UNIVERSITI PUTRA MALAYSIA

EVALUATION OF DICYANDIAMIDE TREATED UREA AND ORGANIC MANURE ON NITROUS OXIDE EMISSION, NITROGEN UPTAKE AND YIELD OF RICE GROWN ON ACID SULPHATE SOIL

S.M. SHAMSUZZAMAN

ITA 2015 17

EVALUATION OF DICYANDIAMIDE TREATED UREA AND ORGANIC MANURE ON NITROUS OXIDE EMISSION, NITROGEN UPTAKE AND YIELD OF RICE GROWN ON ACID SULPHATE SOIL

By

S. M. SHAMSUZZAMAN

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

April 2015

DEDICATION

To my loving parents

To my wife Masuda Begum, PhD

Also to my children, Mahatab Zaman and Fardina Zaman

Abstract of thesis presented to the Senate of University Putra Malaysia in fulfilment of the requirement for the Degree of Doctor of Philosophy

EVALUATION OF DICYANDIAMIDE TREATED UREA AND ORGANIC MANURE ON NITROUS OXIDE EMISSION, NITROGEN UPTAKE AND YIELD OF RICE GROWN ON ACID SULPHATE SOIL

By

S. M. SHAMSUZZAMAN

April 2105

Supervisor: Professor Mohamed Hanafi Musa, PhD
Institute: Tropical Agriculture

Rice soil is a major source of nitrous oxide (N_2O), and the application of N as inorganic and/or organic is an important factor affecting N_2O emissions. The nitrification inhibitor (NI), dicyandiamide (DCD) is effective in suppressing nitrification and N_2O emission. Therefore, the purpose of this study was to find out a feasible fertilization practice including DCD and organic manure (OM) for reducing N_2O emission with better yield and soil health of acid sulphate soil. An incubation study was conducted to observe the impacts of DCD with OM and urea on N dynamics and N_2O emission from acid sulphate soil. The experiment was conducted with two-level factorial: seven N sources and two NI levels. After 30 days of incubation, the mineral-N (NH_4^+ + NO_3^-) was highest (255.07 µg g^{-1}) for DCD with oil palm compost (OPC) + urea. The highest net N-mineralization (213.07 µg g^{-1}) was recorded for DCD with urea and net nitrification (16.26 µg g^{-1}) was recorded for urea alone, but the highest cumulative N_2O emission (5.46 µg g^{-1}) was in poultry dung (PD) + urea. In addition, DCD could effectively inhibit net N nitrification and N_2O emission (22.01-32.40%). A glasshouse experiment was conducted to investigate the effects of DCD with OM and urea on yield of MR219 rice and N_2O emission from acid sulphate soil. The experiment used a two-level factorial with four N sources and two NI levels. Nitrogen source and DCD interaction significantly increased the grain yield of rice (4.76-21.95%) compared to urea alone. The combined application of DCD with OPC + urea was most effective in a higher grain yield (22.81 g/hill), nutrient uptake; N (631.64 g/hill), P (234.79 g/hill), K (651.01 g/hill), and S (87.95 g/hill) followed by DCD with PD + urea. Seasonal peaks of N_2O flux occurred 3rd - 10th day after urea fertilization during the rice growing season with the value of 319.84-424.63 µm m^{-2} h^{-1}. Cumulative N_2O emission (CNE) during rice growth season was 3.10-3.63 kg N_2O-N ha^{-1} for N source and application of DCD decreased the CNE by 21.97-27.07%, respectively. A field experiment was conducted at Semerak, Kelantan, Malaysia to evaluate the influence of DCD with OM and urea on N_2O emission from MR 219 rice field and fertility of acid sulphate soil. The experimental design was similar to glasshouse experiment. The highest grain yield increase (31.62%) and total uptake of N (164.79 kg ha^{-1}), P (55.42 kg ha^{-1}), K (153.28 kg ha^{-1}), and S (21.88 kg ha^{-1}) was obtained for the application of DCD with OPC + urea followed by DCD with PD + urea. The trend of seasonal peaks of N_2O flux was similar to glasshouse, but the values were 347.65-456.60 µm m^{-2} h^{-1} for the N source. Cumulative N_2O emission during rice growth season was 3.27- 3.83 kg N_2O-N ha^{-1} for N source. Application DCD decreased the CNE by 15.72-24.72 %. Soil pH, organic carbon, and soil primary- (N, P and K), secondary- (Ca, Mg and S) and micro-nutrient (Zn, Cu, Fe and Mn) were significantly influenced by N source only following the order of OPC + urea-N ≥ PD + urea-N > rice straw + urea-N > urea-N (control). Finally, the integrated use of DCD with OPC and urea was more effective in reducing N_2O emissions with improving rice yield and soil health. Hence, combination of 13.5 kg ha^{-1} (15% of applied N) DCD with 1.8 t ha^{-1} (30% N of recommended dose) OPC and 90 kg ha^{-1} (75% N of recommended dose) urea may be the most potential combination to reduce N_2O emission, improve rice yield and health of acid sulphate soil in Malaysia.

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

PENILAIAN UREA DAN BAJA ORGANIK DENGAN RAWATAN DISIANDIAMID TERHADAP PEMBEBASAN GAS NITRUS OKSIDA, PENGAMBILAN NITROGEN DAN HASIL PADI DI TANAH BERASID SULFAT

Oleh

S. M. SHAMSUZZAMAN

April 2015

Penyelia: Professor Mohamed Hanafi Musa, PhD
Institut: Pertanian Tropika

Sawah padi adalah sumber utama gas nitrus oksida (N_2O), dan penggunaan sumber N dari bahan bukan organik dan organik merupakan faktor penting yang mempengaruhi pelepasan gas N_2O. Perencat nitrifikasi (NI) disiandiamid (DCD) adalah berkesan dalam mengurangkan proses nitrifikasi dan pembebasan gas N_2O. Oleh itu, kajian ini dijalankan untuk mengetahui samada amalan pembajaan menggunakan DCD dan baja organik dapat mengurangkan pembebasan gas N_2O disamping meningkatkan hasil tanaman dan kesuburan tanah. Satu kajian inkubasi dijalankan untuk melihat kesan DCD bersama OM dan urea terhadap dinamik N dan pembebasan N_2O dari tanah asid sulfat. Eksperimen dijalankan secara dua peringkat faktorial: tujuh jenis sumber N dan dua jenis NI. Selepas 30 hari proses inkubasi dijalankan, mineral-N (NH_4^+ + NO_3^-) adalah tertinggi (255.07 µg g^{-1}) bagi DCD berserta kompos kelapa sawit + urea. Kadar bersih proses mineralsasi direkodkan bagi DCD bersama urea (213.07 µg g^{-1}) dan kadar bersih nitrifikasi (16.26 µg g^{-1}) dari rawatan urea sahaja, namun kadar kumulatif pelepasan N_2O didapati tertinggi (5.46 µg g^{-1}) dari baja tahi ayam (PD) + urea. Disiandiamid berkesan menghalang proses bersih nitrifikasi dan pelepasan N_2O (22.01-32.40%). Satu eksperimen rumah kaca dijalankan untuk menyiasat kesan DCD bersama OM dan urea terhadap hasil tanaman padi MR219 dan pembebasan N_2O dari tanah asid sulfat. Eksperimen yang dijalankan secara dua peringkat faktorial dengan empat jenis sumber N dan dua jenis sumber NI. Interaksi sumber N bersama DCD didapati meningkatkan hasil padi secara signifikan (4.76-21.95%) berbanding rawatan urea. Kombinasi rawatan DCD bersama OPC + urea adalah yang paling efektif dalam meningkatkan hasil tanaman (22.81 g/hill) dan pengambilan nutrien diikuti dengan rawatan DCD bersama PD dan urea. Puncak pembebasan gas N_2O berlaku pada hari ke-3 - 10 selepas pembajaan urea semasa musim pertumbuhan padi dengan anggaran 319.84-424.63 µm m^{-2} h^{-1}. Pembebasan kumulatif N_2O (CNE) semasa musim pertumbuhan padi adalah sebanyak 3.10-3.63 kg N_2O-N ha^{-1} bagi sumber N dan penggunaan DCD mengurangkan CNE sebanyak 21.97-27.07%. Satu kajian lapangan dijalankan di Semarak, Kelantan, Malaysia untuk mengkaji pengaruh DCD dengan OM dan urea terhadap pembebasan N_2O dari sawah padi MR 219 dan tahap kesuburan tanah asid sulfat. Rekabentuk eksperimen adalah serupa dengan eksperimen rumah kaca. Hasil tertinggi didapati meningkat (31.62%) dan jumlah pengambilan N (164.79 kg ha^{-1}), P

(55.42 kg ha^{-1}), K (153.28 kg ha^{-1}), dan S (21.88 kg ha^{-1}) telah diperolehi bagi applikasi DCD bersama OPC + urea diikuti dengan DCD bersama PD + urea. Trend puncak bermusim pembebasan gas N_2O adalah serupa dengan kajian rumah kaca, namun kadar pembebasan adalah sebanyak 347.65-456.60 µg m^{-2} h^{-1} terhadap sumber N. Pembebasan N_2O kumulatif semasa musim pertumbuhan padi adalah 3.27-3.83 kg N_2O-N ha^{-1} terhadap sumber N. Penggunaan DCD mengurangkan CNE sebanyak 15.72-24.72%. pH tanah, karbon organik dan nutrient-primer (N, P dan K), nutrient-sekunder (Ca, Mg dan S) dan nutrient-mikro (Zn, Cu, Fe dan Mn) adalah signifikan terhadap penggunaan sumber N sahaja mengikut turutan: OPC + urea-N ≥ PD + urea-N > jerami padi + urea-N > urea-N (kawalan). Kombinasi penggunaan DCD bersama OPC dan urea adalah lebih efektif dalam pengurangan pembebasan N_2O disamping meningkatkan hasil tanaman padi dan kesuburan tanah. Oleh itu, gabungan DCD bersama OPC dan urea adalah kombinasi yang paling berpotensi untuk mengurangkan pelepasan gas N_2O, meningkatkan hasil padi dan kesuburan tanah jenis asid sulfat di Malaysia.

This thesis was 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 were as follows:

Mohamed Hanafi Musa, PhD
Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Chairman)

Halimi b Mohd Saud, PhD
Associate Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Member)

Samsuri bin Abd Wahid, PhD
Senior Lecturer
Faculty of Agriculture
Universiti Putra Malaysia
(Member)

BUJANG KIM HUAT, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

Declaration by graduate Student

I hereby confirm that:

- this thesis is my original work;
- quotations, illustrations and citations have been duly referenced;
- this thesis has not been submitted previously or concurrently for any other degree at any other institutions;
- intellectual property from the thesis and copyright of thesis are fully-owned by Universiti Putra Malaysia, as according to the Universiti Putra Malaysia (Research) Rules 2012;
- written permission must be obtained from supervisor and the office of Deputy Vice-Chancellor (Research and Innovation) before thesis is published (in the form of written, printed or in electronic form) including books, journals, modules, proceedings, popular writings, seminar papers, manuscripts, posters, reports, lecture notes, learning modules or any other materials as stated in the Universiti Putra Malaysia (Research) Rules 2012;
- there is no plagiarism or data falsification/fabrication in the thesis, and scholarly integrity is upheld as according to the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) and the Universiti Putra Malaysia (Research) Rules 2012. The thesis has undergone plagiarism detection software.

Signature: ________________________ Date: ________________________

Name and Matric No: S. M. Shamsuzzaman, GS29924

Declaration by Members of Supervisory Committee

This is to confirm that:

- the research conducted and the writing of this thesis was under our supervision;
- supervision responsibilities as stated in the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) are adhered to.

Signature: ______________________
Name of Chairman of Supervisory Committee: ______________________

Signature: ______________________
Name of Member of Supervisory Committee: ______________________

Signature: ______________________
Name of Member of Supervisory Committee: ______________________

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATION

AAS	-	Atomic absorption spectrometry
AEN	-	Apparent nitrogen efficiency
AH-N	-	Alkali-hydrolyzable Nitrogen
AMO		Ammonia monooxygenase
ANOVA	-	Analysis of variance
ANR	-	Apparent N recovery
AOB	-	Ammonia oxiding bacteria
C/N ratio	-	Carbon and nitrogen ratio
CD	-	Cow dung
CEC	-	Cation exchangeable capacity
CI	-	Controlled irrigation
CM	-	Cow manure
CNS	-	Carbon nitrogen and sulphur
CP	-	2-chloro-6-(trichloromethyl)-pyridine
CRNF	-	Control release nitrogen fertilizer
CV		Coefficient of variance
DAT	-	Day after transplanting
DCD	-	Dicyandiamide
DMPP	-	3, 4 dimethyl pyrazole phosphate
DMRT	-	Duncan Multiple Range test
EC	-	Electric conductivity
ECD	-	Electron capture detector
EENF	-	Enhanced-efficiency N fertilizers
EENF	-	Enhanced-efficiency N fertilizers
EF	-	Emission factor
EFB	-	Palm oil empty fruit bunches
FAO	-	Food and Agriculture Organization
FDE	-	Fresh dairy effluent
FYM	-	Farm yard manure
GHG	-	Greenhouse gas
GML	-	Ground magnesium limestone
GWP	-	Global warming potential
HI	-	Harvest index
IAEA	-	International Atomic Energy Agency
ICP-MS	-	Inductively coupled plasma mass spectrometer
IFA	-	International Fertilizer Industry Association
INM	-	Integrated nutrient management
IPCC	-	Intergovernmental Panel on Climate Change
MARDI	-	Malaysian Agriculture Research and Development Institute
MOP	-	Muriate of potash
NBTPT	-	N-(n-Butyl) Thiophosphoric Triamide

NI	-	Nitrification inhibitor
NPK	-	Nitrogen, Phosphorus and Potasium
NPKM	-	Nitrogen, phosphorus, potasium and organic manure
NUE	-	Nitrogen use efficiency
OA	-	Organic amendment
OM	-	Organic manure
OPC	-	Oil palm compost
PCU	-	Polymer-coated urea
PCUD	-	Polymer-coated urea with the nitrification inhibitor dicyandiamide
PD	-	Poultry dung
PFMC	-	Plastic film mulching cultivation
POME	-	Palm oil mill effluent
PVC	-	Polyvinyl chloride (PVC) pipe
RCBD	-	Randomized complete block design
RDN	-	Recommended dose of nitrogen
REN	-	Nitrogen recovery efficiency
RS	-	Rice straw
SAS	-	Statistical analysis system
SGMC	-	*Sesbania aculeata* greening manuring crop
SOM	-	Soil organic matter
SPAD	-	Silicon Photon Activated Diode
TI	-	Traditional irrigation
TN	-	Total nitrogen
TSP	-	Triple super phosphate
WFPS	-	Water-filled pore space
WHC	-	Water holding capacity

CHAPTER 1

INTRODUCTION

Nitrous oxide (N_2O) is an important trace gas that plays a significant role to global warming and the depletion of stratospheric ozone (Forster et al., 2007). The concentration of N_2O in atmosphere is lower than that of CO_2, but its global warming potential (GWP) is 298 times higher than CO_2 (IPCC, 2007a) and it accounts for 5% of the total greenhouse effect (Houghton et al., 1996). The concentration of atmospheric N_2O has increased 16% over the last 250 years at a rate of 0.25% $year^{-1}$ (IPCC, 2007b).

