Knowledge and Precaution. On Organic Farmers Assessment of New Technology

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Abstract

Organic farming is under constant pressure to reinvent itself by adopting new technologies. This article examines the role of precaution in organic farmers' assessments of new technologies, and asks how their assessments draw on different types of knowledge. The article further explores how knowledge type compares to the role of knowledge and precaution expressed in the principles of organic farming as defined by the organic movement organisation, IFOAM. Results from a study of the introduction of sewage sludge as an alternative source of nutrients in organic agriculture are presented. Empirically, this case-study builds on the analysis of five focus groups made up of Danish organic farmers. While some farmers called for precaution, supporting this with claims about lacking knowledge, others trusted the authorities and accepted sewage sludge provided it was officially approved for organic use. Our analysis suggests that when assessing new technologies Danish organic farmers rely on scientific knowledge and do not automatically draw on the experiential knowledge they possess and employ in other contexts. It is concluded that if IFOAM wishes include farmers' experiential knowledge as a basis for decisions about precaution, there is a need to develop instruments making it possible to tap into this knowledge.

Introduction

Over the past few decades, organic agriculture has undergone rapid growth, and it is now practiced in more than 150 countries globally and has a global market value of more than US $60 billion (Willer and Lernoud 2014). This expansion has transformed the organic food system from the informal groupings of local, loosely organised networks in the early 1970s to a global, formalised and regulated food network (Raynolds 2004).

The growth has also been accompanied by technological developments in the organic sector, where new technologies such automatic milking systems, robot-based

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weed control systems, and the development of new organic fertilisers and plant breeding, are widely applied or finding their way into organic farming, while other advances such as genetic technologies are contested and rejected as inappropriate organic technologies. The technological development reflects in part a desire to develop organic technologies that differ from those applied in conventional farming. It also underlines the fact that organic producers, though they are guided by values pointing beyond the profit motive, are under constant pressure to produce more efficiently to remain competitive in the challenging global food market.

The transformation and technological developments in organic farming have made it necessary to develop a means of determining when technologies are compatible with organic production and when they are not. Thus, standards have played an increasingly important role in the regulation of the organic sector, defining what is, and what is not organic, and guiding decisions about methods of production (Courville 2006). Apart from providing a normative framework for the many certification systems governing organic production in different countries, the standards have also supplied sets of norms guiding producers in their daily practices; they are important tools for determining whether new technologies comply with the organic ideal.

Historically, the International Federation for Organic Agricultural Movements (IFOAM), established in 1972, has played an important role in the technological development of the organic sector. IFOAM has formulated and frequently revised principles which define organic production and thus guide decisions on whether a technology can be used in organic production systems (Luttikholt 2007). In 2003, IFOAM indicated that there was a need to reflect on and discuss the fundamental principles underpinning organic production in light of the rapid global changes that were occurring (Luttikholt 2007). Following a global-scale participatory process, four new principles were formulated: the principles of care, health, ecology and fairness. IFOAM said these principles were 'Composed as inter-connected ethical principles to inspire the organic movement ...' and expressive of 'the roots from which organic agriculture grows and develops' (IFOAM 2006). Apart from reflecting the interests of IFOAM members, and thus expressing a common value base for members of this organisation, the new principles must also be recognised as having been influenced by the already existing organic standards forming the regulatory framework of organic production.

Although IFOAM's four principles are statements of the organic vision offering an interpretation of the core organic values, they do not provide useful guidelines for decisions about new technologies or for organic farmers' actual production practices. Furthermore, they may or may not match the individual organic farmer's understanding of what organic farming is. More concrete guidelines are formulated as standards in legally binding regulations where precise criteria for organic production are set out. In the EU, for example, the directive on the production and labelling of organic products (European Union 2007) introduces standards that national regulations in the member states must comply with. These standards define a concrete framework for determining whether, within the EU, a given technology should or should not be classified as organic. On the one hand, the legal standards are the result of negotiations between different interests, and as such they cannot be regarded as 'translations' of the organic principles into a tangible set of rules. On the other hand, the standards will inevitably have been inspired by the IFOAM principles, and they therefore link the ideology of an important organic movement organisation like IFOAM with enforceable rules on which technologies are, and which are not, permitted.

While the legal standards in this way make up an inescapable framework for the individual organic farmer, at least if he or she wants to market produce as organic, the organic principles represent an ideological frame the farmer may or may not subscribe to. The overall aim of this article is to explore how an important element of the four organic principles, namely precaution, is understood and expressed by organic farmers. Insights into this will deepen our scientific understanding of precaution and its role in practitioners' assessment of technology. It will also shed light on the differences between organic practitioners' views and the common principles of organic farming laid out by IFOAM. In this way, it will help to explain potential tensions in parts of the organic movement as well as the dynamics driving future developments in the organic sector.

