Manure management: research knowledge into best practice

K.A. Smith[1], P.M.R. Dampney[2], J.R. Williams[2] and B.J.Chambers[3]
[1] ADAS Wolverhampton, Wergs Road, Woodthorne, Wolverhampton WV6 8TQ
[2] ADAS Boxworth, Battlegate Road, Boxworth, Cambridge CB23 4NN, UK
[3] ADAS Gleadthorpe, Meden Vale, Mansfield, Notts., NG20 9PF, UK.
e-mail: ken.smith@adas.co.uk

Introduction

Farm manures are valuable sources of major crop available nutrients (i.e. nitrogen, phosphorus, potassium, magnesium and sulphur). They also supply organic matter which helps to maintain and improve soil physical properties, and biological activity. However, farm manures are also recognised as a major cause of controllable nutrient pollution in 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 many 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 Emissions Ceilings Directive, Kyoto Protocol etc.). Underpinning the success of these 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 (Chambers *et al.,* 2006).

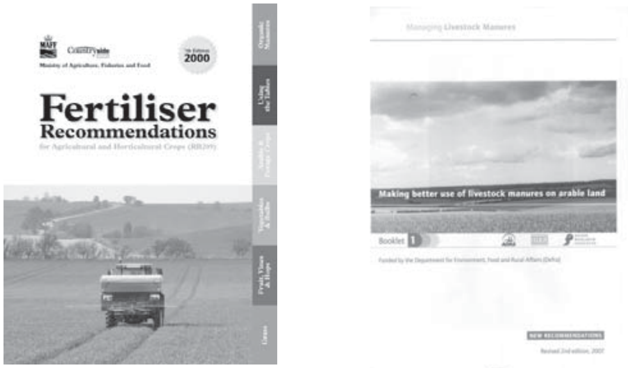
This paper outlines approaches used to present research knowledge to farmers and growers in the UK, in order to promote best management practices for the benefit of environmental protection and profitable farming.

Methods for Knowledge Transfer

(i) Written publications
Reference Book 209 – "Fertiliser Recommendations for Agricultural and Horticultural Crops" 'RB209' (Anon., 2000) (Figure 1) provides information on the nutrient value of farm (and other organic) manures and is recognised as the industry standard for nutrient management advice in England, Wales and Northern Ireland. Over 12,500 copies of the latest (7th) edition of RB209 have been distributed to farmers and growers. The organic manures chapter provides comprehensive guidance on the utilisation of manure nutrients, including data on the typical nutrient content (total and readily available N, total P, K, S, Mg and dry matter) of a range of farm manures and biosolids products. The latter are based on laboratory analysis data compiled over many years and are presented according to manure type (e.g. farmyard manure, poultry manure, slurry etc.) and for slurries, typical nutrient contents are related to dry matter content. Manure N use availabilities (i.e. the percentage of total N applied available to the next crop grown) are presented for each manure type in relation to application timing and soil type. An integrated nutrient management strategy is emphasised, in which organic manure nutrients are balanced with inorganic fertiliser applications according to soil analysis and crop requirements. Soil analysis is used to identify fields that are low in P and K and, potentially, most suitable for manure applications; and conversely, those high in P and K, where manure applications

would be less beneficial. Worked examples, calculating the nutrients supplied from typical manure applications, are used to demonstrate the value of organic manure applications in reducing the need for inorganic fertilisers. Indeed, given recent fertiliser price rises there has never been a stronger economic driver to utilise manure nutrients effectively.

Figure 1. Defra Reference Book 209 and Managing Livestock Manure booklets (number 1)



In addition to RB209, a series of four "Managing Livestock Manures" booklets (Chambers *et al.,*2001a; b; c; Shepherd *et al.,*2002) provide more detailed information on manure management and efficient nutrient utilisation. Three of the booklets (1, 2 and 4) promote better use of manures on arable, grassland and organic farms; booklet 3, on manure spreading systems, provides guidance on calibration and operation of spreaders and how to take representative samples of solid manures and slurries for analysis. The booklets have proved universally popular with farmers, consultants and agricultural colleges, with over 25,000 copies distributed.

(ii) Computer based decision support systems
Decision support systems (DSSs) have an important role to play in improving manure nutrient use efficiency on farms. Among two of the most widely used nutrient management DSSs in the UK are MANNER (MANure Nitrogen Evaluation Routine) and PLANET (Planning Land Applications of Nutrients for Efficiency and the environmenT). Indeed, MANNER was used to generate the manure N availability 'look-up' tables in RB 209 and the Managing Livestock Manures booklets and is embedded in the PLANET DSS.

