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REFEREED ARTICLE

SOIL MANAGEMENT AND THE SINGLE PAYMENT SCHEME: AN ASSESSMENT OF KNOWLEDGE PRIORITIES WITH IMPLICATIONS FOR KNOWLEDGE TRANSFER ACTIVITY.

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The availability of soil management advice to UK farmers was evaluated in the context of the Single Payment Scheme through expert consultation supported by a questionnaire survey. Feedback from service providers indicated that the highest current priority was provision of advice to meet cross compliance obligations. Gaps were identified in the information available to guide management of soil organic matter, structural and biological quality. More support is needed to allow farmers to make optimum use of the scheme to improve soil management without adverse impact on yield or product quality.

Keywords Soil management, Single Payment Scheme, Cross Compliance, knowledge transfer.

Introduction

Farmers have long recognised the importance of good soil management to optimise crop establishment, growth and yield. With soils used for agriculture, horticulture or commercial forestry it is easy to appreciate that they have a utilitarian value – if the soil becomes damaged and this has an impact on plant yield or quality, income will be lost (i.e., its quality for production functions declines). Some soil management practices that seem appropriate may nonetheless have adverse off-site impacts that impose a monetary cost on others, despite negligible impact on the land manager. An example is low level or occasional soil erosion which may have little effect on crop yields or a farmer's income for many years, but the cost of clean up to neighbouring households, local authorities or water companies is often considerable. The cost to water companies and their customers of removing nitrate, phosphate or pesticides is another example of how the choice of soil management practice by a land manager can cause a financial cost to others (Pretty 2003). Over recent decades the wider range of environmental services provided by soils have been valued (Environment Agency, 2004); for example Defra's Soil Action Plan for England (2004) explicitly recognises the need to protect a range of soil functions where the production of food and fibre is only one of six. Within more general concerns linked to sustainable development the finite nature of soil resources has been recognised and the need for explicit soil protection legislation has moved up the agenda (European Commission, 2002).

As a result of the Common Agricultural Policy Reform agreement (Regulation 1782/2003) all subsidy payments to farmers will be linked to compliance with a range of EU standards covering the environment, public, plant and animal health and animal welfare objectives. This formalises the requirement for soil to be maintained in good condition by those in receipt of public funds. The introduction of the Single Payment Scheme for agriculture from 1st January 2005 means that for the first time CAP subsidies are linked to

good practice and not to production levels. Cross compliance (1782/2003) requires the maintenance of agricultural land in Good Agricultural and Environmental Condition (GAEC) which specifically addresses standards linked to soil erosion, soil structure and soil organic matter (Table 1). Farmers are required to take action against soil management practices which lead to

Table 1. Definition of Good Agricultural and Environmental Condition (defined in Annex IV of Regulation 1782/2003 and referred to in Article 5) as will be required within the EU from 1 January 2005 of farmers receiving subsidy payments.

Issue	Standards
Soil erosion:	
• Protect soil through appropriate measures	• Minimum soil cover • Minimum land management reflecting site specific conditions • Retain terraces
Soil organic matter:	
• Maintain soil organic matter levels through appropriate practices	• Standards for crop rotations where applicable • Arable stubble management
Soil structure:	
• Maintain soil structure through appropriate measures	• Appropriate machinery use
• **Minimum level of maintenance:**	
• Ensure a minimum level of maintenance and avoid the deterioration of habitats	• Minimum livestock stocking rates or/and appropriate regimes • Protection of permanent pasture • Retention of landscape features • Avoiding the encroachment of unwanted vegetation on agricultural land

loss of soil productivity and on or off site environmental degradation. The link between cross compliance payments and soil management means that aside from direct productivity gains available to farmers through better soil management, maintenance or increase of income through subsidies could be directly affected by their awareness of soil management issues.

With the greater emphasis now placed on soil management as part of the

Single Payment Scheme, there is a need to evaluate the information and training available to farmers to enable them to meet their obligations and manage their soil resources effectively The main focus of this evaluation was to identify gaps in the provision of subject specific information on soil management.

