NITROUS OXIDE EMISSIONS AS A FUNCTION OF N APPLICATION RATE TO BIOFUEL FEEDSTOCKS

Tracy M Wilson, Jason G. Warren and Gopal Kakani
Dept. of Plant and Soil Sciences, Oklahoma State University

INTRODUCTION

The sustainability of any cellulosic bioenergy feedstock production system is in part a function of its ability to decrease net greenhouse gas emissions into the atmosphere compared to the combustion of fossil fuels. Nitrous oxide emissions can be a significant component of the total greenhouse gas budget for any bioenergy feedstock production system. Recent estimates suggest that the feedstock production phase of cellulosic bioenergy production may emit 60% of the total GHG's and that emissions of nitrous oxide (N_2O) are responsible for 36% of this number. Nitrous oxide is a potent GHG that is emitted from soils containing inorganic N (NO_3 and NH_4) (Fig. 2). Therefore N_2O emissions are generally proportional to the rate of N fertilizer applications. However, the rate of N_2O emission may also be influenced by meteorological conditions, soil texture, soil organic C, microbial activity, and crop type. Few studies have evaluated N_2O emissions from forage sorghum and switchgrass grown for cellulosic bioenergy and no research has been conducted to evaluate this important component of the production system in Oklahoma.

MATERIALS AND METHODS

- Nitrous oxide emissions were measured in small plots (9.1 m by 9.1 m) of forage sorghum and switchgrass located at Stillwater, OK.
- Sorghum and switchgrass plots were treated with urea ammonium nitrate (UAN) (28-0-0) fertilizer at rates of 0, 84, 168, and 252 kg N ha^{-1} at 4 leaf stage and green up, respectively.
- Nitrous oxide emissions were measured for all sorghum N rates and the 84 kg N ha^{-1} rate for switchgrass using a vented chamber technique (Mosier et al., 1991).
- Base anchors (38.1 cm by 12.7 cm) were forced into the soil of each plot.
- A vented chamber lid was placed on the base anchor such that an air tight seal was formed, only allowing air exchange through the vent tube. The air tight seal was formed by placing water in the trough into which the lid was placed (Fig. 1).
- 20 ml air samples were collected from a septum in the chamber at 0, 15, 30 and 45 minutes after the chamber lids were placed on the base anchors (Fig. 1).
- Air samples were stored in evacuated vials and analyzed using a gas chromatograph with an electron capture detector.
- Chamber headspace N_2O concentrations were used to calculate fluxes using linear regression between concentration and time.
- These flux measurements were made at 24, 48, 72, 96, 120, 144, and 168 hours after application and then weekly for the remainder of the growing season.
- Total growing season emissions were estimated with linear extrapolation between sampling periods.

Figure 1: Parallel oriented chamber with sampling vials and syringe primed for sampling.

UID: 73633

OBJECTIVE

Evaluate the response in N_2O emissions to N rates applied to forage sorghum and switchgrass grown as bioenergy feed stocks.

