A simple software tool to assist in making better use of manure nitrogen: *MANNER v.5 (2008)*

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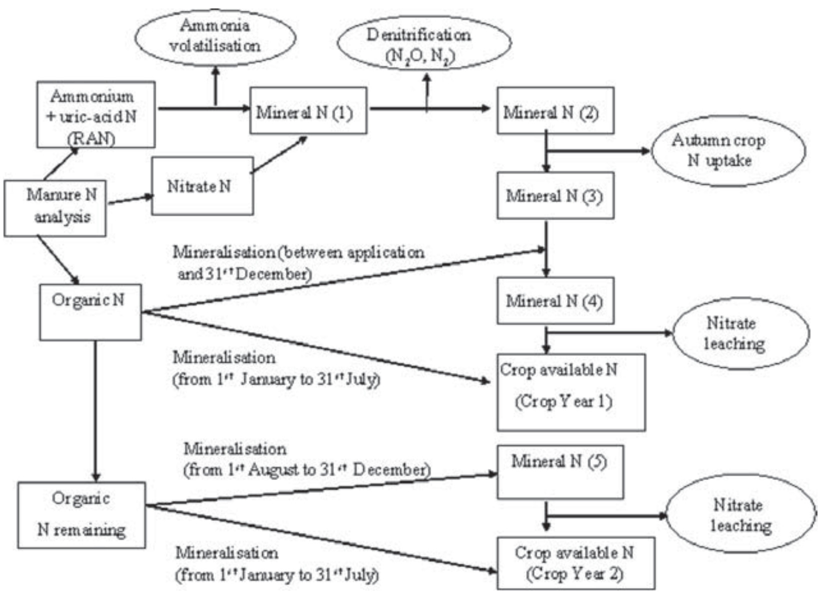
Introduction

MANNER (MANure Nitrogen Evaluation Routine) version 3.0 (Chambers *et al*., 1999) has proved to be a valuable tool enabling farmers and advisors to quantify manure crop available nitrogen (N) supply, and to assess how changing the timing and method of manure application can affect N losses via ammonia volatilisation or nitrate leaching. More than 10,000 copies have been distributed to users following the launch of version 3.0 in 2000. The development of *MANNER v.5 (2008)* involved the incorporation of recent research information where significant advances had been made in our understanding of N transformations and losses following manure application to land.

Model development

Conceptual model. The MANNER conceptual model (Figure 1) was updated to incorporate a new module (covering nitrous oxide and di-nitrogen losses) and to take into account autumn crop N uptake. Important changes were also made to the way that the existing (i.e. ammonia loss, nitrate leaching and organic N mineralisation) and new modules interrelated to better represent N pathways and transformations that occur following manure application to land.

Figure 1. The *MANNER v.5 (2008)* conceptual model



In particular, MANNER v.5 (2008) estimates the quantity of N available in crop year 2 (i.e in the cropping year following the year in which the manure was applied) through the mineralisation of manure organic N.

Manure N analysis. The manure N analysis module was revisited in order to include typical N analysis data for additional manure types (i.e. dirty water, sheep straw-based farmyard manure - FYM, duck FYM, thermally dried sludge, lime stabilised sludge, green compost, food 'wastes', paper crumble) and to accommodate manure nitrate-N (NO_3-N) analysis data, which can be an important for some solid manure types (e.g. 'old' FYM, poultry manure).

Ammonia volatilisation. Recent research information on ammonia emissions following the land spreading of manures was used to develop an enhanced ammonia volatilisation module for *MANNER v.5 (2008)*. MANNER (version 3.0) estimated ammonia losses based on the manure type, dry matter content (of slurries) and the delay between manure application and soil incorporation. In *MANNER v.5 (2008)*, ammonia loss algorithms for the different manure types (which define the maximum potential ammonia loss and the loss rate) were refined based on newly available experimental data. Moreover, the ammonia loss algorithms were modified to account for a number of additional factors i.e. slurry application technique and soil incorporation method, land use, application timing and environmental conditions at the time of spreading (windspeed, rainfall and soil moisture content), which had all been shown in field experiments to influence ammonia emissions (e.g. Smith *et al.*, 2000; Misselbrook *et al*., 2004)

Nitrate leaching. The *MANNER-PSM* nitrate leaching module was enhanced to improve predictions of nitrate leaching losses from sandy soils (where leaching losses largely occur via matrix flow) and to better represent leaching losses from clay soils where water movement to depth (and hence nitrate leaching losses) largely occurs via by-pass (crack) flow. An updated drainage model was developed, which takes into account differences in evapo-transpiration losses between grassland and tillage land. In addition, a nitrification delay was introduced to more realistically estimate when manure ammonium-N was likely to be at risk from loss via nitrate leaching.

Organic N mineralistion. The release of manure organic N (mineralisation) following land application was dealt with very simply in MANNER (version 3.0) by estimating that 10% of the applied organic N in slurries/FYM/spring applied poultry manures and 20% in autumn applied poultry manures was released and utilised by the next crop grown. In *MANNER v.5 (2008)*, a more sophisticated approach was developed to estimate organic N mineralisation based on soil temperature (thermal time), which recognised N mineralisation differences between rapid (i.e. pig slurry and poultry manures) and slow (i.e. FYM and cattle slurry) organic N release manure types.

