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Methane Emission in Paddy Field with Local Rice Variety in Peat- Swamps Agricultural Lands, South Kalimantan

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Abstract : *Rice cultivation in peat swamp agricultural lands in South Kalimantan has significant relationship with the issues of global warming. The aims of the study was to identify the methane gases releases from paddy field which are cultivated by local rice in Tamban sub district, Barito Kuala, Kuala Regency in South Kalimantan. Four local rice cultivars namely Siam Unus Putih, Pandak Putih, Siam 11 and Siam Rukut were cultivated in peat swamp paddy field. Methane release from each paddy cultivar was measured using close chamber technique. Research of the study shows that the emissions of methane from peat swamp paddy field with local rice cultivation during vegetative growth was increase and decrease during generative growth periods. The total methane emission in one season from Siam Unus local rice was estimated about 0.032 Kg/Ha while Siam Pandak rice was release methane about 0.019 Kg/Ha. This data shows that the contribution of paddy field with local rice has lowest methane emission compared from the peat swamp agricultural land with superior rice about 1.3 Ton/Ha.*

Keywords: *peat swamp, global warming, local rice cultivar*

I. Introduction

The international effort to mitigate global warming has released a global policy called Kyoto Protocols in 1997. In such global policy, during the period of 2008-2012 the developed countries has to decrease gases emission at least 5% of the total emission at 1990 Recently, scholars notes that the earth temperature has increase about 0,6±0,2°C. The increase of temperature was influenced by the increase of green houses gases, i.e. CO_2, CH_4 and N_2O in atmosphere due to the human activity in the earth. The contribution of CO_2 was about 60%, methane 20% and Di-nitrogen monoxide was about 6%. Global monitoring shows that there are significant increases of greenhouses gases between 1750 to 2005. In such periods, CO_2 increase from 280 ppm to 380 ppm. Methane increase from 700 to 1,745 ppb. Impact of the increase of temperature in crops productivity was reported significant. Increase of temperature about 10C will inhibits starch development in paddy grains and therefore decrease rice productively about 0.5 tons per ha [1] [2] [3].

Peat swamp is one of the ecosystem with high emission of CH4, and this ecosystems responsible to the CH_4 emission in atmosphere about 25% [4] [5] [6] [7]. Paddy field in peat swamp contributes about 10% of CH_4 emissions. Some researcher confirm that such paddy field contributes to the 26-61Tg per years, or equal to 6-29% of CH_4 emissions per year [8] [9] [10]. In Indonesia there are about 10.6 million Ha of paddy field which are estimated contributes about 1% of global emission of methane in the earth [11].

According to statistical data, the total area of paddy field in Indonesia in 2002 was about 7,748,840 Ha. In 2011, it was decrease about 6.758.840 Ha or equal to 6.8% of the total global paddy field which are potentially release methane about 3.2-5.8 Tg CH_4 per year [3] [12] [13]. Methane emission was influenced by several aspect, encompasses soil types, water irrigation management, soil temperature, plants and crop variety, and fertilizing methods [11] [14].

Peat swamp often viewed as marginal lands. However, there are potentiality of peat swamp for plat crops and plantation commodity development. There is a lot of potentiality for the development of fisheries in peat swamp ecosystems. Rapid population grows and the increase of land for agricultural and industrial activity lead to the rapid changes of peat swamp forest become settlement area, agricultural area and industrial sites [15]. In Kalimantan, the development in peat swamp ecosystem was initiated by Dutch colonial government in 1930s and systematically was continued by Indonesia government through transmigration programs. Physically, changes and degradation of ecosystem was started by the development of canals in delta area in Petak Island between Barito River in South Kalimantan and Kapuas Murung River in Central Kalimantan [16] [17] [18].

Green house and Methane emission is very interesting field to study. Scholars point out that about 20% was released because land use changes, and 66% was caused from other activity [19]. The increase of greenhouses at 19th century by CO_2 was about 30%, CH_4 was about 45% and N2O was about 15% [19] [20]. The agricultural activity in peat swamp lands lead to the anaerobes process under soils and therefore provides

ideals habitat for the production of CH_4 [21]. Methane has produced from Methanogenesis in anaerobes situation [22]. This process was done by methanogens bacteria which are able to changes CO_2, formic acid, acetate, methanol, Methylamine and CO_2 becomes CH_4 [23]. The aim of the research was to identify the methane release from paddy rice in peat swamp soils in South Kalimantan.

