Improving nitrogen fertiliser use efficiency in Australian cotton

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THE rates of nitrogen fertiliser used in Australian cotton systems continue to rise as producers strive to maximise cotton lint yields. Aligning nutrition management with crop demand is essential to improving the industry's carbon emissions losses which were detailed in the recent CRDC sustainability report.

Within my PhD research I plan to investigate the pathways of plant uptake and remobilisation of nitrogen fertiliser, and develop management strategies to improve fertiliser use efficiency. The research is supported by funding from the Australian Government Department of Agriculture, Water and the Environment as a part of its Rural R&D for Profit program through the More Profit from Nitrogen Program, CRDC and NSW DPI.

Nitrogen uptake by cotton plants

Like many plants, cotton can utilise nitrogen (N) from several sources within the soil profile, including nitrate, ammonium, soluble organic N compounds (proteins, amino acid etc) and fertilisers. The high fertility of Australian cotton soils provides an important source of N. The addition of irrigation water and the retention of organic matter feed the localised N cycle, which can provide up to 70 per cent of the crop's N requirements.

N plays a critical role in developing cotton plants as it's an essential element for developing meristem matter within the plant. All vital physiological functions within cotton plants are reliant on proteins, of which N is a major component, mainly through the development of amino acids.

The accumulation of N into cotton plants is relatively low initially in the growing season, with uptake being <0.3 kg N/ha for the first 30 days after sowing (DAS). Once flowering begins (50 DAS), N uptake increases exponentially throughout the fruiting period, before declining at plant maturity (120 DAS). During the peak uptake of N, the plant can use up to 4 kg N/ha/day. If N uptake is hindered during this period, N deficiency can impact yield potential.

Conversely, excessive application of N fertiliser can result in the plant continuing to produce vegetative growth rather than reproductive matter. The balance between generating high N uptake and promoting reproductive production can be fragile, especially if local climatic conditions and irrigation management are not aligned with N management.

Internally assimilated nitrogen

Not only can cotton source N from external sources but cotton can remobilise assimilated N from internal sources to meet the demand of developing meristem activity. The dominant

Large scale field studies are also investigating fertiliser timing dates and plant recovery rates.

source for remobilised N in plants is aging and senescing leaves. Approximately 80 per cent of stored assimilated plant N is contained in chloroplast proteins within the leaves. Rubisco, a major chloroplast protein (accounting for approximately 50 per cent of total plant soluble proteins) is prone to degradation and release of stored N and is responsible for the majority of remobilised N during seed fill.

Remobilised N is a critical source for crops requiring N in amounts that exceed the uptake potential from the soil.

Australian cultivar nitrogen remobilisation improvement

The improvements in cotton lint yield of Australia cotton cultivars over the past 40 years has coincided with greater internal N use efficiency (NUE) of modern cultivars. As these modern cultivars have improved reproductive capacity, the reproductive matter has become more efficient in the utilisation of N compared to older cultivars – in terms of kilograms of N required to produce a kilogram of lint and seed (as shown in Figure 1).

As the yield potential continues to increase, so does the required amount of N for production of reproductive parts, especially seeds. Improving the plant's ability to utilise internal and external N sources will be paramount to meet the greater N requirements for the higher yield potential of future cultivars.

Applied fertiliser NUE (f NUE) is the conversion of the amount of applied N fertiliser to produce fibre lint (f NUE = applied nitrogen fertiliser/lint yield).

