A study of relative contribution of ammonia oxidizing archaea (AOA) and ammonia oxidizing bacteria (AOB) to nitrification under different land use types

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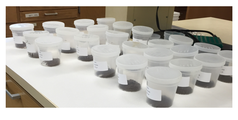
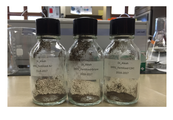
INTRODUCTION



Soil nitrification is a biological process that converts ammonia to nitrate. Excess nitrate is prone to leaching, which results in financial loss for farmers and water pollution. It is known that ammonia oxidizing archaea (AOA) and ammonia oxidizing bacteria (AOB) are able to nitrify, but it is unclear how much they contribute to this process individually. To answer this question, we conducted an experiment at the Kellogg Biological Station (KBS) Long Term Ecological Research (LTER) site to determine how AOA and AOB contribute to soil nitrification. Soil samples were taken from seven different ecosystems including Conventional Wheat (T1), Biologically Based Wheat with Cover Crop (T4), Poplar (T5), Early Successional Community (T7), T7 fertilized subplots, Deciduous Forest (DF), and DF fertilized subplots.

METHODS

We sampled soils two days after rainfall on June 19, 2016. Soil was then sieved through 4mm meshes. 12 grams of sieved soil was placed in Wheaton bottles in triplicate. Chemical inhibitors including 10 Pa C_2H_2 (inhibits both AOA and AOB) and octyne (inhibits AOB only) were injected into the bottles to separate the relative contribution of heterotrophs, AOA and AOB to soil nitrification. The bottles were incubated in their respective ecosystems (buried in soil: 15 cm deep) for four weeks. Every week, we removed the bottles and flushed with water-saturated air and then injected inhibitors again. CO_2 samples were taken at the first week of the experiment and measured at 2 hours and 24 hours. The accumulation of CO_2 over the 22 hour period was used to calculate the CO_2 emission rates of different ecosystems. At the 28th day, the bottles were removed and soil nitrate was extracted with KCL and analyzed with Latchat.

We also tested soil pH immediately after the soils were brought back to the lab. The amount of nitrate accumulation with different inhibitors over four weeks was used to calculate the nitrification rates by AOA and AOB.

RESULTS

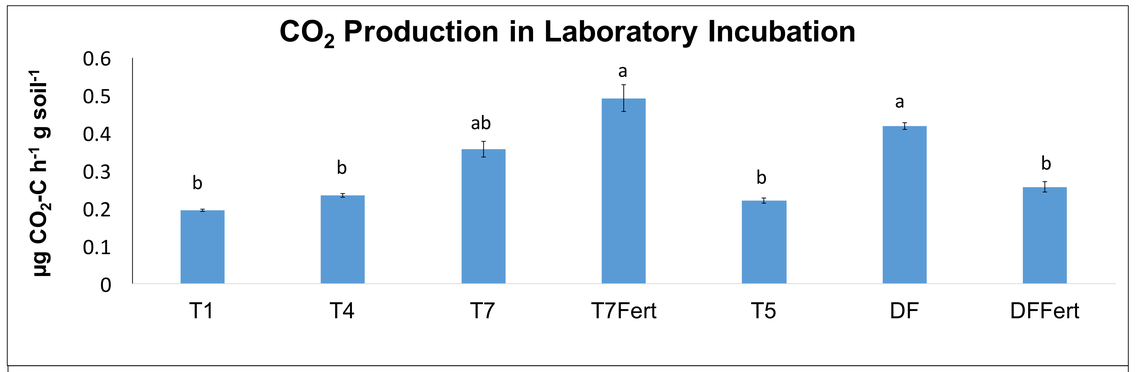


Figure 1: The CO_2 Production in laboratory incubation after one week of field incubation for different ecosystems. Different letters indicate significant differences among treatments ($p<0.05$).

