healthy soils case study

GREENHOUSE GASES

healthy soils for sustainable farms a natural heritage trust initiative

Cotton Catchment Communities CRC

Improving Nitrogen Management and Reducing Greenhouse Gas Emissions

AT A GLANCE

Greenhouse gas emissions associated with growing crops include:

- Carbon dioxide from tillage
- Carbon dioxide from fuel use (during planting, cultivation, harvesting, chemicals, pumping)
- Nitrous oxide from fertiliser
- Nitrous oxide and methane from burning stubble (if applicable)
- Methane during extreme waterlogging

Generic rules to reduce nitrogen losses and maximise productivity and profitability:

- Reduce time between fertiliser application and planting
- Increase the amount of nitrogen applied later in the season relative to upfront applications
- Use urea in preference to ammonia in water run applications
- Green manures can replace standard sources of nitrogen
- Set realistic yield goals based on the capacity and characteristic of the farm

"We have to start looking at the bigger picture and what we can do to help."

"Nitrogen is getting more expensive – why lose it?"

Brett Crother and gas chambers monitoring the greenhouse gases released from his cotton crop near Dalby

The background

The principal greenhouse gases are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). While methane and nitrous oxide are emitted in smaller quantities than carbon dioxide, they have much higher global warming potentials than carbon dioxide. In fact, in terms of their contribution to the global warming and the greenhouse effect, one molecule of methane is equivalent to 20 molecules of carbon dioxide and nitrous oxide is equivalent to over 310 molecules of carbon dioxide.

But what relevance does agriculture – and more specifically the cotton industry – have to the emission of these greenhouse gases? Nitrous oxide and methane are produced naturally when living and dead biomass is consumed, decays or burns. Agriculture activities like cultivation, addition of fertilisers, stubble burning and flooding modify and increase these emissions.

These on-farm biological processes account for about one third of the 19.2 per cent of Australia's total greenhouse gas emissions from agriculture.

"Using climate modelling it is considered that the number of summer days over 35°C in Narrabri will rise from the present average of 21 to between 36 and 48 days by 2030," according to Dr Peter Grace, Professor of Global Change at the Queensland University of Technology.

"As a result, hotter drier conditions in the cotton areas are expected and this may have economic effects through reduced yields. Hence, humans can modify their impact by better managing their industrial processes and agricultural operations."

Tillage disrupts aggregates and promotes the degradation of soil organic matter, which results in the production of carbon dioxide with an overall loss of carbon from the soil. These losses also occur when soils are fallowed for lengthy periods of time. Soil carbon is also critical for maintaining soil structural stability and is an indicator of soil fertility.

Why act?

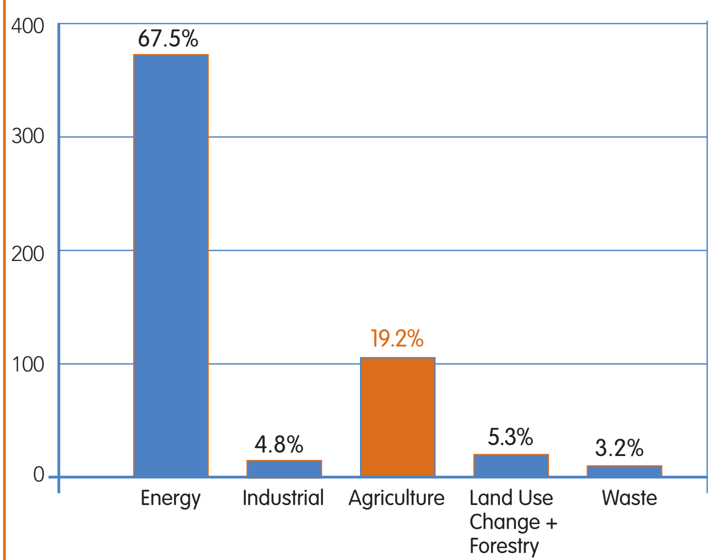
- Since 1990 there has been a 130 per cent increase in nitrous oxide emissions in Australia, predominantly from fertiliser application to horticulture, fibre and grain crops.
- Nitrogen fertiliser losses may exceed 100kg/ha each season of which 98 per cent is returned to the atmosphere as nitrogen and 2 per cent as the greenhouse gas nitrous oxide through the process of denitrification.
- Nitrogen that is applied in excess of crop demand is more likely to be returned to the atmosphere, or leached below the root zone into the groundwater.