Risks and precaution

Risk and precaution are important elements of the IFOAM principle of care, when it comes to decisions regarding the use of new technology in the organic standards. The IFOAM care principle states that: 'Organic Agriculture should be managed in a precautionary and responsible manner to protect the health and well-being of current and future generations and the environment' (IFOAM 2012). Later the principle describes how organic agriculture should deal with risks arising from the use of new technologies, in particular in situations where knowledge is limited, or where the risks are uncertain and hard to quantify: 'When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically. In this context the proponent of an activity, rather than the public, should bear the burden of proof' (IFOAM 2012). In using this strong definition, the principle puts the burden of proof on those who create potential risks, and requires activities to be regulated even if it cannot be shown that those activities are likely to produce significant harm (Sunstein 2003). IFOAM's stance is that organic agriculture should 'prevent significant risks by adopting appropriate technologies and rejecting inappropriate ones' (IFOAM 2006).

The precautionary principle is not unique to the organic movement and is applied in the regulation of various technologies and activities. In the EU, for example, precaution is written into the Treaty on the Functioning of the European Union (see European Union 2012) and is a fundamental principle of European legislation: it must be invoked where urgent measures are needed in the face of a possible danger to human, animal or plant health, or to protect the environment where scientific data do not permit a complete evaluation of the risk. Tosun (2013) notes that the precautionary principle is a legal principle applying to cases of risk and scientific uncertainty which operates at three levels within the EU: when EU institutions propose European policies, when member states seek exemptions from common rules, and when the EU interacts with third parties in international trade. Thus, according to the EU, there can be no question of merely taking a negative attitude towards risk. However, risk management through the use of the precautionary principle can occur in different ways.

In the decades preceding 1990, US and European risk policies were more or less similar. However, as noted by David Vogel (2012), a transatlantic shift in regulatory stringency occurred around 1990, after which European regulations tended to be more precautionary. Whilst the EU is typically proactive in regulating uncertain risks, the United States has been shown to take a different stance, waiting for evidence of harm before regulating (Wiener and Rogers 2002). In their comparison of EU and US approaches to the precautionary principle Wieners and Rogers (2002) identify three general variations in its application, signifying that the principle can be used in a strong and weak manner. The three variations are typified by an increase in the aggressiveness of the application. The first, 'Uncertainty does not justify inaction', is identified as the most basic form of the principle and permits regulation in the absence of complete evidence about the particular risk in question. The second, 'Uncertainty justifies action', is exemplified in the first part of the IFOAM definition above: 'precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically'. Here, cause and effect are not established, and it remains unclear what causes harm and what measures would actually prevent it. The third variation, 'Uncertainty requires shifting the burden and standard of proof', is the most aggressive. It requires a ban to be put on activities of uncertain risk until it has been demonstrated that no (or an acceptable) risk exists. The second part of the IFOAM definition aligns with this requirement that the proponent bears the burden of proof.

In Europe organic agriculture and the processing of organic products are regulated by standards set out in the EU regulation on organic farming, Council Regulation (EC) No 834/2007 (European Union 2007). The EU regulation does not adopt the terminology used by IFOAM, but the council regulation does set out the principles, aims and overarching rules of organic production, and it includes the precautionary principle: it states that organic production shall be based on 'the appropriate design and management of biological processes based on ecological systems' and goes on to describe methods which, among other things, 'are based on risk assessment, and the use of precautionary and preventive measures, when appropriate'.

In all interpretations of the precautionary principle knowledge plays a central role. Quantitatively, this introduces questions about the amount, or level, of knowledge that is required as sufficient to assess the risk, and, where there is a lack of knowledge, about the threshold below which the precautionary principle should be invoked. While these are important issues, they are fundamentally questions that should be addressed by the relevant scientific fields as part of a risk assessment. We will instead discuss the equally important qualitative question, namely: What kind of knowledge is considered relevant and therefore capable of demonstrating that the precautionary principle should be invoked?

In the regulatory arena politicians and authorities typically turn to scientists and their risk assessments for greater certainty and conclusive evidence of the risks of a new technology. In contrast, IFOAM's principle of care explicitly acknowledges the relevance of knowledge from other sources, including the knowledge possessed by practitioners: 'Science is necessary to ensure that Organic Agriculture is healthy, safe and ecologically sound (...) scientific knowledge alone is not sufficient. Practical experience, accumulated wisdom and traditional and indigenous knowledge offer valid solutions, tested by time' (IFOAM 2006).

Despite this epistemological difference between the regulatory and administrative culture, which focuses on scientific knowledge, and IFOAM, which refers additionally to farmers' practical knowledge, it has not yet been explored whether there is agreement between the organic practitioners and the organic movement organisation over what kind of knowledge is considered legitimate is situations where precaution is being considered. To date a number of scientific studies have addressed farmers' use of knowledge, stressing that farmers rely on a mix of several kinds of knowledge in their practice (e.g., Morgan and Murdock 2000; Ingram 2008b; Kaup 2008). These studies point to the fact that farmers rely on scientific knowledge alongside knowledge of a different nature and from other sources. Morgan and Murdoch (2000) even suggest that while today's conventional agriculture is largely guided by scientific knowledge, organic farming, because its practitioners have been forced to re-learn ways of farming that are in closer relation to the ecosystems and rhythms of nature, is dominated by what Morgan and Murdoch term 'local knowledge'.