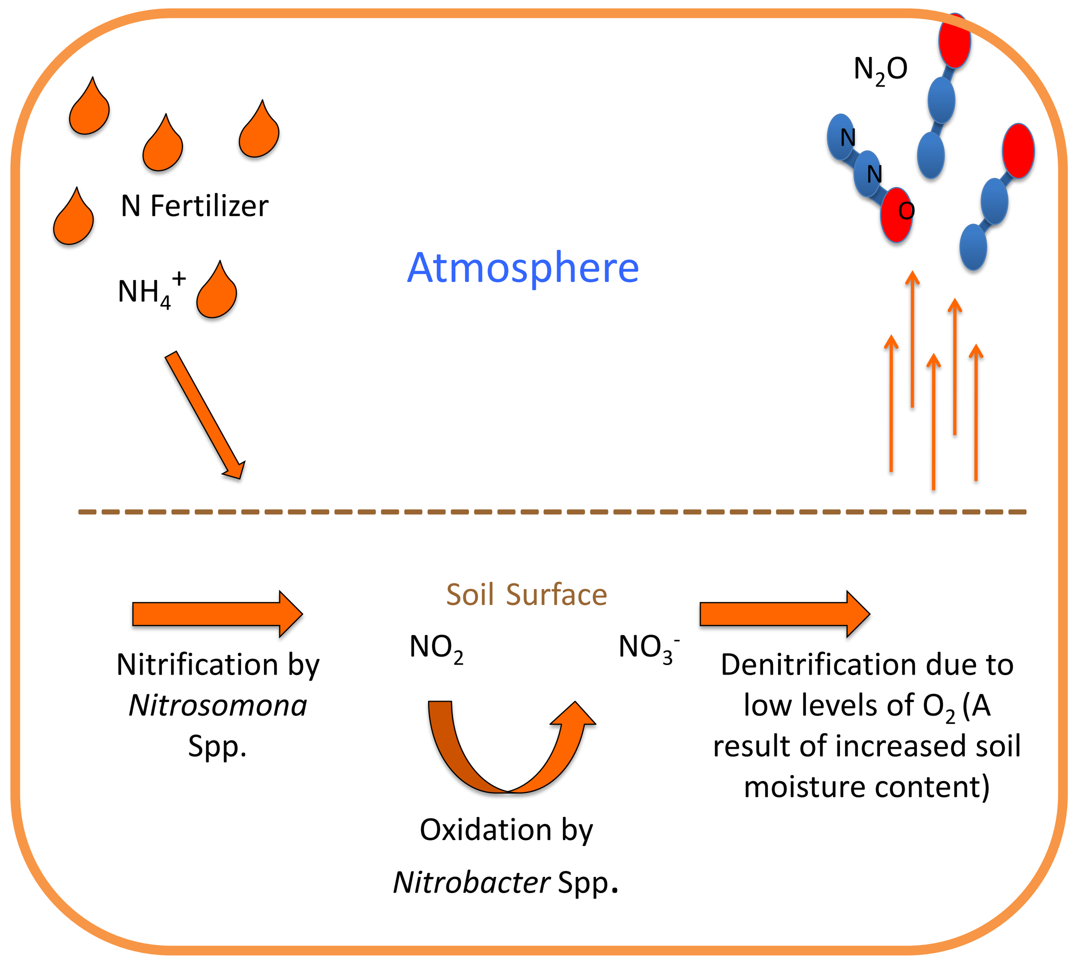

Figure 2: Simplified Nitrogen Cycle

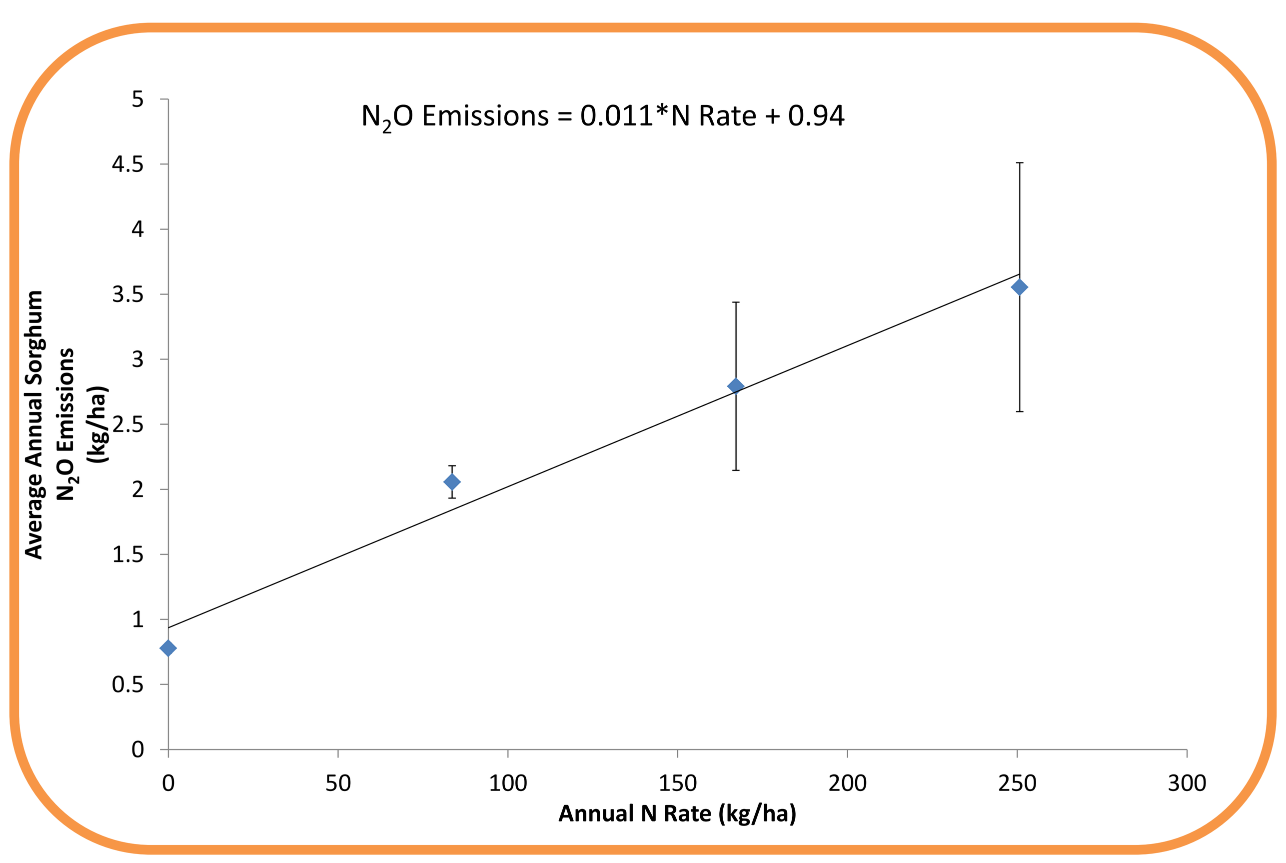

Figure 3: The relationship between the cumulative N_2O emitted