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COVER PAGE

Technical and social dimensions of farmer learning: an analysis of the emergence of reduced tillage systems in England

Abstract

Reduced tillage systems potentially provide both environmental and economic benefits. However, the system is not universally applicable and requires a higher standard of overall management than ploughing, the conventional from of tillage, particularly with respect to maintenance of yield and soil structure, straw and stubble treatment, grass weed and slug control. As such reduced tillage systems are knowledge intensive and non-prescriptive and, rather than simply acquiring knowledge about the system, require farmers to learn. This paper examines the technical and social dimensions of such learning through a study of farmers practising reduced tillage in England. Semi-structured face to face interviews were carried out with 12 farmers implementing reduced tillage and four promoters associated with an initiative promoting reduced tillage. The results show that a community of reduced tillage farmers, motivated by different interests, has been emerging in England since the 1970s. Individual farmers are learning at the farm level through experimentation and adaptation, and have used a variety of networking devices to take this learning and validate and reflect on it by interacting with others with the same experiences. The networks were also found to extend to researchers and some agronomists. Thus the individual activity of on-farm learning, the technical dimension, is accompanied and enhanced by a process of social learning, the social dimension. However, there are barriers to this social learning which themselves are intimately connected with the technical complexities of the system. The results show that farmers' willingness to share their experiences about the system is not universal. The complex and difficult nature of reduced tillage, and high standard needed to implement it well, has made some farmers reluctant to engage in networks. This is due to fear of criticism from other farmers, wanting to

protect new found knowledge from competitors, or poor regard for the standards of farmers new to the system.

Key words

reduced tillage systems; knowledge, technical learning; social learning; networks; farmers; England

Introduction

In England arable farmers are being urged to farm both in a more sustainable and in a more economically efficient manner. Compliance with agricultural and environmental conditions under the European Union's (EU) Common Agricultural Policy (CAP) and Directives means that farmers cannot ignore the environmental consequences of their farming practices. However, at the same time many farmers are battling with a period of rising input costs and fluctuating farm incomes. They are also facing the prospect of declining levels of farm economic support coupled with increased exposure to the vagaries of the market following a CAP move towards decoupling. In response to these economic challenges farmers are continually looking for ways of making their farming operations more efficient. Reduced tillage systems offer a solution to these two sets of challenges since they can potentially provide both environmental and economic benefits (Jordan et al. 2000; Knowler and Bradshaw 2007).

Reduced tillage is a term used to describe a broad range of soil tillage systems that do not invert the soil and aim to leave residue cover on the soil surface. The system offers the potential to improve soil structure, reduce erosion and water quality impacts and enhance wildlife (Jordan

et al. 1997; 2000). At the same time reduced cultivations use less fuel and labour and thus offer reductions in crop establishment costs. Indeed these systems have been defined as 'sustainable cultivation systems which are less expensive than traditional systems; they may be less energy demanding, and/or quicker and/or have a lower labour demand' (Davies and Finney 2002:2).

However, for the farmer, moving to a reduced tillage system represents a significant change from the conventional cultivation of ploughing (Lahmar 2005). Reduced tillage is not a one-off tillage technology but is a whole system approach, which requires daily judgements informed by knowledge of local agro-ecological conditions as well as continuous experimentation and adaptation (Davies and Finney 2002). In short, it represents a significant shift in knowledge production, habits, and behaviour compared to ploughing. In this sense reduced tillage systems share characteristics with other alternative systems such as organic or integrated farming systems in that they all require learning rather than the passive adoption of a technology (Coughenour 2003). The new modes of learning comprise both technical on-farm knowledge generation by the individual and the exchange and sharing of this knowledge through social interaction (Kloppenburg 1991; Murdoch and Clark 1994; Röling and Jiggins 1994; Engel 1997; Röling and Wagemaker 2000).

As such, this paper examines the nature and extent of farmer learning through a study of farmers practising reduced tillage in England. Specifically the research explores how the technical dimensions of on-farm experimentation, adaptation and learning interact with the social dimensions of sharing knowledge through networking and social learning.

Reduced tillage

A range of terms are used to describe reduced cultivations[1], including reduced tillage, minimum tillage, lo-till, conservation tillage, and conservation agriculture. They all refer to shallower, non-inversion cultivation that is plough-free in which the soil is left undisturbed from harvest to planting and weed control is accomplished primarily with herbicides, limited cultivation, and, in more sustainable systems, with cover crops (Lahmar 2005).

