How does inorganic N fertilizer affect soil N mineralization?
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INTRODUCTION

• Fertilizer nitrogen (N) use efficiency (FNUE) is key to improve nitrogen use efficiency (NUE) of agricultural systems.
• Two methods are used to measure FNUE:
  1) Indirect ‘N Difference’ = (N uptake in fertilized plot – N uptake in zero N plot)/ N fertilizer applied
  2) Direct 15N Tracer = 15N fertilizer to track uptake of individual fertilizer atoms
• These methods consistently produce different results; the N difference method always measures higher FNUE.
• The N Difference method may overestimate FNUE if N fertilizer increases N mineralization in fertilized plots, but not the zero N controls (i.e. priming).
• Alternatively, the 15N Tracer method may underestimate FNUE because the 15N isotope mixes with the native soil N pool resulting in a diluted 15N signal.

OBJECTIVE & QUESTIONS

Our goal was to quantify the effects of inorganic N fertilizer addition on gross ammonification rate (soil organic matter mineralization) across gradients of SOM in a continuous maize system in Iowa (USA).

• Does inorganic N fertilizer enhance SOM decomposition?
• Which method of FNUE measurement is more accurate?

HYPOTHESIS

• Inorganic N fertilizer increases soil N mineralization.

METHODS

Soil Organic Matter gradient

• At central and southern Iowa trials (fig. 1(A)), long term inorganic N fertilizer (1999-2014) applied to continuous maize increased the residue/yield and soil organic matter stocks with the increase in fertilizer rates (fig 1 (B)).

Experimental set-up

• In 2015, three of the historic N rates (1999-2014) were selected at each site:
  • Zero, Agronomic Optimum N Rate (AONR) (202 kg N/ha), excessive rate (269 kg N/ha) at central Iowa site.
  • Zero, lower than AONR (224 kg N/ha), AONR (269 kg N/ha) (highest rate) at southern Iowa site. At this site, the AONR was the highest rate.
  • From 1999-2014 the average AONR for each site was 202 and 269 kg N/ha at central and southern site, respectively.
• In 2015, each historic N rate plot (N=4 plots/rate) was subdivided into 3 subplots i) the historical rate; ii) fertilized with the empirically determined AONR for that site, and iii) zero N (without AONR) (fig. 2 (A)).
• Soil samples from 5-15 cm depth were collected at V5 (5 collared leaves) and V12 (12 collared leaves) maize growth stages from with and without AONR subplots (fig 2 (B)).
• Gross ammonification rates were determined using 15N isotope dilution in the laboratory immediately after sampling (ambient moisture, no pre-treatment).

RESULTS

• Across all historic N fertilizer rates at the V5 maize growth stage, N fertilizer input at the AONR in 2015 reduced gross ammonification rates by 15% as compared to zero fertilizer addition at the central Iowa site, and by 12% at the southern Iowa site.
• No effect of N fertilizer on gross ammonification at the V12 maize growth stage at either site.

CONCLUSIONS

• N fertilizer application reduces gross ammonification rate.
• Impact of fertilizer decreases with the increase in historic N rate.
• N fertilizer application does not enhance SOM decomposition.
• ‘N difference’ method is more accurate for measurement of FNUE.

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Figure 3. Mean gross N mineralization rate and standard error (vertical bars) in continuous maize for three historic N rates of 0, 202 (long-term AONR) and 269 kg N/ha (highest rate) at the central Iowa site (A) and 0, 224 (rate increment just below the AONR) and 269 (long-term AONR) at the highest rate at southern Iowa site (B) where either no N or the long-term AONR fertilizer rate was applied, determined at the V3 and V12 maize growth stage. ** indicates the difference between zero and AONR fertilizer application is significant at P < 0.05 and * indicates the differences are significant at P < 0.1.

Figure 4. Difference between the gross ammonification rate for with and without AONR application in 2015 at three historic N rates of 0, 202 (long-term AONR) and 269 kg N/ha (excessive rate) at (A) central Iowa site; and 0, 224 (rate increment just below the AONR) and 269 (long-term AONR) at the highest rate at (B) southern Iowa site determined at the V5 maize growth stage. *** indicates the differences are significant at P < 0.005, ** P < 0.05 and * indicates the differences are significant at P < 0.1.
• Impact of AONR application in 2015 on N mineralization decreased with an increase in the historic N rate/SOC stock (Fig 1 B) at both sites.
• At the V5 growth stage at the central Iowa site, N fertilization at the AONR in 2015 reduced gross ammonification rate by 20 and 18% in the historic zero and AONR (202 kg N/ha), respectively.
• Similarly, at the southern Iowa site, AONR application in 2015 reduced gross ammonification rates by 17 and 13% in the historic zero and 224 kg N/ha, respectively.
• In contrast, at the highest long-term historic N rate (269 kg N/ha), the AONR rate had no effect on gross ammonification compared to no N fertilizer input at either site.

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• Impact of fertilizer decreases with the increase in historic N rate.
• N fertilizer application does not enhance SOM decomposition.
• ‘N difference’ method is more accurate for measurement of FNUE.