NSW DEPARTMENT OF PRIMARY INDUSTRIES

The University of Sydney

Biochar reduces N_2O emissions and nitrogen leaching from soils

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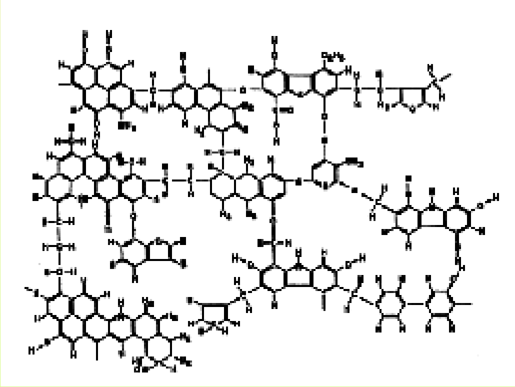
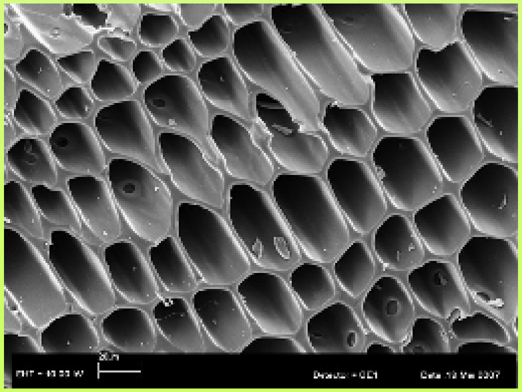
What is ‘biochar’?

Biochar is a carbon-rich material (also known as black carbon, charcoal or char) produced through the burning of biomass preferably in thermal reactors at 300 to 600°C in an oxygen-limited environment, a process called pyrolysis.



Biochar properties:

- Predominant aromatic structure
- Highly porous
- Alkaline (usually)
- Large specific surface area and CEC
- Source of many essential nutrients

