Animal slurry acidification: more than a solution for ammonia emissions abatement?

D. Fangueiro, S. Surgy, I. Regueiro, F. Gioelli, M. Hjorth, J. Coutinho

Hinc patriam sustinet
Instituto Superior de Agronomia
Universidade de Lisboa

DISAFA
Università degli studi di Torino

AARHUS UNIVERSITY

UNIVERSIDADE DE TRÁS-OS-MONTES E ALTO DOURO
utad

Structure of the presentation

1) Introduction

2) Slurry composition and separation

3) Gaseous emissions during storage

4) N, P and C dynamics after soil application

5) Agronomic value

Introduction

✓ **pH lowering of animal manure: logical and direct solution to minimize ammonia emissions.**

$$NH_3 + H^+ \rightarrow NH_4^+$$

✓ **Additives used: nitric and sulfuric acid with liquid manure and aluminium sulfate with solid manure**

Introduction

Restrict utilization due to some limitations

Acid hazard

Foam formation in barns and storage

And costs depending on:

- **which acid is used (H_2SO_4 is one of the cheapest)**
- **at which stage is acidification performed (in barn, storage, field)**

Introduction

- Today, safe and efficient solutions are proposed to farmers for slurry acidification in barn, in slurry store or immediatly before soil application
- But such service is still limited to Denmark where 15% of slurry was acidified in 2013 with an expected increase to 20% in 2014
- More information is needed to export such technology to countries from South Europe

Introduction

- **Strong focus of research on efficiency to decrease NH_3 but few data on other gas emissions neither on N, P and C dynamics in soil;**

- **Most studies performed in North Europe and few available information on the applicability of this technique in Mediterranean countries where pedo-climatic conditions are very different from North Europe.**

Objective

Provide an overview about the potential for slurry acidification application as a slurry management tool in Mediterranean countries.

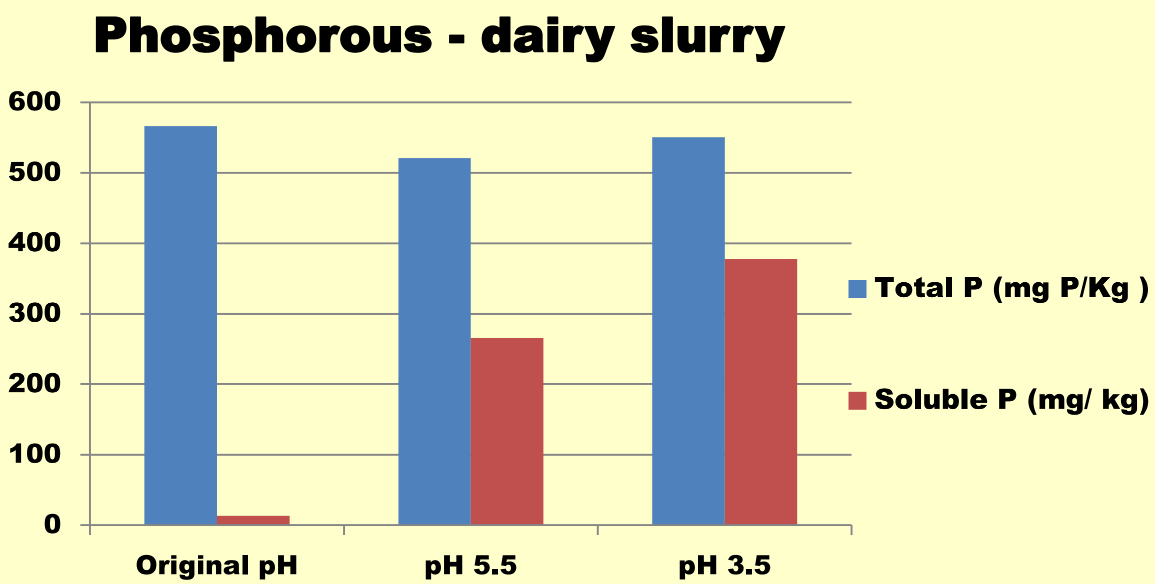
Structure of the presentation

1) Introduction
2) **Slurry composition and separation**
3) Gaseous emissions during storage
4) N, P and C dynamics after soil application
5) Agronomic value

Slurry composition and separation

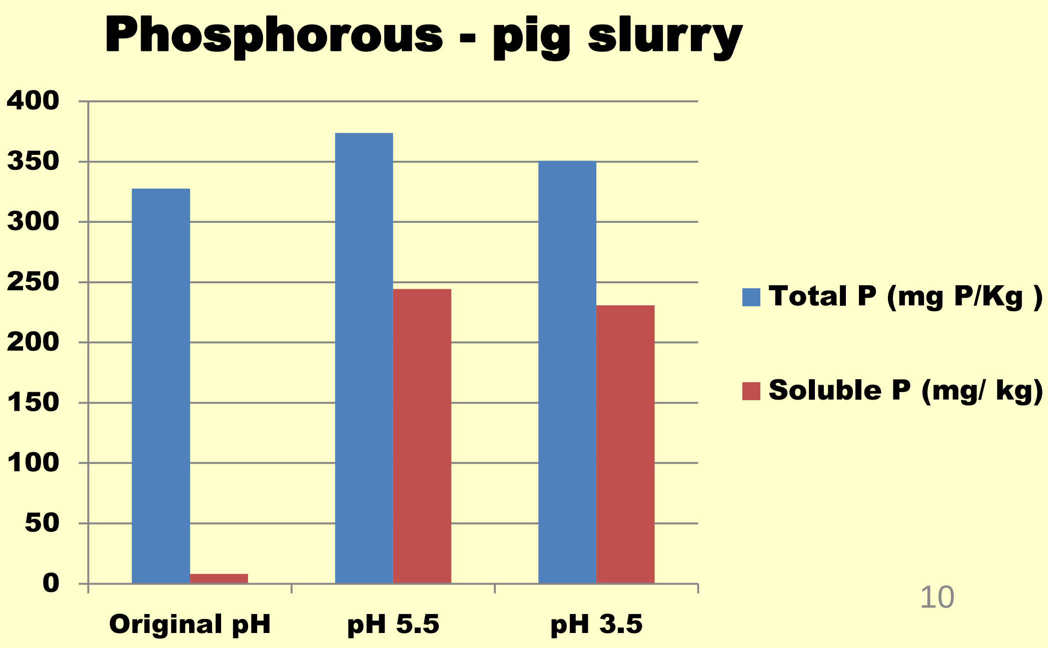
	Pig slurry	Acidified pig slurry
Dry matter content (g kg^{-1})	49.6	62.6
Total N (g kg^{-1})	4.2	4.3
Total P (g kg^{-1})	1.1	1.0
Total C (g kg^{-1})	14.9	13.3
Inorganic C(g kg^{-1})	0.8	0.0
Ca (g kg-1)	2.4	2.4
Mg (g kg^{-1})	1.1	1.0

