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Research Article

Effects of organic matter application on methane emission from paddy fields adopting organic farming system

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Abstract: A study that was aimed to determine the effect of the use of organic manure and azolla on methane emission on paddy field of organic systems was conducted on paddy fields in the Gempol Village, Sambirejo District of Sragen Regency, Indonesia. The experimental design performed for this study was a completely randomized block design consisting of three factors; the factor I was rice cultivars (Mira-1; Mentik Wangi; Merah Putih); factor II was dose of organic manure (0 t/ha and 10 t/ha) and factor III was Azolla inoculums dose (0 t/ha and 2 t/ha). Gas sampling was conducted 3 times in one growing season when the rice plants reached ages of 38, 66 and 90 days after planting. The results showed that there was no correlation between the uses of organic fertilizers for rice production on methane emission. The increase of methane emission was very much influenced by the redox potential. Methane emission from Mira-1 field was higher than that from Mentik Wangi and Merah Putih fields. Emission of methane gas from Mira-1 field ranged from -509.82 to 791.34 kg CH_4/ha; that from Wangi ranged from -756.77 to d 547.50 kg CH_4/ha and that from Merah Putih ranged from -399.63 to 459.94 kg CH_4/ha. Application of 10 t organic manure /ha and 2 t azolla/ha in Mentik Wangi reduced methane emissions with a high rice production compared to Merah Putih and Mira-1.

Keywords *: methane, organic fertilizers, rice cultivars*

Introduction

Rice production from year to year has decreased, which are caused by the degradation of wetland. With the increasingly widespread land degradation due to the intensity of the continuous cultivation with the use of organic fertilizers and most crops carried out and no other additional organic matter (Mujiyo and Syamsiyah, 2006) led to many rice fields have low levels of soil organic matter (Sirappa and Razak, 2007). Yet to obtain optimum productivity organic C in excess of 2.5% is needed (Simanungkalit et al., 2006). Low content of soil organic matter causes additional inputs (inputs such as fertilizer) cannot be offset by the increase in results (leveling off).

The emergence of symptoms of leveling off productivity of rice is a reflection of the decline in the efficiency of the use of fertilizers and soil health disorders (Rochayati and Adiningsih, 2002). One indicator of the declining quality of land resources, especially rice fields is declining of soil organic C content. One of efforts to improve the condition is with the use of organic fertilizer on paddy rice farming. As has been done by Farmers Group "Margorukun Satu" Gempol Village, Sambirejo District of Sragen. Farmers Group has been implementing a system of organic paddy rice since 2001. Farmer Group uses only fertilizer from cow manure with some additional inputs such as the use of Azolla, straw compost and organic hormone (mixture of honey and milk).

However, organic farming is now suspected as a contributor to greenhouse gas emissions (GGE), which have an impact on global warming. Gases that are categorized as greenhouse gases are gases that affect, either directly or indirectly to the greenhouse effect. Methane (CH_4) is a greenhouse gas emissions that contribute to wetland, because methane is produced as intermediate and final products of microbial processes, such as anaerobic decomposition of organic matter by methane bacteria (Setyanto, 2006). Waterlogged conditions are ideal conditions for the decomposition of organic matter in paddy fields. In addition, cow manure as a source of organic material is also able to increase the production of methane (Kongchum, 2005). Setyanto et al. (2004) suggested that the addition of organic matter 10 t / ha yielded CH_4 emissions by 230.3 kg / ha. This value is greater than the addition of 5 t / ha of CH_4 emission of 216.4 kg / ha. Greenhouse gasses from paddy fields are expected to continue to increase with increasing management intensity.

So far, there is a presumption that the organic paddy rice systems that increase greenhouse gas emissions of CH_4 will affect the comfort and sustainability of rice production, including organic rice paddy fields in the Gempol village, Sambirejo District, Sragen. Therefore, we need a study of how the influence of the organic paddy rice systems management, especially the use of organic fertilizers in several different varieties of rice, to the CH_4 emissions. This study is an attempt to support the mitigation of GGE emissions, especially methane (CH_4) through reclamation of paddy fields with the aim of increasing the productivity of land, but it can minimize the emission of CH_4. The purpose of this study was to determine the effect of the use of organic materials on rice production and methane emission in organic paddy rice systems.

