The Fate of Nitrogen Fertilizer Applied to Cotton

Liz Humphreys, John Freney, Dianne Lilley & Barry Smith

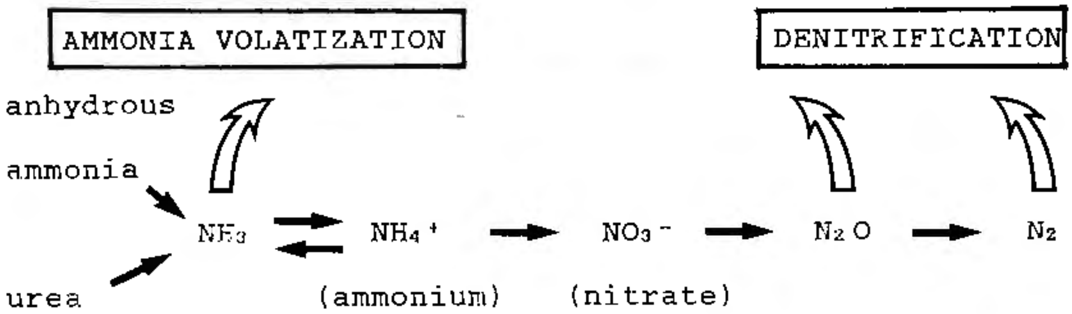
CSIRO Division of Plant Industry, Canberra.

INTRODUCTION

Cotton growers commonly apply nitrogen (N) fertilizer at rates of between 100 and 200 kg N/ha, yet the cotton plants seldom recover more than 40% of the applied N, and often much less.

What happens to the fertilizer N not recovered in the plants? Some of it remains bound in the soil, and part of this may gradually become available to succeeding crops. Some of it is probably lost to the atmosphere in gaseous forms. Some of it may be leached below the root zone; however, on heavy clay soils, leaching is not generally considered to be an important N loss mechanism.

Gaseous N losses. The major gaseous N loss forms are ammonia (NH_3), dinitrogen (N_2) and nitrous oxide (N_2O). The pathways for gaseous loss are summarized as follows:



In other irrigated crops (such as wheat and rice) total N losses have ranged from 0 to 80% of the applied N. Currently there is no information, in Australia or worldwide, on either the amount of N lost or the forms of N lost from fertilizers applied to cotton.

Aims. The aims of our work are:

1. To determine the total N loss from fertilizer applied to cotton under a variety of conditions (e.g. for different seasons; crop rotations; N application times, methods and rates).
2. To determine the importance of each loss pathway (denitrification, ammonia volatilization, leaching).
3. To identify and/or develop fertilizer management strategies which maximize the efficiency of N fertilization by reducing the losses.

METHODS

Total N loss is determined in the field using the **N-15** balance technique. Most of the N that occurs in nature (in the atmosphere and in soil) has a mass of 14 atomic mass units. However, by using **"labelled" fertilizer** in which the N has a mass of 15, we can follow the transformations and movement of the fertilizer N in the soil and plants.

N-15 labelled fertilizers are extremely expensive (~$350 per gram! of N-15). Therefore, N-15 balance studies are conducted in small plots called **microplots**, which are usually surrounded by a metal or plastic barrier inserted into the soil.

At selected sampling times, all of the plants are harvested, the soil inside the microplot frame is dug out, and deeper soil cores are also taken. The plant material and soil are dried, ground and subsampled. They then undergo several chemical treatments in the laboratory before the amounts of N-15 recovered in both the plants and the soil can be determined.

The total N loss is calculated by subtracting the amounts recovered in the plants and the soil from the original amount of N-15 applied in the fertilizer.

Ammonia loss is measured directly by sampling the air above the centre of a large fertilized area (usually a circular area with a diameter of 50 m).

Denitrification loss is usually estimated by subtracting the measured ammonia loss from the total N loss.

Leaching loss. The movement of N-15 down the soil profile in the microplots gives an indication of the importance of leaching loss. The bromide ion (Br^-) is also used to estimate the importance of leaching because its mobility in soil is similar to that of the most mobile form of N in soil - the nitrate ion (NO_3^-).

Experiments in 1987/88. Experiments 1, 2 and 3 (below) were carried out in one of Greg Constable's continuous cotton maximum tillage plots, while Experiments 3, 4 and 5 occurred in Field 9 or 10 at Auscott, Narrabri.

