NITRICITY

Field nitrous oxide emissions from nitrogen fertilizers

WHAT IS NITROUS OXIDE AND WHY IS IT IMPORTANT TO MANAGE IT WELL?

The Intergovernmental Panel on Climate Change (IPCC) sent out a loud and clear message in March 2023 that can be resumed with the following words: the time to prevent irreparable damage from climate change is almost up, and we have to act now. There is no alternative nor more time to spare. Global atmospheric temperatures are about 1.1 ^{0}C higher than pre-industrial levels. However, there is still a chance to avoid the 1.5 ^{0}C increase, which is the supposed threshold for sparking self-reinforcing climate change events.

Carbon dioxide (CO_2) is by far the most discussed greenhouse gas (GHG) while nitrous oxide (N_2O) is usually neglected. It happens despite the fact that N_2O has a GHG effect about 300 times more potent than CO_2, and that N_2O emissions account for approximately 6% of the US total GHG emissions. Agriculture is the biggest contributor to N_2O emission, accounting for 75% of total, most of which coming from nitrogen (N) fertilizer application.

HOW TO MANAGE NITROUS OXIDE EMISSIONS

Nitrogen fertilizer management is a difficult task due to how complex is the N cycle in soils and the different loss mechanisms it is prone to (e.g., ammonia volatilization, nitrate leaching, and denitrification). Such losses impact both agronomic efficiency and environmental impact of N fertilizers. Farmers can use different strategies to help with N fertilizer management. First and foremost is the 4Rs principle, which stands for the use of the right fertilizer source, right rate, right time, and right place. Any farmer can easily adopt the 4Rs principle without additional cost but rather with good planning. Another option is the use of enhanced efficiency fertilizers (EEFs) that are designed to mitigate specific loss mechanisms and improve N fertilizer use efficiency. Examples of EEFs are inhibitor technology and controlled-release fertilizers However, the use of EEFs requires farmers to assess the economic return of using it. Ammonium-based fertilizers [e.g., Urea, Urea Ammonium Nitrate solution (UAN), and Aqua Ammonia] tend to emit more N_2O through the nitrification process in well drained soils than nitrate-based fertilizers [e.g., Calcium Nitrate (CN)]. On the other hand, nitrate-based fertilizers tend to emit more N_2O through the denitrification process in poorly drained soils.

NITROUS OXIDE EMISSION FROM DIFFERENT FERTILIZERS

Almonds

In a study conducted in Belridge, CA in 2013 with Nonpareil almond, researchers evaluated N_2O emissions between UAN and liquid nitrate-based formulation (calcium nitrate and potassium nitrate). UAN is a popular N fertilizer in California representing about 55% of the total N fertilizer demand in the state. Calcium Nitrate has a relatively small share of the market (2%), but with a significant potential to increase due to its agronomic and environmental benefits. Fertilizers were applied at a rate of 280 lbs N/acre via drip irrigation (high-frequency application). The researchers found higher N_2O emission with UAN treatment compared to nitrate-based treatment (Fig. 1). This higher N_2O emission from UAN was due to the nitrification process that the urea and ammonium forms in it had to go through.

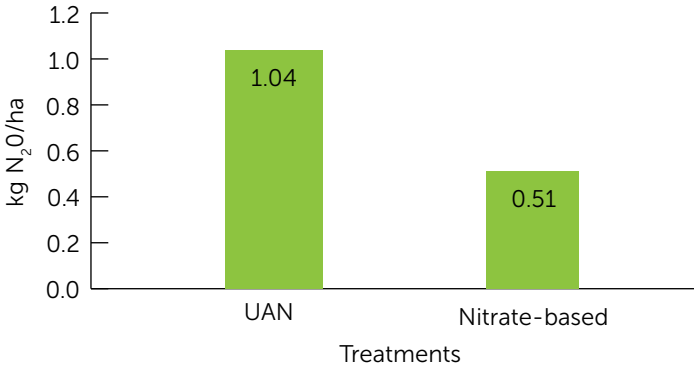

Fig. 1: Nitrous oxide emission from an almond field in California fertilized with UAN and liquid nitrate-based fertilizers. Adapted from Wolff et al., 2017.

