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Interactive comment on "Nitrogen use efficiency and N_2O and NH_3 losses attributed to three fertiliser types applied to an intensively managed silage crop" *by* Nicholas Cowan et al.

Anonymous Referee #1

Received and published: 24 April 2019

General comments

The authors describe a field experiment in a silage system where plant N yield, NH3 and N2O emissions after application of different fertilizers are compared, including ammonium nitrate, urea as well as urea with a urease inhibitor. The commercially available urease inhibitor is designed to slow down urea hydrolysis; this might reduce gaseous NH3 losses and increase plant yield by shifting the competitive balance between plants and soil microorganisms.

I see a set of major problems in the design of this study.

First, the motivation is unclear. The authors argue that urease inhibitors might not only

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decrease NH3 emissions but also increase N2O emissions compared to untreated urea. It is not explained by what mechanism this would occur. The two main N2O-producing processes of nitrification and denitrification use NH4+ and NO3- as substrates and consequently also depend on urea hydrolysis. Urease inhibitors should therefore rather decrease than increase N2O emissions. The reference cited by the authors (Lam et al., 2017) does also not mention a potential increase in N2O release by urease inhibitors, but in contrast discusses a potential increase in NH3 release by nitrification inhibitors that are designed to reduce N2O emissions.

In addition, I am wondering about long-term effects of the urease inhibitor on NH3 fluxes. NH3 was measured over 14 days after fertilization (in contrast to a 30-day period for N2O – why?). No increase in plant N yield was observed by the inhibitor-treated urea compared to untreated urea and on average 55% of the applied fertilizer was accounted for in the experiments. Is it possible that a large fraction of the inhibited urea remained in the soil and will eventually release NH3 once the (short-term) inhibitor stops working? The short-term nature of the experiment is briefly mentioned in the conclusions, but the resulting limitations should be discussed more thoroughly.

I further find the introduction and discussion of previous studies on the effect of urease inhibitors on plant yields, NH3 and N2O emissions rather shallow (e.g., introduction in lines 83-88, rare mentioning of previous work in the discussion). A range of papers have been published on the topic, e.g. recently Graham et al. (2018, Soil Science Society of America Journal), as well as multiple papers by Zaman et al.

Specific comments

Line 34-35: Are the mentioned reductions by 90% and 47% or did the reduced values correspond to 90% and 47% of the comparison value?

Line 42: Please add examples of agriculturally important Nr forms.

Lines 48-51: I suggest to change the sequence of this sentence, first introducing dif-

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ferent pathways of N loss to link to the sentence before, and then mention the resulting environmental damage.

Line 62: Do you mean an increase in rates of fertilizer application? Please also add a reference to support this projection.

Line 90-93: Please rephrase this sentence. It is unnecessarily complicated and contains the word “required” three times.

Lines 98-100: I am not sure I understand. Do you mean that the study area is representative for agriculturally used grasslands in the UK? Please clarify.

Lines 115-118: Please add some details to the description of the two fields. Are exposure, slopes, soil types etc. similar? Is grazing/mowing history similar? Anything else that might affect the results? I also suggest to move the different pH values presented in the paragraph below here.

Lines 138-140: How were these parameters measured?

Line 142-144: Considering the high variability between replicates and often similar values of control and treatment plots, how did you treat uncertainties in this calculation and in others?

Line 261: Measurements of soil moisture and soil temperature are mentioned here but not presented in the manuscript. Soil moisture data in particular would be a good complement to the manuscript, for instance for interpreting the observed N2O fluxes.

Line 268: Considering the discussed large variability of measured parameters, please present uncertainty estimates (e.g., standard deviation) together with the averages throughout the Results section.

Line 273: How can meteorological conditions be ruled out as the reason behind the observed differences between the two fields in the two years? If site properties lie behind the differences, what specific properties could that be (e.g., are there differences

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in N availability to start with)? Also, in what sense was the 2016 yield “exceptional” – compared to 2017, or compared to the usually observed yield in such systems?

Line 288: Are the values after subtraction of the background? How good was the fit of the log-normal distribution?

Lines 292-293: I find it hard to see to see a consistent pattern of overall later peaks in the urea than the Nitram treatments.

Line 309: Are these values after the subtraction of the background? Also, why was the measurement period for NH3 shorter than for N2O?

Lines 308-309 and 314-315: These sentences have considerable overlap; please re-structure.

Lines 331-333: It looks more like an additional peak in NH4+ concentrations; there is also a peak in the beginning of similar magnitude than for the other events.

Line 334: What do you mean with variation on a log-normal scale?

Line 339: Differences between sites and years cannot be distinguished in this setup; please rephrase accordingly.

Line 353-355: Were the 2017 plots not grazed by sheep before? Please add potential differences in grazing history and intensity to the site description in the Material & Methods section.

Lines 357-359: With the scaling of the y-axes of Figure 4, it is almost impossible to compare initial ammonium and nitrate concentrations between fertilization events. It would help to present control concentrations here again to support the claimed differences in initial Nr concentrations between events.

Line 375: The Lam et al. 2017 reference does not indicate that a reduction in NH3 emissions might result in higher N2O production – the paper is about nitrification inhibitors and a potential increase in NH3 emissions that follows reduced N2O emissions.

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Line 378: Please add some details on the tested correlations. Also, why is “although” used here?

Line 392: Does the accounted for Nr include measured ammonium and nitrate, additional N in the harvested plants, as well as NH3 and N2O emissions? Please specify. Considering that no increase in plant N yield was observed by urease inhibitor compared to untreated urea and the short duration of the NH3 flux measurements, is it possible that a large fraction of the inhibitor-treated urea still remains in the soil at the end of the experiment and will eventually release NH3 once the (short-term) inhibitor stops working?

Tables 2, 3, 4: Considering the high variability within treatments, please add information on whether differences between treatments (in particular also between background and fertilizer NH3 and N2O fluxes) were statistically significant.

Figure 1: It might help to indicate the experimental periods (fertilizer addition and run time of flux measurements).

Technical corrections

Line 25: The first “and” is superfluous.

Line 32: The abbreviation “Nr” has not been introduced yet.

Lines 33-34: “The urea coated with a urease inhibitor did not significantly increase yields” – compared to what treatment?

Line 71: Add “to” before “convert”.

Line 73: Add “N” after “less”.

Line 77: Change “trialed” to “tested”.

Line 83: Typo, this should be “losses”. Are the losses quantified in these studies in the form of NH3, N2O or both?

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Line 87-88: I suggest "... reduction of one form of Nr pollution may contribute to increase another".

Line 147: Please change to "for both 2016 and 2017 experiments" or similar; the sentence gives the impression of measurements throughout the entire growing season of multiple years.

Line 149: "a sealed lid"

Line 238: "several"

Line 239: "holds" and "centre"

Line 253: "to provide"

Line 335: Do you mean gaseous NH3 or NH4+ in the soil solution?

Line 345: Change "was" to "were".

Lines 348-349: Please add uncertainties.

Line 350: Typo, should be "trials".

Line 353: Why "although"?

Line 358: "show"

Line 365: Change to "under the conditions".

Line 368: "the treatment effect"

Line 382: FIDES is the mathematical approach, not the measurement method.

Line 386: Change to "... while Nitram treatments do not ...".

Line 399: Add "of" before "applied".

Line 402: "under the right conditions". Also, which conditions would be "right"?

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Line 410: Change “emitters” to singular.

Line 413: Please specify that this decrease is by 90%, not to a level of 90%.

Figure 2: The headers are not consistent with the other figures (Ammonium Nitrate instead of Nitram).

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