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
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The concentration of methane (CH₄), 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 CH₄. This study was conducted with the objectives of (i)
assessing CH₄ 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
CH₄ 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 CH₄ 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
CH₄ 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

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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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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.

____________________
PRIHASTO SETYANTO

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# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEDICATION</td>
<td>ii</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>iii</td>
</tr>
<tr>
<td>ABSTRAK</td>
<td>v</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>vii</td>
</tr>
<tr>
<td>APPROVAL</td>
<td>x</td>
</tr>
<tr>
<td>DECLARATION</td>
<td>xii</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>xvii</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>xxii</td>
</tr>
<tr>
<td>LIST OF PLATES</td>
<td>xxvi</td>
</tr>
</tbody>
</table>

## CHAPTER

1 INTRODUCTION  

2 LITERATURE REVIEW  

2.1 The Greenhouse Gas and Global Warming  

2.2 Effect of Climate Change  

2.2.1 Sea level rise and coastal zones  

2.2.2 Impacts on food and fiber production  

2.2.2.1 Agriculture  

2.2.2.2 Fisheries  

2.2.2.3 Forestry  

2.2.3 Impacts on water supply  

2.2.4 Impacts on terrestrial ecosystem  

2.2.5 Human health  

2.3 Risk of Climate Change in Indonesia and Domestic Climate Change Policy  

2.4 Carbon Trade  

2.5 Methane as a Greenhouse Gas  

2.6 Chemistry of Methane in the Troposphere  

2.7 Wetland Rice Field as a Source of Methane Emission  

2.8 Methane Production in Rice Soils  

2.8.1 Factors affecting CH\(_4\) production from flooded rice soil  

2.8.1.1 Reduction processes in soil  

2.8.1.2 Soil pH  

2.8.1.3 Soil temperature  

2.8.1.4 Sulfate concentration and presence of sulfate reducing bacteria  

2.8.1.5 Organic matter in paddy soils  

2.8.1.6 Substrate and nutrient availability  

2.8.2 Methane production potential  

2.9 Mitigation of CH\(_4\) Emission from Flooded Rice Soil  

2.9.1 Rice cultivars  

2.10 | 2.11 |
| 2.13 |
| 2.16 |
| 2.21 |
| 2.22 |
| 2.23 |
| 2.23 |
| 2.24 |
| 2.25 |
| 2.26 |
| 2.26 |
| 2.27 |
| 2.28 |
| 2.30 |
| 2.30 |
2.9.1.1 Rice cultivar morphological and physiological traits affecting CH₄ emission and production 2.31
2.9.1.2 Rice roots distribution and root exudates 2.33
2.9.1.3 Relationship between plant growth parameters and CH₄ emission, and production 2.38
2.9.2 Water regime 2.40
  2.9.2.1 Effect of water regime on root structure 2.41
2.9.3 Crop establishment 2.43
2.9.4 Organic matter amendment 2.45
2.9.5 Nitrification inhibitors 2.48
2.9.6 Biogas generator 2.49
2.10 Cost of Mitigation 2.50
  2.10.1 Cost effectiveness analysis 2.50
2.11 Methane Emission from Rice Field in Indonesia 2.52
2.12 Summary 2.54

3 METHANE EMISSION FROM RICE FIELD UNDER DIFFERENT CROP ESTABLISHMENTS AND RICE CULTIVARS 3.1

3.1 Introduction 3.1
3.2 Methodology 3.3
  3.2.1 Field site description 3.3
  3.2.2 Description of selected cultivars 3.5
3.2.3 Experimental layout and field management 3.9
  3.2.3.1 Experiment I: Methane emission from transplanted rice cultivars 3.9
  3.2.3.2 Experiment II: Methane emission from direct-seeded rice cultivars 3.13
  3.2.3.3 Experiment III: Methane emission under different crop establishment and rice cultivars 3.16
3.2.4 Redox potential and pH measurements, and collection of meteorological data 3.21
3.2.5 Sampling and measurement of plant parameters 3.22
3.2.6 Methane emission measurement 3.24
3.2.7 Statistical analysis 3.25
3.3 Results and Discussion 3.26
  3.3.1 Methane emission from transplanted rice cultivars 3.26
    3.3.1.1 Plant growth parameters and yield 3.26
    3.3.1.2 Methane flux, climate and redox potential 3.29
    3.3.1.3 Total seasonal CH₄ emission 3.37
  3.3.2 Methane emission from direct-seeded rice cultivars 3.40
    3.3.2.1 Plant growth parameters and yield 3.40
    3.3.2.2 Methane flux and climate 3.44
    3.3.2.3 Total seasonal CH₄ emission 3.50
  3.3.3 Methane emission under different crop establishments and rice cultivars 3.51
    3.3.3.1 Plant growth parameters and yield 3.51
3.3.3.2 Climate and CH$_4$ flux 3.57
3.3.3.3 Relationships between CH$_4$ flux and plant growth parameters 3.61
3.3.3.4 Total seasonal CH$_4$ emission 3.71

3.4 Conclusions 3.73

4 METHANE EMISSION IN DIFFERENT WATER REGIMES 4.1

4.1 Introduction 4.1
4.2 Methodology 4.2
   4.2.1 Experimental layout 4.2
   4.2.2 Modes of irrigation 4.4
   4.2.3 Soil management 4.6
   4.2.4 Methane flux measurement 4.8
   4.2.5 Measurement of redox potential, pH, plant growth parameters, and yield components 4.8
   4.2.6 Statistical analyses 4.9
4.3 Results and Discussion 4.10
   4.3.1 Plant growth parameters and yield 4.10
   4.3.2 Methane flux, redox potential and pH 4.15
   4.3.3 Total seasonal CH$_4$ emissions 4.21
4.4. Conclusions 4.22

5 POTENTIAL CH$_4$ PRODUCTION AND CH$_4$ EMISSION OF CENTRAL JAVA RICE SOILS 5.1

5.1 Introduction 5.1
5.2 Methodology 5.3
   5.2.1 Soil classification and sampling 5.3
   5.2.2 Soil analyses 5.3
   5.2.3 Measurement of potential CH$_4$ production 5.10
   5.2.4 Field estimate of CH$_4$ emission 5.13
      5.2.4.1 Evaluation of CH$_4$ sampling time 5.13
      5.2.4.2 Estimation of CH$_4$ emission during growing period 5.18
      5.2.4.3 Evaluation of CH$_4$ gas in the syringe during sampling 5.24
      5.2.4.4 Measurement of CH$_4$ emission from rice field using manually operated chamber 5.25
   5.2.5 Statistical analyses 5.26
5.3 Results and Discussion 5.28
   5.3.1 Potential CH$_4$ production in soils 5.28
   5.3.2 Total potential CH$_4$ production of soils 5.31
   5.3.3 Total seasonal CH$_4$ emission in soil 5.34
   5.3.4 Relationship between total potential CH$_4$ production and CH$_4$ emission in soils 5.37
5.4 Conclusions 5.38
6 MITIGATION OPTION AND ECONOMIC ANALYSIS 6.1

- 6.1 Introduction 6.1
- 6.2 Methane Emission Mitigation from Rice Field 6.1
- 6.3 Cost Effectiveness of Mitigation Option 6.5
- 6.4 Conclusions 6.14

7 SUMMARY AND CONCLUSIONS 7.1

REFERENCE R.1
APPENDIX A.1
BIODATA OF AUTHOR B.1