Injection of filtered pig slurry into a subsurface drip irrigation system: agronomic and environmental issues in a maize crop

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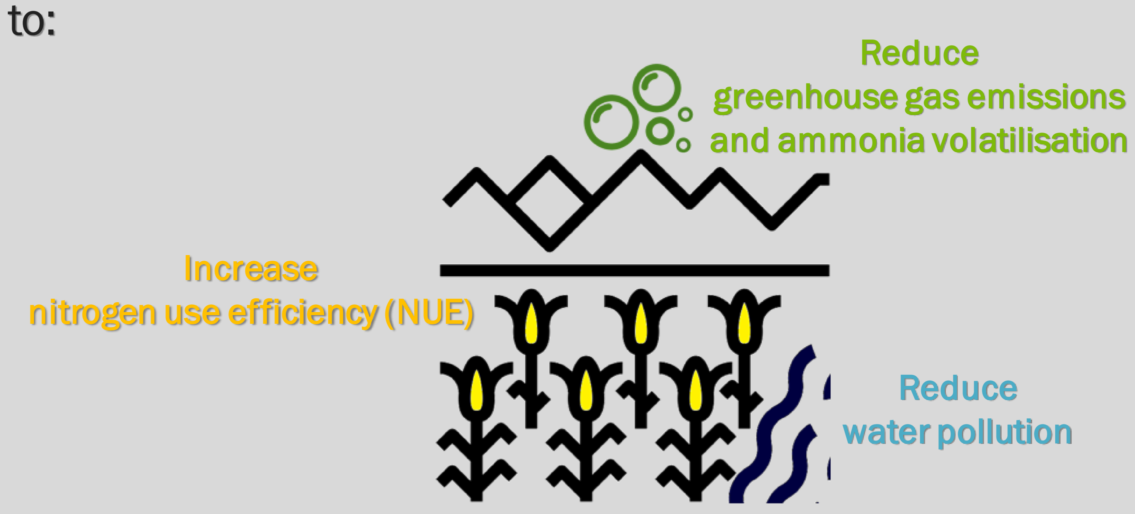
Introduction

- The high density of intensive livestock in some areas makes difficult the adequate management of manures and slurries to:



Objective:

- To evaluate the feasibility of the injection of filtered pig slurry (PS) into a subsurface drip irrigation system (SDIS) in a maize crop: evaluating the yield, nitrous oxide (N_2O) emissions and nitrate (NO_3^-) leaching risk in comparison to the traditional PS surface spreading and mineral fertilisation.

Materials and methods

- The experimental field was located in the middle Ebro river basin (Zaragoza, Spain).
- Results presented correspond to one maize growing season (sowing: 18/04/17; harvest: 03/10/17).
- SDIS at 30-cm depth. Irrigation requirements were calculated weekly with FAO methodology.
- Completely randomised block design with 3 fertiliser treatments with a rate of 308 kg N ha^{-1} and 4 replications:
  - '**Mineral**': urea applied at V5 and N32 twice injected into the SDIS at V8 and VT.
  - '**PS-Surface**': pig slurry spread on the soil surface at V5 and N32 injected into the SDIS just before VT.
  - '**PS-Injection**': filtered (100 µm-mesh) pig slurry injected into the SDIS from V5 to VT.
- N_2O emissions were quantified with unvented static chamber and gas chromatography.
- The risk for NO_3^- leaching was compared using NO_3^- concentration in soil solution below the crop root zone (extracted with ceramic suction cups at 1.2-m depth).

  Frequency of samplings increased after fertilisation: 22 N_2O and 23 NO_3^- samplings from 22/05/17 to 17/10/17.
- Yield, biomass and N content were measured. NUE was calculated as N uptake/N applied (NH_4^+-N for PS). Yield-scaled N_2O emissions were calculated as cumulative N_2O emissions/grain yield.
- Effects of treatments were determined by ANOVA and analysis of repeated measures with time. Treatments were compared using Tukey's test at p=0.05.

Results

Grain yield (14%), Mg ha^{-1}

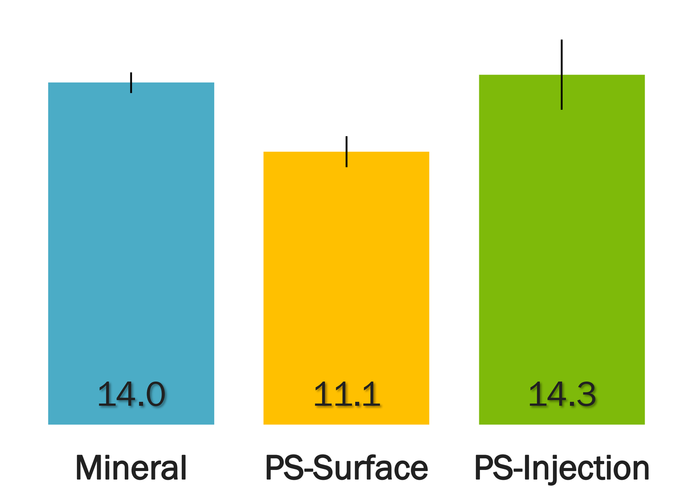


Figure 1. Average grain yield (Mg ha^{-1}) in the different treatments. Vertical lines indicate mean ± 1 standard error (n=4).

