NANORP FERTCARE®

National Agricultural Nitrous Oxide Research Program

HORTICULTURE INDUSTRY FACT SHEET

Nitrous oxide emissions in the Horticultural Industry

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PHOTO: UNIVERSITY OF MELBOURNE

NANORP research examining celery crops on sandy soils in southern Victoria found that applying urea coated with a nitrification inhibitor could reduce nitrogen fertiliser losses as nitrous oxide by up to 44 per cent.

KEY POINTS

- Uptake of applied nitrogen (N) fertiliser in irrigated vegetable crops rarely exceeds 50 per cent and can be as low as 20 per cent, indicating there is considerable scope to improve N use efficiency in horticulture.
- Nitrous oxide (N_2O) emissions from denitrification are generally highest when warm weather coincides with waterlogging, high levels of mineral N and decomposable organic material.
- Management strategies that aim to better match N supply to crop demand could help to reduce unnecessary N_2O emissions and N fertiliser losses through other pathways (such as leaching).
- NANORP research indicates nitrification inhibitors have the potential to reduce N_2O emissions from intensive vegetable production systems.
- Research in celery crops grown on sandy soils in southern Victoria found the nitrification inhibitor 3,4-dimethylpyrazole phosphate reduced N_2O emissions by 37 to 44 per cent compared with untreated controls.

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, which means 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, sugarcane, 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 a significant 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 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 a industrial process that converts N gas into N fertilisers. A small amount is also fixed in soils by lightning strikes.

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) though leaching.

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^-);

PHOTO: DR SHU KEE LAM, UNIVERSITY OF MELBOURNE

NANORP research measured nitrogen fertiliser losses as nitrous oxide gas from a celery crop at Clyde, Victoria.

- plants take up ammonium and nitrate, and convert it 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 nitrogen compounds (N_2, N_2O and NO).

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

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

When waterlogged soil (low in oxygen pockets), 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 HORTICULTURE INDUSTRY

The proportion of applied N fertiliser taken up by irrigated vegetable crops rarely exceeds 50 per cent and can be as low as 20 per cent – indicating there is considerable scope to improve N use efficiency in horticultural farming systems.

The horticulture industry accounts for about 10 per cent of nitrogenous fertiliser use in Australia: an amount comparable to that used on pastures and greater than that used by either the cotton, oilseed or pulse industries.

Of all Australian agricultural systems, horticulture farming poses one of the highest risks in terms of N fertiliser losses as N_2O emissions. Measurements of N_2O emissions from horticultural soils in Australia suggest that these annual gaseous N losses vary from 1.1 to 7.6kg N_2O-N/ha depending on the crop and on-farm conditions, such as soil pH and moisture content.

MANAGING NITROGEN LOSSES

On-farm management strategies that aim to better match N supply to crop demand could help to reduce N_2O emissions and N fertiliser losses through other pathways.

N management practices to help minimise N_2O losses include:

- soil and tissue testing to predict fertiliser requirement;
- assessment of soil constraints, such as waterlogging;
- nutrient budgeting;
- better timing and placement of N fertiliser to deliver N when and where it is needed by the crop; and
- use of enhanced efficiency fertilisers, such as nitrification inhibitors and controlled-release fertilisers.

NITRIFICATION INHIBITORS

NANORP research indicates nitrification inhibitors have the potential to mitigate N_2O emissions from intensive vegetable farming systems.

Research in celery crops grown on sandy soils in southern Victoria found urea coated with the nitrification inhibitor 3,4-dimethylpyrazole phosphate (DMPP) reduced N_2O emissions by 37 to 44 per cent compared with conventional urea.

Nitrification inhibitors work by temporarily suppressing the microbial conversion of ammonium to nitrate. The research further showed that DMPP-coated urea applied to celery decreased nitrate losses by 49 per cent on average, allowing for a reduction in N_2O emissions.

In other NANORP research, DMPP-coated urea was generally effective in reducing N_2O emissions by up to 28 per cent for at least 34 days after manure was applied at 7.5 tonnes/ha (225kg N/ha).

However, DMPP also has the potential to increase ammonia (NH_3) losses from animal manures applied in horticultural systems, particularly in alkaline soils. While not a direct greenhouse gas, ammonia emissions also represent inefficiency in organic fertiliser use, so reducing the amount of this N gas lost from the soil could generate cost savings. Incorporating manures before sowing or transplanting seedlings could help mitigate ammonia emissions.

IRRIGATION AND N_2O

N fertiliser losses from the soil are also influenced by the relationship between the soil's water-filled pore space and emissions of N_2O and N_2.

Provided the soil's oxygen content is low and there is a ready supply of labile (reactive) soil carbon, N_2O emissions begin to escalate when 40 per cent of the soil's total pore space is filled with water. Emissions then peak when the soil's total pore space is 60 per cent filled with water, and they are negligible at 90 per cent because the predominant N gas produced at this stage is N_2 gas.

Where fertigation is used, horticulturalists typically fill about half of the soil pores with water that contains dissolved mineral salts of nitrate and/or ammonium.

Irrigation should ideally be based on managing the amount of plant-available water in the soil's root zone.

MORE INFORMATION:

Dr Shu Kee Lam, University of Melbourne, 03 9035 9619, shukee.lam@unimelb.edu.au

Dr Mei Bai, University of Melbourne, 03 9035 7427, mei.bai@unimelb.edu.au

Dr Helen Suter, University of Melbourne, 03 8344 0179, 0438 456 602, helencs@unimelb.edu.au

Professor Deli Chen, University of Melbourne, 03 8344 8148, 0417 508 887, delichen@unimelb.edu.au

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