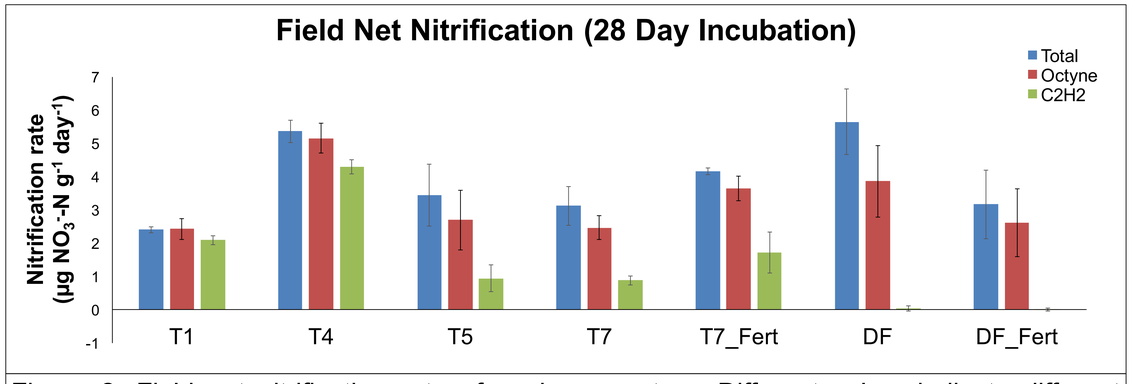


Figure 2: Field net nitrification rate of each ecosystem. Different colors indicate different contributors: total nitrification (blue), octyne (red), or acetylene (green).

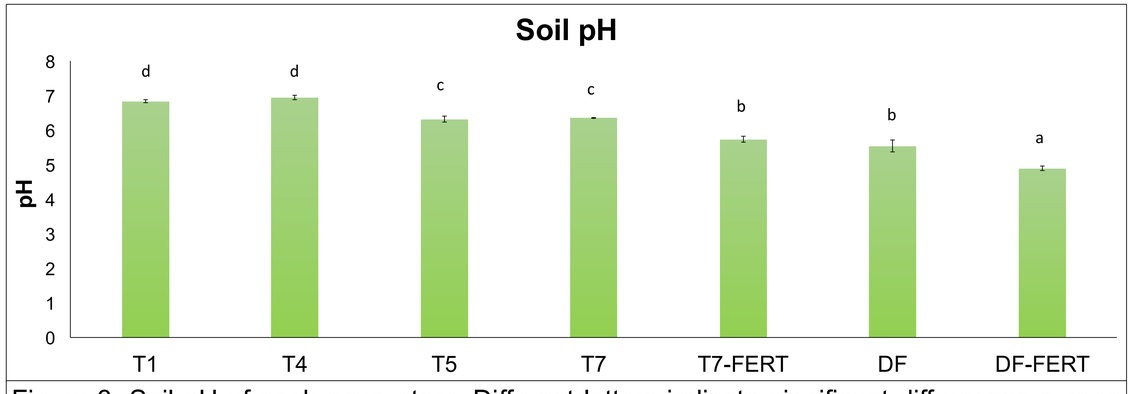


Figure 3: Soil pH of each ecosystem. Different letters indicate significant differences among treatments ($p<0.05$).

DISCUSSION

By sampling seven different ecosystems, we were able to obtain CO_2 emission rates, field net nitrification rates, and soil pH.

CO_2 emission rates in T7 fertilized subplots are significantly higher than T1, T4 and T5. This might be because there is more organic carbon that accumulated in T7 fertilized subplots.

T4 and DF have the highest field net nitrification rates. This reflects the constant supply of organic matter from the cover crop in T4 and plant detritus in DF. Heterotrophs dominated nitrification in T1 and T4; however, in DF there is no evidence of heterotrophic nitrification.

The pH of the fertilized subplots were significantly lower than their non-fertilized treatments (as shown in T7 and DF). This is expected because fertilizer facilitates nitrification, which causes soil acidification.

Except DF and DF fertilized subplots, heterotrophic nitrification contributed to at least 30% of the total nitrification. In T5, T7 and T7 fertilized subplots, autotrophic nitrification was responsible for at least 70% of nitrification.

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KBS LTER Kellogg Biological Station Long-term Ecological Research

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