during the 19 month observation period and the annual fertilizer N rate applied.

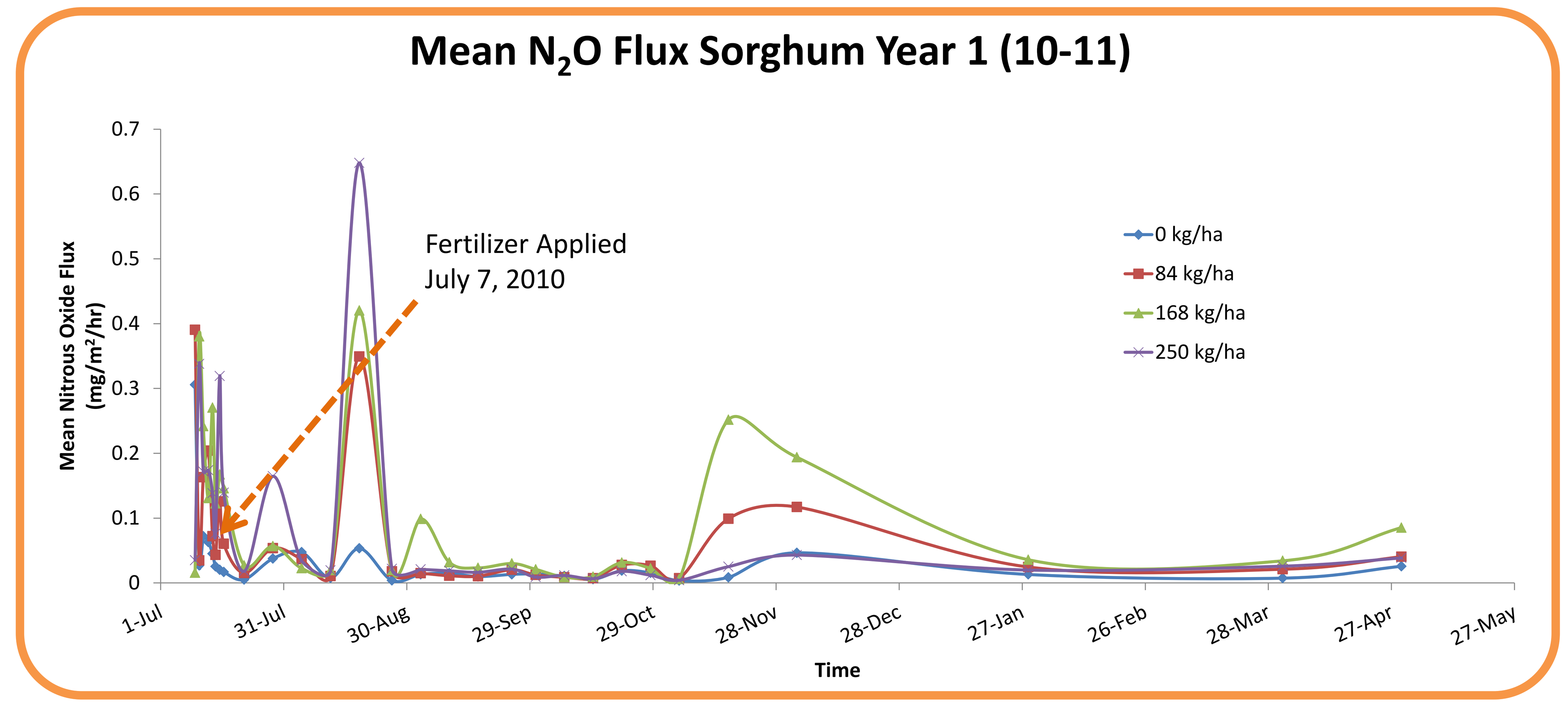

Figure 4: N_2O flux during the 2010 growing season.