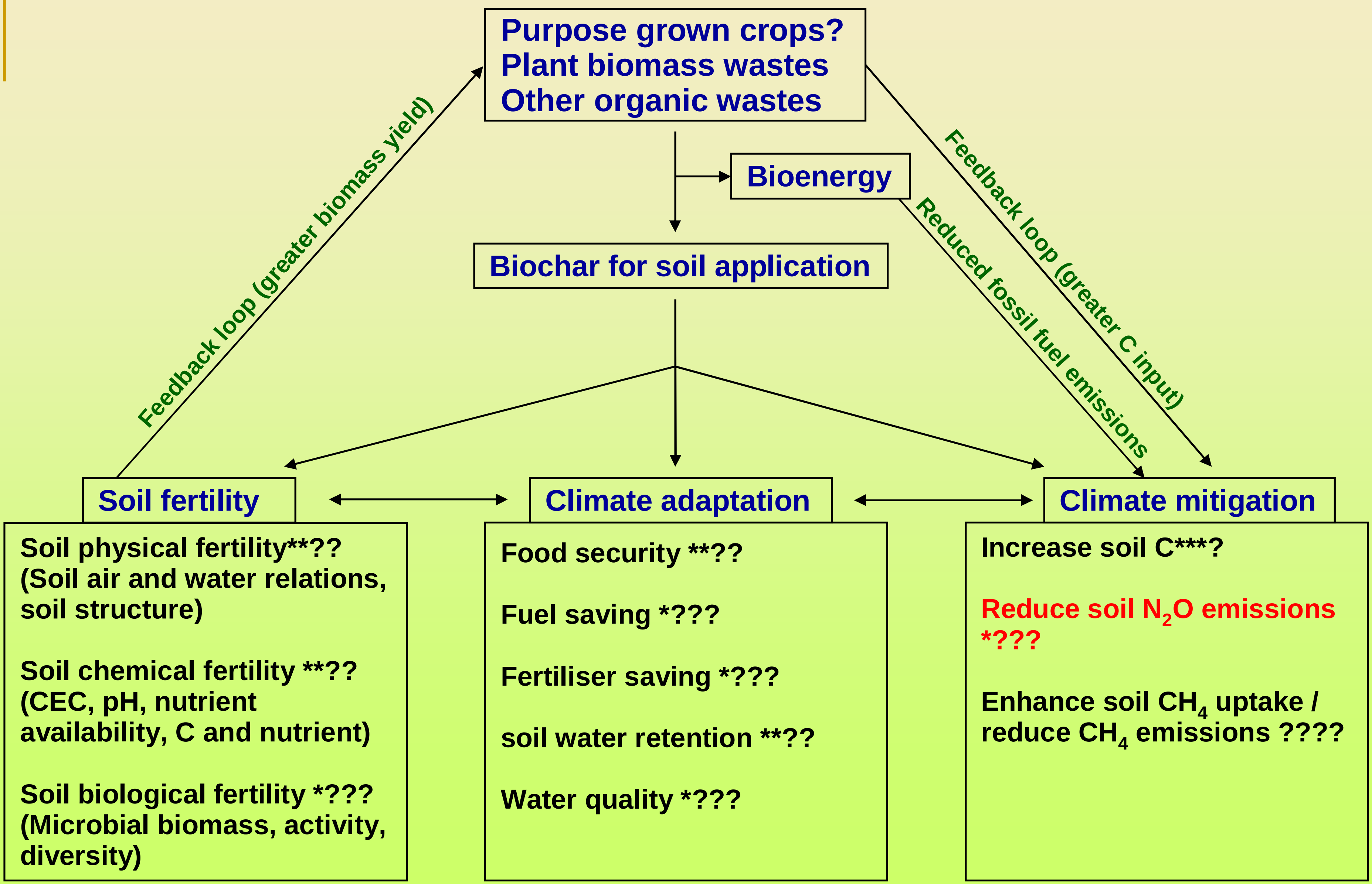


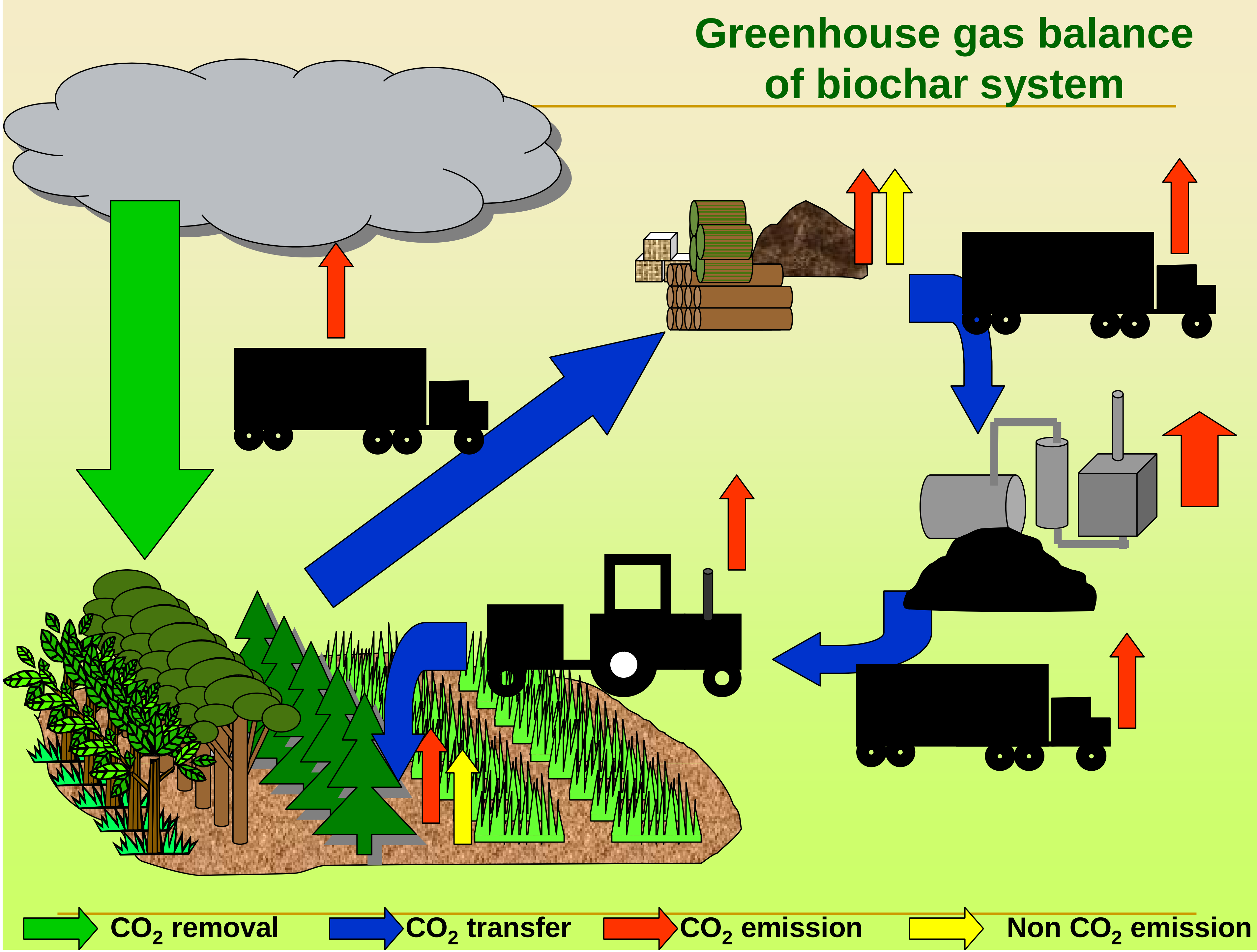
Claims about biochar:

- Carbon negative technology?

