NANORP FERTCARE®

National Agricultural Nitrous Oxide Research Program

SUGAR INDUSTRY FACT SHEET

Nitrous oxide emissions in the Sugar Industry

Northern Region

MARCH 2016

PHOTO: QUEENSLAND DSITI

NANORP research shows growing soybeans in the fallow period between sugarcane crops reduced soil nitrogen losses as nitrous oxide by 55 per cent.

KEY POINTS

- Optimising nitrogen (N) application rates is one of the most effective ways to reduce nitrous oxide (N_2O) emissions from sugarcane soils.
- More than 50 per cent of applied N fertiliser can be lost from sugarcane soils through denitrification, leaching and run-off.
- Annual N_2O emissions from Queensland sugarcane farms range from 3.6 to 18.2 kilograms of N equivalent (N_2O-N) per hectare, depending on farm management practices, soil and climatic conditions.
- Inclusion of soybeans in rotation with sugarcane reduced N fertiliser requirements for the following sugarcane crop by about 120kg N/ha, and N_2O emissions by 55 per cent compared with bare fallow using a conventional fertiliser application of 145kg N/ha.
- Trials with the nitrification inhibitor, 3,4-dimethylpyrazole phosphate-coated urea, reduced the N_2O emission factor by 1.7 per cent on average.

Agriculture is responsible for an estimated 85 per cent of Australia's emissions of nitrous oxide (N_2O), a greenhouse gas with almost 300 times the potency of carbon dioxide.

N_2O emissions represent inefficiency in fertiliser use and lowering the amount of this nitrogen (N) gas lost from the soil could generate on-farm cost savings.

The amount of N_2O emitted when N fertiliser escapes into the atmosphere varies between farming systems, soil types, climates and farm management practices. There is no single solution to reducing emissions.

N losses as N_2O emissions from Australian agricultural systems vary from about 10 grams of N per hectare from no-till cereal crops receiving 100 kilograms of N/ha in low-rainfall areas of Western Australia to nearly 15.5kg nitrous oxide-nitrogen (N_2O-N)/ha from sugarcane receiving 140kg N/ha in northern Queensland.

This fact sheet highlights research during round one of the National Agricultural Nitrous Oxide Research Program (NANORP), from June 2012 to June 2015, which aimed to quantify N_2O emissions and develop ways to drive down emissions across five of Australia's agricultural industries: grains, sugar, cotton, horticulture and dairy.

Fertcare® is a joint initiative of Fertilizer Australia and the Australian Fertiliser Services Association, which supports the objective of decreasing N_2O emissions through best practice in fertiliser supply, advice and contract application. A key component of Fertcare® is dissemination of information so that N fertiliser decisions can be made based on facts and scientific findings.

NITROGEN USE EFFICIENCY

NANORP research shows that, on average, 40 per cent of applied N fertiliser is permanently lost from Australian agricultural soils via leaching, run-off and as N gas. This equates to an estimated $400 million loss of fertiliser per year, plus a significant environmental risk to waterways and contribution to global warming.

THE NITROGEN CYCLE

While nearly 80 per cent of our atmosphere is N, most living organisms cannot access this gaseous N pool until it has been 'fixed' into an inorganic, reactive form that plants can use.

There are two main ways that atmospheric dinitrogen gas (N_2) is fixed into an inorganic form as mineral N.

The first is a biological process via N-fixing bacteria in the soil, and the second is an industrial process that converts N gas into N fertilisers. A small amount is also fixed via lightning strikes.

The cycling of N gas from the atmosphere through soil microbes, plants, animals and manufactured fertilisers is known as the N cycle.

Keeping this cycle in balance is the key to minimising losses of plant-available N into the atmosphere and into waterways (or beyond plant roots) via leaching or run-off.

Nitrogen cycle processes:

- N-fixing bacteria convert N_2 into ammonium (NH_4^+);
- nitrifying bacteria convert ammonium into nitrite (NO_2^-) and then into nitrate (NO_3^-);
- plants take up ammonium and nitrate, and convert them into plant tissue, which is then consumed by animals;

- organisms, such as bacteria and fungi, convert animal excrement and dead animal and plant tissue to ammonium, which then also goes through the nitrifying process above; and
- denitrifying bacteria complete the N cycle by converting nitrate back to gaseous N compounds (N_2, N_2O and NO).