Slurry composition



Influence of pH target storage time

Possible dissolution of the dominants mineral P species in manure (struvite and di-calcium phosphate)



Slurry composition and separation

	Slurry	Acidified Slurry	Liquid fraction	Acidified Liquid fraction	Solid fraction	Acidified Solid fraction
Dry matter content ($g\ kg^{-1}$)	49.6	62.6	10.2	30.9	194.8	195.5
Total N ($g\ kg^{-1}$)	4.2	4.3	2.8	2.9	10.4	9.9
Total P ($g\ kg^{-1}$)	1.1	1.0	0.04	0.69	4.7	2.1
Total C ($g\ kg^{-1}$)	14.9	13.3	2.7	1.9	72.4	67.6
Inorganic C ($g\ kg^{-1}$)	0.8	0.0	0.4	0	2.4	1.0
Ca (g kg-1)	2.4	2.4	0.1	0.9	10.6	6.7
Mg ($g\ kg^{-1}$)	1.1	1.0	0.05	0.5	4.7	2.8

Structure of the presentation

1) Introduction
2) Slurry composition and separation
3) **Gaseous emissions during storage**
4) N, P and C dynamics after soil application
5) Agronomic value

Gaseous emissions during storage

Methane Emissions

- **Slurry acidification can decrease CH_4 emissions during storage (Berg et al., 2003)**

- **Acidification efficiency to decrease CH_4 emissions depends strongly on the acid used (Berg et al., 2003; Petersen et al.2012) :**
  - **>90% with lactic acid**
  - **40-65 % with HCl**
  - **17-75% with nitric acid**

- **Below pH 5, this decrease does not depends on the target pH .**

Gaseous emissions during storage

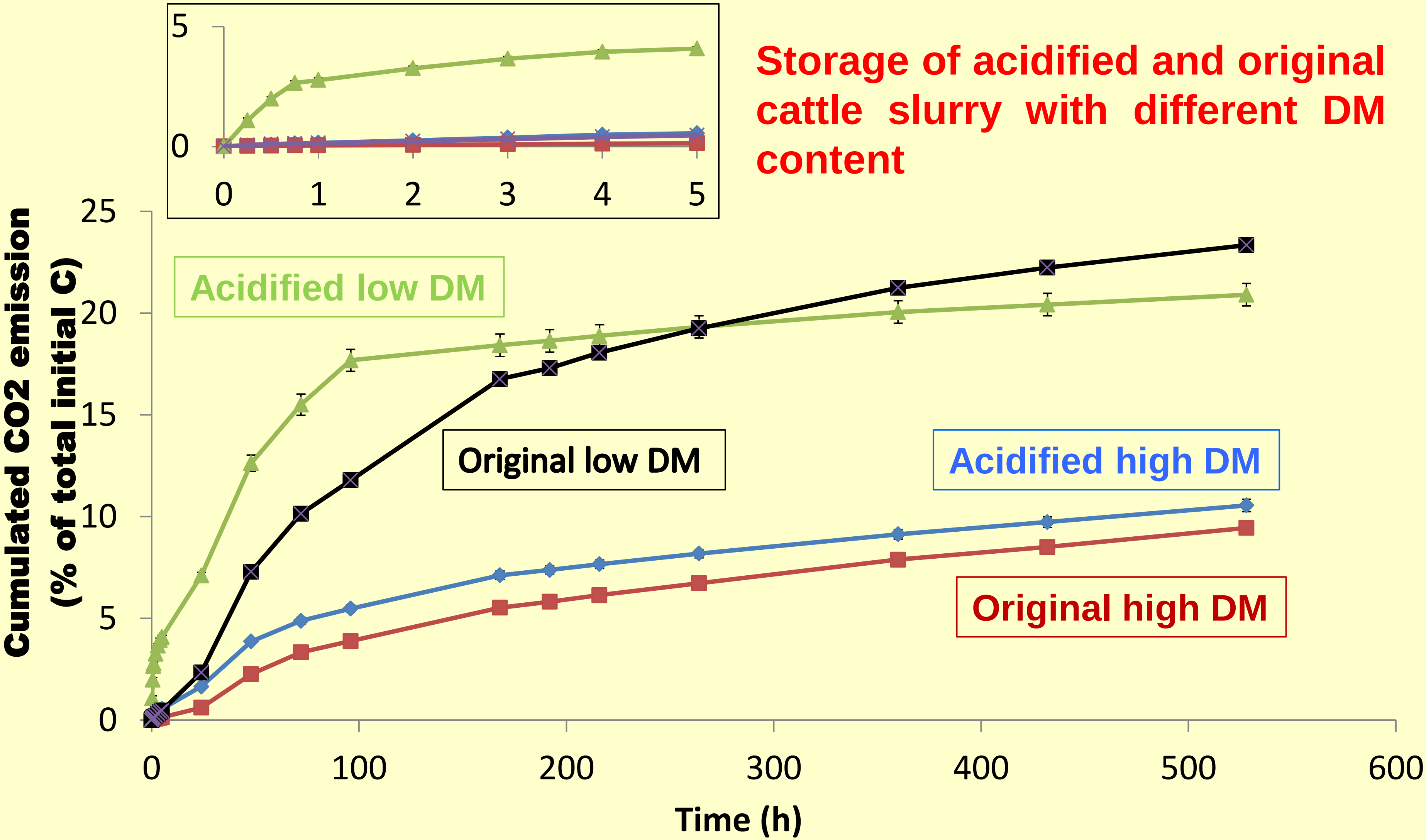
Carbon dioxide emissions

✓CO_2 emission occurred mainly during the acidification process and can be 2-10 times higher than during subsequent storage (Fangueiro et al., 2013; Dai and Blanes Vidal, 2013).

