OPTIMISING COTTON NUTRITION

Ian Rochester[1], Mark Peoples[2]

[1]CRC for Sustainable Cotton Production, CSIRO Plant Industry, ACRI, Narrabri.
[2]CRC for Sustainable Cotton Production, CSIRO Plant Industry, Canberra.

Although cotton is grown on fertile soils, commonly nutrient deficiencies become apparent due to many factors. Cotton has a high demand for many nutrients which are taken up over a period of weeks (Table 1).

Table 1. Nutrients (kg/ha) taken up by high-yielding cotton crops.

N	P	K	S	Ca	Mg	Mn	Fe	Zn	Cu
180	30	200	50	220	50	0.4	1.2	.18	.05

Nutrient deficiency (or excess) can reduce crop yields. Nitrogen deficiency, for example, is easily detected, but usually by the time the deficiency is recognised and remedied, the crop has suffered some nutritional stress.

Legume rotation crops

Some legume crops have become important rotation crops in cotton cropping systems as growers realise the benefits these crops to following cotton crops. The amount of N fertilizer required by the cotton crop is substantially reduced following reasonable legume crops. In commercial fields, N rates have commonly been reduced by 50% and in some cases, no fertilizer N is needed (Fig. 1).

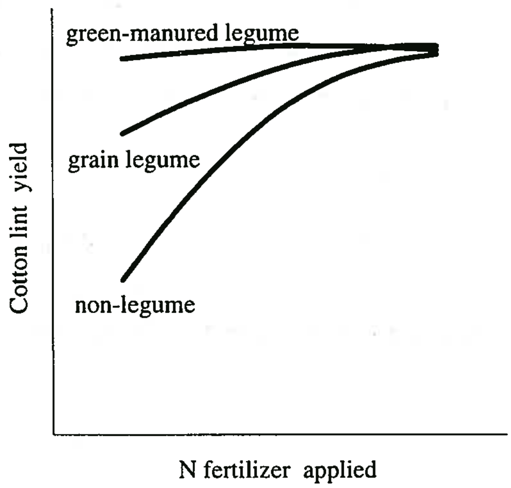

Fig. 1. Legume crops return much of the N they fix to the soil as organic N. Soil micro-organisms mineralize this N over time, making the legume N available to following crops, thus reducing the amount of N fertilizer they require.

Legume crops produce root nodules containing rhizobia which convert atmospheric N into plant N (N fixation), which is the soil system through which occurs in the. All legumes have the potential to fix N from the atmosphere, but some species are much more efficient N-fixers than others. This is indicated in Table 2 which indicates the proportion of crop N fixed through N fixation.

Faba beans have been grown successfully following cotton. Yields of 2.5-3 t/ha are common, but normally require at least one irrigation to achieve this. Importantly, faba bean crops can fix up to 350 kg N/ha and return up to 250 kg N/ha to the soil in stubble (Fig 2). Normally, only about 40% of the N fixed by faba beans is removed in the harvested seed.

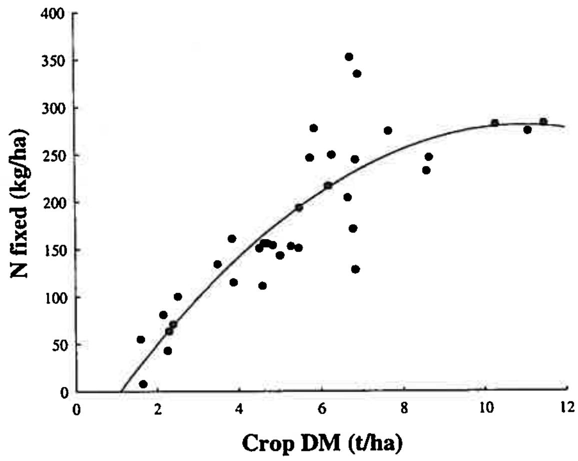

Fig. 2. N fixed in 36 faba bean crops assessed between 1994 and 1996 in the Macquarie, Namoi and MacIntyre valleys. More N is fixed by crops of higher biomass. Some dryland crops produced little biomass and therefore could devote little energy to fixing N.