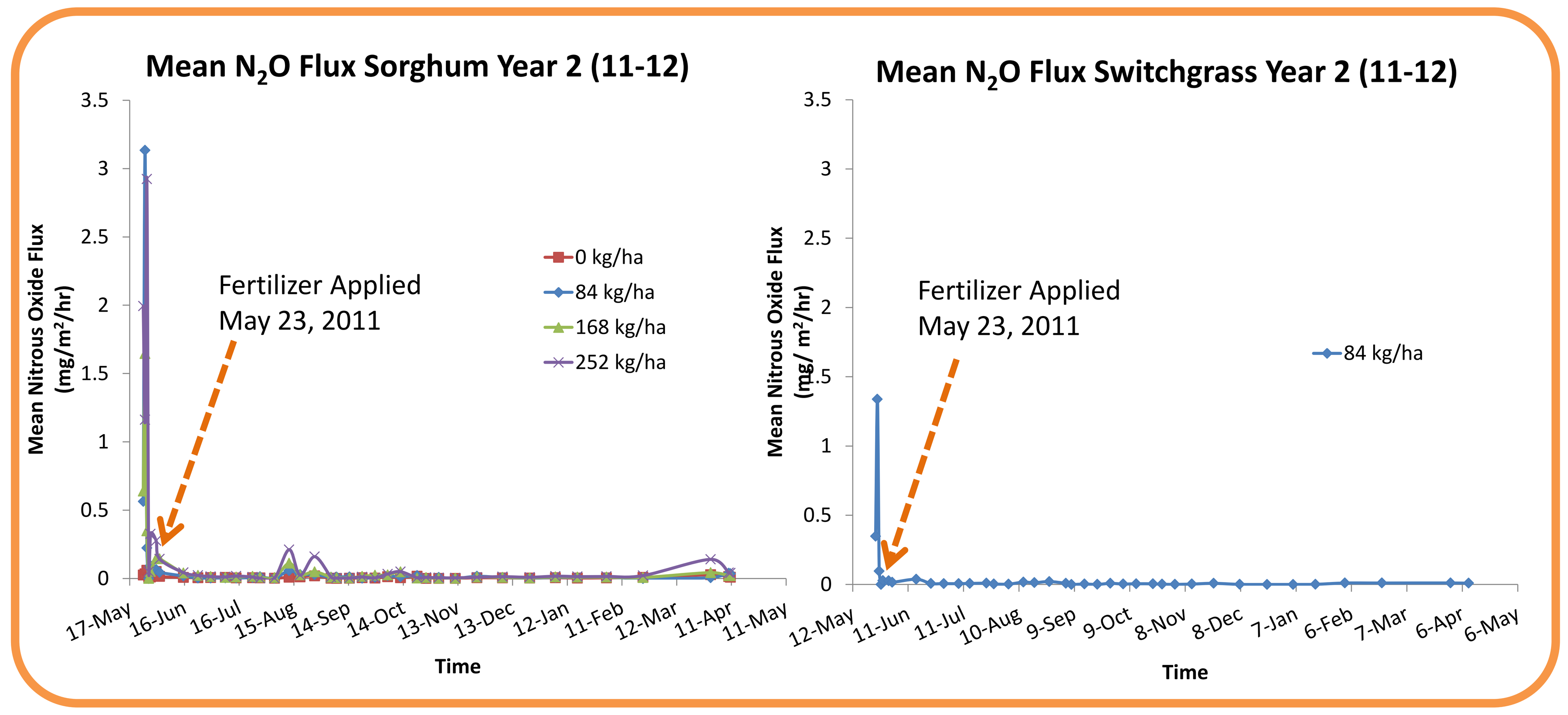

Figure 5: N_2O flux during the 2011 growing season.

