GROWING HIGH-YIELDING NITROGEN-EFFICIENT COTTON

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Summary

High-yielding cotton can be grown without causing environmental damage. Most growers aim to do this but believe high levels of inputs are required, but this is not necessarily the case. High (excessive) inputs of resources (water, fertiliser, energy) reduce profitability where these resources are not optimised. Excess N fertiliser results in increased green house gas (GHG) emissions, especially nitrous oxide, which damages the cotton industry's environmentally responsible image. Excess fertiliser and water applications promote excess crop growth and reduce yield and profits. In many cases, growers can produce higher-yielding crops and increase profits by optimising fertiliser and water applications.

Introduction

To use N fertilisers efficiently requires the grower to optimise N fertiliser inputs with respect to soil fertility, crop response to applied N and the economics of diminishing returns from increased inputs. Where N fertiliser is used in excess, emissions of the green-house gas nitrous oxide (N_2O) become significant and this contributes negatively to the carbon balance of the cotton enterprise. Where optimal amounts of N fertiliser are applied, N_2O emissions remain at the background level. Growers are able to determine the economic optimal N rate by combining soil analysis, in-crop leaf analyses and post harvest seed analyses to assess the crop's N fertiliser requirement. Several means of assessing N fertiliser use-efficiency in cotton have been developed and have been calibrated with experiments that determine the economic optimum N fertiliser rate. Several recent surveys of the cotton industry's use of N fertiliser have shown that many growers use excessive amounts of N fertiliser in relation to the lint yields afforded.

Methods

Experiments conducted at ACRI Narrabri determine the optimum N fertiliser rate and optimum time of N fertiliser application by assessing cotton response to N fertiliser application at several rates between 0 and 320 kg N/ha. The economic optimum N rate is where $1 spent on N fertiliser returns $1 in lint.

Results

Figure 1 shows the response to N fertiliser in 2013-14. The economic optimum N rates were 220, 135 and 153 kg N/ha for cotton following fallow, vetch or faba bean crops; cotton yielded 14.0, 12.3 and 12.8 bales/ha respectively at the optimum N rates. Soil testing (0-30 cm) for nitrate-N indicated relatively low N fertility, possibly due to the dry soil during much of the fallow prior to sampling the soil. The NutriLOGIC program predicted the cotton crops N fertiliser requirement of 250, 200 and 140 kg N/ha following fallow, vetch and faba bean crops. The predictions were on average about 15% higher than was required, due to the dry spring. Also, the flatness of the two curves describing the N fertiliser response in the cotton-legume systems (Figure 1) limits the accuracy of predicting the optimum N fertiliser rate.

These relatively high yields (12-14 b/ha) have been achieved consistently over the past three years with N fertiliser applications of less than 250 kg N/ha and with conservative water management; the 2013/4 experiment received six in-crop irrigations when soil water deficit approached 50 mm, in one of the driest seasons in memory.

Several means of measuring N use-efficiency have been devised, and require measuring crop yield, crop N uptake, or seed N concentration. However, to provide some practical information to the grower, they all need to be related to the economic optimum N fertiliser rate. It is not practical to measure crop N uptake for commercial crops, but determining seed N concentration post-harvest can give growers a sense of under or over-use of N

fertiliser. By far, the most practical method for growers to use is to simply divide their lint yield (in kg/ha) by the N fertiliser applied (also kg/ha). Figure 2 shows that to achieve the economic optimum N fertiliser rate, the yield/N fertiliser index should be between 13 and 18. If the index is greater than 18, insufficient N has been applied; if less than 13, too much N has been applied.

In 2010, seed N% was assessed as a means of indicating N fertiliser use-efficiency in commercial fields in 3 valleys, and 449 modules were sampled (Rochester 2012). Only 10% had low seed N%, 45% had ideal seed N% and 45% had high seed N%, and indicated for this group more than 80 kg N/ha may have been applied in excess of what was required. In 2009, 79% of the 82 commercial cotton crops surveyed received an average of almost 50 kg N/ha in excess of the optimum N fertiliser required (Rochester 2011).

Surveys of grower practices by Roth in 2011/2 and 2012/3 indicated that the majority of growers have used excess amounts of N fertiliser to achieve relatively moderate yields. The survey of 2011/2 (189 respondents) reported average lint yields of 9.45 b/ha and 218 kg N /ha applied. The yield/N fertiliser index for this data set was 10.9, indicating an excess of 75 kg N/ha was applied on average (Figure 2). The 2012/3 data (Roth 2014) indicate growers used 243 kg N/ha on average and produced 10.2 b/ha, indicating the yield/N fertiliser index for this data set was 9.53, indicating an excess of 110 kg N/ha was applied on average (Figure 2). Applying more N than is required to satisfy the crop's demand will not increase yield. Rather, growers need to assess their cropping system's N use-efficiency and determine if other factors are limiting their cotton production.

