Observed ammonia fluxes during maize production in mesocosms with basalt amendments

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Materials and Methods

Overview

We grew corn (*zea mays,* Reid's Yellow Dent Open Pollinated Corn Seed, Bradley Seed Brand) in a Yale Science Building research greenhouse (affiliated with Yale University's Marsh Botanical Garden's plant growth facility) controlled by an Argus Prime automation system with and without basalt amendments under average growing season conditions. We measured the ammonia (NH_3) fluxes, and soil pH, and temperature. System settings and measurements taken are listed in Table 1.

System Settings

All corn was grown in 121-liter containers. We chose to use large containers relative to those used in other enhanced rock weathering (ERW) mesocosm experiments (e.g., ~55-liter (Amann et al., 2020), and ~7.8-liter (Buckingham et al., 2022)) given that small column experiments may lead to differences in soil and system behavior that can alter ERW rates and therefore may alter NH_3 fluxes. In each container, we planted 8 corn seeds at standard agricultural densities, (8-12in apart), and thinned to 4 stalks after 2 weeks if necessary, selecting the smaller stalk to be removed in all cases. We applied fertilizer at a high rate of 216 lbs N/acre because many farms in major corn producing states apply nitrogen fertilizer in excess (Xia et al., 2021). Each container received fertilizer via injection of urea-ammonium-nitrate fertilizer at least 5 cm away from the seeds to minimize risk of seed burning.

We also maintained other factors than soil pH (via basalt amendments) including soil moisture, soil texture, crop type, fertilizer timing and application rate, soil organic carbon content, temperature, and upper soil modification (tilling practice). We kept these variables as constant as possible with the Argus Prime automation system between containers within each iteration of the experiment except for soil pH, which was adjusted via the basalt amendments. The system was programed to mimic average July conditions in Spring Grove, Illinois, USA. We chose to aim for 60% saturated soil moisture – which was in our case, a volumetric water content (VWC) of 25. We maintained consistent soil moisture via automated irrigation lines dispensing reverse osmosis water (Argus Prime system). A porous drainage medium was placed at the bottom of each container. We ended the experiment approximately 4 weeks after fertilizer addition.

We sourced waste basalt dust from the East Haven Trap Rock Quarry and prepared it by passing it through a 1mm sieve. The basalt applications were introduced to the system by homogenization in the upper 10 cm of soil to simulate light disc tillage. Control containers received the same tilling practice without any basalt application.

Measurements

Surface soil was collected weekly to measure soil pH (from a 1:2.5 soil to water ratio). The surface soil temperature of each container was continuously monitored by the Eosense automated soil flux chambers (eosAS-LT/LO).

NH_3 fluxes were measured with a Picarro Cavity Ringdown Spectrometer (CRDS) model G2508 paired with 10 Eosense automated soil flux chambers (eosAS-LT/LO) and an Eosense recirculating multiplexer (eosMX). A 10-minute measurement period was used, with a linear fit and a pre- and post-delay of 1.5 minutes, to ensure high resolution flux measurements while measuring maximum samples per container per day. The mass spectrometer was calibrated at the start of the iterations.

Experiment Iterations and Different Settings

Table 1: Experimental Settings and Measurements

Soil Type	Paxton Agricultural Soil*
Amendment Types	5 tonnes basalt/acre (n=5), Control (n=5)
Fertilizer Rate	216
Day Temperature (C)	28
Night Temperature (C)	17
Light Intensity (umol/m^2s)	325
Photoperiod (hours)	15
Daily Light Integral (mol/m^2d)	17.5
Expected Soil Saturation (%, VWC)	60%, 25
Irrigation	5 oz once per day
Drainage Medium	Plastic gridded louver covered by landscaping fabric
Other	added leaf compost at a rate of 15% by volume, added 1L 0.5N HCl
Measurements Taken	NH_3 fluxes; soil pH, buffer pH (beginning and end); alkalinity, soil moisture (10cm, 2

*Sourced from a vegetable farm in northern Connecticut with Paxton-Woodbridge soil type (brownish, gently sloping, moderately well drained loamy soils with a firm substratum).

