Testing NutriLOGIC, a decision aid for nitrogen fertiliser management in cotton

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ABSTRACT

Soil nitrogen management is fundamental to the success of a cotton crop. Too little nitrogen can limit yield, while too much nitrogen can promote excessive vegetative growth, making pest management difficult and causing delays in harvest which often reduces fibre quality. NutriLOGIC is a user-friendly, computerised decision support tool for nitrogen management in cotton. The program predicts the economic optimum nitrogen fertiliser rate, using soil and petiole nitrate estimates. To test the nitrogen fertiliser recommendations generated by nutriLOGIC, we conducted five nitrogen fertiliser response experiments in the field and the observed economic optimum was compared to the nutriLOGIC recommendation. The results demonstrate both the robust capabilities of nutriLOGIC, and a need to further calibrate the system for adaptation to a greater range of regions and growing seasons.

KEY WORDS

CottonLOGIC, NutriLOGIC, Decision support system, Nitrogen fertiliser, Soil, Petiole nitrate analysis.

INTRODUCTION

The management of soil nitrogen (N) in cotton production is an essential component for producing a profitable crop. The optimum rate of N fertiliser depends on factors such as the soil nitrate-N status, the regional responses of the crop to N and the economics. In the case of cotton production, the decision to apply N fertiliser does not solely focus on maximizing yields. The management of the crop should also focus on achieving harvestable lint in a timely manner. When crop growth continues too long, insect pests are often difficult to control and the weather can reduce lint grades considerably. The over use of N fertiliser can cause excessive vegetative growth, which can delay maturity, cause complications with insecticide penetration and have a major impact on the efficacy of defoliation (4). This complex management decision provided the impetus for the decision support tool, nutriLOGIC.

NutriLOGIC recommends N fertiliser rates for cotton crops using soil or petiole nitrate N analysis. Prior to the crop being sown, nutriLOGIC makes fertiliser recommendations using the relationship of Rochester et al. (6):

$$F = 280 - 11 \times SN$$

Where F is the fertiliser requirement (kg/ha) and SN is the soil nitrate-N based on sampling to 30cm.

The N fertiliser rate recommended is the economic optimum rate (at a specific soil nitrate level) derived from responses of lint yield versus the N fertiliser application rate (1). The relationships of N requirement versus soil nitrate N are adjusted for different soil structure and sampling times (6).

During crop development, nutriLOGIC can be used to recommend whether further N fertiliser is required to achieve economic optimum lint yield. The program uses petiole analysis to determine N fertiliser requirement by comparing measurements with an optimum plant N status or by a rate of change in petiole nitrate (2). The recommendation changes at different stages of crop development. Petiole and soil analysis combined, give a much clearer indication of N fertiliser requirements than soil analysis alone, and enables immediate action to be taken to avoid loss of production (6).

In this paper we aim to examine the performance and the current limitations of nutriLOGIC by comparing its N fertiliser recommendations with the observed optimum N fertiliser rate derived by measuring yield responses in five field experiments.

MATERIALS AND METHODS

The sites selected for the experiments covered a range of rotations, irrigation regimes and climates. All experiments were situated on commercial cotton farms. The major soil types were grey and black vertisols, representative of the cotton growing soils in these regions.

The experiments were located near Boggabri NSW (Exp.1), Narrabri NSW (Exp. 2), Moree NSW (Exp. 3), Goondiwindi QLD (Exp. 4) and near Theodore QLD (Exp. 5).

Soil samples were taken from each field in July/August prior to planting, to a depth of 30cm. These samples were dried, ground, and nitrate extracted using K_2SO_4 and then analysed using a nitrate Radiometer™ electrode. The results were then entered into NutriLOGIC to formulate the treatments.

Treatments were designed to generate fertiliser response curves to determine the economic optimum rate of N fertiliser, which could then be compared with the N fertiliser requirement recommended by nutriLOGIC. The treatments were:

- Treatment 1, NutriLOGIC Recommendation;
- Treatment 2, NutriLOGIC Recommendation – 40 kg N / ha;
- Treatment 3, NutriLOGIC Recommendation + 40 kg N / ha; and
- Treatment 4, Nil.

