NITROGEN FERTILISER USE EFFICIENCY ACROSS THE REGIONS

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Question/Issue being addresses?

In the Australian cotton industry nutrition is a significant cost with 75% of irrigated cotton respondents to the 2012-13 grower practice survey spending between $300 and $600 per hectare on nutritional inputs for their 2012-13 cotton crop (Anon, 2013). Within nutrition expenditure nitrogen (N) is the most significant input however, nitrogenous fertiliser use has increased to the point where significantly more is being applied in commercial crops than is recommended as part of industry best practice. This additional N is a significant additional cost to growers that can equate to many thousands of dollars spent that does not always result in lint yield increases. The Regional Development Officers (RDO) initiated N trials as a means of gaining an understanding of how N fertiliser management influences Nitrogen Fertiliser Use Efficiency (NFUE) as a simple tool to review crop performance.

Key results and findings

Combined data from RDO N field trials and Cotton Seed Distributor (CSD) crop management field trials highlighted a weak (R2 = 0.15) although significant ($P<0.05$) correlation between fertiliser N applied and lint yield (Figure 1). Highlighting that while fertiliser N does influence lint yield there are other factors that influence the utilisation of N in the production of lint.

Nitrogen Fertiliser Use Efficiency (NFUE) is an industry-developed measure that can provide an indication of the efficiency of N use in the production of lint by dividing lint yield (kg/ha) by N fertiliser applied (kg/ha). Rochester (2013) determined the optimum NFUE to be in the range of 13 - 18 kg lint/ha per kg of N applied/ha with efficiencies outside this range indicating that N application has not been appropriate for the amount of lint produced. Lint production may have been limited by other factors other than applied N.

The combined data showed that only 24% of 147 irrigated sites achieved the optimum NFUE and 74% of sites were below the optimum NFUE, meaning that a reduced amount of lint was produced for the amount of N applied. The 2% of sites above the optimum NFUE are less of an issue. The use of organic amendments to supplement N supply from fertiliser is a scenario that would produce a higher than optimum result within the current parameters, unless that organic N was accounted for with the N fertiliser.

There was some separation in NFUE between fallow-cotton and back-to-back cotton. When cotton was planted

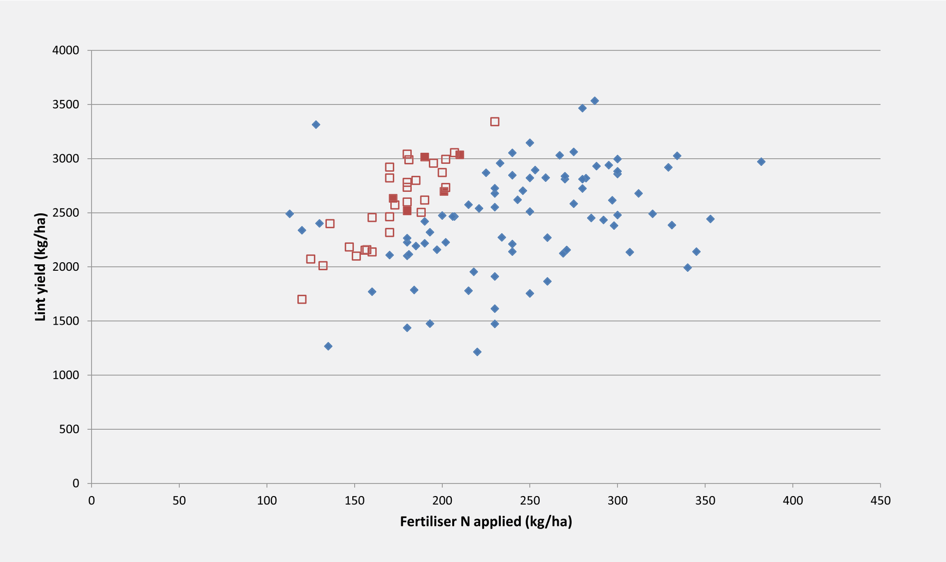

FIGURE 1. Correlation between fertiliser N applied and lint yield with crops in the NFUE optimum range highlighted in the red squares (CSD trial data). Open red squares represent crops in the optimum NFUE range planted following a fallow period.

following a fallow period 47% of those crops achieved the optimum NFUE however, only 20% of sites planted as back-to-back cotton achieved the optimum. Of all sites in the NFUE optimum range, 78% were planted following fallow period.