Agricultural soils have been identified as the main anthropogenic source of N_2O entering the atmosphere; globally releasing approximately 1.7-4.8 Tg N_2O-N yr^{-1}. It accounts for approximately 42% of anthropogenic N_2O emissions (IPCC, 2007c), and nitrogen (N) fertilization is considered as a basic source of N_2O emissions from agricultural soils (Mosier and Kroeze, 2000). Key agricultural management practices regulating N_2O formation and release from agricultural fields include use of organic manure as a fertilizer, crop cultivation and land management (Clayton et al., 1997). The type of N fertilizer and the application method also affect N_2O emissions (Ma et al., 2009). As a result, N_2O flux from soil increases with increasing N fertilization rates and intensive cropping (Mosier et al., 2004).

Rice (*Oryza sativa* L.) is the main crop of 89 countries in the world and also the stable food for half of the world population (Nachimuthu et al., 2007). Nearly 92% of the world rice is produced and consumed in Asia (Singh and Chinnusamy, 2006). In Malaysia, it is the third most important crop after oil palm and rubber with an annual production of 2154 thousand tons from 645 thousand hectares of land (USDA, 2008). Unfortunately, some of the soils in the rice farms are too acidic (acid sulfate soils) for rice cultivation, with soil pH frequently less than 3.5. When this occurs, AI and Fe contents in the solutions are usually very high. Rice yield in the area varies from to year, but always remain within the limit of 1.29 and 3.06 tha^{-1}. According to Rutger (1981), rice plant requires pH of 5.0-7.5 to grow optimally, although it can tolerate a pH of 4.3-8.7 (Duke, 1973). Coronel (1980) also found no adverse effect of pH of 3.5-5.0 on rice root growth in a nutrient culture study in the Philippines. Ameliorative steps are needed to put acid sulfate soils into productive use.

Nitrogen (N) is the most important nutrient for rice but it is the most limiting element in almost all soils (Shukla et al., 2004). Cereals including rice accounted for approximately 50% of the worldwide N fertilizer utilized (IFA, 2009), but N recovery efficiency (REN) in rice plant is low. Based on a worldwide evaluation, REN has been observed to be around 30% in rice (Krupnik et al., 2004). This low REN is associated with large loss of N fertilizer from the soil plant system (Houshmandfar et al., 2008). Significant N losses can occur through NO_3^- leaching, NH_4^+ runoff and gaseous emissions of NH_3 and N_2O. These N losses from agricultural land pose a major threat to environmental quality worldwide as agriculture activities are reported to contributes 70% of N_2O emissions (Janzen et al., 1998).

Nitrous oxide related to rice cultivation is emitted to the atmosphere through denitrification and/or nitrification processes after chemical or organic fertilization (Tsuruta, 2002). Nitrification is the biological oxidation of NH_4^+ to NO_3^- and form NO_2^- intermediate and N_2O as by-product during this change after NH_4 fertilizer or NH_3 forming fertilizer appliation in aerobic soil. During denitrification process when the soil NO_3-N is reduced to dinitrogen (N_2), N_2O is emitted. It has been reported that N_2O is produced from paddy soil processes as a by-product of microbial nitrification and denitrification (Malla et al., 2005), which are affected by field water management and fertilizer application and so on (Xiong et al., 2007). The type of N fertilizer and the application method also affect N_2O emissions (Ma et al., 2009). Thus, controlling the mineral N supply is expected to be a useful method for reducing N_2O production (Yan et al., 2003).

The present irrigated rice system is characterized as low fertilizer N use efficiency due to over use of N fertilizers, which also poses potential adverse effects on environment and health (Jing et al., 2007). Application of urea in rice field is the potential source for N_2O. It was studied that the rice wheat system consumes very high amount of N fertilizer (about 240 kg N $ha^{-1}y^{-1}$), which has considerable impact on N_2O emissions (Pathak et al., 2002). On the other hands, the excessive application of fertilizer has made the soil environment worse year by year and has affected the growth of plants and crop yield (Bhattacharya et al., 2006).

Incorporation of organic manure (OM) with synthetic N fertilizers has been shown to support high grain yields and soil fertility in rice-wheat systems (Aulakh et al., 2001). In contrast, some studies have shown that the incorporation of crop residues generally increases the readily available C and N in soils, and therefore affects N_2O production and emissions from soils (Lemke et al., 1999). For example, Zou et al. (2005) found that the application of rape seedcake along with N fertilizer increased N_2O emissions, but combined application of wheat straw and N fertilizer decreased N_2O emissions. Therefore, it has been proved that organic fertilizer contributes to N_2O emission after soil application, but introduction of appropriate manure management techniques represents one opportunity for greenhouse gases mitigation (Cayuela et al., 2010).

Another strategy is the use of nitrification inhibitors (NIs) which has been shown to be highly effective in increasing the utilization efficiency of N by reducing leaching and nitrification/denitrification losses (Aulakh et al. 2001; Weiske et al. 2001; Hatch et al. 2005; Di and Cameron 2002, 2003). Nitrification inhibitors, such as DCD, nitrapyrin (NP) and 3,4-dimethylpyrazole phosphate (DMPP) help to slow down the conversion of NH_4^+ -N into NO_3^- -N by depressing the activities of ammonia-oxidizing microbes in soil, and thereby reducing NO_3^- -N leaching and N_2O emissions (Amberger 1989; Abbasi and Adams 2000; Di and Cameron 2002; Di et al. 2009). The DCD (containing 66.7% N) is the most widely used nitrification inhibitor because it is cheaper, nontoxic, less volatile, relatively water soluble, and relatively benign to non-target microbial communities (Zacherl and Amberger 1990; O'Callaghan et al. 2010; Di et al. 2011). Many studies have shown that DCD can significantly decrease NO_3^- leaching and N_2O emissions from cropping systems or grazed pasture systems (Di and Cameron 2002b, 2003; Di et al. 2007; Jumadi et al. 2008; Cui et al. 2011). It is well established that NIs reduce the risk for NO_3 leaching, decrease N_2O emission, increase yield with better nutilization by plants (Zerulla et al., 2001). However, the persistence of excess NH_4^+ -N in soil for a longer time in alkaline soils may increase NH_3 volatilization (Gioacchini et al. 2002; Banerjee et al. 2002; Asing et al. 2008) and some studies have reported that the amount of NH_3 volatilisation increased after the application of DCD (Banerjee et al. 2002; Mkhabela et al. 2006; Pi et al. 2009), while others showed DCD reducing NH_3 volatilisation (Dendooven et al. 1998; Tao et al. 2008). Dicyandiamide reduced the N_2O emission on average by 26% (Weiske et al., 2001), and reduced N_2O emission from irrigated rice by 11% (Kumar et al., 2000). Various formulations of DCD have been developed and their efficacy has been justified under a range of environmental and soil conditions (Di et al., 2007; Kelliher et al., 2008; Monaghan et al., 2009), and summerised that there was no environmental impacts from the use of these products.

To date, there are several findings of N sources (organic and inorganic) on the yield of rice and soil properties but limited study documented on the effect of DCD with organic manure and urea on N dynamics. Moreover, considerable work has been done in the past with DCD and urea for mitigating N_2O emission and enhancing N use by different crops, but very few information are available where combination of DCD, organic manure and urea are used for reducing N_2O gas emission and enhancing the use efficiency of applied urea-N by rice, and assessing their impacts on soil fertility. Rice is the third most important crops in Malaysia and urea is used to fulfil the N requirement of this crop which is consider as a main source of N_2O emission. In addition, acid sulfate soils are widespread along the coastal plains of the Malay Peninsula, with some being cultivated with rice. Following farmers' practice, rice yields are very low due to low pH and prevailing adverse conditions such as Al and/or Fe toxicity. Hence, the general objective was to find out a feasible fertilization practice including DCD and organic manure for reducing N_2O emission with better yield and soil health. The specific objectives were:

i. to determine the effect of DCD with OM and urea on soil mineral-N content, net N-mineralization and net nitrification.

ii. to identify the best combination of DCD with OM and urea which could minimize N_2O emission in rice growing season.

iii. to search a feasible fertilization practice including DCD and OM for reducing chemical fertilizer for better yield and soil health.

REFERENCES

Aarnio, T. and Martikainen, P. J. 1992. Nitrification in forest soil after refertilization with urea or urea and dicyandiamide. Soil Biology and Biochemistry, 24: 951-954.

Abbasi, M. K. and Adams, W. A. 2000. Gaseous N emission during simultaneous nitrification–denitrification associated with mineral N fertilisation to a grassland soil under field conditions. Soil Biology and Biochemistry, 32:1251–1259.

Adviento-Borbe, M. A. A., Haddix, M. L., Binder, D. L., Walters, D. T. and Dobermann, A. 2007. Soil greenhouse gas fluxes and global warming potential in four high-yielding maize systems. Global Change Biology, 13:1972–88.

Agbede, T. M. and Adekiya, A. O. 2012. Effect of wood ash, poultry manure and NPK fertilizer on soil and leaf nutrient composition, growth and yield of okra (*Abelmoschus esculentus*). Emirates Journal of food and Agriculture, 24: 314-321.

Ahmad, S., Li, C., Dai, G., Zhan, M., Wang, J., Pan, S. and Cao, C. 2009. Greenhouse gas emission from direct seeding paddy field under different rice tillage systems in central China. Soil and Tillage Research, 106: 54–61

Akiyama, H., Morimoto, S., Hayatsu, M., Hayakawa, A., Sudo, S. and Yagi, K. 2012. Nitrification, ammonia-oxidizing communities, and N_2O and CH_4 fluxes in an imperfectly drained agricultural field fertilized with coated urea with and without dicyandiamide. Biology and Fertility of Soils, 49: 213–223.

Akiyama, H., Yagi, K. and Yan, X. Y. 2005. Direct N_2O emissions from rice paddy fields: summary of available data. Global Biogeochemistry Cycle, 19: 1001–1010.

Akiyama, H., Yan, X. Y., Yagi, K. 2010. Evaluation of effectiveness of enhanced-efficiency fertilisers as mitigation options for N_2O and NO emissions from agricultural soils: meta-analysis. Global Change Biology, 16: 1837–1846.

Amberger, A. 1989. Research on dicyandiamide as a nitrification inhibitor and future outlook. Communications in Soil Science and Plant Analysis, 20 1933-1955.

Armstrong, W. 1971. Radial oxygen losses from intact rice roots as affected by distance from the apex, respiration and waterlogging. Physiologia Plantarum, 25: 192-97.

Anzoua, K.G., Junichi. K., Toshihiro. H., Kazuto, I. and Yutaka, J. 2010. Genetic improvements for high yield and low soil nitrogen tolerance in rice (*Oryza sativa* L.) under a cold environment. Field Crops Research, 116: 38-45.

Arth, I. and Frenzel, P. 2000. Nitrification and denitrification in the rhizosphere of rice: the detection of processes by a new multi-channel electrode. Biol. Fertil. Soils, 3: 427- 435.

Arth, I., Frenzel, P. and Conrad, R. 1998. Denitrification Coupled To Nitrification In The Rhizosphere of Rice. Soil Biol. Biochem. 30: 4, Pp. 509-515

Asing, J., Saggar, S., Singh, J. and Bolan, N.S. 2008. Assessment of nitrogen losses fromurea and organic manure with and without nitrification inhibitor, dicyandiamide, applied to lettuce under glasshouse conditions. Aust. J. Soil. Res., 46: 535-541.

Aslan S, Cakici H. 2007. Biological denitrification of drinking water in a slow sand filter. J Hazard Mater, 148: 253-258.

Atkinson, C. J., Fitzgerald, J. D. and Hipps, N. A. 2010. Potential mechanisms for achieving agricultural benefits from biochar application to temperate soils: a review. Plant and Soil, 337: 1-18.

Aulakh M.S. and Malhi S. S. 2005. Interactions of nitrogen with other nutrients and water: effect on crop yield and quality, nutrient use efficiency, carbon sequestration, and environmental pollution. Advances in Agronomy, 86: 341-409.

Aulakh, M. S., Doran, J. W., Walters, D. T., Mosier, A. R. and Francis, D. D. 1991. Crop residue type and placement effects on denitrification and mineralization. Soil Science Society of American Journal, 55: 1020–1025.

Aulakh, M. S., Khera, T. S., Doran, J. W. and Bronson, K. F. 2001. Denitrification, N_2O and CO2 fluxes in rice-wheat cropping system as affected by crop residues, fertilizer N and legume green manure. Biology and Fertility of Soils, 34: 375–389.

Awan, T. H., Ali, R. I., Manzoor, Z., Ahmad, M. and Akhtar, M. 2011. Effect of different nitrogen levels and row spacing on the performance of newly evolved medium grain rice variety. Journal of Animal and Plant Science, 21: 231-234.

Baggs, E. M. and Philippot, L. 2010. Microbial terrestrial pathways to N_2O. In: Smith, K. A. (ed) Nitrous oxide and climate change. Earthscan, London, pp. 4–35.

Baggs, E. M., Rees, R. M., Smith, K. A. and Vinten, A. J. A. 2000. Nitrous oxide emission from soils after incorporating crop residues. Soil Use and Management, 16: 82–87.

Baggs, E. M., Stevenson, M., Pihlatie, M., Roger, A., Cook, H. and Cadisch, G. 2003. Nitrous oxide emission following application of residues and fertiliser under zero and conventional tillage. Plant and Soil, 254: 361–370.

Bailey, V.L., Fansler, S.J., Smith, J.L. and Bolton Jr., H. 2010. Reconciling apparent variability in effects of biochar amendment on soil enzyme activities by assay optimization. Soil Biology and Biochemistry, 43: 296-301.

Banerjee, B., Pathak, H. and Aggarwal, P.K. 2002. Effects of dicyandiamide, farmyard manure and irrigation on crop yields and ammonia volatilisation from an alluvial soil under a rice (*Oryza sativa* L.) wheat (*Triticum aestivum* L.) cropping system. Biol. Fertil. Soils, 36: 207-214.

Banger K, Toor, G.S., Biswas A, Sidhu S S, Sudhir K. 2010. Soil organic carbon fractions after 16-years of applications of fertilizers and organic manure in a Typic Rhodalfs in semi-arid tropics. Nutrient Cycling in Agroecosystems, 86: 391-399

Banik, P. and Bejbaruah, R. 2004. Effect of vermicompost on rice (*Oryza sativa* L.) yield and soil fertility status of rainfed humid sub-tropics. Indian Journal of Agricultural Sciences, 74: 488-491.

Basu, S.K., Talukder, N.M., Nahar, N.N., Rahman, M.M. and Prodhan, M. Y. 2012. Evaluation of Nutritional Status of Grain of Boro Rice (CV. BRRI Dhan 28) Applying Chemical Fertilizers and Organic Manure Cultivated Under System of Rice Intensification (SRI). Bangladesh Journal of Progressive Science and Technology, 10: 053-056.

Bazaya, B. R., Avijit Sen, and Srivastava V. K. 2009. Planting methods and nitrogen effects on crop yield and soil quality under direct seeded rice in the Indo-Gangetic plains of eastern India. Soil and Tillage Research, 105: 27–32.

Beauchamp, E.G., 1997. Nitrous oxide emissions from agricultural soils. Can. J. Soil Sci. 77: 113-123.

Beaulieu, J. J., Tank, J.L., Hamilton, S.K., Wollheim, W.M., Hall Jr, R.O. and Mulholland, P.J. 2011. Nitrous oxide emission from denitrification in stream and river networks. Proc. Acad Sci., 108: 214-219.