II. Methods

Four rice cultivars were planted in field following agricultural techniques standard for rice cultivation. The measurement of rice seedling and grows until harvesting times was measured in each two week. The measurement was conducted directly in the field. The measurement of CH_4 emission was done using close chamber technique. Methane emission measurement was done in three sites, which are previously selected, and in each sites emission measurement was done. The methane sample gases was isolated and trapped using polypropylen injectors 10ml. It was done and replicated four time using intervals times 5, 10, 15, and 20 minutes after cover set up. Time measurement was done between 08.00 to 12.00. Sampled gases was collected in injector and stored in ice box with temperature 50°C. It is done to countermeasure CH_4 evaporation during sample transfer from field to laboratory [14]. The sampled gasses was analyzed using gases chromatography with flame ionization detector (FID) which area calibrated using 10.1 ppm CH_4 (Shimadzu 8A) with high precision at injector temperature 1100°C and column temperature 900C [24]. The CH_4 content which area measured in integrator of collected sampled gasses from field was calculated using formula:

$$Ki = \frac{Ko \times A2}{A1} \dots\dots\dots\dots (1)$$

Notes: Ki : content of gasses in which its emission was measured (µl/L)
Ko : content of standard gases (µl/L)
A1 : reading area of integrator for standard gases
A2 : reading area from sample gasses measured

The result of calculation of gases was used to estimate the slope rate of emission increase using regression curve estimation linear model in parameter estimates. The result of slope rate value of methane was used to estimate the methane emission following formula developed by Lantin et al. [24] as follow:

$$E = \frac{dc}{dt} \cdot \frac{Vch}{Ach} \cdot \frac{Wm}{Vm} \cdot \frac{273,2}{273,2 + T} \dots\dots\dots\dots\dots\dots (2)$$

Notes: E : CH_4 emission (mg/m2/minutes)
dc/dt : different level of CH_4 per times (µl/L/minutes)
Vch : cover volume (m3)
Ach : cover size (m2)
Wm : molecule weight CH4 (16g)
Vm : molecule volume CH4 (22,41 L)
T : Temperature average (0C)

III. Result and Discussion

Kalimantan is home of biodiversity and diverse ecosystem contributes to the global warming, including forest, man-made landscape (i.e. home-garden and paddy field). These provide opportunities for Kalimantan Island to contribute in global warming mitigation [25]. Agriculture however, contributes to both carbon sequestration and methane emission. In the observation related to the impact of local rice cultivation in peat swamp, the rate of CH4 emission was given in Table 1.

Table 1. Rate of CH_4 emission in each variety of local rice in peat swamp agricultural lands

No.	Rice ages after planted (weeks)	Rate of emission (*dc/dt*) (µl/L/minutes)			
		Siam Unus Putih Rice	Pandak Putih Rice	Siam 11 Rice	Siam Rukut Rice
1	2	0.287	0.177	0.388	0.308
2	4	0.420	0.205	0.450	0.430
3	6	0.238	0.136	0.503	0.304
4	8	0.481	0.210	0.618	0.503
5	10	0.347	0.249	0.638	0.468
6	12	0.462	0.296	0.427	0.226
7	14	0.401	0.219	0.379	0.246
8	16	0.537	0.176	0.307	0.436
9	18	0.326	0.191	0.388	0.308
10	20	0.144	0.137	0.331	0.238
11	22	0.264	0.168	-	-

The relationship between Methane emission and ages of rice after planted in each rice variety was analyzed using trend line polynomial regression order 3, and shows the determinant confession (R^2) and correlation value (r), in which it is represent the relationship among variable. In each rice variety, the CH4 emission was described below.