Although farmers in England do not face the same challenges as those in USA, South America and Australia, where conservation tillage has been popularised as an anti-erosion practice, they do have to contend with a changing policy landscape with respect to soil protection. With the proposed EU Soil Directive, the Soil Action Plan for England and its proposed successor the Soil Strategy (Defra 2004, 2008); the soil management compliance conditions required for receipt of the Single Farm Payment under the CAP; the implementation of EU's Nitrates and Water Framework Directives which aim to reduce agriculture's impact on water quality; and the emerging interest in soil's role in carbon sequestration, soil protection has risen on the policy agenda. As such, reduced tillage, which potentially reduces the effects of erosion, provides benefits to wildlife, mitigates the effect of agriculture on water quality and provides a sink for carbon has potential to meet a number of policy challenges (Jordan et al. 1997, 2000; Freibauer et al. 2004**).** It is the pressure to reduce production costs by optimising labour and machinery use in cereal establishment, however, that is driving a move away from traditional plough-based cultivation in Europe. With an emphasis on cost cutting, a quest for efficiency, coupled with an increase in the size of farm units, and reduction in farm labour, many farmers

[1] To most practitioners 'minimum or minimal tillage' probably signifies 'shallow tillage' (<100 mm without inversion), but in practice often includes 'direct drilling' (no cultivation prior to drilling) and deep tillage (>100 mm without inversion). 'Lo-till' is defined more specifically as equivalent to 'shallow tillage'. 'Conservation tillage' is a widely used international term describing any non inversion tillage which leaves at least a third of the soil surface covered by crop residues; it includes direct drilling, shallow and deep tillage, provided they pass the residue test. 'No-till' and 'Zero-tillage' are equivalent to 'direct drilling' (Davies and Finney 2002). Conservation agriculture refers to conservation tillage together with the use of cover crops, extensive crop rotations, and straw mulch.

are attracted to a system that enables them to cultivate more land for less input, labour, time and fuel.

Emergence of reduced tillage

In effect the emergence of reduced tillage in England has occurred in three phases. During the 1970's direct drilling was popular with one third of crops grown in England established by reduced tillage. The interest at the time was driven largely by agrochemical companies and farmers. However, by 1988 the area grown had fallen to about one tenth due to loss of yield caused by increases in grass weed populations, the expense of, and resistance to herbicides, topsoil compaction and the need to incorporate straw because of restrictions on burning (Davies and Finney 2002). Interest was renewed in the 1990s when results from research conducted as part of the Less-Intensive Farming and the Environment (LIFE) project showed that, compared with ploughing, reduced tillage substantially decreased sediment loss in run off, total and soluble phosphorus (P) losses, and isoproturon loss in drainage; resulted in larger numbers of earthworms than the conventional system and had comparable yields to ploughed plots while the cost of crop establishment was reduced by one third (Jordan et al. 1997, 2000). The emphasis was on soil and environmental improvements and farmers visiting the research trials, largely motivated by this aspect, became enthusiastic practitioners and advocates of the system (Ingram 2004). At the same time machinery and agrochemical companies, taking a more commercial perspective, began to popularise the system. Linked by their shared interests the LIFE researchers and farmers, together with representatives from environmental NGOs and agencies and commercial companies, formalised their association when the Soil Management Initiative (SMI)[2], an independent organisation, was established in 2000. Thus SMI was there to offer support, through publications, workshops and demonstrations, to a third wave of farmers

[2] SMIs aims were to promote the adoption of cultivation systems designed to protect and enhance soil quality and to minimise soil erosion and water pollution, whilst maintaining or enhancing farm economic returns

who at this stage were motivated by cost-cutting in a climate of restructuring. As such, although there is a discernible groups of farmers who are practising reduced tillage of some form in England, they are not homogenous, they have different experiences, motivations and have been responding to different drivers. Estimates of numbers and characteristics of farmers implementing reduced tillage in England are vague, although typically, large scale farms are the most likely to benefit from incorporating reduced tillage due to economies of scale achieved and their ability to absorb the risk (Lahmar 2005).

Throughout these phases of emergence support from the formal research, advisory and policy community in general has been weak. Some in the research and extension community were quick to caution against universal adoption of reduced tillage arguing that, whereas the mouldboard plough is universally applicable, successful reduced tillage systems are individually suited to soil, site, scale and management of an operation. In addition, they questioned the environmental benefits of reduced tillage describing them as 'unclear, sometimes contrary, and far from assured' (Davies and Finney 2002:3). They also suggested that it is only severe financial pressure which is forcing large numbers of farmers to adopt quicker cheaper tillage.

