NUTRIENT MANAGEMENT TOOLS: THE FERTILISER MANUAL AND MANNER-*NPK*

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1 INTRODUCTION

Livestock manures are valuable sources of crop available nutrients (i.e. nitrogen, phosphorus, potassium, magnesium and sulphur) and organic matter, which help to maintain and improve soil fertility physical properties and biological activity. However, livestock manures are also recognised as a major cause of controllable nutrient pollution from farming systems and applications need to be carefully managed to minimise ammonia (NH_3) and nitrous oxide (N_2O) emissions to the atmosphere, and nitrate (NO_3), ammonium (NH_4), phosphorus (P) and microbial pathogen losses to water. Over recent years, research programmes have aimed to improve the knowledge base to support policies to reduce diffuse water and air pollution, and to comply with existing and forthcoming EU Directives and International agreements (e.g. Nitrates Directive, Water Framework Directive, National Emission Ceilings Directive, Kyoto Protocol etc.).

Underpinning the success of policies to reduce diffuse pollution from agricultural systems is the ability of farmers and growers to adopt improved management practices to maximise the utilisation of manure nutrients. It is important that advice on best management practices is easily understood and consistent. Also, advice should be based on robust, scientific evidence, in order to be credible. This is particularly important as significant capital investment is often required on farms to increase manure storage capacity and to purchase improved spreading equipment, as part of the improved management practices necessary to reduce diffuse nutrient pollution.

2 MATERIALS AND METHODS

2.1 The Fertiliser Manual

An organic manures section was first included in the 7th edition of Defra's "Fertiliser Recommendations Booklet (RB 209)", which was published in December 2000 (Anon., 2000). The section provides comprehensive guidance on the utilisation of manure nutrients, including data on typical nutrient contents (total and readily available N, total phosphate, potash, sulphur and magnesium, and dry matter) of a range of livestock manure and biosolids (sewage sludge) products. These values were based on laboratory analysis data compiled over many years; presented according to livestock manure type (e.g. farmyard manure-FYM, poultry manure, slurry etc.) and for slurries are related to dry matter content.

Manure crop N availabilities (i.e. the percentage of total N applied available to the next crop grown) were presented for each manure type in relation to soil type, application timing and for slurries dry matter content. An integrated nutrient management strategy was promoted, in which organic manure nutrients are balanced with manufactured fertiliser applications, in relation to soil analysis and crop requirements.

The revised Organic Manures Section that will be included in the 8th edition of RB 209 ("The Fertiliser Manual") has been enhanced to provide updated guidance on:

- Typical nutrient contents of a wider range of livestock manures, biosolids, composts and organic 'waste' materials (e.g. paper crumble) that are commonly applied to agricultural land.
- Revised nutrient contents of livestock manures and biosolids, and readily available nitrogen contents.
- Nitrogen availabilities to the next crop grown, using the recently revised MANNER-*NPK* software (see below)
- Nutrients produced during the period when livestock are housed.

- The benefits of using bandspreading and shallow injection slurry application methods, in terms of reduced ammonia emissions and odour nuisance, and increased spreading days.
- The interpretation of laboratory analyses and manure sampling guidelines.

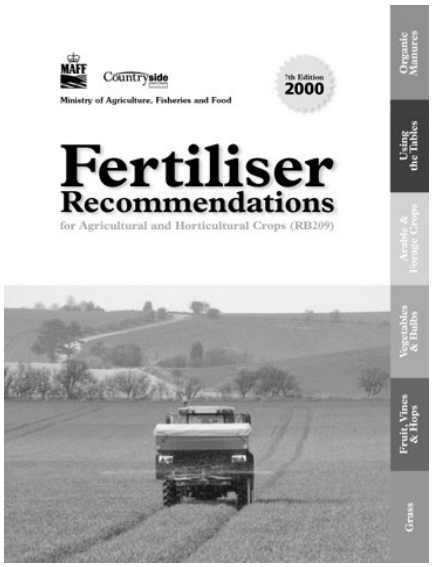

FIGURE 1 **Defra Fertiliser Recommendations booklet (RB209)**

2.2 MANNER-*NPK*

MANNER (MANure Nitrogen Evaluation Routine) version 3.0 has proved to be a valuable decision support tool for quantifying manure crop available N supply and assessing how changing the timing and method of manure application can affect N losses e.g. via ammonia volatilisation or nitrate leaching (Chambers *et al.,* 1999). More than 10,000 copies have been distributed to users following the launch of version 3.0 in 2000. The updated version of MANNER (MANNER-*NPK*) retains the user-friendly characteristics of the earlier version, but includes an increased number of inputs to drive new and revised N loss/transformation modules.