Implications of regional differences in legislative requirements

The European Council has provided a framework within which Good Environmental and Agricultural Condition should be considered (Table 1). The definition of GAEC however, is the responsibility of the member states of the EU and may differ, reflecting national or regional differences in soil, climate, land use, farming practices and existing farming systems. Because agriculture is a regionally devolved policy area in the UK, England, Scotland, Wales and Northern Ireland have independently developed their definitions of GAEC and have different requirements to meet cross compliance, partly reflecting regional differences in farming practices.

Despite differences in approach to cross compliance, the actual requirements of farmers in the UK regions appear relatively similar. However there are some notable differences which may have implications for information needs. The GAEC system for Scotland differs from the other 3 regional schemes having compulsory requirements for organic matter management (through crop rotation and arable residue retention; Scottish Government, 2005). The requirement to take actions to increase organic matter levels is *only* explicit in the English and Welsh schemes when there are visible signs of organic matter depletion. In the English scheme action is required where soil capping or slumping are visible, which will not be problematic on all soils, while the Welsh system makes no mention of what the 'visible indicators' of organic matter depletion are (Welsh Assembly, 2007). The scheme in Northern Ireland notably has no explicit requirements regarding soil organic matter management (DARDNI, 2006). This relates to a regional emphasis in the scheme on management within grassland based systems, which predominate in Northern Ireland, and where risks of organic matter depletion are relatively low (European Commission, 2002).

The English scheme requires a soil management plan for the farm. In contrast, the Scottish and Northern Irish schemes do not require the completion of an official record of soil management, although in the Northern Irish scheme there is emphasis on farmer identification of visible soil management issues as in the Welsh and English schemes. The Scottish GAEC code does not offer guidance relating to the identification of soil problems. The Welsh scheme is similar to the English in this respect, although farmers are required to take consideration of soil management issues on a *field by field* basis rather than taking a generalised view of the whole farm, possibly meaning more rigour is required in assessments and actions taken against management issues for cross compliance. In general it appears the Scottish and Northern Irish schemes make fewer demands on farmers to identify problems and than the Welsh and English.

A key implication of regional differences in approaches to GAEC/cross

compliance for knowledge transfer (KT) is the major disparity in the accompanying government advice. The information provided to farmers through official publications is much less detailed in all the devolved regions than the cross compliance soil guidance document provided by Defra (2006), which is required reading for farmers in England as part of cross compliance. Although this is unlikely to affect farmer achievement of cross compliance (as the level of advice will probably be considered in inspections) it may have some effect on demand for further information by farmers in some regions, in particular the lack of practical advice in the identification of soil management problems outside England. This should, however, be set alongside the fact that the provision of farm level advice receives different levels of support in UK regions. Farm advice in England and Wales is less government driven/funded than elsewhere. Farm advice in NI remains free and in Scotland, SAC receives a substantial part of its budget as support for its advisory role.

Environmental stewardship schemes differ much more widely between the regions. Entry Level Schemes include a variety of soil management options. Nutrient budgeting is compulsory in the Welsh system, whereas there are no explicit soil management requirements in the Northern Irish system. Generally the technical requirements of nutrient budgeting approaches included in the schemes are low, and are unlikely to require specialist soils advice. Only the English system includes an option of a Soil Management Plan which requires explicit and field by field management of erosion risks, although this is only one option from those available to farmers to meet the Entry Level Stewardship requirements. Higher Level Schemes seek to include more complex environmental management where land managers need advice and support and consequently include a very wide range of management options which are targeted to support key local landscape characteristics, one consideration of which will be soil characteristics. Soil management information required for Higher Level Schemes is likely to be detailed and site specific and as such appears best sought from local specialists. Regional differences are unlikely to have implications for soil management information demand from HLS schemes.

While the implications of the Single Farm Payment Scheme are likely to be a major driver of soil management KT requirements for the foreseeable future, merely meeting the standards required for cross compliance is unlikely to result in the maximum productivity benefits that improved soil management has the potential to deliver. Conversely there may be indirect productivity implications in meeting these requirements, such as the necessity to make more efficient use of fertilisers through limitations to use, or increased land management costs associated with limiting erosion and runoff. Farmers must also, wherever possible, take advantage of entry and higher level schemes to improve soil condition (through less intensive cultivation or set aside for example) offsetting short term losses in productivity with subsidy payments. The ability of farmers to consider soil management as part of a whole farm system while maximising their income from the Single Payment Scheme will be an important factor in maintaining and increasing productivity in all sectors.

