Nitrogen management has to be good for best yields, but factors such as soil condition, irrigation and pest management may have greater effects on cotton yield than N rate.

We have had much improved cotton yields in the past few years. We believe that is due more to improved utilization of N by plants than to increased application of N. In other words, improved soil management, irrigation scheduling and pest management have allowed the cotton plants to use N more efficiently. One point of importance is that high yields deplete the soil of nutrients rapidly. For example, there is the equivalent of 11 kg N in each bale, so 10 bales/ha will remove 110 kg N/ha from a field each year. The practice of burning stubble will also encourage loss of nutrients.

**Fertilizer recovery**

The most important factor determining the rate of N application is the recovery of applied N fertilizer by the crop. We monitor this parameter in our experiments by measuring apparent fertilizer N recovery:

\[
\text{Recovery} = \frac{\text{N taken up by fertilized crop} - \text{N taken up by unfertilized crop}}{\text{Rate of N fertilizer applied}}
\]

Our measurements of recovery average about 40%, with few instances above 50%. Figure 1 summarises data showing the extent to which the following factors control N recovery:

- Soil structure/texture. Improved soil condition will improve recovery of fertilizer N.
- Irrigation management. Waterlogging and water stress both reduce recovery of fertilizer N.
- N fertilizer application strategies. Timing and placement of fertilizer both affect the recovery of applied N by the crop. Very early N fertilizer applications lead to poor N recovery by the crop (see John Freney's paper); reliance on side-dressing for all N requirements can also reduce recovery. Placement of the fertilizer N below and to the side of the crop row results in greater recovery of applied N than broadcast or a band in the furrow.
Figure 1. Cultural effects on fertilizer recovery. Showing the effects of tillage/compaction (A); five days of water stress or waterlogging (B); and application timing and placement (C and D). In each case the data is from at least three seasons research (see references).

Deciding on N rates

Better decisions need better information. Soil and plant tests for N are better than their reputation, and commercial laboratories need more customers in order to improve the reliability of their tests. Problems in the past have arisen from:

- Different sampling methods in the field (date, depth),
- Different storage and handling methods from field to laboratory,
- Different testing methods or reporting units at the laboratory.

We need to be more consistent and standardise methods to improve the reliability of data.

Soil nitrate

Soil nitrate values fluctuate through the year in response to temperature and moisture. We have found the most reliable data to sample soil to be early September. We have also standardised on a sampling depth of 30 cm. That depth is a compromise between ease of
sampling and detecting further mineral N at depth. The nitrate measured at this time does not represent all of the N taken up by the crop, as more nitrate becomes available during the growing season. However crop N uptake can be predicted from soil nitrate samples (taken from unfertilized soil), as shown in Figure 2.

![Figure 2. The relationship between soil nitrate (measured in September to a depth of 30 cm) and subsequent crop N uptake.](image)

In order to achieve maximum yield, growers must ensure that their cotton crop has taken up 100-130 kg N/ha by mid February (the higher value for hotter areas). The desired N application rate can be calculated from a soil nitrate test result using the relationship in Figure 2. The steps in the calculation are given in the following example:

<table>
<thead>
<tr>
<th>Step</th>
<th>Data, assumption or calculation</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Soil nitrate:</td>
<td>10 ppm</td>
</tr>
<tr>
<td>2</td>
<td>Expected N uptake from 10 ppm (Fig 2):</td>
<td>56 kg N/ha</td>
</tr>
<tr>
<td>3</td>
<td>Desired N uptake:</td>
<td>115 kg N/ha</td>
</tr>
<tr>
<td>4</td>
<td>subtract 2 from 3:</td>
<td>59 kg N/ha</td>
</tr>
<tr>
<td>5</td>
<td>Expected fertilizer recovery (see Figure 1):</td>
<td>40%</td>
</tr>
<tr>
<td>6</td>
<td>N fertilizer needed to achieve 115 kg N/ha uptake (59/0.40):</td>
<td>148 kg N/ha</td>
</tr>
</tbody>
</table>

It is important to note that in this example (and in our experiments), non-fertilizer N provides more than half of crop requirements. Furthermore, the role of fertilizer recovery in affecting N requirement can be highlighted in the above example: changing the recovery value to 50% reduces the fertilizer requirement by 30 kg N/ha.
**Petiole nitrate**

Concentrations of nitrate in petioles are as high as 30000 ppm at squaring and fall linearly to as little as 1000 ppm 900 day degrees from sowing. Concentrations decline most rapidly in N deficient crops and our data indicate that the rate of decline in petiole nitrate is a more accurate indication of crop N status than the absolute petiole nitrate value. That difference can be highlighted by the following comparison:

Optimum crop N status as measured by petiole nitrate at first flowering is 21500 ppm. The statistical confidence of that value is that you are only within 133 kg N/ha of the optimum fertilizer rate, i.e., your crop N status is somewhere between 101 kg N/ha overfertilized, to requiring an additional 32 kg N/ha.

Optimum crop N status as measured by the decline in petiole nitrate at first flowering is 32 ppm/day degree. The statistical confidence is 58 kg N/ha, i.e., your crop N status is somewhere between 37 kg N/ha overfertilized, to requiring an additional 21 kg N/ha.

The relationship between rate of decline in petiole nitrate and fertilizer N requirement is shown in Figure 3.

![Figure 3. The relationship between rate of decline in petiole nitrate at the early flowering stage and the predicted rate of N to be sidedressed.](image)

It is very important that the pattern of petiole nitrate with time be measured accurately. Regular (weekly) samples from squaring to flowering are recommended. Furthermore if severe waterlogging or water stress occurs during that time, then the data will not generate accurate or realistic patterns.
Summary

Nitrogen management has to be good for best yields, but other factors have a greater influence on cotton production.

Management factors which favour good plant growth and soil conditions also favour efficient N fertilizer recovery and efficient conversion of the N taken up into yield.

Soils depleted of N will require fertilizer rates around 200 kg N/ha. Fertile soils may require rates less than 100 kg N/ha.

Soil and plant tests for N are better than their reputation. More precise estimates of fertilizer needs will only come from using precise measurements of soil or crop N status.

For petiole nitrate monitoring, the rate of decline with time is a better indication of crop N status than the absolute value at any one time. Regular (weekly) samples from squaring to flowering are recommended to obtain accurate data.

References