The remainder of this article will contribute to this discussion and seek to explore how scientific and other forms of knowledge are used by organic farmers when they assess new technology. Thus we will seek to answer the following questions: 1) What role does precaution play in organic farmers' arguments for and against the adoption of new and contentious technologies?, 2) What types of knowledge do organic farmers draw upon when they consider the application of a new technology that may require precautionary handling. But first we need to clarify our understanding of knowledge.

Knowledge

Scientific knowledge (as we shall call it in what follows) is often referred to as 'codified' or 'standardised' (Morgan and Murdock 2000; Raymond *et al.* 2010) or as 'know why' (Lundvall and Johnson 1994). It is typically characterised as an output of formalised studies, where there is common agreement on principles of validity and reliability. Another feature of scientific knowledge is that it is decontextualised, that is, produced, presented and communicated in a standardised way and not connected to a specific place; this makes it applicable in different contexts (Ingram 2008a).

Regardless of their focus, studies of farmers' knowledge typically distinguish between scientific knowledge, on the one hand, and knowledge that is highly dependent on the context, on the other. This other kind of knowledge is referred to as, for example, local knowledge (Kloppenburg 1991), experiential knowledge (Goven and Morris 2012; Krzywoszynska 2015) or tacit knowledge (Morgan and Murdock 2000; Curry and Kirwan 2014). These 'other' kinds of knowledge share the feature that knowledge is produced informally in a specific context, typically as a result of watching or carrying out practical work. Stressing the common reference to experience, we will for the purpose of our study characterise this kind of knowledge as *experiential knowledge*. (For overviews of experiential knowledge see Fazey *et al.* 2006 and Raymond *et al.* 2010).

Most studies of farmers' knowledge look at knowledge in a context of concrete farming activities. Some focus on the different kinds of knowledge applied in specific situations during everyday activities on the farm, where the farmer needs to decide what to do (e.g., Kaltoft 1999; Kaup 2008). Ingram (2008) and Ingram *et al.* (2010), for example, studied farmers' knowledge of soil management practices. Others have investigated how the knowledge applied in these everyday farming contexts is learned, acquired or shared (Curry and Kirwan 2014; Krzywoszynska 2015). Besides the experience-based knowledge that farmers can articulate, these studies include a tacit knowledge element. Tacit knowledge, according to Wilbur (2014), is embodied, experience-based knowledge, and because it is unconscious not articulated.

Unlike these studies of practical farming, our focus on farmers' assessments of new technology fall within a small group of studies which look at the knowledge farmers draw on when they engage in more general discussions of policies and the regulation of technology within agriculture. Only a few such studies exist, and they typically address farmers' knowledge either in relation to the assessment of the risks and regulation of genetic technologies (Mauro and McLachlan 2008; Mauro *et al.* 2009; Goven and Morris 2012) or in relation to farmers' decisions to adopt a new technology in their own practice (Kaup 2008).

As our question is not about practical farming, but a more general one about the assessment of new technology, we are interested in what Failing *et al.* (2007) refer to as fact-based knowledge claims. Fact-based knowledge may refer to practical experience (experiential knowledge), or it may refer to science (scientific knowledge). It should be noted that although we recognise its importance in practical farming, tacit knowledge is excluded from the analysis we shall present. This is because tacit knowledge is not articulated and therefore is not a visible element in discussions of new technologies – to the extent that it does play a role, tacit knowledge is expressed in normative claims about the right technology lacking a detectable knowledge basis.

Alternative nutrient sources as a context for investigating knowledge and precaution

Our analysis of the role of precaution and the kind of knowledge applied when justifying precaution will be based on a case-study of Danish organic farmers' views on the adoption of sewage sludge fertiliser technologies in organic farming. These technologies, which are controversial because there are potential contamination issues, have been suggested as alternative fertiliser solutions for organic farms in Denmark previously reliant on manure from conventional farms.

The organic agriculture sector in Denmark recently made a landmark decision to phase out and ultimately ban the use of nutrients from conventional farms (e.g., in manures or straw) (Oelofse *et al.* 2013). Following this decision, the Danish organic sector has had to rethink its management of current nutrient resources and seek alternative sources of nutrients that are capable of meeting its needs. No one-off technological solution to this challenge exists; instead, meeting future nutrient requirements will require a tapestry of smaller initiatives. One such initiative involves the application of sewage sludge (in some countries referred to as 'biosolids') as a fertiliser in arable organic systems. However, although sewage sludge is a source of increasingly contested phosphorous and other nutrients, its use is banned in organic farming in the EU because there are concerns about the potentially harmful and toxic elements it contains (Möller and Stinner 2010) and about hygene problems.