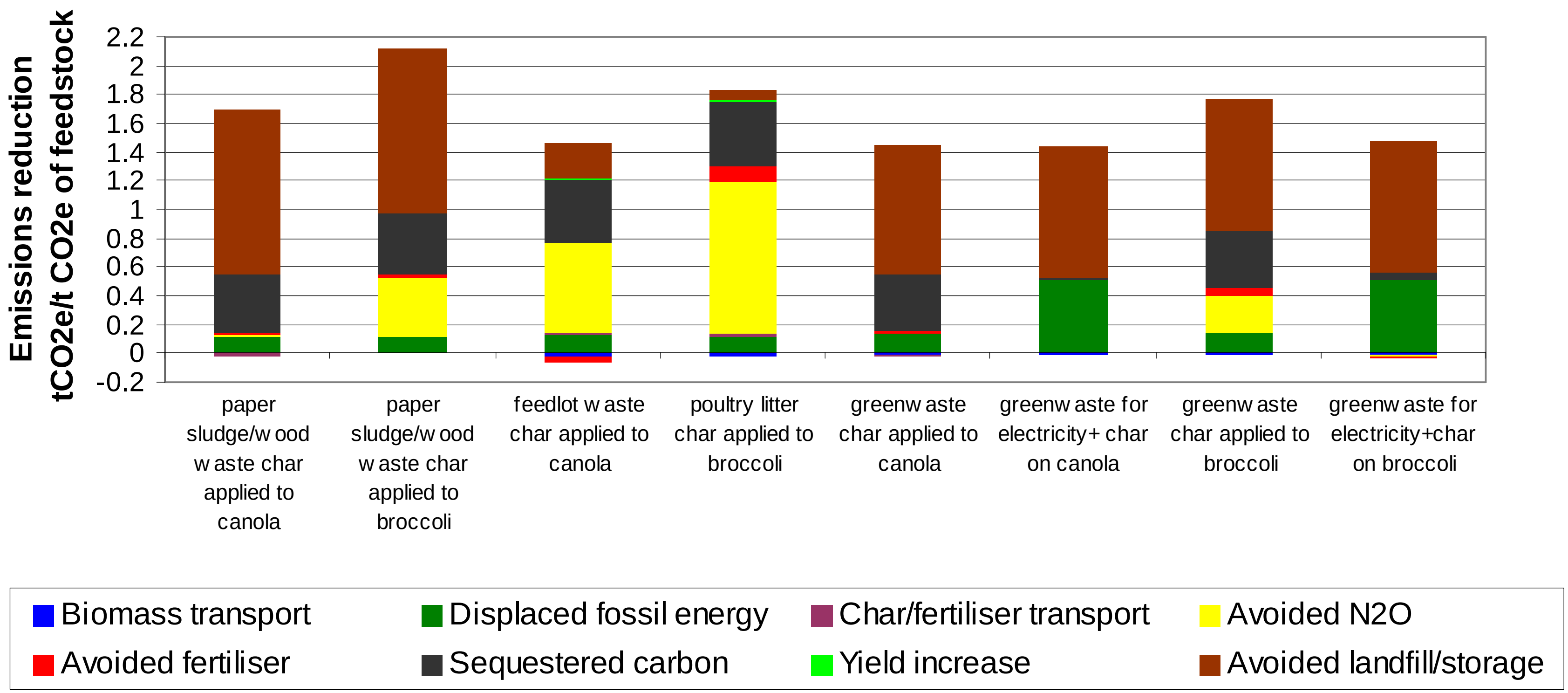
S. Joseph

Benefits of ‘biochar’ production and application?