Bergaust, L., Mao, Y., Bakken, L.R. and Frostegård, Å. 2010. Denitrification response patterns during the transition to anoxic respiration and post transcriptional effects of suboptimal pH on nitrogen oxide reductase in Paracoccus denitrificans. Appl. Environ. Microbiol., 76: 6387-96.

Bertora, C., Alluvione, F., Zavattaro, L., van Groenigen, J. W., Velthof, G. and Grignani C. 2008. Pig slurry treatment modifies slurry composition, N_2O, and CO_2 emissions after soil incorporation. Soil Biology and Biochemistry, 40: 1999-2006.

Bhandari, A.L., Ladha, J.K., Pathak, H., Padre, A.T., Dawe, D. and Gupta, R.K. 2002. Yield and soil nutrient changes in a long-term rice–wheat rotation in India. Soil Science Society of American Journal, 66: 162–170.

Bhatia, A., Pathak, H., Jain, N., Singh, P.K. and Singh, A.K.2005. Global warming potential of manure amended soils under rice–wheat system in the Indo-Gangetic plains. Atmospheric Environment, 39: 6976–6984.

Bhatia, A., Sasmal, S., Jain, N., Pathak, H., Kumar, R. and Singh, A. 2010. Mitigating nitrous oxide emission from soil under conventional and no-tillage in wheat using nitrification inhibitors. Agriculture, Ecosystems and Environment, 136: 247–253.

Bhattacharya, T, Banerjee, D. K. and Gopal, B. 2006. Heavy metal uptake by *Scirpus littoralis* schrad. from fly ash dosed and metal spiked soils. Environmental Monitoring and Assessment, 121: 363-380.

Bhattacharyya, P., Nayak, A.K., Mohanty, S., Tripathi, R., Mohammad Shahid, Anjani Kumar, Raja, R., Panda, B.B., Roy, K.S., Neogi, S., Dash, P.K., Shukla, A.K. and Rao, K.S. 2013. Greenhouse gas emission in relation to labile soil C, N pools and functional microbial diversity as influenced by 39 years long-term fertilizer management in tropical rice. Soil and Tillage Research, 129: 93–105.

Bhattacharyya, P., Roy, K. S., Neogi, S., Adhya, T. K., Rao, K. S. and Manna, M. C. 2012. Effects of rice straw and nitrogen fertilization on greenhouse gas emissions and carbon storage in tropical flooded soil planted with rice. Soil and Tillage Research, 124: 119–130.

Bi, L., Zhang, B., Liu, G., Li, Z., Liu, Y., Ye, C., Yu, X., Lai, T., Zhang, J., Yin, J. and Liang, Y. 2009. Long-term effects of organic amendments on the rice yields for double rice cropping systems in subtropical ChinaLong-term effects of organic amendments on the rice yields for double rice cropping systems in subtropical China. Agriculture, Ecosystems and Environment, 129: 534–541.

Boeckx, P., Xu, X. and Van Cleemput, O. 2005. Mitigation of N_2O and CH_4 emission from rice and wheat cropping systems using dicyandiamide and hydroquinone. Nutrient Cycling in Agroecosystems, 72: 41–49.

Bolan, N.S., Saggar, S., Luo, J., Bhandral, R. and Singh, J. 2004. Gaseous emissions of nitrogen from grazed pastures: processes, measurements and modelling, environmental implications, and mitigation. Advances in Agronomy, 84: 37-120.

Bouwman, A. F., Boumans, L. J. M. and Batjes, N. H. 2002. Modeling global annual N_2O and NO emissions from fertilised fields. Global Biogeochemistry Cycle 16: 37 – 46.

Bray, R.M. and Kurtz, L.T. 1945. Determination of total organic P and available forms of phosphorus in soils. Soil Science, 59: 39-45.

Bronson, K. F., Cassman, K. G., Wassman, R., Olk, D. C., Van Noordwijk, M. and Garity, D. P. 1997. Soil carbon dynamics in different cropping systems in principal ecoregions of Asia. In Management of carbon sequestration in soil (R. Lal, J. M. Kimble, R. F. Follet and B. A. Stewart, eds), pp. 35-57. 1. CRC Press. Baxa raton, Florida, USA.

Bruce, B. A., Linquist, A., Liu, L., van Kessel, C. and van Groenigen, K. J. 2013. Enhanced efficiency nitrogen fertilizers for rice systems: Meta-analysis of yield and nitrogen uptake. Field Crops Research, 154: 246–254.

Bruun, E.W., Müller-Stöver, D., Ambus, P. and Hauggaard-Nielsen, H. 2011. Application of biochar to soil and N_2O emissions: potential effects of blending fast-pyrolysis biochar with anaerobically digested slurry. European Journal of Soil Science, 62: 581-589.

Burau, R.E. 1982. Methods of Soil Analysis, Part 2: Chemical and Microbiological Properties, 2nd ed., Agron. Monogr. Vol. 9 (ASA and SSSA, Madison, WI: U.S.A. pp. 347–366.

Buresh, R.J. and De Datta, S.K. 1991. Denitrification losses from puddled rice soils in the tropics. Biol. Fertil. Soils, 9: 1-13.

Buresh, R. J. and Witt, C. 2008. Balancing fertilizer use and profit in Asia's irrigated rice systems. Better Crops, 92:18-22.

Buresh, R. J., Reddy, K. R. and van Kessel, C. 2008. Nitrogen transformations in submerged soils. In: Schepers JS, Raun WR (eds) Nitrogen in agricultural systems. Agronomy Monograph 49. ASA, CSSA, and SSSA, Madison, WI, USA, pp. 401–436.

Burger, M. and R.T. Venterea**.** 2011. Effects of nitrogen fertilizer types on nitrous oxide emissions. In, L. Guo et al. (eds.) Understanding Greenhouse Gas Emissions from Agricultural Management. ACS Symposium Series; American Chemical Society: Washington, DC.

Burney, Steven J. Davis and David B. Lobell. 2009. Greenhouse gas mitigation by agricultural intensification. Proceedings of the National Academy of Science of the United States of America, 107: 12052–12057.

Cabello, P., Roldán, M.D. and Moreno-Vivián, C. 2004. Nitrate reduction and the nitrogen cycle in Archaea. Microbiology, 150: 3527-3546.

Cai, Z. C., Laughlin, R. J. and Stevens, R. J. 2001. Nitrous oxide and dinitrogen emissions from soil under different water regimes and straw amendment. Chemosphere, 42: 113-121.

Cai, Z. C., Xing, G. X., Yan, X. Y., Xu, H., Tsuruta, H., Yagi, K. and Minami, K. 1997. Methane and nitrous oxide emissions from rice paddy fields as affected by nitrogen fertilizers and water management. Plant and Soil, 196: 7–14.

Campbell, C. A., LaFond, G. P., Leyshon, A. J., Zentner, R. P. and Janzen, H. H. 1991. Effect of cropping practices on the initial potential rate of N mineralization in a thin Black Chernozem. Canadian Journal of Soil Science, 71: 43-53.

Campbell, C.A., Lafond, G.P., Zentner, R.P. and Jame, Y.W. 1994. Nitrate leaching in a Udic Haploboroll as influenced by fertilization and legumes. Journal of Environmental Quality, 23: 195–201.

Castaldi, S., Riondino, M., Baronti, S., Esposito, F. R., Marzaioli, R., Rutigliano, F. A., Vaccari, F. P. and Miglietta, F., 2011. Impact of biochar application to a Mediterranean wheat crop on soil microbial activity and greenhouse gas fluxes. Chemosphere, 85: 1464-1471.

Cayuela, M. L., Velthof, G. L., Mondini, C., Sinicco, T. and van Groenigen, J. W. 2010. Nitrous oxide and carbon dioxide emissions during initial decomposition of animal by-products applied as fertilisers to soils. Geoderma, 157: 235-242.

Chandel, G., S. Banerjee, S., See, R., Meena, D. J., Sharma, S. B. and Verulkar. 2010. Effects of Different Nitrogen Fertilizer Levels and Native Soil Properties on Rice Grain Fe, Zn and Protein Contents. Rice Science, 17: 213−227.

Chaudhary, S.K., Singh, J.P. and Jhair, S. 2011. Effect of integrated nitrogen management on yield, quality and nutrient uptak of rice (*Oryza sativa*) under different dates of planting. Indian Journal of Agronomy. 56: 228-231.

Chen, X., Cabrera, M. I. and Zhang, L. 2002. Nitrous oxide emission from upland crops and crop-soil system in northeastern China. Nutrient Cycling in Agroecosystems, 62: 241-247.

Chen, X., Zhang, L. M., Shen, J. P., Wei, W.X. and He, J. Z. 2011. Abundance and community structure of ammonia-oxidizing archaea and bacteria in an acid paddy soil. Biology and Fertility of Soils, 47: 323–331.

Chen, D. 2010. Simulation of N_2O emissions from an irrigated dairy pasture treated with urea and urine in Southeastern Australia. Agric. Ecosyst. Environ. 136: 333-342.

Chen, G., Guo, S. W., Kronzucker, H. J. and Shi, W. M. 2013. Nitrogen use efficiency (NUE)in rice links to NH_4^+ toxicity and futile NH_4^+ cycling in roots. Plant Soil, 369: 351-363.

Cheng, H. F., Xu, W. P., Liu, J. L., Zhao, Q. J., He, Y. Q. and Chen G. 2007. Application of composted sewage sludge (CSS) as a soil amendment for turfgrass growth. Ecological Engineering, 29: 96-104.

Chiaradia, J. J., Chiba, M. K., de Andrade, C. A., do Carmo, J. B., de Oliveira, C. and Lavorenti, A. 2009. CO_2, CH_4 and N_2O fluxes in an ultisol treated with sewage sludge and cultivated with castor bean. The Revista Brasileira de Ciência do Solo, 33: 1863–1870.

Chun-yan, W., Yi, C., Xu,T., Sheng-mao, Y. and Jia-yu, Y. 2010. Fate of Nitrogen from Organic and Inorganic Sources in Rice-Wheat Rotation Cropping System. Agricultural Sciences in China, 9: 1017-1025

Clay, D. E., Malzer, G. L. and Anderson, J. L. 1990. Ammonia volatilisation from urea as influenced by soil temperature, soil water content, and nitrification and hydrolysis inhibitors. Soil Science Society of American Journal, 54: 263–266.

Clayton, H., McTaggart, I. P., Parker, J., Swan, L. and Smith, K. A. 1997. Nitrous oxide emissions from fertilised grassland: a 2-year study of the effects of N fertiliser form and environmental conditions, Biology and Fertility of Soils, 25: 252–260.

Clough, T. J., Rolston, D. E., Stevens, R. J. and Laughlin, R. J. 2003. N_2O and N_2 gas fluxes, soil gas pressures, and ebullition events following irrigation of $^{15}NO_3^-$ labelled subsoils. Aust. J. Soil Res., 41: 401-20.

Conrad, R. 2002. Soil microorganisms as controllers of atmospheric trace gases (H_2, CO, CH_4, OCS, N_2O, and N_2). Microbiological Reviews, 60: 609-640.

Coronel, V. P. 1980. Response of Rice and Wheat at Seedling Stage to Aluminum in Nutrient Solution and Soil. M.S Thesis, UPLB, The Philippines. Nutrient Solution and Soil. M.S Thesis, UPLB, The Philippines.

Cuhel, J., Simek, M., Laughlin, R. L., Bru, D., Chenaby, D., Watson, C. J. and Philippot, L. 2010. Insights into the effect of soil pH on N_2O and N_2 emissions and denitrifier community size and activity, Applied Environmental Microbiology, 76: 1870–1878.

Cui, M., Sun, X., Hu, C., Di, H.J., Tan, Q. and Zhao, C. 2011. Effective mitigation of nitrateleaching and nitrous oxide emissions in intensive vegetable production systemsusing a nitrification inhibitor, dicyandiamide. J. Soils Sediments, 11 (5): 22-730.

Das, S. and Adhya, T. K. 2014. Effect of combine application of organic manure and inorganic fertilizer on methane and nitrous oxide emissions from a tropical flooded soil planted to rice. Geoderma, 213: 185–192.

Das, S., Ghosh, A. and Adhya, T. K. 2011a. Nitrous oxide and methane emission from a flooded rice field as influenced by separate and combined application of herbicides bensulfuron methyl and pretilachlor. Chemosphere, 84: 54–62.

de Klein C. A. M., Cameron, K. C., Di, H. J., Rys, G., Monaghan, R. M. and Sherlock, R. R. 2011. Repeated annual use of the nitrification inhibitor dicyandiamide

(DCD) does not alter its effectiveness in reducing N_2O emissions from cow urine. (Special Issue: Greenhouse gases in animal agriculture - finding a balance between food and emissions.). Animal Feed Science and Technology, 166: 480-491.

Dendooven, L., Bonhomme, E., Merckx, R. and Vlassak, K. 1998. N dynamics and sources of N_2O production following pig slurry application to a loamy soil. Biol. Fertil. Soils, 26: 224-228

de Ponti, T., Rijk, B. Martin K. van Ittersum. 2012. The crop yield gap between organic and conventional agriculture. Agricultural Systems, 108: 1–9.

DeDatta, S.K., 1995. Nitrogen transformations in wetland rice ecosystems. Plant and Soil, 42: 193–203.

Denman, K. L., Brasseur, G. and Chidthaisong, A. 2007. Couplings between changes in the climate system and biogeochemistry. In: Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Avery, K. B., Tignor, M., Miller, H. L. (eds) Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, pp. 500–587.

De-Zhi, Y., De-Jian, W., Rui-Juan, S. and Jing-Hui, L. 2006. N Mineralization as Affected by Long-Term N Fertilization and Its Relationship with Crop N Uptake. Pedosphere, 16: 125-130.

Di, H.J. and Cameron, K. C. 2012. How does the application of different nitrification inhibitors affect nitrous oxide emissions and nitrate leaching from cow urine in grazed pastures? Soil Use and Management, 28: 54-61.

Di, H. G. and Cameron, K. C. 2003. Mitigation of nitrous oxide emissions in spray-irrigated grazed grassland by treating the soil with dicyandiamide, a nitrification inhibitor. Soil Use and Management, 19: 284–290.

Di H.J. and Cameron K.C. 2002. The use of nitrification inhibitor, dicyandiamide (DCD), to decrease nitrate leaching and nitrous oxide emissions in simulated grazed and irrigated grassland. Soil Use Management. 18: 395-403.

Di, H. G. and Cameron, K. C. 2008. Nitrous oxide emissions from two dairy pasture soils as affected by different rates of a fine particle suspension nitrification inhibitor, dicyandiamide. Biology and Fertility of Soils. doi:10.1007/s00374-0038-5.

Di, H. G. and Cameron, K.C. 2004. Effects of temperature and application rate of nitrification inhibitor, dicyandiamide (DCD), on nitrification rate and microbial biomass in grazed pasture soil. Australian Journal of Soil Research, 42: 927–932.

Di, H. J, Cameron, K. C. and Sherlock, R. R. 2007. Comparison of the effectiveness of a nitrification inhibitor, dicyandiamide, in reducing nitrous oxide emissions in four different soils under different climatic and management conditions. Soil Use and Management, 23: 1–9.

Di, H. J., Cameron, K. C, Shen, J. P, Winefield, C. S, O'Callaghan, M., Bowatte, S. and He, J. Z. 2009. Nitrification driven by bacteria and not archaea in nitrogen-rich grassland soils. Nature Geoscience, 2:621–624.