✓ A stronger and faster decay of CO_2 emissions is observed in acidified slurry relative to non acidified during the first days of storage.

✓Over the whole storage period, differences between acidified and non acidified slurry in terms of CO_2 emissions were generally not significant.

Gaseous emissions during storage



Fangueiro D., Surgy S., Coutinho J., Vasconcelos E. 2012 Impact of cattle slurry acidification on carbon and nitrogen dynamics during storage and after soil incorporation. Journal of Plant Nutrition and Soil Science, In press

Gaseous emissions during storage

Hydrogen sulfide emissions

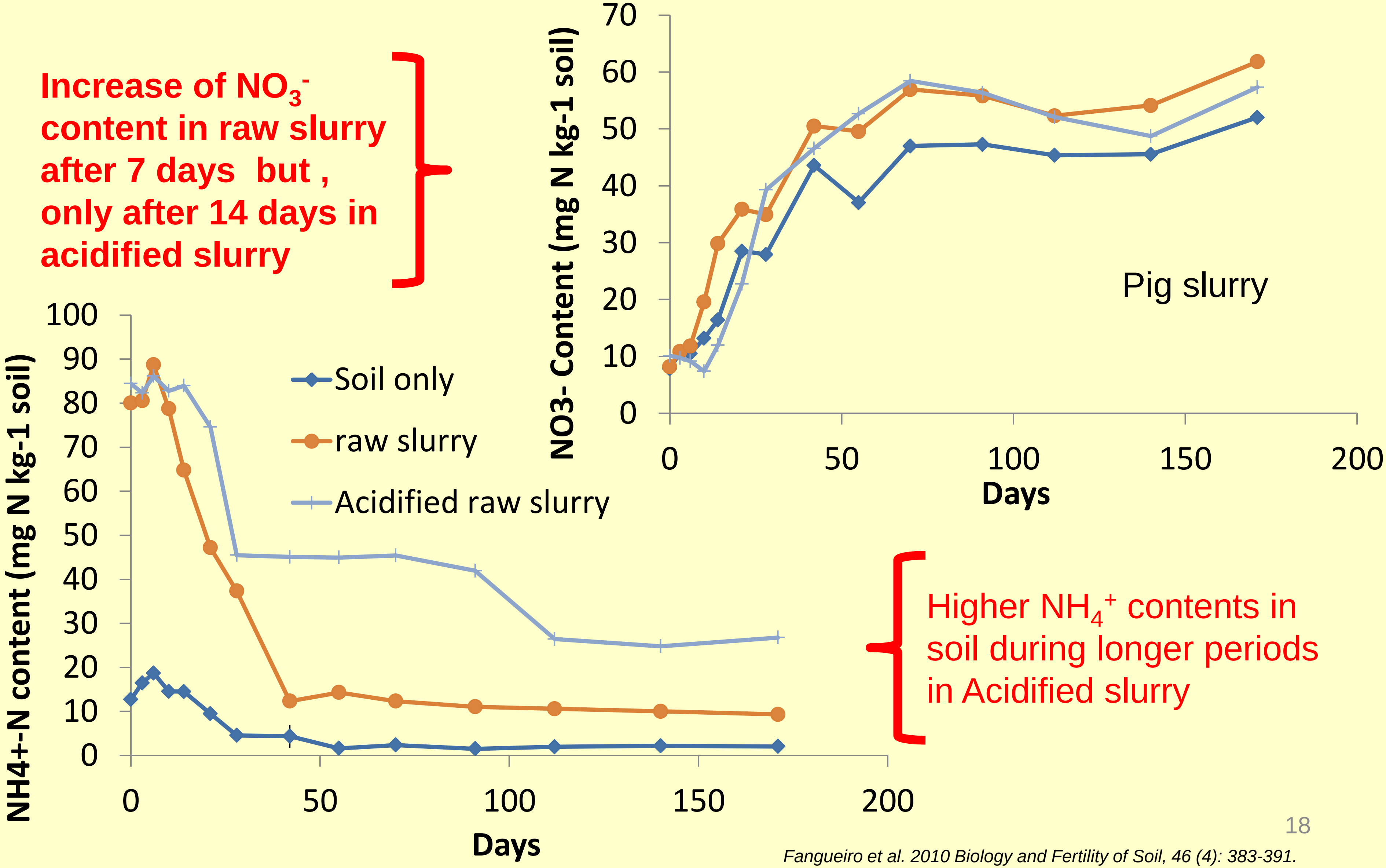
- ✓ **As occurred with CO_2 emissions, a strong burst of H_2S emissions may happened during the acidification process followed by a strong decrease over the first days of subsequent storage.**
- ✓ **BUT acidification has no significant effect on H_2S emissions over the whole storage period (Dai and Blanes-Vidal (2012))**
- ✓ **More than the pH effect, the slurry mixing that was performed in all treatments strongly influence H_2S emissions.**

Structure of the presentation

1) Introduction
2) Slurry composition and separation
3) Gaseous emissions during storage
4) **N, P and C dynamics after soil application**
5) Agronomic value

Influence of slurry acidification on N mineralization and nitrification

Increase of NO_3^- content in raw slurry after 7 days but, only after 14 days in acidified slurry