MANNER-*NPK* enables the effects of manure application technique and timing on N losses by ammonia volatilisation, nitrate leaching, nitrous oxide emission and denitrification to be estimated based on the latest UK scientific information. To update and strengthen the MANNER-*NPK* N loss and crop available N supply predictions, updated information on N transformations and losses following manure application to land was incorporated into the software. A new module was added to estimate N losses via denitrification, as nitrous oxide (N_2O-N) and di-nitrogen (N_2). Although these losses are generally small in agronomic terms compared with ammonia volatilisation and nitrate leaching, N_2O is a powerful greenhouse gas with a global warming potential around 300-fold greater than carbon dioxide. Additionally, a module was included to accommodate autumn crop N uptake, which decreases the amount of N at risk from over-winter nitrate leaching, especially when manure applications are made to grassland or before oilseed rape. Important changes were also made to the way that the existing (i.e. ammonia loss, nitrate leaching and organic N mineralisation) algorithms and new modules interrelated, to better represent N loss pathways and transformations that occur following manure application to land. A nitrification delay was included to better represent when manure ammonium-N (following nitrification to nitrate-N) was likely to be at risk from loss via nitrate leaching. Also, a more sophisticated approach to estimating organic N mineralisation was developed based on soil temperature, which recognised N mineralisation differences between rapid (e.g. pig slurry and poultry manure) and slow (e.g. straw-based FYM and cattle slurry) organic N release manure types. Additionally, MANNER-*NPK* estimates the quantity of N available to the *following* crop through the mineralisation of manure organic N.

MANNER-*NPK* provides an estimate of manure phosphate (as P_2O_5), potash (as K_2O), sulphur (as SO_3) and magnesium (as MgO) supply, together with a facility for estimating the nutrient supply from more than one manure application in a cropping year and a laboratory analysis convertor tool. Although there have been considerable modifications and improvements, MANNER-*NPK* retains the user-friendly characteristics of the earlier version, whilst providing users with enhanced functionality. The requirements for extra data inputs, beyond those

which were needed to run MANNER (version 3.0), are relatively small and restricted to information that can be readily provided (e.g. crop type, wind speed and soil moisture content).

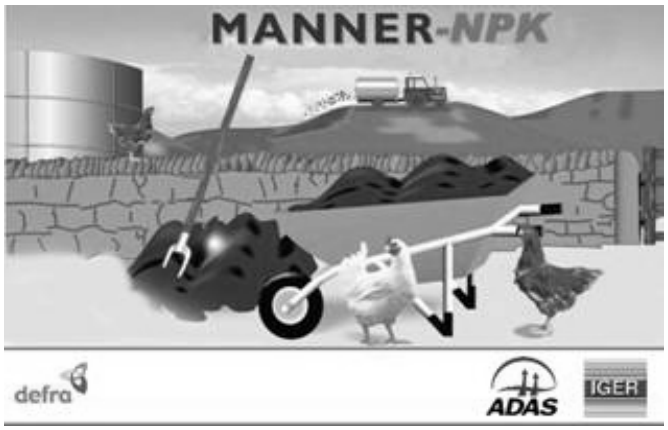

FIGURE 2 **MANNER-*NPK* 'splash' screen**

The MANNER-*NPK* ammonia module was validated using data from >140 measurements undertaken between 1994 and 2001, where ammonia emissions were measured using the micro-meteorological mass balance technique (Misselbrook *et al.*, 2005). For cattle slurry, pig slurry, FYM and poultry manure the slope of the relationship was not significantly (P>0.05) different from 1.0, indicating good quantitative agreement between predicted and measured ammonia emissions (P<0.01; R^2 =17-80%). Validation of the nitrate leaching module showed that for both permeable soils (where matrix leaching is the predominant nitrate loss pathway) and for drained clay soils (where by-pass flow is the major pathway) the slope of the relationship was not significantly different from 1.0, indicating quantitative agreement between predicted and measured nitrate leaching losses. Furthermore, the relationship between the predicted and measured values was highly significant (P<0.001, R^2=36% for free draining soils and R^2=39% for clay soils).