Materials and Methods

The experiment was conducted in paddy fields in the Gempol village, Sambirejo District of Sragen. Geographically, this area is located on the slopes of Mount Lawu northwestern part at position 111^0 08 '42' '- 111^0 08' 46 " E and 07^0 31 '02' '- 07^0 31' 11 " S. Irrigation system with irrigation water from the eyes of the region, so that the irrigation system of the land is inundated throughout the day. Cropping pattern common in this area is rice-paddy-rice continuously 3-4 times a year. Paddy soil used in this study contains 4.17% organic matter with a pH of 5.

The treatments tested were combination of three varieties of rice (Mira-I, Mentik Wangi, and Merah Putih), two doses of manure (0 and 10 t / ha), two doses of Azolla inoculums (0 and 10 t / ha). Azolla used was *Azolla mycrophylla* L., obtained from the Laboratory of Microbiology, Department of Soil Science, Faculty of Agriculture, Gadjah Mada University. The Azolla characteristics were as follows: 2.06% organic C, 3.55% organic matter, and the C/N ratio of 0.5. Manure used for this study had the following composition: 20.5% organic C, 35.34% organic matter, and the C / N ratio of 16.8. Twelve treatments were arranged in a randomized block design with three replications. Seedlings of each of the three varieties of rice were grown in paddy fields the size of 3m x 3m with spacing of 20 x 20 cm, three seedlings per hole and each plot contained 15 x 15 rice plants. Cow manure was applied after tillage. Azolla was applied after 5 days. Methane sampling was done using the Closed chamber (Kongchum, 2005). Collection of CH_4 samples was performed at 38 days, 66 days, and 90 days after planting.

The gas sample was introduced into the venoject tube and then analyzed using gas chromatography equipped with a Flame Ionization Detector (FID) to establish CH_4 flux. The positive value of CH_4 indicates release of CH_4 to the atmosphere (Hou et al., 2000); while the negative value indicates that the soil is able to act as sink (Suprihati et al, 2006). Emission rate of CH_4 was calculated according to the following equation (Khalil, 1992),

$$E = \frac{dc}{dt} \text{ x } \frac{Vch}{Ach} \text{ x } \frac{mW}{mV} \text{ x } \frac{273.2}{273.2 + T}$$

Remarks:

E	:	CH_4 emission (mg / m^2 / min)
dc/dt	:	The difference in the concentration of CH_4 per time (ppm / minute)
Vch	:	Closed chamber volume (m^3)
Ach	:	Wide closed chamber (m^2)
mW	:	The molecular weight of CH_4
mV	:	CH_4 molecule volume at STP (= 22.41 l)
T	:	The average temperature during sampling (^oC)

To convert to the amount of flux in one growing season, the following equation was employed,

$$E = \frac{F(0-38) + F(39-66) + F(67-90)}{HT - N} \text{ x } (H - N) \text{ x } \frac{10{,}000 m^2}{1{,}000{,}000 kg}$$

Remarks:

E	:	Total of CH_4 emission (kg / ha / season)
F_{0-38};F_{39-66};F_{67-90}	:	Cumulative flux at 0-38, 39-66 and 67-90 days (mg / m^2 / day)
N	:	Seedling age (days)
HT	:	Last day of observation (day)
H	:	Age of plants from the nursery until the harvest (day)

Harvesting was done when the rice grain was hard, the colour of the flag leaf and panicle were yellow (yellow phase). At the time of this harvest, dry grain weight was measured. Data obtained were analyzed descriptively and supported by statistical analysis by F test at levels of 95% and 99% to determine the effect of treatment. Duncan test was used to compare the mean between combined treatments. Correlation was performed to determine the closeness of the relationship between variables.

Results and Discussion

Effect of organic fertilizers on methane emission

Data presented in Figure 1 show the variation of methane that was produced when the plant was at 38, 66 and 90 days. When the plant was at 38 days, methane flux through Mira-1 variety ranged from -0.02094 to 0.0486 mg CH_4 / m^2 / minute, whereas through Mentik Wangi variety ranged from -0.7204 to 0.3875 mgCH_4 / m^2 / minute, and through the Merah Putih variety ranged from -0.1223 to 0.0429 mg CH_4 / m^2 / minute.