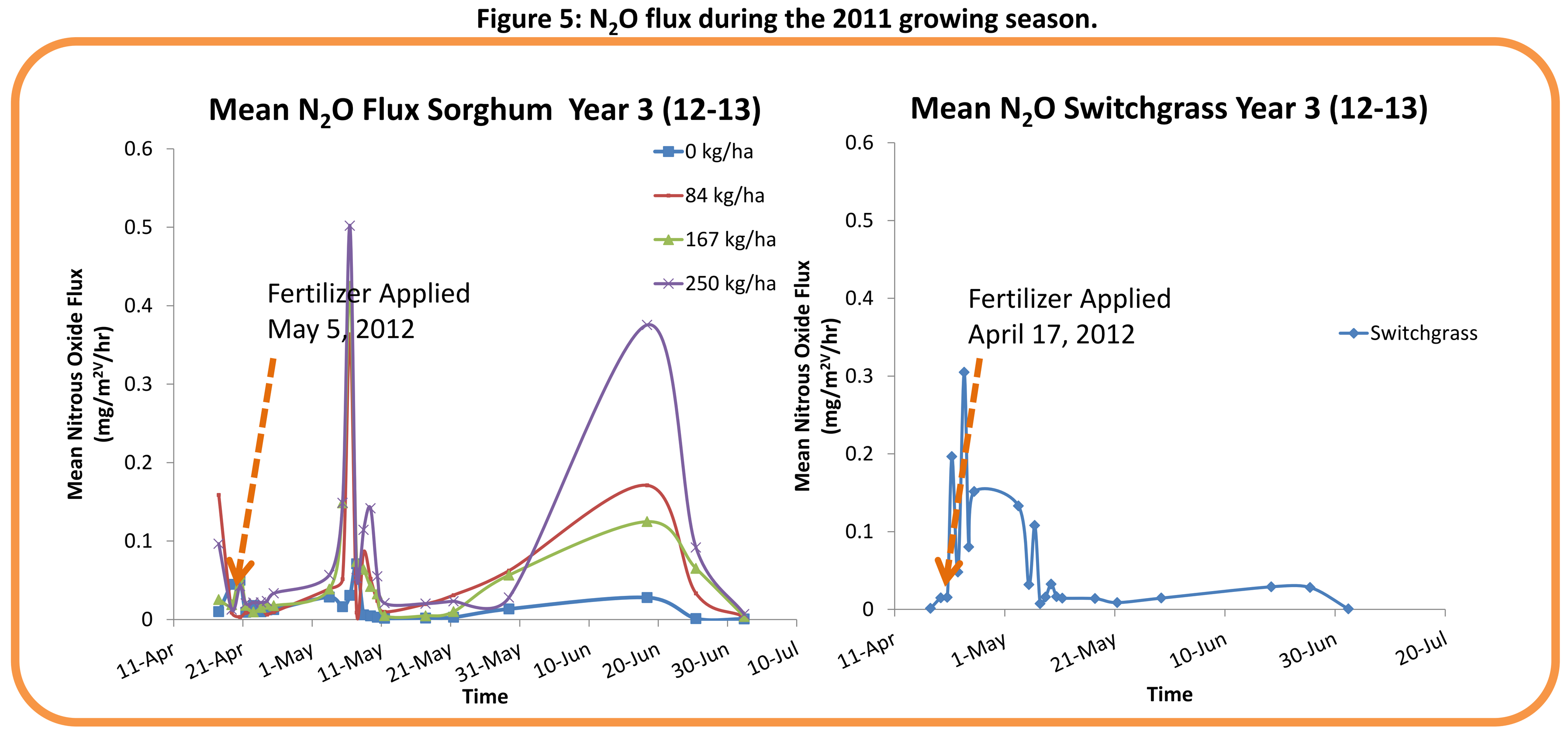

Figure 6: N_2O flux during the 2012 growing season.

RESULTS AND DISCUSSION

- N_2O fluxes were highly variable and generally responded to rainfall events sufficient to increase soil moisture to above 0.3 cm^{-3} H_2O cm^{-3} soil (data not shown).
- Multiple flux events occurred in 2010 (Fig. 4). In contrast, a single large event occurred in 2011 which resulted in similar cumulative emissions despite the drought conditions experienced during the remainder of the growing season (Fig. 5). In 2012, emissions thus far are even less than the 2010 growing season, demonstrating how variable N_2O emissions can be.
- The slope value resulting from linear regression of average cumulative emissions vs. annual N fertilizer applied (Fig. 3) shows 0.01 kg N_2O is emitted per kg fertilizer N applied. This is similar to the tier 1 estimates (0.01 kg N_2O per kg fertilizer N) used for life cycle analyses.
- The average annual N_2O emission rate for an application of 168 kg N ha^{-1} is 2.79 kg N_2O ha^{-1}. Given that the global warming potential of N_2O is 310 times that of CO_2, this N_2O emission is approximately equivalent to 0.86 Mtons CO_{2eq} ha^{-1}.