Characterizing ammonia oxidizing communities under legumes and non-legume plants in the Sonoran Desert

Brenda Ramirez, Yevgeniy Marusenko and Sharon J. Hall

School of Life Sciences, Arizona State University, Tempe, Arizona

INTRODUCTION

- Nitrogen (N) from the atmosphere can be converted to ammonium (NH_4^+) by the process of nitrogen fixation.
- Microorganisms that oxidize ammonia are called ammonia oxidizers, they possess specialized enzymes, such as ammonia monooxygenases[1, 2].
- Ammonia oxidation studies enhance the expansion of the knowledge about the relationship between ammonia oxidizer communities and the environment.
- N-fixation, which occurs via N-fixing bacteria in legume root nodules, free-living microorganisms in soil, and mineralization increases NH_4^+ in soil[1].
- Increased NH_4^+ in soil is expected to lead to higher ammonia oxidation rates.

RESEARCH QUESTION

What is the difference between the function of ammonia oxidizing microbial communities under legume and non-legume plants?

HYPOTHESIS

An elevated concentration of nitrogen in the soil signifies higher ammonia oxidizer abundance and ammonia oxidizing rates.

- Due to the additional NH_4^+ available from N fixation, we expected the nitrogen fertilized soil under non-legume (non-legume + N) to have the highest ammonia oxidation rates, followed by the legume soil.

Fig. 1

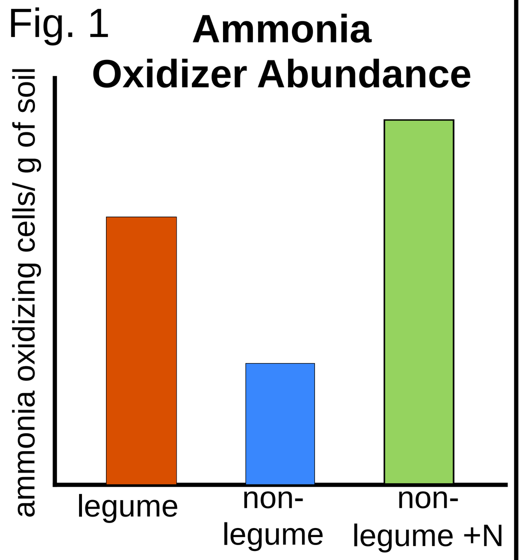
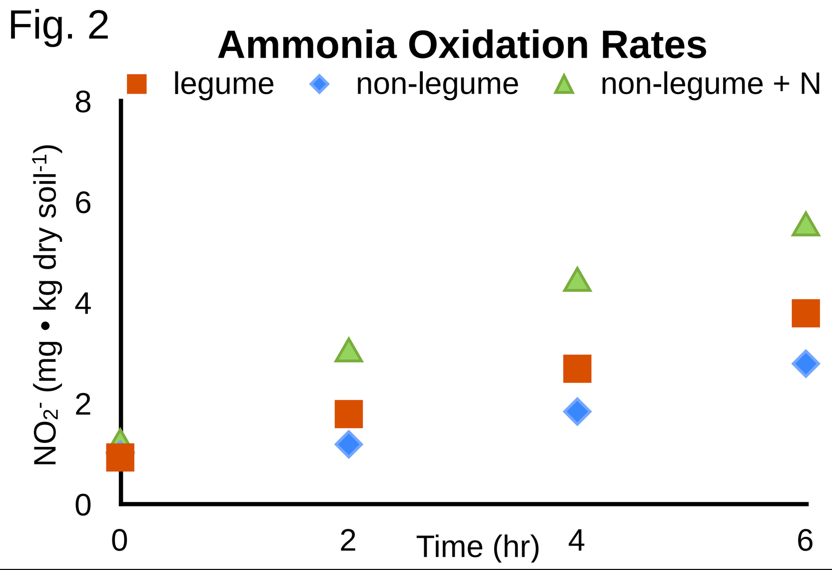


Fig. 2



- Fig. 1 and Fig. 2 represent hypothesized patterns.

