How agroecological farmers develop their own practices: a grid to describe the objects and mechanisms of learning

Cristofari, H., Girard, N., Magda, D.

Institut National de la Recherche Agronomique (INRA)

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Abstract

The agroecological transition -defined here as a transition toward practices based on the management of ecological processes- requires innovations involving a wide range of stakeholders, from farmers to scientists or intermediaries. An extensive literature has shown that agroecological farmers' practices cannot be exclusively based on the application and adaptation of general recipes to the specific context of their farms: for intermediaries, supporting farmers thus calls for opening innovation spaces in which they can develop their own practices and generate innovative agroecological knowledge rooted in their peculiar agroecosystem. As a consequence, we argue that it is important to better understand how this knowledge is developed. However, the ways in which farmers learn remain poorly investigated at the individual level. The major role of experience in learning leads us to build on Kolb's pragmatist theory and to consider the individual learning process as a continuous interplay between a farmer's experience and his or her capacity for action. The purpose of this paper is to propose an analytical grid to describe the mechanisms connecting the farmer's experience and his pragmatic judgements. To do so, we focused on the case of conservation agriculture. We conducted five semi-structured interviews with experienced farmers and qualitatively analyzed them. The resulting grid exposes an array of learning mechanisms as well as the objects they may be linked with. This analytical grid may, in the future, be applied to a wider sample of farmers, as a means to better grasp the possible diversity of their learning processes. A deeper understanding of these processes would then help intermediaries to identify which types of support are the most adequate for farmers engaged in the agroecological transition.

1. Introduction

Agroecological practices, defined here as production practices based on the management of ecological processes, need to take into account the complexity of these processes as well as their very local characteristics, since minor variations in soil composition, microfauna communities and so on may affect the results of a given practice. Consequently, farmers cannot simply apply general recipes produced by agronomists at a large scale, with only minor adaptations to the ecological specificities of their farm; on the contrary, it has been extensively argued (Altieri 2002) that agroecological practices need to be developed by farmers in close relationship with their own local context (which includes both the ecological environment and the specificities of the production system). In other words, this questions the system of knowledge transfer, where intermediaries would have a role of expert in charge of educating farmers and giving them the technical solutions ready to be applied.

An agroecological farmer's knowledge must be, at least partly, very specific to his local conditions (Richardson 2005, Knapp et Fernandez-Gimenez 2009). However, even though recognizing the importance of farmers' knowledge seems crucial in the agroecological transition, this knowledge cannot be directly "transferred and applied", from one farmer to another: knowledge exchange between farmers has been shown to provide great benefits to the participants (Millar and Curtis 1997, Ingram 2010) but more as a way to promote the circulation of ideas that still have to be tested, adapted and so on. Therefore, understanding not only what agroecological farmers learn, but also how they learn it, seems especially interesting. Such an understanding could indeed help intermediaries (Koutsouris 2014) in supporting farmers willing to engage in agroecological practices, by highlighting ways to foster the development of adequate solutions by the farmers themselves.

2. Theoretical background: understanding the learning processes as a way to support farmers in their own transition

Various studies have explored farmers' knowledge in a large range of production systems, from traditional smallholders in poorer countries to larger conventional farms, from fruit and vegetables producers to cattle breeders (Thomas and Twyman 2004, Richardson 2005, Knapp and Fernandez-Gimenez 2009). According to Girard (2014), these works can be classified in four categories, depending on their goal regarding farmers' knowledge: use farmers' knowledge as an inspiration for innovation, evaluate the current state of farmers' knowledge to improve it, promote knowledge exchange between farmers, and document farmers' knowledge to support its role in development. In addition to these four types of use of farmers' knowledge, other authors developed ways to describe more precisely this knowledge. This is for example the case of Toffolini et al. (2014), who proposed a grid to describe the different forms and characteristics of knowledge used by farmers in their daily activities. Although such works shed light on what farmers' knowledge is and how it can be used, they let aside the question of how farmers come to develop such knowledge.

2.1. Farmers' learning in particular situations

Other works did approach the way farmers learn, but focusing on particular "learning situations". Drawing on the pragmatist distinction between a context and a situation, we here consider a learning situation as a "set of conditions taking part in the development of an individual's capacities" (Zask 2008). Moreover, this "set of conditions" is taken here in a restricted sense, to indicate a situation fairly limited over time: a learning situation could thus be an interaction with a scientist, a meeting of a knowledge exchange group among peers and so on.