Whilst the organic sector is adamant about banning sewage sludge, over the past twenty years approximately 60 per cent of sewage sludge produced in Denmark has been applied to conventional agricultural land (Jensen and Jepsen 2005; Danish Ministry of the Environment 2010). What might explain this discrepancy between conventional and organic systems? Does sludge really pose a serious risk? Oelofse *et al.* (2013) reviewed studies of sewage sludge's content of contaminants, and concluded that, although a complete risk assessment cannot be undertaken (due mainly to emerging contaminants), there is overwhelming evidence that: 'recycling of sewage sludge on farmland is not constrained by concentrations of inorganic or organic contaminants found in contemporary sewage sludge'. Clarke and Smith (2011) maintain that the most sustainable option for biosolid use is land application. However, they stress the need for 'continued vigilance' in monitoring and assessing the implications of emerging organic contaminants.

Thus, sludge-use in organic farming would amount to the introduction of a novel and contested technology: one in conflict with the principles of health and care as a result of the risks, yet in keeping with ecological principles because it involves the recycling of nutrients. As such sewage sludge serves as an illustrative case for studying not only the relation between knowledge and precaution in the organic sector, but also differences between the approaches of organic practitioners and the organic movement to the assessment of new technologies.

Methods

Since there is limited scientific information on the way organic farmers perceive and assess technologies, a semi-exploratory qualitative approach was chosen. Five focus group interviews with Danish organic farmers were carried out in 2012. Participants were recruited strategically to ensure the representation of a diversity of positions on the role of precaution and knowledge in arguments over organic legitimacy: the strategy was chosen to ensure that there were differences in expected value orientations and structural differences in, for example, current farming practices and backgrounds.

Recruitment according to the value criterion was based on the assumption that organic farmers represent a diversity of values. As it was assumed that these value differences would be reflected in their assessment of potential organic technologies, the recruitment ensured a fair distribution of participants' values. This criterion was operationalised by recruiting farmers from the two producer organisations: 'Organic Denmark', which is known primarily to organise farmers with traditional organic values, and the 'Danish Agriculture and Food Council', which has historically represented conventional farming but now also represents organic farmers with values that tend to be closer to those of conventional farmers.

Recruitment according to the structural criterion was based on the degree of technical and economic difficulty the replacement of conventional nutrients would present to the farmers. This was operationalised with reference both to the farm's geographical location and to the type of production. Thus the criteria included distance to alternative nutrients from other organic producers, as well as whether the farm was a dairy farm (assumed to face fewer challenges) or a plant producer (assumed to face more severe difficulties following the decision to phase out). In addition, the recruitment ensured diversity in how many years the farm had been organic. Recruitment was carried out using a snowballing technique in which contacts within Organics Denmark and the Danish Agriculture and Food Council identified potential participants on the basis of detailed instructions.

The interviews were semi-structured and carried out using a funnel-shaped interview guide. This allowed the discussion to develop from general, exploratory themes, starting from the participants' associations with, and visions for, organic production, and then moving on to more structured discussions of the decision to phase out conventional nutrients, and finally to concrete technological solutions to the nutrient problem. In the structured part, the participants were invited to discuss specific technological solutions to the problem of phasing out and banning nutrients from conventional sources. Three of these solutions were specifically related to the use of sewage sludge:

1. The use of untreated sewage sludge from the waste water treatment plant
2. The use of composted sewage sludge from the waste water treatment plant
3. The use of pure phosphorous recovered from sewage sludge by heating it to 1500°C

The first two solutions are, to varying degrees, already used in conventional agriculture in Denmark, but they are banned in organic farming. The third option uses a technology that is not yet fully developed and hence is not adopted on a large scale in Denmark. It does not meet the present regulatory requirements of organic farming in Denmark. The three solutions were chosen because they illustrate some of the dilemmas organic farming is encountering and therefore provide a good basis for exploring the role of knowledge and uncertainty.

All the interviews were audio-recorded and transcribed verbatim. Our analysis of the transcripts concentrated on the question: What type of knowledge do organic farmers consider to be legitimate in their decision-making about technologies compromised by uncertainty? Legitimate knowledge types were identified by analysing the reasoning that farmers employed when arguing for or against the three proposed solutions, specifically focusing on the knowledge types used as a basis for the reasoning.

In the analysis the qualitative software NVivo was used to code the interviews. We coded statements as *scientific knowledge* claims if they referred to abstract, generalised information – e.g., to facts about chemical composition – which could be supported by referring to scientists or other recognised experts (although in fact such support was not necessarily provided). Characteristically, this kind of information was not based on the farmer's own experience; nor was it related to specific geographical localities.

Statements were coded as experiential knowledge claims if they referred to the farmer's own experience or colleagues' experiences. The colleagues in question could be organic or conventional. Such experiences could refer to uses of sewage sludge or be based on parallels with other technologies.

It should be noted that our analysis is not confined to claims about technical aspects of the agricultural system. Following Failing *et al.* (2007), who note that local knowledge (like our experiential knowledge) includes indirect impacts of proposed actions such as sociocultural and economic effects of a given action, we include such non-technical claims in the scientific as well as the experiential codes.

In addition to this deductive approach, we employed an inductive approach, where knowledge claims that were neither scientific nor experiential were coded in a third category. Finally, it should be noted that our primary interest was in the nature of the knowledge, and in how it is used in arguments about sewage sludge. This means the analysis does not examine whether the data referred to are accurate, and whether the conclusions based on the data are reasonable.

