# Nutrients removed in harvested seed-cotton

Ian Rochester and Greg Constable

*CSIRO Plant Industry, Cotton Catchment Communities CRC, LB 59, Narrabri NSW 2390*

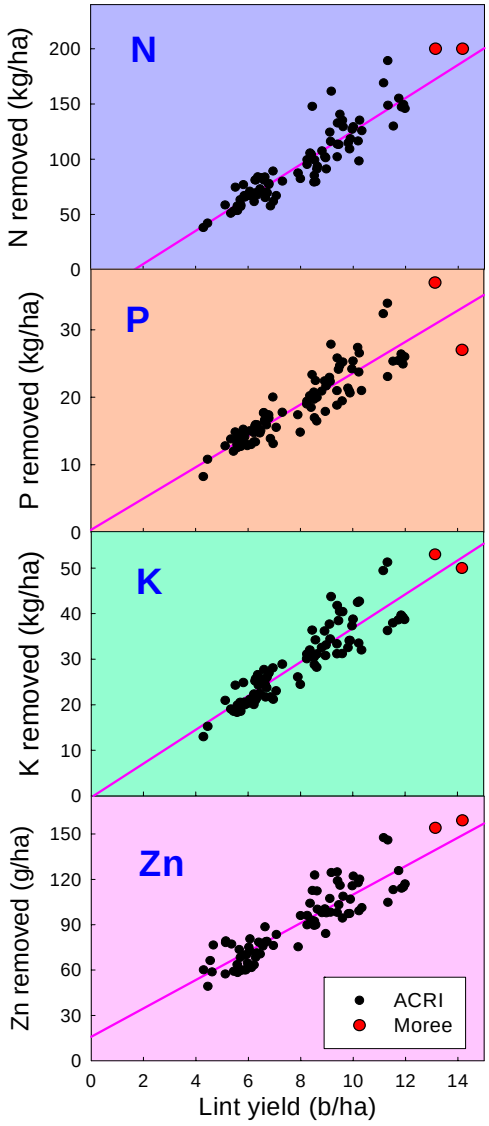
Lint yields from Australian flood-irrigated cotton crops have increased steadily over the past 25 years. Cotton Australia reported the average yield for the 2004/05 season was 9.0 bales/ha and in the previous 5 years averaged 7.2 bales/ha, 2.6 times the world average. Soil fertility may decline as a result of nutrient removal from high-yielding cotton crops and this may limit the productivity of future crops unless these nutrients are replaced.

Nutrient removal escalates as yield increases. Hence, there is increased grower interest to maintain high soil fertility by applying equivalent amounts of macronutrients nitrogen (N), phosphorus (P) and potassium (K) to those removed in seed cotton. By applying these nutrients, growers can arrest soil fertility decline and delay or avoid the onset of nutrient deficiencies, even though there may be no lint yield response to P or K application. This constitutes a strategic change in nutrient management, instead of applying fertilisers where there was an economic response to nutrient application. While we have published estimates of nutrient removal in NUTRIpak, this report updates the amounts of each nutrient removed at higher yield levels. By combining nutrient removal information with more traditional soil and tissue testing, growers can ensure soil fertility is maintained and crop nutrition improved.

Nutrient removal in seed-cotton was measured at ACRI Narrabri from two crop rotation experiments from 1999 to 2005. Lint yields of the seven crops assessed ranged from 4 to 12 bales/ha. After picking and ginning, the fuzzy seed was acid-delinted, then finely ground and the nutrient content was determined. Nutrient removal was computed as the product of nutrient concentration and the mass of delinted seed. No allowance was made for the small quantities of nutrients contained in trash, fuzzy seed and lint in these calculations.

Nutrient removal was correlated with lint yield, as shown for N, P, K and Zinc in Figure 1.

***Figure 1.*** **The relationships between N, P and K removal in cottonseed and lint**




The response was linear for all nutrients over the yield range. To confirm this, we also sampled two high-yielding commercial crops near Moree. The relationships derived from the ACRI data (Figure 1) accurately predicted nutrient removal at the Moree sites. The predicted quantities of each nutrient removed at various yield levels are given in Table 1 .

