Nitrogen Losses

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Nitrogen losses in cotton production

Cotton is one of many agricultural industries heavily reliant on nitrogenous fertilisers to maintain high levels of production; it is therefore a potentially high-risk agricultural system with respect to nitrogen losses through denitrification and nitrate leaching. On average, more than one third of applied N is lost and this loss may exceed 100 kg N/ha each season. As well as environmental concerns with greenhouse gas emissions (from nitrous oxide) and nitrate leaching, N losses also have a significant economic impact on farm income.

Denitrification is the process where soil nitrate N is converted into N gases (including nitrous oxide, the most potent greenhouse gas) and returned to the atmosphere. Denitrification is encouraged by high soil temperatures and saturated soil conditions so is normally the most significant form of N loss in irrigated cotton production.

Nitrate leaching occurs when nitrates are washed through the soil profile with water. Nitrate is mobile in wet soil and has the potential to move beyond the root zone following large rainfall events or if too much irrigation water is applied.

Where there are high levels of soil nitrogen, cotton makes limited use of applied fertiliser N and a greater proportion of applied N is lost through denitrification and leaching.

Cotton crops use less than half of the N applied during that season, obtaining most of their nitrogen from soil N rather than applied N. An average of 33% of applied N is recovered, 25% remains in the soil at crop maturity and the remainder (approximately 42%) is lost from the system.

Figure 1 shows that ideal N uptake in cotton crops increases with lint yield, but this is not a linear relationship.

Higher yielding crops do not necessarily take up more nitrogen as improved soil N conversions and recovery rates facilitate higher yields with less fertiliser.

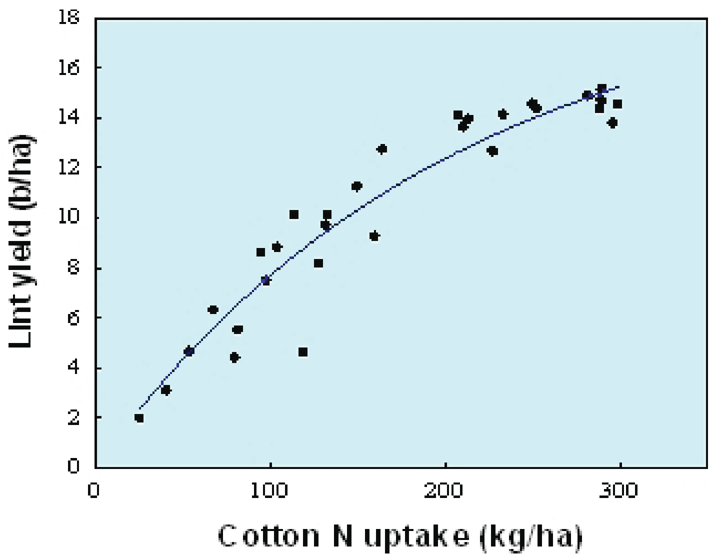

Figure 1. Crop N uptake kg/ha. Data collected over two decades at ACRI.

Cotton crops need to accumulate approximately 250-300kg N/ha to achieve maximum yield potential. While crops can take up more N than this, N uptake greater than 300kg N/ha will not increase lint yield; and nitrogen fertiliser recovery and nitrogen use efficiency will be reduced. These figures of amount of N uptake per hectare represent soil N uptake, *not* the amount of applied N.

The data presented in Figure 2 indicates that increasing applied N fertiliser from 200 to 400 kg N/ha does not correspond to a similar increase in N recovery by the crop; however the nitrogen lost from the system increases considerably. Soils have limits to the amount of nitrogen fertiliser that can be retained. The data presented in Figure 2 is from a light-medium clay soil. Nitrogen fertiliser recovery would be lower in heavier clay soils due to greater denitrification from reduced aeration.

Compaction has a similar effect on nitrogen fertiliser recovery.