Some studies explored the learning situations involving an "expert", such as a more experienced farmer or a technician. For instance, Labarthe (2009) investigated the role of agricultural extension services in farmers' learning, and showed how the complex relationships between public and private agricultural extension stakeholders may hamper a real support for farmers' learning. In a different setting, Chrétien (2015) examined the transmission of organic farms, and described the specificities of the learning processes involved in the interactions between the newcomer and the leaving farmer. Another set of studies concentrate on learning situations involving knowledge exchange groups. Building on two case-studies of Australian breeders, Millar and Curtis (1997) thus suggested that farmers may undervalue their own knowledge, and that exchange among peers may help them get aware of their own knowledge, as well as facilitate the construction of common understandings between farmers and scientists. Along the same line, McGreevy (2012) examined the synergies and blocking points in the knowledge exchanges between incoming organic farmers and local family farmers in upland Japan.

Finally, some authors have focused on learning situations corresponding to farmers' experiments: Lyon (1996) explores how English farmers "research and learn" and compares this process with scientific methodology, arguing that these two types of experiments are driven by different goals, and should thus be regarded as complementary. More recently, quite a few studies have further documented farmers' experiments in diverse production systems (Milestad et al. 2010, Kummer et al. 2012).

These studies have contributed to describe and analyze a diversity of learning situations for farmers, but in a somewhat fragmented way, in the sense that these varied situations (exchanging with peers, experimenting…) are explored independently from one another.

2.2 Farmers' learning across multiple learning situations

Farmers experiment and exchange with peers and experts on a regular basis: these different learning situations must in some way interact with one another, and their combinations may produce a variety of outcomes. Consequently, we argue that it is especially interesting to understand the learning process as a whole, across multiple learning situations.

In the past few years, some authors have started to adopt such an approach. Among others, Kilpatrick and Johns (2003) showed that a random sample of Australian farmers display a diversity of "learning patterns", each including a variety of learning mechanisms such as seeking information from experts, observing a practice chosen by a peer and so on. In the same line, Ingram (2010) explored the learning processes of farmers practising reduced tillage, and described them according to two main dimensions, namely "on-farm learning, the technical dimension" and "social learning, the social dimension", thus providing some elements on how to combine different learning situations. Lately, Chantre et al. (2014) identified "configurations of learning conditions" for farmers who try to reduce their use of fertilizers and pesticides: in other words, they described how farmers articulate experience and information gathering, and more specifically how they integrate inputs from resource persons, along three phases of learning, namely warning sign, experiencing and evaluating.

We here wish to build on these works to investigate the learning processes of farmers, but in the more specific case of agroecology: as developed earlier, such practices rely on very local knowledge, and require farmers to learn in a context of uncertainty and lack of information. As a consequence, the learning process of farmers who practice agroecology may present specificities that have not yet been analyzed.

2.3. Conceptual framework and goal of this study

Experience is clearly highlighted in these studies of diverse farming systems as a major aspect of learning; moreover in the context of agroecology, practices are deeply rooted in a particular environment, which leads us to consider that an agroecological farmer's continuous experience may play an especially important role in his learning process. We thus chose to mobilize elements of the pragmatist experiential learning theory (Dewey 1938, Kolb 1984). Contrary to the view that learning can be seen as a simple transfer of knowledge from a knowledgeable person to a learner (a point of view which has been largely criticized, see Freire 1970), this theory considers the experience lived by a person as the very basis of this person's learning. As a consequence, we here consider learning as a continuous interplay between a farmer's experience and his or her pragmatic judgement (Pastré 2005), as presented in the figure below. By "pragmatic judgements", we here mean the diversity of "concepts that organize actions" (Pastré 2005), which can include decision rules at a very specific level, more general principles of action.

