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Incubation study on the effect of soil moisture and rainfall on NH_3 emissions from different inhibited urea fertilizers

Introduction:

- NH_3 emissions are affected by soil and weather conditions after fertilizer application.
- Influence of soil water content likely not linear, low NH_3 emissions only under dry and very wet soil moisture conditions.
- With medium water content: fast dissolution of the fertilizer granule, fast hydrolysis of urea, low pH buffering due to low spatial distribution in the soil (see Fig 1), resulting in high emission potential.
- How do urease- and nitrification inhibitors interact on NH_3 emissions at different soil water contents and after rainfall?

Fig 1: Hygroscopic urea granule on dry soil starting to dissolve after a dewy night.

Materials & Methods:

- Incubation study in controlled environment → NH_3 emission potential

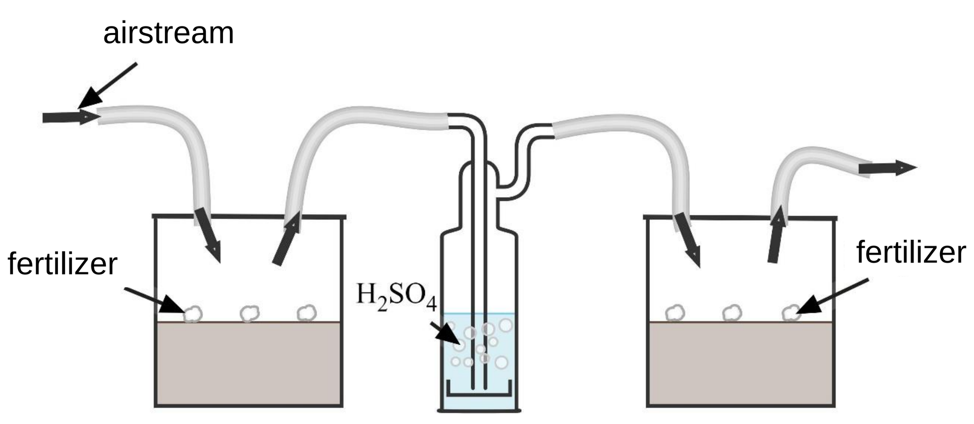

Fig 2: Experimental setup from main incubation glass (left), NH_3 scrubbing bottle containing H_2SO_4 (middle) and incubation glass for soil samples (right)

	Experimental run 1	Experimental run 2
• Influencing factor	Soil water content	Rainfall after fertilization
• Soil	Sandy loam	
• Fertilizer rate	100 kg N ha^{-1}	
• Air exchange	1 headspace min^{-1}	
• Fertilizer treatments	Unfertilized control (**N0**), Urea (**U**), Urea + urease inhibitor (**U+UI**), Urea + urease inhibitor + nitrification inhibitor (**U+UI+NI**)	
• Gravimetric water content	10, 17.5, and 25 %	17.5 %
• Simulated rainfall	None	1, 5, 10 mm 4 days after fertilizer application

Results & Discussion:

Water content:

- Low water content resulted in low emissions (Fig 3b), because of the slow fertilizer granule dissolution. No NH_4^+ accumulation due to simultaneous nitrification (not shown).
- Medium water content resulted in highest NH_3 emissions (Fig 3a), as NH_4^+ release from urea hydrolysis was faster than NH_4^+ oxidation during nitrification (not shown).
- High water content resulted in low emissions, likely due to a better diffusion of urea exploiting a higher soil volume, thus increasing soil pH buffer.

Fertilizer type:

- Urease inhibitor resulted in a slower NH_4^+ release compared to none inhibited urea. A lower NH_3 peak occurred 4 days delayed.
- As supported by the N_{min} values (data not shown), the nitrification inhibitor resulted in an accumulation of NH_4^+ thus enhancing NH_3 volatilization, compared to U+UI (Fig 3b).

Rain amount:

- The higher the rainfall, the lower the NH_3 emissions (Fig 3d).
- A combination of rainfall and inhibitor always decreased emissions (Fig 3d) compared to no rainfall (Fig 3b).
- At rainfall amounts ≥ 5 mm, NH_3 emission from U+UI treatment and N0 did not significantly differ (Fig 3d).
- Each rainfall amount (Fig 3d) significantly reduced NH_3 loss when compared to the treatment without rain (Fig 3b).