Methods

The aim of the study was to identify i) what the current priorities for KT were and ii) how well these priorities were currently being met. These issues were explored separately both with non-government funders of KT provision, specifically agricultural and horticultural levy bodies, and service providers and potential service providers across the UK. Communication was largely facilitated by Email to allow optimum coverage in the three month survey period, May-July 2006. Given the short timescale this study did not attempt to assess farmers' perceptions directly.

An Email with an attached short survey form was sent to the KT managers (or equivalent) at each of the agricultural and horticultural levy bodies across the UK; these individuals co-ordinate sector specific (dairy, pigs, beef and sheep, combinable crops, horticulture etc) KT in response to the perceived needs of their levy paying members. These were asked to identify and prioritise (1-5 ranking) the current relative need for information provision on soil management to farmers, to describe any provision of information of which they were aware and to comment on any key gaps.

150 Emails were sent out directly by the project team to named contacts at all key organisations involved in research and information provision as well as other key organisations, private companies and individuals identified from professional registers and marketing information, with coverage across all UK regions. A snowball approach was taken to distribution of the Email, with attached survey form, to service providers; respondents recommended new respondents until no new targets were identified. In addition some recipients forwarded the message; as 3 replies were received from individuals not contacted directly by the project team. Service providers were asked to identify and prioritise (1-5 ranking) the current relative need for information provision on soil management to farmers, by sector if applicable, to describe any information provision in which they were engaged and to identify any areas in which they would be able to provide information/training if needed/ funded. In total 44 survey responses were received from organisations and independent consultants. This is a satisfactory response rate and provided a snapshot of the views of all the key organisations plus other interested parties. It was not possible to carry out a regional analysis of the responses due to a low response rate from Scotland and Northern Ireland coupled with the fact that a large proportion of the respondents (mainly private individuals and companies) reported a UK-wide coverage for all their activity.

The survey responses received on KT priorities and current service provision were grouped into the following categories for analysis: meeting cross compliance; organic matter; structure; water erosion/runoff; wind erosion; soil fertility; soil biology and other. The choice of categories was based partially on those highlighted by GAEC (Table 1) with additional categories identified where topics identified did not fit within this framework. Given the knowledge priorities identified in the surveys, we carried out a brief review of the scientific literature to determine whether any of the KT gaps identified were matched by a lack of published research. We also assessed both current KT activities by levy bodies and the scope of provision/capacity

by other organisations and individuals, using the information provided in the surveys and a wider search, to carry out a simple analysis of the gaps in current service provision. A wider review of agricultural KT activities was also conducted to evaluate the appropriateness and likely success of different forms of KT.

Perceived priority areas and current provision of soil management advice

There was a general consensus between the current priorities identified by levy boards and the providers of KT services for soil management (KT providers; Table 2). Over 85% of the service providers responding to the survey were not providing services via the levy bodies. In some cases levy body priorities may directly guide the priorities of providers, a case of consultants doing "what we can get money for". However, it is not surprising that both groups are also being separately but strongly influenced by the policy agenda driven by changes in EU support to farmers. Meeting cross compliance and controlling water erosion and runoff were regarded as the highest priorities, with soil fertility, biology and poaching being seen as of significantly lower priority. Much of the impetus for KT is being driven by a number of current policy pressures, which take effect at landscape scale (e.g. expansion of Nitrate Vulnerable Zones, implementation of the Water Framework Directive) giving priority to the management of water erosion and runoff issues on farm, as well as the requirements of cross compliance, which

Table 2: Median scores (1 most important to 5 least important) of the priority assigned to areas of knowledge transfer for soil management and statistical differences

Order of priority			Significance of difference in individual responses (Mann-Whitney test *P<0.05, **P<0.01)						
Levy body	Service providers	Soil related topic	Organic matter	Structure	Water erosion/ runoff	Fertility	Biology	Poaching	% KT providers
1	2	Cross compliance	ns	Ns	ns	*	*	*	-
4	4	Organic matter		Ns	ns	ns	ns	ns	30
3	3	Structure			ns	ns	ns	*	50
2	1	Water erosion/ runoff				*	*	**	82
3	4	Fertility					ns	ns	34
5	5	Biology						ns	7
6	6	Poaching							7

also specifically deal with issues such as soil compaction and organic matter management at a field scale.