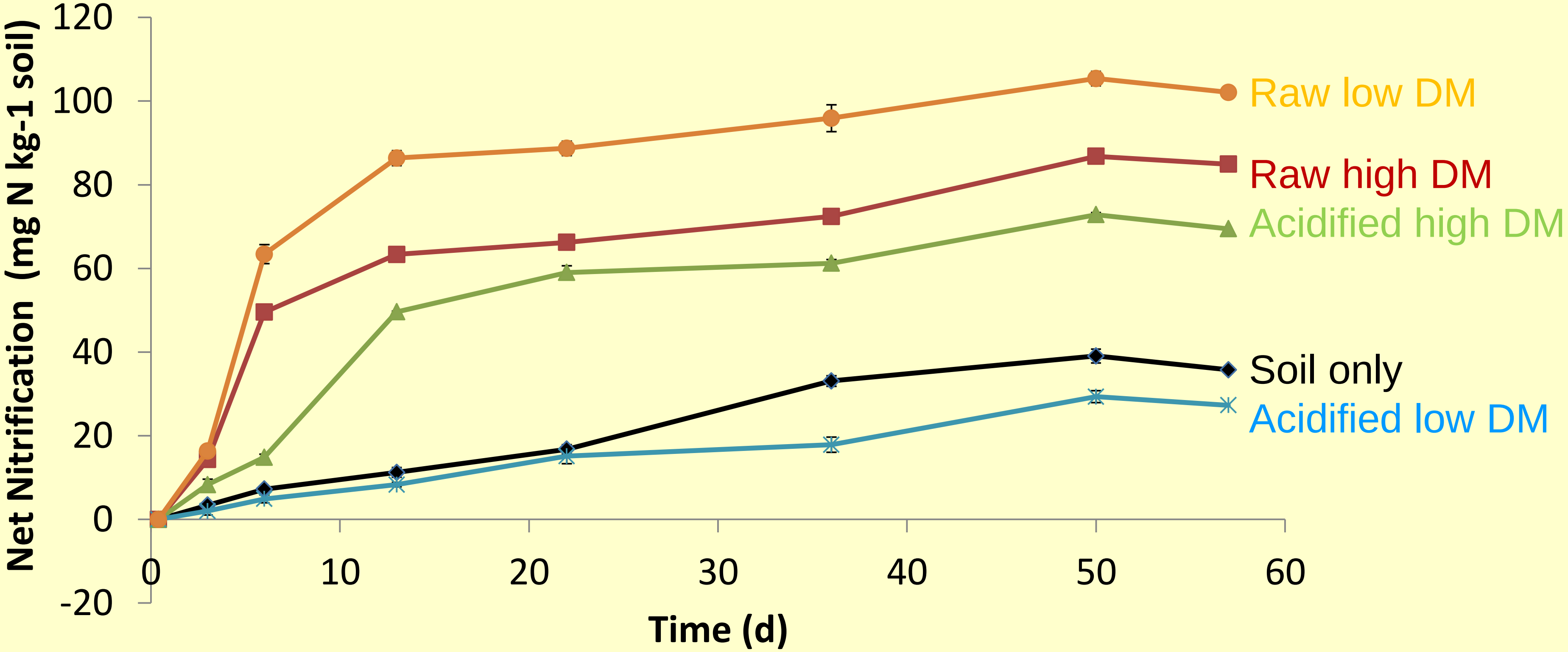


Higher NH_4^+ contents in soil during longer periods in Acidified slurry

Fangueiro et al. 2010 Biology and Fertility of Soil, 46 (4): 383-391.

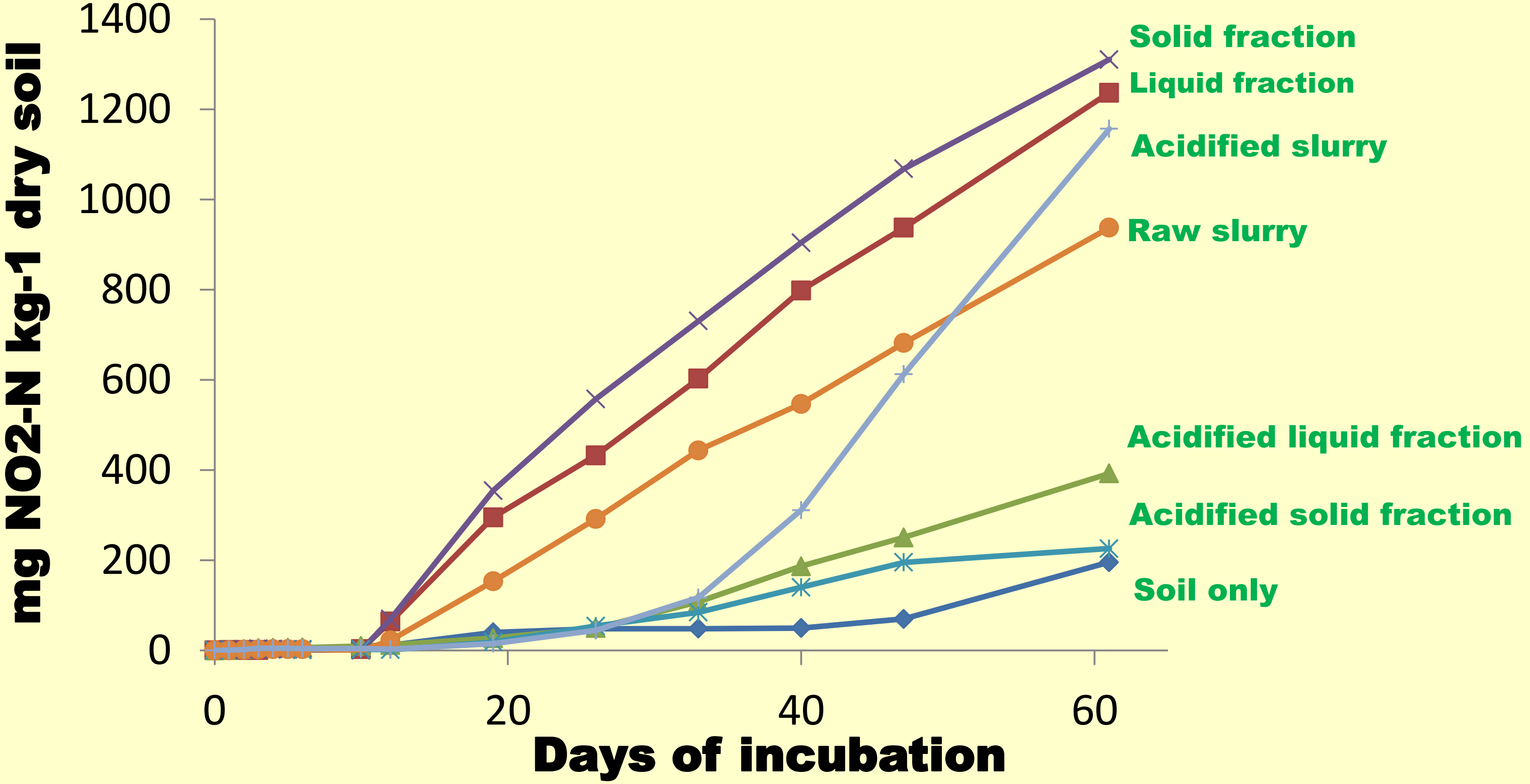
Influence of slurry acidification on N mineralization and nitrification