Cotton is one of many agricultural industries reliant on nitrogenous fertilisers and water storages to maintain high levels of production. Therefore, cotton-based farming systems are labelled as potentially high-risk agricultural systems with respect to gas losses of nitrogen to the atmosphere and nitrate leaching. The inefficient use of fertiliser-applied nitrogen also reduces profitability. One possible pathway to this loss is denitrification, which normally occurs when soils become waterlogged, as can occur on the heavy clay soils found in our cotton growing regions. The more nitrogen that is applied in excess of crop demand but not utilised, the greater the potential loss of nitrogen to the atmosphere.

As well as the environmental concerns, there is a significant monetary cost in losing nitrogen from farms:

- Around 80 000 tonnes of nitrogen is applied across the cotton industry per season
- Cost of of nitrogen at approximately $1200 per tonne is $96 million across the industry per year.
- On average, about one third of applied nitrogen is lost (for example, 60kg of the 180kg per hectare that is a common application rate). This equals a $32 million loss across the industry per year
- With approximately 800 cotton growers, this equals an average loss of $40,000 per grower per year: a significant economic loss.

The promotion of best management practices which improve water and nitrogen efficiency, and reduce tillage operations in combination with a reduction in the length of fallow periods, can actually provide a win–win situation for the cotton industry in terms of both economic and environmental health.



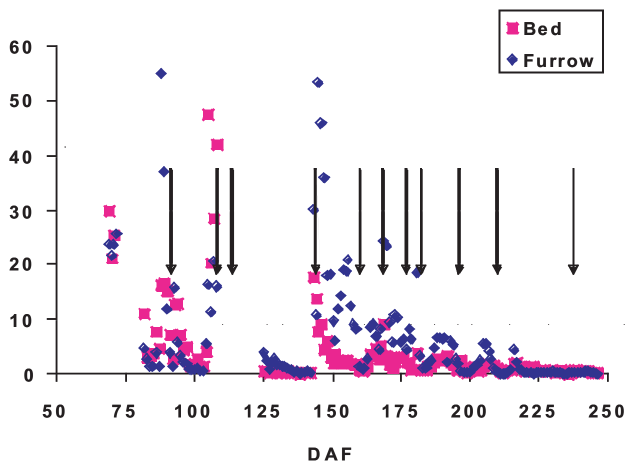
Sources of Australia's greenhouse gases across industry
(*Source: Australian Greenhouse Office www.greenhouse.gov.au*)

What is science saying?

An on-farm study was undertaken on Brett Crother's farm, near Dalby during the 2005–06 season by Peter Grace, Professor of Global Change at the Queensland University of Technology. The field was furrow irrigated and has been under continuous cotton (with winter fallow) for 10 years. The block is conventionally tilled, with a management regime typical for cotton production in this area.

The black clay, with a surface clay content of 68 per cent, is typical of the region: surface soil (0–10cm) averages 1.0 per cent organic carbon and pH is 8.5. Urea was banded on twice, at 92 and 70 kg of nitrogen per hectare, respectively. Cotton was sown, with 30 kg of ammonium nitrogen per hectare applied with irrigation water, and an additional 15 kg nitrogen per hectare water run urea applied. A total of 207 kg of nitrogen per hectare was applied during the season, with post-sowing irrigation events restricted to a single occasion because the fact the farm received exceptional rainfall during the trial.

Three greenhouse gas measuring chambers were located in a single bed and three to an adjacent furrow after skipping two rows. Gas sampling was then undertaken. Nitrous oxide emissions depicted in the graph below are from 69 to 257 days after the initial fertiliser application. Note the incidence of rainfall and irrigation events (arrowed), which resulted in the surface soil being saturated, and the occasions – 108, 144 and 170 DAF (days after fertiliser was applied – where nitrous oxide emissions significantly increased due to the favourable conditions for denitrification.