Di, H. J., Cameron, K. C., Shen, J. P., Winefield, C. S., O'Callaghan, M. Bowatte, S. and He. J. Z. 2010. Ammonia-oxidizing bacteria and archaea grow under contrasting soil nitrogen conditions. FEMS Microbiology Ecology, 72: 386–394.

Ding, W. X., Yu, H. Y. and Cai, Z. C. 2011. Impact of urease and nitrification inhibitorson nitrous oxide emissions from fluvo-aquic soil in the North China Plain. Biol. Fertil. Soils, 47 (1): 91-99.

Ding, W., Yagi, K., Cai, Z. and Han, F. 2010. Impact of long-term application of fertilizers on N2O and NO production potential in an intensively cultivated sandy loam soil. Water, Air and Soil Pollution. doi:10.1007/s11270-010-0328-x

Dobbie, K. E. and Smith, K. A. 2003. Impact of different forms of N fertilizer on N_2O emissions from intensive grassland. Nutrient Cycling in Agroecosystems, 67: 37-46.

Dobermann, A. and Cassman, K. G. 2004. Environmental dimensions of fertilizer nitrogen: What can be done to increase nitrogen use efficiency and ensure global food security? In: Mosier AR, Syers JK, Freney JR, editors. Agriculture and the nitrogen cycle: assessing the impacts of fertilizer use on food production and the environment. Washington, DC: Island Press. pp. 261-278.

Du, Z. Y., Zhou, J. M., Wang, H. Y., Du, C. W. and Chen, X. Q. 2005. Effect of nitrogen fertilizers on movement and transformation of phosphorus in an acid soil. Pedosphere, 15:424–31

Duan-sheng, J., Xi-bai, Z., Ju-sheng, G. A. O. and Lian-fang, L. 2008. Changes of Organic Matter, N, P and K Content of Soils in Red Soil Areas under Long-Term Experiment. Agricultural Science in China, 7: 853-859.

Duke, J. A. 1979. Ecosystematic data on economic plants. Quart. J. Crude Drug Res., 1**7**: 91-110.

Ebid, A., Ueno, H., Ghoneim, A. and Asagi, N. 2008. Uptake of Carbon and nitrogen derived from carbon-13 and nitrogen-15 dual-labeled maize residue compost applied to radish, komatsuna, and chingensai for three consecutive croppings. Plant and Soil, 304: 241-248.

Eichner, M. J. 1990. Nitrous oxide emissions from fertilized soils: summary of available data. Journal of Environmental Quality, 19: 272–280.

El-Haris, M. K., Cochran, V. L., Elliot, L. F. and Bezdicek, D. F. 1983. Effect of tillage, cropping and fertilizer management on soil nitrogen mineralization potential. Soil Science Society of American Journal, 47: 1157–1161.

Ellert, B. H and Janzen, H. H. 2008. Nitrous oxide carbon dioxide and methane emissions from irrigated cropping systems as influenced by legumes manure and fertilizer. Canadian Journal of Soil Science, 88:207–217.

Enwall, K., Nyberg, K., Bertilsson, S., Cederlund, H., Stenstrom, J. and Hallin, S. 2007. Long-term impact of fertilization on activity and composition of bacterial communities and metabolic guilds in agricultural soil. Soil Biology and Biochemistry, 39:106–15.

Fan, X. H., Song, Y. S., Lin, D. X., Yang, L. Z. and Zhou, J. M. 2005. Ammonia volatilization losses from urea applied to wheat on a paddy soil in Taihu Region, China. Pedosphere, 15: 59–65.

Fangueiro, D., Fernandes, A., Coutinho, J., Moreira, N. and Trindade, H. 2009. Influence of two nitrification inhibitors (DCD and DMPP) on annual ryegrass yield and soil mineral N dynamics after incorporation with cattle slurry. Commun. Soil Sci. Plant Anal. 40: 3387-3398.

Fei, X., Zhong, W., Yun-jie, G. U., Gang, C. and Peng, Z. 2008. Effects of Nitrogen Application Time on Caryopsis Development and Grain Quality of Rice Variety Yangdao 6. Rice Science, 15: 57–62.

Fernández-Luqueño, F., Reyes-Varela, V., Martínez-Suárez, C., Reynoso-Keller, R. E., Méndez-Bautista, J., Ruiz-Romero, E., López-Valdez, F., Luna-Guido, M. L. and Dendooven, L. 2009. Emission of CO_2 and N_2O from soil cultivated with common bean (*Phaseolus vulgaris* L.) fertilized with different N sources. Science of The Total Environment, 407: 4289-4296.

Firestone, M. K. and Davidson, E. A. 1989. Microbiological basis of NO and N_2O production and consumption in soils. In: Andreae, M.O., Schimel, D.S. (Eds.), Exchanges of Trace Gases between Terrestrial Ecosystems and the Atmosphere. John Wiley & Sons, New York.

Flessa, H. and Beese, F. 2000. Laboratory estimates of trace gas emissions following surface application and injection of cattle slurry. Journal of Environmental Quality, 29: 262–268.

Forge, T. A. and Simard, S. W. 2001. Short-term effects of nitrogen and phosphorus fertilizers on nitrogen mineralization and trophic structure of the soil ecosystem in forest clearcuts in the southern interior of British Columbia. Canadian Journal of Soil Science, 81: 11-20.

Forster, P., Ramaswamy, V., Artaxo, P., Berntsen, T., Betts, R., Fahey, D., Haywood, J., Lean, J., Lowe, D. and Myhre, G. 2007. Changes in atmospheric constituents and in radiative forcing, In: Solomon S, Qin D, Manning M, Chen Z, Marquis M, Averyt KB, Tignor M, Miller HL (eds) Climate Change 2007: The Physical Science Basis. Contribution of Working Group 1 to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Gaskin, J. W., Speir, R. A., Harris, K., Das, K. C., Lee, R. D., Morris, L. A. and Fisher, D. S. 2010. Effect of peanut hull and pine chip biochar on soil nutrients, corn nutrient status, and yield. Agronomy Journal, 102: 623-633.

Ge, G., Li, Z., Fan, F., Chu, G., Hou, Z. and Liang, Y. 2010. Soil biological activity and their seasonal variations in response to long-term application of organic and inorganic fertilizers. Plant and Soil, 326: 31–44.

Gee, G.W., and Bauder, J.W.1986. Particle-size analysis. In: A. Klute, editor, Methods of soil analysis. Part 1. Physical and mineralogical methods. SSSA, Madison, WI. pp. 383–411.

Gentile, R., Vanlauwe, B., Chivenge, P. and Six, J. 2008. Interactive effects from combining fertilizer and organic residue inputs on nitrogen transformations. Soil Biology and Biochemistry, 40: 2375-2384.

Ghosh, S., Majumdar, D. and Jain, M. C. 2003. Methane and nitrous oxide emissions from an irrigated rice of North India. Chemosphere, 51: 181–195.

Gilbert, B. and Frenzel, P. 1995. Methanotrophic bacteria in the rhizosphere of rice microcosms and their effect on porewater methane concentration and methane emission. Biology and Fertility of Soils, 20; 93-100.

Giltrap, D. L., Singh, J., Saggar, S. and Zaman, M. 2010. A preliminary study to model the effects of a nitrification inhibitor on nitrous oxide emission from urine amended pasture. Agric. Ecosyst. Environ., 136: 310-317.

Gioacchini, P., Marzadori, A. C., Antisari, L. V. and Gessa, C. 2002. Influence of urease and nitrification inhibitors on N losses from soils fertilized with urea. Biol. Fertil. Soils, 36: 129-135.

Goyal, S., Chander, K., Mundra, M. C. and Kapoor, K. K. 1999. Influence of inorganic fertilizers and organic amendments on soil organic matter and soil microbial properties under tropical conditions. Biology and Fertility of Soils, 29: 196–200.

Goyal, S., Sakamoto, K., Inubushi, K. and Kamewada, K. 2006. Long-term effects of inorganic fertilization and organic amendments on soil organic matter and soil microbial properties in Andisols. Archives of Agronomy and Soil Science, 52: 617-625.

Granli, T., Bockman, O.C., 1994. Nitrous oxide from agriculture. Norwegian J. Agric. Sci. 12 (Suppl.): 7-128.

Grossman, R.B. and Reinsch, T.G. 2002. Bulk density and linear extensibility. In: Dane JH, Topp GC (eds) Methods of Soil Analysis, Part 4: Physical Methods, Soil Sci. Soc. Amer., Book Series No. 5, Soil Science Society of America, Madison, WI, USA, pp. 201–228.

Gu, Y. F., Zhang, X. P., Tu, S. H. and Lindström, K. 2009. Soil microbial biomass, crop yields, and bacterial community structure as affected by long-term fertilizer treatments under wheat-rice cropping. European Journal of Soil Biology, 45: 239-246.

Guan, G., Shu-xin, T., Jun-cheng, Y., Jian-feng, Z. and Y. Li. 2011. Effects of Nitrogen Fertilization Modes on Nutrient Uptake, Crop Yield and Soil Biological Properties in Rice-Wheat Rotation System. Agricultural Sciences in China, 10: 1254-1261.

Guillard, K., Griffin, G. F., Allinson, D. W., Yamartino, W. R., Rafey, M. M. and Pietryzk, S.W. 1995. Nitrogen utilization of selected cropping systems in the U.S. northeast. II. Soil profile nitrate distribution and accumulation. Agronomy Journal, 87: 199–207.

Guiraud, G., Marol, C. and Thibaud, M. C. 1989. Mineralization of nitrogen in the presence of a nitrification inhibitor. Soil Biology and Biochemistry, 2:29-34.

Guo, J. H., Liu, X. J., Zhang, Y., Shen, J. L., Han, W. X., Zhang, W. F., Christie, P., Goulding, K. W. T., Vitousek, P. M. and Zhang, F. S. 2010. Significant acidification in major Chinese croplands. Science, 327: 1008–1010.

Guo, J., Liu, M.H. and Gong, H.X. 2013. Carboxymethyl superabsorbent.'' BioResources, 8: 6510-6522.

Hadas, A., Feigin, A., Feigenbaum, S. and Portnoy, R. 1989. Nitrogen mineralization in the field at various depths. Journal of Soil Science, 40: 131-137.

Halvorson, A. D., Curtis, A. R. and Follett, R. F. 1999b. Nitrogen fertilization effects on soil carbon and nitrogen in a dryland cropping system. Soil Science Society of American Journal, 63: 912–917.

Halvorson, A. D., Grosso, S. J. and Jantalia, C. P. 2011. Nitrogen source effects on soil nitrous oxide emissions from strip-till corn. Journal of Environmental Quality, 40: 1775-1786.

Hao, X., Liu, S., Wu, J., Hu, R., Tong, C. and Su, Y. 2008. Effect of long-term application of inorganic fertilizer and organic amendments on soil organic matter and microbial biomass in three subtropical paddy soils. Nutrient Cycling in Agroecosystems, 81:17–24.

Hart, S.C., Stark, J.M., Davidson, E.A. and Firestone, M. K. 1994. Nitrogen mineralization, immobilization, and nitrification. In: Hart SC, Stark JM, Davidson EA, Firestone MK (eds) Methods of soil analysis part 2: microbiological and biochemical properties. Soil Science Society of America, Madison, WI, pp. 985–1018.

Hatch, D., Trindale, H., Cardenas, L., Carneiro, J., Hawkins, J., Scholefield, D. and Chadwick, D. 2005. Laboratory study of the effects of two nitrification inhibitors on greehouse gas emissions from a slurry-treated arable soil: impact of diurnal temperature cycle. Biology and Fertility of Soils, 41: 225–232.

Hati, K., Swarup, A., Dwivedi, A., Misra, A. and Bandyopadhyay, K. 2007. Changes in soil physical properties and organic carbon status at the topsoil horizon of a vertisol of central India after 28 years of continuous cropping, fertilization and manuring. Agriculture, Ecosystems and Environment, 119: 127–134.

Hayatsu, M., Tago K. and Saito, M. 2008. Various players in the nitrogen cycle: diversity and functions of the microorganisms involved in nitrification and denitrification. Soil Science and Plant Nutrition, 54:33–45.

Hoben, J., Gehl, R., Millar, N., Grace, P. and Robertson, G. 2011. Nonlinear nitrous oxide (N_2O) response to nitrogen fertilizer in on-farm corn crops of the US Midwest. Global Change Biology, 17: 1140–1152.

Honeycutt, C. W. 1999. Nitrogen mineralization from soil organic matter and crop residues: Field validation of laboratory predictions. Soil Science Society of American Journal, 63: 134-141.

Hou, A. X., Chen, G. X., Wang, Z. P., van Cleemput, O. and Patrick Jr, W. H. 2000. Soil Sci. Soc. Am. J., 64: 2180-2186.

Houghton, J. T., L. G. Meira Filho, B. A. Callander, N. Harris, A. Kattenberg, and K. Marskell (Eds.) (1996), Climate Change 1995: The Science of Climate Change, 572 pp., Cambridge Univ. Press, New York.

Houshmandfar, A., Tehrani, M.M. and Delnavaz-Hashemlouyan, B. 2008. Effect of different nitrogen levels on grain protein and nitrogen use efficiency of wheat. Plant Ecosystem, 15: 52-62.

Huang, S. Peng, X. X., Huang, Q. R. and Zhang, W. J. 2010. Soil aggregation and organic carbon fractions affected by long-term fertilization in a red soil of subtropical China. Geoderma, 154: 364-369.

Huang, Y., Zou, J., Zheng, X., Wang, Y. and Xu, X. 2004b. Nitrous oxide emissions as influenced by amendment of plant residues with different C/N ratios. Soil Biology and Biochemistry, 36: 973–981.

Huang, Y., Zou, J., Zheng, X., Wang, Y., Xu, X., 2004. Nitrous oxide emissions as influenced by amendment of plant residues with different C/N ratios. Soil Biology and Biochemistry, 36: 973–981.

Hu-lin, H., You-zhang, W., Xiao-e, Y., Ying, F. and Chun-yong, W. 2007. Effects of Different Nitrogen Fertilizer Levels on Fe, Mn, Cu and Zn Concentrations in Shoot and Grain Quality in Rice (*Oryza sativa*). Rice Science, 14: 289-294.

Hussain, F., Bronson, K. F., Singh, Y., Singh, B. and Peng, S. 2000. Use of chlorophyll meter sufficiency indices for nitrogen management of irrigated rice in Asia. Agronomy Journal, 92:In A Japanese Ordinary Paddy Field. Science World Journal, 5: 47-54.

IAEA (International Atomic Energy Agency). 1978. Isotope studies on rice fertilization: Results of a five- year co-ordinated research programme of the Joint FAO/IAEA Division of Atomic Energy in Food and Agriculture Using Nitrogen-15-labelled Fertilizers. Vienna.

IFA (International Fertiliser Association). 2009. Fertilizers, climate change and enhancing agricultural productivity sustainably. IFA, Paris. Available at: html//www.fertilizer.org/ifa/HomePage/LIBRARY/Publication-database. Fertilizers-Climate-Change-and-Enhancing-Agricultural-Productivity-Sustainably.html (accessed 24 February 2012)

IPCC (Intergovernmental Panel on Climate Change). 2007a. Contribution of working group III to the fourth assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge.

IPCC (Intergovernmental Panel on Climate Change). 2007b. Contribution of working group I to the assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge.

IPCC (Intergovernmental Panel on Climate Change). 2007c. Agriculture. In: Metz, B., Davidson, O.R., Bosch, P.R. (Eds.), Climate Change 2007: Mitigation, Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom/New York, NY, USA.