Delay and decrease of nitrification with acidification: effect more intense in low DM slurry



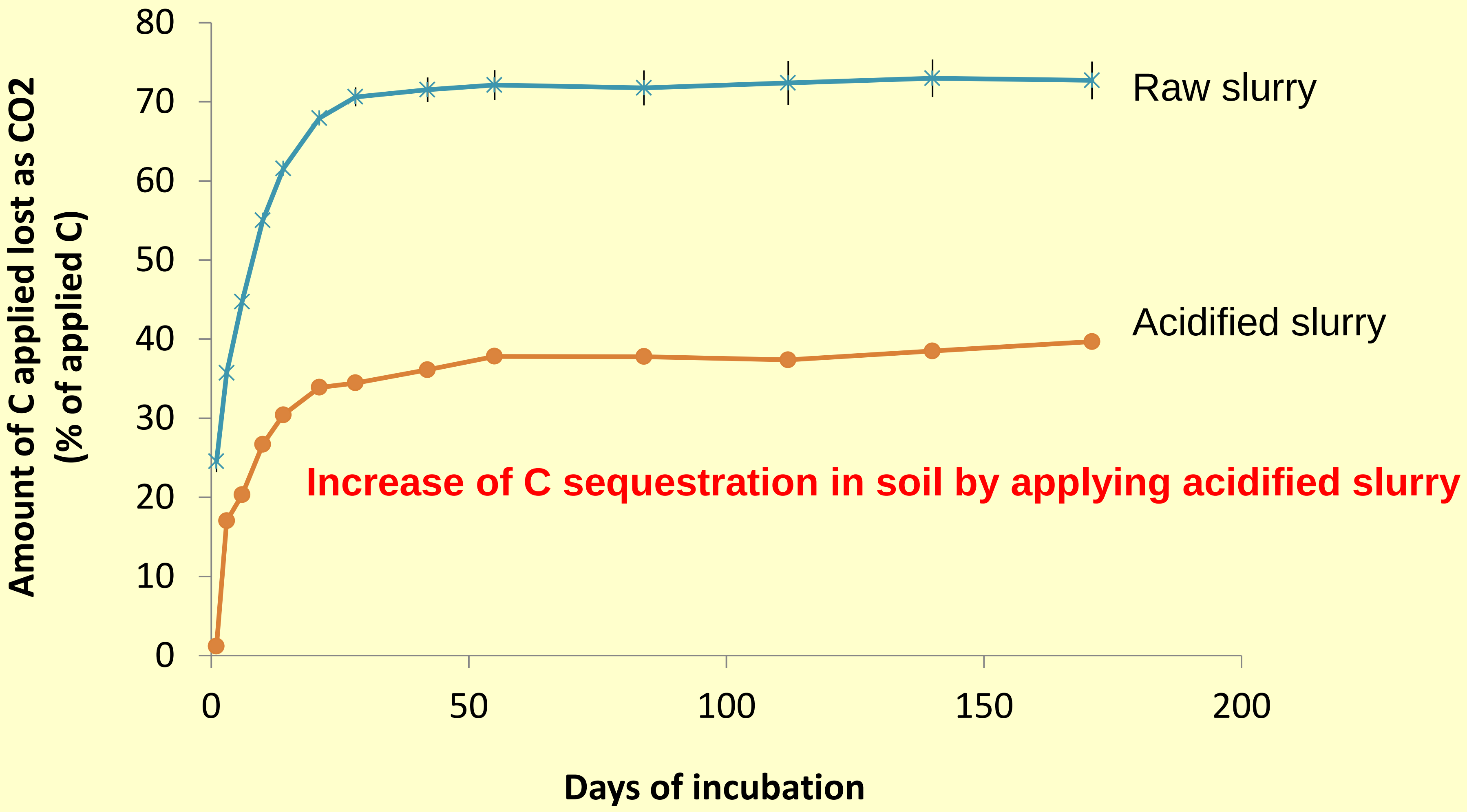
Soil application of acidified and non acidified cattle slurry with different DM content

Influence of slurry acidification on N_2O after soil application – pig slurry



Fangueiro D., Ribeiro H., Coutinho J., Cardenas L., Trindade H., Cunha-Queda C., Vasconcelos E., Cabral F. 2010 Nitrogen mineralization and CO2 and N2O emissions in a sandy soil amended with original or acidified pig slurries or with the relative fractions. Biology and Fertility of Soil, 46 (4): 383-391.