Validation of MANNER-*NPK* crop available N supply predictions was undertaken using data from more than 200 field experimental studies where manure fertiliser N replacement values had been measured. The measurements covered a range of different manure types, application and soil incorporation methods/timings, as well as different soil textures, crops (grass and arable) and environmental conditions. The relationships between the predicted and measured fertiliser N replacement values were highly significant (P<0.001). For cattle (Figure 1) and pig (Figure 2) manures, the slope of the line was not significantly different from 1.0, indicating that MANNER-*NPK* predictions were quantitative (R^2= 57% and 44%, respectively). Similarly, for poultry manures (i.e. broiler/turkey litter and layer manure) MANNER-*NPK* predictions (slope of line not significantly different from 1; R^2 = 47%) were in good agreement (P<0.01) with independently measured experimental values.

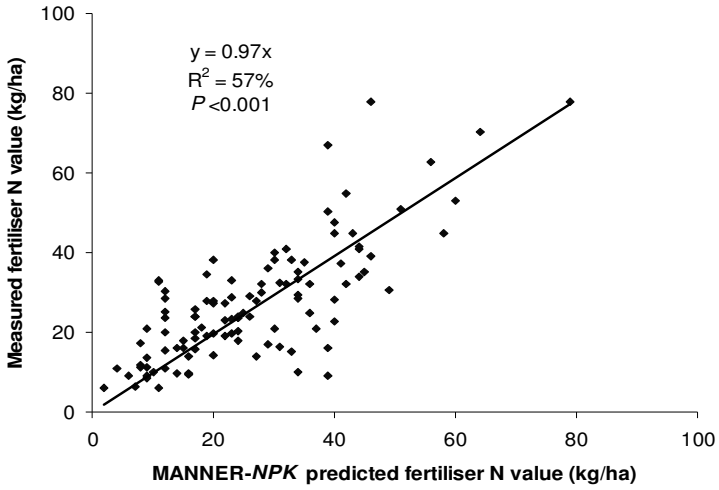

FIGURE 1 **Comparison of measured and MANNER-*NPK* predicted cattle manure fertiliser N replacement values**

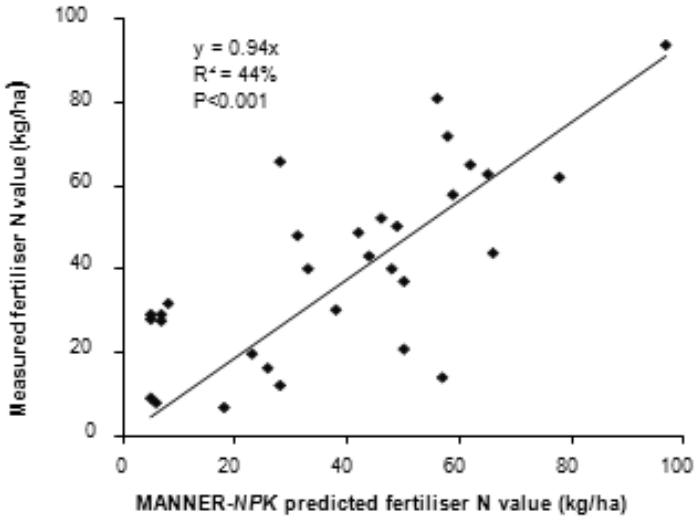

FIGURE 2 **Comparison of measured and MANNER-*NPK* predicted pig manure fertiliser N replacement values**

CONCLUSIONS

Many farmers still do not make adequate allowance for the contribution of organic manures to crop nutrient requirements which leads to nutrient overuse and pollution of the water and air environments. Tools such as the "Fertiliser Manual" and MANNER-*NPK* provide valuable support to farmers enabling them to assess the nutrient value of their manures, which is a "win-win" outcome for the economic performance of their businesses and the wider environment.

ACKNOWLEDGEMENTS

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REFERENCES

Anon 2000. Fertiliser Recommendations for Agricultural and Horticultural Crops. Defra Reference Book 209 (Seventh Edition). The Stationery Office, Norwich.

Chambers BJ, Lord EI, Nicholson FA, Smith KA 1999. Predicting Nitrogen Availability and Losses Following Land Applications of Manures: MANNER. Soil Use & Management 15, 137-143.

Misselbrook TH, Nicholson FA, Chambers BJ, Johnson RA 2005. Measuring ammonia emissions from land applied manure: an intercomparison of commonly used samplers and techniques. Environmental Pollution 135, 389-397.