ASSESSING THE RELATIVE POTENTIAL OF ORGANIC AMENDMENTS TO EMIT SOIL N_2O: TOWARDS A STANDARD METHOD

A. Charles[1,2], P. Rochette[1], J. Whalen[2], M. Chantigny[1], D. Angers[1] and N. Bertrand[1]

[1] Agriculture and Agri-Food Canada, Québec, QC, G1V 2J3, Canada

[2] Department of Natural Resource Sciences, McGill University, Québec, Canada, H9X 3V9

Agriculture et Agroalimentaire Canada / Agriculture and Agri-Food Canada

McGill

Centre SÈVE recherche en sciences du végétal

INTRODUCTION

Agricultural soils emit nitrous oxide (N_2O), a potent greenhouse gas and a dominant ozone-depleting substance [1]. Predicting and mitigating soil N_2O emissions is not easy, especially following the application of organic amendments because of their variable composition and complex interactions with soil biota and minerals.

OBJECTIVES

To develop a standard method to **classify organic amendments** (OAs) and assess:

The Relative Potential of Organic Amendments to enhance soil net N_2O emissions ($RPOA_{N_2O}$)

Criteria for a standard method include the ability to:

1. discriminate OAs based on their $RPOA_{N_2O}$
2. provide reasonably robust $RPOA_{N_2O}$ estimates
3. run large numbers of experimental units

MATERIALS AND METHODS

Comparative laboratory incubations

- 92 days, darkness, 22°C
- Clay loam soil (0-10 cm), sieved at 6 mm, Carbon content = 36.27 g gk^{-1} dry soil

4 METHODS WITH 1 OXIC-ANOXIC CYCLE

		Dry-Wet soil cycle method [2] (DW)	Iso-soil moisture method + C_2H_2 (ISO^+)	Closed-jar method (CJ^-)	Closed-jar method + C_2H_2 (CJ^+)
Jars		Open 1-h flux		Closed $[N_2O]$ monitoring	
Soil moisture (SM)		20 to 33%	30%	30%	
Phase 1	Duration	57 days	57 days	2 to 14 days	
	Oxic phase	SM : 30 → 20%		$[O_2]$ jar headspace: 21 to 5%	
Phase 2	Duration	35 days		78 to 90 days	
	Anoxic event	Rewetting to SM: 20 % → 33% → 20%	N_2 Flush at 10% C_2H_2	N_2 Flush	N_2 Flush at 10% C_2H_2

7 TYPES OF FERTILIZATION

	Properties							Application rate
	C/N ratio	total C	total N	Dry matter	NO_3-N	NH_4-N	Lignin	N-input
		g kg-1	g kg-1	g kg-1	mg kg^{-1}	mg kg^{-1}	%, dry basis	kg-N/ha
Control								
Fertilizer (NH_4NO_3)		--	343	996	2.66E+05	7.71E+04	--	120
Pig slurry	na	na	4	53	0.0	46.8	0.2	120
Alfalfa residues	9	437	49	144	35.8	4.2	0.8	120
Poultry manure	10	414	41	565	0.0	11.7	4.4	120
Sheep manure compost	30	278	9	394	0.0	0.0	18.8	120
Wheat straw residues	140	491	4	961	0.0	0.0	12.0	18

4 REPLICATES

112 1-L JARS, distributed in completely randomized design

RESULTS

Soil N2O emissions as influenced by methodology : three indices to estimate $RPOA_{N_2O}$