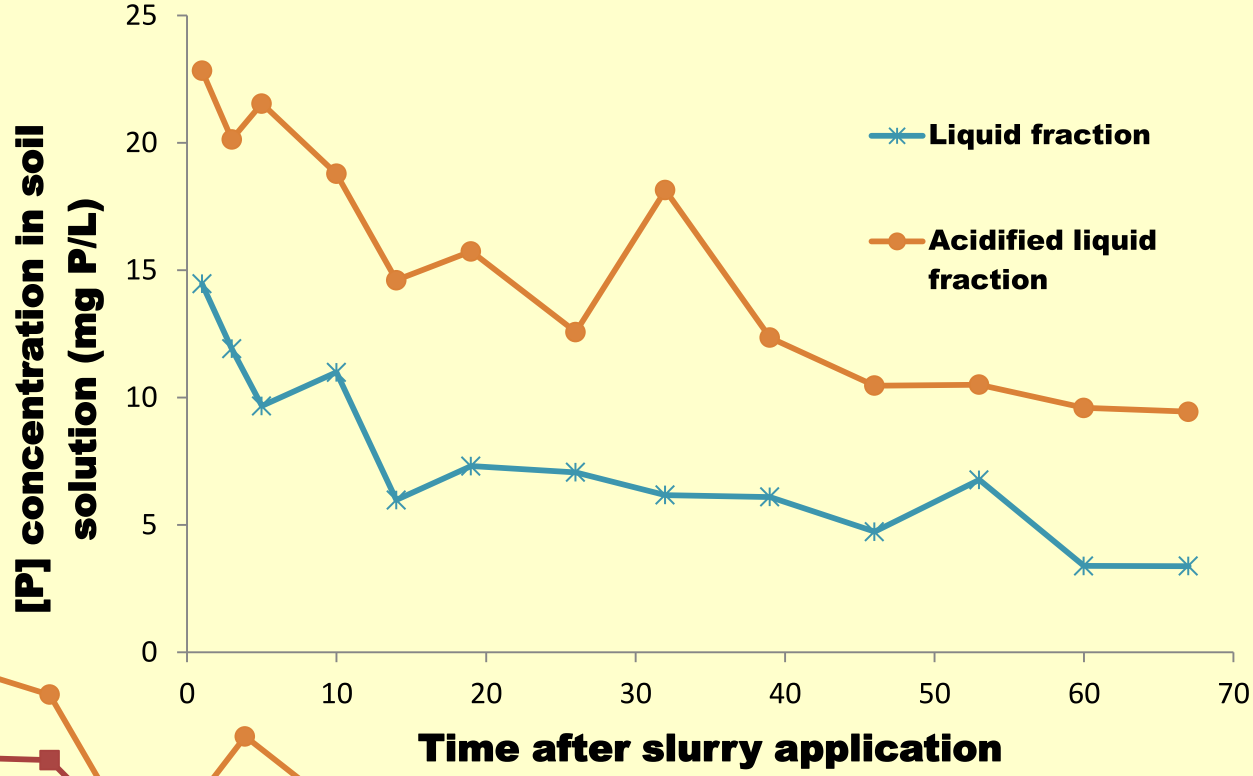
Influence of slurry acidification on CO_2 emissions after soil application – pig slurry

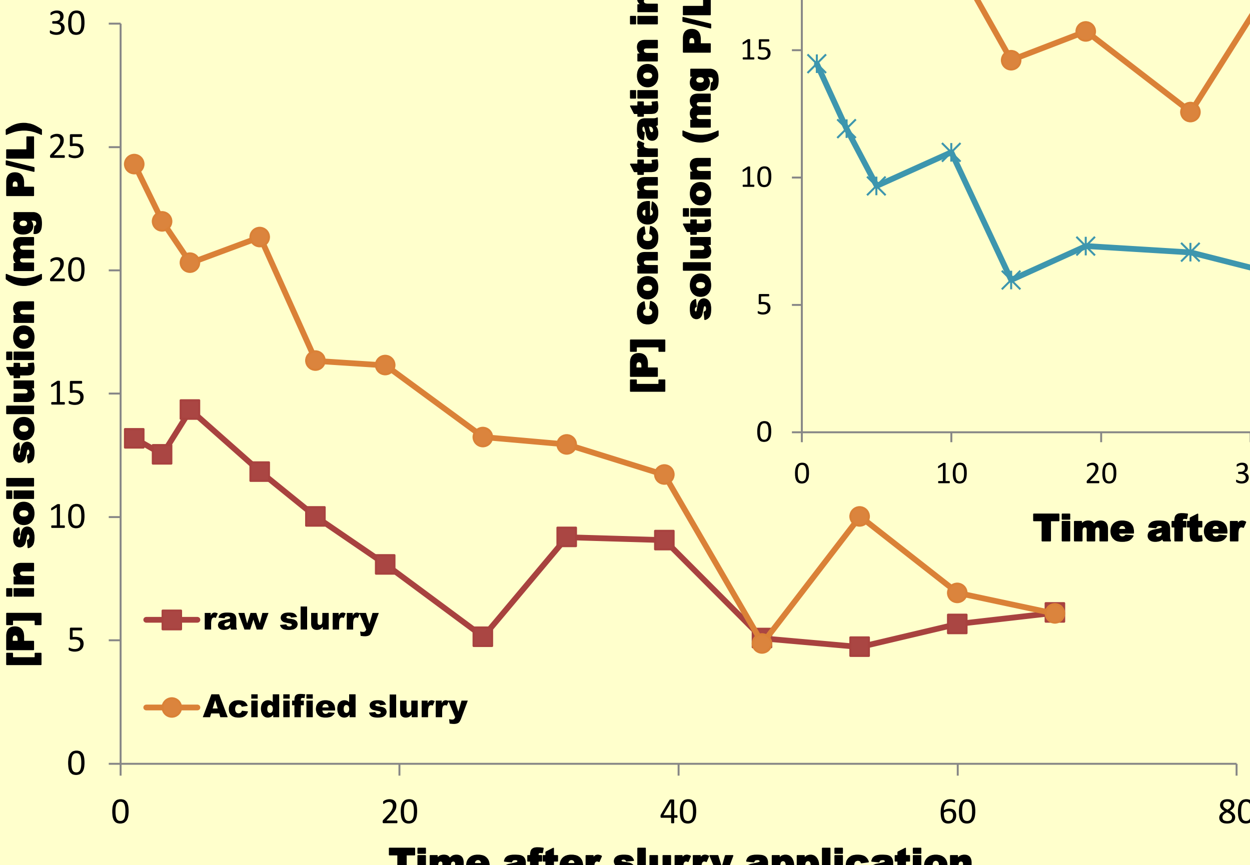


Fangueiro D., Ribeiro H., Coutinho J., Cardenas L., Trindade H., Cunha-Queda C., Vasconcelos E., Cabral F. 2010 Nitrogen mineralization and CO2 and N2O emissions in a sandy soil amended with original or acidified pig slurries or with the relative fractions. Biology and Fertility of Soil, 46 (4): 383-391.