Cross compliance

The introduction of GAEC requirements have been accompanied by a drive by to provide training for farmers in meeting cross compliance requirements. Training activity funded by government and other organisations (e.g. farming unions) been intense during late 2005-spring 2006 in all regions of the UK. Evaluation of the success of this training has not been reported. While further KT is not considered to be necessary to enable producers to *meet* the requirements of cross compliance, it is unlikely that state provision of services will provide farmers with sufficient information on the options available for management, and in particular the tools needed to assess implications for sector productivity.

Erosion and runoff

Knowledge transfer information for the control of water erosion and runoff was seen as the highest priority area; the drivers being GAEC and the expected impact of the Water Framework Directive. How to identify and mitigate risks on-farm stand out from the survey as the key issues. Because a Soil Protection Review is required of all farmers to meet GAEC in England, documentation is available from Defra (PB10222B) which outlines how risks should be identified and the steps that can be taken to mitigate risk. Support for preparation of the more detailed soil management plan in the Entry Level Scheme is also being provided through farm advisors in England. This area was the most frequently cited area of provision in the survey (82% of respondents) suggesting that information is already available to farmers wishing to carry out a soil management plan from a number of sources across the UK. In contrast, wind erosion was regarded as inapplicable or a low priority, as it is an issue of local significance in a few areas of England. There therefore appears to be limited perceived demand at a UK scale for information relating to this issue.

Soil structure

Soil structure management was identified as a high priority for KT in the arable and horticultural production sectors. In particular, information on the link with quality and yield, influence of cultivation methods and means of assessment are seen as priorities. Rotation and subsoiling are also issues in the cropping sectors, in particular the relationship their relationship to soil structural condition and crop establishment. Soil structure information was regarded as less of a priority in livestock sectors; the main priority identified was how to limit poaching damage, particularly while minimising the housing period for animals to reduce feed costs. Maintenance of vegetation cover is also a priority area. Poaching is clearly less of an issue for arable producers, other than on mixed farms or rented land where structural damage through poaching under rotational pasture can have a detrimental effect on soil structure which may have consequences for succeeding crops.

There is some commonality across all sectors in the need to identify structural problems in the field and determine the most appropriate options for ameliorative action. Although there is a fairly good sector-specific coverage, there is more limited information relating to the effect of different crops in rotation, and management options for improving soil structure. 50% of the service providers responding to the survey carry out KT directly relating to soil structure. The Soil Management Initiative (SMI), the Environment Sensitive Farming (ESF) Programme run by ADAS in England and documentation and workshops by SAC in Scotland have done a lot of work to collate the existing information and present it in ways that meet farmer requirements. There are now a number of systems for field assessment of soil structure. SMI are providing training (mainly to farmer advisors) in the use of at least one of these assessment techniques; this is a rapidly developing area. The ability of arable farmers to identify when a crop or other rotational practice has resulted in structural deterioration, and for livestock farmers to distinguish between suitable and unsuitable out wintering areas, are both linked to ability to assess soil structure in the field. Environmental stewardship options may provide an opportunity to take land out of intensive production and ameliorate structural problems while meeting environmental stewardship goals.

Soil organic matter

Priorities for KT in this area were explicitly linked to GAEC requirements for action to increase organic matter levels. Maintenance of organic matter levels was seen as less of an issue for livestock farmers. However, livestock-related issues are important on mixed farms and issues relating to the application of organic waste (including manures) to arable crops were also noted. The Nitrates Directive (Directive 91/676/EEC) exercises significant controls on the options for application of organic wastes to land in Nitrate Vulnerable Zones and river basin management plans in response to the Water Framework Directive may limit the ability of farmers to use organic wastes constraining options for organic matter management. There is a large amount of sector-specific information available on the effects of the use of organic inputs (manures and composts) in the arable sectors, but little on other options for increasing soil organic matter (e.g. the use of rotation, crop residue incorporations and reduced tillage operations).