Unlike some other European and North American countries, where policy support and subsidies have advanced the use of reduced tillage (Lahmar 2005), in England there are no such mechanisms. Equally the advisory community have been unsupportive, sometimes critical, and, it is argued, have lacked the appropriate technical knowledge to support farmers' transition to reduced tillage (Davies and Finney 2002; Ingram and Morris 2007). Consequently the main thrust of support for reduced tillage has been from the practising farmers themselves,

SMI and the chemical and machinery companies who have commercial interest in selling drills and agro-chemicals.

At the same time some within the farming community have been unsupportive. Many who remember, or experienced, the failings of direct drilling in the 1970s are cautious (Ingram 2004). They also question the high investment required for new machinery and view the involvement of commercial firms with cynicism, a view shared by some scholars (Hall 1998). Scholars also recognise that changing from a traditional system of tillage, ploughing, to another involves a major shift in how a farm operates involves a cultural readjustment (Coughenour and Chamala 2000; Tebrugge and Bohrnsen 2001; Derpsch 2002; Wilson et al. 2003; Lahmar 2005).

As such the system has sometimes been perceived as contentious, meaning that not only do farmers wishing to practice reduced tillage have to overcome difficulties of learning a new system, they may also lack support from policy, research and advisory community as well as from their peers. Any examination of farmer learning must be considered in this context.

Conceptual framework

Due to their complexity alternative systems, like reduced tillage systems, are thought to be qualitatively different from conventional one-off technologies (Kloppenburg 1991; Hassenein and Kloppenburg 1995; Coughenour and Chamala 2000) and it is argued that research and traditional extension systems are ill-equipped to support them (Röling and Jiggins 1994; Cerf et al. 2000; Ison and Russell 2000; Derpsch 2002). Instead they require new ways of knowing which go beyond the notion of knowledge transfer to, and adoption by, farmers. Recognition

that they require the generation of knowledge through experimentation and technical innovation on-farm by farmers, and the sharing of this knowledge through social interaction and dialogue has brought about a shift in the paradigm of knowledge exchange (Röling and Jiggins 1994; Röling and Wagemaker 2000). As such, scholars have argued that there is a need to understand both the technological and social dimensions of the transition to, and integration of, alternative systems (Coughenour 2003; Kroma 2005).

With respect to the technical dimension, the transition to an alternative system is not a simple technical change (Padel 2001; Lahmar 2005). Alternative systems has been shown to be complex, non-prescriptive and risky, requiring more observation, monitoring and judgement compared to conventional practices as well as an understanding of the local agroecosystem (Murdoch and Clark 1994; Padel 2001). For example, rotational grazing, which was studied in Wisconsin (Hassanein and Kloppenburg 1995) and southeast Minnesota (Nerbonne and Lentz 2003), was described as complex, demanding skills, flexibility, ingenuity and profound attention to detail. The graziers reported that they learnt by doing and observing, and they adopted a different way of thinking about production compared to conventional dairying. Reduced tillage systems are equally demanding, they constitute a new or different 'tillage and planting system' (Coughenour 2003:281) in which there are no standard procedures and the farmers' choices about crop, tillage and planting method will vary from year to year (Davies and Finney 2002). Such a non-prescriptive systems require the adaptation of principles to place rather than knowledge transfer and as such, it is argued that, the tillage planting system is reconstructed, not adopted, by a farmer (Cougherbour 2003)

In combination with these technical learning processes at the farm level, the integration or reconstruction of a new farming system is thought to be a social process in which the

knowledge constructed on-farm is shared through dialogue and interaction between people, networks and communities (Long 1992; Vanclay 1992; Röling and Jiggins 1994). These learning processes have been explored in the context of alternative or sustainable practices using a number of different perspectives, such as: knowledge networks (Engel 1997); learning in communities (Falk and Kilpatrick 2000); local ecological knowledge systems (Kroma 2005); knowledge communities (Nerbonne and Lentz 2003); social movement theory (Hassanein and Kloppenburg 1995); actor network theory (Coughenour 2003); diffusion theory (Padel 2001); agricultural innovations systems (Lahmar 2005); and the interchange of local and scientific knowledge in groups (Millar and Curtis 1999). All these conceptualisations recognise the importance of interactions and linkages among parties with a shared experience. Such collective experiences provide a forum for social learning, a process in which actors collaborate and adopt a shared style of problem solving through local experimentation and observation (Woodhill and Röling 2000; Leeuwis and Pyburn, 2002; Kroma, 2005). At the centre of social leaning is a shared interest and a common purpose, philosophy and ethos (Padel 2001, Guijt and Proost, 2002).

