francaviglia, et al., 2018). Applying straw to the soil can increase soil organic carbon (Syamsiyah, 2014). There is a positive relationship between increase in organic carbon in the soil and improvement in soil properties (Blair, et al., 2006). Improved of soil properties are associated with better soil productivity and quality (Lal, 2004b). Soil organic carbon play a role in the nutrition cycle, soil quality and the sustainability of agricultural systems. Minardi et al. (2012) stated that organic carbon play a role in increase soil fertility, support plant growth, and increase crop yield. Soil organic carbon can increase soil fertility and nutrient use efficiency, so that crop productivity increases (Nusantara et al., 2014).

Organic matter affects the availability of nutrients in the soil (Magdoff and Van Ess, 2009), which is influenced by the level of decomposition. Environmental conditions, including climate and soil condition, play a role in mineralization and immobilization which determine the accumulation of organic carbon, nutrient availability and the sustainability of agricultural systems (Seiter and Horwath, 2004).

Carbon sequestration is a transformation process for atmospheric CO2, to be stored in plant biomass and in the soil (Lal, 2004b). The carbon cycle returns the plant material into the soil, which further increases the soil organic carbon content. Soil organic carbon improve soil quality, agricultural production and the sustainability of agricultural systems.

This study aimed to evaluate carbon dynamics (organic carbon inputs and losses) in irrigated rice fields under organic and conventional rice management systems. Lal (2001) mentioned that carbon storage occurs when inputs of organic carbon was greater than losses of organic carbon. Furthermore, Lal (2004a) divides inputs of organic carbon with losses of organic carbon as a sustainability index (IS). The value of IS more than 1 indicates the system tends to sustainable.

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MATERIALS AND METHODS

The study was conducted at Kebonagung Imogiri Bantul D.I. Yogyakarta, to determine inputs and losses of organic carbon from irrigated rice fields with organic and conventional management systems in September 2016 – February 2017. The organic rice management system in this study is defined as eliminating the use of agrochemical materials that are poisoning the environment and relying on the use of organic materials, while conventional rice systems are defined as relying on the use of agrochemical materials. Mentik Wangi variety of rice are grown with organic and conventional system.

Interviews were carried out on key farmers to find out the factors that influence the flow of organic matter. Organic carbon flow are divided into input of organic carbon and loss of organic carbon. The dosage of organic fertilizer on irrigated rice fields with organic systems 8.500 t.ha-1 (at 20% moisture content) contributes organic carbon 2.128 t.ha-1, but not in conventional systems. Input and loss of biomass from irrigated rice fields are measured with three replications. Input and loss of organic carbon components can be seen in Figure 1.

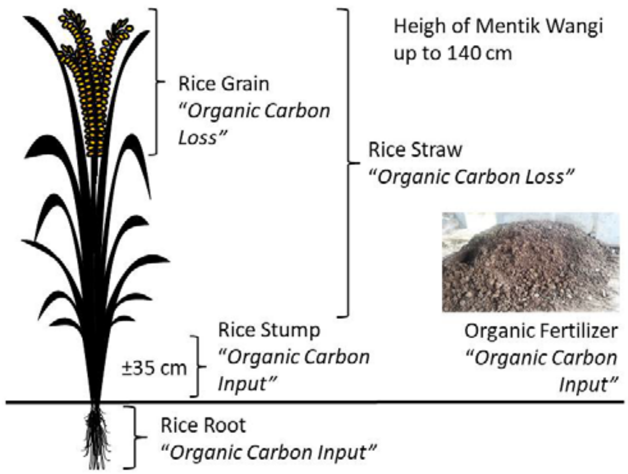

Figure 1. Illustration of organic carbon input and loss from irrigated rice field

Rice harvesting was carried out by harvest workers, which determines the height of straw and stump. Organic carbon input derived from the the organic fertilizer, the roots of rice left in the soil and rice stumps that are not transported by harvest. Loss of organic carbon in the form of grain were transported by harvest and straw were harvested by harvesters. Straw is taken for animal feed and stump are left on the land. Rice straw is transported out from the land, not returned to the land, loss, as animal feed, causing loss of organic carbon from the land.