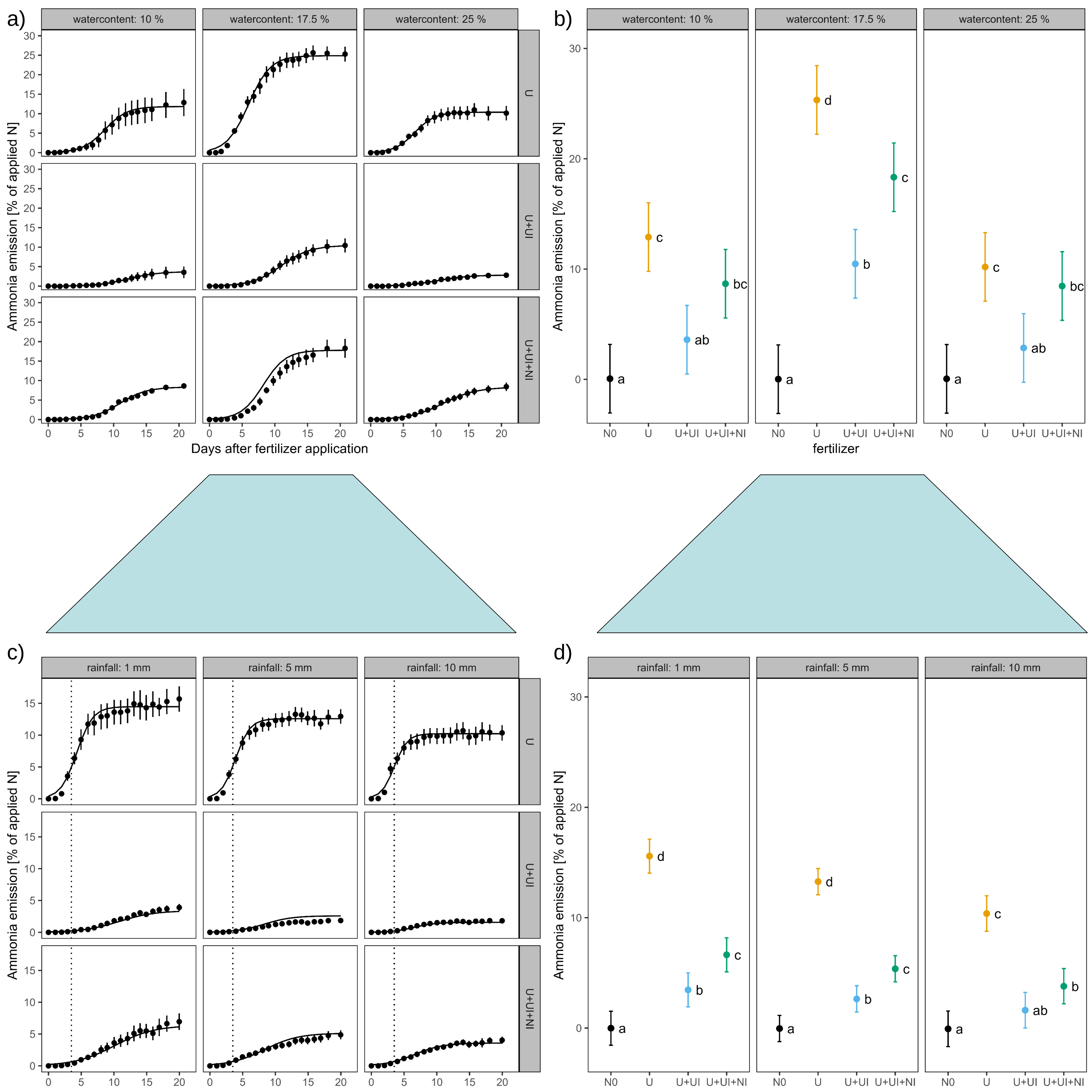

Fig 3: a)+c) Daily cumulative emissions (kg N ha^{-1} day^{-1}, corresponding to % of applied N), as affected by fertilizer and gravimetric soil water content (a) or by fertilizer and rain amount (c). Error bars give standard deviation. b)+d) Cumulative emissions at last experimental day, as affected by fertilizer and soil water content (b) or by fertilizer and rain amount (d). Dots and error bars represent estimated means ± 95% confidence interval per group. For each water content and rain amount separately, means not sharing any letter are significantly different by the Tukey-test ($p<0.05$).

Conclusion

Soil moisture is a strong driver for NH_3 emissions after fertilizer application. Rainfall effectively decreases emissions. UI reduces emissions effectively, while UI+NI can increase emissions.

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