Farmers are unlikely to be interested in increasing organic matter for its own sake. Even in the organic sector, training courses concerned with the management of organic matter are often linked to management of soil fertility, maintenance of soil biological activity and mitigation of soil borne disease. However, as a result of GAEC requirements within the Single Farm Payment scheme, maintaining and/or increasing soil organic matter is now a necessary consideration for farmers. Only 24% of service providers mention soil organic matter as an aspect of their training. Options for increasing organic matter are rarely presented as a stand alone issue, though this may change with an increasing focus on farm-scale approaches to carbon sequestration; in contrast cultivation practices have been the focus of large amount of KT activity.

Consequently there is lots of very good practical information available (particularly through the Soil Management Initiative) on reducing cultivation related costs while optimising soil condition particularly through organic matter accumulation. This approach directly links soil management with cost implications for farmers and should enable them to make the most of the options available to them through the single farm payment scheme, while maximising productivity - sustainability and productivity do not necessarily need to be antagonistic. There is a lack of KT which focuses on the benefits of increasing organic matter on arable land (water, nutrients, cultivation costs etc), together with better information for all farmers on the likely effects of other management practices on the organic matter status of their land. Farmers also need to be given tools to help assess their options for increasing organic matter within the context of whole farm management. A programme which provides farmers with the skills to identify problems which are caused by or could be ameliorated by changing organic matter levels would be of particular value.

Soil biology

The main area of interest in soil biology identified in the survey was in the control of soil borne diseases (in both arable and livestock sectors). There was some interest in making information available to farmers to increase the understanding and relevance of soil biology for maintaining the range of soil functions. Soil biology has been anecdotally reported as a 'wow factor' for farmers beginning to think about soil – few have a good understanding of the diversity of life in soil and its importance in soil function. Although there are large amounts of ongoing research and development, there appears to be an absence of information relating to the effects of different soil management on specific crop pests and diseases, and more general information providing best practice information for maintaining soil health and function. Only 3 of the service providers who responded stated they provided training in this area. Training on soil biology is only mentioned explicitly for the organic sector. Little practical information is available on management effects, for example the effects of compaction, pH or increased soil moisture as a result of measures to reduce runoff on soil borne diseases. Some general educational material is being made available relating to the role of soil biology in soil function and maintaining soil health.

Other areas

The need to provide soil fertility information was highlighted as more of a priority for livestock (managing grassland fertility) than for the arable sectors. The main issues identified in all sectors were reducing needs for chemical fertilisers (through both precision farming, and improved use of organic amendments), and the need to comply with the requirements under the Nitrates Directive in Nitrate Vulnerable Zones (NVZs and the expected requirements of catchment plans under the Water Framework Directive). Representatives of the British Potato Council highlighted a sector-specific interest (which may also apply to horticultural producers) of the effects of crop rotation on rented

land on management of fertility for potato production. However, past levy body activities in soil management have focussed on this area, and they are perceived to have a successful record. Therefore this is not seen as a significant gap.

Making best use of existing research

A recent audit of UK soil research carried out for Defra (Research project SP0524) highlighted some concerns about the skills base amongst researchers but generally noted that there was much research of international status carried out into soils and soil function in the UK. The brief literature search carried out on the topic areas above (Table 3) highlights that there is generally no lack of basic scientific research available to underpin KT. Within the UK and similar farming systems there is a wealth of published research (and even more research only available in the so-called "grey literature" not located in searches such as that reported in Table 3) which provides information for specific climate/soil/management combinations relating to the KT gaps highlighted in this study i.e. soil organic matter, soil structure, runoff and erosion. Given the relative newness of the terms cross compliance and GAEC, it is not surprising that few papers were found linking soil management directly with the achievement of cross compliance. Although gaps in currently available knowledge suitable for direct transfer to farmers have been highlighted in the previous sections, it does not seem appropriate to

Table 3: Total number of ' hits ' for Web of Science Abstract searches for the period 2001-2005 using ' agriculture OR farming' AND soil and the sub-group search terms linked to areas of knowledge transfer priorities for soil management indicated in the table [=wildcard]. Total number of abstracts before application of the sub-group screening = 3411*

Sub group search term	Total number of 'hits
'cross compliance' OR GAEC	2
erosion OR runoff	578
'organic matter' OR carbon	842
structure	264
structure AND tillage	54
structure AND poach*	2
fertil*	1164
'microbial biomass' OR disease	222

commission new primary research in these areas before making best use of the information that currently exists. The only topic where the may be a lack of published research work to support KT is the impacts of poaching on soil structure and strategies for structural remediation after poaching damage.