Social learning through networking has been shown to be pivotal to the emergence of alternative systems such as conservation tillage (Coughenour 2003), organic farming (Padel 2001; Kroma 2005) and rotational grazing (Hassanein and Kloppenburg 1995; Nerbonne and Lentz 2003). Often the need to share knowledge and tap into others' experiences arises because of the absence of both information, and peer and professional support. Farmers experimenting with new systems have found that, in turning away from the conventional paradigm of production, their formal structures of information provision have failed them (Hassanein and Kloppenburg 1995; Padel 2001). Networks therefore enable the generation of agricultural knowledge and local solutions within a supportive social environment. The benefits, when

people seek information from interpersonal contacts within their social relationships, of problem solving and reformulation, access into other knowledge sources, validation and legitimation and reduced risk, have been widely described (Guijt and Proost 2002; Sligo and Massey 2007).

Social learning within such systems can also involve a small number of other supportive actors such as advisors and researchers (Hassenein and Kloppenburg 1995). This has been described for conservation agriculture where farmers have networked with research, policy, NGOs, advisors, public and private sectors leading to effective and dynamic innovation systems (Coughenour 2003; Lahmar 2005). Thus social learning can encompass a diverse number of actors and networks.

Reduced tillage in England shares a number of characteristics with alternative systems described here in that the system has emerged with little formal institutional advisory or policy support and represents new knowledge claims which challenge the dominant conventional ones. The emergence of alternative systems have been explained by the co-evolution of technical and social systems in which the technical system provides a model for the operational system and a social system comprises the shared cultural knowledge of farmers and other actors (Coughenour 2003; Nerbonne and Lentz: 2003). As such any analysis of the integration of reduced tillage in England needs to take account of these two systems of learning.

Methodology

The research[3] involved a series of face-to-face farmer interviews with farmers implementing, and promoters supporting, reduced tillage. Farmers were identified for interview using the SMI who provided a list of those who had contacted or visited an SMI event at some point. From this list 12 farmers agreed to be interviewed and it transpired that they were all practising reduced tillage to some extent. Four promoters linked to SMI were also interviewed. These were researchers, advisors and farmers who have been involved with SMI since its inception.

The farmers interviewed had been practising reduced tillage for a range of years, as such the interview sample is broadly representative of the three phases of emergence described above. For most interviewed it was common to have a combination of owned and tenanted land. Four were farm managers or tenants on sizeable estates, comprising 1500-2000 acres. Most interviewed were arable only with a number of different crops in the system including potatoes, sugar beat. Geographically the sample was dispersed, stretching from Pembrokeshire to Oxfordshire, Leicestershire, Lincolnshire and Somerset.

Results

The farmers

In very general terms three types of farmer were revealed in the sample: older farmers (two) who are passionate about soil and have been experimenting for 20-30+ years, one since he had started direct drilling in the 1970s; farmers (eight) who had been practising for 7-10 years, a number since visiting the LIFE trials; and those (two) who have started more recently, in the

[3] This study was part of a larger piece of research carried out for Department for Food, Environment and Rural Affairs (Defra) in 2006-7 investigating how to influence farmers' positive environmental behaviour in the context of waste, soil and water. The research involved a series of face-to-face farmer interviews and discussion groups within five case studies, one of which looked at reduced tillage, the subject of this paper

last 3-4 years, prompted by the need to improve efficiency. The motivation for those who have been experimenting with direct drilling and reduced tillage for a longer period was principally soil improvement, for example:

> What initially started me was our tractor driver –it's very traditional in Hereford, they plough and plant, I never liked it….anyway our driver said one day 'you realise we've got no worms', I said yes it's been worrying me (SMI1)

For those who have been interested in the last 3-4 years the motivation was establishing a more efficient system to save costs and time. These tend to be the farmers who had expanded and simplified their systems recently, or started contract farming, for example, one farmer (SMI3) commented 'We were 100% ploughing - with a brilliant yield and no problems but we knew if we expanded we had no chance of keeping it up because of time and labour'. A promoter explained that a few years ago the type of farmer who was interested (usually because of soil quality issues) was the pioneer but that reduced tillage is now 'almost mainstream' with larger farms attracted to it because they it allows them to cultivate large areas quickly and more cheaply.