N_2 is often the main form of gas produced from denitrification when soil microbes convert nitrate into N gases. The ratio of N_2 to N_2O in a typical season is usually about 50:1, but this ratio can vary significantly depending on soil pH and moisture content.

Soils do not need to be noticeably waterlogged to stimulate denitrification.

When waterlogged soil (low in oxygen) with high soil nitrate and high soil organic matter occur simultaneously, then denitrification can be significant. Up to 45 per cent of applied N was found to be lost as gaseous N emissions following a large storm event.

N_2O AND THE SUGAR INDUSTRY

N fertiliser rates in the sugar industry range from more than 200kg/ha in Queensland's Burdekin region to 140 to 155kg/ha in other regions of the state. However, studies showed that more than 50 per cent of this applied N fertiliser can be lost from sugarcane soils through denitrification, leaching and run-off.

High levels of decomposable organic matter (following stubble retention), low soil pH levels and high N fertiliser application rates, combined with subtropical to tropical climates and intense summer rainfall all favour N_2O production from denitrification.

In Queensland's sugarcane regions, annual N_2O emissions ranged from 3.6 to 18.2kg N_2O-N/ha. These annual emissions are significantly higher than those observed in cereal-cropping systems in Queensland, which are generally less than 2kg N_2O-N/ha.

There is considerable scope in the sugar industry to improve N management practices to help reduce N fertiliser losses, decrease N_2O emissions and increase farm business profitability.

The primary aim is to better match N supply with crop demand by managing the amount, timing and placement of fertiliser.

MITIGATING N_2O EMISSIONS

Management strategies that can reduce N_2O emissions from sugarcane soils include:

- avoiding excessive N applications;
- matching N supply to crop requirements by assessing available soil N, setting realistic yield targets and placing N fertiliser below the soil surface;
- using enhanced efficiency fertilisers;
- using water-efficient irrigation methods;
- growing legume break crops or companion crops;
- using minimum-tillage and controlled-traffic farming practices; and
- maintaining a healthy and robust crop to help ensure effective use of soil N and water.

LEGUME ROTATION

Growing soybeans during the fallow period between sugarcane crop cycles enables partial replacement of N fertiliser with N from soybean crop residue.

Including soybeans in rotation with sugarcane at a research site in Bundaberg, Queensland, reduced N fertiliser requirements for the following sugarcane crop by 120kg N/ha and N_2O emissions by 55 per cent compared with bare fallow using a conventional fertiliser application at 145kg N/ha.

Modelling data confirmed that growing a legume break crop in the fallow period between sugarcane crop cycles reduced the N fertiliser rate at which the yield plateau was reached.

While incorporating soybean crop residue into the soil could result in high N_2O emissions, spraying the residues with nitrification inhibitor 3,4-dimethylpyrazole phosphate (DMPP) before tillage prevented N_2O emission spikes.

NO-TILLAGE

Practicing no-till and growing an N-catch crop, such as triticale, during the period between soybean harvest and sugarcane planting resulted in considerably lower N_2O emissions compared with tillage.

NITROGEN FERTILISER FORMS AND APPLICATION RATES

Research on sugarcane farms in Queensland found that N_2O emissions were generally lower at reduced fertiliser application rates.

While nitrification inhibitors require further examination, trials showed DMPP-coated urea reduced the N_2O emission factor of N fertiliser by 1.7 per cent on average. Annual savings for the sugar industry (based on 61,000 tonnes of N fertiliser applied per year) would be 1037t of N_2O-N. At a carbon price of $41/t of carbon dioxide equivalent, the higher cost of DMPP-coated urea, which is about $180/t more expensive than conventional urea, could be largely offset by the carbon credit.

Higher N_2O emissions were seen with the polymer-coated urea (PCU) compared with conventional urea. The slow-release of N from PCU during early sugarcane development may restrict crop growth at lower N fertiliser rates. While the slow release of N means there is a sustained supply of N late in the growing season, the crop might be unable to recover from the early-season growth loss. Mixing conventional urea with PCU at a sub-optimal N application rate might offer a solution to meeting the crop's N requirements early in the growing season, and also reduce fertiliser costs compared with using PCU only.

MORE INFORMATION:

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