Influence of slurry acidification on P availability

Slurry acidification increases P availability for plants





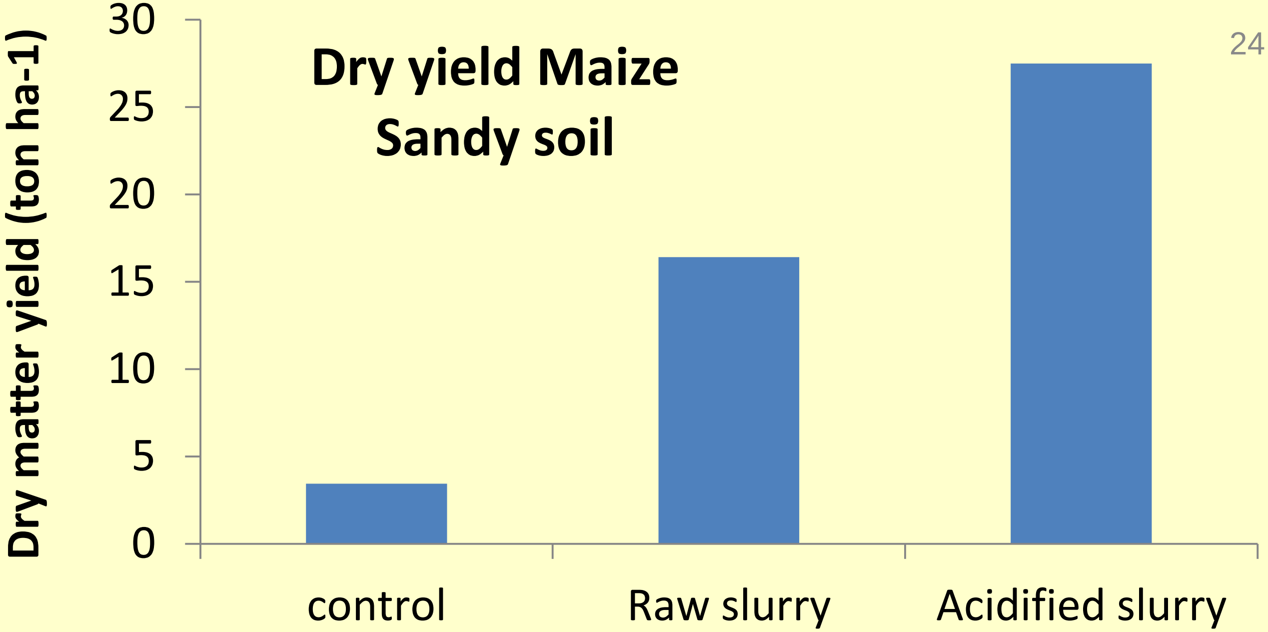
Soil application of acidified and non acidified cattle slurry and derived liquid fraction

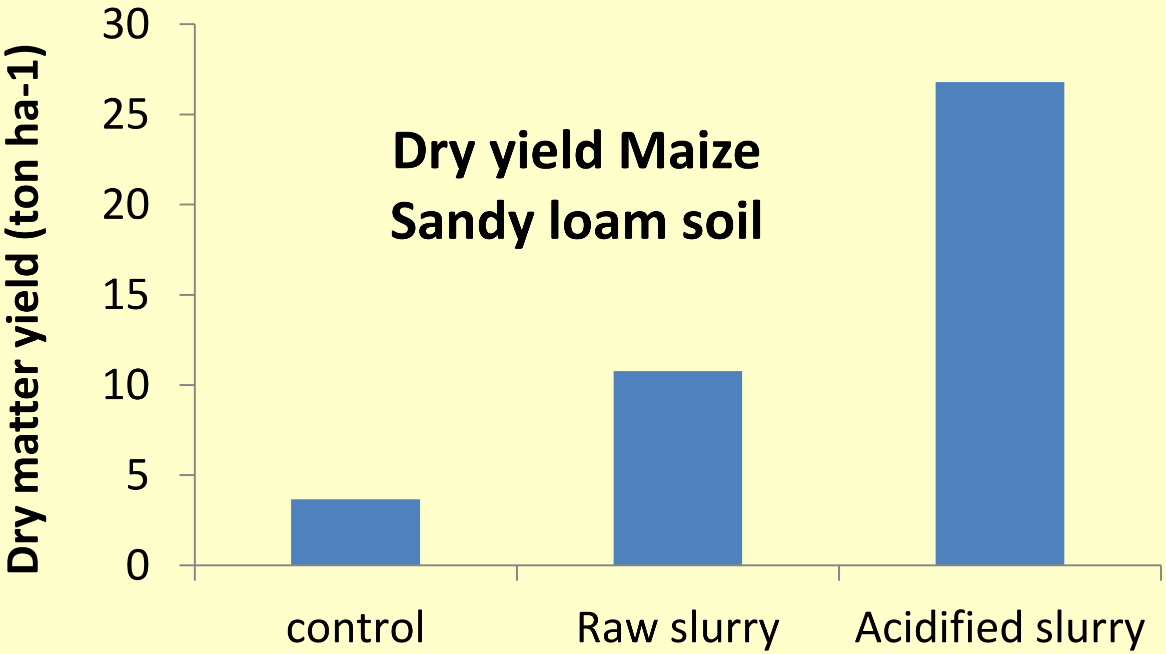
Structure of the presentation

1) Introduction
2) Slurry composition and separation
3) Gaseous emissions during storage
4) N, P and C dynamics after soil application
5) **Agronomic value**

