Efficient Nitrogen Management in Cotton

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The utilisation of fertilizer N by cotton crops has historically been low. Of the 100 - 200 kg N/ha applied to each cotton crop, normally less than 40% is recovered by the crop; Constable and Rochester (1988) reported a mean fertilizer recovery of 30%. Most of the crop's N is derived from soil organic N; only 1/3 of the N contained in the crop is derived from the fertilizer.

Recently, these figures were confirmed where applications of labelled fertilizer have enabled the tracing of fertilizer N through the system, indicating that 22 - 44% (average 33%) of the fertilizer N is recovered by the crop, ~25% of the N remains in the soil at harvest and 30 - 55% (average 42%) of the N may be lost from the system. The amount of N lost is of great concern, as it infers a substantial waste of fertilizer N and inefficient use of a valuable resource.

N is lost from the system primarily by denitrification. This is a biological process whereby soil-borne microorganisms convert nitrate into N gases, primarily N_2 - but also traces of N_2O - which escape from the soil system. The process is encouraged by high soil temperatures (as occur in our summers) and requires low soil oxygen concentrations (as in waterlogged soil following each irrigation). The presence of readily decomposable organic matter also enhances N loss through denitrification.

Significant amounts of N may be lost as ammonia through the crop's foliage, particularly during boll-filling and crop maturation. Leaching of nitrate beyond the crop's rooting zone is relatively slow in our soils, although nitrate does percolate through the profile into regions of low oxygen concentration and high saturation where it may be denitrified.

Having previously identified poor N recovery as largely a denitrification problem, research began to investigate means of reducing N loss. In theory, denitrification loss can be reduced by controlling the concentration of nitrate in the soil using nitrification inhibitors (which retard the oxidation of ammonium to nitrate), thus reducing the amount of nitrate available to the denitrification organisms. A recently-completed 3-year project evaluated the ability of nitrification inhibitors to improve N fertilizer recovery.

Terrazole has been highly effective in retarding nitrification (N-Serve has also been effective, many other chemicals have performed relatively poorly). Where substantial N loss occurred, Terrazole significantly improved fertilizer recovery in the plant and soil. Terrazole also increased lint yield (by ~10%) in several situations where irrigation and N fertilization were sufficient to produce near maximum lint yield (ie crops were not stressed for water or N). The yield increases have afforded increased profits, after allowing for the cost of the chemical (~$50/ha). No deleterious effects of Terrazole were observed. The concurrent applications of Terrazole and N fertilizer allow us to reduce denitrification loss on a commercial scale, although Terrazole is not currently registered for use as a nitrification inhibitor in cotton.

The complete recovery of applied N is ideal but virtually unobtainable in irrigated cotton production where high soil temperatures and frequent irrigations promote denitrification loss. The best recovery observed at Narrabri was ~80% with an inhibitor (70% without) which possibly indicates the potential for N recovery under relatively good conditions. Very high N recoveries (>90%) have been recorded in winter cereal systems with inhibitors where N losses are low due to little waterlogging and low soil temperatures.

Nitrate derived from the mineralization of soil organic N is just as susceptible to denitrification as nitrate derived from fertilizer N. As the highest nitrate concentrations occur post-fertilizer application, the N lost at this time is mostly derived from the fertilizer. A continual background loss of N derived from the soil has been reported but amounts to a relatively small N loss. We should regard denitrification as a natural, biological phenomenon and accept that some N loss from our cotton-growing systems is inevitable, but aim to implement management strategies (other than inhibitor use) to reduce its impact.

Means of improving N use efficiency

1) Timing and placement of N: Low fertilizer recovery and high N loss are often associated with early pre-season N applications. The longer fertilizer N is exposed to conditions favourable for denitrification, the greater is the potential for N loss. For instance, N applied in Jan/Feb (in a wheat/fallow rotation) will on average suffer greater N loss than fertilizer applied in June/July (in a continuous cotton rotation). N application is recommended in the winter months when soil temperatures are lowest and the period of severe denitrification loss (summer/autumn) is avoided. The N lost during the period of crop growth (~42%, as mentioned earlier) severely reduces the effectiveness of N application; further unnecessary pre-plant N losses can be avoided, as indicated in Fig. 1.

