Department of Plant, Soil & Microbial Sciences
Announcement of Ph.D. Thesis Defense Seminar

Crop & Soil Sciences

Candidate's Name: **Di Liang**

Seminar/Examination Information:

Date: **Tuesday, December 10th, 2019**
Time: **10:00 am**
Location: **Room 237, Kellogg Biological Station**

The KBS zoom link is https://msu.zoom.us/j/598073986

Title of Dissertation:

Microbial Sources of Nitrous Oxide Emissions from Diverse Cropping Systems

Members of the Examining Committee and their Department:

- **Dr. G. Philip Robertson (Chair); Plant, Soil and Microbial Science**
- **Dr. Sasha Kravchenko; Plant, Soil and Microbial Science**
- **Dr. Sarah Evans; Integrative Biology**
- **Dr. Nathaniel Ostrom; Integrative Biology**

The seminar will precede the examination, beginning at the time indicated above

Cc: Faculty
Grad Students

ABSTRACT

By: Di Liang

Nitrous oxide (N_2O) is a potent greenhouse gas with a global warming potential ~300 times higher than CO_2. As the primary source of reactive nitrogen oxides (NO_x) in the stratosphere, N_2O also depletes stratospheric ozone. N_2O concentrations in the atmosphere are increasing rapidly, primarily due to agricultural activity. Nitrification, an autotrophic process that converts ammonia (NH_3) into nitrite (NO_2^-) and nitrate (NO_3^-), and denitrification, a heterotrophic process that reduces NO_3^- into NO, N_2O and N_2, are the two major processes leading to N_2O emissions. Nitrification has been reported to dominate N_2O emissions from agricultural soils under aerobic conditions.

Ammonia oxidizing bacteria (AOB) and ammonia oxidizing Archaea (AOA) are the two main taxa involved in nitrification. Both AOA and AOB are capable of producing N_2O, but their relative importance in nitrification is still largely unknown. In this dissertation I address three nitrification knowledge gaps: 1) Importance: what is the contribution of nitrification versus other microbial processes for producing N_2O in systems under different management intensities (Chapter 2)? 2) Ecology: can high NH_4^+ inputs induce niche differentiation between AOA and AOB (Chapter 3)? 3) Complexity: how do plants mediate N_2O emissions from AOA and AOB in-situ in annual and perennial bioenergy cropping systems (Chapter 4)?

In Chapters 2 and 3, I sampled soils from ecosystems under a management intensity gradient ranging from heavily-managed row crop agriculture to unmanaged deciduous forest. Results in chapter 2 show that soil nitrification is unlikely to be the dominant source of N_2O in annual row crop systems, as the 25th – 75th percentile of the maximum potential contribution ranged only between 13-42% of total N_2O. In contrast, a maximum potential contribution of 52-63% of total N_2O emissions could be attributed to nitrification in perennial or successional systems. In chapter 3, I found high NH_4^+ inputs could inhibit nitrification of AOB but not AOA,

especially in perennial and successional systems. Moreover, long-term N fertilization significantly promoted nitrification potentials of both AOA and AOB in the early succession but not in the deciduous forest systems. In summary, results from these two chapters suggest 1) nitrification is a minor source of N_2O, especially in row crop systems, and 2) NH_4^+ inhibition of AOB could be another mechanism leading to niche differentiation between AOA and AOB in terrestrial environments.

In chapter 4, I examined nitrifier N_2O emissions from annual (corn) and perennial (switchgrass) bioenergy cropping systems during different seasons that differ in plant nutrient demands. Both AOA and AOB responded to N fertilizer applications in-situ but N fertilizer-induced N_2O emissions were mainly observed in corn but not in switchgrass system. Because plants can compete with soil nitrifiers for NH_4^+ during the growing season, competition for NH_4^+ appeared to reduce N_2O emissions from nitrification. Thus, synchronizing fertilizer application with plant nutrient uptake can be an important strategy for mitigating nitrification-derived N_2O. Overall, results from this dissertation suggest that nitrifier-derived N_2O in terrestrial ecosystems is significant but not a dominant source of N_2O, and although AOB are more responsive to added N than are AOA, AOB can also be inhibited by high NH_4^+ concentrations in soil.