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Final Report

Cotton Research and Development Corporation

Project CRC 1C

Improving the Nitrogen nutrition of cotton using rotation crops

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Final Report

Part 1 - Summary Project Details

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Project Title: (< 15 words) Improving the N nutrition of cotton using rotation crops.

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Part 3 - Final Report Format

A plain English summary:
The N nutrition of cotton crops was investigated with respect to the effectiveness with which rotation crops improve the supply of N to cotton and reduce the amount of N fertilizer required. The CRC farming systems experiments were examined to demonstrate these principles by monitoring the N status of each system. This has helped to identify the more N efficient cropping systems and allow for more effective N nutrition of cotton.

Summer and winter growing rotation crops (including grain, green-manure and forage legumes) were compared in field experiments at ACRI and the benefit of these legume systems and savings in N fertilizer for cotton was assessed. Both back-to-back and rotational cotton systems were investigated. The biofumigatory effect of Brassica species will also be determined through lint yield and VAM assessment. The value of other rotation crops was evaluated in terms of improved N nutrition, soil structure, weed and insect management, VAM and cotton pathogen survival.

Improvements to soil and crop nitrate tests for predicting N fertilizer requirement and crop N status will enhance grower confidence and adoption of this technology by allowing on-farm determination of soil nitrate levels. These results will be incorporated into the Nutripak /Nutrilogic program.

Background to the project
Legume crops vary enormously in their capacity to supply N to cotton crops. Our measurements indicate that up to 350 kg N/ha can be fixed by faba bean crops grown atter cotton, although some of this N (~100 kg N/ha) is removed in seed. This input of organic N replaces much of the fertilizer N required for the next cotton crop which is conducive to an improved sustainability of the cotton industry.

The objectives and the extent to which these have been achieved
- We have assessed a large range of commercial legume crops throughout the cotton-growing areas for N fixation and their input of N into the soil.
- Cropping system experiments are continuing in Field 6 at ACRI to compare summer and winter growing legume and other rotation crops, including forage legumes, double legume cropping in systems where cotton is sown back-to-back or with rotation crops and fallows. The benefits of these crops on the following cotton crop are assessed by its response to N fertilizer.
- N status in the three CRC farming systems experiments has been monitored regularly.
- Investigation into on-farm testing methods for improved assessment of plant N status is continuing and is showing positive results.
- Collaborators have monitored disease and insect incidence, and compared soil structural characteristics in these experiments.
- Considerable effort was put into the development of the NutriLOGIC program. The writing of NUTRIpak is now requiring intensive work by researchers in the nutrition field.
- We have assessed a large range of commercial legume crops throughout the cotton-growing areas for N fixation and their input of N into the soil.

The methodology and a justification for the methodology used
Field experiments were conducted to ascertain N fixation in legume rotation crops and determine the response to applied N fertilizer in the following cotton crops. The cotton phase was sown to Ingard and non-Ingard cotton to indicate the effect of N nutrition on Ingard efficacy. Laboratory experiments indicated that simplified soil nitrate tests (using Merck test strips) were not accurate and this research was not continued. Leaf nitrogen testing with the hand-held SPAD meter has shown much more potential and requires further development before this technology is released to the industry. NutriLOGIC development is continuing with upgraded calibrations forthcoming from this research. NUTRIpak has been written and requires some editing before publication in late 2000.

Detailed results including the statistical analysis of results

Legume cropping systems experiments

Experiment 1: Prior to sowing cotton in Oct 1997, three cropping treatments were set up in the previous winter, by growing wheat, faba beans or field peas. The field peas were green-manured after fixing 210 kg N/ha, the wheat yielded 0.6 t/ha and removed 10 kg N/ha, the faba beans yielded 2.4 t/ha which removed 90 kg N/ha, but fixed 240 kg N/ha, therefore 150 kg N/ha was returned to the soil. The response to N fertilizer by the following cotton crop is shown in Fig 1 attached.

