

THE FATE OF YOUR N FERTILIZER

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Introduction

Australian cotton production has increased rapidly during the last ten years, and there has been a parallel trend for nitrogen fertilizer rates to increase over this period. There have also been changes in the timing and methods of application. For convenience some growers apply nitrogen early, such as at the time of listing after the previous wheat crop; other growers side-dress nitrogen close to the time of peak demand. Before advice on timing of fertilizer application can be given to growers, precise information is required on the fate and utilization of the applied nitrogen.

The objective of the experiments reported in this paper is to determine the fate of fertilizer nitrogen applied to the grey clays in the Namoi Valley.

Materials and methods

All experiments were conducted at the Agricultural Research Station, Narrabri or on the adjoining property of Auscott Ltd in 1987-1989. The main soil in the area is a grey clay with pH 8.2 and total nitrogen content usually <10 mg/kg. Cotton (*Gossypium hirsutum* L. vars Deltapine 90, Siokra 1-1 or Siokra 1-4) was sown in October each year at 1m row spacing and furrow irrigated.

Four experiments were conducted to study the fate of fertilizer nitrogen applied to cotton. These were, (i) urea banded at 0.20 m depth below the hill between January and June after incorporating cereal residues in summer, (ii) urea banded at 0.20 m depth below the hill 21 days before sowing, (iii) urea applied in solution in furrows 67 days after sowing, and (iv) nitrogen applied in solution as a foliar application 98 days after sowing.

The fate of the fertilizer was followed by labelling it with the ^{15}N -isotope of nitrogen. This enabled us to determine the total loss of fertilizer nitrogen from the plant/soil system, the recovery of fertilizer nitrogen in the various plant parts, and the movement of fertilizer nitrogen down the soil profile by leaching. Ammonia volatilization was measured by determining the ammonia concentration and wind speed profiles in the air over a fertilized circular area. Denitrification was estimated by subtracting ammonia and leaching losses from the total loss.

Results and discussion

Experiment (i). This experiment compared the fate of nitrogen applied in summer or autumn i.e. well before sowing. When urea was banded in March or June 1988, by the time the cotton crop emerged in October, 74% and 21%, respectively, of the applied nitrogen had been lost from the soil. In 1989, urea was banded in January or May, and at sowing 92% and 73%, respectively, of the applied nitrogen had been lost from the soil. There was no evidence for leaching of the fertilizer nitrogen below the root zone, and it is concluded that the nitrogen was lost by denitrification following the above average rainfall which fell in the autumn of 1988 and 1989. The significance of these losses can be gauged by the results of a parallel field trial (1988/89) using anhydrous ammonia. Lint yield from a February application was 10% lower than yields from August and September applications.

Experiment (ii) was conducted to determine the fate of nitrogen banded three weeks before sowing. When urea was applied in September 1987 to cotton growing in a continuous cotton rotation, the plants had recovered only 27% of the applied nitrogen by mid February, 23% remained in the soil and 50% had been lost. When the experiment was repeated in the following season on a more fertile cotton/wheat rotation site, the plants had recovered 55% of the applied nitrogen by mid-February and 31% of the applied nitrogen remained in the soil (i.e. 14% had been lost). Thus the efficiency with which cotton plants can recover the applied nitrogen varies greatly. The cotton plants on the cotton/wheat site grew much more vigorously than the plants on the impoverished continuous cotton site and presumably were able to compete much more strongly for the fertilizer in the soil before it could be lost by denitrification. In both experiments most of the fertilizer nitrogen was taken up by the cotton between mid November and early January.

Experiment (iii). This experiment was conducted to determine the fate of nitrogen applied as water run urea to a cotton crop in mid-December. Negligible amounts of nitrogen were lost by ammonia volatilization. As in Experiment (ii), the fate of the applied nitrogen depended on the ability of the plants to compete with soil microorganisms for the nitrogen. In a trial at Auscott where the plants grew vigorously, by the time of maximum nitrogen uptake, the plants had taken up 58% of the applied nitrogen and 26% had been immobilized in the soil. Only 16% was lost by denitrification. However, at the same time on an impoverished site in a continuous cotton rotation, the cotton plants recovered only 28% of the applied nitrogen, 24% was immobilized in the soil and 48% was lost by denitrification. Plant growth on the cotton/cotton site was poor and the dry weight of the plant tops was only 25% of that at Auscott at the time of fertilizer application.

Experiment (iv) was conducted at Auscott to determine the fate of foliar applications of urea, ammonium nitrate, ammonium sulfate and urea-ammonium nitrate solution (Easy-N) applied in January at 20 kg N/ha. When the plants were harvested five weeks later, recovery of applied nitrogen in the plants ranged from 51% to 62%. The greatest uptake was obtained from Easy-N. Some of the applied nitrogen was transferred from the plant to the soil, but it is also apparent that some of the foliar spray penetrated the plant canopy and lodged on the soil surface; at the time of harvest 18% to 31% of the applied nitrogen was recovered in the soil. Recoveries of applied nitrogen varied from 73% to 87%, with the maximum being recovered from Easy-N.

Plant recoveries of urea nitrogen applied as a foliar spray in January or banded in September were similar (55%). However, the distribution of the nitrogen in the plants from the two experiments was quite different; 35% of the foliar applied nitrogen was found in the bolls compared with only 15% from banded urea.

Conclusions

The results show that negligible amounts of fertilizer nitrogen are lost by ammonia volatilization and leaching, but that large amounts can be lost by denitrification. The amount lost depends on the time of application, soil conditions and plant vigour at that time. Losses of fertilizer N were very large from early (summer/autumn) applications when this was followed by heavy rain creating wet soil conditions. The practical consequences of these results are that in order to prevent nitrogen loss, a grower preparing land for cotton following wheat or fallow should not apply the nitrogen fertilizer until winter, particularly if heavy rain is common in summer and autumn. However, if rain does fall, the nitrogen application may have to be performed on wet soil, possibly creating soil compaction problems. Therefore the decision, as to whether nitrogen should be applied at the time of listing, depends on the relative penalties of nitrogen loss and compaction. If the soil is prone to compaction, the nitrogen could be applied in autumn, since this is usually the dry season. If heavy rain occurs, then plans should be made to side-dress the cotton, after monitoring crop growth and nitrogen status at squaring.

For continuous cotton, it is recommended that some nitrogen be applied before sowing (see paper by G.A. Constable in the 1988 Cotton Conference Proceedings). If the nitrogen is applied in late autumn/winter, when temperatures are low, denitrification loss is expected to be lower than that resulting from an application in summer/early autumn when temperatures are high.

Depth of application \rightarrow effect on denitrification - less microbial activity