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Research paper

Farmers' use of fundamental knowledge to re-design their cropping systems: situated contextualisation processes

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ABSTRACT

When they re-design their cropping systems to move towards agroecology, farmers implement practices that involve biological processes. Such practices have been qualified as knowledge-intensive, as they involve the renewal of agronomic principles and numerous interactions between the systems' components and their regulation. Several studies recognize the value of discussing knowledge on systems' functioning and component properties with farmers, in relation to technical change processes. This paper investigates some processes of coordination of fundamental and generic knowledge on biological processes, on the situated knowledge that farmers may use when introducing technical changes in their own cropping system, and on the integrated approach to agroecological processes. We perform an inductive inquiry, in the framework of an iterative and instrumental analysis of case studies. We chose five cases of different step-by-step cropping system re-design situations. Through our crosscutting analysis, we highlight the fundamental knowledge on biological objects that the farmers mobilized, and we describe some aspects of the processes involved in its contextualization. In particular, we describe four patterns of connection between fundamental knowledge and farmers' actions, and distinguish three main reformulations of fundamental knowledge that participate in contextualizing it. These involve reinterpretation of individual experiences and identification of the effects of action on the situated biological processes. We conclude on research orientations for considering expert knowledge not as a specific content to integrate, but as a situated way of knowing that should be acknowledged in its processes.

1. Introduction

Re-designing cropping systems to move towards agroecology leads farmers to rely increasingly on biological processes and endogenous resources, and far less on external inputs [1–3]. This has several implications for the application of agricultural practices. First, farmers might have to implement practices corresponding to new agronomic approaches (such as maintaining a canopy for most of the year to cover the soil, trying to control weeds, limiting leaching and possibly increasing nitrogen fixation in the case of legumes). Thus, they may face situations in which they have little experience to guide their decisions about appropriate action. Second, managing such biological processes is made harder by the variability of their functioning according to environment-specific pedo-climatic conditions, and by the numerous and largely underexplored interactions (for example, maintaining a cover crop may lead to an increase in the slug population). This increases the uncertainty of the targeted effects or leads to unintended impacts. In view of these specificities, some authors have described the related practices as "knowledge-intensive practices" [4,5]. This assumes the acute need for new knowledge to apply these, particularly because they involve "*the adoption of technology that requires a high level of management skills, with an emphasis on observation, monitoring and judgement*" [4].

Agronomists have developed three main strategies to fulfil this need. First, they have made more intensive use of the knowledge developed by farmers. It has been recognized that farmers rely on both scientific and local knowledge [4,6]. It has also been shown

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that both sources of knowledge are necessary for agronomists, either to broaden agronomic knowledge, or to design and assess agro-ecological cropping systems [e.g. 7–10]. In particular, there is an emphasis on the tacit knowledge that farmers acquire through acting in their own situation, called "experiential knowledge" [11,12], largely based on know-how. Second, agronomists have carried out experiments with innovative crop systems to quantify the effects of new combinations of practices enhancing biological processes, emphasizing the scope for learning [13–15]. Third, and this is probably the predominant strategy, agronomists have developed integrated and complex models to describe the numerous interactions within a cropping system e.g. [16–20]. By gathering the scientific knowledge available on soil-crop mechanisms, these models are designed to support the *ex-ante* evaluation of farming systems not yet applied on farms e.g. [21]. The value of these models is thus argued to lie in their capacity to extensively take into account feedback loops and the unintended consequences of actions such as the quantification of water and nitrogen needs of wheat at spring when sown densely and early, which have consequences on fertilization and potential water stress induced; or the addition of new weed seeds in the soil seed bank when weed plants reach maturity, leading to harmful weed infestations in the following crops, [21]. With these models, it is also possible to predict long-term trends in the system, such as soil nitrogen and carbon content dynamics under various management practices [22], which are not easy to measure. The use of such quantitative and integrative models has been argued to provide helpful support to change practices e.g. [23,24]. However, many authors have shown that models were of little help for designing new practices, as summarized by Prost et al. [25]. Moreover, the interactions between crops and practices that models simulate mostly concern the amounts of abiotic growing factors (e.g. water, nitrogen). Models rarely take into account biotic processes, while these strongly impact low-input systems (e.g. those linked to diseases, pests, soil biological activity). As a result, these integrated models may lack contextualization variables to be used successfully to design locally-adapted crop systems.