Siam Unus Putih rice variety

The relationship between CH^4 release (E) and Siam Unus Putih rice ages which are planted in peat swamp paddy field was given in Fig. 1

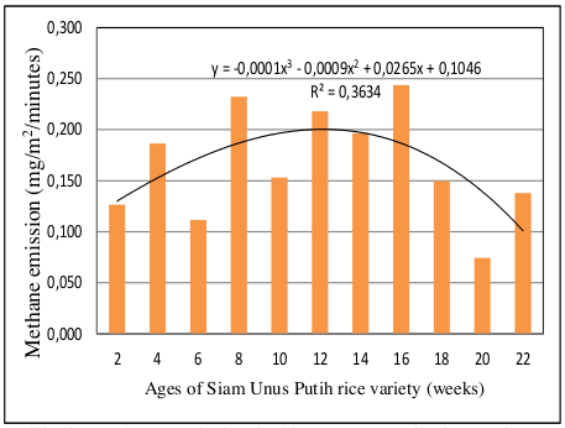

Fig.1. Methane emission in Siam Unus Putih rice variety

From this figure, the relationship between CH_4 release and rice age has coefficient value (R^2) about 0.3634 or 36.34%. It means that release of CH4 36.34% was influenced by paddy rice age, while the remaining 63.66% was influenced by other aspects. The coefficient value was about (r) = 0.6028, derived from √0.3634; in which it has strong relationship between increase of rice ages and CH_4 release. Methane release during vegetative grows in Siam Unus Putih from 0-11 weeks after planting shows trend to increase, while in the reproductive stages rice from 11 weeks to 15 weeks shows trend to constant; and in generative stages from 15 weeks after plant to 22 weeks shows decrease trend.

Table 2. The estimation of CH4 emission of Siam Unus Putih local rice variety in peat swamp field

Rice ages after planted (weeks)	Increase rate of CH_4 (b1)(µl/L/ minutes)	*Cover volume Vch* (m^3)	*Cover area Ach* (m^2)	Molecule weight CH_4 *Wm (Gr)*	Molecule Volume CH_4 *Vm (L)*	Tempt. Average (^{0}C)	Emission CH_4(mg/m^2/ minutes)
2	0,287	0,064	0,09	16	22,41	39,25	0,127
4	0,420	0,062	0,09	16	22,41	31,25	0,187
6	0,238	0,068	0,09	16	22,41	40,00	0,112
8	0,481	0,067	0,09	16	22,41	27,00	0,232
10	0,347	0,064	0,09	16	22,41	39,25	0,153
12	0,462	0,068	0,09	16	22,41	38,25	0,218
14	0,401	0,069	0,09	16	22,41	33,25	0,197
16	0,537	0,064	0,09	16	22,41	30,50	0,244
18	0,326	0,065	0,09	16	22,41	35,25	0,150
20	0,144	0,074	0,09	16	22,41	37,75	0,074
22	0,264	0,076	0,09	16	22,41	43,00	0,138

Pandak Putih rice variety

The relationship between CH_4 release (E) with local Pandak Putih rice cultivar which are planted in peat swamp forest was shown in Fig. 2. The relationship between CH_4 release and rice ages has coefficient determinant (R^2) 0.3252 or 32.52%. It means that release of CH^4 32.52% was influenced by age of rice; while 67.48% was influenced by other factors. Coefficient correlation value (r) 0,570263 was derived from √0.3252; in which it means there are moderate relationship between rice ages and methane release. Methane release in Pandak Putih rice in vegetative periods of growth, rice with 11 weeks after planted, shows methane increase trend, while in reproductive stages from 11 to 15 weeks after planting shows methane release decrease (Fig.2 and Table 3).

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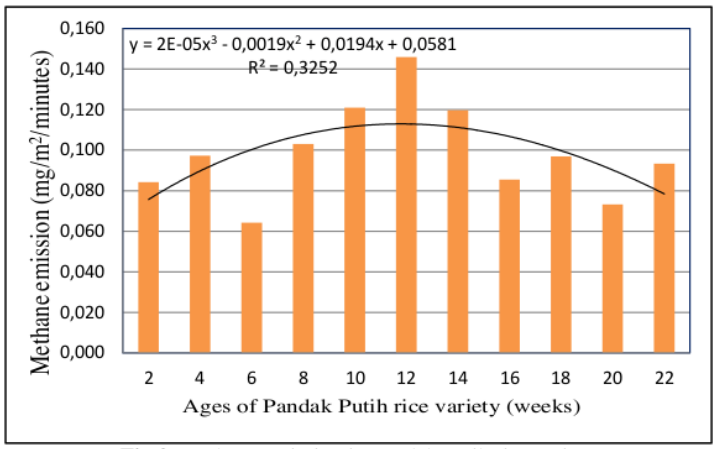