Oxic phase
Immediate and 48-h indices : $I1_{N_2O}$ and $I2_{N_2O}$

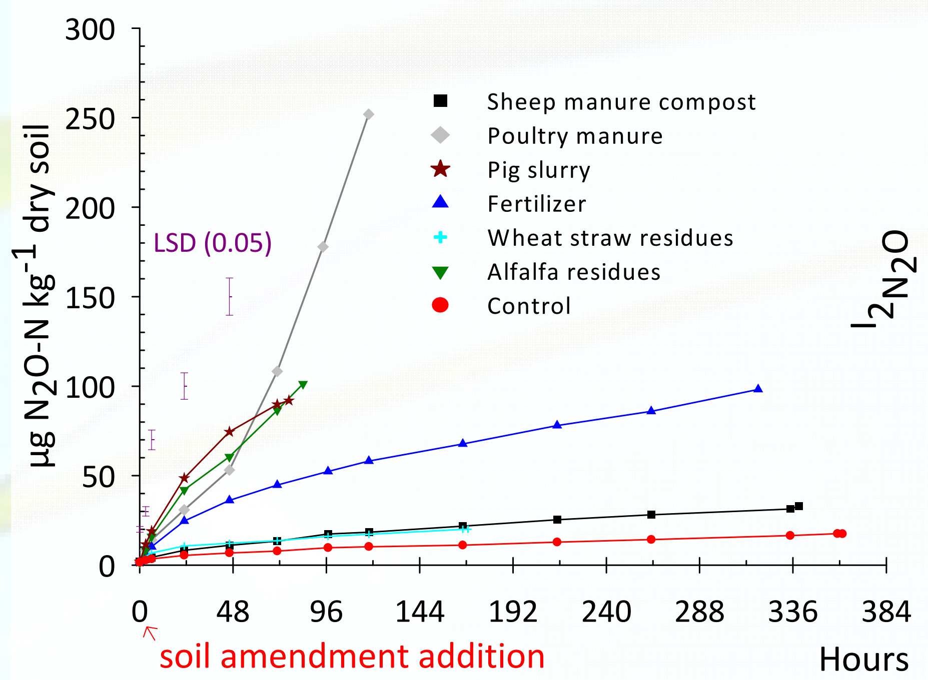

Figure 1. CJ^- and CJ^+ methods

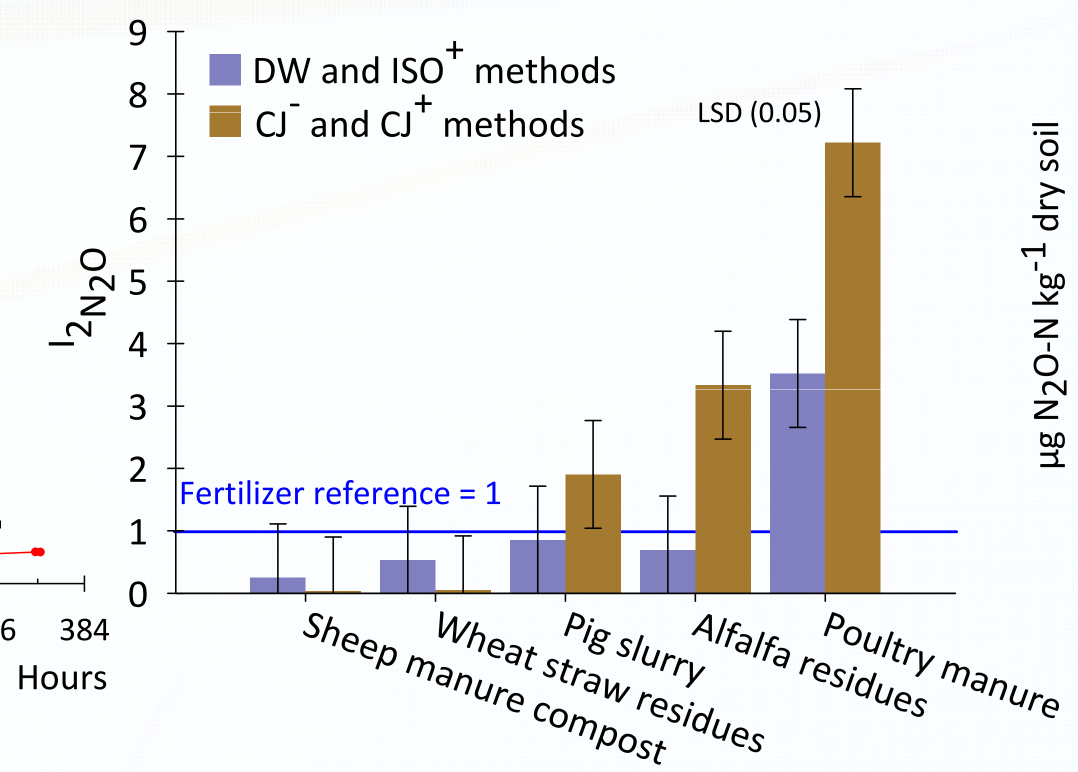

Figure 2. 48-h index: $I2_{N_2O}$

For a diverse set of OAs, each with a distinct mineralization pattern, $I1_{N_2O}$ and $I2_{N_2O}$ are suitable end-points to detect short-term effects of OAs on soil N_2O emissions.