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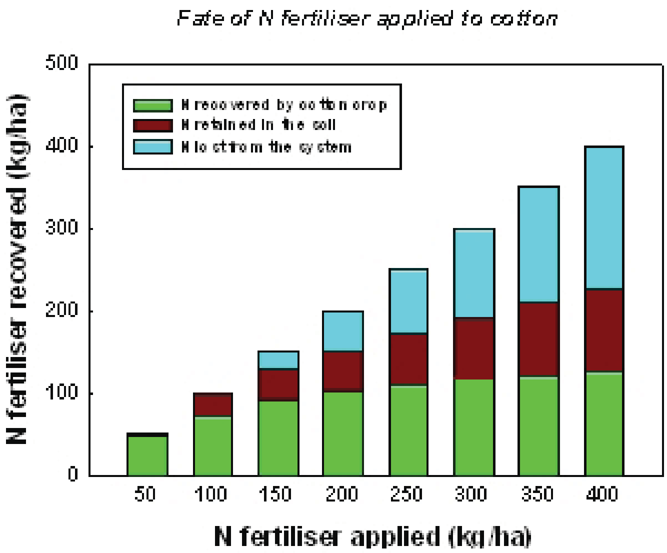

Figure 2. The fate of N fertiliser applied to cotton crops growing in light-medium clay soil. Losses will be greater from heavier soils.

An on-farm study of nitrous oxide emissions was undertaken by Dr. Peter Grace near Dalby in 2005/06. This study showed that nitrous oxide emissions significantly increased when conditions were favourable for denitrification: i.e. after rainfall and irrigation events (Figure 3).

In Figure 3, nitrogen losses were higher from

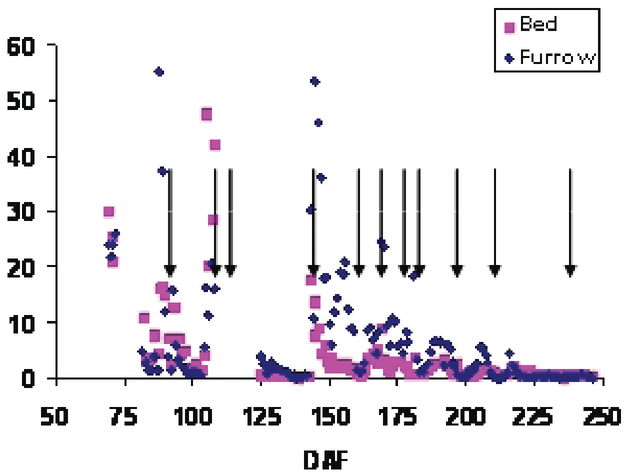

Figure 3. Observed nitrous oxide emissions from a black clay at Dalby (2005/06) fertilised with a split application of 207kg N. (DAF – days after fertiliser applied). Arrows represent an irrigation or significant rainfall event.

the furrow than from the bed. This confirms the movement of nitrate from beds to furrows and the higher potential for N2O emissions where soils are saturated for longer periods of time.

Managing nitrogen losses

Nitrogen is an essential input to cotton production; therefore, reducing nitrogen fertiliser inputs and losses of applied nitrogen is beneficial to increasing nitrogen use efficiency, profitability and reducing greenhouse gas emissions. There are a number of control strategies to reduce nitrogen loss, based on managing and avoiding denitrification and nitrate leaching.

- Fertiliser management decisions should be based on soil and plant tissue analyses. To use nitrogen fertilisers efficiently, you must optimise the amount of N fertiliser applied,
- More frequent applications of smaller amounts of water and nitrogen reduce both the potential for nitrogen loss and increase water use efficiency,
- Redesigning fields (this may include reducing run lengths or altering field slope) to reduce irrigation run times to avoid waterlogging soils,
- Metered nitrogen fertiliser applications or the use of green manures as a form of slow release nitrogen will potentially reduce nitrogen emissions into the atmosphere,
- Reducing tillage and the retention of crop residues can increase soil organic matter and soil carbon storage,
- Legume cropping will reduce reliance on synthetic nitrogen fertilisers and improve yield through enhanced soil health.