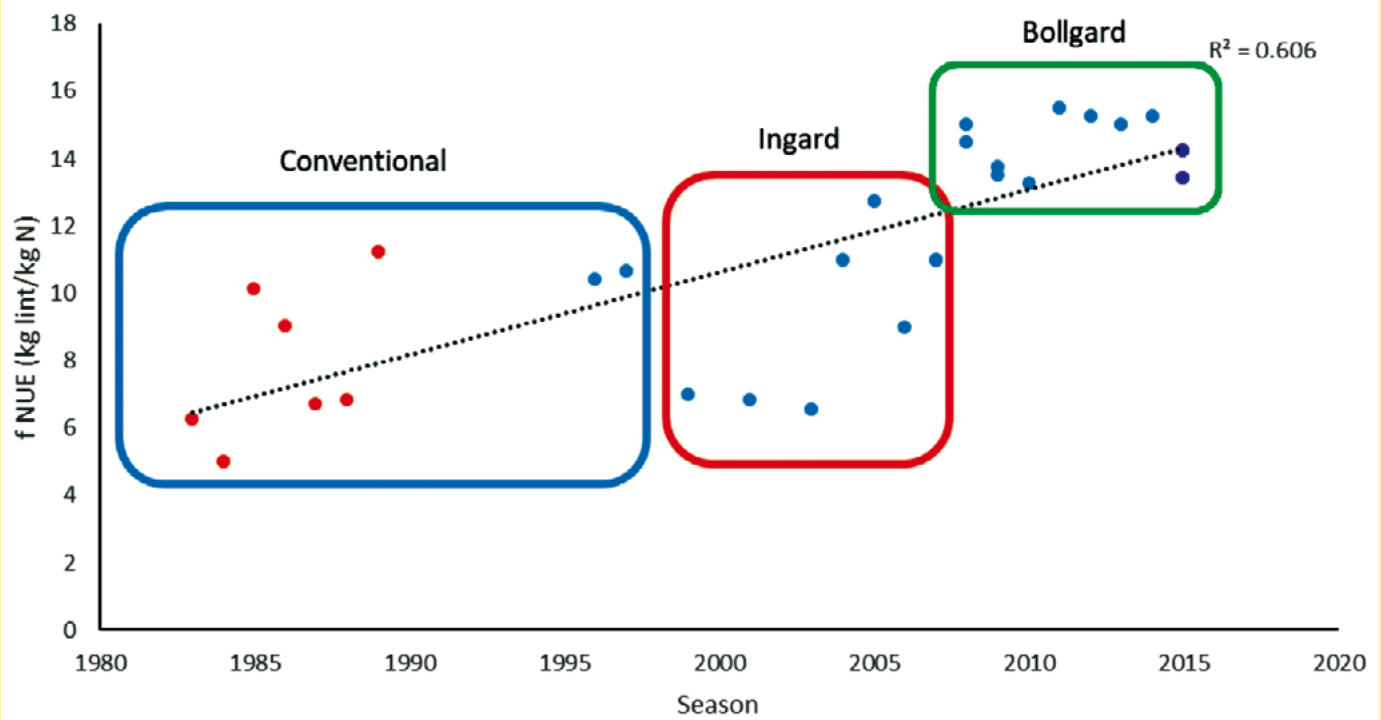
Understanding nitrogen fertiliser use in cotton plants through isotopic tracers

Both glasshouse and field trials will monitor the uptake of N fertiliser into cotton plants using labelled nitrogen fertiliser with a stable isotopic tracer (15N), enabling accurate monitoring of nitrogen movement within plant tissues. The 15N tracer has a heavier atomic weight compared to standard nitrogen sources (14N). With mass spectrometry, the enriched N can be located within the plant and measured in terms of grams of N.

This method will be used to measure the fate of the fertiliser which was applied at various points during the growing season and will highlight which N strategy promotes greatest NUE and recovery by reproductive matter. The investigation will help develop N management strategies to meet the requirements of high yielding modern cultivars.

Potted cotton plants being measured for nitrogen remobilisation and growth response when applied with nitrogen fertiliser at various timing dates.

FIGURE 1: Australian cultivar improvement of fertiliser NUE when N fertiliser was applied at 200 kg N/ha



Data compiled from (Constable et al. 1988, Constable et al. 1992, Rochester et al. 2001, Rochester et al. 2005, Rochester 2011, Rochester et al. 2016, Antille 2018).