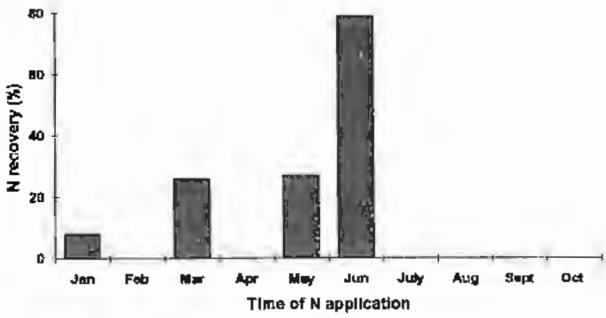

Fig 1. N recovered at sowing (Oct.) from N applied in January, March, May and June.

N placed beneath or close to the crop row is better utilised than N placed beneath the furrow. Surface-placed N is in danger of loss through ammonia volatilization. Placing N more deeply may not improve fertilizer recovery, as the soil at depth remains saturated for longer periods after each irrigation.

2) Duration of irrigations: The selection of technologies that minimise the period of soil saturation following irrigation (ie syphon diameter, length of cotton rows, slope of fields) will all assist the reduction of waterlogging and N loss.

3) Rotations: Fallowed fields generally require lower rates of N application for optimum cotton yields; the recovery of N appears not to be affected by rotation or tillage treatments. Fertilizer recovery may be slightly lower in more fertile sites where less fertilizer is required by the crop. Stubble burning has the long term effect of reducing both lint yield and N fertilizer recovery. Introduction of legumes into the system may reduce reliance on fertilizer N to some extent.

4) Fertilizers: No evidence exists for better crop utilisation or reduced N loss from particular N fertilizers, eg anhydrous ammonia and urea are recovered similarly. Water-run urea has the added advantage of being applied to fields either before or during crop growth without soil or crop disturbance, but requires additional expertise in managing water movement around the farm.

5) Soil compaction: Structural damage to cotton-growing soils occurs inevitably to some degree. It may drastically decrease crop N utilisation by reducing the oxygen concentration, porosity and gas diffusion throughout the soil profile, factors which greatly enhance the soil's susceptibility to N loss through denitrification, which is in part responsible for reduced yields in compacted soils.

6) Inhibitors: These have been discussed earlier. Terrazole may also directly inhibit the organisms responsible for denitrification as well as nitrification. They may assist in reducing N loss and promote yield, but do not eliminate the need for sound agronomic practices. Fig. 2 relates the yield response of cotton to applications of N and Terrazole. The arrows indicate the optimum N rates for the 2 inhibitor treatments; profitability was increased by $77/ha with Terrazole.

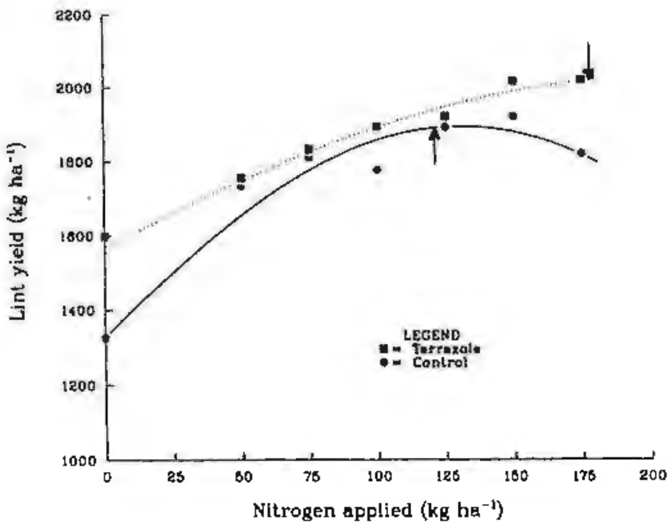

Fig. 2

7) Do-it-yourself kit: The response to applied N is rarely assessed on farms - growers assume that the N they apply is well utilised. N response can be gauged visually and inexpensively by leaving nil fertilizer strips (say 30 metres x the width of the fertilizer rig) in several fields over the farm. Differences in colour, crop growth rate, height and maturity will become evident where the applied N is being used effectively.

Conclusion: Inevitably, the denitrification process reduces N fertilizer use efficiency in cotton-growing systems. Agronomic management practices can be implemented to avoid or reduce the exposure of fertilizer N to conditions favouring denitrification; adoption of inhibitor use has the potential to further reduce N loss from the system.