The technical dimension

There is agreement amongst all those interviewed that reduced tillage is more difficult than ploughing, that it takes more observation, local knowledge and continuous on-the-spot decision making, taking into account the vagaries of the weather and the quality of seedbeds in the presence of straw. Specifically judgements have to be made about when to cultivate and drill, how to deal with trash and how to deal with slugs and weeds. One farmer explained:

> The mintill management side of it is fraught, we seem to be working all the time. There are big weather gaps –now the weather seems to be more extreme, we are often waiting for an opportunity to cultivate and judging the right time is difficult. It's all or nothing, you're always waiting. You are always concerned about whether you go in too early or not, I'm petrified, it's the fear factor. Ploughing is a lot easier because you know what to do, you don't have to make so many decisions, and you can carry on ploughing in bad weather. Going into mintill there are lots of things to change. Is it greened up enough? Has the straw been incorporated properly? We're always rolling to kill the slugs and have to invest in new drill technology. You're learning all the time and it's more management. Also you go in straight after harvesting to use the moisture in the soils, so there is no breathing space. It makes you hair go grey early (SMI12).

Because of the demanding management regime many of the farmers regard practising reduced tillage as a continuous process of learning, problem solving, and experimentation, a number described the process of transition to reduced tillage as moving along a 'learning curve' in which 'you're for ever increasing your knowledge on the subject'. Many interviewees consider that, whilst acquiring knowledge about reduced tillage through demonstrations and publications is helpful, the best way of learning is to practically try it out it on their own land. Farmers regarded implementing reduced tillage as a matter of trial and error, experiencing both successes and failures. One described the process:

> You know what works, you look at it, discuss it with people, have a go. You don't change your mind by the [farming] press. You try something out on a small area, if it works, push on with it. I'm a believer in your own judgement (SMI4).

Other farmers described similar processes of building up knowledge and getting to know 'what works and what doesn't'. There is agreement that there is no 'right or wrong way' to implementing it and that 'you have to be prepared to make mistakes'. Changing to reduced tillage is a big decision for many farmers because it is an unfamiliar system. Expressions used by practising farmers, such as 'taking the plunge', 'dive in the water', taking a 'deep breath' and 'it was a massive gamble' suggest that for most it is perceived as a risky decision. Because the transition takes time and entails risk of failure, it takes commitment and a long term vision, as one farmer (SMI10) noted 'you have to be convinced and have faith in it'. Some more established reduced tillers believe that farmers who have recently started trying reduced tillage to save costs give up very quickly because they do not have the staying power and are not prepared to suffer mistakes. Promoters and farmers alike recognise that the transition from ploughing to reduced tillage can be troublesome and that it takes time before the benefits are apparent, as a promoter explained:

> We always claim that it takes at least three years to get this cycle going. Year one after you've ploughed the crops are usually good, year two you take a bit of a dip in yield because you've lost the good structure you had from ploughing yet you've haven't got the natural structure or the worms but in year three yields start to go up again and of course an awful lot people bunk out after year two (SMI13).

Farmers practising reduced tillage demonstrated confidence in their own decisions but looked for affirmation that it was bringing benefits, particularly during the transition period. Observing the benefits of reduced tillage practice provides a positive feedback to farmers and motivates them to continue. Observing positive outcomes also allows reflection and validation

of management decisions, it is part of the learning process. Farmers tend to either compare results with adjacent ploughed fields, or refer to the same field under previous ploughing management. For example, one farmer (SMI11) remarked 'you see the soil changing and compare it with your neighbours and this bolsters you up'. Another described a formative event that had changed his appreciation of reduced-tillage:

> In one field we ploughed, and the other ones we minimum tilled, and we had massive soil erosion on them when we ploughed and we didn't on the other two. It just so happened we had a deluge of rain a couple of weeks after drilling, and it was obvious, you could just see the difference. But until we had that experience they could say as much as they like that you don't get the soil erosion with minimum tillage, but when you see it on your own farm you remember it (SMI9).

Clearly farmers practising reduced tillage are continuously problem solving, experimenting and adapting their systems; all processes important to the technical innovation and learning on-farm. A difficult transition phase means that commitment to the system change is important, and this is reinforced by farmers constant affirmation of the decision to change.