***Table 1.*** **The amount of each nutrient removed at various yield levels.**

| Yield | N | P | K | S | Ca | Mg | B | Cu | Zn | Fe | Mn |
|---|---|---|---|---|---|---|---|---|---|---|---|
| b/ha | | | kg/ha | | | | | | g/ha | | |
| **4** | 35 | 10 | 15 | 4 | 2 | 5 | 13 | 12 | 53 | 85 | 6 |
| **5** | 50 | 12 | 18 | 5 | 3 | 7 | 20 | 14 | 63 | 98 | 8 |
| **6** | 65 | 14 | 22 | 6 | 3 | 8 | 28 | 16 | 72 | 112 | 9 |
| **7** | 80 | 17 | 26 | 7 | 4 | 10 | 35 | 18 | 82 | 125 | 11 |
| **8** | 95 | 19 | 29 | 8 | 4 | 11 | 42 | 20 | 91 | 138 | 12 |
| **9** | 110 | 21 | 33 | 9 | 5 | 13 | 49 | 22 | 100 | 151 | 14 |
| **10** | 125 | 24 | 37 | 10 | 6 | 14 | 56 | 24 | 110 | 164 | 15 |
| **11** | 140 | 26 | 41 | 11 | 6 | 16 | 63 | 26 | 119 | 178 | 17 |
| **12** | 155 | 28 | 44 | 12 | 7 | 17 | 70 | 28 | 129 | 191 | 18 |
| **13** | 170 | 31 | 48 | 13 | 7 | 19 | 78 | 30 | 138 | 204 | 20 |
| **14** | 185 | 33 | 52 | 14 | 8 | 20 | 85 | 32 | 148 | 217 | 21 |
| **15** | 200 | 35 | 55 | 16 | 8 | 22 | 92 | 34 | 157 | 230 | 22 |
| **16** | 215 | 37 | 59 | 17 | 9 | 23 | 99 | 36 | 166 | 244 | 24 |
| **17** | 230 | 40 | 63 | 18 | 9 | 25 | 106 | 38 | 176 | 257 | 25 |
| **18** | 245 | 42 | 67 | 19 | 10 | 26 | 113 | 40 | 185 | 270 | 27 |
| **19** | 260 | 44 | 70 | 20 | 10 | 28 | 120 | 42 | 195 | 283 | 28 |

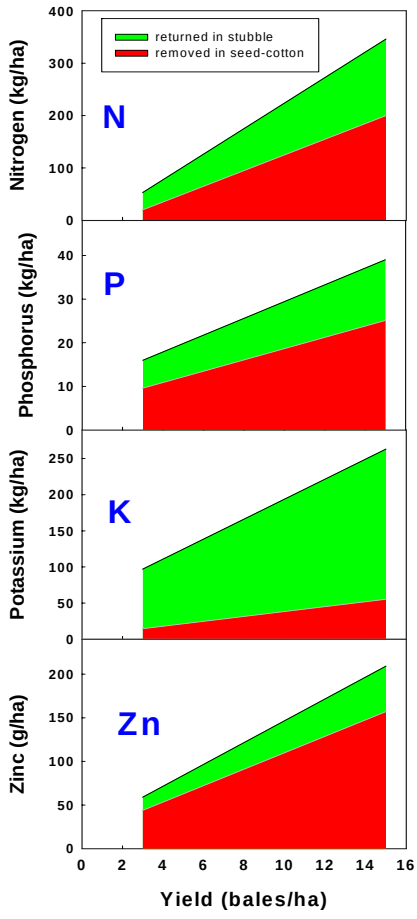
We also measured nutrient uptake before the crops were defoliated so we could determine the proportion of each nutrient contained in the plant that was removed in the seed cotton. Table 2 shows that for crops yielding 10 bales/ha, about 60% of the Zn and P taken up were removed in the seed, and about half of the N. This indicates the very high importance of P nutrition in modern high-yielding crops, especially where soil P fertility may be low and P removal has not been balanced with P fertiliser. Current cotton cultivars appear to translocate P and Zn from the leaves to the seed very efficiently, as indicated by P-deficient leaves on high-yielding crops grown on high-P soils.

