NANORP

National Agricultural Nitrous Oxide Research Program

HORTICULTURE INDUSTRY FACT SHEET

Nitrous oxide emissions in the Horticulture Industry

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Nitrogen (N) is vital for crop growth, yet uptake of N fertiliser applications in irrigated vegetable crops can be as low as 20 per cent in the horticultural industry. These N inputs can be lost into the atmosphere as nitrous oxide (N_2O), a greenhouse gas about 300 times more potent than carbon dioxide. Maximising N availability using on-farm practices that improve N use efficiency can help lift productivity and profitability and reduce N_2O emissions in horticulture farming systems.

PHOTO: MEI BAI, UNIVERSITY OF MELBOURNE

NANORP research showed that a nitrification inhibitor reduced nitrogen fertiliser losses as nitrous oxide emissions by up to 44 per cent in a celery crop at Boneo, Victoria.

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, showing there is considerable scope to improve N use efficiency in horticultural crops.
- Nitrous oxide (N_2O) emissions from denitrification are generally highest when warm weather coincides with waterlogging, high mineral N and decomposable organic matter in the soil.
- Management strategies that aim to better match N supply to crop demand can help reduce 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 on sandy soils in southern Victoria found the nitrification inhibitor 3,4-dimethylpyrazole phosphate reduced N_2O emissions by 37 to 44 per cent.

FERTILISER 'EMISSIONS'

Nitrogenous fertiliser is a major, consistent investment in crop growth that Australian horticultural growers make in order to meet yield targets.

However, research under the National Agricultural Nitrous Oxide Research Program (NANORP) has found a high proportion of nitrogen (N) fertiliser applications are lost as nitrous oxide (N_2O).

Over a 100-year period, N_2O has up to 310 times more potency than carbon dioxide and it is the fourth largest contributor to greenhouse gas emissions.

For example, measurement of emissions from Australian horticultural soils suggests that these annual losses of N as N_2O, or nitrous oxide-nitrogen (N_2O-N), per hectare vary from 1.1 to 7.6 kilograms, depending on the crop and on-farm conditions such as soil pH and moisture content.

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

This fact sheet highlights research relating to the horticulture 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 soluble 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 moisture 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 oxides and N_2 gas.

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 more soil N is lost as N_2O in high-rainfall areas than in dry areas.

For growers, mitigating the denitrification process is important in terms of on-farm productivity and profitability.

NITROGEN AND YIELD

N is an essential macronutrient for horticultural crop growth, and growing a high-yielding crop requires a significant supply of plant-available N.

The N required by the crop can come from fertiliser applications, mineralisation of soil organic matter and N-fixing legumes.

N is typically applied as manufactured fertilisers and composted manure in intensive vegetable production systems, which were the main focus of the NANORP research examining N_2O emissions from horticultural soils.

NUE AND YIELD

NUE is a measure of how effectively N is taken up by plants for crop growth. Improving NUE increases the crop yield achievable per unit of fertiliser applied because more N is available to the plant and not lost into the atmosphere as gas.

However, N_2O emissions are closely linked to total denitrification losses, which can result in the loss of up to 80 per cent of N fertiliser applications.

As a consequence of this link, increasing NUE by reducing N losses from denitrification has the potential to reduce N_2O emissions and provide cost benefits for growers.

Denitrification remains a challenge, however, because horticultural crops are prevalent in high-rainfall areas where soils are prone to saturation, increasing the risk of N losses as N_2O. Irrigated crops are also susceptible to high N_2O emissions due to waterlogging.

ON-FARM PRACTICES TO BOOST NUE

Fertiliser management

Irrigated vegetable crops rarely take up more than half of N fertiliser applications and N uptake can be as low as 20 per cent, highlighting the potential to improve NUE in the horticulture sector.

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 the cotton, oilseed or pulse industries.

Of all Australian agricultural systems, horticultural crops pose one of the highest risks in terms of N fertiliser losses as N_2O emissions.

However, matching N supply to the changing needs of different crops and maintaining organic matter in cultivated soils is a considerable challenge.

On-farm practices that aim to maximise NUE and minimise N_2O emissions are:

- soil and tissue testing to predict crop fertiliser requirements;
- assessment of soil constraints, such as waterlogging;
- nutrient budgeting;
- better timing and placement of 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 showed 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 in the soil. The research further showed that DMPP 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 was 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 increased gaseous ammonia (NH_3) losses from animal manures applied in vegetable production 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, but they are negligible at 90 per cent because the predominant N gas produced at this stage is N_2.

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

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

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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.

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