IPCC (Intergovernmental Panel on Climate Change). 2001. The Scientific Basis, Cambridge Univ. Press, New York. International Rice Research Institute (IRRI) (1989), IRRI Toward 2000 and Beyond, Manila, Philippines.

Islam, M.S. 2008. Soil fertility history, present status and future scenario in Bangladesh. Bangladesh Journal of Agriculture and Environment, 4: 129-151.

Jagadamma, S., Lal, R., Hoeft, R. G., Nafziger, E. and Adee, E. A. 2007. Nitrogen fertilization and cropping system impacts on soil properties and their relationship to crop yield in the central corn belt, USA. Soil and Tillage Research, 98: 120-129.

Janzen, H. H., Campbell, C. A., Izaurralde, R. C., Ellert, B. H., Juma, N., McGill, W. B. and Zentner, R. P. 1998. Management effects on soil C storage on the Canadian prairies. Soil and Tillage Research, 47: 181-195.

Jennifer A. Burney, Steven J. Davis and David B. Lobell. 2009. Greenhouse gas mitigation by agricultural intensification. Proceedings of the National Academy of Science of the United States of America, 107: 12052–12057.

Jensen, L. S., Mueller, T., Magid, J. and Nielsen, E. N. 1993. Temporal variation of C and N mineralization, microbial biomass and extractable organic pools in soilk after oilseed rape straw incorporation in the field. Soil Biol. Biochem., 29: 1043-1055.

Jiang, T.B, Dai, D., Jiang, W.X. Cao, X.Q.and Gan, S.Q. 2004. Characterizing physiological N-use efficiency as influenced by nitrogen management in three rice cultivars. Field Crops Research, 88: 239–250.

Jin, J., Xu, D. Y., Cai, Y. X., Hu, S. Y., Ge, M. and Zhu, Q. S. 2004. Effect of N-fertilizer on main quality characters of rice and RVA profile parameters. Acta Agronomica Sinica, 30:154-158. (in Chinese with English abstract)

Jin, X., Huang, J. and Zhou, Y. 2012. Impact of coastal wetland cultivation on microbial biomass, ammonia-oxidizing bacteria, gross N transformation and N_2O and NO potential production. Biology and Fertility of Soils, 48: 363-369.

Jing, Q., Bouman, B.A.M., Hengsdijk, H., Van Keulen, H.and Cao, W. 2007. Exploring options to combine high yields with high nitrogen use efficiencies in irrigated rice in China. Eurropean Journal of Agronomy, 26: 166–177.

Johnson-Beebout, S. E., Angeles OR, Alberto, M. C. R and Buresh, R. J .2009. Simultaneous minimization of nitrous oxide and methane emission from rice paddy soils is improbable due to redox potential changes with depth in a greenhouse experiment without plants. Geoderma, 149: 45–53.

Jumadi, O., Hala, Y., Muis, A., Ali, A., Palennari, M., Yagi, K. and Inubushi, K. 2008. Influences of chemical fertilizers and a nitrification inhibitor on greenhouse gas fluxes in a corn (*Zea mays* L.) field in Indonesia. Microbes Environ., 23: 29-34.

Kaewpradit, W., Toomsan, B. Cadisch, G., Vityakon, P., Limpinuntana, V., Saenjan, P., Jogloy, S. and Patanothai, A. 2009. Mixing groundnut residues and rice straw to improve rice yield and N use efficiency. Field Crops Research, 110: 130–138.

Kaewpradit, W., Toomsan, B., Cadisch, G., Vityakon, P., Limpinuntana, V., Saenjan, P., Jogloy, S. and Patanothai, A. 2008. Regulating mineral N release by mixing groundnut residues and rice straw under field conditions. European Journal of Soil Science, 59: 640–652.

Kaleem, M. Abbasi, Hina, M. and Tahir M. H. 2011. Effect of *Azadirachta indica* (neem), sodium thiosulphate and calcium chloride on changes in nitrogen transformations and inhibition of nitrification in soil incubated under laboratory conditions. Chemosphere, 82: 1629-1635.

Kaur, T., Brar, B. S. and Dhillon, N. S. 2007. Soil organic matter dynamics as affected by long-term use of organic and inorganic fertilizers under maize-wheat cropping system. Nutrient Cycling in Agroecosystems, 10: 110-121.

Keeney, D.R. and Nelson, D.W. 1982. Nitrogen-inorganic forms. In: Page, A.L., Miller, R.H., Keeney, D.R (eds) Methods of soil analysis, part 2. Madison, Wise, Agronomy, 9:643-698.

Kelliher, F.M., Clough, T. J., Clark, H., Rys, G. and Sedcole, J. R. 2008. The temperature dependence of dicyandiamide (DCD) degradation in soils: A data synthesis. Soil Biology and Biochemistry, 40: 1878–1882.

Kemmitt, S. J., Wright, D., Goulding, K. W. T. and Jones, D. L. 2006. pH regulation of carbon and nitrogen dynamics in two agricultural soils. Soil Biology and Biochemistry, 38: 898–911.

Khalil, M. I. and Baggs, E. M. 2005. CH_4 oxidation and N_2O emissions at varied water-filled pore spaces and head space CH_4 concentrations. Soil Biology and Biochemistry, 37: 1785–1794.

Khalil, M. I., Gutser, R. and Schmidhalter, U. 2009. Effects of urease and nitrification inhibitors added to urea on nitrous oxide emissions from a loess soil. Journal of Plant Nutrient and Soil Science, 172: 651–660.

Khalil, M. I., Rosenani, A. B. and, Cleemput, O Van. 2002. Nitrous ovide production from an ultisol of the humid tropics treated with different nitrogen sources and moisture regimes. Biology and Fertility of Soils, 36: 59-65.

Khan, A. R., Chandra, C., Nanda, P., Singh, S. S., Ghorai, A. K. and Singh, S. R. 2004. Integrated nutrient management for sustainable rice production. Archives of Agronomy and Soil Science, 50:161-165.

Kiran, B., Kaushik, A. and Kaushik, C.P. 2008. Metal-salt co-tolerance and metal removal by indigenous cyanobacterial strains. Process Biochemistry, 43: 598–604.

Kirk, G. J. D. 2001. Plant-mediated processes to acquire nutrients: Nitrogen uptake by rice plants. Plant and Soil, 232:129 -134.

Knoblauch, C., Maarifat, A.A., Pfeiffer, E.M. and Haefele, M.S. 2010. Degradability of black carbon and it impact on trace gas fluxes and carbon turnover in a paddy soils. Soil Biology and Biochemistry, 43: 1768-1778.

Kolberg, R. L., Westfall, D. G. and Peterson, G. A. 1999. Influence of cropping intensity and nitrogen fertilizer rates on in situ nitrogen mineralization. Soil Science Society of American Journal, 63: 129-134.

Komilis, D. P. and Ham, R. K. 2006. Carbon dioxide and ammonia emissions during composting of mixed paper yard waste and food waste. Waste Management, 26: 62–70.

Kong, W. J. and Ni, W. Z. 2006. Effects of integrated fertilization with commercial organic manure and chemical fertilizers on heavy metal balance in soil-rice cropping system. Chinese Journal of Rice Science, 20: 517-523. (in Chinese)

Krupnik, T.J., Six, J., Ladha, J.K., Paine, M.J and van Kessel, C. 2004. An assessment of fertilizer nitrogen recovery efficiency by grain crops,pp. 193-207. In Mosier et al. (eds) Agriculture and the nitrogen cycle: Assessing the impacts of fertilizer use on food production and the environment. Island Press, Washington DC, USA, p. 296.

Kumar, U., Jain, M. C., Pathak, H., Kumar, S. and Majumdar, D. 2000. Nitrous oxide emission from different fertilizers and its mitigation by nitrification inhibitors in irrigated rice. Biology and Fertility of Soils, 32: 474-478.

Kyaw, K. M. and Toyota, K. 2007. Suppression of nitrous oxide production by the herbicides glyphosate and propanil in soils supplied with organic matter. Soil Science and Plant Nutrition, 53: 441–447.

Lal, R. 2004. Carbon sequestration in soils of central Asia. Land Degradation and Development, 15: 563–572.

Lan, T., Han, Y., Roelcke, M., Nieder, R. and Cai, Z. 2013. Effects of the nitrification inhibitor dicyandiamide (DCD) on gross N transformation rates and mitigating N_2O emission in paddy soils. Soil Biology and Biochemistry, 67: 174-182.

Leininger, S., Urich, T., Sclotter, M., Schwark, L., Qi, J., Nicol, G.W., Prosser, J.I., Schuster, S.C. and Schleper, C. 2006. Archaea predominate among ammoniaoxidizing prokaryotes in soil. Nature, 442: 806-809.

Lemke, R.L., Izaurralde, R.C. Nyborg, M. and Solberg, E.D. 1999. Tillage and N source influence soil-emitted nitrous oxide in the Alberta Parkland region, Canadian Journal of Soil Science, 79: 15– 24.

Li, Y. L., Zhang, Y. L., Hu, J. and Shen, Q. R. 2006. Contribution of nitrification happened in rhizospheric soil growing with different rice cultivars to N nutrition. Biology and Fertility of Soils, 43: 417-425.

Li, B. Y., Zhou, D. M., Cang, L., Zhang, H. L., Fan, X. H. and Qin, S. W. 2007. Soil micronutrient availability to crops as affected by long-term inorganic and organic fertilizer applications. Soil and Tillage Research, 96: 166–173.

Li, J. T. and Zhang, B. 2007. Paddy soil stability and mechanical properties as affected by long-term application of chemical fertilizer and animal manure in subtropical China. Pedosphere, 17: 568-579.

Li, X., Zhang, X., Xu, H., Cai, Z. and Yagi, K. 2009. Methane and nitrous oxide emissions from rice paddy soil as infulenced by timing of application of hydroquinone and dicyandiamide. Nutrient Cycling in Agroecosystems, 85: 31–40.

Li, Z., Liu, M., Wu, X., Han, F. and Zhang, T. 2010. Effects of long-term chemical fertilization and organic amendments on dynamics of soil organic C and total N in paddy soil derived from barren land in subtropical China. Soil and Tilliage Research, 106: 268–274.

Lian, S. 1994. Some aspects of the proper use of chemical fertilizers combined with organic manures in rice production. Combined use of chemical and organic fertilizers; Proceedings of the international seminar 'Proper use of chemical fertilizers combined with organic fertilizers in crop production, Universiti Pertanian Malaysia, Nov. 9-14, 1992, Serdang, Malaysia, Universiti Pertanian Malaysia (UPM) and Food & Fertilizer Technology Center (FFTC/ASPAC), 237-251.

Li-mei, Z, Hong-bin, L., Ji-zong, Z., Jing, H. and Bo-ren, W. 2011. Long-Term Application of Organic Manure and Mineral Fertilizer on N2O and CO_2 Emissions in a Red Soil from Cultivated Maize-Wheat Rotation in China. Agricultural Science in China, 10: 1748-1757.

Lin, S., Iqbal, J., Hu, R. G. and Feng, M. L. 2010. N_2O emissions from different land uses in mid-subtropical China. Agriculture, Ecosystems and Environment, 136: 40-48.

Linquist, B. A, Hill, J. E. and Mutters, R. G. 2009. Assessing the necessity of surface applied pre-plant nitrogen fertilizer in rice systems. Agronomy Journal, 101: 906–915.

Linquist, B., van Groenigen, K. J., Adviento-Borbe, M. A., Pittelkow, C. and van Kessel, C. 2012. Anagronomic assessment of greenhouse gas emissions from major cereal crops. Global Change Biology, 18: 194–209.

Liu, L. J., Xu, W., Tang, C., Wang, J. C. and Yang, J. C. 2005. Effect of indigenous nitrogen supply of soil on the grain yield and fertilizer-N use efficiency in rice. Chinese Journal of Rice Science, 19: 343-349. (in Chinese with English abstract)

Liu, M., Hu, F., Chen, X., Huang, Q., Jiao, J., Zhang, B. and Li, H. 2009. Organic amendments with reduced chemical fertilizer promote soil microbial development and nutrient availability in a subtropical paddy field: The influence of quantity, type and application time of organic amendments. Applied Soil Ecology, 42: 166–175.

Liu, S, Qin, Y., Zou, J. and Liu, Q. 2010. Effects of water regime during ricegrowing season on annual direct N_2O emission in a paddy rice winter wheat rotation system in southeast China. Science of The Total Environment, 408: 906–913.

Liu, X., Qu, J., Li, L., Zhang, A., Jufeng, Z., Zheng, J. and Pan, G. 2012. Can biochar amendment be an ecological engineering technology to depress N_2O emission in rice paddies? - A cross site field experiment from South China. Ecological Engineering, 42: 168– 173.

Lu, H. J., Ye, Z. Q., Zhang, X. L., Lin, X. Y. and Ni, W. Z. 2010. Growth and yield responses of crops and macronutrient balance influenced by commercial organic manure used as a partial substitute for chemical fertilizers in an intensive vegetable cropping system. Physics and Chemistry of the Earth, (Parts A/B/C), 36: 387-394.

Luo, J., Saggar, S., Bhandral, R., Bolan, N., Ledgard, S., Lindsey, S. and Sun W., 2008. Effects of irrigating dairy-grazed grassland with farm dairy effluent on nitrous oxide emissions. Plant and Soil, 309: 119-130.

Ma, J., Li, X. L., Xu, H., Han, Y., Cai, Z. C. and Yagi, K. 2007. Effects of nitrogen fertiliser and wheat straw application on CH_4 and N_2O emissions from a paddy rice field. Australian Journal Soil Research, 45: 359–367

Ma, J., Ma, E., Xu, H., Yagi, and K. Cai, Z. 2009. Wheat straw management affects CH_4 and N_2O emissions from rice fields. Soil Biology and Biochemistry, 41:1022–1028.

Ma, Q., Tipping, R.H. and Gamache, R.R. 2010. Uncertainties associated with theoretically calculated N_2-broadened half-widths of H_2O lines. Molecular Physics, 108: 2225-2252

Ma, W. K., Bedard-Haughn, A., Siciliano, S. D. and Farrell, R. E. 2008. Relationship between nitrifier and denitrifier community composition and abundance in predicting nitrous oxide emissions from ephemeral wetland soils. Soil Biology and Biochemistry, 40: 1114-1123.

Ma, Y., Rajkumar, M. and Freitas, H. 2009. Improvement of plant growth and nickel uptake by nickel resistant-plant-growth promoting bacteria. Journal of Hazardous Materials, 166: 1154-1161.

Ma. Y., Wang, J., Zhou, W., Yan, X. and Xiong, Z. 2012. Greenhouse gas emissions during the seedling stage of rice agriculture as affected by cultivar type and crop density. Biology and Fertility of Soils, 48: 589–595.

Maag, M. and Vinther, F.P. 1999. Effect of temperature and water on gaseous emissions from soils treated with animal slurry. Soil Science Society of American Journal, 63: 858–865.

Magdoff, F. R., Ross, D. and Amadon J. 1984. A soil test for nitrogen availability to corn. Soil Sciece Society of American Journal, 28: 1301-1304.

Major, J., Rondon, M., Molina, D., Riha, S.J. and Lehmann, J., 2010. Maize yield and nutrition during 4 years after biochar application to a Colombian savanna oxisol. Plant and Soil, 333: 117-128.