Observed nitrous oxide (N_2O) emissions from a black clay at Dalby (2005–06) fertilised with a split application of 207 kg nitrogen (DAF – Days after fertiliser applied); arrows indicate rainfall and irrigation events which have restored the surface soil to saturation. *(Source: GCRCC4 Final Report, CRDC & CCC CRC)*

Nitrous oxide emissions from the beds were 643 grams of nitrogen per hectare during the measurement period of 188 days, whilst the nitrous oxide emissions from the furrows were significantly higher at 967 grams of nitrogen per hectare.

This observation confirms the leakage of nitrate from beds to furrows and the higher potential for emissions where soils were saturated for longer periods for time. As the majority of growers use furrow irrigation, this is an area of concern.

Nitrogen is an essential, but expensive input to cotton farming systems. Reducing nitrogen inputs, or the losses of applied nitrogen to the atmosphere is beneficial in terms of increased nitrogen use efficiency, profitability and reducing the global warming foot print of cotton farming systems.

Above: Gas chambers as part of the farm trial measuring the greenhouse gasses from a cotton crop east of Dalby, QLD.

Below: Monitoring equipment used to track the greenhouse gases from a cotton crop on the farm trial.

The Solution

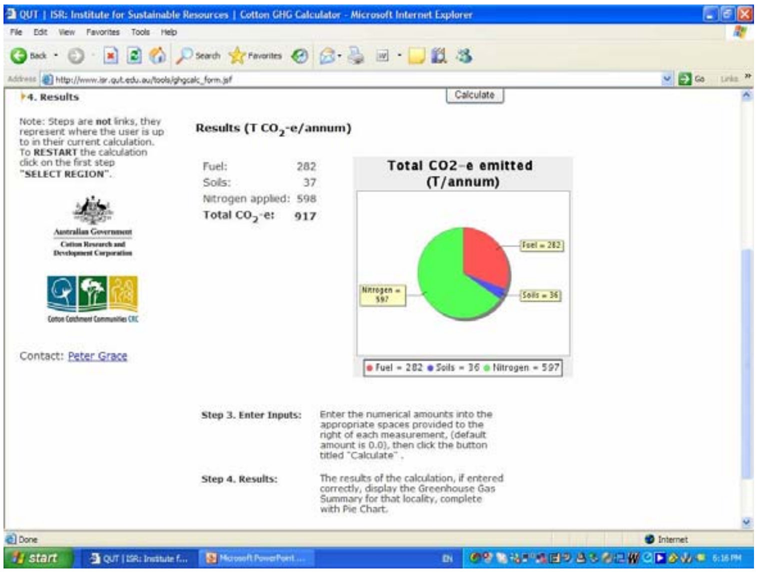
Reduction of nitrogen loss to the atmosphere has major environmental and economical benefits. There are several control strategies available, based on managing or avoiding denitrification:

- Reduced or no-tillage and the consistent return of crop residues to the soil will promote and increase soil organic matter and carbon stores. These practices are being promoted and utilised around the globe as a means for growers to play a direct role in reducing carbon dioxide emissions and at the same time increasing their own productivity as a result of the improved soil physical and chemical conditions of their fields.
- More frequent applications of smaller amounts of water and nitrogen reduce both the potential for loss of nitrogen to the atmosphere and increases water use efficiency.
- Legume cropping, this allows for a reduced nitrogen fertiliser requirement for cotton (emissions of nitrous oxide from a vetch-cotton system may be reduced by two thirds, relative to a wheat-cotton system having 180kg/ha of nitrogen applied).
- Metered nitrogen fertiliser applications or the use of green manures as a form of slow release nitrogen will potentially minimise any losses of standard nitrogen stocks and nitrous oxide to the atmosphere.

What impact is your farm having?

A greenhouse gas calculator has been developed as an indicator of emissions from cotton farms. Individual growers can locate their property on the map and enter the relevant details to determine their contribution to the greenhouse gas footprint we are leaving behind. This tool can be found at www.isr.qut.edu.au

Cautious use of water and nitrogen, in combination with reduced tillage and the use of cover crops and shortened fallows, promotes economic and environmental sustainability. Soil carbon is increased, reducing carbon dioxide emissions as well as improving soil structure. This reduces the potential for waterlogging events and subsequent emission of nitrogen and the greenhouse gas, nitrous oxide, to the atmosphere.



Example of an output from the greenhouse gas calculator at www.isr.qut.edu.au

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