Within the data set, sites in the optimum NFUE range have very similar lint yield to crops outside the optimum (Figure 1).

When the correlation between fertiliser N applied and lint yield was restricted to those crops where NFUE was optimised there is a strong ($R2 = 0.805$) and significant relationship ($P<0.05$) between the two factors, which indicates the inherent fertility of the various sites and differing management practices among them.

What impact will this have on the Australian cotton industry?

The result of the trials clearly shows that within the majority of cases the amount of lint produced from the amount of N applied is outside the optimum, highlighting that there is opportunity for increased production with current levels of fertiliser input if the influencing factors are better understood. In addition the results also showed that there are farming systems that enable NFUE to be optimised without sacrificing lint yield.

There is a strong relationship between fertiliser N applied and lint yield when the NFUE is optimised. The variability in the complete data set highlights that there are management and/or environment factors impacting on the production of lint relative to the application of N fertiliser and thereby impacting on profitability. The predominance of crops with optimal NFUE following fallow indicates that there is something in that rotation that improves the ability to match N fertiliser requirements to plant requirements.

When NFUE is below optimum (ie consistent with the majority of sites), it is the consequence of either:

1) lint yield being restricted relative to the amount of N applied or
2) an excess of N applied relative to the lint yield achieved.

Reduced lint yield can be the result of a wide range of management and environmental factors with Maas (2013) considering successful management of cotton to be making informed decisions around diseases and disorders, irrigation, nutrition, pests and beneficials and weeds. CSD (no date) considers 13 practices, from planting and establishment through to picking, to maximise lint yield with limitations in any one of those factors restricting lint yield relative to the amount N applied.

Given the responsiveness of cotton to N, inefficient management of N can influence both sides of the equation to produce a below optimum result where excessive losses of N may reduce lint yield with consequential increases in N application carried out to try and account for any perceived losses. Within the complex N cycle, denitrification, immobilisation, volatilisation and leaching are N loss pathways that potentially impact on the amount of applied N available for crop growth and lint production. Denitrification is the dominant process contributing to loss of fertiliser N with losses commonly exceeding 50% of applied N (Freney et al, 1993 cited in Rochester and Constable, 2000).

Denitrification occurs under anaerobic, usually waterlogged conditions, where soil organisms utilise oxygen from nitrate ($NO3-$) for their metabolism and is a permanent loss of the N. The process is favoured under high soluble organic carbon, high soil water, low aeration, pH above 4.5 (water) and increases with increasing soil temperatures (Anon, 2006). Areas of compaction within soils can promote denitrification because of poor structure that restrict aeration (Rochester and Constable, 2000) exacerbated under wet soil conditions (Rochester et al, 1991).

Denitrification of applied N could occur in: waterlogged conditions experienced at any point following N application most commonly associated with irrigation especially if the irrigation followed by a rainfall event, also related to irrigation layouts and how well paddocks drain following irrigation; compacted soil areas such as wheel tracks associated with ground operations during the production cycle, these are also exacerbated by wetter than ideal conditions when operations are being carried out.

Immobilisation of mineral N is not a permanent loss of N rather a temporary change of form resulting from the addition soluble carbon in the form of stubble. Rochester et al (1992) demonstrated immobilisation with the addition of cotton stubble and Rochester et al (1991) showed greater immobilisation of mineral N associated with low temperature and reported on work by others showing increased immobilisation in situations of high soil water content. Net immobilisation of mineral N will normally only be for a periods of days to weeks (Herridge, 2011).