Nitrogen management decisions

Soil testing is the best way of quantifying N fertiliser requirements to use nitrogen fertilisers effectively. Nitrogen fertiliser rate decisions should consider available soil N at sowing and the crop rotation system (which indicates how much native soil N is likely to be present).

The NutriLOGIC program can assist in determining N fertiliser requirements. The program is able to interpret soil nitrate-N and plant tissue analyses and indicate N fertiliser requirements to prevent N deficiency and ensure yield is maximised, for each situation (including soil type, region, N fertility). This tool takes into account all N loss processes including N removal in seed cotton. For more information on NutriLOGIC contact your local Regional Cotton Extension Officer or visit the Cotton CRC website http://tools.cotton.crc.org.au/CottonLOGIC/NutriLOGIC/

Monitoring nitrogen use efficiency

Many cotton growers are focusing on how to optimise inputs and fertiliser is one such input. This is also one of the components of the Australian cotton industry's Best Management Practices (BMP) program within the Land and Water module.

Nitrogen use-efficiency benchmarking can be undertaken on farm. The outline given below indicates the measurements that are required currently. Some of these measurements are laborious and complicated but provide the most convenient method of assessing how efficiently N fertiliser is utilised by crops. These assessments of efficiencies are required to assist growers and consultants to manage N fertiliser and help identify where management practices could optimise nutrition programs.

Crop N uptake

Refers to the amount of N contained in the crop (the small amount of N in the root system is not normally included). Crop N uptake is determined at approximately 20% bolls open. The important factor with timing of this sample is to ensure it is before leaf starts to drop. It requires sampling 1 square metre of plants, drying, weighing, grinding and analysing the plant material for N content. Cotton crops normally take up about 200kg N/ha.

Nitrogen fertiliser Recovery (NFR)

Refers to the proportion of fertiliser N that is taken up by the crop expressed as a percentage of that applied. It is calculated as the difference in crop N uptake between fertilised and unfertilised cotton, divided by the rate of fertiliser applied. This is rarely measured in commercial cotton fields due to grower reluctance to leave small unfertilised plots. However, the very small cost involved in any potential yield loss from these small plots is offset by the valuable information gained on the effectiveness of N fertiliser use.

Crop Nitrogen Use Efficiency (NUE)

Refers to how effectively a crop produces lint yield from the N that is has accumulated. It is calculated by dividing the lint yield by the crop N uptake. The crop NUE measurement includes both soil N and fertiliser N sources and is therefore independent of how much N fertiliser was applied. It indicates how efficiently a cotton crop uses N from all sources.

If you are interested in assistance to carry out a nitrogen use efficiency assessment program on your farm, please contact your local Regional Cotton Extension Officer.

More information

More information on nitrogen losses in cotton production can be found in the following publications available from the Cotton CRC website www.cottoncrc.org.au:

- Healthy Soils Case Study: 'Improving Nitrogen Management and Reducing Greenhouse Gas Emissions'
- Economic and Environmental Costs of Greenhouse Gases for Cotton Farming. March 2006. Peter Grace, Ian Rochester and Tony Horn.
- NutriPAK
- SoilPak

For more information contact your local Cotton Extension Officer.

Central Queensland Regional Cotton Extension Officer on 07 4983 7403 & 0409 499 691

Darling Downs Regional Cotton Extension Officer on 07 4669 0815 or 0428 271 599

Macintyre Regional Cotton Extension Officer on 07 4671 6711 or 0428 879 900

St George Regional Cotton Extension Officer on 07 4625 4779 or 0427 635 621

Gwydir Regional Cotton Extension Officer on 02 6750 6308 or 0427 018 684

Macquarie Regional Cotton Extension Officer on 02 6883 7101 or 0407 952 056

Southern NSW Regional Cotton Extension Officer on 02 6993 1608 or 0447 773 791

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