MANNER version 3.0 (Chambers *et al.,*1999) (Figure 2) predicts the fate of N following organic manure applications to land and was launched in August 2000. MANNER takes into account the following factors in predicting crop available manure N supply: manure analysis (dry matter, total and readily available N), application rate, NH_3 volatilisation and NO_3 leaching losses and the mineralisation of manure organic N. MANNER provides a simple, quick and accurate estimate of crop available N from different manure types spread under a range of circumstances. It also allows farmers to assess how the timing and method of manure application can affect N losses via NH_3 volatilisation or NO_3 leaching, and to highlight ways in which these losses can be reduced. MANNER predictions of the fertiliser N replacement value of manure applications have been shown to closely relate with independently collected experimental data. By March 2008, over 10,000 copies of MANNER had been distributed to users. An updated version, MANNER v.5 (2008), will shortly be available and will include improved algorithms for the prediction of NH_3 volatilisation, NO_3 leaching losses and organic N mineralisation; and new modules for predicting N_2O and di-nitrogen (N_2) losses following land spreading (Nicholson *et al.,* 2008).

Figure 2. MANNER welcome splash screen

PLANET (Dampney and Sagoo, 2008) was first released in January 2005, and the current version (1.3), in May 2006. An updated version is due for release in 2008 and will contain modules that will help farmers comply with the revised Nitrate Vulnerable Zone Action Programme rules in England, including modules to calculate livestock manure farm N loadings, organic manure storage requirements and crop N requirements. The nutrient recommendations in PLANET take account of previous cropping, soil type and analysis, overwinter rainfall and organic manure use. Field P and K balances for each harvest year are calculated based on inputs in manures and fertilisers and offtakes in harvested crops so that surpluses or deficits can be identified. The development of PLANET has been funded by government and the CD is available, free of charge, to farmers and consultants; over 7,500 copies had been distributed to users, at the end of March 2008. In addition, 4 companies have integrated PLANET into their commercial agronomy software. Many farmers and advisers have been briefed and/or trained in the use of PLANET in dedicated, full- or half-day workshops and training courses.

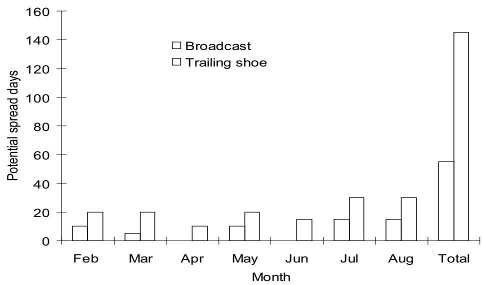
The SPREADS (**SPR**eader **E**conomic **A**ssessment and **D**ecision **S**upport) DSS has been developed to provide farmers with a tool for assessing the costs and associated performance characteristics of a range of solid manure and slurry spreading techniques (Gibbons *et al.,* 2007). SPREADS makes use of published information on machine performance and costs, supplemented by expert knowledge and field performance data. A database contains information on a wide range of application systems, including slurry bandspreading and shallow injection techniques. Also, umbilical supply systems are included and there are options to cover contractor spreading operations and equipment hire options. The DSS calculates work rates and the cost of manure application, with the outputs displayed in both graphical and tabular formats. Validation of SPREADS has been undertaken by comparison of costings with specific examples on commercial farms and with the outputs of a simulation model developed in the Netherlands, CAESAR (**C**omputer simulation of the **A**mmonia **E**mission of **S**lurry application and incorporation on **AR**able land; Huijsmans & de Mol, 1999). The latter model has been successfully used to evaluate the costs of slurry application and, taking scenarios outlined by Huijsmans & de Mol (1999), the two models gave similar estimates of costs, where the baseline information and assumptions were the same.

(iii) Farm demonstrations
On-farm demonstrations are an important part of putting theory into practice i.e. “seeing is believing”. Also, such demonstration studies provide researchers and policy makers with the opportunity to understand some of the practical constraints that influence manure management on the ground. Improved nutrient management was the focus of a recent Demonstration Farms project on four commercial farms covering a range of livestock and cropping enterprises (Williams *et al.,* 2001). The project involved the adoption of improved

manure management practices, including the use of bandspreaders (trailing hose and trailing shoe) for slurry spreading on arable or grassland.