***Table 2.*** **The proportion of each nutrient *removed* relative to that *taken up* by the crop we measured at three yield levels.**

| | % nutrient removed relative to nutrient uptake | | |
|---|---|---|---|
| | 8 b/ha | 10 b/ha | 12 b/ha |
| Nitrogen | **52** | **47** | **45** |
| Phosphorus | **69** | **61** | **57** |
| Potassium | 17 | 16 | 15 |
| Sulfur | 21 | 18 | 17 |
| Calcium | 3 | 2 | 2 |
| Magnesium | 34 | 27 | 23 |
| Sodium | 2 | 1 | 0 |
| Iron | 17 | 12 | 10 |
| Manganese | 3 | 3 | 2 |
| Boron | 13 | 11 | 10 |
| Copper | 37 | 32 | 29 |
| Zinc | **73** | **63** | **58** |

Nutrients not removed in seed are returned to the soil in leaf and stalk material and become available to future crops (see Figure 2).

***Figure 2.*** **The proportions of crop N that are removed in seed cotton (RED) or returned to the soil in leaf and stubble after harvest (GREEN).**



The amounts of N, P and Zn removed can pose a serious threat to maintaining soil fertility and future crop production unless they are replaced.

Soil type, poor soil structure and waterlogging may all affect the uptake of nutrients. For example, low boron (B) or sulfur (S) uptake and removal may be due to lighter soil where mobile nutrients such as B and S may be leached into the subsoil, compared with heavier soils. Very little sodium (Na) was removed in the seed (about 120 g/ha), although substantial amounts of Na were taken up by the crop; higher yields did not remove more Na.

*Planning a fertiliser program with a nutrient replacement strategy*

A fertiliser management program should rely principally on *soil and plant tissue analyses*. The nutrient removal information provided here should not replace this method of formulating a fertiliser management program. For instance, where soil and/or tissue tests indicate a plentiful storage and supply of nutrients, replacement is not justified. Many of our cotton-growing soils are able to supply adequate amounts of P and K for high-yielding cotton crops; hence P and K applications may not be necessary. Where the removal of P and K exceeds the amounts of these nutrients applied as fertilisers, P and K fertility gradually declines. But where P and K levels are not high, a replacement strategy is recommended, especially where nutrient concentrations approach the recognised deficiency levels. Fertiliser rates greater than the replacement rates can be justified where analyses indicate deficient nutrient levels. The macro-nutrients N, P, K and S are the most obvious nutrients to be replaced, because of the masses of nutrients removed.

Nitrogen

Nitrogen fertiliser rates should be determined by soil nitrate analysis assessed before sowing (the NutriLOGIC program will do this - *http://www.cotton.crc.org.au/tools/n-rate.cgi*). This tool takes all N loss processes into consideration, not just N removal. This program indicates the amount of N fertiliser required to prevent N deficiency and allow the cotton crop to attain the highest yield for that situation (soil type, region, N fertility). Normally, N fertiliser application rates exceed the N removed in the previous crop.

Phosphorus and Potassium

Soil and plant analyses will indicate where these nutrients are deficient or may limit production. Where P or K fertility is marginal, the replacement strategy is appropriate. To build the level of P or K in the soil, P and K applications should exceed the values of P and K removal given in Table 1. Hence, Table 1 can be used as a guide to indicate rates of P and K fertiliser application.

Other nutrients

Calcium can be replaced with gypsum or lime. Magnesium is highly abundant in most of our soils and replacement is not normally recommended. Sodium is taken up in large amounts by cotton growing in soils that contain more than 6% of their cations as sodium (ESP greater than 6), but little sodium is removed in seed cotton.

The micro-nutrients (boron [B], copper [Cu], zinc [Zn], iron [Fe] and manganese [Mn]) normally pose few problems in these soils, with the exception of Zn, which is normally replaced by applying zinc sulfate at 1 kg/ha. No response to copper has been reported, although boron and sulfur may be leached down the soil profile, especially in wet years when B or S application may be worthwhile. Iron deficiency may be a problem in highly alkaline, sodic soils. Leaf tissue analyses at flowering provide the best information on micronutrient levels.

*When should I replace the nutrients removed?*

**Essential**: It is essential to replace N removed, either by fertiliser or legume rotation crops.

**Recommended**: Replace those nutrients that are deemed at or close to marginal levels, as determined by soil and plant tissue analyses (eg P, K, Ca, Zn, B, Fe, Cu, Mn).

**Not recommended**: It is not recommended to replace the sodium or magnesium removed, as both these nutrients or normally at excess levels in our alkaline clay soils.

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