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Komunikasi Pendek

N_2O Emissions from Rainfed Sugarcane Plantation

Anggri Hervani, Rina Kartikawati, Miranti Ariani, and Prihasto Setyanto
Balai Penelitian Lingkungan Pertanian
Jalan Raya Jakenan-Jaken km 05, Pati, Jawa Tengah
E-mail: anggrihervani@yahoo.com
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ABSTRACT

Expansion of sugarcane areal to support enhancement production and fulfilment target of self-sufficiency for national sugar should be conducted to see environment impact, particularly related to greenhouse gases emission. The objective of this study was to figure out N_2O emission from conventional sugarcane plantation by farmer in rainfed area. The observation of N_2O gas was carried out in sugarcane plantation in Sidomukti Village, Jaken District, Pati, Central Java. Sampling of N_2O gas was conducted by *close chamber method*. The study showed that maximum fluxes of sugarcane plantation before and after fertilizer application are 4.011 and 223 µg N_2O m^{-2} day^{-1}. Meanwhile, after fertilizer application the maximum and minimum fluxes of N_2O are 6.408 and 25 µg N_2O m $^{-2}$ day^{-1}. N_2O emission from sugarcane plantation recorded in rainfed area as 4.21 ± 2.53 kg N_2O ha^{-1} $year^{-1}$ with potential of global warming number as 1.31 ton CO_2-e per hectar per year.

Keywords: Emission, N_2O, plantation, sugarcane

Emisi N_2O dari Pertanaman Tebu di Lahan Tadah Hujan

ABSTRAK

Perluasan areal tanam tebu untuk mendukung peningkatan produksi dan pemenuhan target swasembada gula nasional sudah dianggap perlu untuk melihat dampak lingkungan khususnya mengenai evaluasi emisi gas rumah kaca dari pertanaman tebu. Tujuan dari penelitian ini adalah untuk mengetahui emisi gas N_2O dari sistem pertanaman tebu secara konvensional petani di lahan tadah hujan. Pengamatan gas N_2O dilakukan pada lahan perkebunan tebu di Desa Sidomukti, Kecamatan Jaken, Kabupaten Pati,Jawa Tengah. Pengambilan sampel N_2O menggunakan metode sungkup tertutup. Hasil penelitian menunjukkan bahwa fluks maksimum pada pertanaman tebu sebelum pemupukan sebesar 4,011 µg N_2O m^{-2} $hari^{-1}$ dan fluks minimum sebesar 223 µg N_2O m^{-2} $hari^{-1}$, sedangkan fluks maksimum setelah pemupukan sebesar 6,408 µg N_2O m^{-2} $hari^{-1}$ dan fluks minimum sebesar 25 µg N_2O m $^{-2}$ $hari^{-1}$. Emisi N_2O pertanaman tebu sebesar 4.21 ± 2.53 kg N_2O $ha^{-1}tahun^{-1}$ dengan nilai potensi pemanasan global sebesar 1.31 ton CO_2-e per hektar per tahun.

Kata kunci: Emisi, N_2O, perkebunan, tanaman tebu

INTRODUCTION

Three major gases emission from agriculture sector are CH_4 around 67% from the total emissions from agriculture sector, following by N_2O (30%) and CO_2 (3%). Total emission from this sector in 2000 approximately 75.419,73 Gg CO_2-e. Between 2000 and 2005, emission from agriculture was increase as 6,3% (Ministry of Environment SNC 2009).

Dinitrogen oxide (N_2O) emissions not only contribute through GHG effect but also as a damage causes of statosfer ozon layers.

Almost 90% global N_2O emissions formed during the nitrate (NO_3-) and amoniac (NH_4+) microbe transformation in the soil and water. Globally, contribution from agriculture sector for N_2O emissions is 65–80 percent from total emissions, especially from nitrogen fertilizer in the soil management system, livestock, and manure. Agriculture contribution in Indonesian N_2O emissions estimated at 70 percent (SNC). N_2O emissions from soils comes from N productive loses. Nitrogen input (synthetic fertilizer and biomass) and also nitrogen mineralization in the soils which is reach of organic materials contribute to N_2O emissions. The N_2O emissions from rice fields depends on nitrgen fertilizer rates. Global Warming Potential (GWP) from greenhuse gases to carbondioxide as big as 21 times for CH_4 and 310 for N_2O reported in IPCC Second Assessmen Report National Standard of Indonesia/*Standar Nasional Indonesia* (SNI ISO 14064 2009).