Experiment 2: Prior to sowing cotton in Oct 1998, six cropping treatments were set up by growing wheat, faba beans or field peas as traditional rotation systems or in back-to-back cotton systems where vetch or field peas were grown and green-manured (or short fallow) prior to cotton planting. The green-manured field peas and vetch fixed 160 and 200 kg N/ha, respectively, the wheat yielded 3 t/ha and removed 50 kg N/ha, the faba beans yielded 3.2 t/ha which removed 120 kg N/ha, but fixed 210 kg N/ha, therefore 90 kg N/ha was returned to the soil. The response to N fertilizer by the following cotton crop is shown in Fig 2 attached.

Experiment 3: Prior to sowing cotton in Oct 1999, three cropping treatments were set up by growing wheat, (either followed by fallow or cowpeas) or soybeans. The cowpeas were green-manured after fixing 190 kg N/ha, the wheat yielded 1.7 t/ha and removed 25 kg N/ha, the soybeans yielded 3 t/ha which removed 190 kg N/ha, but fixed 560 kg N/ha, therefore 370 kg N/ha was returned to the soil. The response to N fertilizer by the following cotton crop is shown in Fig 3 attached.

The outcomes of the three experiments show that the inclusion of legume cropping can substantially reduce N fertilizer rates for cotton. Vetch has been identified as a very efficient N fixer and growers are starting to adopt or investigate this crop as a means of reducing N fertilizer input. Vetch crops have fixed on average 200 kg N/ha at ACRI, when grown between back-to-back cotton crops, ie 4-5 months during the winter.

Most legume crops also improve soil structure to a noticeable extent. Vetch, faba beans and lablab are possibly the most effective soil improvers. In Experiment 2, soil in the vetch treatments had the lowest bulk density during the cotton phase, indicating that the vetch had a beneficial effect by loosening soil which possibly had been compacted during the previous cotton crop.

When vetch is incorporated, it has the added benefit of reducing Black Root Rot in the following cotton crop. Its potential for Fusarium wilt management is being investigated more thoroughly in the 2000/2001 season. Because many legume crops are alternate hosts for some cotton pathogens, they may potentially enhance disease problems. Legume stubble should be incorporated into the soil as soon as possible to reduce seedling diseases in following cotton crops. It is important for growers to be aware of this.

SPAD 502 chlorophyll meter. This meter is being used to indicate cotton N status throughout the season and is already proving more accurate and useful than the petiole nitrate test. IT enables grows to assess crop N nutrition in the field, bypassing the need for petiole collection and laboratory analysis. In Experiment 1, there was a strong correlation between SPAD meter output and N fertilizer application rate. This was further investigated in the following season, where all treatments were assessed with the meter. A strong relationship resulted (r=0.87) between crop N uptake and SPAD meter output. However, yield in this expt was reduced by Heliothis damage through the season. There appeared little difference in SPAD meter output between commonly grown cultivars in this season, except for Pima (S7). The cotton in Expt 3 (1999/2000) experienced a cold start to the season, which led to a slightly different calibration. Separate calibrations may be required for hot, warm and cool cotton areas, or at least, allowance made for various regions. Currently, correlation of the SPAD meter output with N fertilizer requirement is good (r=0.84). This allows growers some confidence in assessing crop N status throughout the growing season.

Discussion of results including an analysis of research outcomes compared with objectives

- Legume rotation crops add substantial quantities of N to cotton cropping soils.
- Legume stubble N is less prone to loss than fertilizer N and acts as a slow-release form of N.
- The following cotton crop takes up about 30-40% of the previous legume crop N, most of the remaining N will become available to following crops as the legume stubble slowly mineralises.
- Chlorophyll meters are able to indicate crop N status instantaneously in the field. This should take over from the time-consuming petiole analysis methodology currently employed.
- NutriLOGIC was released in 1998. NUTRIpak will be published in 2000/2001.