Results of the analysis of variance showed that the application of cow manure and Azolla did not significantly affect methane emissions, but from the pattern of methane emissions, the emission tended to increase with the addition of cow manure and decrease with the addition of Azolla. The lowest methane flux was obtained through Mentik Wangi variety of the V2K2A2 treatment (-0.7204 mg CH_4 / m^2 / minute) followed by Merah Putih variety of the V3K2A2 treatment (-0.1223 mg CH_4 / m^2 / minute), and Mira-1 variety of the V1K1A2 treatment (-0.0295 mg CH_4 / m^2 / minute) (Figure 1). The low methane emissions were due to the sinks that were performed by Azolla.

Based on correlation test at 38 days after planting, the methane emissions were negatively correlated (r = -0.40) to the V2A2 treatment. This means that application of 2 t Azolla / ha to the Mentik Wangi variety caused a decrease in methane emissions. In addition, the redox potential (Eh) was also negatively correlated with pH (r = -0.37), which means that the Eh increase was influenced by the pH decrease and then affected the reduction of methane emissions.

The increase in methane emissions were affected by the use of organic materials associated with the provision of substrate for methanogenic bacteria in producing methane (Setyanto, 2004). According to Nieder and Benbi (2008), application of organic matter will increase methane production through its influence on the decrease in Eh and providing a source of C. However, the rate and methane production rate depends on the quantity and quality of organic materials applied (C/N ratio, cellulose content, degree of humification and others).

Application of rice straw (high C/N ratio) significantly increases methane production. The addition of compost (humified, low C/N ratio) does not give effect to the production of methane.

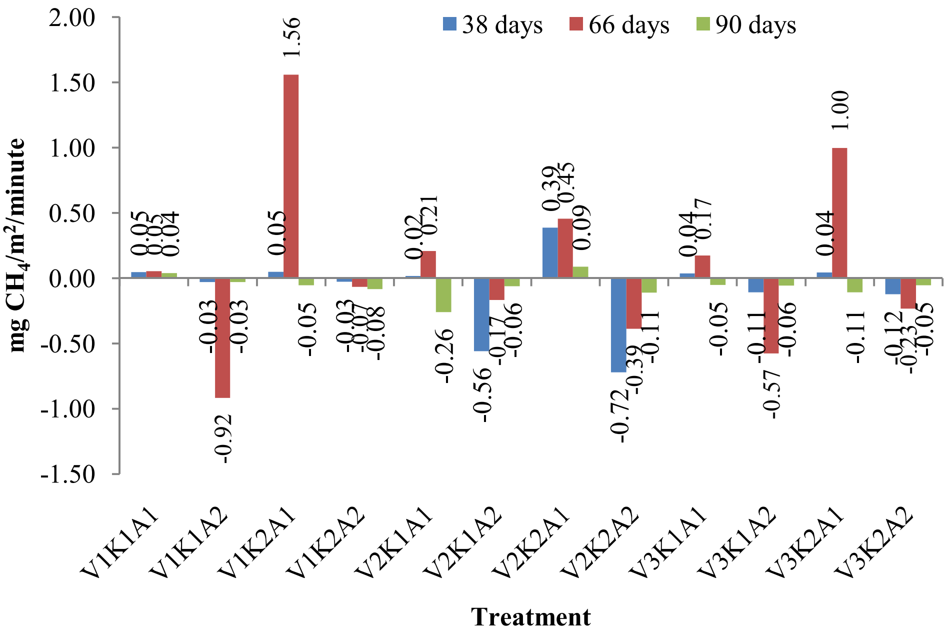

Figure 1. Variation of methane produced when the rice plant at ages of 38, 66, and 90 days after planting.

Flooded paddy soil conditions (anaerobic) contribute to the production of methane (CH_4) because of methanogenic bacteria (methane forming bacteria) can only perform metabolism and active in the absence of oxygen (anaerobic). In waterlogged soil, the water pushes out oxygen so that the soil pore space is occupied by water and the availability of oxygen in the soil is reduced drastically. Oxygen can only enter through diffusion into the water at a speed of 10,000 times slower than diffusion through the pores (Kongchum, 2005), and thus causing oxygen deficit.