METHODS

- Samples were collected at South Mountain Park-East (SME) in Phoenix, AZ (Fig. 3).
- Soil samples were collected at a depth of 5cm from below the canopy of treatment plants.
- The treatments are: control mesquite (legume; Fig. 4), control ambrosia (non-legume; Fig. 5), and nitrogen fertilized ambrosia (non-legume + N).
- Nitrogen fertilized soil receives 60kg of N/hectare/year[1].
- Nitrification potential[2] was used to analyze the rate at which the ammonia oxidizing bacteria oxidized NH_4^+ into nitrite (NO_2^-) at 0, 2, 4, 6 hrs (Fig. 6).

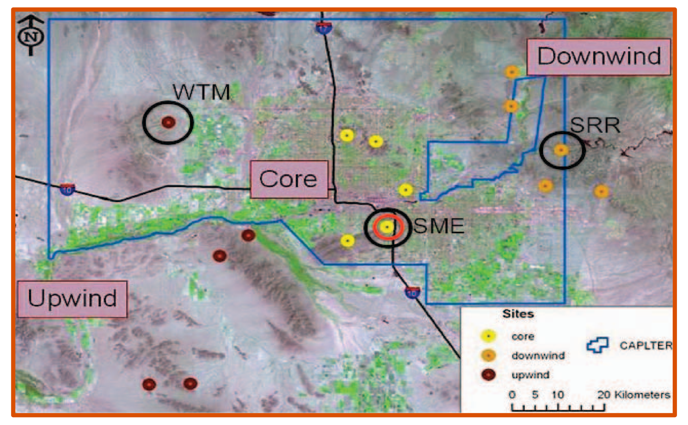
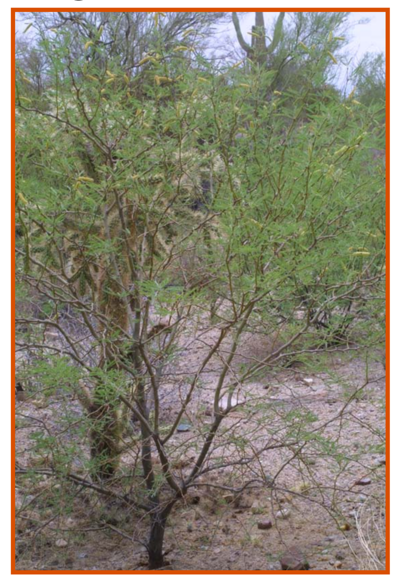


Fig. 3. Map of soil sampling location.

Fig. 4[3]

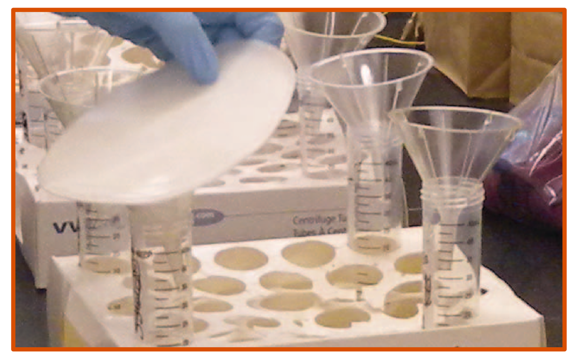


Legume:
Prosopis glandulosa (mesquite)

Non-legume:
Ambrosia deltoidea (triangle bur ragweed)

Fig. 5[3]

Fig.6



Nitrification potential extract filtration

RESULTS

Are ammonia oxidation rates higher in non-legume + N than in the legume treatments?

- Rates of ammonia oxidation are not significantly different between legume, non-legume, and non-legume + N.
- Soils under legumes appear to have higher mean rates of ammonia oxidation than non-legume soil. (n=5)