The social dimension

The pattern of knowledge exchange and networking revealed is complex. Whilst some farmers look for the support of fellow implementers and demonstrate a willingness to share knowledge and engage in networking others choose not to.

Isolation

Early practitioners of reduced tillage appear to have experienced a certain amount of isolation, particularly those who pioneered the practice, often in the face of ridicule, opposition and lack of institutional support. One such farmer describes his experiences at the time:

> Twenty years ago it was difficult to find people who knew about it [reduced tillage], we learnt by the seat of our pants, we still are… I took a deep breath and did it. Everybody said I was a fool. It was a leap of faith, we sold the plough…. I knew we could make it work, I couldn't get anyone to do the cultivations to my satisfaction so I did them (SMI1).

This gives a sense of the lack of support and knowledge from the professions and from peers. It also reveals the extent of commitment and faith that these farmers had in being able to make the system work, and the high standards they set themselves, characteristics demonstrated by a number of reduced tillers interviewed. The acceptance that 'you've got to be prepared to make a fool of yourself' was also a recurring theme. They regard themselves as being out on a limb and they know their (ploughing) neighbours are sceptical, as one said: 'they all think we're completely mad' and another 'Oh yes, we cause a great deal of interest – they think what the hell he's doing?'

As well as derision and suspicion from their peers, these farmers also lacked support from the advisory community. Cynically advisors seem to dismiss reduced tillage as being commercially motivated, and offering a quick but inappropriate solution to farmers needing to save costs. According to promoters interviewed, a key concern of advisors was that farmers were not sufficiently informed or competent about the operations involved. Advocates of reduced tillage, however, attribute advisors' reluctance to their unfamiliarity, inexperience and

lack of knowledge about the system. This lack of support from other farmers, neighbours and advisors, served to both connect and disconnect farmers, depending on the response of the individual.

Sharing knowledge and experiences

For a number of farmers, isolation has helped to forge a strong community amongst those struggling to implement reduced tillage. A small discernable group of farmers, some researchers, and one or two agronomists emerged with a collective interest in reduced tillage, centering around a few key pivotal actors with links to SMI.

The technical on-farm learning by individuals, as described above, has been supported by networks of farmers linking up to discuss and share knowledge, ideas and experiences. Farmers use an array of networking devices to share knowledge such as chatting to a neighbour, visiting other farms, joining a discussion group, attending SMI workshops and using the internet. The more established reduced tillage farmers interact using informal discussion groups to 'bounce off each other or 'get together and chew the fat'. The value of learning in these groups by reflecting on problems has been highlighted, as a farmer (also a promoter) explained: 'we have a group that we meet occasionally and walk around each others farms literally look at our mistakes and try and find out where we've gone wrong and that seems to work quite well' (SMI13).

Some pioneers of reduced tillage have become advocates for the system, keen to share their ideas and experiences with newcomers. Often they were inspired by visiting the LIFE trials and experimented on their own farms. They also expanded their knowledge by visiting other

farmers outside the country, three interviewees, for example, had visited farms in north America and Australia to learn about the systems there. Some key figures have initiated farmer groups, held demonstrations on their farms and become involved in SMI. Farmers who host other farmers' visits were described as taking pride in their systems. They had gone through difficulties in the early stages and made mistakes themselves, but as one promoter (SMI14) said 'if you believe in it you have to find the solutions which are there, but once you've gone through it…you're proud to show others'. Sharing their experiences can give confidence to those more hesitant farmers starting off in reduced tillage.

For those considering, or new to, reduced tillage, talking to other farmers is often found to be the best approach to learning. As one promoter commented:

> If someone wants to change [to reduced tillage] there are so many farmers doing it, you just need to go and talk to someone who is doing it. Farmers listen to scientists but farmers learn from farmers. Once they have gathered information from others they might try it for themselves, sometimes on a small scale and then if it is successful they would 'run with it' (SMI14)

SMI recognise the value of using other farmers and have developed a workshop format to suit this mode of learning:

> We go to an area where a guy is using mintill effectively and has had advice and got through the difficult stages and is happy to demonstrate. We organise a workshop around that area and put him on a platform then get out in the field and farmers fire questions at him. That's how they learn, some of them try one or two fields, we suggest

> suitable fields and help them if they get into difficulty or they go back to Joe farmer who has gone through all this, the difficult stages (SMI14).