The highest methane flux was achieved in Mira-1 variety of the V1K2A1 treatment (0.0486 mg CH_4 / m^2 / minute), followed by Merah Putih variety of the V3K2A1 treatment (0.0429 mg CH_4 / m^2 / minute) and Mentik Wangi variety of the V2K2A1 treatment (0.3875 mg CH_4 / m^2 / minute) (Figure 1). The high methane emissions were affected by the use of cow manure at 10 t / ha, where cow manure is a source of organic material organic substrates that can stimulate the formation of methane as an energy source for methanogenic bacteria. In addition, the flooding conditions also affected the amount of methane emissions due to the low Eh value that was optimal the formation of methane by methanogenic bacteria. When the plant reached 66 days old, addition of cow manure and Azolla also did not significantly affect methane emissions, although addition of cow manure tended to increase methane emissions, and addition of Azolla tended to reduce methane emissions.

Methane flux through the Mira-1 variety ranged from -0.9177 to 1.5584 mg CH_4 / m^2 / minute, that through Mentik variety ranged from -0388 to 0.4548 mg CH_4 / m^2 / minute, and that through Merah Putih variety ranged from -0.5748 to 0.9966 mg CH_4 / m^2 / minute. The lowest methane flux was achieved in Mira-1 variety of the V1K1A2 treatment (-0.9177 mg CH_4 / m^2 / minute) followed by Merah Putih variety of the V3K1A2 treatment (-0.5748 mg CH_4 / m^2 / minute) and Mentik Wangi variety of the V2K2A2 treatment (-0388 mg CH_4 / m^2 / minute). The V1K2A2 treatment significantly reduced methane emissions compared with the V1K2A1 treatment. Application of Azolla effectively reduced methane emissions. This occurred because of the use of Azolla that has been fully decomposed that cause methane could be oxidized completely so that methane emissions released into the air decreased.

The highest methane flux was achieved in Mira-1 variety of the V1K2A1 treatment (1.5584 mg CH_4 / m^2 / minute), followed by Merah Putih variety of the V3K2A1 treatment (0.9966 mg CH_4 / m^2 / minute), and Mentik Wangi variety of the V2K2A1 treatment (0.4548 mg CH_4 / m^2 / minute). The high methane emissions was not only due to the flooding conditions that caused the increase of Eh value but was also influenced by the use of cow manure at 10 t / ha as a source of soil organic matter. Methane flux values at harvest (90 days) through Mira-1 variety ranged from -0.0834 to 0.0398 mg CH_4 / m^2 / minute, that through Mentik Wangi variety ranged from -0.2606 to 12:08 mg CH_4 / m^2 / minute, and that through Merah Putih variety ranged from -0.1077 to -0.0504 mg CH_4 / m^2 / minute.

The lowest methane flux was achieved Mentik variety of the V2K1A1 treatment (-0.2606 mg CH_4 / m^2 / minute), followed by Mira-1 variety of the V1K2A2 treatment (-0.0834 mg CH_4 / m^2 / minute), and Merah Putih variety of the V3K1A1 treatment (-0.0504 mg CH_4 / m^2 / minute). The low methane flux occurred due to the sinks for CH_4 as to the effect of Azolla application of 2 t / ha.

Results of analysis of variance showed that at 90 days Azolla significant effected methane emissions, it is supported by the correlation test showing that at 90 days emissions were positively correlated (r = 0.46), to the A1 and negatively correlated to the A2 treatment (r = -0.46). This suggests that the use of 2 t Azolla / ha reduced methane emissions when compared to treatment without the use of Azolla (0 t / ha). Azolla is one of organic fertilizers that has low C / N ratio that makes Azolla easily decomposed and having large amount of organic C. This makes methanogenic bacteria do not get energy in methane formation (Mujiyo and Syamsiyah, 2010).

This is consistent with results of study conducted by Bharati et al. (2000) which showed that application of Azolla could reduce methane emissions up to the age of 90 days. At 90 days, the highest methane flux was achieved by Mentik Wangi variety of the V2K2A1 treatment (0088 mg CH_4 / m^2 / minute) followed by Mira-1 variety of the V1K1A1 treatment (0.0398 mg CH_4 / m^2 / minute), and Merah Putih variety of the V3K1A1 treatment (-0.0504 mg CH_4 / m^2 / minute). This was still influenced by the use of 10 t cow manure / ha as a source of organic material, that could stimulate the formation of methane as an energy source for methanogenic bacteria. Emissions at 90 days were negatively correlated (r = -0.33) with V2K1 treatment and positively correlated (r = 0.32) with V2K2 treatment. This means that treatments without cow manure (0 t / ha) were less able to increase methane production when compared with the use of cow manure (10 t / ha) as this cow manure acted as a source of energy for the methanogenic bacteria to produce methane.