The savings in fertiliser N use as a result of the improved utilisation of slurry N, as a result of reduced NO_3 leaching (moving applications from autumn/winter to spring/summer) and reduced NH_3 volatilisation (from using bandspreaders compared with surface applications) were up to 5,000 euros/year (based on a cost of 75 eurocents/kg fertiliser N). In addition, there were other less tangible, though important, practical benefits arising from the use of slurry bandspreading. On one farm, trailing shoe slurry application increased the number of available slurry spreading days, on grassland, from an estimated 55 days/year for surface broadcasting, to 145 days/year (Figure 3). This increase was a consequence of reduced sward contamination, allowing grazing to occur within a few days of application, rather than the normal 3-4 week grazing exclusion following surface spreading and a greater "spreading window" before silage cutting (rather than the 6-8 weeks closure before cutting with surface broadcasting). A further benefit associated with the trailing shoe technique was reduced odour nuisance. Overall, the farmer considered these benefits well worth the increased investment in the trailing shoe equipment.

Figure 3. Number of days slurry could be spread on grassland using bandspread (trailing shoe) and surface broadcast techniques (all spring and summer applied).



Impact of knowledge transfer

A survey of existing users of RB209, MANNER and the "Managing Livestock Manures" booklets was undertaken in 2004 (Chambers, 2004). One thousand farmers and 500 consultants were sent a questionnaire asking for detailed information on their level of use of the advice tools and their impact on decisions made on fertiliser and organic manure use. Questions sought feedback on the helpfulness of RB209 and MANNER, and their perceived effect on farm gross margins. Also, feedback was obtained on the sources of technical information and advice used by farmers and consultants, along with opinions on the effectiveness of communication methods, ranging from one-to-one advice to information technology (IT) systems. A total of 524 usable responses were received (35% overall response rate), with a 37% return from farmers and 30% from consultants.

The survey showed that 95% of consultants who responded had a copy of RB209 and *c*.50% of farmers. Interestingly, 78% of arable farmers had a copy of RB209, but only 27% of grassland farmers. RB209 was widely used by consultants (95%), with around 20% indicating that it had a major influence on changes they had made to N and other major nutrient use in the last ten years. Also, around 20% of consultants considered that RB209 had a major influence on changes they had made in manure, crop available N allowances, and around one in eight for other nutrients supplied from organic manures in the last 10 years. Approximately half of the respondents had copies of the manure booklets. Over 95% of consultants and farmers, who had copies, regarded the booklets as useful sources of information and advice.

RB209, MANNER and farmer meetings/conferences were the most commonly used sources of information and advice. Also, farmer workshops and on-farm demonstrations were widely used. Arable farmers (76%) made far more use of RB209 than grassland farmers (24%). Farmers (46%) and, in particular, arable farmers (56%) made frequent use of independent consultants, with consultants using a wide range of information sources, including trade representatives. The farming press, although frequently used, was not well regarded as a source of credible technical information by either farmers or consultants. Farmers and consultants rated one-to-one advice as the most effective means of communicating manure nutrient management information. Around 80% of arable farmers and 70% of grassland farmers had made use of IT systems - although the survey database was skewed towards software users (i.e. they had all been supplied with a copy of MANNER). IT systems were highly regarded, with *c*.80% of arable farmers and consultants, and *c*.75% of grassland farmers regarding them as either effective or very effective.

The annual Farm Practices Survey (FPS) in England, which is sent to a representative sample of farms, covers a wide variety of agri-environmental topics which can be used to evaluate the impact of agriculture on the environment and, over time, can also provide information on change. The 2006 survey covered many livestock and manure management issues, including approaches to nutrient management (Anon, 2006). Across the 8 farming types in the survey, 26% of farms were found to use RB209 as a tool to calculate fertiliser requirements, 7% MANNER, and 10%, PLANET (some farms used more than one method). However, with 60% indicating they used no specific tool to assist decisions on fertiliser use, there is clearly a need for more work. Conclusions of the recent Environment Sensitive Farming initiative to promote improved farming practices, indicate a progressive reduction in concern amongst farmers about barriers to change, from 2005 to project close, in 2008 (MacLeod, 2008).

Conclusions

Making correct decisions on the management and efficient utilisation of nutrients contained in organic manures is important both for the profitability of farm businesses, and to minimise the risks of environmental pollution. It is important to provide **clear and consistent** advice to help farmers and their advisers apply best management practices in the use of organic manures. An *integrated approach*, using a range of technical information, from 'hard-copy' reference books and leaflets, through to computer-based decision support systems supplemented with on-farm demonstrations, farmer and consultant meetings/workshops and one-to-one advice is required to provide the necessary support for farmers. Support of this type is increasingly important as farmers face, not only increasing economic pressures, but also the challenge of complying with legally enforceable and increasingly complex rules to minimise diffuse pollution. In most cases, these rules will require significant financial investment to implement the necessary changes in practice.

