Potential residual value of nitrogen fertilisers in central Queensland

R.D. Armstrong and N.V. Halpin

Queensland Department of Primary Industries, LMB 6, Emerald Qld 4720

Summary. Studies were undertaken to determine the fate of N applied to wheat if the crop fails in Central Queensland (CQ). ^{15}N labelled ammonium nitrate (50 kg N/ha) was applied to wheat at planting and half the plots were immediately sprayed with glyphosate to simulate a failed crop. Of the labelled N added to the soil, 46% and 54% were recovered in the plant at maturity in conventionally and zero-tilled plots, respectively. A further, 35 and 39% of the original N was found in the soil. In the failed crop plots, 75 and 87% of the original nitrogen could still be found in the soil in conventionally and zero tilled plots, respectively.

Introduction

Low grain protein levels in cereal crops have increased awareness of the declining fertility of cracking clay soils in Central Queensland (CQ). However, yield responses to nitrogen (N) fertilisers are highly variable and crop failures are common due to the unreliability of rainfall in this region. Despite recognising the potential economic benefits of applying nitrogen in good seasons, farmers are reluctant to risk applying N in case the crop fails. There is a widespread perception that if the crop fails, any N added to the soil is 'lost'

Knowledge of the fate of N applied to crops that subsequently fail has significant implications for the economics of applying fertilisers. If the majority of fertiliser N remains in the soil after crop failure, it is potentially available to subsequent crops. Studies in Southern Queensland (SQ) (2) have demonstrated that a significant proportion of N applied prior to planting wheat can be lost from the system. However, temperatures are higher in CQ and rainfall less reliable. Consequently, the potential to lose N in CQ may differ considerably from SQ. In this paper, we examined the fate of N applied to wheat at planting and in adjacent fallow plots on cracking clay soils in CQ.

Methods

The experiment was a factorial design of five rates of N fertiliser (0, 12.5, 25, 50, 75 kg N/ha applied as ammonium nitrate, 34.5% N) and two tillage practices (conventional (CT) and zero (ZT) tillage), replicated three times. An additional treatment comprising plots sprayed with glyphosate immediately after wheat emergence was included. A basal application of phosphorus (12 kg P/ha) and zinc (2 kg Zn/ha) was banded with the seed at planting. The trial site had been previously cropped to wheat. The CT treatment consisted of chisel ploughing and harrows to control fallow weeds whereas the ZT treatment used spray applications of glyphosate and 2,4 D ester. Stubble in ZT plots was burnt immediately prior to planting. Wheat (cv. Hartog) was sown on the 3 June, 1991 and harvested on the 3 October. Planted plots were 1.8 m x 13 m and contained 7 rows of wheat (22.5 cm row spacing). Fallow plots were 2 by 2.5 m. Soil nitrate (0-60 cm) was measured at planting by extracting soil in 2M KCI collected from three 3.75 cm diameter cores per tillage block . Dry matter and grain yield were measured at anthesis and grain maturity, respectively, in two 0.5 m quadrats.

After planting, steel rings (30 cm diameter x 30 cm long) were inserted 25 cm into the soil in the fallow and planted No plots. An additional set of rings were placed in the fallowed plots. 15N labelled ammonium nitrate (5% excess ^{15}N) was applied as a band at approximately 5 cm depth at a rate of 50 kg N/ha next to the seed. At grain maturity (21 September), plants were cut at ground level, oven dried at 60?C for 36 hours, and divided into grain and remainder (straw) before weighing and grinding. In half of the 'failed crop' plots and all of the planted plots, soil in the steel rings was removed in 0-10, 10-25, 2540 cm increments by totally excavating the soil. Soil in the 40-60 and 60 plus depth was sampled using a composite of three 3.75 cm diameter cores per ring. The remaining steel rings in the 'failed crop' plots were sampled on the 20 December. Total N and ^{15}N content of both the plant and soil was determined in a procedure similar to that listed in (4). Soil weight was not measured so it was necessary to estimate this variable.

Results

In-crop rainfall totalled 29 mm and occurred as a single event on 9 July. Soil nitrate (NO_3) level at planting was significantly higher in ZT plots than in CT plots (32.1 ? 0.6 v's 25.3 ? 1.9 kg/ha). There was a significant ($P < 0.05$) grain yield response to N fertiliser, despite the poor in-crop rainfall (Fig. 1). ZT plots yielded more than CT plots but tillage practice did not significantly ($p > 0.05$) influence grain response to N. Grain protein levels were very low (less than 9%) without added N and responded significantly to added N (data not presented). Similar to yield, grain protein was higher in ZT plots than in CT plots.

Of the 50 kg N/ha applied to the wheat, 46% was recovered in the grain plus straw in the CT plots and 54% in the ZT plots at grain maturity (late September) (Fig. 2). An additional 35% of the original fertiliser N was recovered in the planted soil in the CT plots and 39% in the ZT plots. In contrast. 75 and 87% of the original fertiliser N was recovered in the failed crop plots. By late December, 68% and 63% of the original fertiliser N was still present in the failed plots for CT and ZT treatments, respectively. In the September sampling, nearly all of the 15N was located in the top 25 cm of soil. Although there was some leaching of /=N from the 0-10 cm layer to the 10-25 cm between September and December, less than 3 % of the 15N was found in the 25-40 cm layer.