The CH_4 flux tended to increase during the 38-66 days after planting (early growth) and decreased at 90 days (harvest). Setyanto and Kartikawati (2007) suggested that soil conditions with continues flooding relatively emitted higher than non-flooding conditions. This can be seen in V1K1A1, V2K1A1 and V2K2A1 treatments which showed an increase in methane emissions at 38 to 66 days, and then decreased at 90 days.

In V1K2A1, V2K1A1, V3K1A1 and V3K2A1 treatments at 90 days showed the sink. The sinks occurred because the drying period created aerobic conditions on the soil and activated the role methanotroph bacteria to oxidize CH_4 to CO_2 so that more CH_4 was oxidized before being released into the atmosphere (Setyanto and Kartikawati, 2007). The ability of Azolla as a methane sink also varied at 38, 66, and 90 days. Results of this study showed that that sink was highest in the V2K2A2 treatment at 38 days after planting (Figure 12). This could happen because Azolla had low C / N ratio so that at the initial growth there was only fresh Azolla that could be decomposed perfectly which then increased the levels of dissolved oxygen in the soil and eventually inhibited the growth of methanogenic bacteria in producing methane (Bharati et al., 2000). Results of this study were in accordance with a study conducted by Bharati et al. (2000) which showed that application of Azolla reduced methane emissions up to the age of 60 days and continues until the age of 90 days when compared with no use of Azolla.

The total methane flux during one season with Mira-1 variety ranged from -89.81 to 791.34 kg CH_4 / ha / season, that through Mentik Wangi variety ranged from -756.77 to 547.50 kg CH_4 / ha / season, and that through Merah Putih variety ranged from -399.63 to 459.94 kg CH_4 / ha / season (Figure 2). Cow manure and Azolla did not significantly affect the total methane flux during the first season.

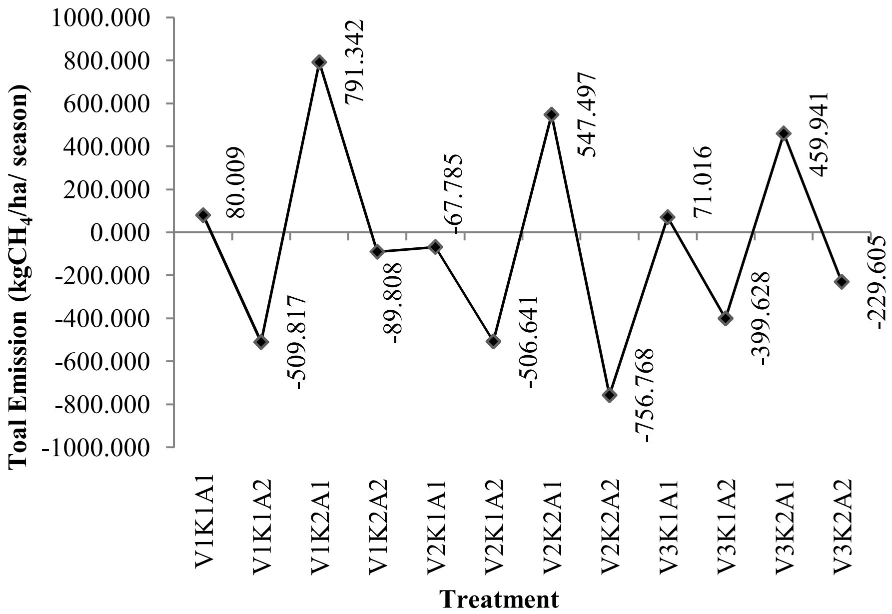

Figure 2. The flux of total CH_4 for one season

According to Wihardjaka and Setyanto (2007), the addition of manure does not significantly increase methane emissions despite the addition of organic material such as rice straws, especially which still having high C/N ratio value, will increase methane emissions into the air. Figure 2 shows an increase in total CH_4 flux for treatments using cow manure, and a decline in total CH_4 for treatments using Azolla. The highest total methane flux during the first season was achieved by Mira-1 variety of the V1K2A1 treatment (791.34 kg CH_4 / ha / season), followed by Mentik Wangi variety of the V2K2A1 treatment (547.50 kg CH_4 / ha / season), and Merah Putih variety of the V3K2A1 treatment (459.94 kg CH_4 / ha / season). Application of 10 t cow manure / ha was able to produce methane that greater than that without cow manure (0 t / ha). According to