Assessment of the likely impact of the results and conclusions of the research project for the cotton industry. Where possible include a statement of the costs and potential benefits to the Australian Cotton industry and future research needs

Vetch is being assessed on many farms throughout the cotton-growing regions. N input, soil amelioration and pathogen suppression are the perceived benefits of this cropping system. Because vetch has a short winter-growing season, it could be used to reduce the time fields are left fallow, improving soil biology, nutrient cycling and soil health generally.
Publication of NutriLOGIC and NUTRIpak will empower growers to apply the fertilizers they require at the optimum rate, thereby optimising the nutrition of their cotton crops.

Description of the project technology (eg. commercially significant developments, patents applied for or granted, licenses, etc)

The growing of vetch between annual cotton crops or after wheat has the potential to reduce N fertilizer rates for the following cotton crop, as significant amounts of N are fixed by vetch. Vetch has been identified as the most efficient N-fixing annual legume crop in this project. SPAD meter technology may be included in NutriLOGIC in future releases.

A technical summary of any other information developed as a part of the research project including discoveries in methodology, equipment design, etc.

Vetch is sown as soon as possible following cotton picking, rates between 10 and 20 kg seed/ha are used. The crop may be watered up, and the seed will emerge where sown as deep as 8 cm. No in-crop irrigations have been required in experiments to date. Vetch can be successfully green-manured using a mulching slasher set very close to the soil surface and incorporated in the next few days. Knock-down herbicides have not been completely successful. Regrowth has not been a problem where the above procedure has been followed. Vetch has not become a weed in the following cotton crop, even where the vetch may have flowered for 2 or 3 weeks prior to green-manuring, mature seeds have not been set.

Recommendations on the activities or other steps the may be taken to further develop, disseminate, or to Exploit the Project Technology

Further research is required to assess vetch productivity on commercial cotton farms in a wide variety of environments and soils. While many growers are willing to experiment with green-manuring of forage legumes, considerable expertise is required to organise farming operations prior to sowing. Similarly, the SPAD meter requires further calibration in various environments to allow reasonably accurate assessments of crop N status to be made. Wider testing of vetch intercropping and validation of the SPAD meter calibrations are essential to enable acceptance by the cotton industry.

A list of publications arising from the research project

Rochester IJ, Peoples MB, Long K and Kauter G (1997). Faba beans reduce N fertilizer requirement of cotton. (Australian Cottongrower Nov-Dec, 34-35). This article also appeared in Australian Grain.

Rochester IJ, Peoples MB, Constable GA and Gault RR (1998). Faba beans and other legumes add Nitrogen to irrigated cotton cropping systems. Aust J. Experimental Agriculture 38, 253-60.

Rochester IJ (1998). Nitrogen nutrition of cotton. Proceedings of the cotton cropping systems forum (ACRI).

Rochester IJ, Peoples MB. (1998) 'Optimising cotton nutrition'. 9th Australian Cotton Conference. (Broadbeach, 1998) 139-144

Peoples M, Bowman A, Gault R, Herridge D, McCallum M, McCormick K, Norton R, Rochester I, Scammell G, Schwenke G. (2000). Factors regulating the contribution of fixed nitrogen by pasture and crop legumes to different farming systems of eastern Australia. Plant and Soil (in press).

Rochester IJ, Peoples MB, Hulugalle NR, Gault RR and Constable GA (2000). Using legumes to enhance nitrogen fertility and soil condition in cotton cropping systems. (submitted to Field Crops Research).

Rochester IJ, Peoples MB and Constable GA (2000). Assessing the Nitrogen nutrition of cotton grown after legume crops. (submitted to Field Crops Research).

Rochester IJ (2000). Legume rotation crops for cotton farming systems. Farming Ahead 99, 53 7.

Rochester IJ, Constable GA and Peoples MB (2000). Monitoring cotton nutrition. 10th Australian Cotton Conference. (Brisbane, 2000) pp283-287.

Figure 1. Lint yield of cotton following green-manured field peas, harvested faba beans or wheat – 1997-1998 season.