Grain yield in PS-Injection did not differ significantly from PS-Surface and Mineral (p>0.05).

Nitrous oxide emissions, kg N ha^{-1}

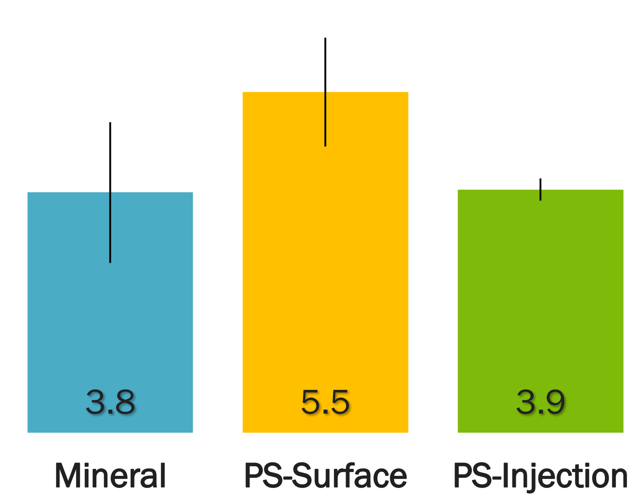


Figure 2. Average N_2O emissions (kg N ha^{-1}) in the different treatments. Vertical lines indicate mean ± 1 standard error (n=4).

No differences in N_2O emissions were detected (p>0.05) among treatments.

Yield-scaled N_2O emissions, kg N Mg^{-1} grain

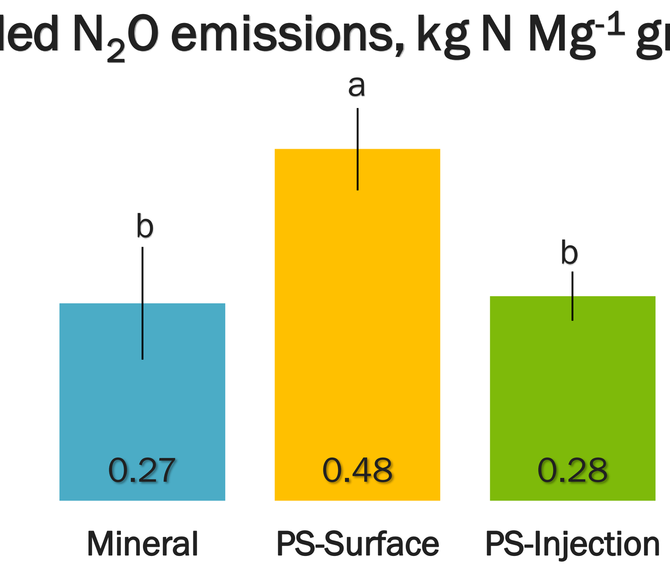


Figure 3. Average yield-scaled N_2O emissions (kg N Mg^{-1}) in the different treatments. Vertical lines indicate mean ± 1 standard error (n=4).

Yield-scaled N_2O emissions presented significant differences between PS-Surface and the other two treatments, PS-Injection and Mineral.