In 2006–2012, the area of state sugarcane plantation in Indonesia have been expanded from 213.900 ha to 247.800 ha that support increase in sugar production as 1.028.700 ton in 200 6 to 1.445.100 ton in 2012 (BPS 2015), while for private sugarcane plantation owned by big company decreased from 396.400 ha to 194.900 ha. Because of those expansion, environ-mental issues such as Greenhouse Gas's (GHG's) emission from cultivation practices should be evaluated. GHG's emission from sugarcane plantation correlated with land use change, fertilization, irrigation and residue management (including litter burning), and fossil fuel use (Figueiredo & La Scala Jr 2011; Lisboa *et al*. 2011). Study in Brazil showed that N fertilizer is main contributor to GHG's emission in sugarcane plantation (Lisboa *et al*. 2011).

Studies on GHG's emission in sugarcane plantation, particularly in rainfed area are limited. Therefore we conducted a research aimed to figure out N_2O emission from sugarcane plantation conventionally conducted by the farmer in rainfed area.

MATERIALS AND METHOD

Observation was conducted in the state of sugarcane plantation in Sidomukti village, District of Jaken, Pati City, Central Java Province in 2014. Sampling was carried out in existing sugarcane plantation owned by farmer of those village that consist of three blocks distinguish by water pathways and four replication with "*Bulu Lawang*" cultivar. The plant was one month days after showing. Before sampling, base for chamber was set up in each point observation (Figure 1) for reduce gas leakage from cracked soil. N_2O was captured use 40 cm length x 20 cm width x 30 cm height close chamber, 6 times during observation (each of 3 times before and after fertilizer application). Chamber placement in sugarcane plantation was showed in Figure 2. Taking the gas sampling in erly morning at 06.00 AM with time interval for N_2O sampling was 10, 20, 30, 40, and 50 minute. The point of observation for N_2O sampling was in row and between crops. Sampling was conducted every month before fertilization and after second fertilizer application in 3, 7, and 15 days after fertilization (DAF). Gas samples were analyzed using Greenhouse Gas (GHG) Chromatography type Varian 450 equipped by Electron Capture Detector (ECD) as N_2O detector with Argon (Ar), Hydrogen (H_2), Helium (He), and Nitrogen (N_2) as the carrier gas.

N_2O emissions were calculated by using equation below (Lantin *et al*. 1998):

$$E = \frac{dc}{dt} x \frac{Vch}{Ach} x \frac{mW}{mV} x \frac{273,2}{(273,2 + T)}$$

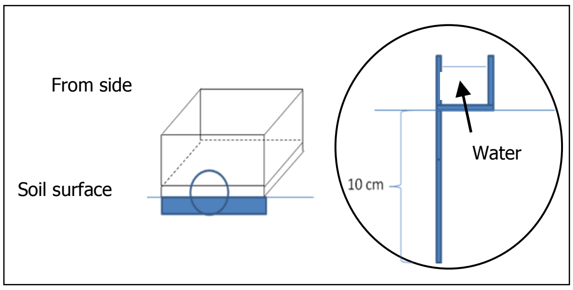

Figure 1. Base for chambers observation

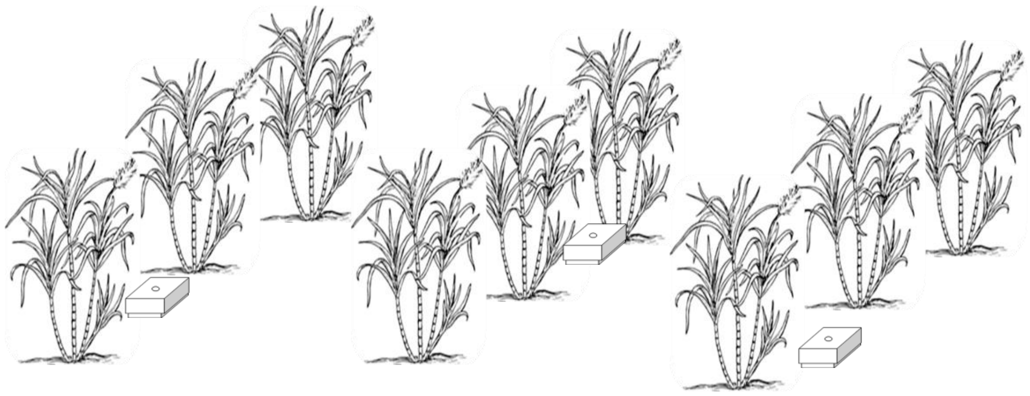

Figure 2. Position of base and chambers observation in the sugarcane plantation

Table 1. The results of soil analyze from Sidomukti Village, Jaken District, Pati City 2014