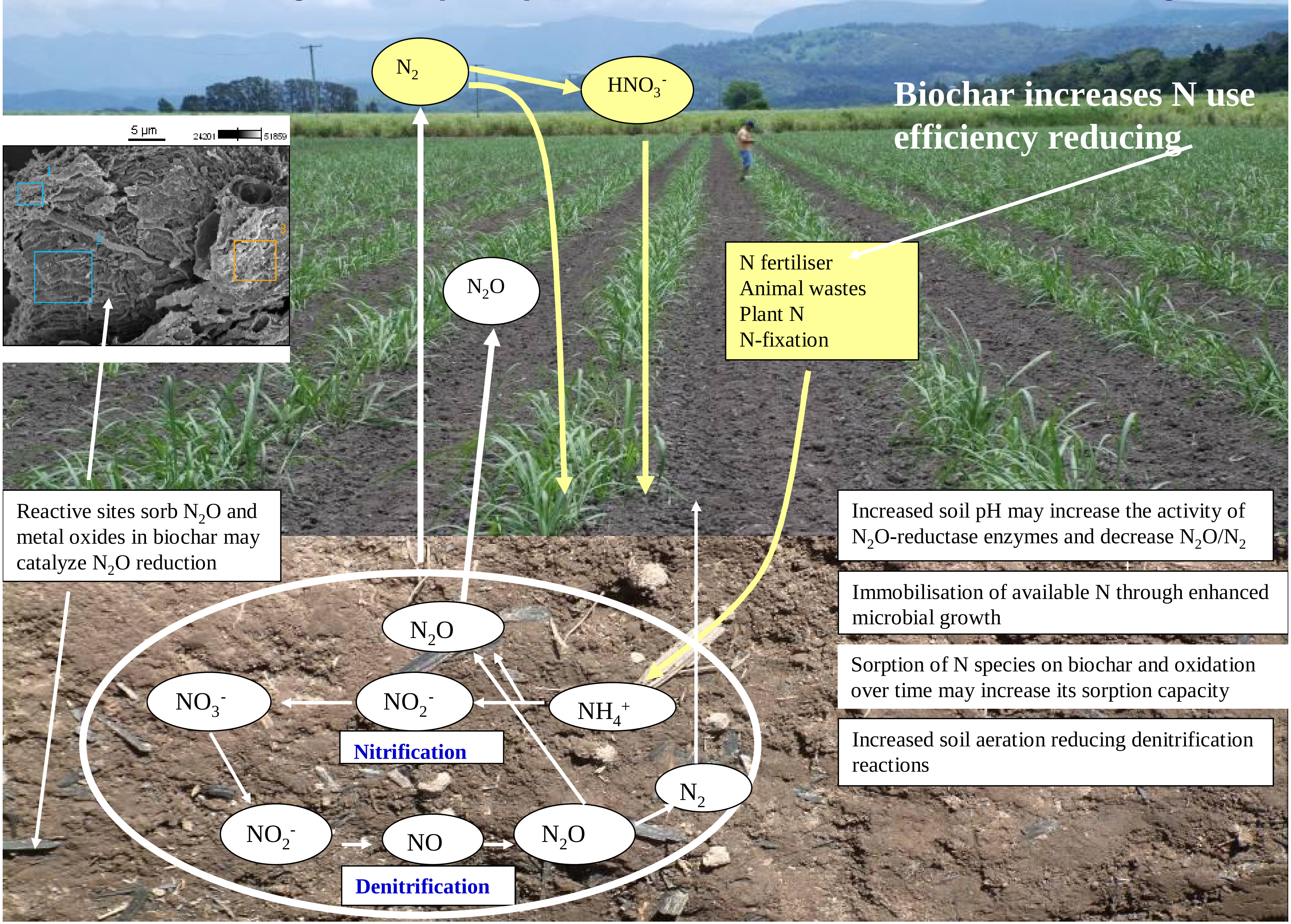



Greenhouse gas balance
of biochar system
CO2 removal
CO2 transfer
CO2 emission
Non CO2 emission

Factors contributing to mitigation



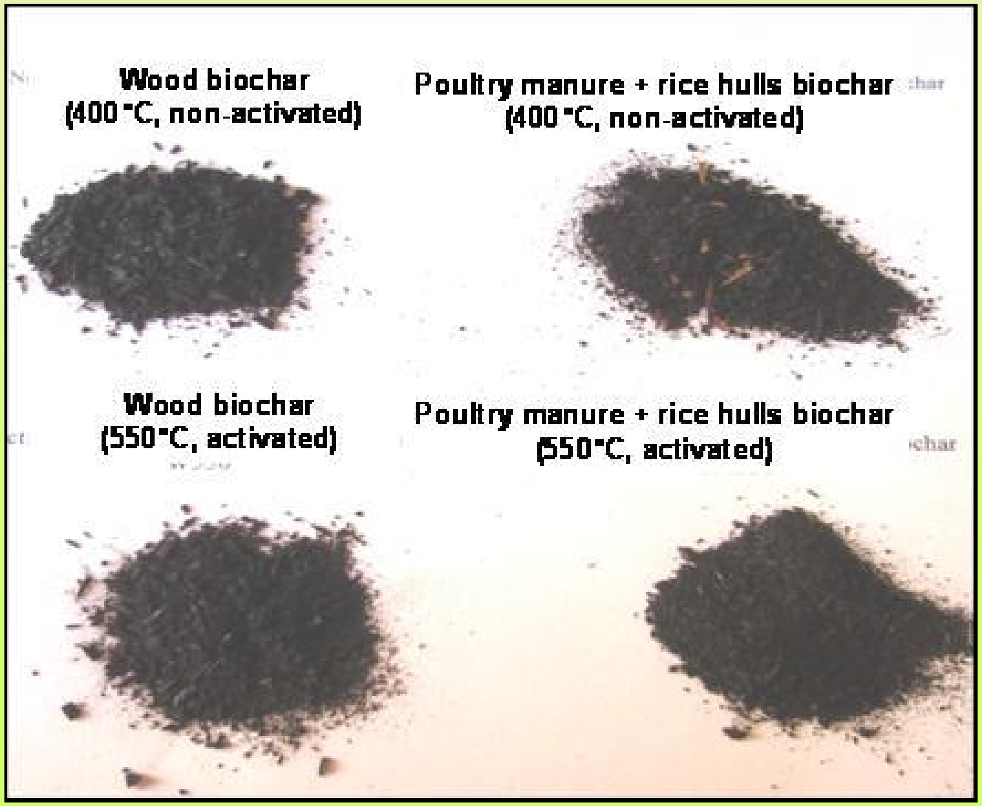
Van Zwieten, Singh et al. (2009). In: Biochar for Environmental Management