Majumdar, D. 2003. Methane and nitrous oxide emission from irrigated rice fields: Proposed mitigation strategies. Current Science, 84: 1317-1326.

Majumdar, D., Kumar, S., Pathak, H., Jain, M.C. and Kumar, U. 2000. Reducing nitrous oxide emission from an irrigated rice field of North India with nitrification inhibitors. Agriculture, Ecosystem and Environment, 81: 163–169.

Majumdar, D., Pathak, H., Kumar, S., Jain, M.C., 2002. Nitrous oxide emission from a sandy loam Inceptisol under irrigated wheat in India as influenced by different nitrification inhibitors. Agriculture, Ecosystems and Environment, 91, 283–293

Majumder, B., Mandal, B., Bandypadhyay, P. K., Gangopadhyay, A., Mani, P. K., Kundu, A. L. and Mazumndar, D. 2008. Organic amendments influence soil organic carbon pools and rice-wheat productivity. Soil Science Society of American Journal, 72: 775–785.

Malhi, S. S., Lemke, R., Wang, Z. H. and Baldev S. Chhabra. 2006. Tillage, nitrogen and crop residue effects on crop yield, nutrient uptake, soil quality, and greenhouse gas emissions. Soil and Tillage Research, 90: 171–183.

Malla, G., Bhatia, A., Pathak, H., Prasad, S., Jain, N. and Singh, J., 2005. Mitigating nitrous oxide and methane emissions from soil in rice–wheat system of the Indo-Gangetic plain with nitrification and urease inhibitors. Chemosphere, 58:141–147.

Mandal, S. And Adhikary, J. 2005, Effect of integrated nitrogen management on growth and yield of rice (*Oryza sativa* L.). Agricultural Sciences Digest, 25: 136-138.

MARDI (Malaysian Agriculture Research and Development Institute). 2002. *Manual penanaman padi berhasil tinggi* (1st edn) (High yielding rice cultivation manual). Institut Penyelidikan dan Kemajuan Pertanian Malaysia. Serdang, Malaysia. p. 12.

Marris, E. 2006. Putting the carbon back: Black is the new green. Nature, 442: 624–626.

Masschelyn, P. H., DeLaune, R. D. and Patrick Jr, W. H. 1993. Methane and nitrous oxide emissions from laboratory measurements of rice soil suspensions: effect of soil oxidation–reduction status. Chemosphere, 26:251-260.

Massey C. G., Slaton N. A., Norman R. J., Gbur E. E., Jr., DeLong R. E. and Golden B. R. 2011. Bermudagrass forage yield and ammonia volatilization as affected by nitrogen fertilization. Soil Science Society of American Journal, 75: 638-648.

McCarty, G.W. and Bremner, J. M. 1989. Laboratory evaluation of dicyandiamide as a soil nitrification inhibitor. Communication in Soil Science and Plant Analysis, 20: 2049–2065.

McGeough, K.L., Laughlin, R. J., Watson, C. J., Muller, C., Ernfors, M., Cahalan, E. and Richards, K. G. 2012. The effect of cattle slurry in combination with nitrate and the nitrification inhibitor dicyandiamide on in situ nitrous oxide and dinitrogen emissions. Biogeosciences Discuss, 9: 9169–9199.

Melillo, J. M. 1981. Nitrogen cycling in deciduous forests. In: Clark, F. E., Rosswall T. (Eds.), Terrestrial Nitrogen Cycles: Processes, Ecosystem Strategies and Management Impacts. Ecological Bulletins, Stockholm, pp. 427–442.

Menendez, S., Lopez-Bellido, R. J., Menitez-Vega, J., Gonzalez-Murua, C., Lopez-Bellido, L. and Estavillo, J. M. 2012. Long-term effect of tillage crop rotation and N fertilization to wheat on gaseous emissions under rainfed Mediterranean conditions. European Journal of Agronomy, 28: 559–69.

Meng, L., Ding, W. X., Cai, Z. C. 2005. Long-term application of organic manure and nitrogen fertilizer on N_2O emissions, soil quality and crop production in a sandy loam soil. Soil Biology and Biochemistry, 37, 2037-2045.

Merino, P., Estavillo, J. M., Graciolli, L. A., Pinto, M., Lacuesta, M., Munoz-Rueda, A. and Gonzalez-Murua, C. 2002. Mitigation of N_2O emissions from grassland by nitrification inhibitor and Actilith F_2 applied with fertiliser and cattle slurry. Soil Use and Management, 18: 135–141.

Ming-gang, X. U., Dong-chu, L. Ju-mei, Q. Dao-zhu, K. Yagi and Y. Hosen. 2008. Effects of Organic Manure Application with Chemical Fertilizers on Nutrient Absorption and Yield of Rice in Hunan of Southern China. Agricultural Science in China, 7: 1245-1252.

Monaghan, R. M., Smith, L. C. and Ledgard, S. F. 2009. The effectiveness of a granular formulation of dicyandiamide (DCD) in limiting nitrate leaching from a grazed dairy pasture, New Zeal. Journal of Agricultural Research, 52: 145–149.

Mondal, S. S. Sarkar, Sitangshu Ghosh Arup and Das, J. 2003, Response of summer rice (*Oryza sativa* L.) to different organic and inorganic sources of nutrients. Crop Research, 25: 219-222.

Mørkved, P. T., Dörsch, P. and Bakken, L. R. 2007. The N_2O product ratio of nitrification and its dependence on long-term changes in soil pH. Soil Biology and Biochemistry, 39: 2048-2057.

Morley, N., Baggs, E. M., Dorsch, P. and Bakken, L. 2008. Production of NO, N_2O and N_2 by extracted soil bacteria, regulation by NO_2 and O_2 concentrations. FEMS Microbiology Ecology, 65:102–112.

Mosier, A. R., Wassmann, R., Verchot, L., King, J. and Palm, C. 2004. Methane and nitrogen oxide flux in tropical agricultural soils: sources, sinks and mechanisms. Environment Development and Sustainability, 6: 11–49.

Motavalli, P.P., Goyne, K.W. and Udawatta, R.P. 2008. Environmental impacts of enhanced-efficiency nitrogen fertilizers. Online. Crop Management doi:10.1094/CM-2008-0730-02-RV.

Moyin Jesu E.I. 2007. Incorporation of agricultural biomass and their effects on growth and Nutrient content of four successive crops of amaranthus. ed. Porto Alegre: ARTMED. p. 719.

Muhrizal, S., Shamshuddin, J., Fauziah, I. and Husni, M.H.A. 2003. Alleviation of aluminum toxicity in acid sulfate soils in Malaysia using organic materials. Commun. Soil Science and Plant Analysis, 34: 2999-3017.

Muramoto, J., Goto, I. and Ninaki, M. 1992. Rapid analysis of exchangeable cation and cation exchange capacity (CEC) of soils by shaking extraction method. Japanese Journal of Soil Science and Plant Nutrition, 63: 210-215. (In Japanese with English summary)

Myint, A. K., Yamakawa, T. and Zenmyo, T. 2009. Plant growth, seed yield and apparent nutrient recovery of rice by the application of manure and fertilizer as different nitrogen sources on paddy soils. Journal of the Faculty of Agriculture, Kyushu University, 54: 329-337.

Myint, A. K., Yamakawa, T., Kajihara, Y. and Zenmyo, T. 2010. Aapplication of Different Organic and Mineral Fertilizers on the Growth, Yield and Nutrient Accumulation of rice in a Japanese Ordinary Paddy Field. Science World Journal, 5: 47-54.

Nachimuthu , G., Velu, V., Malarvizhi, P., Ramasamy, S. and Jayakumar Bose. 2007. Relationship Between Index Leaf Nitrogen and Leaf Colour Chart (LCC) Values in Direct Wet Seeded Rice (*Oryza sativa* L.). Asian Journal of Plant Science, 6: 477-483.

Nelson, D.W., and D. Huber. 2001. Nitrification inhibitors for corn production. NCH-55. Iowa State University.

Nemeth, J. A., Rafe, A., Steiner, M. and Goolsby, C. L. 1996. TIMP-2 growth-stimulatory activity: a concentration- and cell type-specific response in the presence of insulin. Experimental Cell Research, 224: 110-115.

Noguera, D., Kam-Rigne Laossi, M., Hoyos, V., Lavelle, P., de Carvalho, M.H.C. and Barot, S. 2010. Contrasted effect of biochar and earthworms on rice growth and resource allocation in different soils. Soil Biology and Biochemistry, 42: 1017–1027.

Nori, H., Halim, R. A. and Ramlan, M. F. 2008. Effects of Nitrogen Fertilization Management Practice on the Yield and Straw Nutritional Quality of Commercial Rice Varieties. Malaysian Journal of Mathematical Science, 2: 61-71.

Norton, J.M. 2008. Diversity of ammonia monooxygenase operon in autotrophic ammoniaoxidizing bacteria. Archive of Microbiology, 177:139–149.

O'Callaghan, M., Gerard, E. M., Carter, P. E, Lardnerb, R., Sarathchandrac, U., Burchc, G., Ghanic, A. and Bellc, N. 2010. Effect of the nitrification inhibitor dicyandiamide (DCD) on microbial communities in a pasture soil amended with bovine urine. Soil Biology and Biochemistry, 42: 1425–1436.

Ohyama, T., Ito, M., Kobayashi, K., Araki, S., Yasuyoshi, S., Sasaki, O., Yamazaki, T., Soyama, K., Tanemura, R., Mizuno, Y. and Ikarashi, T. 1991. Analytical procedures of N, P, K contents in plant and manure materials using H_2SO_4-H_2O_2 Kjeldahl digestion method. Bulletin of the Faculty of Agriculture, Niigata University.

Oo, C.O., Nnabude, P.C. and Omoba, E. 2007. Effects of kitchen waste compost and tillage on soil chemical properties in Nigeria. Journal of soil Science, 15: 69-71.

Pan, G., Li, L., Wu, L.S. and Zhang, X. 2004. Storage and sequestration potential of topsoil organic carbon in China's paddy soils. Global Change Biology, 10: 79–92.

Pan, G., Zhou, P., Li, Z., Smith, P., Li, L., Qiu, D., Zhang, X., Xu, X. Shen, S. and Chen, X. 2009. Combined inorganic/organic fertilization enhances N efficiency and increases rice productivity through organic carbon accumulation in a rice paddy from the Tai Lake region, China. Agriculture Ecosystems and Environment, 131: 274–280.

Pandey, C. B., Srivastava, R. C. and Singh, R. K. 2009. Soil nitrogen mineralization and microbial biomass relation, and nitrogen conservation in humid-tropics. Soil Science Society of American Journal, 73: 1142–1149.

Paramasivam, S., Fortenberry, G. Z., Julius, A., Sajwan, K. S. and Alva, A. K. 2008. Evaluation of emission of greenhouse gases from soils amended with sewage sludge. Journal of Environmental Science and Health, Part A. Toxic/Hazardous Substances and Environmental Engineering, 43: 178-185.

Parvez, M.S., Islam M.R., Begum, M.S. Rahman, M.S. and Abedin Miah M.J. 2008. Integrated use of manure and fertilizers for maximizing the yield of BRRI dhan30. Journal of the Bangladesh Society for Agricultural Science and Technology, 5: 257-260.

Pastor J., Aber J. D., McClaugherty C. A. and Mellilo J. M. 1984. Aboveground production and N and P cycling along a nitrogen mineralization gradient on Blackhawk Island, Wisconsin. Ecology, 65: 256-268.

Pathak, H. and Nedwell, D.B. 2001. Nitrous oxide emission from soil with different fertilizers, water levels and nitrification inhibitors. Water, Air and Soil Pollution. 129: 217-228.

Pathak, H., Bhatia, A., Prasad, S., Jain, M. C., Kumar, S., Singh, S. and Kumar, U. 2002. Emission of nitrous oxide from soil in rice-wheat systems of Indo-Gangetic plains of India. Environmental Monitoring and Assessment, 77: 163–178.

Peng, S. B., Buresh, R. J., Huang, J. L., Zhong, X. H., Zou, Y. B., Yang, J. C., Wang, G. H., Liu, Y. Y., Tang, Q. Y., Cui, K. H., Zhang, F. S. and Dobermann, A. 2010. Improving nitrogen fertilization in rice by site-specific N management. A review. Agronomy for Sustainable Development, 30: 649-656.

Peng, S. B., Huang, J. L., Zhong, X. H., Yang, J. C., Wang, G. H., Zou, Y. B., Zhang, F. S., Zhu, Q. S., Roland, B. and Christian, W. 2002. Research strategy in improving fertilizer-nitrogen use efficiency of irrigated rice in China. Agricultural Science in China, 35: 1095–1103. (in Chinese with English abstract)

Peng, S. Z., Li, D. X., Xu, J. Z., Ding, J. L., He, Y. and Yu, J. Y. 2007. Effect of water-saving irrigation on the law of CH_4 emission from paddy field. Environmental Science, 28: 9–13 (in Chinese)

Peng, S., Garcia, F.V., Laza, R.C., Sanico, A.L., Visperas, R.M. and Cassman, K.G. 1998. Increased N-use efficiency using a chlorophyll meter on high-yielding irrigated rice. Field Crops Research, 47:243-252.

Peng, S., Hou, H., Xu, J., Mao, Z., Abudu, S. and Luo, U. 2011. Nitrous oxide emissions from paddy fields under different water managements in southeast China. Paddy Water Environment, 9: 403–411.

Peterson, M. E., Curtin, D., Thomas, S., Clough, T. J. and Meenken, E. D. 2013. Denitrification in vadose zone material amended with dissolved organic matter from topsoil and subsoil. Soil Biol. Biochem., 61: 96-104.

Petersen, S. O., Regina, K., Pöllinger, A., Rigler, E., Valli, L., Yamulki, S., Esala, M., Fabbri, C., Syväsalo, E. and Vinther, F. P. 2003. Nitrous oxide emissions from organic and conventional rotations in five European countries. Agriculture, Ecosystems and Environment, 112: 200-206.

Philippot, L., Hallin, S. and Schloter, M. 2009. Ecology of denitrifying prokaryotes in agricultural soil. Advances in Agronomy, 96: 249-305.

Philippot, L., Hallin, S. and Schloter, M. 2007. Ecology of denitrifying prokaryotes in agricultural soil. In: Donald, L.S., editor. Advances in Agronomy, 96: 249-305.

Pittelkow, C. M., Adviento-Borbe, M. A., Hill, J. A., Six, J. van Kessel, C. and Linquist, B. A. 2013. Yield-scaled global warming potential of annual nitrous oxide and methane emissions from continuously flooded rice in response to nitrogen input. Agriculture, Ecosystems and Environment, 177: 10– 20.

Pramanik, P., Ghosh, G. K., Ghosal, P. K. and Banik P. 2007. Changes in organic - C, N, P and K and enzyme activities in vermicompost of biodegradable organic wastes under liming and microbial inoculants. Bioresource Technology, 98: 2485–94.

Prasad, R. and Power, J. F. 1995. Nitrification Inhibitors for Agriculture, Health, and the Environment. In: Donald, L.S. (Ed.), Advances in Agronomy. Academic Press, pp. 233-281.

Priha, O. and Smolander, A. 1995. Nitrification, denitrification and microbial biomass N in soil from two N-fertilized and limed Norway spruce forests. Soil Biology and Biochemistry, 27: 305– 310.

Qi, X., Nie, L., n Liu, H., Peng, S., Shah, F., Huang, J., Cui, K. and Sun, L. 2012. Grain yield and apparent N recovery efficiency of dry direct-seeded rice under different N treatments aimed to reduce soil ammonia volatilization. Field Crops Research, 134: 138–143.