Nitrogen use efficiency

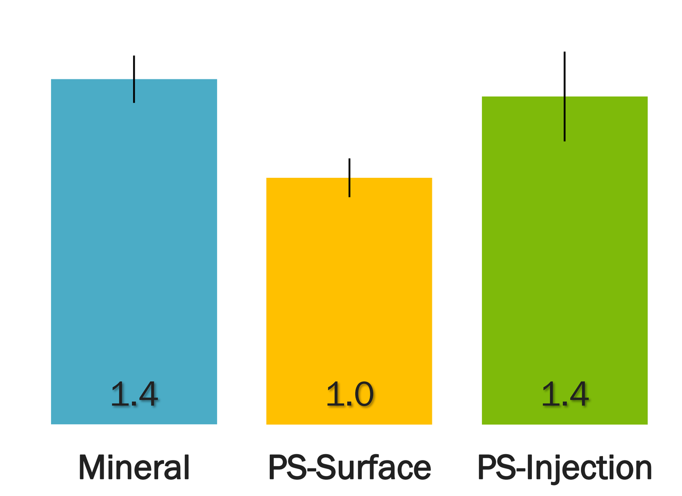
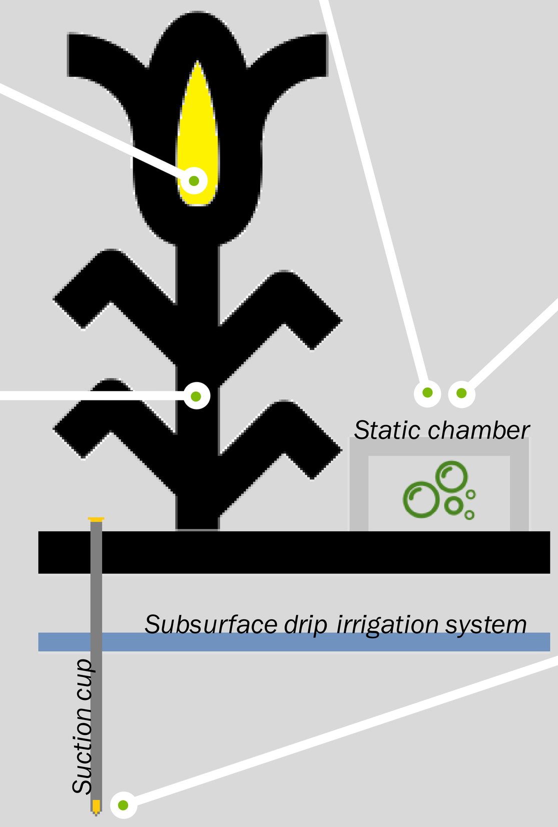


Figure 4. Average NUE in the different treatments. Vertical lines indicate mean ± 1 standard error (n=4).

There were no differences among treatments (p>0.05).



Nitrate in soil solution (mg N L^{-1}) at 1.2-m depth

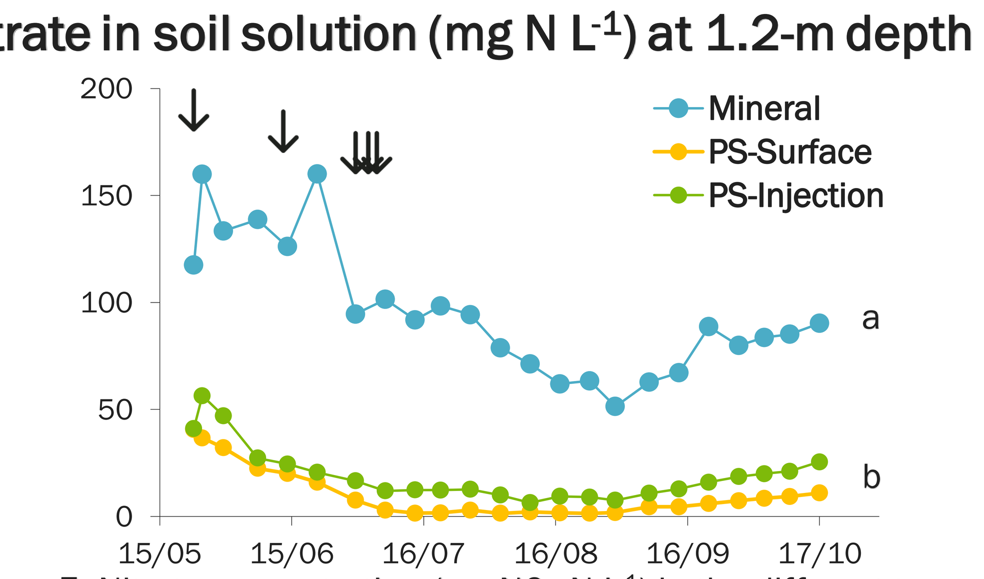


Figure 5. Nitrate concentration (mg NO_3-N L^{-1}) in the different treatments during the crop cycle. Arrows indicate the dates of fertiliser applications.

Mineral treatment showed higher NO_3^- concentration in soil solution than the rest of the treatments.

Nitrate concentration at the first sampling date showed high variability, but non-significant differences among treatments were detected.

PS-Injection treatment reached agronomic efficiencies (grain yield and NUE) similar to the other two treatments and showed some environmental benefits: lower yield-scaled N_2O emissions than the PS-Surface treatment and lower risk for NO_3^- leaching than the Mineral treatment. Results should be confirmed with data of the two following cropping seasons.

Conclusions

The injection of filtered pig slurry into a SDIS allowed the lengthening of the time window for PS application and to substitute all synthetic N fertiliser in a maize crop, maintaining agronomic production and reducing environmental risks in comparison to the traditional fertiliser treatments. Thus, farmers could optimise inputs, contributing to the circular economy and nutrient recycling, at the same time that their investment in the SDIS is being counterbalanced.

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