NANORP

National Agricultural Nitrous Oxide Research Program

SUGAR INDUSTRY FACT SHEET

Nitrous oxide emissions in the Sugar Industry

Northern Region

MARCH 2016

Nitrogen (N) is vital for sugarcane growth, yet up to 10 to 20 kilogram of N per hectare per year can be lost to the atmosphere as nitrous oxide (N_2O), a greenhouse gas about 300 times more potent than carbon dioxide. Maximising N availability by improving N use efficiency could help boost productivity and profitability, and reduce N_2O emissions.

PHOTO: DR WEIJIN WANG, QUEENSLAND DSITI

Measuring nitrous oxide emissions from sugarcane soils as part of Dr Weijin Wang's NANORP research.

KEY POINTS

- Nitrogenous fertiliser is a considerable investment for growers, yet the proportion of nitrogen (N) lost to the atmosphere as gases is high.
- Researchers measured nitrous oxide (N_2O) emissions of nearly 15.5 kilograms of N per hectare per year from sugarcane receiving 140kg N/ha.
- Denitrification – the process in which soil microbes convert soil nitrate into N gases – is the principal source of N_2O emissions from Australia's agricultural soils.
- Improving N use efficiency (NUE) – with emphasis on reducing N losses as N_2O – can provide economic and environmental benefits.
- Rainfall/soil moisture is important in triggering large N_2O emission events.
- On-farm practices, such as better synchrony between fertiliser application and crop uptake, and split fertiliser applications, can increase NUE, reduce N losses and minimise N_2O emissions.
- Nitrification inhibitors can significantly reduce N_2O emissions from soils by an average of 60 per cent.

FERTILISER 'EMISSIONS'

Nitrogenous fertiliser is a considerable and consistent investment that Australian sugarcane growers make in order to meet yield targets.

However, research under the National Agricultural Nitrous Oxide Research Program (NANORP) has found a proportion of nitrogen (N) is lost as nitrous oxide (N_2O), which is a significant greenhouse gas with a global warming potential nearly 300 times that of carbon dioxide. For example, annual N_2O emissions measured on a property in northern Queensland were almost 15.5 kilograms of N per hectare from sugarcane receiving 140kg N/ha.

But NANORP has also shown that improving N use efficiency (NUE) – with a focus on reducing N lost as N_2O – can provide both economic and environmental benefits for growers.

This fact sheet highlights research relating to the sugar industry completed during round one of NANORP, which ran from June 2012 to June 2015.

The nitrogen cycle

The process in which N is converted into various chemical forms is called the N cycle.

N is present in the soil in two major forms:

- inorganic, as mineral N; and
- organic, such as soil organic matter, soil microorganisms and plant residues.

Organic N typically accounts for more than 90 per cent of all N in soil but it is usually not directly available to plants. It must first be converted to soluable, inorganic forms, such as ammonium or nitrate, before it can be used by plants.

Denitrification is the conversion, by soil microbes, of nitrate into N gases, including N_2O, nitric oxide (NO) and dinitrogen (N_2). N_2 is the main form of N gas lost into the atmosphere, although the proportion of each N gas produced depends on soil pH and water content.

The microbes that convert nitrate into N gases need oxygen for metabolism. Under waterlogged conditions, where oxygen is limited, they obtain oxygen from nitrate molecules. This results in the production of gaseous N oxides and N_2.

NANORP research has confirmed denitrification is the principal source of N_2O emissions from Australian agricultural soils. Denitrification occurs more readily in waterlogged soils, which means in wetter areas – such as some tropical sugarcane-growing areas – more soil N is lost as gases than in dry areas. For sugarcane growers, mitigating the denitrification process is important in terms of on-farm productivity and profitability.

Nitrogen and yield

N is vital for crop growth and growing a high-yielding crop requires a significant supply of plant-available N. For example, a sugarcane yield of 100 tonnes/ha requires 100 to 200kg N/ha. The N required by the crop can come from mineralisation of soil organic matter, N-fixing legumes and fertiliser applications.

NUE AND YIELD

Improving NUE improves the yield achievable per unit of fertiliser applied because more N is available to the plant and less is lost into the environment.

However, N_2O emissions are closely linked to total denitrification losses (N_2O and N_2), which can result in the loss of more than 50 per cent of N fertiliser applications.

As a consequence of this link, increasing NUE by reducing denitrification losses could automatically reduce N losses and provide a financial benefit for sugarcane growers.