Qiao, Y., Miao.a, S., Han, X., You, M., Zhu, X. and Horwath, W. R. 2014. The effect of fertilizer practices on N balance and global warming potential of maize–soybean–wheat rotations in Northeastern China. Field Crops Research, 161: 98–106.

Qiao-gang, Y., Jing, Y., Shao-na, Y., Jian-rong, F., Jun-wei, M., Wan-chun, S., Li-na, J., Qiang, W. and Jian-mei, W. 2013. Effects of Nitrogen Application Level on Rice Nutrient Uptake and Ammonia Volatilization. Rice Science, 20 : 139-147.

Raimbault M., Rinando G., Garcia J. L. and Boureau M. 1977. A device to study metabolic gases in the rice rhizosphere. Soil Biol. Biochem., 9: 193-196.

Rao, D., Niranjan and Mikkelsen D. S. 1976. Effect of rice straw incorporation on rice plant growth and nutrition. Agronomy Journal, 69: 752–755.

Rasmussen, P. E., Douglas Jr., C. L., Collins, H. P. and Albrecht, S. L. 1998. Long-term cropping system effects on mineralizable nitrogen in soil. Soil Biology and Biochemistry, 30: 1829-1 837.

Rasool, R., Kukal, S. S. and Hira, G. S. 2007. Soil physical fertility and crop performance as affected by long term application of FYM and inorganic fertilizers in rice-wheat system. Soil and Tillage Research, 96: 64 -72.

Rhoades, J.D, Kandiah. A, and Mashali, A.M. 1992. The use of saline waters for crop production. In: FAO Irrigation and Drainage Paper 48, Food and Agriculture Organization of the United Nations, Rome, Italy, p. 133

Rochette, P., Angers, D. A., Chantigny, M. H., Macdonald, D., Bissonnette, N. and Bertrand, N. 2008. Ammonia volatilization following surface application of urea to tilled and no-till soils: a laboratory comparison. Soil and Tillage Research, 103: 310–315.

Rogovska, N., Laird, D., Cruse, R., Fleming, P., Parkin, T. and Meek, D. 2011. Impact of biochar on manure carbon stabilization and greenhouse gas emissions. Soil Science Society of American Journal, 75: 871-879.

Russow, R., Spott, O. and Stange, C. F. 2008. Evaluation of nitrate and ammoniumas sources of NO and N_2O emissions from black earth soils (Haplic Chernozem) based on ^{15}N field experiments. Soil Biology and Biochemistry, 40: 380–391.

Rutger, J. N. 1981. Rice: *Oryza sativa*. In Handbook of Bioresources, ed. T.A. McClure and E.S. Lipinsky, pp.199-209. Boca Raton, Florida:CRS Press Inc.

Saha. P. K., Ishaque, M. Saleque, M. A. Miah, M. A. M. Panaullah, G. M. and Bhuiyan, N. I. 2007. Long-term integrated nutrient management for rice-based cropping pattern: effect on growth, yield, nutrient uptake, nutrient balance sheet, and soil fertility. Soil Science and Plant Analysis, 38: 579-610.

Sahrawat, K. L. 2006. Organic matter and mineralizable nitrogen relationships in wetland rice soils. Communication in Soil Science and Plant Analysis, 37: 787-796.

Santoro, A. E., Buchwald, C., McIlvin, M. R. and Casciotti, K. L. 2011. Isotopic signature of N_2O produced by marine ammonia-oxidizing archaea. Science 333:1282-1285.

Sanz-Cobena, A., Sánchez-Martín, L., García-Torres, L. and Vallejo A. 2012. Gaseous emissions of N_2O and NO and NO_3^- leaching from urea applied with urease and nitrification inhibitors to a maize *(Zea mays*) crop. Agriculture, Ecosystems and Environment, 149: 64-73.

SAS Institute. 1996. SAS User's Guide. SAS Institute Inc., Cary, NC, USA.

Sasaki, A., Ashikari, M., Ueguchi-Tanaka, M., Itoh, H., Nishimura, A., Datta, S. K., Ishiyama, K., Saito, T., Kobayashi, M., Khush, G. S., Kitano, H. and Matsuoka, M. 2002. Green revolution: a mutant gibberellin synthesis gene in rice. Nature, 416: 701-702.

Savant, N. K. and Dedatta, S. K. 1982. Nitrogen transformation in wetland rice soils. Adv. Agron., 35: 241-302.

Schiemenz, K. and Eichler-Loebermann, B. 2010. Biomass ashes and their phosphorus fertilizing effect on different crops. Nutrient Cycling in Agroecosystems, 87: 471-482.

Sepaskhah, A. R. and Barzegar, M. 2010. Yield, water and nitrogen-use response of rice to zeolite and nitrogen fertilization in a semi-arid environment. Agricultural Water Management, 98: 38–44.

Serrano-Silva, N., Luna-Guido, M., Luqueno-Fernandez, F., Ceballos, J.M., Marsch, R. and Dendooven, L. 2011. Dynamics of carbon and nitrogen and the emission of greenhouse gasses in an agricultural soil amended with urea: a laboratory study. Applied Soil Ecology, 47: 92-97.

Sey, B., Manceur, A., Whalen, J., Gregorich, E. and Rochette, P. 2008. Small-scale heterogeneity in carbon dioxide, nitrous oxide and methane production from aggregates of a cultivated sandy-loam soil. Soil Biology and Biochemistry, 40: 2468–2473.

Shang, Q., Yang, X., Gao, C., Wu, P., Liu, J., Xu, Y., Shen, Q., Zou, J. and Guo, S. 2011. Net annual global worming potential and greenhouse gas intensity in Chinese double rice-cropping systems: a 3-years field measurement in long term fertilizer experiments. Global change Biology, 17: 2196-2210.

Shibu, M.E., P.A. Leffelaar, H. Van Keulen, and P.K. Aggarwal. 2006. Quantitative description of soil organic matter dynamics: A review of approaches with reference to rice-based cropping systems. Geoderma, 137:1-18.

Shoun, H., Fushinobu, S., Jiang, L., Kim, S.W. and Wakagi, T. 2012. Fungal denitrification and nitricoxide reductase cytochrome P450nor. Philos. Trans. R. Soc. B., 367:1186-94.

Shukla, M. K., Slater, B. K., Lal, R. and Cepuder, P. 2004. Spatial variability of soil properties and potential management classification of a chernozemic field in lower. Australian Journal of Soil Science, 169: 852–860.

Singh, B. P., Hatton, B. J., Singh, B., Cowie, A. L. and Kathuria, A. 2010. Influence of biochars on nitrous oxide emission and nitrogen leaching from two contrasting soils. Journal of Environmental Quality, 37: 1432-1438.

Singh, J., Saggar, S., Giltrap, D. L. and Bolan, N. S. 2008. Decomposition of dicyandiamide (DCD) in three contrasting soils and its effect on nitrous oxide emission, soil respiratory activity, and microbial biomass – an incubation study. Australian Journal of Soil Research, 46: 517–525.

Singla, A. and Inubushi, K. 2014. Effect of Biogas Digested Liquid on CH_4 and N_2O Flux in Paddy Ecosystem. Journal of Integrative Agriculture, 13: 635-640.

Smith, J. L., Collins, H. P. and Bailey, V. L. 2010. The effect of young biochar on soil respiration. Australian Journal of Soil Science, 42: 2345-2347.

Smith, J. L., Halvorson, J. J. and Jr, H. B. 2002. Soil properties and microbial activity across a 500 m elevation gradient in a semi-arid environment. Soil Biology and Biochemistry, 34: 1749–1757.

Smith, P., Martino, D., Cai, Z. C., Gwary, D., Janzen, H., Kumar, P., McCarl, B., Ogle, S., O´Mara, F. and Rice, C. 2007. Policy and technological constraints to implementation of greenhouse gas mitigation options in agriculture. Agriculture, Ecosystems and Environment, 118: 6-28.

Snyder, C. S., Bruulsema, T. W., Jensen, T. L. and Fixen, P. E. 2009. Review of greenhouse gas emissions from crop production systems and fertilizer management effects. Agriculture, Ecosystems and Environment, 133: 247-266.

Sohi, S. P., Krull, E., Lopez-Capel, E. and Bol, R. 2010. A review of biochar and its use and function in soil. In: Sparks, D.L. (Ed.), 2010. Advances in Agronomy, 105: 47-82.

Spiertz, J. H. J. 2010. Nitrogen, sustainable agriculture and food security. A review. Agronomy for Sustainable Development, 30: 43-55.

Spokas, K. A. and Reicosky, D. C. 2009. Impacts of sixteen different biochars on soil greenhouse gas production. Annals of Environmental Science, 3: 179-193.

Stein, L. Y.2011. Surveying N_2O-producing pathways in bacteria. Research on nitrification and related processes, part 1-methods in enzymology. In: Klotz, M.G., editor. Michigan, Academic Press. pp. 131-52.

Steiner, C., Glaser, B., Teixeira, W.G., Lehmann, J., Blum, W.E.H. and Zech, W. 2008. Nitrogen retention and plant uptake on a highly weathered central Amazonian Ferralsol amended with compost and charcoal. Journal of Plant Nutrition and Soil Science, 171: 893–899.

Steiner, C., Teixeira, W.G., Lehmann, J., Nehls, T., Macêdo, J.L.V.D., Blum, W.E.H. and Zech, W. 2007. Long-term effects of manure, charcoal, and mineral fertilization on crop production and fertility on a highly weathered central Amazonian upland soil. Plant and Soil, 291: 275–290.

Stevens, R. J. and Laughlin, R.J. 2001. Effect of liquid manure on the mole fraction of nitrous oxide evolved from soil containing nitrate. Chemosphere, 42: 105-111.

Streubel, J. D., Collins, H. P., Garcia-Perez, M., Tarara, J., Granatstein, D. and Kruger, C. E. 2011. Influence of contrasting biochar types on five soils at increasing rates of application. Soil Science Society of American Journal, 75: 1402-1413.

Su., C. G., Yin, B., Zhu, Z. L. and Shen, Q. R. 2005. Gaseous loss of nitrogen from fields and wet deposition of atmospheric nitrogen and their environmental effects. Soils (in Chinese), 37: 113-120.

Suna, H., Zhangc, H., Powlsond, D., Mina, J. and Shia, W. 2015. Rice production, nitrous oxide emission and ammonia volatilization as impacted by the nitrification inhibitor2-chloro-6-(trichloromethyl)-pyridine. Field Crops Research, 173: 1-7.

Suvarnalatha, A. J. 2001 Integrated use of fertilizer and poultry manure on nutrient availability and yield of rice Abstract of M.Sc. (Agri) Thesis. Journal of Research ANGRAU, 32 (3): 126.

Suzuki, A. 1997. Fertilization of rice in Japan. Japan FAO Association, Tokyo, Japan.

Tao, F., Hayashi, Y., Zhang, Z., Sakamoto, T. and Yokozawa, M. 2008. Global warming, rice production and water use in China: Developing a probabilistic assessment. Agric. For. Meteorol., 148: 94-110.

Tenuta, M. and Beauchamp, E. G. 2003. Nitrous oxide production from granules of different sizes. Journal of Environnmental Quality, 29: 1408–1413.

Thelen, K. D., Fronning, B. E., Kravchenko, A., Min, D. H. and Robertson, G. P. 2010. Integrating livestock manure with a cornesoybean bioenergy cropping system improves short-term carbon sequestration rates and net global warming potential. Biomass and Bioenergy, 34: 960-966.

Tian, Y. H., Yin, B., Yang, L. Z., Yin, S. X. and Zhu, Z. L. 2007. Nitrogen runoff and leaching losses during rice-wheat rotations in Taihu Lake region, China. Pedosphere, 17: 445-456.

Tiedje, J.M. 1988. Ecology of denitrification and dissimilatory nitrate reduction to ammonium. In: Zehnder, A. J. B, editor. Biology of anaerobic microorganisms. California: Wiley, pp. 179-244.

Tillman, D., Cassman, K. G., Matson, P. A., Naylor, R. and Polasky, S. 2002. Agricultural sustainability and intensive production practices. Nature, 418: 671-677.

Totok Suswanto, Shamshuddin, J., Syed Omar, S. R., Peli Mat and Teh, C. B. S. 2007. Alleviating An Acid Sulfate Soil Cultivated To Rice (*Oryza Sativa*) Using Ground Magnesium Limestone And Organic Fertilizer. Jurnal Tanah dan Lingkungan, 9: 1-9.

Tran, K.T. and Vo, T.G. 2004. Effects of mixed organic and inorganic fertilizers on rice yield and soil chemistry of the 8^{th} crop on heavy acid sulfate soil (Hydraquentic Sulfaquepts) in the Mekong Delta of Vietnam. A paper presented at the 6th International Symposium on Plant Soil at Low pH. August 1-5, 2004; Sendai: Japan.

Turner, F. T. and Jund, M. F. 1994. Assessing the nitrogen requirements of rice crops with a chlorophyll meter. Australian Journal of Experimental Agriculture, 34:1001−1005.

USDA (United State Department of Agriculture). 2008. Economic research Service Briefing Room. The economics of food, farming, natural, resources and rural America.

Ussiri, D. and Lal, R. 2013. Soil Emission of Nitrous Oxide and its Mitigation, DOI 10.1007/978-94-007-5364-8-7, Springer Science, Business Media, Dordrecht.

Vallejo, A., Diez, J. A., Lopez-Valdivia, L. M., Gasco, A. and Jiminez, C. 2001. Nitrous oxide emission and denitrification nitrogen losses from soils treated with isobutylenediurea and urea plus dicyandiamide. Biology and Fertility of Soils, 34: 248–257.

van Groenigen, J. W., Velthof, G. L., Oenema, O., Van Groenigen, K. J. and Van Kessel, C. 2010. Towards an agronomic assessment of N_2O emissions: a case study for arable crops. European Journal of Soil Science, 61: 903–913.

van Zwieten, L., Kimber, S., Morris, S., Downie, A,. Berger, E., Rust, J. and Scheer, C. 2009. Influence of biochars on flux of N_2O and CO_2 from Ferrosol. Soil Research, 48: 555–568.

van Zwieten, L., Kimber, S., Morris, S., Downie, A., Berger, E., Rustm J, and Scheer, C. 2010. Influence of biochars on flux of N_2O and CO_2 from Ferrosol. Soil Research, 48: 555–568.

Varinderpal, S., Bijay, S., Yadvinder, S., Thind, H. S. and Gupta, R. K. 2010. Need based nitrogen management using the chlorophyll meter and leaf colour chart in rice and wheat in South Asia: a review. Nutrient Cycling in Agroecosystems, 88: 361-380.

Velthof, G. L. and Oenema, O. 1993. Nitrous oxide flux from nitric-acid-treated cattle slurry applied to grassland under semi-controlled conditions, Netherlands Journal of Agricultural Science, 41: 81–93.

Velthof, G. L., Kuikrnan, P. J. and Oenema, O. 2003. Nitrous oxide emission from animal manures applied to soil under controlled conditions. Biology and Fertility of Soils, 37: 221-230.

Venterea, R. T., Burger, M. and Spokas, K. A. 2005. Nitrogen oxide and methane emissions under varying tillage and fertilizer management. Journal of Environmental Quality, 34: 1467–1477.

Venterea, R.T. and Stanenas, A.J. 2008. Profile analysis and modeling of reduced tillage effects on soil nitrous oxide flux. Journal of Environmental Quality, 37: 1360-1367.