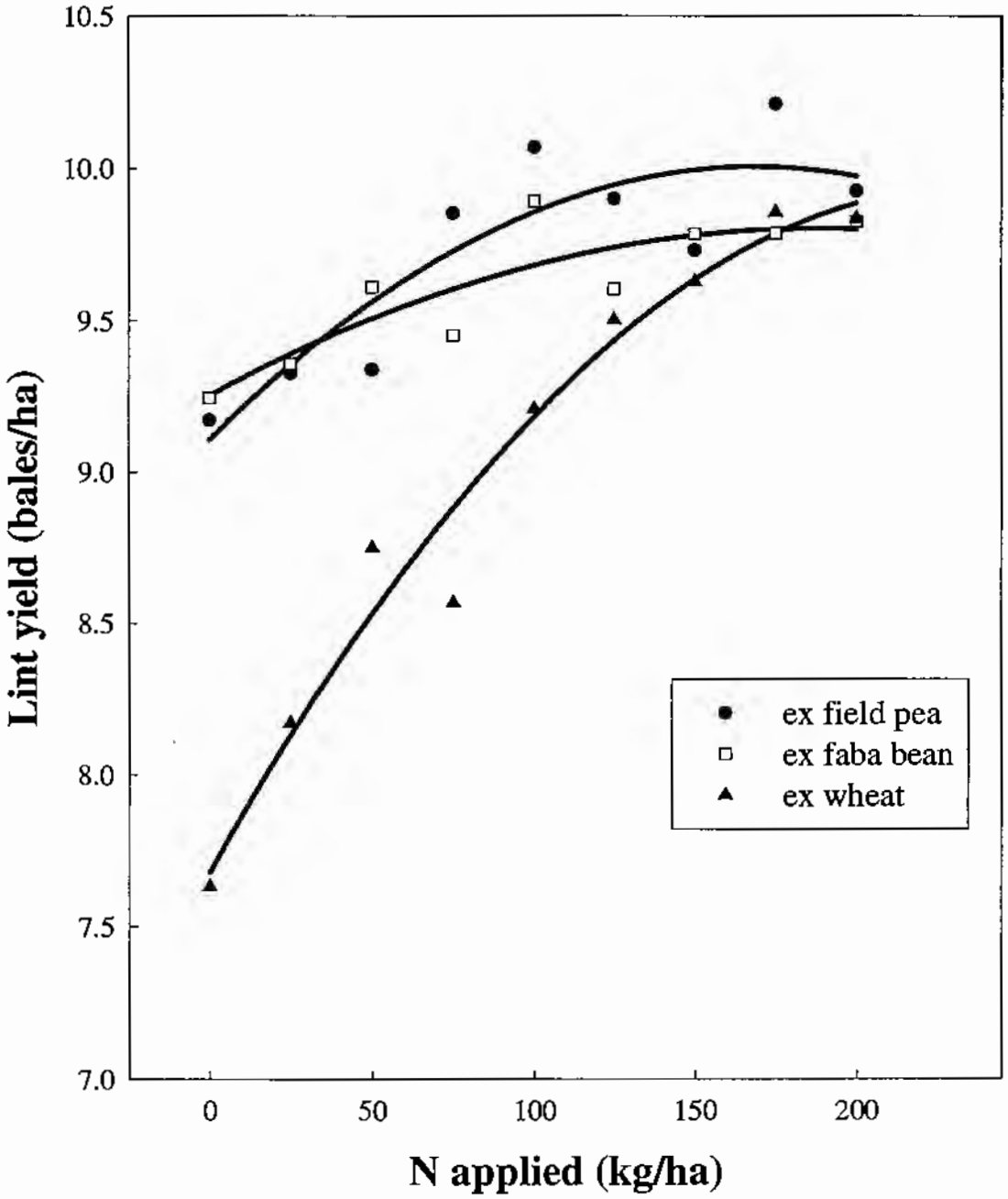
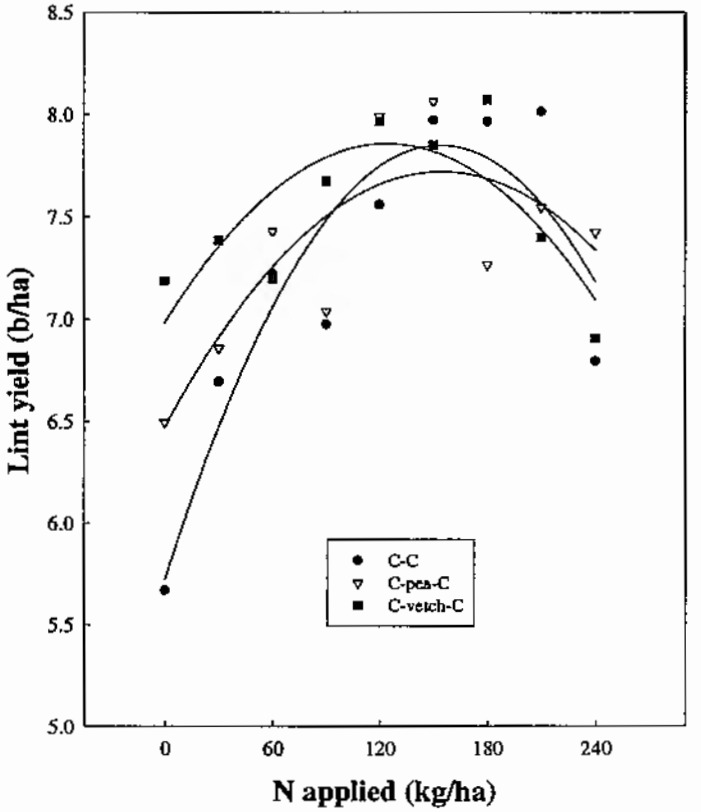