To support effective KT it is essential that the relevant practical knowledge sitting in back issues of scientific journals is integrated and translated so that it

can be shared with farmers and their advisors in relevant and engaging ways. There is a vast amount of forgotten research into relevant areas on which CAP reform has placed renewed emphasis, such as managing rotations, organic matter, tillage and use of organic amendments (for example Lowe (1972) which reviews the accumulated experimental evidence for the effect of cultivations on soil physical conditions in both arable and grassland sectors in the post war years of intensive research in the field). Importantly, there is a wealth of highly applied research for particular crops/farming systems and soils/localities buried within the reports of these experiments lies information that may be of increasing value to us. In many cases this involves us today in making use of results in ways the authors had not originally intended. Although (agronomic) technology has developed greatly in the intervening years, this is not necessarily a barrier to the application of this previous research. Due consideration of the implications of technological development on the findings of 'historic' research will inform new research directions. However, much of this research predates digitisation of resources, and to locate it would require a thorough investigation of archives. This is also not an issue limited to the application of knowledge to soil management, awareness of, and access to, early literature is a critical but oft neglected step for much scientific research. The alternative, which occurs too often, is to invest heavily in new research which replicates forgotten past research and therefore returns predictable results, resulting in inefficiency in both financial terms and in the rate of development of suitable KT.

The Defra research audit (Research project SP0524) found that there was generally a poor awareness of the scale and scope of UK soils research amongst those who were expected to apply the results of such research, such as farmers and land managers. However, the audit concluded that it was not sufficient simply to rely on KT activities associated with individual projects and carried out by individual scientists; for KT to be effective there was a need for additional resources focussed on integrating and translating the results of individual research projects. However, because of the nature of soils and the issues associated with their management it is unlikely that simple prescriptive messages can be developed that will have wide applicability within sectors, let alone across sectors. Instead farmers will need to assess information they collect on soil condition and then use their best judgement in the light of the range of possible options available to determine the best management practices for their soil/crop/environment combination. Supporting this kind of farmer learning is likely to need a different approach than simply providing the direct outputs of research projects, even if they are compiled in a farmer-usable way. There is also a need to integrate research on soil management with consideration of the impacts of soil management actions on other farm management practices and consequently on profitability. Little work has been carried out to quantify the impacts of changes in management practices (to support best practice soil management goals) on profitability (e.g. work in the US by Valentin *et al*. 2004). At present much of the understanding of soil function lacks this critical application to real farming systems.

Review of forms of knowledge transfer

Service providers identified 4 main ways that they were providing KT to farmers and their advisors – publication of information (leaflets, booklets); interactive and less-interactive web resources; courses (including BASIS/ FACTS accredited training) and workshops (including farm walks and open days). A video which considers the implications of changing cultivation practices on soil structure (amongst other issues) has also been produced (SMI). 82% of respondents communicated soils knowledge by workshops, 34% through one-to-one advice to farmers, 26% via publications, 24% through courses and 9% through the web. Educators recognise a clear distinction between the provision of information (transmission) and learning by the recipient (Ramsden, 2003). However this study suggests service providers seek to achieve both aims, often not clearly distinguishing between them. In the majority of cases service providers indicated that they would be prepared to provide information in a range of formats including one-to-one advice on farm but that the key constraint to their delivery of KT activity was funding.

A similar range of approaches is used in other countries, and for other fields of agricultural KT within the UK. Facilitated farmer groups (e.g. the Landcare approach in Australia; Department of Agriculture, Fisheries and Forestry, Australia, 2006) are also a commonly reported means of sharing knowledge and promoting farmer-farmer learning. In New Zealand farmers are able to benchmark the health/quality of their soils (Landcare Research, 2006); this approach is more common for economic indicators in the UK. Wander *et al*. (2002) report a participatory approach to developing such a soil quality benchmarking system as a result of farmer and researcher interaction in cropping systems in Illinois, which highlighted that farmers often have the desire to take soil quality into account in decision making but lack tools which actually enable this to happen in the field. In their carefully considered review of advisory support for land management, Garforth *et al*. (2003) indicate that the appropriate form of KT will vary; and except where the task is simply that of making information available, facilitation to provide assistance or support in using the information is important.

