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METHANE EMISSION AND ITS MITIGATION IN RICE FIELDS UNDER DIFFERENT MANAGEMENT PRACTICES IN CENTRAL JAVA

By

PRIHASTO SETYANTO

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

August 2004

I Would Like to Dedicate This Thesis to My Respected Parents

Dr. Achmad Mudzakkir Fagi and Aniek Tuti Rochiani

And

My Beloved Wife for Her Patience and Support, Andriana Nurvianti

Dearest Sons, Raihan Abirega Fagi and Rafid Adrianto Fagi

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

METHANE EMISSION AND ITS MITIGATION IN RICE FIELDS UNDER DIFFERENT MANAGEMENT PRACTICES IN CENTRAL JAVA

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August 2004

Chairman : Associate Professor Rosenani Abu Bakar, Ph.D.

Faculty : Agriculture

The concentration of methane (CH_4), one of the greenhouse gases in the atmosphere is increasing at 1% per annum and rice soil is one of the sources that contribute to about 25% of the atmospheric CH_4. This study was conducted with the objectives of (i) assessing CH_4 emission from rice fields with various rice management practices in Central Java, Indonesia, (ii) identifying potential mitigation methods by taking into consideration the economic analysis of these methods, and (iii) determining the potential CH_4 production and emission from rice soils of Central Java using laboratory incubation method and in-situ field measurements. Field experiments were conducted to investigate the effects of rice cultivars (Memberamo, Cisadane, IR 64 and Way Apo Buru), water management (continuous flooding 5 cm, continuous flooding 1 cm, intermittent irrigation, and pulse irrigation), and crop establishment methods (direct seeding and transplanting) on CH_4 emissions using automatic chamber and continuous sampling technique. These experiments were conducted in four seasons beginning in the wet season of 2001/02 and ended in the dry season of 2003. In determining the potential CH_4 production and emission from rice field of Central Java, soil types under rice were

identified. In-situ measurements of CH_4 fluxes from 13 soil types under rice were made and topsoil samples were incubated for laboratory incubation.

There were no significant differences between cultivars in yield either through direct seeding or transplanting. Cisadane cultivar established through direct seeding emitted significantly higher amount of CH_4 due to higher root and aboveground biomass than transplanting. Since no significant differences in yield between the cultivars were found in this study, Cisadane cultivar should not be used in Central Java. Emission of CH_4 could also be reduced by intermittent (46%) and pulse (62%) irrigation compared to conventional continuously flooded systems. Potential CH_4 production (282 – 6,408 kg ha^{-1}) for 13 flooded rice soils in Central Java Province was significantly positively related to the in-situ field emission (107 – 799 kg ha^{-1}). Measured CH_4 emission estimated was only 16.6% of the potential CH_4 production.

Based on economic analysis of selected data from the field experiments, a few mitigation options could be recommended. During the wet season, for transplanted rice, Way Apo Buru gave the higher incremental benefit of CH_4 mitigation technology adoption, but for direct seeded rice, Memberamo and Way Apo Buru gave the higher benefit. During the dry season, transplanted Cisadane cultivar gave higher benefit than IR 64. Also, during this season, when planted with IR 64, intermittent irrigation gave higher benefit than continuous flooding 1 cm and pulse irrigation. However, further investigation on the mitigation potentials of the management practices need to be done.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

EMISI METANA DAN MITIGASINYA DARIPADA KAWASAN SAWAH PADI MELALUI PERBEZAAN PENGURUSAN TANAMAN DI JAWA TENGAH

Oleh

PRIHASTO SETYANTO

Ogos 2004

Penyelia : Profesor Madya Rosenani Abu Bakar, Ph.D.

Fakulti : Pertanian

Kepekatan gas metana (CH_4), yang merupakan salah satu daripada gas rumah hijau, meningkat pada kadar 1% setahun dan sawah padi merupakan salah satu sumber yang menyumbang 25% keseluruhan kepekatan CH_4 di atmosfera. Objektif daripada kajian ini adalah (i) untuk menilai kepelbagaian amalan pengurusan tanaman terhadap pelepasan CH_4 di Jawa Tengah, Indonesia, (ii) mengenalpasti potensi kaedah mitigasi dan mengambil kira analisis ekonomi bagi kaedah tersebut, dan (iii) untuk mengenalpasti potensi penghasilan dan emisi CH_4 daripada sawah padi di Jawa Tengah dengan kaedah inkubasi dan pengukuran secara terus di sawah padi. Kajian lapangan dilakukan untuk mengetahui pengaruh (i) varieti tanaman padi (Memberamo, Cisadane, IR 64 dan Way Apo Buru), (ii) pengurusan pengairan (pengairan berterusan 5 cm, pengairan berterusan 1 cm, pengairan berselang, dan pengairan terputus), dan (iii) cara penanaman padi (tabur terus dan tanam pindah) terhadap pelepasan CH_4 dengan menggunakan alat pengumpul gas automatik dan teknik persampelan secara berterusan. Kajian ini dilaksanakan selama empat musim bermula pada musim hujan 2001/02 dan berakhir pada musim kemarau 2003. Dalam mengenalpasti potensi penghasilan dan emisi gas CH_4 daripada sawah padi di Jawa Tengah, jenis tanah sawah dikenalpasti.

Pengukuran terus CH_4 fluks daripada 13 tanah sawah yang berbeza dilakukan dan bahagian atas daripada tanah diinkubasi di makmal.

Tidak terdapat perbezaan diantara varieti padi yang diuji dalam menghasilkan padi daripada cara tabur terus atau tanam pindah. Cisadane dengan tabur terus melepaskan CH_4 dalam jumlah yang paling banyak kerana jumlah akar dan biomas bahagian atas pokok padi lebih tinggi daripada cara tanam pindah. Ini menyebabkan varieti Cisadane tidak sesuai ditanam di Jawa Tengah. Pelepasan CH_4 dapat juga dapat dikurangkan dengan cara pengairan berselang (46%) dan pengairan terputus (62%) jika dibandingkan dengan pengairan berterusan. Potensi penghasilan CH_4 (282 - 6408 kg ha^{-1}) daripada 13 jenis tanah sawah padi di Jawa Tengah adalah sangat berkaitan dengan pelepasan secara terus (136 - 799 kg CH_4 ha^{-1}) dari kawasan padi sawah. Pelepasan CH_4 secara terus adalah hanya 16.6% daripada potensi penghasilan dari dalam tanah.

Beberapa kaedah mitigasi dapat dicadangkan berdasarkan analisis ekonomi daripada data terpilih hasil kajian lapangan. Pada musim hujan, dengan cara tanam pindah, Way Apo Buru memberikan keuntungan tertinggi apabila kaedah mitigasi diterapkan, tetapi untuk cara tanam tabur terus, Memberamo dan Way Apo Buru memberi keuntungan tertinggi. Pada musim kemarau pula, Cisadane ditanam dengan cara tabur terus memberikan keuntungan tertinggi dibandingkan dengan IR 64. Selain itu, pada musim ini juga, apabila ditanam dengan IR 64, kaedah pengairan berselang memberikan keuntungan tertinggi daripada pengairan berterusan 1 cm dan pengairan terputus. Kajian lain untuk melihat potensi mitigasi daripada pengurusan tanaman perlu dilakukan.

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I certify that an Examination Committee met on August 10, 2004 to conduct the final examination of Prihasto Setyanto on his Doctor of Philosophy thesis entitled "Methane Emission and its Mitigation in Rice Fields under Different Management Practices in Central Java" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

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PRIHASTO SETYANTO

Date:

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