

## Influence of biochars on flux of N<sub>2</sub>O and CO<sub>2</sub> from amended ferrosol

Van Zwieten, L<sup>a\*</sup>; Kimber, S<sup>a</sup>; Morris, S<sup>a</sup>; Downie, A<sup>b</sup>; Berger, E<sup>a</sup>; Rust, J<sup>a</sup>

<sup>a</sup>NSW Industry and Investment, 1234 Bruxner Highway, Wollongbar NSW 2477 Australia; <sup>b</sup>Pacific Pyrolysis, Somersby NSW 2250 Australia

\*E-mail: lukas.van.zwieten@industry.nsw.gov.au

Key words: *greenhouse gas flux, nitrogen, mechanism*

### Introduction

Nitrous oxide (N<sub>2</sub>O) is a potent greenhouse gas with global warming potential 298 times greater than the equivalent mass of CO<sub>2</sub> in the atmosphere. Anthropogenic sources of N<sub>2</sub>O contributed 3 GT CO<sub>2</sub>e, around 8 % of global emissions in 2004 with agriculture being responsible for 42 % of this total [1].

N<sub>2</sub>O is formed in soil through three key biological mechanisms, nitrification, nitrifier denitrification and denitrification. Denitrification is often discussed as the main pathway for N<sub>2</sub>O production [2], occurring primarily in moist soils. The key processes controlling production of N<sub>2</sub>O are however not well understood [3]. The factors that significantly influence emissions of N<sub>2</sub>O from farmed soil can include; N application rate, the form of N that has been applied, crop type, soil organic C content, pH and redox, water content and gas diffusivity.

N enters soil primarily through the application of fertilizers, biological N<sub>2</sub> fixation, addition of organic material and the excreta of animals. Independent of the source of N, IPCC (1997) assign a value 1.25 % conversion of soil nitrogen to N<sub>2</sub>O, although values greater than this have been recorded in some agricultural systems. For example, up to 21 % of applied N in a sugarcane crop in northern NSW, Australia, was converted into N<sub>2</sub>O [4], equivalent to 45.9 kg N<sub>2</sub>O-N/ha/ annum.

Recently, biochar application to soil has been suggested as a means of reducing N<sub>2</sub>O emissions [5,6], although data supporting these observations are still limited.

### Results and Discussions

In an attempt to better understand the influence of biochars on processes which lead to emissions of N<sub>2</sub>O, we tested a range of contrasting biochars under conditions where emissions would be expected. Soil microcosms containing acidic red ferrosol were amended with biochars derived from the slow pyrolysis of greenwaste (GW), poultry litter waste (PL), papermill waste (PS) and biosolids (BS), as well as the un-pyrolysed GW feedstock. These

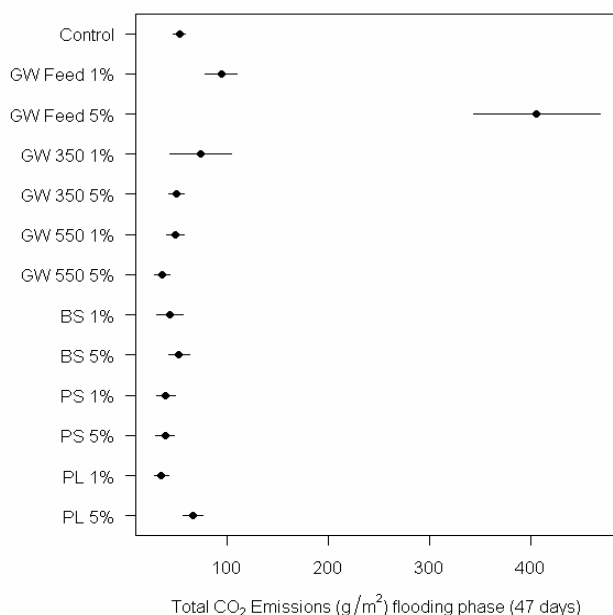
amendments were applied at rates of 1 and 5% w/w. Following stabilisation of emissions and ageing of the biochar in soil, the microcosms were amended with 165 kg N/ha (as solubilised urea). At field capacity moisture contents, this did not result in significant emissions of N<sub>2</sub>O. Upon stabilisation of emissions, the microcosms were flooded. During this phase, significant emissions occurred from all treatments with the control soil releasing the greatest amount at 3165 mg N<sub>2</sub>O-N m<sup>2</sup>. The percentage of N lost to N<sub>2</sub>O during the incubation (totaling 134 days) is described in Table 1.