There is clearly a need to engage more fully with farmers to discover what processes of KT (formal and informal) actually have the largest effect in informing and/or changing practice. It is important to note that "an almost universal finding from studies of farmers' sources of information and influence is that other farmers are their most frequently reported source" (Garforth *et al*. 2003). Drew (2001) also found that the internet was not ranked highly by farmers as a preferred source of information. However, anecdotal evidence suggests that farmer use of the internet has increased significantly since the Foot and Mouth outbreak. Learning in this area will not be restricted to issues related to soil management; most farm management issues require practical in-field assessment and decision making, which distinguishes them from other business decisions and may distinguish the most appropriate form of KT from that applied in other sectors.

In the tropics there has been an increasing move from KT programmes which take results from research farms and seek to educate farmers to apply

these approaches, towards a more farmer-centred approach in the research and knowledge generation processes (Bunch, 1982; Chambers *et al*., 1990). This 'rural development perspective' has demonstrated economic and social advantages through supporting farmers in assessment and innovation for land management (particularly Integrated Pest Management) rather than regarding them as passive recipients of a relatively slow technology transfer system (e.g. Bentley and Andrews 1996; Selener, 1997; Ooi, 1998). Links between participatory action research and quantitative analysis have been critical to success in improving soil management in areas vulnerable to soil degradation in Mali for example (Defoer *et al*., 1998). Deugd *et al*. (1998) stress the most effective approach is to support innovation by increasing farmers' control over the processes of research and emphasising the process of learning rather than the teaching of content. Such an approach works best where the main blockage is not access to information, but rather farmers' adoption, understanding and integration of that knowledge into practice.

The development of such programmes in the tropics were a response to the poor uptake of farming systems technology, which had been based upon research station findings, and neglected the realities of farmer decision making which often made these technologies impractical or unsuitable in the real world. Although KT in the UK has proven much more successful, there are important parallels. Sherwood and Uphoff (2000) see the challenge for improving soil management as one of engaging farmers rather than changing them. Approaches taken should engage farmers in processes of identifying and prioritising problems and opportunities, testing and evaluating innovations and being partners in sharing the information gained. In this way the findings of soil management research can be best transferred into real soil management improvement and future research acknowledge the existing barriers to implementation in developing the most practical solutions.

Conclusions

The Single Payment Scheme represents a new challenge to farmers, but also an excellent opportunity to take actions to increase productivity through better soil management, offsetting short term costs (direct set up costs or reduced output) with subsidy payments, while reaping the benefits over a longer timeframe. The gaps identified in current KT activities on soil management are in the closely related areas of management of soil organic matter, structure and biological activity. The new requirements and options for soil management of the Single Payment Scheme place a renewed emphasis on land husbandry techniques, which have been relatively neglected over recent decades. The focus of KT over the next 5 years should be to enable farmers to take advantage of the single farm payment and environmental stewardship schemes, by making use of environmental management options eligible for subsidy payments to improve soil management (organic matter levels, structural condition, erosion control). Examples include the use of beetle banks for erosion control, improving organic matter and structure through conservation tillage or identifying poor out-wintering land and creating alternative low intensity management wildlife habitats. However, the cost

implications and technical considerations of different management strategies at a farm scale are complex, and better support is needed to allow farmers to learn what options will best fit their situations. Although this study has identified the areas seen as priorities by both the levy bodies and by soils experts, this is not a substitute for the views of the farmers themselves. In order to accurately assess producer priorities (the demand for and the most appropriate forms of KT for soil management), consideration of the views of farmers should be taken into account, either formally or informally. The absence of such consideration makes prediction of demand difficult, particularly relating to regional differences related to different state provision of farmer training and legislative compliance of the devolved governments.

References

Bentley, J. W. and Andrews, K. L. (1996). *Through the road blocks: IPM and Central American Smallholders. IIED Gatekeeper Series* Volume 56. International Institute for Environment and Development. London.