In addition to SMI one or two agronomists have begun to join the emerging reduced tillage networks, they facilitate farmer groups and set up farm trials. They have acquired knowledge by learning from farmers' experiences, observing trial outcomes and in some cases undertaking field cultivations themselves.

Thus a social learning community has emerged characterised by farmer-farmer supportive networks as well as vertical networks between a wider group of actors. The technical difficulties farmers experienced led them to seek out the support of other practising farmers. The willingness of certain pioneers to share knowledge both between themselves and with newcomers meant that the practice spread and social learning emerged. There is evidence from the interviews as well that early reluctance of some farmers has been replaced by interest and acceptance that this is a system they need to consider if cost savings are to be made, it is a pragmatic decision rather than one due to environmental or soil protection motivations. At the same time some advisors are now increasingly responding to farmers' interests and becoming trained. Indeed now it would appear that reduced tillage is becoming more mainstream, with, according to one promoter, up to 45% practising reduced tillage to some extent in England.

Disconnection – failure to share knowledge

Whilst the lack of support from peers and advisors led some farmers and interested actors to look for encouragement and knowledge by forging networks with like-minded farmers and actors, in some cases it served to isolate farmers and disconnect them, not only from their local community, but also the emerging reduced tillage community. These 'isolationist' farmers

chose not to interact with other farmers; they were unwilling to share their experiences and knowledge. One such farmer (SMI1) explained that he does not like publicity so has not gone out of his way to broadcast or share his experiences with a wider community; he has resisted visitors to his farm saying 'I don't shout about what we do'. A promoter (SMI15) described one successful reduced tillage farmer he had heard about saying 'I've been trying to get on his farm for 12 year to have a look' but without success due to the farmers' secretive and reclusive nature. This reluctance to be more open may stem from experiences of criticism from neighbours or simply from having a competitive nature but it was not uncommon amongst the farmers who changed to reduced tillage in the 1980s and 1990s. Some farmers are very protective of their hard-earned knowledge, one (SMI2), for example, does not seem to interact with many other farmers, he is competitive and not willing to share has secrets as he has put a lot of effort into learning about the new system and wants to protect that investment. It seems that there are a number of farmers operating in isolation from the emerging reduced tillage networks. Some may stay abreast of developments using the farming press, internet or contacting SMI, but they do not network or interact with other practising farmers, it is a one way process of knowledge acquisition.

There were also other reasons for these farmers wanting to detach themselves from the current interest and dissemination of information about reduced tillage. They are established reduced tillers and see themselves as purists. They are highly principled, and criticise SMI as not understanding the system and giving poor recommendations about weed control. Remarks like 'Well, I was around before they were' demonstrate a sense of grievance. These pioneer reduced tillers in particular have high standards and question the motivation of other farmers, one remarked 'I suspect most are doing it to cut costs and they think it's easy, but they are not doing it properly and some are making a mess of it'(SMI1).

These comments demonstrate that there is cohort of individuals who have elected not to engage with the reduced tillage learning community. Their reasons are varied but they are all pioneers of reduced tillage who have invested time and energy into changing their farming system over the years, in many cases motivated by a desire to improve their soil. They are now witnessing a revival of reduced tillage but one that is engaging people motivated by financial reasons. Thus they persevere with technical learning at the farm level but do not contribute to, or benefit from, the social learning that is now leading to an emergent and more mainstream practice.

Discussion

These results show that a community of reduced tillage farmers has been emerging in England with distinctive practices and modes of interaction characteristic of alternative agriculture systems. Individual farmers are learning at the farm level through experimentation, adaptation, and have used a variety of networking devices to take this learning and validate and reflect on it by interacting with others with the same interest. Thus the individual activity of on-farm technical learning is accompanied and enhanced by a process of social learning. Reduced tillage has emerged as a product of these technical and social learning systems, as Coughenour (2003) noted, it is a product of new social networks among farmers. However, the results have also shown that willingness to share knowledge is not universal, there are barriers to social learning in the context of reduced tillage which themselves are intimately connected with the technical complexities and capacities of on-farm learning.