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Corn

A 2012 corn study in California measured field N_2O emissions from different liquid N fertilizers applied at a rate of 180 lbs N/acre each. All fertilizers were applied at a depth of 6 inches. The ammonium-based fertilizers were tested with and without inhibitors (urease and nitrification inhibitors) to assess the performance of this technology. The results showed that CN fertilizer had the lowest numerical N_2O emission among all tested fertilizers, including those with inhibitor technology. Calcium nitrate N_2O emissions were 75% and 65% lower than those of untreated Aqua Ammonia and UAN, respectively (Fig. 2). Urease and nitrification inhibitors reduced N_2O emissions from UAN, but nitrification inhibitor did not decrease N_2O emissions from Aqua Ammonia.

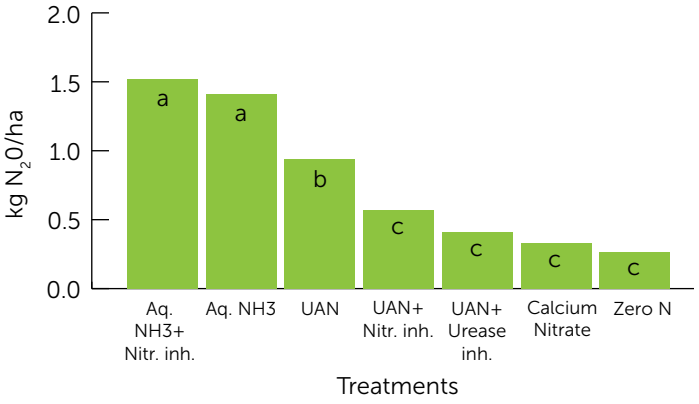

Fig. 2: Nitrous oxide emissions from different fertilizers applied to corn. Bars assigned with the same letters are not significantly different (P<0.05). Adapted from Burger at al., 2016.

Sugarcane

In a sugarcane study conducted in Brazil, researchers evaluated several types of N fertilizers and field N_2O emissions. The study was carried in soil with good drainage and a pH of 5.1. All N fertilizers were applied at a rate of 100 lbs N/acre. Urea and Polymer Sulfur Coated Urea (PCSU) had the highest N_2O emissions (Fig. 3), accounting for 1.7% of the total N applied. Urea N_2O emissions were higher than the 1% estimated by IPCC for this fertilizer. The authors explained the higher N_2O emissions to the losses that take place during the ammonification and nitrification processes. Calcium Nitrate treatment showed N_2O emission 90% lower than Urea treatment.

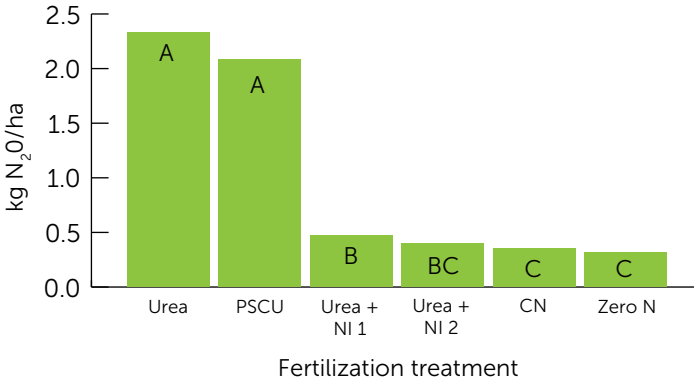

Fig. 3: Nitrous oxide emissions recorded from different fertilizers applied to sugarcane. Bars assigned the same letters are not significantly different (P<0.05). PSCU= Polymer Sulfur Coated Urea; NI 1= DCD; NI 2= DMPP; CN= Calcium Nitrate. Adapted from Soares et al., 2016.

CONCLUSIONS

Foreseeing N_2O emissions can be complicated. It is formed via different processes, soil conditions, and management practices. While there is more attention to reducing the environmental impact of agriculture, agronomists and farmers need to be aware that selecting the right N source has potentially a big impact on field N_2O emissions. Nitrate-based fertilizers tend to be more efficient than ammonium-based fertilizers, resulting in higher agronomic efficiency and lower field N_2O emissions.

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