Laboratory incubation experiment

- To assess the influence of four biochars on the emission of N_2O and leaching of NO_3^--N and NH_4^+-N from two contrasting soils subjected to 3 W–D cycles over a 5-mo period.

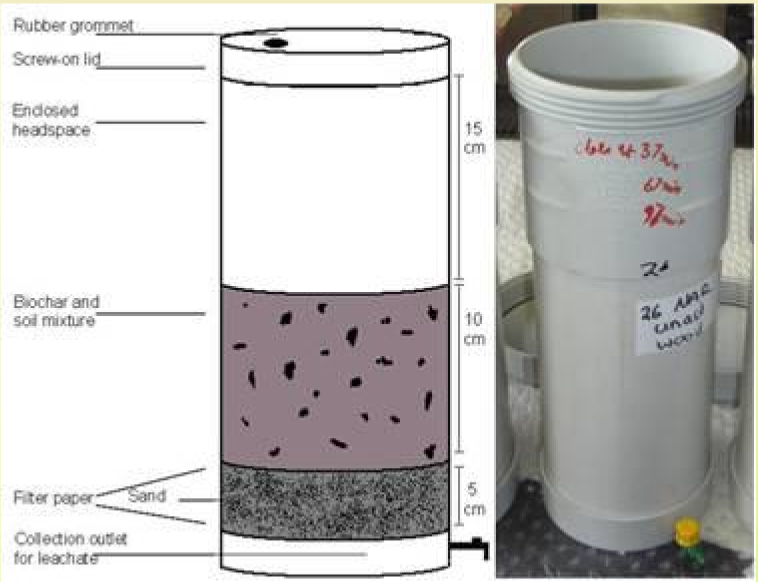
- **Four biochars used were:**
  - Wood biochar (400 °C, NA)
  - Wood biochar (550 °C, A)
  - Poultry litter biochar (400 °C, NA)
  - Poultry litter biochar (550 °C, A)

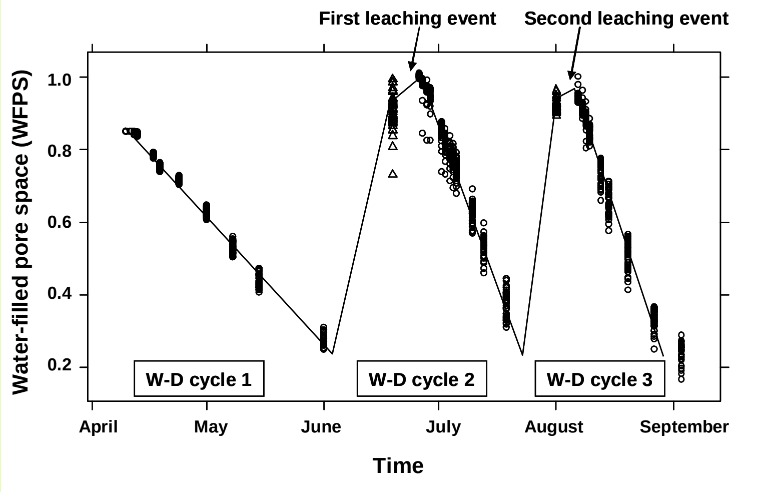


- **Two soils used were:**
  - An Alfisol (sandy loam)
  - A Vertisol (cracking clay)

