NANORP
National Agricultural Nitrous Oxide Research Program

COTTON INDUSTRY FACT SHEET

Nitrous oxide emissions in the Cotton Industry

Northern Region

MARCH 2016

Nitrous oxide (N_2O) is a potent greenhouse gas with a global warming potential almost 300 times that of carbon dioxide. Research under round one of the National Agricultural Nitrous Oxide Research Program (NANORP) has found there is considerable scope for reducing N_2O emissions in cotton farming systems while maintaining productivity and profitability using improved nitrogen management practices.

PHOTO: CLARISA COLLIS

NANORP research has shown that nitrate leakage from cotton beds to furrows in irrigated crops is a major source of nitrogen fertiliser losses.

KEY POINTS

- Use target yields, current soil nitrogen (N) content and (site-specific) anticipated N response to determine N fertiliser needs for cotton.
- Nitrous oxide (N_2O) emissions increase following rainfall and irrigation events.
- Manage N fertiliser application at sowing to avoid large gaseous N losses before crop establishment.
- Banding N fertiliser is a common practice in the cotton industry.
- While build-up of soil organic matter can increase N_2O emissions, this effect is offset by reduced N fertiliser requirements.

Nitrogen (N) is an essential macronutrient for cotton growth and N fertiliser makes up a large component of a grower's input costs. However, providing a cotton crop with optimal amounts of N at the right time can be challenging.

N is present in soil in two mains forms: as inorganic mineral N and as organic N, including soil organic matter, soil microorganisms and plant residues. While most soil N exists in the organic form, it is the inorganic form – such as ammonium or nitrate – that the plant takes up.

The N cycle consists of many processes that transform gaseous N into useable, plant-available forms. N from the atmosphere is fixed in the soil by legumes or manufactured through an industrial process into mineral fertiliser that can be taken up by plants.

Plant residues and roots provide organic sources of N, which are decomposed and mineralised by soil microorganisms to produce ammonium and nitrate. Denitrification (the conversion of soil nitrate into N gases) and volatilisation (loss of N from the soil surface as ammonia) release N gases into the atmosphere. Inorganic or mineral N can be immobilised (converted to an organic form that is unavailable to plants) or mineralised into a plant-available form through nitrification.

The addition of N fertiliser to the soil accelerates the rate of denitrification in low-oxygen conditions, such as saturated soils. Splitting N fertiliser applications is one farm-management practice that can help limit N losses from denitrification.

N_2O EMISSIONS

In low-oxygen soils, microbes use nitrates instead of oxygen for respiration. This process converts plant-available soil nitrates into N gases, such as nitrous oxide (N_2O). N_2O is a greenhouse gas with a global warming potential almost 300 times that of carbon dioxide.

Consequently, N_2O emissions have harmful, long-term effects in the atmosphere. In Australia, agriculture is the dominant human source of N_2O, accounting for about two-thirds of total N_2O emissions.

Unusually high levels of N_2O emissions can indicate inefficiencies in N fertiliser use.

Irrigated cotton grown on alkaline grey clay soils can lose between 50 and 100 kilograms of N per hectare through denitrification annually. These soils – and heavier black clay vertosols – are dominant in Australia's cotton-growing region. High water-holding capacity in these soils means they provide an ideal environment for denitrification, resulting in N losses as N_2O and dinitrogen (N_2). Only a small fraction of the N loss is actually the environmentally harmful N_2O, but these emissions are an indicator of much larger, economically significant N losses as N_2.

Research under round one of the National Agricultural Nitrous Oxide Research Program (NANORP) – funded by the Australian Department of Agriculture and Water Resources – has examined ways cotton growers can implement best management practices to reduce N_2O emissions and nitrate leaching while maintaining productivity and profitability in cotton cropping.

N_2O FROM COTTON SOILS

The cotton industry is reliant on N fertilisers and access to irrigation to maintain high levels of production. As such, cotton farming systems are potentially high-risk for N_2O emissions. Adding to this environmental concern, inefficient use of N fertiliser reduces the profitability of cotton cropping because N input costs are substantial.

N use efficiency (NUE) is defined as the ability of the cotton plant to convert plant-available N into lint yield. N fertiliser use efficiency (NUEf) can be calculated by dividing the lint yield (kg/ha) by the total amount of N fertiliser applied.