Vitousek, P. M., Naylor, R. and Crews, T. 2009. Nutrient imbalances in agricultural development. Science, 19: 1519–1520.

von Lutzow, M. and Kogel-KNabner, I. 2009. Temperature sensitivity of soil organic matter decomposition-what do we know? Biology and Fertility of Soils, 46: 1–15.

Walter, M., Westhead, E. K., Pizarro, C. and Sikora, L. 2005. Recycling of manure nutrients: use of algal biomass from dairy manure treatment as a slow release fertilizer. Bioresource Technology, 96: 451-458.

Wang, Y., Ke, X., Wu, L. and Lu, Y. 2009. Community composition of ammonia-oxidizing bacteria and archaea in rice field soil as affected by nitrogen fertilization. Systematic and Applied Microbiology, 32, 27-36.

Wang, J. Y., Jia, J. X., Xiong, Z. Q., Khalil, M. A. K. and Xing, G.X. 2011. Water regime–nitrogen fertilizer–straw incorporation interaction: Field study on nitrous oxide emissions from a rice agroecosystem in Nanjing, China. Agriculture, Ecosystems and Environment, 141: 437– 446.

Wang, L. F., Cai, Z. C., Yang, L. F. and Meng, L. 2005. Effects of disturbance and glucose addition on nitrous oxide and carbon dioxide emissions from a paddy soil. Soil and Tillage Research, 82: 185-194.

Watanabe, T., Masaki, K., Iwashita, K., Fujii T. and Iefuji H. 2009. Treatment and phosphorus removal from high-concentration organic wastewater by the yeast Hansenula anomala J224 PAWA. Bioresour Technol., 100:1781-1785.

Weiske, A., Benckiser, G. and Ottow, J.C.G. 2001. Effect of the new nitrification inhibitor DMPP in comparison to DCD on nitrous oxide (N_2O) emissions and methane (CH_4) oxidation during 3 years of repeated applications in field experiments. Nutrient Cycling in Agroecosystems, 60: 57–64.

Wei-xin, D., Lei, M., Zu-cong, C. and Feng-xiang, H. 2007. Effects of long- term amendment of organic manure and nitrogen fertilizer on nitrous oxide emission in a sandy loam soil. Journal of Environmental Sciences, 19: 185-193.

Wilson, C.E. Jr., Norman, R.J. and Wells, B.R. 1990. Dicyandiamide influence on uptake of preplant-applied fertilizer nitrogen by rice. Soil Science Society of American Journal 54: 136-152.

Wlodarczyk, T. Stêpniewska, Z. and Brzeziñska, M. 2003. Denitrification, organic matter and redox potential transformations in Cambisols. Int. Agrophysics, 17: 219-227.

Wlodarczyk, T., Stêpniewski W. and Brzeziñska, M. 2005. Nitrous oxide production and consumption in Calcaric Regosols as related to soil redox and texture. Int. Agrophysics, 19: 263-271.

Wrage, N., Velthof, G. L., van Beusichem, M. L. and Oenema, O. 2001. Role of nitrifier denitrification in the production of nitrous oxide. Soil Biology and Biochemistry, 33: 1723-1732.

Xing, G., Zhao, X., Xiong, Z., Yan, X., Xu, H., Xie, Y. and Shi, S. 2009. Nitrous oxide emission from paddy fields in China. Acta Ecologica Sinica, 29: 45–50.

Xiong, Z. Q., Xing, G. X. and Zhu, Z. L. 2007. Nitrous oxide and methane emissions as affected by water, soil and nitrogen. Pedosphere, 17: 146-155.

Xu, M. G., Li, D. C., Li, J. M., Qin, D. Z., Kazuyuki, Y. and Yasukazu, H. 2008. Effects of organic manure application combined with chemical fertilizers on nutrients absorption and yield of rice in Hunan of China. Agricultural Science in China, 41: 3133–3139. (in Chinese with English abstract)

Xu, R. L., Dai, Q. G., Huo, Z. Y. and Wang, X. Q. 2005. Effects of nitrogen fertilizer quantity on different rice variety quality. J Yangzhou Univ: Agriculture and Life Sciences, 26: 66–68, 84. (in Chinese with English abstract)

Yadav, R.L., Dwivedi, B.S. and Pandey, P.S., 2000. Rice–wheat croppingsystem: assessment of sustainability under green manuringand chemical fertilizer inputs. Field Crops Research, 65: 15–30.

Yaduvanshi, N.P.S. 2003. Substitution of inorganic fertilizers by organic manures and the effect on soil fertility in a rice-wheat rotation on reclaimed sodic soil in India. Journal of Agriculture Science (Cambridge), 140: 161-169.

Yan, X. Y., Akimoto, H. and Ohara, T. 2003. Estimation of nitrous oxide, nitric oxide and ammonia emissions from croplands in East, Southeast and South Southeast and South Asia. Global Change Biology, 9: 1080–1096.

Yang, C. M., Yang, L. Z., Yan, T. M. and Ou, Y. Z. 2004. Effects of nutrient regimes on dry matter production and nutrient uptake and distribution by rice plant. Chinese Journal of Soil Science, 35: 199–202. (in Chinese with English abstract)

Yang, S. H., Peng, S. Z., Xu, J. Z. and Wang, P. F. 2010. Influences of different water and fertilizer treatments on distribution of nitrogen profiles and loss of ammonia volatilization in soils of paddy fields. Advance of Science and Technology in Water Resource, 30: 40–44 (in Chinese).

Yao, Z., Zheng, X., Dong, H., Wang, R., Mei, B. and Zhu, J. 2012. A 3-year record of N_2O and CH_4 emissions from a sandy loam paddy during rice seasons as affected by different nitrogen application rates. Agriculture, Ecosystems and Environment, 152: 1-9.

Yao, Z., Zhou, Z., Zheng, X., Xie, B., Mei, B., Wang, R., Bahl, K. B. and Zhu, J. 2010. Effects of organic matter incorporation on nitrous oxide emissions from rice–wheat rotation ecosystems in China. Plant and Soil, 327: 315–330.

Yaqub, M., Mahmood, T., Akhtar, M. Iqbal, M.M. and Ali, S. 2010. Induction of mungbean as a grain legume in the annual rice-wheat double cropping system. Pakistan Journal of Botany, 42: 3125-3135.

Ye, Y., Liang, X., Chen, Y, Liu, J., Gu, J. Guo, R. and Li, L. 2013. Alternate wetting and drying irrigation and controlled-release nitrogen fertilizer in late-season rice. Effects on dry matter accumulation, yield, water and nitrogen use. Field Crops Research, 144: 212–224.

Yogananda, S. B., Reddy, V. C. and Sudhir, K., 2004, Effect of urban compost and inorganic fertilizers on soil nutrient status and grain yield of hybrid rice. Mysore Journal of Agricultural Science, 38: 454-458.

Yu, K. W., Wang, Z. P., Vermoesen, A., Jr Patrick, W.H. and Van Cleemput O. 2001. Nitrous oxide and methane emission from different soil suspensions: effect of soil redox status. Biol. Fertil. Soils, 34: 25-30.

Yuan, L., Zhang, Z., Cao, X., Zhu, S. and Zhang, X. 2014. Responses of rice production, milled rice quality and soil properties tovarious nitrogen inputs and rice straw incorporation undercontinuous plastic film mulching cultivation. Field Crops Research, 155: 164–171.

Zacherl, B. and Amberger, A. 1990. Effect of the nitrification inhibitors dicyandiamide, nitrapyrin and thiourea on *Nitrosomonas europaea*. Fertilizer Research, 22: 37-44.

Zaman, M., Zaman, S., Adhinarayanan, C., Nguyen, M. L., Nawaz, S. and Dawar, K. M. 2013. Effects of urease and nitrification inhibitors on the efficient use of urea for pastoral systems. Soil Science and Plant Nutrition, 59: 649-659.

Zaman M. and Nguyen M.L., 2012. How application timings of urease and nitrification inhibitors affect N losses from urine patches in pastoral system. Agriculture, Ecosystems and Environment, 156: 37-48.

Zaman, M. and Blennerhassett J.D. 2010. Effects of the different rates of urease and nitrification inhibitors on gaseous emissions of ammonia and nitrous oxide, nitrate leaching and pasture production from urine patches in an intensive grazed pasture system. Agriculture, Ecosystems and Environment, 136: 236-246.

Zaman, M., Nguyen, M.L., Blennerhassett, J.D. and Quin, B.F. 2008. Reducing NH_3, N_2O and NO_3^--N losses from a pasture soil with urease or nitrification inhibitors and elemental S-amended nitrogenous fertilizers. Biology and Fertility of Soils, 44: 693-705.

Zaman, M., Saggar, S., Blennerhassett, J. D. and Singh, J. 2009. Effect of urease and nitrification inhibitors on N transformation, gaseous emissions of ammonia and nitrous oxide, pasture yield and N uptake in grazed pasture system. Soil Biology and Biochemistry, 41: 1270–1280.

Zeng, X., Han, B., Xu, F., Huang, J., Caia, H., and Shi, L. 2012. Effects of modified fertilization technology on the grain yield and nitrogen use efficiency of midseason rice. Field Crops Research, 137: 203–212.

Zerulla, W., Barth, T., Dressel, J., Erhardt, K., von Locquenghien, K. H., Pasda, G., R¨adle, M., and Wissemeier, A. H. 2001. 3, 4-Dimethylpyrazole phosphate (DMPP) – a new nitrification inhibitor for agriculture and horticulture, Soil Biology and Biochemistry, 34: 79–84.

Zhang, J., Zhu, T. Meng, T., Zhang, Y., Yang, J., Yang, W., Müller, C. and Cai, Z. 2013. Agricultural land use affects nitrate production and conservation in humid subtropical soils in China. Soil Biology & Biochemistry, 62: 107-114.

Zhang, A., Bian, R., Pan, G., Cui, L., Hussain, Q., Li, L., Zheng, J., Zheng, J., Zhang, X., Han, X. and Yu, X. 2012. Effects of biochar amendment on soil quality, crop yield and greenhouse gas emission in a Chinese rice paddy: A field study of 2 consecutive rice growing cycles. Field Crops Research, 127: 153–160.

Zhang, A., Cui, L., Pan, G., Li, L., Hussain, Q., Zhang, X., Zheng, J., Crowley, D. 2010. Effect of biochar amendment on yield and methane and nitrous oxide emissions from a rice paddy from Tai Lake plain, China. Agriculture, Ecosystems and Environment, 139: 469–475.

Zhang, H. M., Wang, B. R., Xu, M. G. and Fan, T. L. 2009. Crop yield and soil responses to long-term fertilization on a Red Soil in Southern China. Pedosphere, 19: 199-207.

Zhang, M., Heaney, D., Solberg, E. and Heriquez, B. 2001. The effect of MSW compost on metal uptake and yield of wheat, barley and canola in less productive farming soils of Alberta. Compost Science and Utilization, 8: 224–235.

Zhang, Y. M., Chen, D. L., Zhang, J. B., Edis, R., Hu, C. S. and Zhu, A. N. 2004. Ammonia volatilization and denitrification losses from an irrigated maize-wheat rotation field in the north China plain. Pedosphere, 14: 533-540.

Zhao, X., Min, J., Wang, S., Shi, W. and Xing, G. 2011. Further understanding of nitrous oxide emission from paddy fields under rice/wheat rotation in south China. Journal of Geophysical Research. 116. doi:10.1029/2010jg001528

Zhao, X., Xie, Y., Xiong, Z., Yan, X., Xing, G. and Zhu, Z. 2009. Nitrogen fate and environmental consequence in paddy soil under rice-wheat rotation in the Taihu lake region, China. Plant and Soil 319:225–234.

Zheng, X. H., Wang, M. X., Wang, Y. S., Shen, R. X., Gou, J., Li, J., Jin, J. S. and Li, L.T. 2000. Impacts of soil moisture on nitrous oxide emission from croplands: a case study on the rice-based agro-ecosystem in Southeast China, Chemosphere-Global Change Science, 2: 207–224.

Zheng, X., Han, S., Huang, Y., Wang, Y. and Wang, M. 2004. Re-quantifying the emission factors based on field measurements and estimating the direct N_2O emission from Chinese croplands. Global Biogeochemistry Cycles, 18: 380-389.

Zou, J. W., Huang, Y., Lu, Y. Y., Zheng, X. H. and Wang, Y.S. 2005. Direct emission factor for N_2O from rice winter wheat rotation systems in southeast China. Atmospheric Environment, 39: 4755–65.

Zou, J. W., Huang, Y., Zheng, X. H. and Wang, Y. S. 2007. Quantifying direct N_2O emissions in paddy fields during rice growing season in mainland China: dependence on water regime. Atmospheric Environment, 41: 8030–8042.

Zou, J., Liu, S., Qin, Y., Pan, G. and Zhu, D. 2009. Sewage irrigation increased methane and nitrous oxide emissions from rice paddies in southeast China. Agriculture, Ecosystems and Environment, 129: 516–522.

LIST OF PUBLICATIONS

Shamsuzzaman, S. M., Hanafi, M.M., Saud, H. M., Samsuri, A.W. Begum, M. and Jantan, N. M. 2015. Impact of niitrification inhibitor with palm oil byproducts and urea on nitrogen dynamics and N_2O emission in acid sulphate soil. Wulfenia Journal (accepted).

Shamsuzzaman, S. M., Hanafi, M.M., Saud, H. M., Samsuri, A.W. Begum, M. and Jantan, N. M. 2015.Impact of Nitrification Inhibitor with Organic Manure and Urea on Nitrogen dynamics and N_2O emission in Acid Sulphate Soil. Bragantia (accepted).

Shamsuzzaman, S. M., Hanafi, M.M., Saud, H. M., Samsuri, A.W. Begum, M. and Jantan, N. M. 2015. Effect of Nitrification Inhibitor with Organic Manure and Urea on Nutrient Accumulation and Yield of MR219 Rice in Acid Sulphate Soil. Bangladesh Journal of Botany (accepted).

Shamsuzzaman, S. M., Hanafi, M.M., Saud, H. M., Samsuri, A.W. Begum, M. and Jantan, N. M. 2015. Effect of Nitrification Inhibitor with Organic Manure and Urea on Protein and Mineral Contents in Grain of MR219 Rice Cultivated in Acid Sulphate Soil. Bangladesh Journal of Botany (accepted).

Shamsuzzaman, S. M., Hanafi, M.M., Saud, H. M., Samsuri, A.W. Begum, M. and Jantan, N. M. 2015. Impact of Nitrification Inhibitor with Oil Palm Deviated Organic Manure and urea on Nitrogen Dynamics and N_2O Emission in Acid Sulphate Soil. Asian Journal of Chemistry (accepted).

Shamsuzzaman, S. M., Hanafi, M.M., Saud, H. M., Samsuri, A.W., Razi Ismail, M. and Begum, M. 2015.Impact of Dicyandiamide (DCD) on Nitrogen Use Efficiency and Yield Performance of MR219 Rice in Acid Sulphate Soil treated with organic manure and urea. Journal of Environmental Biology (submitted).

Shamsuzzaman, S. M., Hanafi, M.M., Saud, H. M., Samsuri, A.W., Razi Ismail, M. and Begum, M. 2015. Minimization of N_2O emission from MR219 rice planted acid sulphate soil through integrated use of nitrification inhibitor, organic manure, and urea. Polish Journal of Environmental studies (submitted).