**Table 1:** Total N lost as N<sub>2</sub>O during the 134 day incubation.

Treatment	Amendment rate	% N lost as volatilized N <sub>2</sub> O
Control		15.2
GW feedstock	1%	9.0
GW feedstock	5%	3.9
GW 350 °C	1%	9.0
GW 350 °C	5%	8.7
GW 550 °C	1%	7.5
GW 550 °C	5%	5.6
BS	1%	4.8
BS	5%	2.5
PS	1%	4.5
PS	5%	5.2
PL	1%	6.7
PL	5%	4.0

Across the entire incubation, the control lost 15.2% of the applied N as N<sub>2</sub>O. This is significantly greater than the 1.25% default value, but not as great as some of the "worst case" scenarios [4].

All of the amendments resulted in statistically significant reduction in N<sub>2</sub>O flux, with the greatest reduction resulting from application of biochar from biosolids. Mechanisms for reduced emissions following amendment with greenwaste feedstock were possibly due to increased C:N ratio and altering microbial availability of N. Both amendments with the un-pyrolysed feedstock resulted in greater metabolic activity measured by CO<sub>2</sub> emissions (Figure 1).



**Figure 1.** Soil CO<sub>2</sub> emissions during the flooding phase of incubation.

The greenwaste feedstocks also resulted in significantly lower nitrate-N concentrations in the soils throughout the incubation, probably due to the metabolic demand for N.

The reduction in emissions from the biochar amendments however could not be explained by changes in metabolic activity. Likewise, differences in mineral N in the soil throughout the incubation could not explain reductions in N<sub>2</sub>O emission, and they remained similar to controls. The amendments with PL, BS and PS biochars however all resulted in significantly higher pH's in soils (Table 2).

It was hypothesised that the biochars which influenced soil pH, drove denitrification through to dinitrogen during the flooding phase, although a range of mechanisms for reduction in N<sub>2</sub>O emissions were likely to have occurred simultaneously.

**Table 2.** Soil pH following incubation

Treatment	Amendment rate	pH
Control		4.2
GW feedstock	1%	4.3
GW feedstock	5%	4.3
GW 350 °C	1%	4.3
GW 350 °C	5%	4.4
GW 550 °C	1%	4.2
GW 550 °C	5%	4.5
BS	1%	4.9
BS	5%	6.2
PS	1%	6.1
PS	5%	6.8
PL	1%	4.8
PL	5%	5.9

## Conclusions

Organic amendments were capable of altering the emission of N<sub>2</sub>O during a 134 day incubation. It was likely that different mechanisms were responsible for reduced N<sub>2</sub>O flux. Further studies are required to understand mechanisms involved.

<sup>1</sup> Denman, K. L. et al. 2007 Couplings Between Changes in the Climate System and Biogeochemistry. In: Solomon S, et al. (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, United Kingdom and New York, NY, USA.

<sup>2</sup> Opdyke, M. R.; Ostrom, N.E.; Ostrom, P. H. 2009 Global Geochem.Cycles 23

<sup>3</sup> Hernandez-Ramirez, G.; Brouder, S. M.; Smith, D. R.; Van Scoyoc, G. E.; Michalski, G. 2009 Soil Sci. Soc. Am. J. 73, 1182-1191.

<sup>4</sup> Denmead, O. T.; Macdonald, B.; Naylor, T.; Wand, W.; Salter, B.; White, I.; Wilson, S.; Griffith, D.; Moody, P. 2008 Proc. Aust. Soc. Sugar Technol. 30, 105-114.

<sup>5</sup> Van Zwieten, L.; Bhupinderpal-Singh; Joseph, S.; Kimber, S.; Cowie, A.; Chan, Y. 2009 In Biochar for Environmental Management. Earthscan pp227-249.

<sup>6</sup> Singh, B-P.; Hatton, B. J.; Singh, B.; Cowie, A. L.; Kathuria, A. (2010) JEQ 39, 1224-1235.