Figure 2. Lint yield of cotton following green-manured cowpeas, harvested soybeans or wheat – 1998-19999 season.



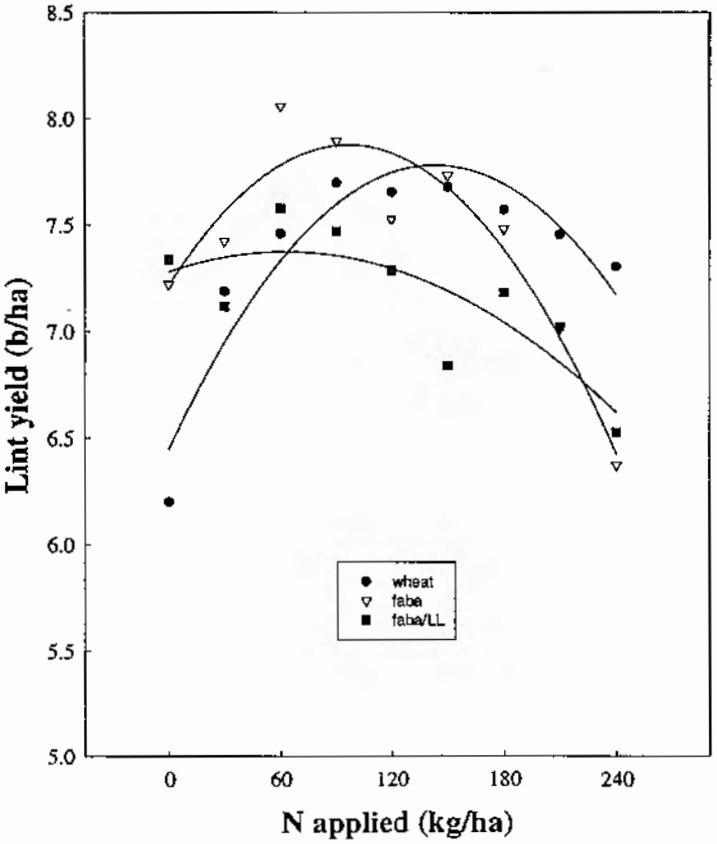


Figure 3. Lint yields of cotton following wheat/fallow, wheat/green-manured cowpeas or harvested soybeans – 1999-2000 season.