$$I1_{N_2O} = \frac{\left[F(N_2O)_{amendment} - F(N_2O)_{control}\right]_{0h \to 3h}}{\left[F(N_2O)_{fertilizer} - F(N_2O)_{control}\right]_{0h \to 3h}}$$

$$I2_{N_2O} = \frac{\left[F(N_2O)_{amendment} - F(N_2O)_{control}\right]_{48h \to 72h}}{\left[F(N_2O)_{fertilizer} - F(N_2O)_{control}\right]_{48h \to 72h}}$$

$F(N_2O) = \mu g\ N_2O\text{-}N\ kg^{-1}\ soil\ h^{-1}$

Anoxic phase
Long-term index : $I3_{N_2O}$

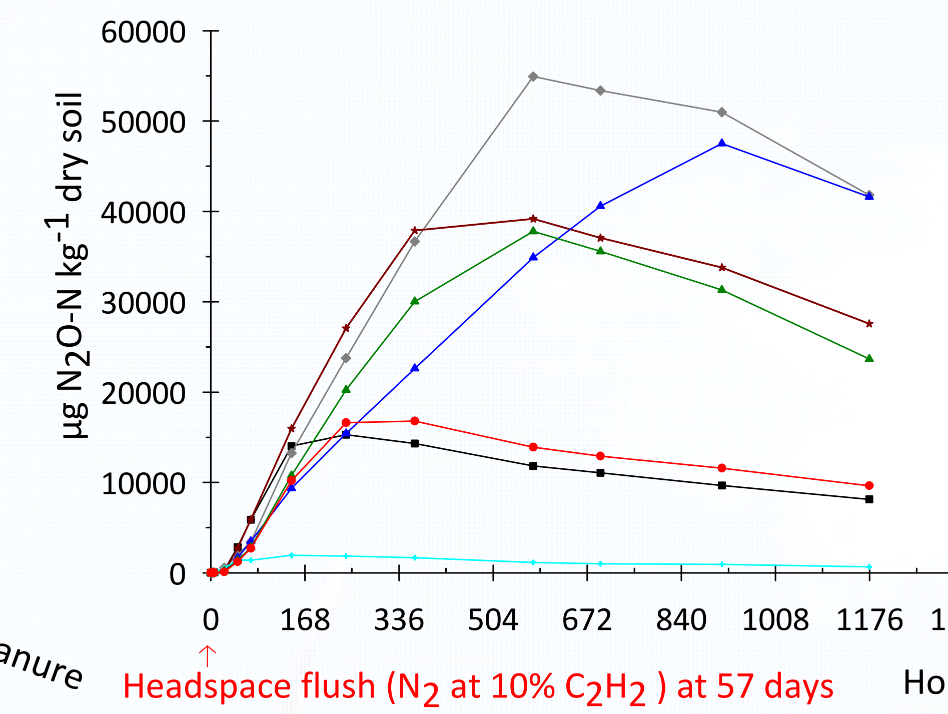

Figure 3. The ISO^+ method

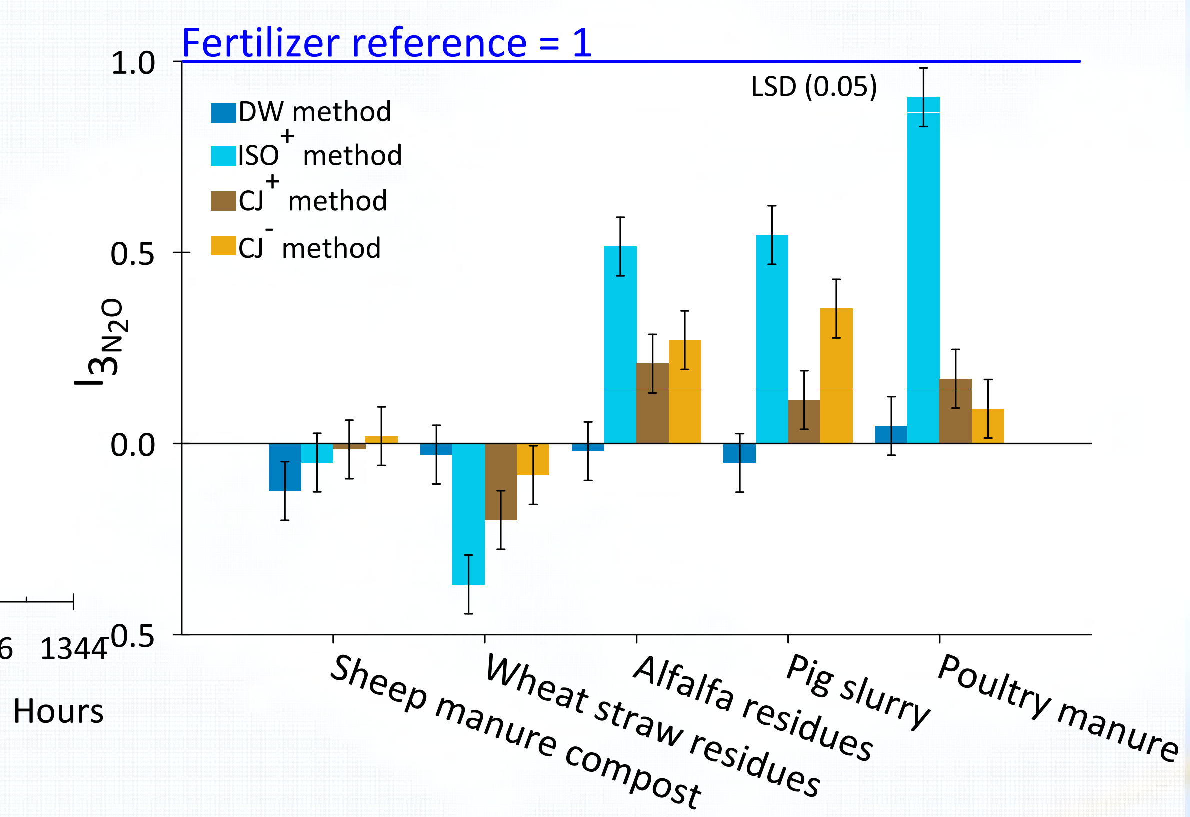

Figure 4. Long-term index $I3_{N_2O}$

$$I3_{N_2O} = \frac{([N_2O]max_{amendment} - [N_2O]max_{control})}{([N_2O]max_{fertilizer} - [N_2O]max_{control})}$$

$[N_2O] = \mu g\ N_2O\text{-}N\ kg^{-1}\ soil$

$I3_{N_2O}$ depends on the decomposition and mineralization of OAs in the soil environment. The ISO^+ method discriminated OAs related to their $I3_{N_2O}$ because the oxic period allows for accumulation of mineral N in the ISO^+ method prior to the anoxic cycle.

$RPOA_{N_2O} = \Sigma I/3$

$$RPOA_{N_2O} = (I1_{N_2O} + I2_{N_2O} + I3_{N_2O})/3$$

Poultry manure	3.35
Pig slurry	1.94
Alfalfa residues	1.89
Fertilizer (NH_4NO_3)	1