These limitations of models highlight the issue of the use of scientific knowledge in re-design situations: how can farmers mobilize general scientific knowledge in a situated action process contending with systemic interactions between biological processes? The effectiveness of knowledge-sharing between agronomists and farmers has been shown to vary, based on agronomists' behaviour and social skills [4,26]. Yet, as these studies focus on social dynamics and actors' behaviours, they provide little information on the actual content of the exchanges, and the processes of their legitimation and organization for action. Furthermore, the hybridization of scientific and local knowledge is sometimes considered difficult and partly impossible because of their differing aims regarding agrosystems: farmers' objective is to manage ecosystems (for a crop or practice to yield satisfying results in a farmer's situation), and scientists' aim is to understand them (i.e. they need to know why and how something works) e.g. [27,28]. Based on these distinct aims, scientists have developed numerous decision support systems, as means to transfer their knowledge to farmers, with the aim of helping farmers make the right choices of practices based on their constraints. In so doing, scientists consider that farmers do not need to understand the functioning of their agrosystem to manage it and they encapsulate scientific knowledge in a usable tool. However, re-designing a cropping system does not just mean managing it, and the validity of this assumption in the context of agroecological transition is questionable. Farmers do not work with a given stable system; they gradually transform an agroecosystem while acting on productive resources, removing, adding or modifying some of its components. Furthermore, in some cases, action research has highlighted that farmers can become interested in very fundamental approaches to some parts of the system. For instance, Jordan et al. [29] mentioned the use of biological knowledge on weed species as an important event in a change process.

Consequently, when the re-design of a cropping system involves biological processes, this seems to require a combination of scientific general knowledge on the corresponding system, the situated knowledge farmers acquire or develop, and an integrated approach to the cropping systems. The core focus of this article relates to this combination: how do farmers re-designing their cropping system mobilize general scientific knowledge in their particular situation? How is this knowledge contextualized? What do such processes tell agronomists seeking to provide relevant resources for re-designing cropping systems? We answer these questions by examining various cropping system re-design situations through an inductive case-study analysis. All these situations share the common feature of mobilizing specific scientific knowledge. In the next section, we briefly present the methods we used in the different cases for data collection. We then describe the five case studies. In the results section, we present four crosscutting findings.

2. Method

We selected five situations of technical change in *step-by-step* re-design processes, as characterized by Meynard et al. [30]. *Step-by-step* re-design is characterized by an initial diagnosis of the practices and state of the system, followed by a range of techniques being proposed, chosen, implemented, monitored and adapted, resulting in the system experiencing new states, as well as leading to the assessment of various performances in order to start a new design loop. The five case studies concerned the implementation of new practices by farmers, in line with certain agroecological principles, as described in Wezel et al. [31]. The changes were aimed at various goals (Table 1): implementing integrated crop management to reduce pesticide use (Cases 2 and 5), diversifying the cultural strategies to reduce weed pressure along the crop sequence (Case 1), and changing soil tillage to improve the soil structure and fertility (Cases 3 and 4).

We investigated these cases through a combination of active and passive participation, and through comprehensive semi-structured interviews. The timescales of the collected data varied from one-day meetings to 5–7 year projects with regular experiments and meetings (Table 1). The number of people concerned by each case and their professions also varied from one individual farmer to a group involving several farmers, advisors and facilitators (Table 1). On the one hand, we observed (Cases 1 and 2) or interviewed (Case 5) groups of farmers in different situations considered as important stages in the *step-by-step* design process [32]: a system experiment visit, and a one-day design workshop (Table 1). On the other hand, we carried out individual semi-structured interviews with farmers, either participating in a development group (Case 5), or not (Cases 3 and 4). These interviews were organized in the same way. After a quick description of the farming system, we first identified, with the interviewee, the main problems and the main technical changes that had been introduced. We then focused on the implementation of one specific technical change, and asked the farmer about the information sources mobilized, the successive steps taken, the observations made, and finally the changes made and kept. Finally, we opened the interview to other technical changes or aspects of the cropping system.

Our inquiry was largely inductive, as we did not base our analysis on a specific hypothesis concerning the way the farmers may mobilize scientific knowledge. We made instrumental use of the cases [33]: in each case, we closely observed the moments when scientific and fundamental knowledge was mobilized, and progressively