In the analysis of the coded claims we applied a simplified version of Toulmin's model of argumentation, where an argument consists of a claim (the statement being argued), followed by the backing (evidence to support the claim) and a warrant (the underlying assumption that connects backing and claim) (Toulmin 2003). This approach is particularly helpful, since in a systematic way it enables us to identify the knowledge basis applied by farmers. Thus the claim will be the conclusion, i.e., whether a certain new technology should be pursued or not in organic farming, while the knowledge basis will be contained in the backing which the farmer uses to justifies the claim.

Participants appearing in the quotations illustrating our analysis in the following have all been anonymised.

The precautionary principle and farmers' assessment of new technologies

The participants in the focus groups found the use of composted sewage sludge and phosphorous recovered from sewage sludge to be more acceptable solutions than the use of untreated sludge, which was clearly less acceptable. Many of the participants agreed, in principle, that a sewage sludge solution to the phasing out of conventional nutrients was a good idea, as it can lead to closed nutrient cycles in organic systems. However, the participants identified a range of problems with the use of sludge, and these were so serious that most participants either wholly rejected the use of sewage sludge in organic farming or could only conditionally accept its use.

In a number of the focus groups participants considered sewage sludge as a resource that can help address the nutrient challenge facing organic farmers as well as a societal problem that should be solved. Some participants considered organic farming to be an integral part of society, which thus entails assuming a shared responsibility for solving societal problems. For some, this would entail taking a risk.

For example, Mads would be willing to accept his fair share of heavy metals: 'But we must say yes to being part of society and therefore "eat" [accept] a certain portion heavy metals'. Mads not only viewed organic farming as part of society, but also, along with other participants, as in part a social construct: on this view, organic farming is not an objective fact; rather it is what you make it. This view entails that some compromises need to be made – e.g., the acceptance of heavy metals in sewage sludge, or imports of organic products from other countries with less restrictive organic regulations. In some cases, however, participants categorically rejected sewage sludge as a solution. Here organic farming was viewed as a separate entity, isolated from society as a whole and driven by rural-urban differentiation. This is exemplified in the discussion below, where the group broadly agree that sewage sludge is largely an urban problem:

> Lauge: I do not see why we should be the ones that have to get public waste. We are the ones criticised all the time by people who live in the city or the public. Why the hell should we suddenly get all their waste? They should damn well deal with it themselves. I don't want it on my fields.
> Lauritz: I don't either
> Lauge: It may be grotesque, as I said, but then we can be of use, then we are damned good enough if we take all the crap they have in the city – so they can get rid of it. Now we can be of use. I will not accept this. I think they must damn well figure out themselves what they will do with it.

The focus group respondents expressed opinions about the application of the three technologies with differing degrees of certainty and differing degrees of precaution. The degree of certainty expressed by respondents was often linked to (1) whether, and in what way, they accepted the given technology, and (2) the source of the knowledge on which they based their expressed opinion. In the following, we present two dominant positions, namely those of certainty and precaution/rejection.

Certainty

On a number of occasions in the focus groups participants were seen to evaluate the acceptability of the three technologies with a high degree of certainty. The participants – at least, in discussion with their peers – expressed their opinions in a highly confident manner, indicating that they were not in doubt about the extent and quality of the knowledge base they were drawing on when judging the acceptability of the three technologies. This confident stance is exemplified in the following discussion, where participants are discussing the acceptability of using pure phosphorous recovered from sewage sludge. Neither those in favour of the technology nor those against it seem to be in any doubt about whether they have sufficient knowledge on which to base their opinion:

> Magnus: This [solution], it has to be the way forward, no doubt about it. It is a temporary solution until society's sewage problem is solved. This [solution] is therefore far more preferable. We are talking about a pure nutrient.
> Mikael: We agree that we have phosphorous [recovered from sewage sludge] and that we then just need some potash and nitrogen, and there you have it – it's a done deal. Now

> it gets damn difficult, now you have to apply it to the field several times. I think, no, I can't go along with this [solution].
> Magnus: But you get the phosphorous back. This is a good thing, as there is not enough phosphate in the ground.

On other occasions, participants displayed just as much certainty in their stance, although here the knowledge they referred to was not their own, but based on that of the authorities. This stance signifies a firm belief in the authorities, based on the logic that if they have approved a technology, then the technology's utility and potential risk must have been checked and found to be acceptable. The stance is illustrated in a discussion between Kurt and Kaj, who, at the start of the discussion, both expressed doubts about the contaminants in composted sewage sludge:

> Kurt: Yes, what is the difference between the two in regard to the issues we are working with ... because the thing is ... it is approved for that use, so that we can apply it to the crops we have ... so ...
> (...)
> Kaj: I could very well [accept it], provided there are no pathogens that can be transferred, but we should probably assume that if it has been approved by the authorities, then we should probably count on that it's okay.

We can thus expect, in such cases – where farmers have full confidence either in the authorities or in their own knowledge – that it is not necessary to introduce precaution in any manner.

