# Long term N fertilizer value of cattle slurry applied to maize

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## Abstract

Results of long-term field experiments were used to calibrate and validate a soil-crop model describing the accumulation of the residual nitrogen (N) effect of cattle slurry. Subsequent calculations indicated that the N Fertilizer Value (NFV) of cattle slurry applied to maize rises from 55-60% when manure is applied for the first time to 80% after 6-8 years. Such more realistic estimates of the NFV could help to save mineral N fertilizer.

Keywords: decomposition, maize, manure, nitrogen, residual effect

## Background and objectives

The Nitrogen Fertilizer Value (NFV) of manures is often derived from one-year (or at best short-term) field trials by comparison with (a) mineral fertilizer nitrogen (N) treatment(s). This design may overlook the cumulative residual N effects of manures (Figure 1). NFV's can hence be underestimated (Schröder & Stevens, 2004).

The N requirement of a crop (Nopt) is generally based on multi-year response trials with mineral fertilizer N. These trials are often carried out on fields to which manures have been applied in preceding years. Initially, crops in these trials benefit from residual N effects. Nopt's are hence underestimated when the eventual recommendations take no account of the N supplying power of a soil resulting from these earlier manure inputs (Schröder, 2005; Schröder *et al.*, 2000).

These combined biases of NFV's and Nopt's will compensate each other somehow in our advices to farmers. However, site specific N management requires a better disentanglement of our imperfect recommendations on NFV and Nopt. We have attempted to better quantify the residual N effect of manures, and thus NFV's, through a combination of experiments and modelling. The focus of this work was on cattle slurry, the most common manure type on dairy farms in the Netherlands.

## Material and methods

From 1997 to 2003 we conducted a field experiment (Experiment 1) on a sandy soil in the Netherlands. Treatments comprised different time series of spring-injected cattle slurry applied to silage maize at rates ranging from 0 to 220 kg total N $ha^{-1}$ $yr^{-1}$, whilst compensating for differences in available phosphorus and potassium. Results were used to calibrate a simple model reflecting the N flows between soils and crops (Schröder *et al.*, 2005a). Subsequently, the model was tested with an independent data set derived from a long-term (1988-2002) field experiment (Experiment 2) on another sandy soil, comprising repeated annual spring-injected cattle slurry applications to silage maize at rates ranging from 0 to 170 kg total N $ha^{-1}$ $yr^{-1}$, with and without mineral fertilizer N supplementations (Schröder *et al.*, 2005b).

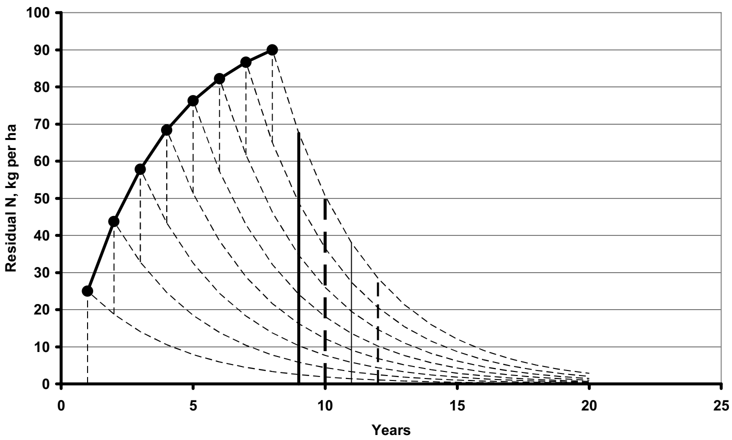


*Figure 1.* *Hypothetical accumulation of residual N effects resulting from repeated manure applications (—•—) and the residual N effect in the first (——), second (— —), third (——) and fourth (— —) year after manuring has stopped.*

## Results and discussion

Dry matter and N yields of silage maize responded positively ($P$<0.05) to both current cattle slurry applications and applications in previous years (Experiment 1, Table 1). N yields could be satisfactorily predicted with a simple N model by adopting an annual relative decomposition rate (RDR) of the organic N in cattle slurry of 25-33% and a RDR of 3% of the native organic N pool in the upper 30 cm soil layer (Experiment 1, Figure 2). The parameter setting did not need any adjustments to achieve a satisfactory match between observed and simulated N yields in the test (Experiment 2, Figure 3). Subsequent model calculations indicated that the relative N fertilizer value (RNFV) of cattle slurry increases from approximately 55-60% when manure is first applied, to approximately 80% after 6 and 8 years for RDR's of 33% and 25%, respectively. Of course, outcomes can be different for other manure types, soil types, application techniques and crops (Schröder *et al.*, 2005a).