Fig. 7

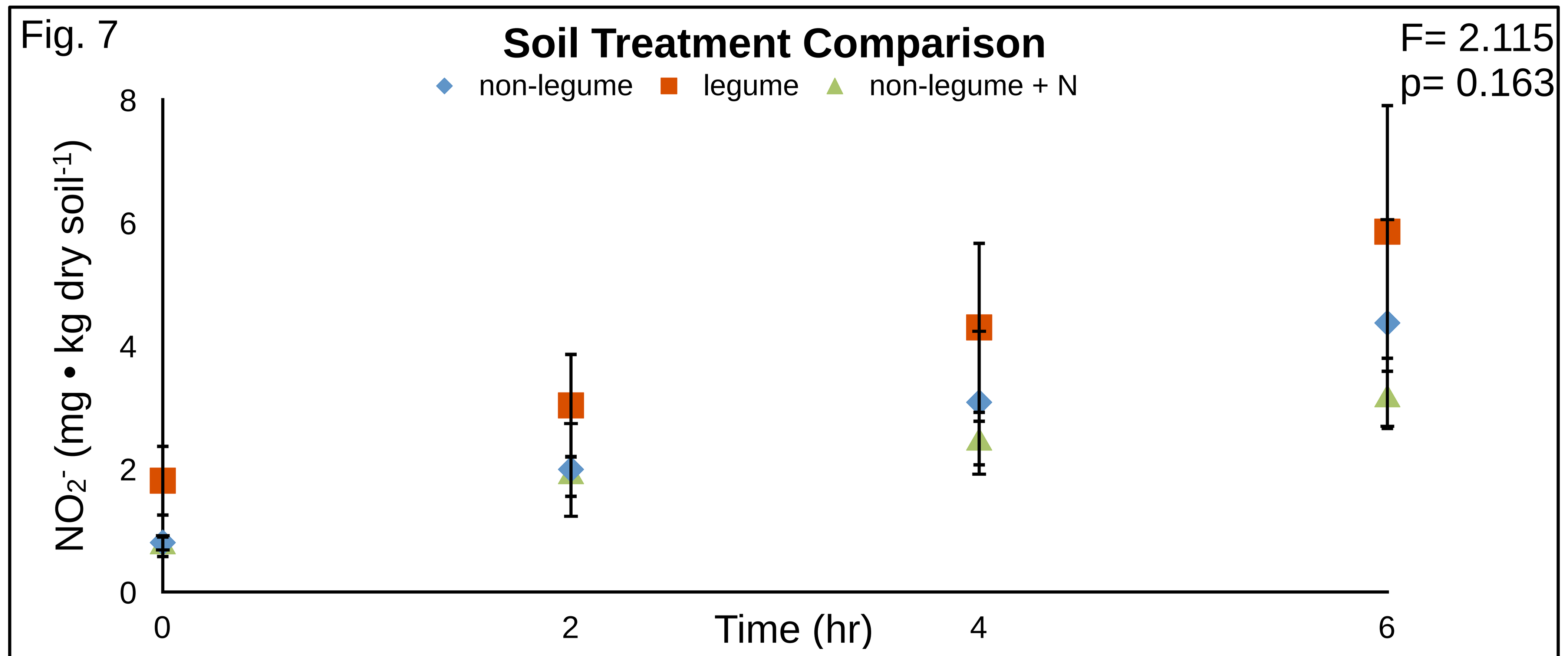


Fig. 7

- The amount of NO_2^- (milligrams of NO_2^- per kilogram of soil) that is accumulated from ammonia oxidation in the given time points.

DISCUSSION

- Non-legume + N (N-fertilized soil) results were lower than expected.
- Even though N-fertilized soils are treated with significant amounts of nitrogen, they are not as fertile as soil under legumes.
- After soils are fertilized;
  - Fate 1: N is not retained and it does not accumulate, hence, microorganisms are not able to utilize it.
  - Fate 2: Even though it is fertilized, ammonia oxidizing communities have not adapted to fertilized environment, therefore not reacting to the nitrogen.
  - Fate 3: Ammonia oxidizers adapt to the new conditions. However, we did not see this response after sampling in only one location.
- Soil under legumes provide a fertility spot for microorganisms, where nitrogen fertilization does not compare to a natural soil.

PROSPECTIVE EXPERIMENTS

- We will collect new samples from three locations to account for the heterogeneity across different soil types. Fig. 3 black circles indicate the two new locations: White Tank Mountain (WTM) and Salt River Recreation (SRR).
- We will choose sites that only vary in presence of legume and supplemental N.
- Molecular detection techniques will be used to characterize the microbial communities in these soils.

REFERENCES

1.Hall, S.J. et al. (2009). *Ecosystems*. 12.
2.Norton, J.M, Stark, J.M. (2011). *Methods in Enzymology*. 486.
3.Fig. 4 & 5: cas.vanderbilt.edu & fireflyforest.net

ACKNOWLEDGEMENTS

I want to thank Yevgeniy Marusenko, Jennifer Learned, the rest of the Hall Lab members, and CAP-LTER for their help, training, and advice. This research has been funded by WAESO (Western Alliance to Expand Student Opportunities) throughout Fall 2011. Thank you.