Laboratory incubation experiment

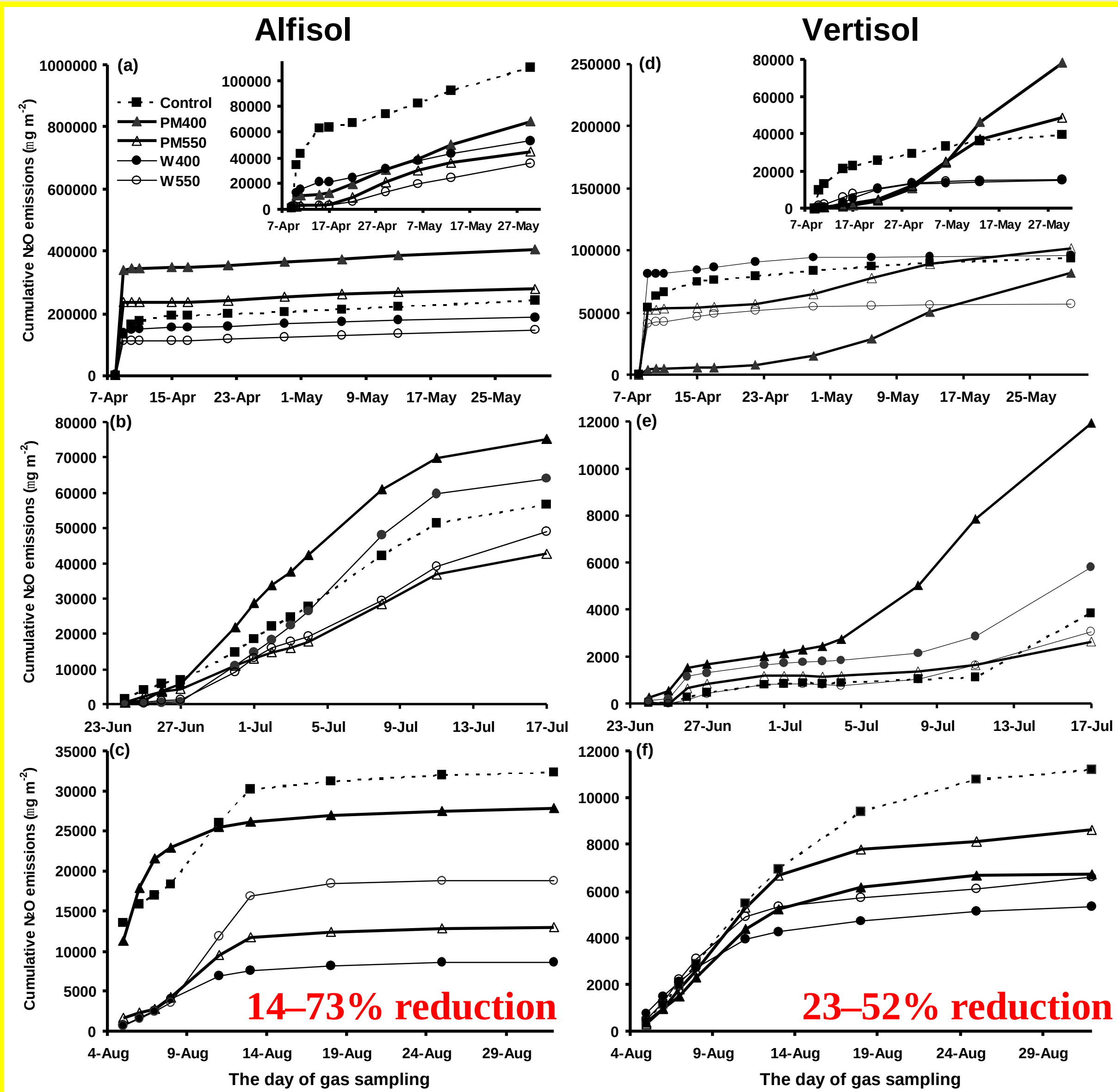
- Biochars or acid-washed sand (control) were mixed with soil.
- Soil-biochar mixtures, adjusted to 0.85 water-filled pore space were packed to 1.3 g cm^{-3} bulk density in PVC columns.
- Glucose-C and nutrient (N, P, K) solution were added.
- Gas samples were collected from the enclosed headspace and analysed for N_2O.
- Following drying to ~0.3 WFPS, the soils were rewetted and gas sampling was continued.
- Leachate was collected at the start of the second and third W-D cycles.



