NANORP FERTCARE®

National Agricultural Nitrous Oxide Research Program

COTTON INDUSTRY FACT SHEET

Nitrous oxide emissions in the Cotton Industry

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PHOTO: CLARISA COLLIS

NANORP research shows late summer rain and high residual soil nitrogen can lead to significant losses of applied nitrogen fertiliser as nitrous oxide gas following harvest in cotton farming systems.

KEY POINTS

- About 40 per cent of nitrogen (N) fertiliser applied to cotton crops can be lost due to nitrification, leaching and drainage in the soil, showing there is scope to lift N use efficiency.
- Cracking black and grey clays (vertosols) prone to surface sealing and waterlogging have higher potential for gaseous N losses than free-draining soils.
- In trials, typical nitrous oxide (N_2O) emissions from irrigated black clays where split applications of N were used on furrow-irrigated cotton were 0.83 per cent of applied N fertiliser.
- N_2O emissions are an indicator of larger and economically significant losses of dinitrogen gas.
- Enhanced efficiency fertilisers may have potential to lift N use efficiency (NUE) in cotton farming systems, particularly where crops are grown on vertosol soils.
- Matching N supply to the crop's needs is key to limiting N losses and lifting NUE.

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 Australian 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 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 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.

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: BRENDAN GRIFFITHS, UNE

Enhanced efficiency fertilisers have the potential to lift nitrogen use efficiency and reduce nitrous oxide emissions from cotton cropping soils.

- 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 in a typical season is usually about 50:1, but this ratio can vary significantly.

Soils do not need to be noticeably waterlogged to stimulate denitrification. All that is needed are low oxygen microsites in soil aggregates.

When waterlogged soil (or pockets of low soil oxygen), high soil nitrate and high soil organic matter occur simultaneously then denitrification can be significant.

N_2O AND THE COTTON INDUSTRY

Research indicates about 40 per cent of N fertiliser applied at 200kg/ha can be lost due to nitrification, leaching and drainage in cotton cropping soils, showing there is scope to lift N use efficiency (NUE) in cotton farming systems.

Wet conditions resulting in water-filled soil porosity greater than 60 per cent cause higher rates of denitrification and N_2O emissions. The intensity of N fertiliser losses as N_2O gas is influenced by the amount of nitrate and labile (reactive) carbon in soil layers, high soil temperature and the duration of water-filled soil porosity greater than 60 per cent.

NANORP research in Dalby, Queensland, found typical on-farm N_2O emissions from irrigated black clays where split applications of N used on furrow-irrigated cotton were 0.83 per cent of applied N fertiliser, and total gaseous N losses (excluding NH_3) were estimated to be 16 per cent of applied N fertiliser.

The research found that N_2O emissions from cotton beds were about 640g N/ha over 188 days, while emissions from the furrows were significantly higher at almost 970g N/ha. Substantial leakage of nitrate from cotton beds to furrows was also measured in the trial, representing a major source of N loss and N_2O emissions.

SOIL TYPE

Soil type can have a significant effect on gaseous N losses from denitrification. Vertosol soils prone to surface sealing and waterlogging have higher potential for N emissions than free-draining soils. However, free-draining soils are more susceptible to N losses from leaching.

NANORP modelling data tested against trial findings further showed potential for an exponential increase in N_2O emissions when N fertiliser applications in cotton on vertosol soils exceeded 250kg N/ha.

MATCHING NITROGEN TO CROP NEEDS

N fertiliser rates for cotton should be based on:

- target yield, which, in turn, depends on the soil's moisture content at sowing, the seasonal forecast and irrigation water availability;
- the anticipated supply of N from the soil, including N in subsoil layers; and
- site-specific knowledge of the N response curves of cotton varieties and soil types.

N fertiliser tactics are important for reducing denitrification losses.

- Keep soil N in the ammonium form for longer with the use of nitrification inhibitors.
- Minimise the amount of nitrate exposed to irrigation using practices such as split fertiliser applications.
- Minimise the duration of inundation under irrigation and paddock areas where soil moisture is more than 60 per cent water-filled soil porosity.

N oversupply, and consequent denitrification losses, can occur as a result of:

- overestimation of yield potential;
- not considering how much soil N will become available to the crop (mineralisation potential);
- soil compaction and irrigation practices; and
- poor calibration of fertiliser application equipment.

NITRIFICATION INHIBITORS

NANORP trial findings in grain crops suggest that enhanced efficiency fertilisers with nitrification-inhibiting and slow-release coatings may have potential to lift NUE in cotton farming systems, particularly in crops grown on vertosol soils.

POST-HARVEST N_2O EMISSIONS

N_2O emissions can be significant following harvest in response to late-summer rain events in cotton paddocks with high residual N fertiliser in the soil and mineralisation of N-rich plant residues.

The high risk of N_2O emissions in these conditions can be managed with careful N budgeting, and early planting of winter or N catch-crops.

MORE INFORMATION:

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