Bunch, R. (1982). *Two ears of corn: A guide to people centred agricultural improvement*. World Neighbours. Oklahoma City,

Chambers, R., Pacey, A and Thrupp, L. A. (1990). *Farmer first: Farmer innovation and agricultural research*. Intermediate Technology Publications. London.

DARDNI, 2006. Cross-Compliance Verifiable Standards 2005 and 2006. Accessed online on 07/01/2008 at http://www.dardni.gov.uk/index/publications/pubs-dard-grants-and-funding.

Defoer, T., De Groote, H., Hilhorst, T. Kante, S and Budelman,A. (1998). Participatory action research and quantitative analysis for nutrient management in southern Mali: a fruitful marriage? *Agriculture, Ecosystems and Environment* **71**, 215-228.

Defra, 2006. *Cross Compliance Guidance for Soil Management 2006 Edition*. Defra.

Department of Agriculture, Fisheries and Forestry Australia (2006) National Landcare Programme Overview 2004-08. www.affa.gov.au/content/output.cfm?ObjectID=58F9E43F-95A0-46CE-85A6286176710B18 Last updated June 2006. Viewed 28th June 2006.

Deugd, M. Röling, N. and Smaling, E. M. A. (1998). A new praxeology for integrated nutrient management, facilitating innovation with and by farmers. *Agriculture, Ecosystems and Environment* **71**, 269-283.

Drew, B. (2001). *Knowledge transfer to the livestock industry. Progress in the new Defra initiative*. ADAS/ IGER/ University of Bristol, Bristol.

Environment Agency (2004). *State of Soils in England and Wales.* Environment Agency, Bristol.

European Commission (2002) Strategy for soil protection. http://europa.eu.int/scadplus/leg/en/lvb/l28122.htm Last modified 30 April 2002, viewed 1 March 2006.

Garforth, C., Angell, B., Archer, J and Green, K. (2003). Fragmentation or creative diversity? Options in the provision of land management advisory services. *Land Use Policy* **20**, 323-333.

Landcare Research (2006) SINDI Soil Quality Indicators on the web. Version 3. http://sindi.landcare.cri.nz/ Last updated not known. Viewed 28th June 2006.

Lowe, A. J. (1972). The effect of cultivation on the structure and other physical characteristics of grassland and arable soils (1945-1970). *Journal of Soil Science* **23**, 363-380.

Ooi, P. A. C. (1998). Beyond the farmer field school. IPM and empowerment in Indonesia. IIED Gatekeeper Series Volume 78. International Institute for Environment and Development. London.

Pretty, J. N., Mason, C.F., Nedwell, D. B., Hine, R. E., Leaf, S and Dils, R. (2003). Environmental costs of freshwater eutrophication in England and Wales. *Environmental Science and Technology* **37**, 201-208

Ramsden, P. (2003). Learning to teach in higher education. 2nd edition. RoutledgeFalmer. London.

The Scottish Government. (2005). *Natural Scotland. Cross Compliance Notes for Guidance*.

Selener, D. (1997). *Participatory Action Research and Social Change*. The Cornell Participatory Action Network. Cornell University, Ithaca, NY.

Sherwood, S. and Uphoff, N. (2000). Soil health: research, practice and policy for a more regenerative agriculture. *Applied Soil Ecology* **15**, 85-97.

Stockdale, EA and Brookes P. C. (2006) Detection and quantification of the soil microbial biomass – impacts on the management of agricultural soils. *Journal of Agricultural Science* **144**, 1–18.

Wander, M. M., Walter, G. L., Nissen, T. M., Bollero, G. A., Andrews, S. S. and Cavanaugh-Grant (2002) Soil Quality: Science and Progress. *Agronomy Journal* **94**, 23-32.

Welsh Assembly Government (2007). GAEC and Statutory Management Requirements (SMR) in Wales for 2007 Part 1 – GAEC. Accessed online on 07/01/2008 at http://new.wales.gov.uk/docrepos/

Valentin, L Bernado, D.J. and Kastens, T.L. (2004). Testing the Empirical Relationship between Best Practice Adoption and Farm Profitability. *Review of Agricultural Economics* **26**, 489-504.

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