Discussion

This study demonstrated that even if a crop fails after N fertiliser is applied, a major proportion of the N remains in the soil. Despite receiving comparatively low in-crop rain. grain yield responded significantly to applied N and nearly half of the fertiliser N was utilised by the target crop. In addition, a significant proportion of the unused fertiliser N remained in the soil in the planted plots.

No direct measurements were made of the cause of N losses in this study. The small quantities of fertiliser N located in the sub-soil layers indicates that leaching was probably not the cause of the N loss. It is likely that most of the N lost from the soil was via denitrification. In-crop rainfall was very low (29 mm) and this corresponded with high recovery of N in both planted and failed crop plots in September. However, several rainfall events occurred between September and December, which may have resulted in temporary anaerobic conditions, and there was a significant loss of N from the soil during this period. In another trial (Armstrong et al. unpubl.) conducted using sorghum, significantly higher losses of N were lost in the failed sorghum crop than in the failed wheat crop. The higher loses from the sorghum corresponded to much higher rainfall in the sorghum crop. Craswell and Martin (2) have found that up to 84% of NO_3 was lost via denitrification on a cracking clay soil under water logged conditions. Given that in-crop rainfall is, on average, much higher for summer crops than winter crops in CQ, (average December to April rainfall = 339 mm; May to October = 182 mm), fertiliser N losses by denitrification are likely to be significantly less when N is applied to winter crops. However, it must also be considered that the chances of crop failure due to drought are significantly greater with winter than summer crops in this region.

Tillage practice significantly influenced grain yield and to a lesser extent, recovery of N fertiliser. As stubble was burnt at planting in ZT plots, this tillage treatment effectively had lower stubble levels than the CT plots. Incorporation of stubble into the soil in CT plots should have increased soluble carbohydrate levels and therefore denitrification potential (3). However, 15N recovery seemed to depend more on soil moisture level than stubble load. The higher recovery of N by wheat in the ZT plots would have been facilitated by the better soil moisture in this treatment. When the crop 'failed' however, this higher soil moisture remained unused and may have resulted in greater denitrification rates. Consequently, 15N recovery was lower in the ZT failed crop plots than in the CT plots in September. ZT practices are considered desirable in CQ due to the lower soil erosion rates, higher soil moisture retention and potentially higher crop yields. However, the potential yield benefits of ZT will only be achieved if correct N nutrition of the crop is obtained.

A large proportion of total (Kjeldahl digestible) N remaining in the soil after crop maturity probably occurs as organic N (I) and must be first mineralised before it is available (as nitrate) to the following crop. However, this study indicates that even when a crop fails, a major proportion of the fertiliser N remains in the system and therefore potentially available for crop use in the future.

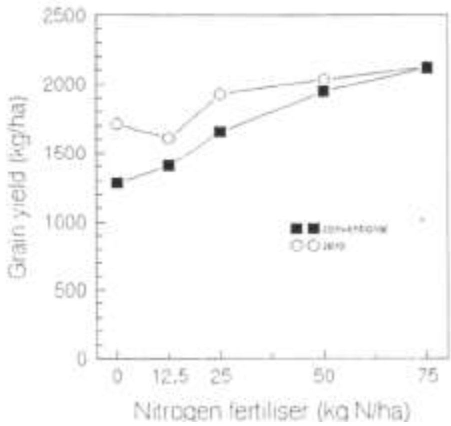

Figure 1: The effect of nitrogen fertiliser and tillage practice on the grain yield of wheat at Capella in 1991. 1.s.d. (P = 0.05) for tillage 196 ; N level 311

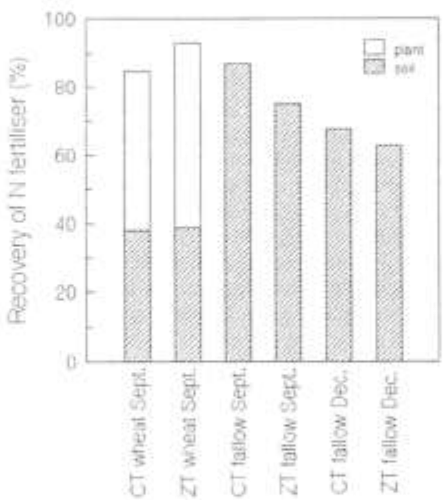

Figure 2: The proportion of ^{15}N fertiliser recovered by wheat and remaining in the soil for conventional (CT) and zero (ZT) tillage at Capella in 1991. 1.s.d. (P = 0.05) 11.4

Acknowledgements

We would like to thank Dr P Chalk (Uni. of Melbourne) for ^{15}N analysis. This experiment was part of a project funded by GRAINCO. RIRDC, and Incitec Ltd.

References

1. Balabane, M., and Balesdent, J. 1992. Soil. Biol. Biochem. 24, 89-96.

2. Craswell, E.T., and Martin, A.E. 1974. Soil Biol. Biochem. 6, 127-29.

3. Cogle, A.L., Strong, W.M., Saffigna, P.G., Ladd, J.N. and Amato, M. 1987 Aust. J. Soil Res. 25, 481-90.

4. Strong, W.M., Saffigna, P.G.. Cooper. J.E. and Cogle, A.L. 1992. Aust. J. Soil Res. 30, 711-21.