Data Management

The only alteration to the NH_3 dataset is that a value of 0 is presented instead of any negative NH_3 flux values.

To calculate total emissions, the flux measurements for each container were integrated over the length of the run using the trapz function from scipy.integrate in Python. The total emissions were tested for statistical significance with the T-test.

Results

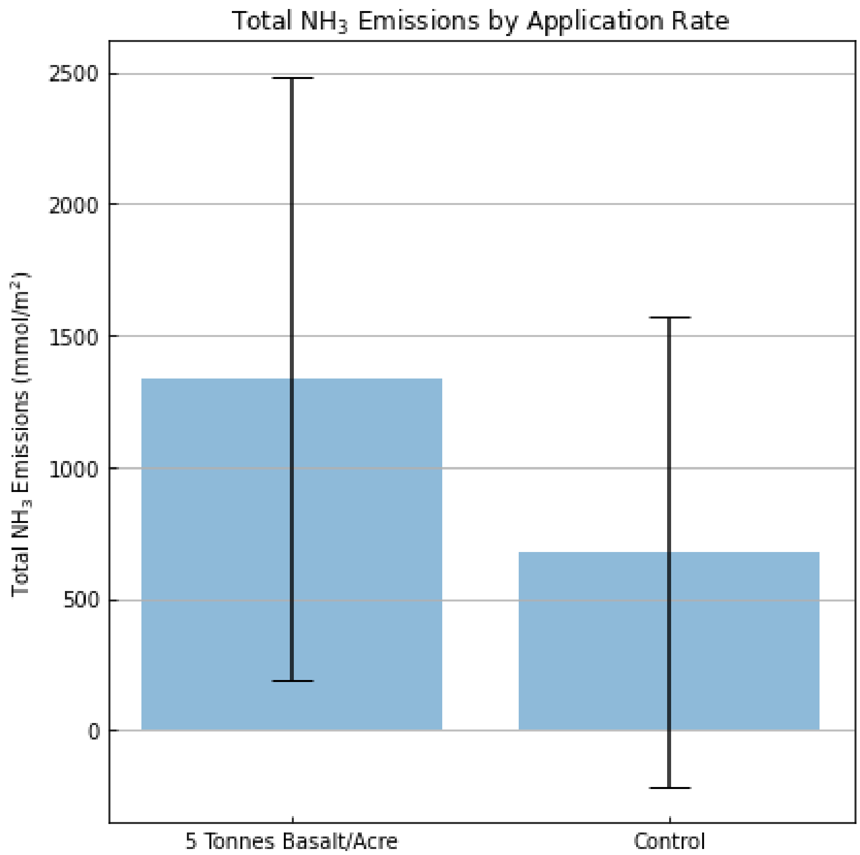

Figure 1:

Figure 1: Bar graph showing the mean cumulative NH_3emissions (umol/m^2) over the experiment period (24 days). Error bars represent standard deviation (1σ).

Table 2: Cumulative NH_3 Emissions

Application	5 tonnes basalt/acre	Control
Mean cumulative NH3 emissions (mmol/m^2)	1338.4642	676.7781
Standard deviation (1σ)	1145.6709	893.5857

Table 3: T-test– Comparison of Means

Group 1	Group 2	t-value	p-value
Basalt (5)	Control	0.9108	0.3890

The data tables (soil pH, CRDS NH_3 fluxes) are presented in the supplemental files below.

Hosted file

`206-230_pH_Data_PrePrint_Server_ESS_Open_Archive.xlsx` available at https://authorea.

com/users/589298/articles/626202-observed-ammonia-fluxes-during-maize-production-in-mesocosms-with-basalt-amendments

Hosted file

CRDS_206-230_NH3_Data_PrePrint_Server_ESS_Open_Archive.xlsx available at https://authorea.com/users/589298/articles/626202-observed-ammonia-fluxes-during-maize-production-in-mesocosms-with-basalt-amendments