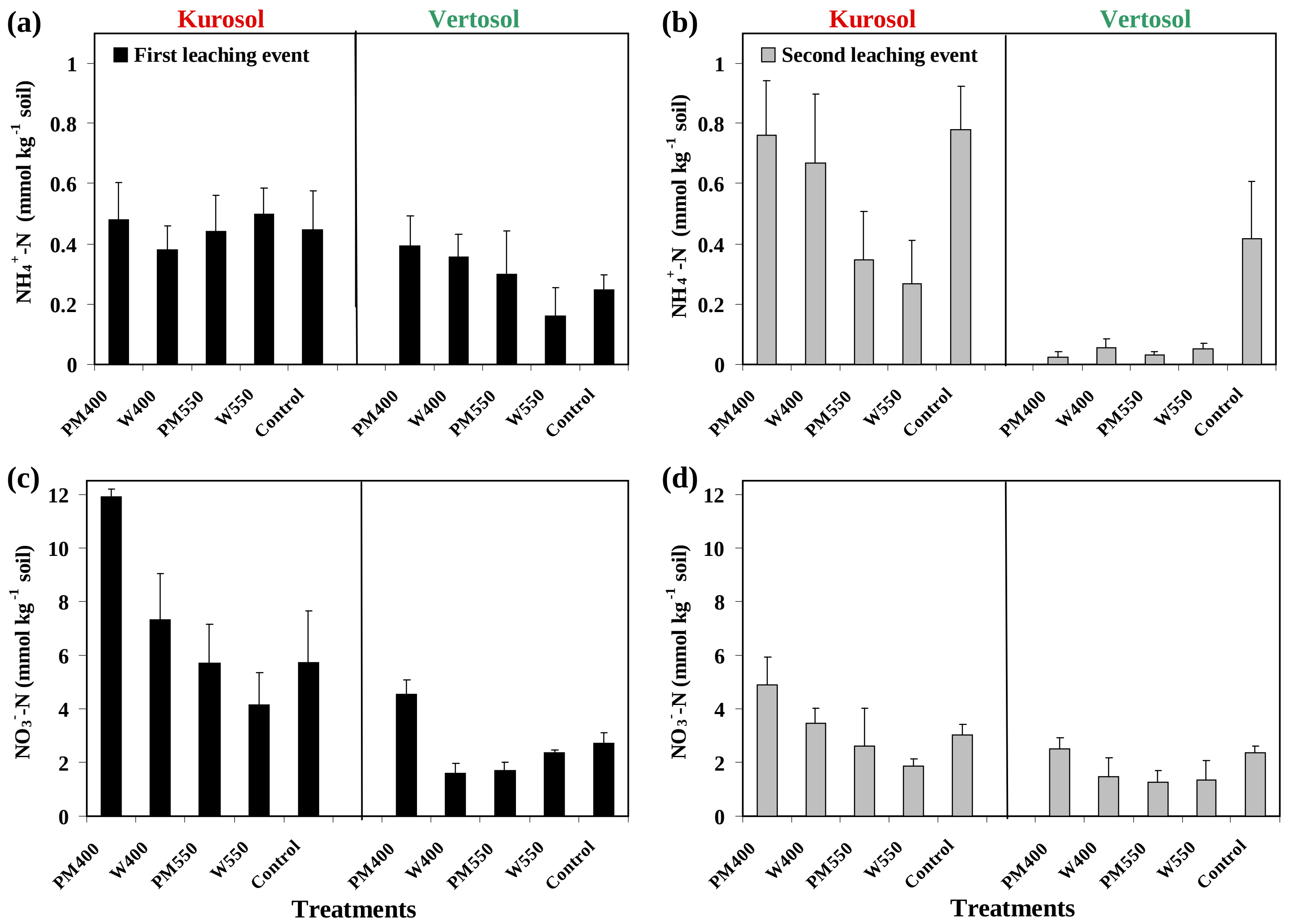


Results: Cumulative N_2O emissions

Singh et al. 2010 (JEQ, accepted)