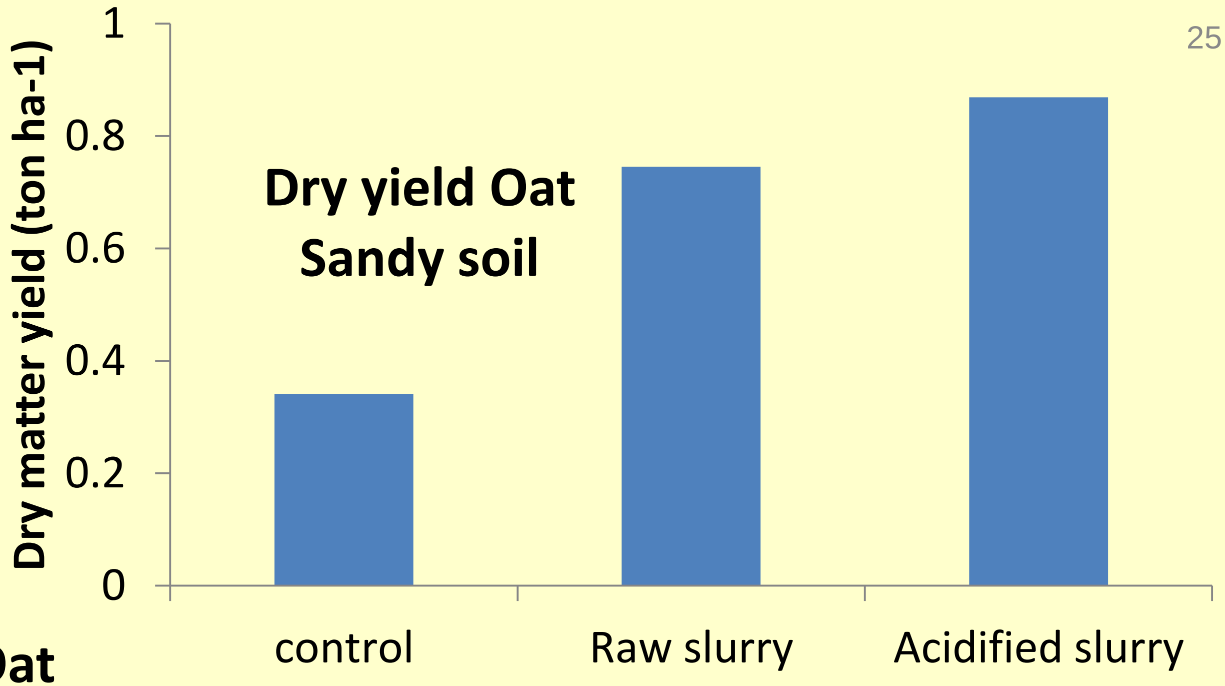
Agronomic Value

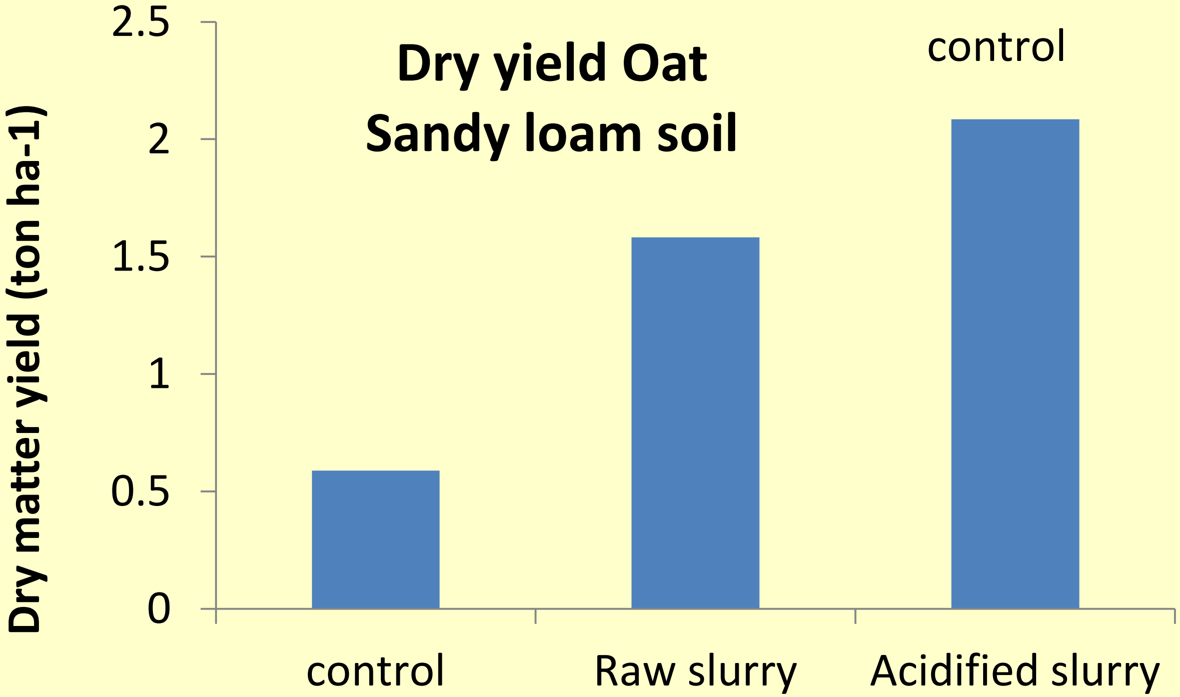
Acidified slurry may act as a starter for maize (Petersen et al., 2013)





Agronomic Value





Conclusions

Slurry composition	**Soluble P** **Inorganic C**	↗ ↘
Storage	CO_2 CH_4 H_2S	→ (initial burst) ↘ → (initial burst)
Soil application	**Nitrification** N_2O CO_2 **P availability** **Crop yields**	↘ (delay) → ↘ ↘ ↗ ↗

Conclusions

YES, slurry acidification can be used as a slurry management tool in Mediterranean countries

Acknowledgements

Co-authors: S. Surgy,
I. Regueiro,
F. Gioelli,
M. Hjorth,
J. Coutinho

Funders:

Fundação para a Ciência e a Tecnologia (FCT) financially supported this research through the projects "Animal slurry management: sustainable practices at field scale" (PTDC/AGR-PRO/119428/2010) and (ProjectPEst-OE/AGR/UI0528/2011) and a grant to David Fangueiro (SFRH/BPD/84229/2012).

The research leading to these results has received funding from the People Programme (Marie Curie Actions) of the European Union's Seventh Framework Program FP7/2007-2013/ under REA grant agreement n° [289887].

Thank you for you attention

Hinc patriam sustinet

Instituto Superior de Agronomia
Universidade de Lisboa