Similarly, **soybeans** are capable of fixing up to 500 kg N/ha, but are more efficient at transferring this N into the seed - a crop yielding 4 t/ha will remove 260 kg N/ha. **Dolichos lablab** is a popular summer-growing legume, but is green-manured before it flowers; it can add more than 200 kg N/ha to the soil. Similar N input can be made by green-manuring **field peas**, where winter-growing species are preferred.

The N fixed by forage legumes grown between back-to-back cotton crops is also being measured. **Clovers and medics** can fix more than 100 kg N/ha; Namoi woolly pod **vetch** has fixed more than 200 kg N/ha, before being green-manured about one month prior to sowing cotton.

During past 4 years, we have assessed the ability of many legume crops to fix N. The grain legumes are amongst the highest for fixing N (soybean, faba bean, peanut) but as much of the N they fix is removed in harvested grain, less N is left for the following crop. The species which have been used for green-manuring may also add substantial amounts of N to the soil system (Table 2).

Table 2. Average values for the proportion of crop N fixed, N fixation and residual fixed N in 98 legume crops grown in rotation with cotton. The crops listed in italics were green-manured and all fixed N was returned to the soil.

Crop	No. of crops	Proportion of crop N fixed (%)	N fixed (kg/ha)	Fixed N returned after harvest (kg N/ha)
Summer				
soybean	6	83	371	194
peanut	2	80	273	168
adzuki bean	4	20	12	5
mung bean	5	51	47	12
pigeon pea	*5*	*14*	*16*	*16*
cowpea	*3*	*74*	*160*	*160*
lablab	*9*	*73*	*140*	*140*
Winter				
faba bean	35	74	177	113
lupin	3	71	176	97
field pea	*5*	*75*	*161*	*161*
lentil	*1*	*61*	*169*	*169*
clover	*9*	*86*	*118*	*118*
medic	*3*	*84*	*149*	*149*
vetch	*4*	*89*	*171*	*171*

Use of legume N by following crops

Because some N is removed in harvested grain, we calculate an N balance (= N fixed - N removed) for each rotation crop. This indicates the net amount of N which has been imported or removed by that crop, which is related to the amount of N fertilizer required to optimise lint yield in the next cotton crop in Fig. 3.

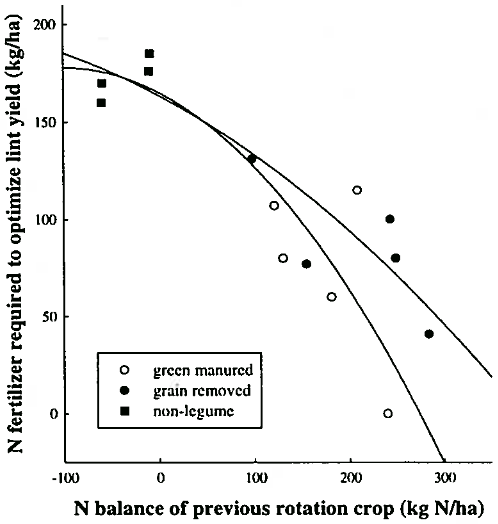

Fig. 3. Large inputs of N through legume cropping reduce the amount of N fertilizer required. Our data indicate that between 30 and 40% of the legume N added to the soil is taken up by the next cotton crop. The remaining legume N will become available to future crops. Only a small fraction legume N is lost from the soil system, compared with fertilizer N, as legume N remains in the soil in organic material.

Other benefits from legume rotation crops

Apart from the improved N nutrition afforded by legume cropping, the uptake of other nutrients by cotton following legumes is also slightly enhanced, particularly where the legume was green-manured. Soil structure is also improved following legume crops (Fig. 4).