Precaution

In the focus groups many participants expressed conditional acceptance of the proposed technological solutions. Each of the three solutions in its basic form was essentially rejected. However, if a number of (variously combined) preconditions could be met for the various technologies, they would then be found acceptable. It can be seen, then, that the participants subscribing to this stance demanded precaution until certain conditions were met. As we shall show below, these conditions pertain to a lack of knowledge about the technology as well as a number of more concrete technical criteria, like guaranteed absence of harmful substances or a demand for structural changes as a precondition for acceptance.

The fact that participants raised concerns about limited knowledge demonstrates that they were unclear about the potential consequences of the three technologies. This position is evidence that the precautionary principle is being applied. Acceptance of a technology demands further evidence or knowledge – a 'knowledge condition' – that confirms that the technologies are not problematic. More knowledge is required in order to satisfy 'the burden of proof'. Concerns about the effects of a new technology on human health and the environment are typical issues which cause the precautionary principle to be invoked.

Although some participants in the focus groups indicated that they would be satisfied with a technology if it met with the authorities' approval, others demanded that they themselves be informed of the consequences (rather than simply trust the authorities). One example is a discussion in which participants had just agreed that the untreated sewage sludge option is unacceptable because the product is not clean enough. In the ensuing discussion, two participants demonstrated an inclination to accept composted sewage sludge if they were presented with evidence that the hormone and heavy metal content is not problematic. Similarly, in another group, participant Henning rejects the use of composted sewage sludge unless he can be one hundred percent certain that the product does not contain 'some of those substances that are otherwise found in normal sewage – hormones, heavy metals and I don't know what else'. At this point in the discussion, even after the interviewer had confirmed that researchers have shown that composting degrades the organic compounds, Henning remained highly sceptical, continuing to demand documentation of this:

> If I get proof that it is as it is, and I can rely on it, then I actually ... and it's ... it's again, what are the threshold values? (...) I just want to know that it's clean, and I want to know what it is, and that it's safe. And there shouldn't, of course, be endocrine disruptors and all kinds of rubbish in it.

Particularly noteworthy here is the fact that, even though Henning had just asserted his need for one hundred per cent certain knowledge as well as proof, he still demonstrated a willingness to soften his demands; he recognised that the setting of threshold values for contaminants is influenced politically and is not based purely on scientific results.

As well as raising concerns about environmental contaminants, almost all groups expressed the need for structural changes in the food and/or waste collection and management systems before sewage sludge could be accepted. Indeed some participants talked about a potential separation of organic consumers from others where waste is concerned, envisaging a dual consumer-waste system allowing organic farms to receive waste from 'organic consumers'. It was clear, though, that these ideas were canvassed primarily as a vision of how things might be:

> Interviewer: Right, let us continue to the next card, which should be C: to use sewage sludge directly from the waste water treatment plant. You receive untreated sewage sludge directly from...
> Max: That won't work as things are now. But when society as a whole has converted, then it will be a good solution.
> Magnus: But we are going to have two sewage systems; one for those who eat organics and one for those that choose to take birth control pills and all the other problems.

Max's suggestion that sewage sludge would be an acceptable solution when the whole population has converted to organic offers a different perspective. His stance represents a conditional acceptance of sewage sludge. The condition is that a larger proportion, if not all, of society's food supply must be organic. It is clear that Max is assuming, albeit tacitly, that society-wide consumption of organic products would eliminate any problematic substances. Magnus, perhaps contentiously, differentiates between organic consumers and those who use birth control pills.

The role of knowledge

On a number of occasions focus group participants indicated that they lacked the knowledge they needed to accept or reject a technology, or even to form an opinion about it. The next section therefore presents an analysis of the types of knowledge that respondents drew upon in forming opinions about the new technologies. The analysis helps us to see what kinds of knowledge the respondents felt they lacked.

Scientific knowledge

One of the dominant knowledge types revealed in the analysed discussions was scientific knowledge: in spite of the fact that organic farmers' scientific knowledge is perhaps not very extensive or deep, the use of this kind of techno-scientific reasoning was common. In their reasoning about sewage sludge technologies the focus group participants typically drew on knowledge of biological and/or chemical processes, often in combination with knowledge of environmental and health-related risks and natural resource problems. This knowledge type was most confidently applied in exchanges where participants expressed a high degree of certainty by presenting 'facts' (e.g., about sewage sludge's chemical composition) as the basis of their own risk assessments and subsequent conclusions. In the following statement, made by Lauritz, this knowledge type is applied as a basis for rejecting the technology:

> Yes, it is absolutely crazy. We know that humans are the last link in the food chain, and we know that all the hormones and all foreign substances and all the heavy metals accumulate in the food chain, and then we want to bloody put it back into the food chain again! That is one of the stupidest things we could do. Because there are actually many more hormones, with all the medicine and all the crap we eat, birth control pills and all kinds of other things that will go back to the food, than there are in the little bit found in animal production. This, this will be a disaster if it is introduced.