Denitrification remains a challenge, however, because sugarcane is mostly grown in the subtropics or tropics with rainfall higher than 1200 millimetres annually, or under irrigation. The highest N_2O emission episodes are generally in the first three to four months following N fertiliser application in warm and wet seasonal conditions.

Queensland Department of Science, Information Technology and Innovation principal scientist Dr Weijin Wang, who has completed research as part of NANORP, says given N fertiliser is now generally applied below the soil surface on sugarcane farms, ammonia volatilisation is no longer a major pathway for N loss.

However, N losses from denitrification and other pathways such as leaching deep into the soil and lateral run-off remain problematic in sugarcane farming systems. As a result, the efficiency of fertiliser use by sugarcane crops is generally low, with about 40 to 60 per cent of applied N lost from the plant-soil system.

ON-FARM PRACTICES TO LIFT NUE

Fertiliser management

Modifying fertilisation practices could boost NUE and reduce N_2O emissions. Dr Wang says that avoiding excessive use of nitrogenous fertilisers provides an effective means for these purposes.

In research led by Queensland University of Technology's Dr Clemens Scheer, six benchmark soils across a range of different industries were tested to better understand denitrification and N_2O emissions in Australian agriculture.

The trials showed high levels of nitrate in the soil profile should be avoided, especially when soil moisture levels are high. Reducing soil nitrate could be achieved through better synchrony between fertiliser application and crop N uptake, such as split fertiliser applications.

Nitrification inhibitors

NANORP research also explored enhanced efficiency fertilisers and their ability to increase NUE and reduce N_2O emissions.

In two experiments conducted by Dr Wang at Ingham, in wet tropical Queensland, the effects of two urea fertiliser coatings – a polymer and the nitrification inhibitor 3,4-dimethylpyrazole phosphate (DMPP) – were tested at different application rates.

The research recorded very high N_2O emissions (11.3 to 18.1kg N/ha/year) in the first experiment at Ingham (2012-13), driven predominantly by rainfall with little differences between different urea formulations.

However, the second experiment, on a different farm (2013-14), demonstrated that using DMPP-coated urea decreased annual N_2O emissions by about 50 per cent compared with conventional urea. It also lifted sugar yield by 30 per cent and increased the crop's gross margin by 23 per cent compared with conventional urea applied at a rate of 150kg N/ha.

The polymer-coated urea was found to substantially increase N_2O emissions compared with conventional urea. Yet a decrease in its application rate from 150kg N/ha to 110kg N/ha reduced the cumulative N_2O emissions by about 50 per cent with no sugar yield loss.

Dr Wang says the research suggests use of polymer or DMPP-coated urea could potentially see a reduction in N fertiliser application rates, increased sugar yields and reduced greenhouse gas emissions from fertiliser application.

Soybeans

Growing legumes in rotation with sugarcane and different residue management practices can also help to increase farm business gross margins and reduce N_2O emissions.

An experiment at Bundaberg, in subtropical Queensland, also by Dr Wang, found a soybean rotation could reduce fertiliser applications by 120kg N/ha and reduce N_2O emissions by 55 per cent compared with bare fallow using a conventional fertiliser application.

N_2O emissions following the soybean rotation were further mitigated by adopting no-till practices, growing a N-catch crop after soybean harvest and spraying the soybean residues with DMPP before tillage. The different fallow, fertiliser and soybean residue management practices did not significantly affect sugar productivity, but the soybean harvest improved overall profitability by $400 to $590/ha compared with the bare fallow regime.

Slow-release fertiliser

Ongoing research by Professor Scott Donne from the University of Newcastle aims to develop a slow-release N fertiliser derived from activated charcoal. The intent is to provide N for plants and at the same time lower N-based greenhouse gas emissions from the soil.

Preliminary studies have shown 'best-bet' materials chosen for the work function effectively to enhance crop yields and better use the N contained in activated charcoal, suggesting the slow-release fertiliser could reduce N_2O emissions.

NANORP

The core focus of research under round one of NANORP was to find ways to increase nitrogen use efficiency (NUE) in agricultural farming systems in order to increase profitability and, at the same time, reduce the risk of nitrous oxide (N_2O) emissions.

NANORP had four research themes:

- inhibitors for reducing N_2O emissions;
- the role of carbon in N_2O emissions;
- reducing N_2O emissions through improved NUE; and
- improved process understanding and new technologies.

MORE INFORMATION:

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