The timing of N fertiliser application seemed to have little bearing on crop yield in 2014 at ACRI. Urea was applied at 200 kg N/ha N, being drilled at 30 cm depth in July, September or December. There was no advantage in applying N at any particular time, the three treatments

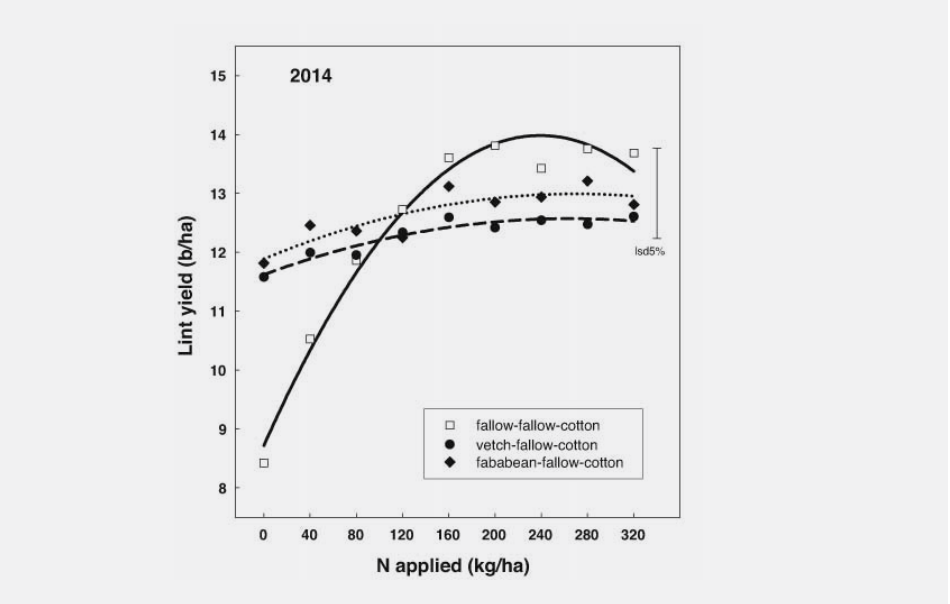

FIGURE 1. Lint yield as influenced by N fertiliser response experiments at ACRI Narrabri. The economic optimum N fertiliser rates were 220, 135 and 153 kg N/ha for cotton in the fallow, vetch and faba bean rotations.

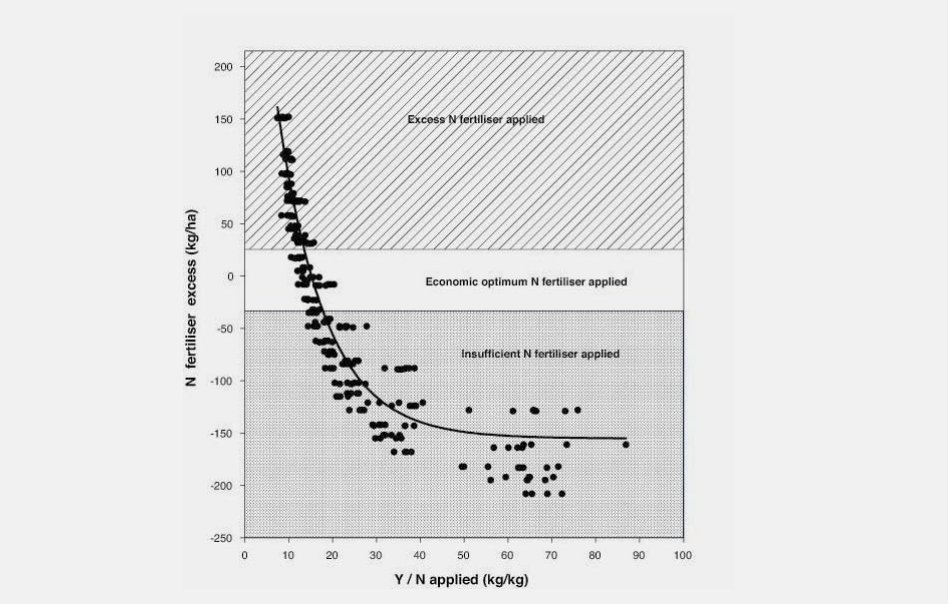

FIGURE 2. The relationship between excess N fertiliser application (relative to the economic optimum N fertiliser rate) and an index of N fertiliser use-efficiency (Lint Yield / N applied).

yielded 12.6, 12.5 and 12.1 b/ha respectively. In the December treatment, more N taken up by the crop but this provided no extra yield; it did not suffer N deficiency prior to December. Most commonly, in-crop N fertiliser is applied in irrigation water or broadcast prior to rain or irrigation - losses of N from these applications may be higher as soil and air temperatures are higher at that time of year. Where the GHG nitrous oxide (N_2O) is produced near the soil surface, there is less opportunity for it to be reduced to less harmful nitrogen gas (N_2).

Conclusion

Experiments have confirmed that high cotton yields can be grown without excessive inputs of N fertiliser or irrigation water. Grower surveys have revealed that N fertiliser application is generally not optimised for most cotton crops. Nitrogen fertiliser can be used much more efficiently within the cotton industry

with important economic benefits and avoiding environmental damage from GHG emissions.

References

Rochester IJ (2011). Assessing internal crop Nitrogen use efficiency in high-yielding irrigated cotton. *Nutrient Cycling in Agroecosystems* 90, 147-156.

Rochester IJ (2012). Using seed nitrogen concentration to estimate crop N use efficiency in high-yielding irrigated cotton. *Field Crops Research* 127, 140-145.

Roth I (2014) Cotton Growing Practices Survey Report 2013. http://crdc.com.au/?post_type=publication&p=3238

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