Elsewhere in the interviews, scientific knowledge was less rigidly applied, although the same line of reasoning was used either to make demands about the conditions which should be met before the technology is acceptable, or to argue why precaution should be exercised. In the remarks above, Lauritz does not specify whether he is referring to the environmental or the health-related risks associated with the technologies. This kind of ambiguity was not uncommon in the discussions. We observed many instances where, in their reasoning, participants did not distinguish between nature/environment and humans/health. It seems reasonable to assume that these two spheres are perceived as one and the same in practice – the idea being that where something represents a risk to nature it is also a risk to humans, as we live in, and consume parts of, the natural world.

We also observed scientific knowledge being applied where participants referred in their reasoning to the organic ideal of nutrient cycling. The considerations presented here were grounded in an ecological and ecosystems perspective. In this perspective organic farming is viewed as an integral part of a closed ecosystem. In this system there is a balance, and this is exemplified by the recycling of nutrients. Nutrient recycling in organic farming is thus an ideal which can be achieved by accepting technologies that promote the recycling of sewage sludge. However, the ideal is threatened by the potential risk of contamination by harmful substances. This is expressed in the following exchange:

Jacob: But we have just spoken about how the solution was to get [the nutrients] back from the cities, and then it's in the form it has to be, and how the rules should be, that we will be allowed to get it. Isn't it that what it's all about?
Joakim: Yes, and break the infection paths. That's what we are currently afraid of.
Jim: And then all those substances in it, heavy metals and Ecstasy and what not.
Jan: Yes, and birth control pills and hormones and other things. You never know exactly what. Even though it's from private homes, a lot of things are used and we don't really…

Finally, some participants referred to political or economic knowledge in presenting their arguments. This resembled the use of knowledge of the biological and chemical sciences discussed above, but here instead economic knowledge, for example, was used to support positions for or against technologies. Such knowledge was used, for instance, when it was claimed that Danish farmers will suffer from new technologies because they will have to compete with farmers from countries where the organic regulations are less restrictive, or that consumers might react badly on discovering that Danish organic farmers had adopted potentially controversial technology.

Experiential knowledge

We observed only one example of the use of experiential knowledge. This can be seen in the following argument, where Kaj drew on his experience with irrigation to back up his view that there may still be unwanted and risky substances in sewage sludge:

Well, I think yes, we should really do so, but whether we should apply it directly, this is something completely different and we should not do so before it is risk free. I think about both the disease and the risk of heavy metals, and there is probably an awful lot that is still active, penicillin in the sewage sludge, I could imagine. Many, many years ago, back in the seventies, we irrigated from a stream where the treatment plant used to be, but I just think it was just some containers, it ran through. When we had irrigated with that water, the soil went completely black, and then I learnt that in the beet field where we used to work, there were some new plants. Then once they got a little bigger, they had tomatoes on them, so if they can go through, then penicillin probably can too. We should, of course, return the nutrients back to the soil, but we should not do so if there is a risk of disease.

Other types of knowledge

Other types of knowledge were displayed when the participants, arguing for the acceptance or rejection of one of the solutions, drew on their understanding of moral or emotional valuations. One can discuss whether this is actually knowledge in the typical sense. However, reasoning based on moral and emotional arguments did appear in the focus group discussions, typically when participants expressed the view that recycling sewage on their own fields was a moral duty that must be performed in order to help solve a societal problem. This knowledge type was applied only a few times, but it can be detected in the following remarks made by Magnus, who expresses a sense of moral obligation:

(…) I think that we have a problem in saying [no to these technological solutions]. It is actually a societal issue, and we are obviously part of society, therefore we cannot say

> that it shouldn't be applied [in organic farming]. This, I do not like at all. We will have to accept just like any other person that we are part of society and we are also part of some of the solutions, and we may even qualify some of the solutions.

Discussion

In general, the participants found solutions based on composted sewage sludge and recovered phosphorous to be more acceptable than using untreated sludge. However, the results show that, while the participants felt that the suggested measures to increase nutrient cycling were a good thing, there was considerable ambivalence over the specific technologies.

There is no simple answer to the question: What role does precaution play in organic farmers' arguments for and against the adoption of contentious technologies based on sewage sludge? Rather our study highlights a challenge in the application of the organic principles – should the principle of care, and thus precaution, outweigh the principle of ecology, or vice versa? Our findings suggest that at least some Danish organic farmers seem to prioritise the principle of care over other principles, although there is no real pattern in their reasons for doing so. Some farmers expressed the need for increased recycling and indicated their belief that they have a societal responsibility to do so; others prioritised precaution (care) over ecology.

Interestingly, we found that a number of the participants did not call for precaution. These farmers felt that they themselves, or the authorities, have sufficient knowledge to decide on the technologies. Among the farmers suggesting some form of precaution, some said they have a societal responsibility and that the potential risk is part and parcel of being a farmer. Although these farmers did not necessarily dismiss precaution, they presented a weaker version of the precautionary principle, since they fundamentally accepted some risks. By contrast, other participants urged precaution and rejected the solutions. Unsurprisingly, the farmers calling for precaution were concerned about the known, as well as unknown, risks to health and the environment. They adopted a stronger version of the precautionary principle on which assurances about the technologies would have to precede their acceptance. Often, however, the requirements were not limited to a call for the proponents to meet the burden of proof, but included a demand for specific structural changes in food and waste management – thus adding a more proactive approach involving changed practices to the precautionary principle.