Wihardjaka and Setyanto (2007), the addition of organic matter to the wetland, especially that still has the C / N high ratio will increase of methane emissions into the air. In addition, application of organic matter will increase of methane production through its influence on the decrease in Eh and providing a source of C (Hou et al., 2000). The V1K2A1 treatment (use of manure alone) produced 791.34 kg CH_4 / ha / season, but on the V1K2A2 treatment (use of cow manure and Azolla) occurred sinks only amounted to - 89.80 kg CH_4 / ha /season. This could happen because Azolla had not been fully decomposed that caused methane could not completely be oxidized so much methane emissions were released into the air.

The lowest total methane flux during the first season was achieved by Mentik Wangi variety of the V2K2A2 treatment (-756.77 kg CH_4 / ha / season), followed by Mira-1 variety of the V1K1A2 treatment (-509.82 kg CH_4 / ha / season), and Merah Putih variety of the V3K1A2 treatment (-399.63 kg CH_4 / ha / season) (Figure 2). Results of the correlation test showed that addition of 2 t Azolla / ha had a negative correlation (r = -0.38), which the total emission of one season. At that, application of Azolla reduced methane emissions. The results were in line with those expressed by Bujak (2007) that Azolla could absorb carbon 6000 kg / ha per year in order to reduce the level of greenhouse gas emissions. The V2K2A1 treatment (use of manure alone) produced 547.50 kg CH_4 / ha / season, the V2K2A2 treatment (use of cow manure and Azolla) occurred sinks that only amounted to - 756.77 kg CH_4 / ha / season (Figure 2). This could happen because Azolla that had been fully decomposed caused methane to be oxidized completely so that methane emissions released into the air decreased. Methane that is oxidized to CO_2 and H_2O will ultimately be used by plants in photosynthesis process. In this case the formation of methane by methanogenic bacteria is inhibited by b methanotroph bacteria that consume methane as the sole source of carbon and energy through the process of oxidation in aerobic conditions (Dunfield et al., 2003; Nercessian et al., 2005; Baani and Liesack, 2008). Methanotroph bacteria are bacteria that oxidize methane and oxygen through aerobic process is a terminal electron acceptor. Methanotroph bacteria are able to consume methane up to 90% before finally released into the atmosphere (Singh, 2010). These bacteria combine methane and oxygen to form formaldehyde and organic compounds.

According to Topp and Pattey (1997), methane oxidation process begins with the transformation of methane to methanol in the presence of particulate methane monoxygenase (pMMO) located in the membrane. This enzyme reduces COO bond into dioxygen. One oxygen atom is reduced to H_2O and the other binds to methane to methanol. Furthermore, methanol is converted to formaldehyde in the presence of soluble methane monooxygenase (sMMO) found in the cytoplasm and formaldehyde is transformed into biomass through two cycles of Rump and serine.

Effect of organic fertilizer on rice yield

Data of total number of tillers, weight of biomass and rice yield of the varieties studied are presented in Table 1. Results of the analysis of variance showed that treatments significantly affected the total number of tillers and biomass weight.

Table 1. Number of total tillers, biomass weight, and rice production

No.	Treatment	Number of Tillers		Biomass Weight (g)		Rice Yield (kg/ha)		CH_4 emission (kg/ha)	
1	V1K1A1	11	a	55.18	a	22.43	a	80.01	a
2	V1K1A2	14	b	62.17	b	37.10	b	-509.82	a
3	V1K2A1	16	c	63.00	b	38.10	b	791.34	a
4	V1K2A2	17	d	78.13	e	42.23	d	-89.81	a
5	V2K1A1	14	d	75.10	e	21.47	a	-67.78	a
6	V2K1A2	16	c	79.87	f	36.13	b	-506.64	a
7	V2K2A1	17	d	80.25	f	38.90	b	547.50	a
8	V2K2A2	19	f	81.19	f	43.83	c	-756.77	a
9	V3K1A1	15	c	65.86	c	21.33	a	71.02	a
10	V3K1A2	17	d	70.43	c	35.80	b	-399.63	a
11	V3K2A1	18	e	71.93	d	39.93	b	459.94	a
12	V3K2A2	19	f	80.47	f	42.23	c	-229.60	a

Remarks: Figures in columns followed by the same letter are not significantly different

Application of 10 t cow manure / ha and 2 t Azolla / ha increased the total number of tillers biomass weight as both materials are sources of nutrients to supply the needs of plants. The total tiller number of the V1K1A1 treatment (11) was significantly different from that of the V1K2A2 treatment (17). The biomass weight of V2K1A1 treatment (75.10 g) was significantly different from that of V2K2A2 treatment (81.19 g). Application of Azolla and cow manure also significantly improved rice production.