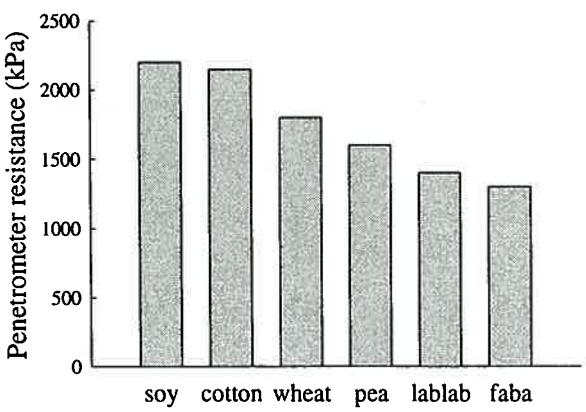

Fig. 4. Where legume crops were grown, the soil offers less resistance to penetration at 40 cm depth during the growth of the next cotton crop. This enables the cotton crop to better exploit a larger volume of soil for water and nutrients.
(data from Hullugalle).

In our legume cropping experiments at ACRI, we have not observed any increase in cotton diseases following legume crops and weeds have been easily controlled. However, both these aspects are being further investigated.

Nutrients removed in seed cotton

Generally, greater quantities of nutrients are removed in higher yielding crops. Further, more nutrients are removed *per bale* from high yielding cotton than low yielding crops (Table 3). For example, twice as much N is removed in crop yielding 9 bales/ha than one yielding 6 bales/ha. Less than 0.2 kg/ha Na, Mn, Fe, Zn, Cu and Al are removed.

Table 3. Nutrients removed in seed cotton from an experiment at ACRI where plot yields ranged from 5.5 to 10.4 bales/ha.

Nutrient	Lint yield (bales/ha)				
(kg /ha)	6	7	8	9	10
N	43	54	68	87	116
P	15	17	20	23	26
K	25	30	34	40	47
Mg	9	10	12	14	16
S	4	5	6	8	10
Ca	3	4	4	5	6

How to assess crop N status

Analysis of petioles collected prior to flowering is probably the most sensitive means of identifying N deficient crops. The petiole nitrate test has shown to be reliable in all situations tested during the past few seasons and indicates the amount of N fertilizer needed to optimise lint yield. The test involves the collection of at least 50 petioles, sending them to a laboratory for analysis and awaiting results. This delay combined with problems interpreting the results has limited the adoption of this technology.

However, last season we evaluated a meter which measures leaf chlorophyll in the field. The meter output from testing 50 to 100 leaves, can be used to estimate crop N uptake as effectively as the petiole nitrate test, without the delay. Therefore, it should be just as reliable at indicating which crops are N deficient. Using this meter would allow for an on-the-spot decision to apply more N fertilizer. Further testing during the next season will indicate if separate calibrations for different varieties (or leaf type) are warranted as well as the effect of leaf age on the test.

Determining N fertilizer application rate

While most growers recognise which fields require higher N fertilizer rates than others, the choice of N fertilizer rates is normally arbitrary. A more precise method of determining the N fertilizer requirement is to test the soil prior to fertilizer application. Nitrate soil testing must be done in unfertilized soil, 0-30 cm depth is sufficient and can be sampled by hand. We are currently evaluating a meter which will allow growers to determine on-farm, the nitrate level in their soil samples. This would enable growers to make N fertilizer decisions on the spot, based on the N fertilizer rate suggested by the NutriLOGIC program.

NutriLOGIC and NUTRIpak

NutriLOGIC is computer-based decision support program which is included in the CottonLOGIC program. It makes suggestions for N fertilizer application rates based on the input of soil nitrate test and petiole nitrate test results. This program has been developed over many years.

NUTRIpak is a manual of crop nutrition designed to provide growers with a fundamental understanding of the nutritional requirements of the cotton crop. It also provides information on interpretation of soil and plant test analyses.

Are other nutrients limiting cotton yields?

Growers who suspect their cotton suffers from nutritional disorder(s) can gain some insight into their problem by collecting upper mainstem leaves for complete nutrient analysis. This can indicate a deficiency, toxicity or imbalance of nutrients. Remedial action can then be taken to alleviate the stress before the next crop is sown. Over time, an improvement or decline in crop nutrition can be gauged from these analyses. Similar trends in soil fertility become obvious from regular soil analysis.