Farmers describe reduced tillage as more difficult than ploughing with the transition phase being particularly challenging. They come to understand their soils, plant and tillage systems

through monitoring and experimentation, they know what works and adapt their practices in response to the vagaries of the weather. There is a sense of continuous and reflective learning and adaptation. As such this learning process is experiential and reflective, farmers review and reaffirm their decisions when they see mistakes or benefits emerging. There is a clear reliance on individual willingness to experiment, problem solve and 'trust [their] own judgement'. In this way reduced tillage requires adaptation of principles to place and is continuously evolving in its reconstruction and adaptation by individual farmers as Coughenour (2003) observed. Those farmers who persisted were single minded, committed and acknowledged that 'you've got to be prepared to make mistakes' and 'have to be convinced and have faith in it'. For some the experience is characterised by uncertainty and worry and the constant need to look for confirmation of their decision to stop ploughing.

The non-prescriptive nature of reduced tillage and the perceived difficulty of moving from a familiar and proven plough system to a no-plough system at the farm level had a number of consequences at a community level. Firstly, as the reduced tillage system had no standard procedures, advisors found it hard to engage with. Many did not want to encourage their farmers to change to, what in their eyes was, a riskier and inappropriate system. Secondly, again because of the perceived technical difficulty and apparent mistakes some farmers made during the transition period, many in the farming community did not embrace this new system and in many cases were openly critical. The results therefore provide a picture of a set of individual reduced tillers experiencing risk, uncertainty, isolation and lack of support from most of their peer group and advisory institutions. Their response is complex in terms of the emerging pattern of knowledge exchange and networking.

In a number of cases the lack of support acted as a stimulus for a small and discernible community of practitioners to interact and forge communication links to share knowledge and build a supportive environment. The networks established allowed farmers' experiences to be exchanged, compared and analysed. A social learning community emerged which enabled many farmers to continuously add to their base of knowledge. It gave farmers a chance to validate, reflect on and reinforce the technical learning that had gone on at the farm level. Through pooling their collective experiences and expanding their knowledge the reduced tillage farmers became 'the experts', other farmers and even advisors sought information from these practising farmers rather than from traditional sources.

Researchers, a small number of agronomists and promoters of SMI have also been engaging with this learning by generating knowledge through farm trials, co-learning with farmers and disseminating knowledge through workshops and publications. Thus practising farmers find themselves embedded in a wide range of networks. This collaboration, exchange of experiences and knowledge of their local experimentation, observation and problem solving are key features of social learning and through this reduced tillage has emerged as the shared knowledge of researchers, promoters, agronomists and farmers..

For some farmers, the lack of support from peers and advisors served to isolate and disconnect them from, rather than bond them to, a community of common interest and shared experiences. They became entrenched and were reluctant to interact, or share knowledge, with other farmers practising, or wishing to learn about, reduced tillage. Whether through fear of criticism, unwillingness to share information with a competitor, or because of a purist attitude towards reduced tillage, it is the non-prescriptive and complex nature of reduced tillage that has led to this reluctance. With respect to the purist approach, the same sentiments were conveyed by

some pioneer organic farmers who were described as idealists as they wanted to restrict entry of the new comers (described as 'profit oriented pragmatists') into organic farming. These 'gatekeeper' farmers did not want to dilute the principles or reduce the standards of the system by letting in less committed newcomers (Padel 2001). The 'isolationist' farmers practising reduced tillage continue to learn as individuals on-farm but do so outside of the learning community that has emerged.

It is interesting to consider how the technical and social dimensions of learning interact. The knowledge intensive nature of reduced tillage has lead to both the sharing and the protection of knowledge. For some the complexity, the risks and the uncertainties experienced in implementing reduced tillage has led them to seek support from, and share knowledge with others in the same situation. For others, however, the difficulties of the system and the time, effort and commitment they have invested in learning how to integrate it into their farming systems, has led them to protect their new found knowledge. While the former proudly demonstrate their successful transition away from the plough, the latter have become the guardians of the principles of reduced tillage unwilling to encourage newcomers.

Conclusion

This research has shown that, in response to policy and economic challenges, a discernible group of farmers have been integrating reduced tillage into their farming systems in England. However, it is clear that the integration of a reduced tillage system relies not only on the willingness and capacity of farmers to experiment, innovate and learn at the farm level but also on their willingness to interact with other farmers and interested actors and to share their

knowledge and experiences. As Kroma (2005) has asserted such ‘systems require, not only a coherent set of technological innovations, but also a corresponding set of social arrangements among stakeholders’. This research has revealed that learning within a social system comprised of the shared knowledge of farmers and other interested actors has complemented learning in a technical system at the farm level. Despite the reluctance of some practising farmers to engage, the willingness of the majority to collaborate in a social learning community has contributed towards the emergence of reduced tillage in England.

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