No	Kinds of analyze	Method	Unit	Results
1.	Textures			
	• Silt	3 fractions by pipeting		42.03
	• Dust			33.37
	• Clay			24.59
2.	C-organic	Walky and black extract with spectrophotometry		1.47
3.	N-Total	N-Kjedahl titrimetry		0.09
4.	P-Total	HNO_3 nitrat acid extract and $HClO_4$ perchlorate analyze with Spectrophotometry	%	0.21
5.	K-Total			0.05
6.	Ca-Total	HNO_3 nitratacid extract and $HClO_4$ perchorat analyze with AAS		0.46
7.	Mg-Total			0.05
8.	Fe-Total			0.57
10.	Cation Exchange Capacity (CEC)	Ammonium asetat extract pH 7 with titrimetri)	(cmol/kg)	7.99
11.	Base saturation		%	91.37
12.	ESP (Na)	HNO_3 nitrat acid extract and $HClO_3$ perchlorat analyze with AAS		52.56
13.	pH			
	• H_2O	H_2O extract (1:5) analyze with pH meter		5.54
	• KCl	KCl 1 M extract (1:5) analyze with pH meter		4.32

Source: Integrated Laboratory of Indonesian Agricultural Environment Research Institute, 2014

Where, E is flux of greenhouse gas emission (mg/m/hour for CO_2 and CH_4, µg/m/hour for N_2O). δc/δt is the change of gas concentration (ppm); h is effective high of closed chamber head space (m); mW is molecule weigh of CO_2 (44 gram/mol), CH_4 (16 gram/mol), and N_2O (44 gram/mol); 273^{o}C is Standard temperature; mV is volume of molecule (22.41 x 10^{-3} m^3); and T is temperature in close chamber (^{o}C).

Applied fertilizer in sugarcane plantation were 600 kg ZA, 200 kg SP36 and 200 kg KCl per ha. The first fertilization was applied as base fertilizer (1/3 dose of ZA, all of SP36 and KCl). The 2/3 dose of ZA was applied in second fertilization when the sugarcane 1.5 month, in the early of rainy season. Application of fertilizer was conducted by spreading in the edge of plant.

RESULT AND DISCUSSION

The result of N_2O observation in sugarcane plantation before and after fertilization in 2014 is showed by Figure 3.

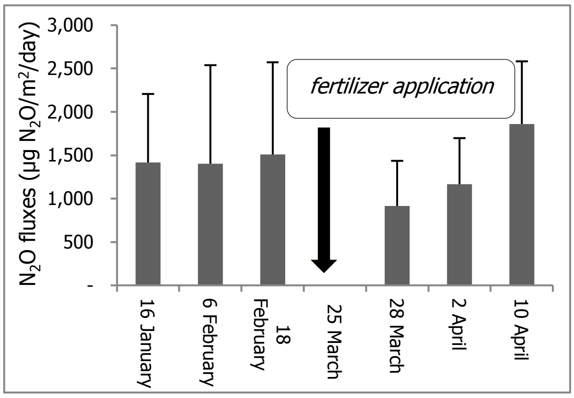

Figure 3. N_2O fluxes before and after fertitilzer application

N_2O fluxes were varies during observation. According to Danevcic *et al.* (2009), it due to many factors influence to N_2O emission such as temperature, soil pH, availability of organic matter, aeration and fertilizer use. Elder & Lal (2008) was also find that N_2O fluxes positively correlated with soil temperature in several depth, air temperature and CO_2 fluxes and one of N loses from plantation is N_2O emission. Denmead *et al.* (2010) mentioned that covering by canopy and high frequency of rainfal lead high humidity of soil that induce high production of N_2O through nitrification and denitrification process. In this study showed that N_2O fluxes increase after fertilizer application (in observation date of March 28 and April 10). Daily average of N_2O fluxes before and after fertilizer application were 2,015 ± 236 and 2,858 ± 690 µg m^{-2} day^{-1}. Total N_2O emission during observation in rainfed sugarcane plantation was 4.21 ± 2.53 kg N_2O ha^{-1} $year^{-1}$. While the Global Warming Potential (GWP) was 1.31 ton CO_2-e.

Several studies found that large variation of N_2O emission occur, particularly in application of N fertilizer either through chemical or organic fertilizer (Dalal *et al.* 2003; *Jantalia et al.* 2008; Signor 2010 *cit* Oliveira *et al. 2013*). Jantalia *et al.* (2008) recorded that N_2O fluxes varies from 0 to 183 mg N_2O-N m^{-2} day^{-1}, while Signor (2010) observed N_2O fluxes from -10 to 2520 mg N_2O-N m^{-2} day^{-1} followed amount of different N fertilizer applied in sugarcane plantation. They showed that variation in N_2O fluxes depend on application of N fertilizer, method of application, soil type, and soil water content.

