Managing soil N using combined application of crop residue and N fertiliser: What is the environmental cost?

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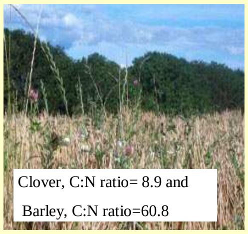
Integrated Nutrient Management: a panacea to soil fertility and productivity decline in Africa?



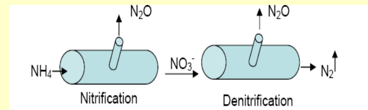
Clover, C:N ratio= 8.9 and
Barley, C:N ratio=60.8

Sustainable agriculture encompasses ecological, social, economic and even policy dimensions.

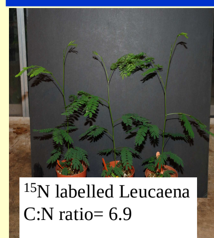
Introduction

- Increasing N_2O emissions are of global concern because of this gas role in stratospheric ozone layer depletion and greenhouse effect
- Direct and indirect emissions from agricultural systems are now thought to contribute significantly to the total global source strength.
- Nitrification and denitrification are the two most important microbial-mediated processes responsible for soil N_2O emissions following application of organic and/or inorganic N sources

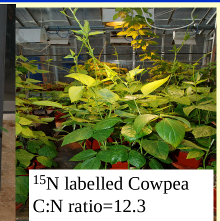
To study the effect of combined application (at different proportional ratios) of crop residues of different quality and N fertiliser on soil N release and N_2O emissions



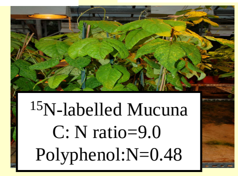
*The "hole in pipe" conceptual model (Firestone and Davidson 1989).



[15]N labelled Leucaena
C:N ratio= 6.9
Polyphenol:N=0.8



[15]N labelled Cowpea
C:N ratio=12.3
Polyphenol:N =0.23



[15]N-labelled Mucuna
C: N ratio=9.0
Polyphenol:N=0.48

Hypothesis: **Fertiliser would supply readily available mineral N. Crop residue would provide organic C source for microbial activity and may also immobilise mineral N from N fertiliser. Therefore** Soil N release and magnitude of N_2O emissions following combined application of crop residues and N fertiliser would depend on the quality (C:N ratio, polyphenol content) of crop residue and ratio of fertiliser N : residue N applied.

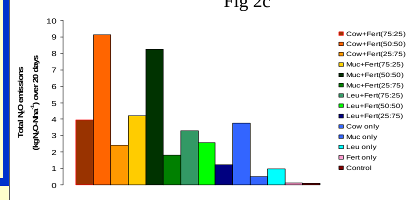
Experiments

A laboratory soil microcosm experiment was conducted in 500ml Kilner jars with 200g soil(60% WFPS, 18ºC)

1. Barley residues, clover residues and/ or N fertiliser(NH_4NO_3) were incubated at 100mgNkg^{-1}(100:0; 25:75;50:50;75:25;0:100, residue N: fertiliser N respectively) in a silty clay soil from NE Scotland
2. [15]N- labelled tropical leguminous species (3.14-4.09 atom %) (Cowpea, Leucaena and Mucuna) were applied either solely or in combination with N fertiliser as in Experiment 1 to a tropical sandy loam soil.

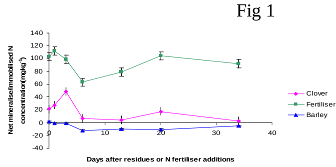
Soil inorganic N (NO_3^- and NH_4^+) concentration was measured colorimetrically, N_2O emissions were determined by gas chromatography and 15N-N_2O concentration was determined using mass spectrometry.

Fig 2c



Total N_2O emissions(kgN_2O-Nha^{-1}) following applications of crop residues and /or N fertilisers to soils

Fig 1

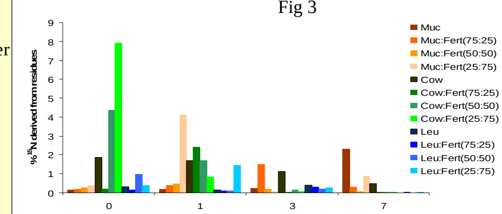


Net mineralised/immobilised N turnover following sole applications of crop residues or N fertiliser

Results

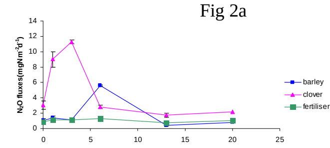
1. Sole clover and sole fertiliser additions resulted in net N mineralisation but sole barley addition led to net N immobilisation(Fig 1)
2. Higher N_2O emissions from sole residues and sole fertiliser additions(Fig 2a). Combined application of N fertiliser and residues further enhanced N_2O emissions (Fig 2b &c)
3. Higher % ^{15}N-N_2O was derived from higher quality (low C:N ratio, low polyphenol content) cowpea and mucuna residues than from low quality leucaena residues (Fig 3)

Fig 3



% ^{15}N derived from residue following combined application of mucuna, cowpea or leucaena and N fertiliser

Fig 2a

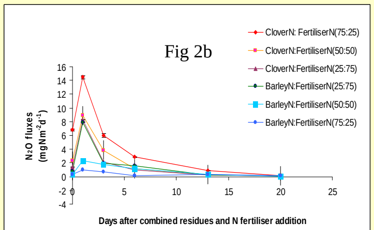


Daily N_2O fluxes(mgN_2O-Nm^{-2}d^{-1}) following sole application of crop residues or N fertiliser to soils

Conclusions

1. Residue contribution to N_2O was short-lived
2. Combined application of crop residue and N fertiliser increased N availability and N_2O emissions depending on the quality (chemical composition) of the residues, and the percentage of inorganic-N applied
3. N_2O emissions were influenced largely by C:N ratio in temperate species and polyphenol:N ratio in tropical species
4. Higher quality (low polyphenol) residues emitted more N_2O

Fig 2b



N_2O fluxes (mgNm^{-2}d^{-1}) following combined application of crop residue and fertiliser to soils

Fig 4a

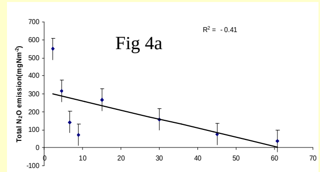


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Fig 4b