New modules. A new module was added to *MANNER v.5 (2008)* to estimate N losses via denitrification as nitrous oxide (N_2O) and di-nitrogen (N_2), Thorman *et al*. (2006). Although these losses are generally small in agronomic terms in comparison with ammonia volatilisation and nitrate leaching losses, N_2O is an important greenhouse gas with a global warming potential 310 times greater than CO_2. Also, a module was included to estimate autumn crop N uptake, which can decrease the amount of N at risk from nitrate leaching loss, especially where manure applications are made to grassland or before oilseed rape. Finally, the software was enhanced to estimate the N available to the following crop (i.e. in crop year 2) from the mineralisation of manure organic N.

Model validation

Validation of the individual modules was undertaken wherever suitable independent experimental data were available, to confirm the accuracy of *MANNER v.5 (2008)* predictions and to highlight where any potential inaccuracies or inconsistencies may be present. Validation of the ammonia volatilisation (cattle slurry, pig slurry, FYM and poultry manure) and nitrate leaching (matrix flow and by-pass flow soils) modules demonstrated that *MANNER v.5 (2008)* predictions were in good agreement with field experimental data ($p<0.01$), Figures 2 - 5.

Figure 2. Predicted and measured ammonia emissions from FYM (kg/ha N)

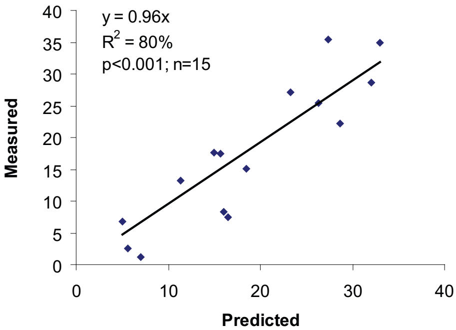


Figure 3. Predicted and measured ammonia emissions from poultry manure (kg/ha N)

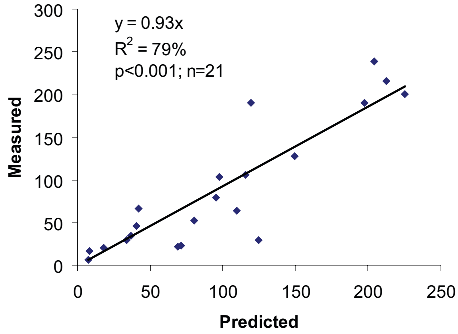


Figure 4. Predicted and measured nitrate leaching losses from free draining (permeable) soils (kg/ha N)

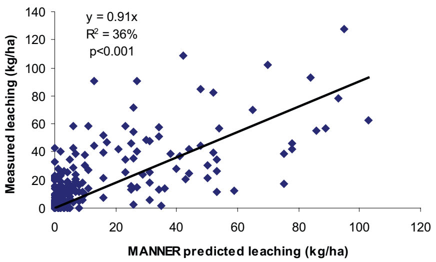
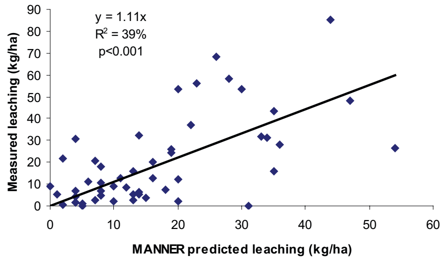


Figure 5. Predicted and measured nitrate leaching losses from drained clay soils (kg/ha N)



Validation of *MANNER v.5 (2008)* crop available N predictions was undertaken by comparing predictions of manure fertiliser N replacement values with >200 field experimental measurements. For cattle, pig and poultry manures there was good agreement ($p<0.001$) between the predicted and measured values. For cattle and pig manures the slope of the regression line was not significantly different from 1.0 ($r^2 = c.50\%$), indicating that *MANNER v.5 (2008)* predictions were quantitative (Figure 6). For poultry manures, *MANNER v.5 (2008)* under-estimated the fertiliser N replacement value by a small amount (*c.*20%), although the amount of variation accounted for was good ($r^2 = 57\%$).

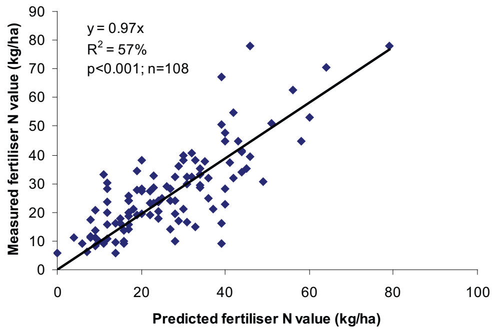
Software

The look and feel of the previous version of MANNER (3.0) was retained, although extensive modifications to the software were made to incorporate the new and enhanced modules and algorithms. Enhanced user graphics were developed and the ActiveX control was modified to enable easy updating and incorporation into other software.

Conclusions

These enhancements to MANNER enable the effects of manure applications on the quantities of N lost by ammonia volatilisation, nitrate leaching and denitrification to be estimated, and to assess the potential for ‘pollution swapping’ to occur based on the latest scientific information.

Figure 6. Predicted and measured fertiliser N replacement values for cattle manures (kg/ha)



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