RESULTS AND DISCUSSION

Plant recoveries of fertilizer N have been determined for all experiments undertaken in 1987/88. The soil analyses have not been completed, and therefore we cannot present the total N losses at this stage.

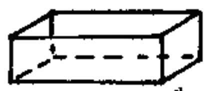
Experiment 1. Comparison of microplot techniques

We need to be sure that the results obtained in a microplot reflect the true field situation. Small frames are desirable, because less N-15 labelled fertilizer is needed, and because soil sampling is simpler. However, it is possible that the results obtained in a small, confined microplot may not give a true result if, for example, (i) the rooting volume of the plants in the microplot is severely reduced, or (ii) roots from plants outside the microplot get in and rob N-15 from the microplot, or (iii) the barrier affects water relations and soil temperature in the microplot.

Therefore 2 types of unconfined (no frame) microplots and 3 different frames were compared:

cylinder (diam. 0.33 m)

"square" (0.54 m x 0.54 m)



"rectangle" (1 m x 0.5 m)

N-15 labelled urea (84 kg N ha^{-1}) was banded beneath the hill inside the microplots, and normal prilled urea was banded outside the microplots. In addition, N-15 labelled urea was used outside some of the microplots (instead of urea prills), to provide an N-15 buffer.

Plants outside the rectangular frames, and from adjacent hills, were found to have removed some of the N-15 fertilizer from within the microplot. This is also suggested by the higher total plant recovery in microplot 5 (rectangular frame with N-15 buffer) compared with microplot 4 (rectangular frame, no N-15 buffer) (Table 1).

Table 1. Plant Recovery of Fertilizer N in Different Microplots (% of applied N)

	Type of Microplot				
	1 cylin.	2 square	3 unconf. N-15 buffer	4 rect.	5 rect. N-15 buffer
Tap roots	1.4	1.1	1.2	1.3	1.3
Plant tops	39.4	26.2	25.6	32.5	38.2
TOTAL	40.8	27.3	26.8	33.8	39.5

An encouraging result was the similar plant recoveries in the small cylinder (1) and the rectangular frame with N-15 buffer areas (5). However, no firm conclusions can be drawn until the soil analyses have been completed.

Experiment 2. N-15 balance for fertilizer banded in September

Most of the plant uptake of fertilizer N occurred between mid-December and mid-January (Table

2). This suggests, considering only the plant's capacity to take up N, that large applications of N fertilizer prior to December are not necessary. There was very little net uptake of fertilizer N after mid-January.

Table 2. Plant Recovery of N from Banded Urea (% of applied N) (unconfined microplot with N-15 buffers)

	Sampling date			
	13 Nov.	10 Dec.	12 Jan.	16 Feb.
Tap root	-	0.2	1.3	1.2
Plant tops	0.3	3.0	22.7	25.6
TOTAL	-	3.2	24.0	26.8

Experiment 3. N-15 balance for water run urea

Water run urea (75 kg N/ha) was applied in mid-December. There was again very little net uptake of fertilizer N by the plants beyond mid-January. Total plant uptake on the continuous cotton maximum tillage site was **27%** of the applied N. In contrast, total uptake on the very fertile site at Auscott was **58%**. These data illustrate two very important points: (i) paddock history can have a large influence on fertilizer recovery by the plants, and (ii) N-15 studies need to be accompanied by agronomic trials to determine whether any increases in plant recovery are reflected in increased lint yield.

Experiment 4. Ammonia loss from water run urea

Water run urea (84 kg N/ha) was applied to a circular area with a diameter of 50 m on 14 December. The amount of ammonia lost during the first 5 days after fertilization (the period of greatest loss risk) was negligible.

Experiment 5. Ammonia loss from foliar-applied N

Two attempts to compare the ammonia loss from urea, ammonium nitrate and ammonium sulphate were thwarted by rain. On the second occasion, the fertilizers (11 kg N/ha) were applied to 3 circular areas in Field 10 at Auscott, on 9 February. Rain (65 mm) fell 1½ days after fertilization. Small ammonia losses were detected from all 3 N sources, but the total ammonia loss after 5 days was less than 0.2 kg N/ha.

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