Acknowledgements

Funding of this work by the Department for Environment Food and Rural Affairs (Defra) is gratefully acknowledged. The PLANET software was funded by Defra, Environment Agency (EA) and Department for Agriculture and Rural Development in Northern Ireland (DARDNI).

References

Anon. (2000). Fertiliser Recommendations for Agricultural and Horticultural Crops. MAFF Reference Book RB209, seventh edition. The Stationery Office, Norwich (ISBN 0-11-243058-9).

Anon. (2006). Farm Practices Survey 2006 – England. Stats 20/06. Defra Farming Statistics.Report available via the link: http://statistics.defra.gov.uk/esg/publications/fps/FPS2006.pdf

Chambers B.J. (2004). Nutrient management decision support systems: process improvement. Defra contract KT0118. Report available via website: http://www.defra.gov.uk/

Chambers B.J., Lord, E.I., Nicholson, F.A., Smith, K.A. (1999) Predicting Nitrogen Availability and Losses Following Land Applications of Manures: MANNER. Soil Use & Management ***15,*** *137-143.*

Chambers, B.J., Nicholson, N., Smith, K., Pain, B., Cumby, T. and Scotford, I. (2001a, b and c). Managing Livestock Manures: (2001a) Booklet 1 - Making better use of livestock manures on arable land (Revised 2nd edition). Published by ADAS, IGER and Silsoe Research Institute. Available from ADAS Gleadthorpe, Meden Vale, Mansfield, Notts., NG20 9PF UK; (2001b) Booklet 2 - Making better use of livestock manures on grassland; (2001 c) Booklet 3 – Spreading systems for slurries and solid manures.

Chambers B.J., Williams, J.R., Sagoo, E., Smith, K.A. and Chadwick D.R. (2006) Economic implications of minimising diffuse nitrogen pollution from livestock manures. In: Agriculture and Environment VI - Managing Rural Diffuse Pollution (Eds. L. Gairns, K. Crighton and B. Jeffrey). Proceedings of the SEPA/SAC Biennial Conference. pp 84-92.

Huijsmans, J.F.M. & De Mol, R.M., 1999. A model for ammonia volatilization after surface application and subsequent incorporation of manure on arable land. Journal of Agricultural Engineering Research, 74, pp. 73-82.

MacLeod, J. (2008) Environment Sensitive Farming. Post event survey report, March 2008. Natural England. Contract RMP2140.

Nicholson, F.A., Gibbons, M., Bhogal, A., Lord, E., Thorman, R.E., Williams, J.R. Smith, K.A. Misselbrook, T.H., Chadwick, D.R. and Chambers, B.J. (2008). A simple tool to assist in making better use of manure nitrogen: MANNER v.5 (2008). This volume.

Gibbons, M.M., Smith, K.A. and Anthony, S.G. (2007). SPREADS – A system for controlling the costs and efficiency of manure and slurry spreading on farms. Proc. 5th Annual Conference of the European Federation of IT in Agriculture, "Environment and Rural Sustainability through ICT". EFITA/WCCA 2007. Glasgow Caledonian University, July 2007. http://www.efitaglasgow.org)

Dampney, P.M.R. and Sagoo, E. (2008). PLANET – The national standard decision support and record keeping system for nutrient management on farms in England. In: Agriculture and Environment VII - Land Management in a Changing Environment (Eds. K. Crighton and R. Audsley) Proceedings of the SAC and SEPA Biennial Conference. pp 239-245.

Shepherd, M.A, Gibbs P. and Philipps, L. (2002) Managing manures on organic farms. Booklet 4. Published by ADAS and Elm Farm Research Centre. Available from ADAS Gleadthorpe, Meden Vale, Mansfield, Notts., NG20 9PF UK.

Williams, J.R., Chambers, B.J., Ellis S., Misselbrook T.H. and D.R. Chadwick (2001). Integration of farm manure nitrogen supply within commercial farming systems In: Proceedings of the 9th International Conference of the FAO Escorena Network on Recycling of Agricultural, Municipal and Industrial Residues in Agriculture (Ed F. Sangiori). Food and Agricultural Organisation of the United Nations, Rome and University of Milan, Italy, pp 263-268.