Immobilisation of applied N is possible if the N is applied within the layer of freshly incorporated stubble where soil micro-organisms will utilise it as a readily available source of N to restore the C:N ratio they require. The potential impact of immobilisation relates to timing of soil tests in relation to stubble incorporation and possible underestimation of available N in the soil and subsequent over application of N fertiliser for target yields.

Volatilisation is loss of N to the atmosphere, usually ammonia gas (Anon, 2006) and is a permanent loss of the N. Loss of applied N in this way is associated with the surface application of N fertiliser (particularly urea). Significant quantities may be lost when urea or urea-containing solutions are surface-applied, without incorporation, to moist soil that is drying out or when heavy dews or light falls of rains are received providing sufficient moisture to dissolve the fertiliser but no enough to carry it into the soil (Anon, 2006). Volatilisation losses can be increased with stubble cover.

Leaching of nitrate-N is of less importance with most movement occurring in the top 30cm of the soil (Rochester et al, 1991) maintaining it within the active root zone of cotton. Although significant leaching is possible if irrigation is used to incorporate surface applied N especially where large cracks are apparent in surface soil.

Conclusions

It is possible to achieve high yielding crops with optimum NFUE however, this is not common within the industry. This suggests that within the farming systems there are factors that are limiting lint yield relative to N fertiliser inputs. The data indicates differences in fallow and back-to-back cotton that enables better use of N fertiliser within a range of lint yields in fallow cotton. These differences are related to soil health issues and the ability of the cotton crop to use tha native soil N and applied N fertiliser better. However, these differences also raise many questions as to why and where these differences occur and provide the industry with opportunity to improve production and profitability relative to current levels of N fertiliser use.

NFUE offers growers the opportunity to consider the performance of their system in terms of the amount of lint produced from the amount of N applied enabling assessment of aspects of their system that are impacting on NFUE with potential for increased production and profitability from current input levels.

Continuing the discussion of how management and environmental factors influence NFUE will be a continuing and major focus for the RDO's.

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References

Anon, 2006. Nitrogen. In Australian Soil Fertility Manual. Ed. Graham Price. CSIRO Publishing, Collingwood Vic. Australia.

Anon, 2013. Cotton growing practices. Roth Rural. Cotton Research and Development Corporation, Narrabri.

Cotton Seed Distributors (no date). Management guidelines for managing high yielding cotton crops. Retrieved from: http://www.csd.net.au/system/resources/files/000/000/027/original/Management_Guidelines_for_Growing_High_Yielding_Cotton_Crops.pdf?1399013141

Freney JR, Chen DL, Mosier AR, Rochester IJ, Constable GA, 1993. Use of nitrification inhibitors to increase fertiliser nitrogen recovery and lint yield in irrigated cotton. Fertiliser Research 34:37-44.

Herridge D, 2011. Managing legume and fertiliser N for northern grains cropping. Grains Research and Development Corporation, Kingston, ACT, Australia.

Maas S, 2013. Monitoring to manage. In, Australian Cotton Production Manual 2013. CottonInfo, Cotton Research and Development Corporation, Narrabri, NSW, Australia.

Rochester I, 2013. Developing N-efficient cotton systems that produce low GHG emissions and promote healthy soil, Final Report. Cotton Research and Development Corporation, Narrabri, NSW, Australia.

Rochester I, Constable G, 2000. Denitrification and immobilisation in flood-irrigated alkaline grey clays as affected by nitrification inhibitors, wheat straw, and soil texture. Aust. J. Soil Res. 38:633-42.

Rochester IJ, Constable GA, MacLeod DA, 1991. Mineral nitrogen dynamics in a fallow grey clay. Australian Journal of Experimental Agriculture 31:237-44.

Rochester IJ, Constable GA, MacLeod DA, 1992. Preferential nitrate immobilisation in alkaline soils. Aust. J. Soil Res. 30:737-49.

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