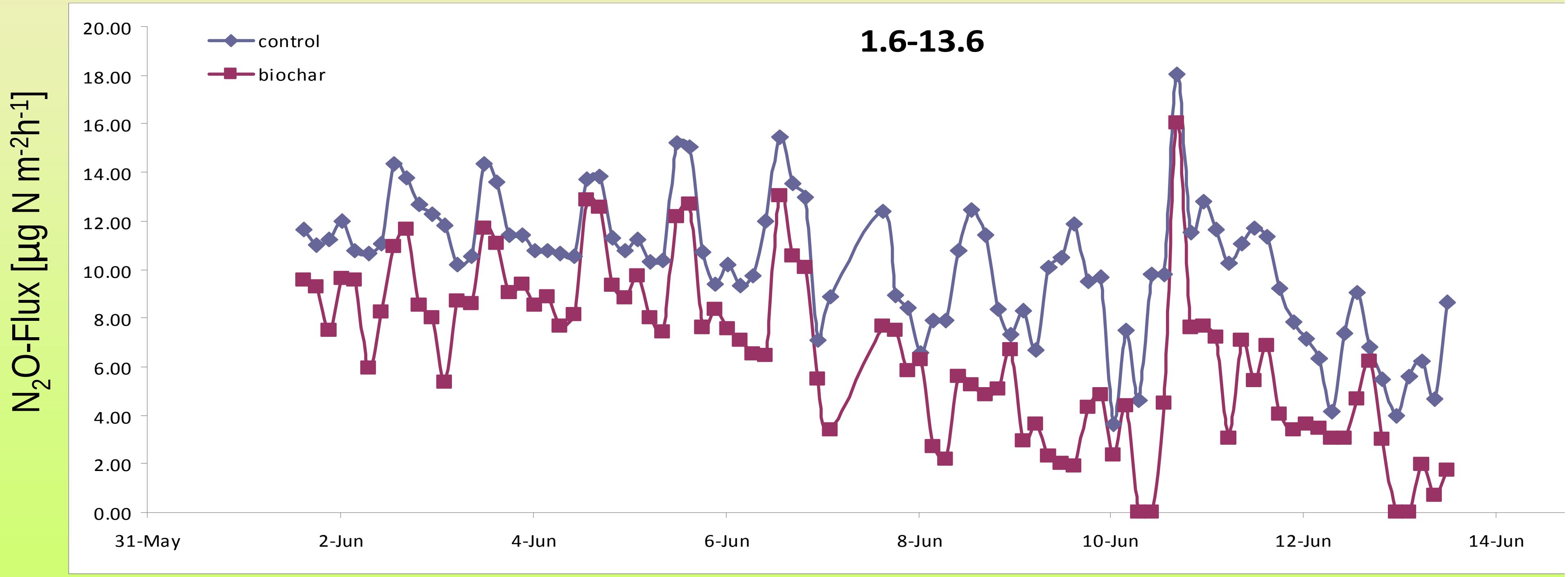
Results: Inorganic N leaching



Inorganic -N (NH_4^+-N, NO_3^--N) leaching from two soils (Kurosol, Vertosol) as affected by biochars

Van Zwieten et al.

Biochar applied in 2006 and gas flux measurement in 2009 using automated chambers



Control = no biochar amendment, fertiliser at N=46units, P=28 units, K =50 (kg/ha)
Biochar = 10t/ha biochar (described in previous slide) applied in December 2006

Project focus: future DAFF funding

Conclusions

- Biochar application can be effective in reducing N_2O emissions and N leaching from soils.
- Initially, in the first 4 months, biochars had inconsistent effects on soil N_2O emissions and inorganic-N leaching.
- After 4 months, all biochars tested, including PM400, effectively decreased soil N_2O emissions by up to 70%, and NH_4^+-N leaching by up to 94%, relative to the control.
- We propose that this increased effectiveness of biochars in reducing soil N losses over time is due to an increase in sorptive properties as biochar 'ages' through oxidative reactions on the biochar surfaces.

Influence of Biochars on Nitrous Oxide Emission and Nitrogen Leaching from Two Contrasting Soils

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The influence of biochar on nitrogen (N) transformation processes in soil is not fully understood. This study assessed the influence of four biochars (wood and poultry manure biochars synthesized at 400°C, nonactivated, and at 550°C, activated, abbreviated as: W400, PM400, W550, PM550, respectively) on nitrous oxide (N_2O) emission and N leaching from an Alfisol and a Vertisol. Repacked soil columns were subjected to three wetting–drying (W–D) cycles to achieve a range of water-filled pore space (WFPS) over a 5-mo period. During the first two W–D cycles, W400 and W550 had inconsistent effects on N_2O emissions and the soils amended with PM400 produced higher N_2O emissions relative to the control. The initially greater N_2O emission from the PM400 soils was ascribed to its higher labile intrinsic N content than the other biochars. During the third W–D cycle, all biochar treatments consistently decreased N_2O emissions, cumulatively by 14 to 73% from the Alfisol and by 23 to 52% from the Vertisol, relative to their controls. In the first leaching event, higher nitrate leaching occurred from the PM400-amended soils compared with the other treatments. In the second event, the leaching of ammonium was reduced by 55 to 93% from the W550- and PM550-Alfisol and Vertisol, and by 87 to 94% from the W400- and PM400-Vertisol only (cf. control). We propose that the increased effectiveness of biochars in reducing N_2O emissions and ammonium leaching over time was due to increased sorption capacity of biochars through oxidative reactions on the biochar surfaces with ageing.

There has been an increased interest in biochar research in recent years due to its potential beneficial effects on soil properties. Biochar is the product of biomass that has been thermally decomposed at 300 to 600°C under partial or complete exclusion of oxygen (pyrolysis). Biochars usually possess strong aromatic structure and hence are biochemically more recalcitrant than many other forms of organic matter in soil (Skjemstad et al., 1996; Baldock and Smernik, 2002). Oxidation of biochar in soil occurs at a slow rate (Kuzyakov et al., 2009), which leads to the production of negatively-charged functional groups, such as carboxyl and phenolic groups, on its surfaces (Liang et al., 2006; Cheng et al., 2008). Biochars are highly porous, usually alkaline, and exhibit large specific surface area (Glaser et al., 2002; Downie et al., 2009). Due to these inherent chemical and physical properties, biochars can potentially influence a number of soil properties including soil pH, porosity, bulk density, and water holding capacity (Glaser et al., 2002; Chan et al., 2007). Furthermore, biochars sorb ions from soil solution by a combination of electrostatic, complexation, and capillary forces on their surfaces and in pores (Major et al., 2009; Moreno-Castilla, 2004). These properties of biochars can potentially [illegible]

Results: N_2O emission rates