All in all, we found a close link between farmers' outright acceptance or rejection of a technology and the degree of certainty expressed. Conversely, when participants were in doubt, and expressed precaution, this was attributed to a lack of knowledge about the technology and its potential risks. There seems therefore to be an interesting interplay between participants' acceptance of the technology and use of precaution and the type of proof (knowledge) they demand before they accept a given solution – an interplay that we will discuss below.

When it comes to our second question about the types of knowledge organic farmers draw upon when considering technologies that may invoke precaution the answer is clearer. It was striking that the interviewed farmers based their argument predominantly on scientific knowledge. Two factors render the contrastingly limited use of experiential knowledge somewhat unexpected. First, what we term 'experiential knowledge' is emphatically classified as valid knowledge in IFOAM principles which organic farmers have been involved in developing. Second, the use of sewage sludge is not entirely alien to Danish organic farmers, as many of their conventional colleagues have used sludge for many years – yet no reference was made to this in the organic farmers' arguments.

The relatively low use of experiential knowledge found here is also contrary to the findings of social psychologists, who have demonstrated that, when assessing new phenomena, our assessments are anchored in existing, known phenomena (Moscovici 1981). Following this line of thought, the organic farmers would not need to have had actual experience with sewage sludge- or sewage-based technologies to make use of experiential knowledge – they could do so with reference to their experience with other, similar technologies. This is exactly what happened in the sole episode in our interviews where a farmer based his assessments on experiential knowledge: he anchored his assessment of sewage sludge in experiences with irrigation.

The heavy reliance on scientific knowledge may also have had something to do with the structure of the education system in Denmark. Historically, Danish farmers were subject to enlightenment in the late nineteenth century, where they were taught new technological insights in, for example, high schools, and integrated these in their production systems and in the corporately owned food processing facilities. This development continued in the early twentieth century and played an important part in securing the establishment of the Danish welfare state. Unlike in Germany, where education, inspired by Humboldt, was largely controlled and organised from above by the state, in the Danish system peasants and other popular movements, organised and controlled education from below (Stråth 2004). Thus the Danish co-op movement was founded partly on a strong movement of peasant farmers who had established an independent culture incorporating their own educational system (Østergård 2004). As a consequence of this, Danish farmers may have established a stronger tradition of scientific approaches to farming in which scientific arguments are considered highly relevant. When organic farming emerged on a larger scale in Denmark in the 1970s and 1980s, it was seen as an alternative to conventional farming, but it did not involve rejecting the scientific approach to farming, but rather questioning the values behind, and criticising the side-effects of, industrialised farming. Moreover, one of the important groups of early Danish organic farmers in the 1970s was rooted in academia, with members who had studied biology or agronomy (Kjeldsen and Ingemann 2009). In this light, it is perhaps less surprising that we find Danish organic farmers largely basing their reasoning on scientific/quasi-scientific knowledge.

As mentioned in the introduction, a few studies have found that in general farmers do make use of experiential knowledge when assessing, for example, GM crops before these are introduced – that is, before they have any experience with them (Mauro *et al.* 2009). These studies, however, are based on a quantitative approach, where farmers are asked more directly about the influence of their experience. By contrast, in our more explorative approach experiential knowledge is applied only if it is taken up proactively by farmers themselves.

Additionally, farmers' employment of experiential knowledge in assessments of new technology differs from their more concrete assessment of technological alternatives made in a context close to their own farming practice. A recent qualitative study of barriers to the implementation of research-based knowledge concerning technical solutions to the nutrient supply problem in organic agriculture (Noe *et al.* 2015) revealed what the authors call a paradoxical knowledge asymmetry – one that emerges when organic farmers' knowledge meets scientific knowledge about solutions to the nutrient problem on their farms. Thus, in concrete discussions of farming practices, organic farmers were found to base their arguments on knowledge of their own specific experiences on their farms.

At a theoretical level, our study shows that to understand farmers' uses of different forms of knowledge we must take the context where the knowledge is applied into consideration. Other studies of (organic) farmers, as mentioned above, have shown how in settings closer to those of actual production experiential knowledge is important and widely used. These studies suggest that experiential knowledge depends much more on actual context and place (see e.g., Fonte 2008). Similarly, we have found that in more abstract discussions of new technologies, detached from concrete production, the balance seems to shift towards scientific knowledge.

At the political level, our findings highlight some challenges for a social movement organisation like IFOAM. First, if our results can be generalised to organic farmers outside Denmark, they indicate a mismatch between the epistemological logics of the social movement organisation and its grass roots. Second, and more importantly, if IFOAM wishes to base its future decisions on whether or not to call for precaution in relation to new technologies on experiential knowledge, there is a need to develop instruments that make it possible to tap into organic farmers' experiential knowledge. Our study clearly indicates that it cannot be taken for granted that organic farmers' experiential knowledge will automatically be brought into discussions of new technologies by the farmers themselves.

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