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ΔC shows the difference between input of organic carbon and loss of organic carbon, positive if input of organic carbon were greater than loss of organic carbon. IS obtained from input of organic carbon divided by loss of organic carbon. IS > 1 shows that the system tends to sustainable. Difference and comparison between input and loss of organic carbon in the irrigated rice fields with organic and conventional systems are calculated.

RESULTS AND DISCUSSION

Organic carbon returned to irrigated rice fields determines the system sustainability. This is determined by the culture and way of life of farmers. Organic fertilization by farmers will contribute organic carbon to the land. When harvesting, farmers cut rice stalks from the land and leave the rice stumps returning to the land. Farmers transport grain and straw out as biomass loss from the land.

Organic fertilizers are obtained from local organic materials around agricultural areas, such as agricultural and livestock waste. Organic matter is an important ameliorant to increase soil fertility both physically, chemically, biologically, and provide nutrients for plants. Organic fertilizers contribute organic carbon to the soil. Stock and flow path of organic carbon in irrigated rice field can be seen in Table 1.

Table 1. C-Organic in the irrigated rice field

Irrigated Rice Field	Organic carbon Component	Organic carbon Input	Organic carbon Loss	Δ C	Is
		t.kg.ha^{-1}.season^{-1}			
Organic System	Rice Root	2,258		0.967	1,16
	Rice Stump	2,775			
	Rice Straw		2,692		
	Rice grain		3,502		
	Organic Fertilizer	2,128			
	Methane		77		
	Total	7,161	6,194		
Conventional System	Rice Root	2,182		-1,985	0,71
	Rice Stump	2,764			
	Rice Straw		2,678		
	Rice grain		4,253		
	Organic Fertilizer	-			
	Methane		38		
	Total	4,946	6,931		

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Farmers in the research area are develops soil fertility by providing soil organic matter in the form of manure, cropping waste, weeds, agricultural processing wastes and non-agricultural organic waste (Anshori, et al., 2016a). Mentik Wangi varieties are cultivated (Anshori, et al., 2016b), which has the high potential to restore biomass to the land.

Mentik Wangi is a local rice variety. Results of the study showed that Mentik Wangi reaching about 140 cm high and producing more organic matter than new varieties. Mentik Wangi in organic rice fields produces rice biomass in dry 11.227 t.ha-1, in conventional rice fields 11.877 t.ha-1 after dry. As comparison, the results of Syamsu and Abdullah's research (2008) with new verieties yielded 6.730 t.ha-1 dry biomass. Mentik Wangi contributes organic carbon greater than new varieties.

The irrigated rice fields with organic systems have a positive ΔC (0.967 t.ha-1), input of organic carbon were greater than loss of organic carbon. Inputs of organic carbon are organic fertilizer, stump and root. Loss of organic carbon are grain and straw. Organic fertilizer provides a great input to the contribution of soil organic carbon. Is equal to 1.16 indicating that irrigated rice field with organic system tends to sustainable.

The irrigated rice fields with conventional systems have a negative ΔC (-1.985 t.ha-1) meaning that input of organic carbon were smaller than loss of organic carbon. Input of organic carbon only derived from stump and root, no addition from organic fertilizer. Loss of organic carbon derived from rice grain and straw for animal feed. Is equal to 0.71, showing that irrigated rice field with conventional system tends to be unsustainable.

Organic fertilizer make a big contribution in returning soil organic carbon. Without the organic fertilizer, organic carbon loss is greather than input, ΔC is negative and the agricultural system tends to be unsustainable.

CONCLUSIONS

Mentik Wangi variety of rice produces large biomass and potentially contribute to soil organic carbon. The input of organic carbon came from fertilizer, rice stumps and roots, while the loss of organic carbon from the system is due to removal of rice grain through harvest and removal of rice straw. Organic rice field have an input of organic carbon greater than loss of organic carbon, with the sustainability index (IS) of more than 1, the system tends to sustainable. Conventional rice field have smaller input of organic carbon than loss of organic carbon, IS less than 1, the system tends to unsustainable.

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