Fig.2. Methane emission in Pandak Putih rice variety

Table 3. The estimation of CH_4 emission of Pandak Putih local rice variety in peat swamp field

Rice ages after planted (weeks)	Increase rate of CH_4 (b1)(µl/L/ minutes)	*Cover volume Vch* (m^3)	*Cover area Ach* (m^2)	Molecule weight CH_4 *Wm (Gr)*	Molecule Volume CH_4 *Vm (L)*	Tempt. Average (^0C)	Emission CH_4 (mg/m^2/ minutes)
2	0,177	0,069	0,09	16	22,41	41,00	0,084
4	0,205	0,068	0,09	16	22,41	36,50	0,097
6	0,136	0,068	0,09	16	22,41	36,50	0,064
8	0,210	0,068	0,09	16	22,41	26,38	0,103
10	0,249	0,070	0,09	16	22,41	38,50	0,121
12	0,296	0,071	0,09	16	22,41	38,00	0,146
14	0,219	0,077	0,09	16	22,41	31,25	0,120
16	0,176	0,068	0,09	16	22,41	28,00	0,085
18	0,191	0,072	0,09	16	22,41	35,50	0,097
20	0,137	0,076	0,09	16	22,41	34,50	0,073
22	0,168	0,080	0,09	16	22,41	40,25	0,093

Padi Siam 11 rice variety

The relationship between methane emission (E) with local Siam 11rice age was given in Fig.3. This figure shows that determinant coefficient was about (R^2) 0.7392 or 73.92%, in which 73.92% of methane release was influenced by rice ages and 26.08% was influenced by other factors. The coefficient value was about 0.859767; derived from $\sqrt{0,7392}$. This means, there are strong relationship between rice age Siam 11 with Methane release. Methane release from Siam 11 rice cultivar in vegetative stage from the beginning of planting to the rice with 8 weeks after plating shows tendency of methane release increase. Rice in generative stage in ages ranging from 9 to 12 weeks after plating shows decrease of methane release. Decrease continuous in generative stage from rice age 12 to 18 weeks sows tendency of methane release decrease, but increase in 18 to 20 weeks after panting. This phenomenon seems to be related to the appearance of number of rice clump with grain and new culms development (Fig.3 and Table 4).

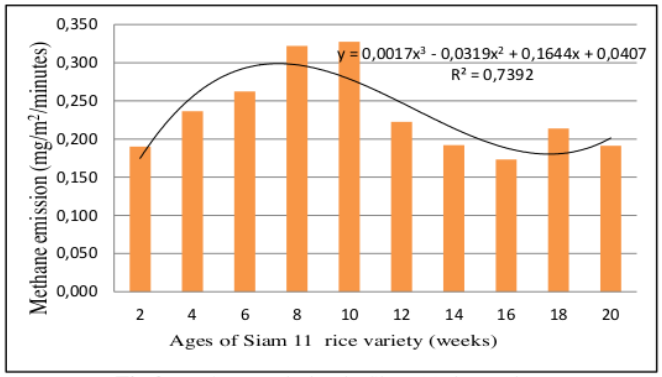

Fig.3. Methane emission in Siam 11 rice variety

Table 4. The estimation of CH_4 emission of Siam 11 local rice variety in peat swamp field