*Table 1.* *Total aboveground silage maize yield (tonnes DM ha$^{-1}$), as affected by cattle slurry application rates (Schröder et al., 2005a).*

| Year(s): | Average cattle slurry rate (kg total N ha$^{-1}$ yr$^{-1}$) in consecutive periods: | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1997-1999 | 0 | 0 | 0 | 106 | 106 | 106 | 212 | 212 | 212 |
| 2000-2002 | 0 | 111 | 221 | 0 | 111 | 221 | 0 | 111 | 221 |
| 2003 | 0 | 96 | 191 | 0 | 96 | 191 | 0 | 0 | 0 |
| 1997 | 12.3 a[a] | | | | 14.2 b | | | | 15.1 b |
| 1998 | 7.6 a | | | | 11.1 b | | | | 12.3 b |
| 1999 | 8.9 a | | | | 13.7 b | | | | 15.8 c |
| 2000 | 7.2 a | 11.7 c | 14.3 d | 9.5 b | 12.9 cd | 14.3 d | 11.3 c | 13.9 d | 14.2 d |
| 2001 | 7.5 a | 11.5 c | 13.3 d | 9.6 b | 12.8 cd | 12.4 cd | 9.6 b | 12.6 cd | 15.1 d |
| 2002 | 9.7 a | 15.1 c | 16.4 d | 11.8 b | 16.0 d | 16.8 d | 12.9 b | 16.6 d | 16.8 d |
| 2003 | 8.9 a | 13.3 de | 14.2 ef | 10.4 ab | 13.5 de | 15.5 f | 11.3 bc | 12.1 cd | 12.2 cd |

[a] *Different letters within rows denote significant (P<0.05) differences.*

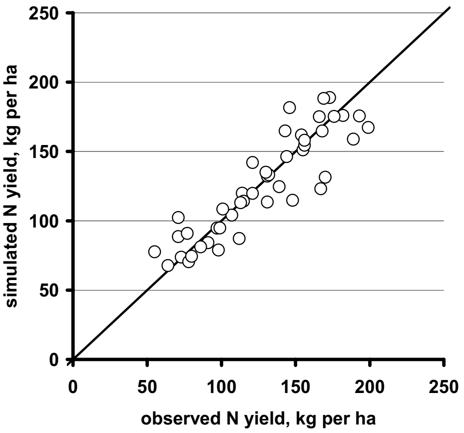


*Figure 2.* *Observed N yields of silage maize versus simulated N yields, when relative decomposition rates of 25% yr[1] for the pool of organic manure-N and of 3% yr[1] for the soil organic N pool had been adopted (Experiment 1, Schröder et al., 2005a).*

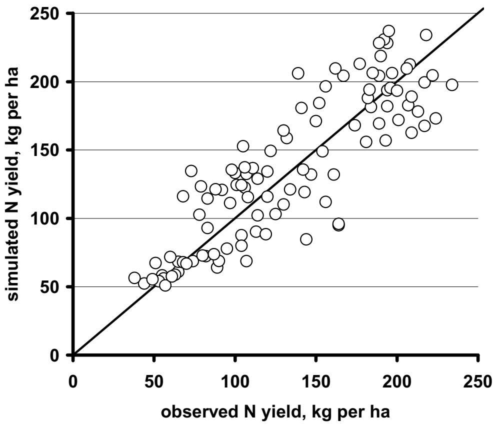


*Figure 3.* *Observed N yields of silage maize versus simulated N yields, when relative decomposition rates of 25% yr[1] for the pool of organic manure-N and of 3% yr[1] for the soil organic N pool were imposed (Experiment 2, Schröder et al., 2005b).*

## Conclusions

The long manuring history of most agricultural systems, justifies adoption of less conservative estimates of the NFV of manures which take better account of the cumulative residual N effects of repeated manure applications. Such *a priori* estimates of the 'native soil fertility' may save mineral fertilizer N and may be more reliable than estimates based on soil tests.

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