Treatments 1,2 and 3 had four replications in a completely randomised design, with treatment 4 replicated twice on either end of the experiment. Experiments 4 and 5 did not have nil fertiliser treatments. Each plot was either 6 or 8m wide and ran the length of the field (over 100m). The final fertiliser treatments applied to each experiment are presented in Table 1.

Table 1. N fertiliser applied (kg/ha) for each treatment in each experiment

Experiment	Treatment 1 (NutriLOGIC)	Treatment 2	Treatment 3	Treatment 4
Exp.1	120	80	160	Nil
Exp.2	150	110	190	Nil
Exp.3	130	90	170	Nil
Exp.4	150	110	190	-
Exp.5	170	130	210	-

Due to a very wet start to the season, N fertiliser applications in experiments 1 through to 4 were delayed until after planting. The grower had applied pre-plant fertiliser treatments in experiment 5 prior to obtaining the nutriLOGIC recommendation. The recommendation given by nutriLOGIC was 200 kg/ha not 170 kg/ha as presented in Table 1.

Following sowing, petiole samples were collected for nitrate analysis to further assess the N fertility status of treatment 1 and determine if any more N fertiliser was required. Samples were taken at three different times between 600 and 750 day-degrees after sowing. To obtain a representative sample, 50 petioles were randomly selected from the first fully expanded leaf. The samples were kept cool before being dried at 60 ?C in a forced draught oven for 24hrs. Nitrate concentration in the petioles was determined using the same method described for soil nitrate determination. Based on these tests, nutriLOGIC recommended that no additional fertiliser was required in any experiment.

At harvest the lint yield (kg/ha) of each plot was determined by weighing the cotton harvesters leaving the plots using trailer scales and using a standard gin turn out of 39%. Lint yield data was regressed against nitrogen applied (kg/ha) by the equation recommended by Ratkowski (5):

$\ln(1/Y) = a + bN + cN^2$

was fitted, where Y is lint yield (kg/ha) N is applied nitrogen fertiliser (kg/ha) and *a*, *b* and *c* are constants that were fitted to describe the data. The economic optimum rate was then estimated from the fitted curve using a cotton lint price of $A2.00/kg and a marginal fertiliser cost of A$1.50/kg which includes the cost of the increased amount of insecticide, irrigation and defoliants associated with the use of N fertiliser (3).

RESULTS

For each treatment in all experiments, lint yield was plotted against the amount of applied N fertiliser (Example Fig.1).

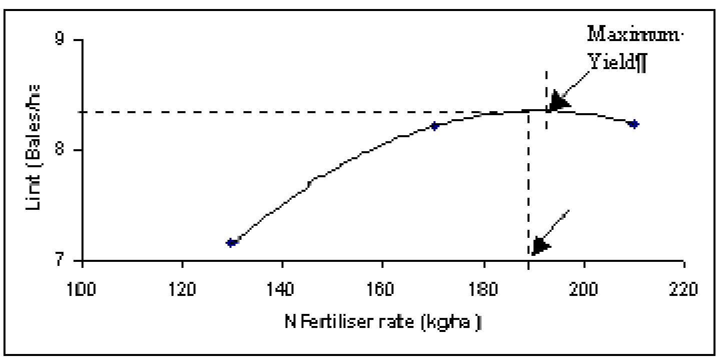

Fig. 1 Lint yield versus N fertiliser rate response curve for Experiment 5.

After generating the response curves for each experiment, the economic optimum yield and N rate for each experiment were estimated from the input and output costs (Fig. 1). The lint yield produced from the nutriLOGIC recommendation (treatment 1) was compared with the estimated economic optimum yield. In all 5 experiments the two were very close (Fig. 2).