Rice ages after planted (weeks)	Increase rate of CH_4 (b1)(µl/L/ minutes)	*Cover volume Vch* (m^3)	*Cover area Ach* (m^2)	Molecule weight CH_4 *Wm (Gr)*	Molecule Volume CH_4 *Vm (L)*	Tempt. Average (^0C)	Emission CH_4 (mg/m^2/ minutes)
2	0,388	0,070	0,09	16	22,41	37,50	0,190
4	0,450	0,074	0,09	16	22,41	33,50	0,237
6	0,503	0,076	0,09	16	22,41	41,00	0,262
8	0,618	0,075	0,09	16	22,41	40,00	0,322
10	0,638	0,075	0,09	16	22,41	43,50	0,327
12	0,427	0,076	0,09	16	22,41	43,50	0,223
14	0,379	0,072	0,09	16	22,41	33,50	0,192
16	0,307	0,080	0,09	16	22,41	33,50	0,173
18	0,388	0,078	0,09	16	22,41	33,50	0,214
20	0,331	0,083	0,09	16	22,41	38,75	0,191

Siam Rukut rice variety

The relationship between rice age and methane emission (E) in Siam Rukut local rice variety was shown in Fig 4. There are relationship between Methane emission and rice age in Pandak Putih rice cultivar with coefficient determinant value about (R^2) 0.1683 or 16.83%, in which it means that methane emission 16.83% was influenced by rice age, while the remain 83.17% influenced by other factors.

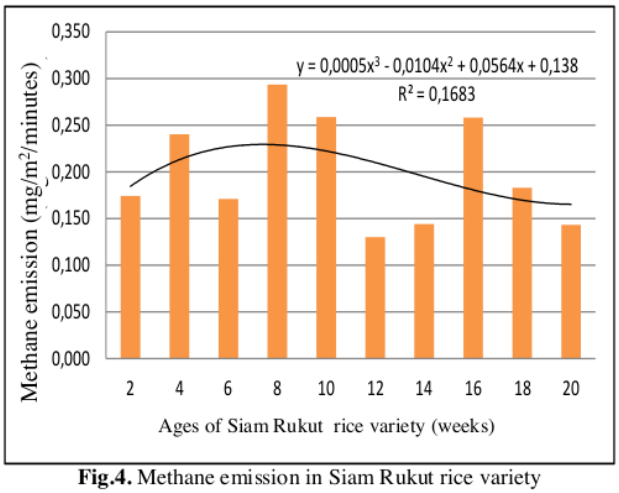

Fig.4. Methane emission in Siam Rukut rice variety

Coefficient correlation value was about (r) 0.410244 derived from √0,1683, in which it means that there are moderated relationship between increase of rice ages and methane emission in Siam Rukut rice cultivar. The trend of emission increase from Siam Rukut rice cultivar occurs on rice with vegetative grows, especially in rive with ages from the beginning of planting to 8 weeks after plating. In reproductive stages, rice with ages 9 to 12 weeks after planting has methane emission decrease trend. Rice with ages 12 to 20 weeks shows decrease of methane emission (Fig.4 and Table 5).

Table 4. The estimation of CH_4 emission of Siam Rukut local rice variety in peat swamp field

Rice ages after planted (weeks)	Increase rate of CH_4 (b1)(µl/L/ minutes)	*Cover volume Vch* (m^3)	*Cover area Ach* (m^2)	Molekul weight CH_4 *Wm (Gr)*	Molekul Volume CH_4 *Vm (L)*	Tempt. Average (^0C)	Emission CH_4 (mg/m^2/ menit)
2	0,308	0,080	0,09	16	22,41	33,50	0,174
4	0,430	0,080	0,09	16	22,41	37,50	0,240
6	0,304	0,082	0,09	16	22,41	42,50	0,171
8	0,503	0,084	0,09	16	22,41	38,75	0,294
10	0,468	0,081	0,09	16	22,41	43,25	0,259
12	0,226	0,084	0,09	16	22,41	42,25	0,130
14	0,246	0,084	0,09	16	22,41	37,50	0,144
16	0,436	0,085	0,09	16	22,41	37,50	0,258
18	0,308	0,085	0,09	16	22,41	37,50	0,183
20	0,238	0,086	0,09	16	22,41	34,75	0,143

IV. Conclusion

Local paddy rice which are planted in peat swamp agricultural land shows advantages in term of Methane emission. Compared to the superior paddy rice, local rice has lowest methane emission, indicated that the cultivation of local rice contributes to the global warming reductions. This finding also support conservation agenda of local rice in South Kalimantan.

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