Enzyme Activity: A New Link to GHG Emissions? A Comparison of Gas Emissions to Enzyme Activity from Agricultural Fields at Shelburne Farms

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Introduction

Agricultural manipulation of land can result in changes in the amount of greenhouse gases, like carbon dioxide, nitrous oxide and ammonium, released from the soil. Greenhouse gases are normally emitted through organic processes within the soil; microbes within this environment create enzymes to break down organic material. Enzyme presence within soil can cause radical differences in soil activity, but enzyme communities are only loosely understood. This project was conduct to find any correlation between enzyme activity and greenhouse gas emissions.

Table 1. Enzyme varieties tested for.

Enzyme	Substrate Concentration for Km (Vmax) test
Cellobiohydrolase (CBH or CB) Degrades cellulose	4-MUB-β-D-cellobioside (500.45 g/mol) 50.1 mg/50 mL **2000 µM**
β-Glucosidase (BG) Degrades cellulose	4-Methylumbelliferyl β-D-glucopyranoside (338.1 g/mol) 33.8 mg/50 mL **2000 µM**
β-Xylosidase (BX or XYL) Degrades hemicellulose	4-Methylumbelliferyl β-D-xylopyranoside (308.28 g/mol) 30.8 mg/50 mL **2000 µM**
β-N-acetylglucosaminidase (NAG) Degrades chitin	4-Methylumbelliferyl N-acetyl-β-D-glucosaminide (379.36 g/mol) 38 mg/50 mL **2000 µM**
Leucine aminopeptidase (LAP) Degrades peptides, amino acids	L-Leucine-7-amido-4-methylcoumarin hydrochloride (324.80 g/mol) 37.94 mg/50 mL **2000 µM**

In the summer of 2015 multiple agricultural sites in Vermont had been established as testing areas for greenhouse gas emissions. Shelburne Farms was selected as the best site for the enzyme comparison for several reasons. The property had two field sites used to grow hay; Site 1 (aerated) and Site 2 (non-aerated). Between the dates of July 21 and July 22 manure was applied to these fields. The differences between the soil aeration of the fields and changing nitrogen levels from manure application created a better comparison for enzyme data than other greenhouse gas testing sites.

Materials and Methods

- **Four chambers were present in each of the sites use. Chambers 25-28 were located in Site 2, chamber 29-32 were located in Site 1.**
- **The chambers were utilized by a gas analyzer device that read CO2 and N levels from soil. This information was logged into a computer.**
- **Soil samples were collected from the area around the chambers at the same time as when the gas analyzer was used.**
- **Collection processes were done at the same time on each sampling date.**
- **A microplate reader was used to test the collected soil samples for enzyme presence. Several enzyme types were screened for (see chart).**
- **Enzyme and gas levels were compared and contrasted graphically to illustrate trends in the data.**
- **Data from the two sites was averaged together before being organized into charts and figures.**

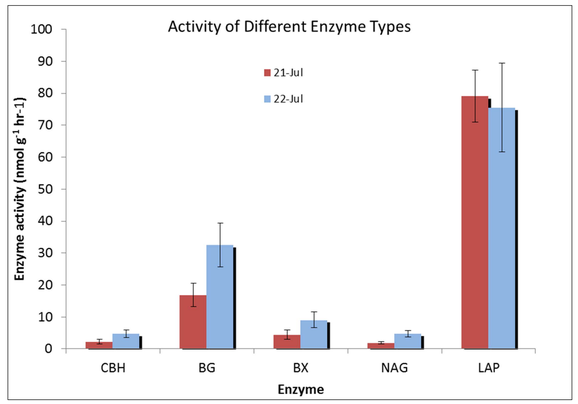

Figure 1. Comparison of enzyme types over the test period.

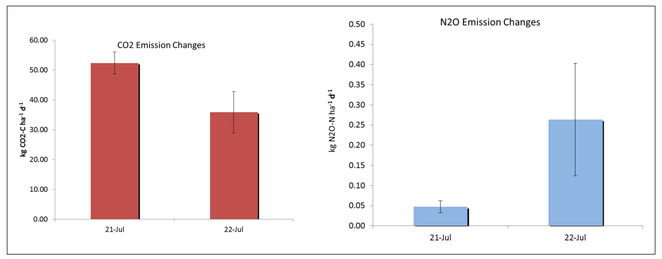

Figure 2. CO2 and N2O gas levels from both sites.

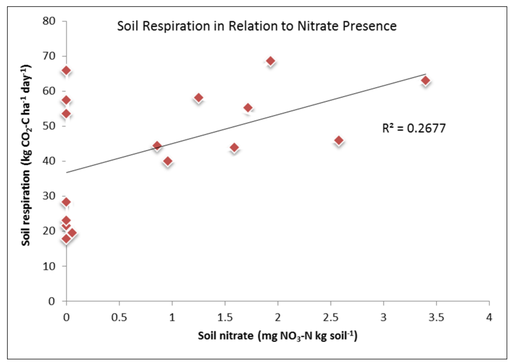

Figure 3. Soil respiration related to nitrate levels in soil.

Results and Conclusions

Enzyme activity from all enzyme types tested for excluding LAP was higher after manure application. LAP is a type of enzyme used by microbes to process N compounds; the higher availability of these compounds in the soil on the second day may have reduced the need for this activity. Soil respiration was shown to have increased slightly with higher nitrate presence, but shows a much more significant decrease with less nitrate. CO2 presence was significantly less on the second day, likely relating to the decreased amount of nitrate presence. The higher amount of ammonium after the manure application suggests an increased amount of denitrification taking place in the soil from the manure. Overall, the data when organized did not show any significant correlations between enzyme activity in soil and higher emission rates.

Past studies have found similar correlations between CO2 and CH4 emissions and organic matter presence in soil, finding that CO2 does not correlate well with enzyme activity due to microbial variance, with stronger trends between N compounds and gases created through nitrogen-fixing processes. Soils that are less disturbed by human activity have also had more enzyme activity in previous studies, suggesting that comparing non-agricultural sites with used land may show stronger results. It may be worth conducting this study over a longer period of time in the future.

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