Compost	0.15
Wheat straw	0.12

CONCLUSION

The standard method that we propose is ... a mix of two!

Oxic phase : the CJ method → robust estimates of $I1_{N_2O}$ and $I2_{N_2O}$

Anoxic phase: the ISO^+method → robust estimates of $I3_{N_2O}$.

Next step: Requiring few measurements, this approach will allow a joint assessment of $RPOA_{N_2O}$ for a large range of organic by-products **towards the prediction of $RPOA_{N_2O}$ risk classes based on OA properties.**

REFERENCES

[1] Ravishankara et al.,2009. Nitrous oxide (N2O): The Dominant Ozone-Depleting Substance Emitted in the 21st Century. Science doi: 10.1126/science.1176985. **[2] Velthof, G. L. et al., 2003**. Nitrous oxide emission from animal manures applied to soil under controlled conditions. Biology and Fertility of Soils 37(4): 221-230.

ACKNOWLEDGMENT

Thank you to the Centre Sève and the Department of Natural Resource Sciences (McGill University) for travel grants.
Thank you to Nicole Bissonnette, Mathieu Bernier-Therrien, Linda Gaulin, Alain Larouche, Mario Laterrière, Gabriel Lévesque, Simon-Pierre Parent, Catherine Pinsonneault, Johanne Tremblay and Lincey Viel for laboratory assistance.