Organic fertilizers play a major role in improving the nutrient content of the soil, especially soil organic C content. Hence, organic fertilizers have to be added to soils having low organic C content in order to improve soil productivity. The increase of soil organic C content will affect the activity of soil microbes so that nutrient availability is increased, and in turn, it will increase the productivity of land (Sirappa and Razak, 2007).

The relationship between emissions of methane and crop parameters

Figure 3, 4 and 5 show the relationship between the total number of tillers, plant biomass rice yield to the total emissions during the first season. The results of this study indicated that there was no significant correlation between total tiller number and weight of plant biomass to the total emissions during the first season. This study was done in accordance with a study conducted by Setyanto and Kartikawati (2007) who stated that there was no positive linear relationship between total tiller number and plant biomass to methane emissions. The cause of this condition was possibly because much of methane has been oxidized in the soil before it was released into the atmosphere. These results were in contrast with those reported by several other studies that the magnitude of the total tiller number and weight of plant biomass is synonymous with high emissions of CH_4 released from a unit area of rice crops.

According to Setyanto et al. (2004), CH_4 flux is strongly influenced by the total number of tillers and plant biomass weight. The more the number of total tillers the higher is the density and number of aerenchyme so that the higher is the transport capacity of CH_4 (Aulakh et al. 2001). The high plant biomass weight will also increase the CH_4 emissions from rice fields. The amount of plant biomass is related to the amount of root exudates removed; the greater the plant biomass the higher is the plant root exudates (Setyanto et al., 2004).

Rice plants play an active role as a carrier medium of wetland methane into the atmosphere. More than 90% of the methane is emitted through a network of intercellular space aerenchyme and rice plants, while less than 10% is from the water bubble. The ability of rice plants in emitting methane vary depending on the physiological and morphological characteristics of a variety. In addition, each variety has the age and activity of different roots that are closely related to the volume of methane emissions (Mulyadi and Wihardjaka, 2014).

Selection of rice varieties grown in an area is determined by the potential of the crop, the condition of the ecosystem, as well as resistance to pests and diseases endemic and extreme conditions.