Table 2. Maximum, minimum, and average of N_2O fluxes in Jaken District, Pati 2014

Time application	N_2O Fluxes (µg N_2O m^{-2} day^{-1})		
	Maximum	Minimum	Average
Before fertilizer	4.011	223	2.015 ± 236
After fertilizer	6.408	25	2.858 ± 690

Increasing of N availability in soil could enhance N_2O gas, however it depend on interaction between soil type, climate and cultivation technique. The important factors for forming and releasing N_2O gas are ammonia content and nitrate in soil, aeration status of soil and soil water content, easily degraded of organic matter, soil pH and temperature (Bauwman 1994 *cit.* Orbanus-Naharia 2002). According to Verge *et al.* (2007), application of organic and chemical fertilizer tend to increase N_2O emission in soil, N_2O emission from soil increase 16% between 1999 and 2000 and N fertilizer contribute around 4%. Machefert *et al.* (2002) stated that the highest N_2O emission produced by agriculture followed by forest and grassland and the main factor which affect are availability of N mineral, soil temperature, water soil content and organic matter.

CONCLUSIONS

Maximum flux in the sugarcane plantation before fertilization as 4.011 µg N_2O $m^{-2}day^{-1}$ and minimum flux as 223 µg N_2O $m^{-2}day^{-1}$. Meanwhile the maximum and minimum flux after fertilization as 6.408 and 25 µg N_2O $m^{-2}day^{-1}$, respectively. N_2O emission from sugarcane plantation was recorded as 4.21 ±

2.53 kg N_2O ha^{-1} $year^{-1}$ with the GWP as 1.31 t CO_2-e.

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REFERENCES

Badan Pusat Statistik (BPS) 2016, Data Luas Areal Tebu, diakses pada 10 Februari 2015 (www.bps.go.id).

Dalal, RC, Wang, W, Robertson, GP, Parton, WJ 2003, Nitrous Oxide Emission From Australian Agricultureal Lands and Mitigartion Options: A Review, *Australian Journal of Soil Research*, 41:165–195.

Danevcic, T, Mandic-Mulec, I, Stres, B, Stopar, D & Hacin, J 2009, Emissions of CO_2, CH_4, and N_2O from Southern European Peatlands, *Soil Biology and Biochemistry*, 42(9):1437–1446.

Denmead, OT, Macdonald, BCT, Bryant, G, Naylor, T, Wilson, S, Griffith, DWT, Wang, WJ, Salter, B, White, I & Moody, PW 2010, Emissions of methane and nitrous oxide from australian sugarcane soils, *Agricultural and Forest Meteorology*, 150:748–756.

Elder, JW & Lal, R 2008, Tillage effects on gaseous emissions from an intensively farmed organic soil in North Central Ohio, *Soil & Tillage Research,* 98:45–55.

Figueiredo, EB & La-Scala, N Jr 2011, Greenhouse gas balance due to the conversion of sugarcane areas from burned to green harvest in Brazil, *Agriculture, Ecosystems and Environment*, 141:77–85.

Jantalia, CP, Santos, HP, Urquiaga, S, Boddey RM & Alves, BJR 2008, Fluxes of nitrous oxide from soil under different crop rotations and systems in the south of Brazil. Nutrient Cycling Agroecosystems, 82:161–173.

Lantin, RS, Wassmann, R, Neue, HU, Aduna, JB, Alberto, MC & Bueno, C 1998, *Methane Emission from Ricefield*, in IRRI-UNDP Final Workshop, Beijing & Hangzhou, 10–13 August 1998.

Lisboa, CC, Butterbach-Bahl, K, Mauder, M & Kiese, R 2011, Bioethanol production from sugarcane and emissions of greenhouses gases-known and unknowns, *Global Change Biology Bioenergy*, 3:277–292.

Machefert, SE, Disel, NB, Golding, KWT & Whitehead, PG 2002, Nitrous oxide emission from a range of land used across Europe**,** *Hydrology and Earth System Sciences*, 6(3):325–337.

Ministry of Environment 2009, Summary for Policy Makers: Indonesia Second National Communication Under the United Nation Framework Convention on Climate Change (UNFCCC), Jakarta, November 2009.

Oliveira-de, BG, Carvalho, JLN, Cerri, CEP, Cerri, CC & Feigl, BJ 2013, Soil greenhouse gas fluxes from vinasse application in Brazilian Sugarcane Areas,*Geoderma,* 200–201:77–84.

Orbanus-Naharia 2002, *Teknologi pengairan dan pengolahan tanah pada budidaya padi untuk pengurangan emisi metana dan N_2O,* Disertasi Program Pascasarjana Institut Pertanian Bogor.

Signor, D 2010, Carbon and nitrogen stagnation and greenhouse gas emissions in sugar-cane areas in Piracicaba, 119 p., Dissertation (Mastery in Soils and Plant Nutrition)-Luiz de Queiroz Agricultural School, University of Sao Paulo, Piracicaba.

SNI, ISO 14064 2009, downloaded 4 December 2016 (www.ssni.bsn.go.id).

Verge, XPC, Kimpe CD & Desjardins, R.L 2007, Agricultural production, greenhouse gas emissions and mitigation potential*, Agricultural and Forest Meteorology,* 142:255–269.