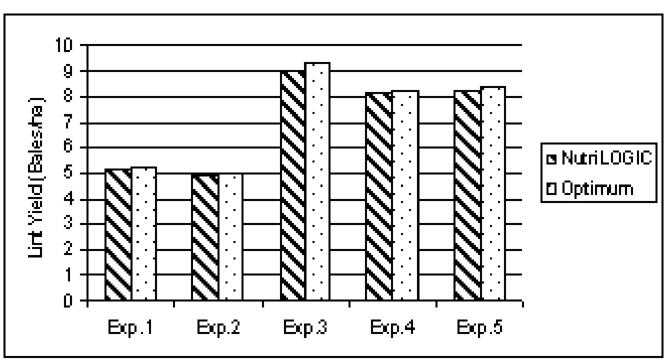

Fig. 2 Comparison of lint yield from the nutriLOGIC recommendation and the economic optimum lint yield.

The N fertiliser rates recommended by nutriLOGIC (treatment 1) were similar to the N fertiliser rates required to achieve the economic optimum yields in Exps. 1, 4 and 5 (Fig. 3). In Exp. 2 the rate recommended by nutriLOGIC was considerably higher than the estimated economic optimum and in Exp. 3 it was lower.

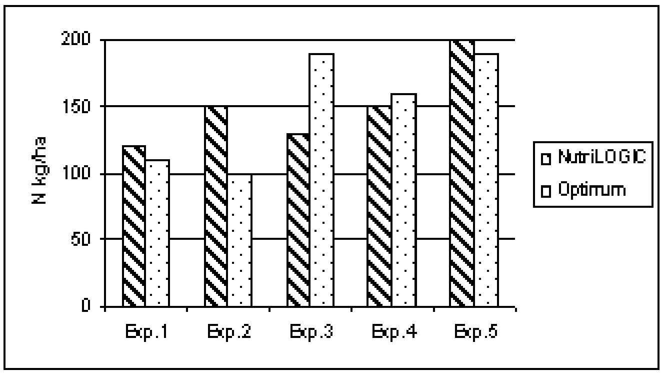

Fig. 3. Comparison of N fertiliser rates recommended by nutriLOGIC and that required to obtain the estimated economic optimum.

DISCUSSION

The experiments highlight the opportunity for cotton growers to refine their N fertiliser management. NutriLOGIC was able to provide a good estimate of the N requirement for the crop from a soil analysis and is a useful tool for growers to reliably estimate N fertiliser requirements for economic optimum yield. A controlled approach should be taken when managing N fertiliser. Applying too much N fertiliser before planting can cause a number of crop management issues, which are difficult to correct. Where the controlled approach is to apply a conservative amount of N fertiliser before planting, and later use petiole analysis to assess the need for additional N fertiliser.

NutriLOGIC recommended the optimum rate successfully in 3 out of the 5 experiments. Experiment 2 had higher yields at lower rates of applied N fertiliser, and nutriLOGIC had a higher recommendation than the economic optimum rate. This unusual trend was not apparent visually, and may have been a result of a fault in the weighing equipment.

Results from experiment 3 showed nutriLOGIC having a lower recommendation than the economic optimum rate. The higher N rate treatments in Exp. 3 were also slightly lower then the economic optimum rate. Recommendations from a series of petiole analysis should have indicated the necessity for the application of further N fertiliser. The nutriLOGIC recommendation from the first petiole analysis, suggested the application of further N fertiliser, however, the subsequent petiole results had a higher nitrate status and therefore nutriLOGIC indicated that adequate N was present to achieve economic optimum yield. Although there were differences in the N fertiliser recommendations, this did not translate to large differences in lint yield. So with the yield response being moderately flat, the difference between the estimated economic optimum N rate and nutriLOGIC’s recommendation is not critical.

One limitation that has been identified is that nutriLOGIC has been designed to predict the economic optimum N fertiliser rate for an average season and currently does not compensate for seasonal variation. Further work is underway to calibrate the system for adaptation to a greater range of regions and growing seasons. A second limitation is the need for accurate sampling and analysis. The predications from nutriLOGIC are only as reliable as the nitrate N data that is entered and the quality of the samples taken. With the nitrate levels in petiole samples dynamic, it is important to collect petioles from crops that are not subject to recent environment stresses (6). The status of a crop however, it is often difficult to accurately assess.

Through further revision and large scale testing, nutriLOGIC is developing into a valuable decision support tool that many growers will use to improve their N fertiliser management. Further field studies are being conducted to test the robustness of nutriLOGIC in a number of seasons.

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