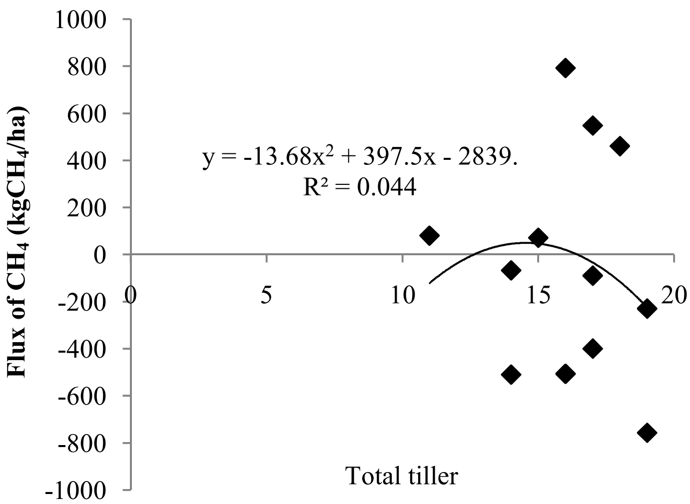

Figure 3. The relationship between total tillers and CH_4 flux during one season

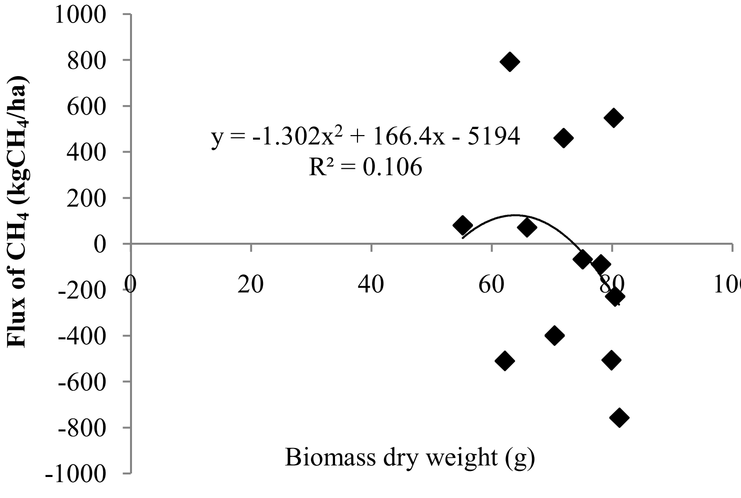

Figure 4. The relationship between biomass weight and CH_4 flux during one season

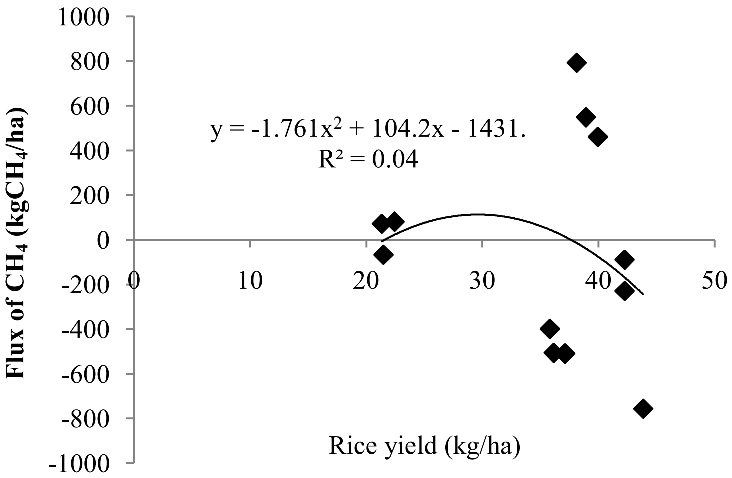

Figure 5. The relationship between rice yield and CH_4 flux during one season

Results of a study carried out by Setyanto (2004) showed that each rice variety produces methane emissions vary, so use appropriate varieties is expected to reduce emissions of methane. Table 1 show that the varieties that emitted the highest methane were in the order of Mira-1 of the V1K2A1 treatment (791.34 kg CH_4 / ha), Mentik Wangi variety of the V2K2A1 treatment (547.50 kg CH_4 / ha), and Merah Putih variety of the V3K2A1treatment of (459.94 kg CH_4 / ha). These all varieties emitted high value of methane as the standard paddy soil methane emissions average was in average of 161 kg CH_4 / ha (Mujiyo and Syamsiyah, 2010). The high methane emissions through the three varieties studied were affected by the addition of 10 t cow manure/ ha, as the addition of organic matter to the wetland, especially that having high C/N ratio, will increase methane emissions to air (Wihardjaka and Setyanto, 2007). Mentik Wangi and Merah Putih varieties had low emission levels because these varieties have better root oxidizing capacity than Mira-I variety, so that the oxygen concentration around the roots increased and methane is biologically oxidized by methanotrophic bacteria (Setyanto, 2006). In addition, Mira-1 variety has a longer growing period than other two varieties. Rice varieties having low emissions because of addition of 2 t Azolla / ha were Mentik Wangi of the V2K2A2 treatment (-756 768 kg CH_4 / ha); Mira-1 variety of the V3K2A2 treatment (-229 605 kg CH_4 / ha), and Mira-1 variety of the V1K2A2 treatment (-89 808 kg CH_4 / ha). Yield of Mentik Wangi variety of the V2K2A2 treatment (43.83 kg / ha) was significantly different from other varieties, so Mentik Wangi variety with the addition of 2 t Azolla / ha could be recommended as one of the varieties that is able to minimize methane emissions but still be able to increase the productivity of land.

Conclusion

There was no correlation between the use of organic fertilizer and rice yield on methane emissions. The increase in methane emissions was influenced by the redox potential. Methane emissions through the Mira-1 variety were higher than that through Mentik Wangi and Merah Putih varieties. Application of 10 t cow manure / ha and 2 t Azolla / ha on Mentik Wangi variety were able to reduce methane emissions and to improve rice yield higher than Merah Putih and Mira-1 varieties.

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