Generally, a NUEf between 13 and 18kg lint/kg applied N denotes efficient N fertiliser use. A NUEf below 13kg lint/kg applied N suggests the fertiliser was not efficiently converted into lint by the crop. The challenge for growers is to find the 'sweet spot', avoiding both the yield penalty for under-fertilisation and the cost of applying too much N fertiliser.

While NUE is also affected by soil type, climate and irrigation practices, there are clear benefits from using best management practices for applying N fertiliser and irrigation management.

EMISSION REDUCTION TACTICS

There is considerable scope for cotton growers to reduce N losses, increase productivity and profitability, and reduce the risk of elevated N_2O emissions through improved on-farm management practices.

In achieving these objectives, the aim is to optimise N fertiliser applications by better matching them to a crop's needs in amount, timing and placement, and to ensure soil N is readily available when there is a demand for it by the cotton crop.

NANORP trial findings have highlighted a suite of management options for cotton growers to help boost NUE, reduce N_2O emissions, lift yield and increase gross margins.

These management practices include:

- fine-tuning the timing, type, amount and placement of N fertiliser applied to the soil;
- improving irrigation practices; and
- better soil management.

In addition, NANORP research in northern grain crops suggests enhanced efficiency fertilisers (EEFs) have the potential to increase NUE in cotton farming systems, especially in crops grown on vertosol soils.

EEFs are coated or mixed with chemicals that inhibit urease activity or nitrification to slow N release and reduce N_2O emissions.

NITROGEN FERTILISER OPTIMISATION

Soil type can have a significant effect on gaseous N losses. Vertosol soils that are prone to surface-sealing and waterlogging have a higher potential for N_2O emissions than free-draining soils, but the risk of gaseous N losses through leaching is higher on free-draining soils. Field data has shown an exponential increase in N_2O emissions when N fertiliser was applied to a vertosol soil at 250kg N/ha.

Measurement of N deep in the soil profile using soil testing is important for determining optimal N fertiliser application rates. Once base N levels are understood, the crop's N fertiliser needs can be calculated using:

- target yield, which is dependent on irrigation water availability and yield performance for the paddock;
- anticipated supply of soil N from mineralisation (there is some uncertainty with budgeting for mineralised N – studies have shown this can vary from 30 to 120kg N/ha); and
- knowledge of the N response curves of cotton varieties and soil types.

NITROGEN BUDGETING AND MANAGEMENT

NANORP and other cotton industry trials have shown N_2O emissions increase following irrigation and rainfall events, particularly early in the season.

Researchers believe this could be the result of:

- high residual N remaining in the soil due to unused fertiliser;
- stimulation of organic matter mineralisation; and
- mineralisation of N-rich crop residues.

These high post-rain losses highlight the need for careful N budgeting and early planting of winter or N catch-crops. Catch-crops are fast-growing, short-season crops that replace fallows and take up mineral N generated in the soil during the off-season. Plant residues from N catch-crops are then returned to the soil to provide a slow-release form of plant-available N.

Compared with heavy or prolonged rainfall, reducing the amount of irrigation applied at any time, and subsequently increasing the number of irrigation events, can reduce the likelihood of soil being saturated for long periods. This also reduces the potential for gaseous N losses from denitrification.

FERTILISER APPLICATION TIMING

The amount of N fertiliser applied before or at sowing should be managed to avoid excess N in the soil at a time when there are insufficient roots to make use of it.

Deep placement of N in the soil, or split N fertiliser applications, can also help to avoid gaseous N losses. The practice of using split fertiliser applications has increased across the cotton industry, allowing growers to reduce N_2O emissions. However, its effect on NUE and yield is less clear.

NANORP research has shown leakage of nitrate from cotton beds to furrows is a significant source of N fertiliser loss and N_2O emissions in furrow-irrigated cotton crops. Applying N fertiliser in irrigation water may be a useful practice when additional in-crop N is required, but it may promote greater losses of N from denitrification and movement of N off-field.

SOIL ORGANIC MATTER

Building up soil organic matter (through residue retention with conservation farming) could result in a small increase in N_2O emissions. However, this increase in N_2O would generally be outweighed by reduced N fertiliser applications because the soil's organic matter would supply more of the crop's N needs. Growing legumes as break crops can increase organic forms of N in the soil, decreasing the risk of N_2O emissions in wet conditions and N fertiliser costs.

MORE INFORMATION:

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