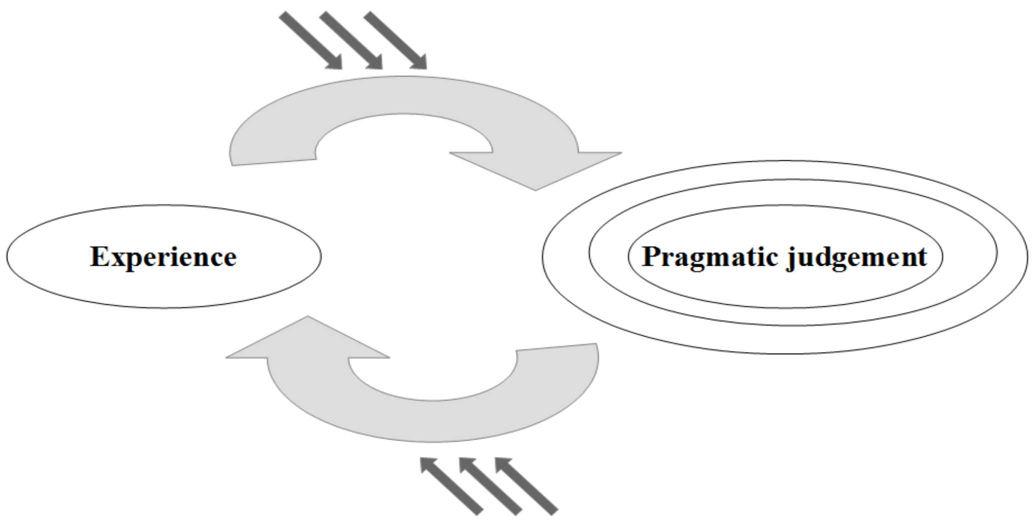


Figure 1 : Learning as a continuous interplay between a farmer's experience and his pragmatic judgement. *The concentric circles represent the diversity of pragmatic judgements. The continuous interactions between experience and pragmatic judgements are shown as thicker light grey arrows, while the thinner dark grey arrows represent inputs from peers, scientific sources and so on, which may affect these interactions.*

A farmer's experience is the basis of his elaboration of a pragmatic judgement, which in turn affects what experience is lived. Interactions with peers or experts, and gathering of information from a diversity of documents, also participate in this process. Consequently, even though we chose to base our study on experiential learning theory, we fully acknowledge that learning does not happen solely in one's field, in a strictly individual way; we only choose to focus on personal experience and the way external sources of knowledge are incorporated in experiential learning, rather than focusing on knowledge dynamics among members of a group for instance.

The succession over time of these interactions between experience and pragmatic judgement is what we here call the *learning process*; meanwhile, we use the term *learning mechanism* to refer to the way in which each of these interactions may happen: the learning process is a sequence of learning mechanisms. Because learning mechanisms may not necessarily be the same depending on what the farmer is learning, we also use the notion of *object of learning* to refer to the object learned about. To understand the learning processes of farmers practicing agroecology, we suggest that a first step may be to describe the diversity of learning mechanisms and learning objects –moreover, we will here restrict the learning objects to those directly related to agroecological production practices.

Consequently, the goal of this paper is to propose two grids to describe the mechanisms and objects of learning, in the case of farmers experienced in terms of agroecological practices.

3. Methodology

3.1 The case study: conservation agriculture

Conservation agriculture is commonly dated back to the 1930s, when the ecological and human catastrophe of the "Dust bowl" in the American Midwest prompted scientists and farmers to develop a set of practices aiming at reducing soil erosion risks, while also improving the agronomic properties of the soil (although similar practices, also linked with soil erosion damages, were likely happening as early as the late 19th century –Birkas et al. 2004). The term is used mostly for field crops, and it is based on three main principles, namely reduced tillage, permanent soil cover and more complex cultural successions (De Tourdonnet et al. 2013, Pittelkow et al. 2014). Each of these principles covers a large diversity of possible practices:

- reduced tillage may include a gradient from shallower ploughing to no ploughing at all, use of tools that crack the soil without disturbing its structure, direct seeding...

- permanent soil cover may be accomplished through the use of mulch, ramial chipped wood, diverse cover crops...

- more complex cultural successions can include varied crops with a diversity of nutrient needs, root systems, symbiotic capacity (in the case of legumes especially)...

However all these practices are directed toward similar goals: for instance, reducing the perturbation of the soil and protecting it through the use of covers globally aims at enabling soil biodiversity to develop and ensure the recycling of organic matter as well as the structuration of the soil itself (Farooq and Siddique 2015). In other words, conservation agriculture principles aim at fostering ecological processes that provide a benefit for the agricultural system. In this sense, it can be considered as an example of agroecological practices as we previously defined them.

3.2 Sample and data collection: semi-structured interviews with 5 South-Western French farmers

Conservation agriculture is a particularly promising example of agroecological practices in South-Western France, since soil erosion is especially high in that region (GIS Sol. 2011), and we consequently chose to base our study in this area. We interviewed 5 farmers (all men), members of a local conservation agriculture association (AOC sols, "Association Occitane de Conservation des Sols", http://aocsols.free.fr/) who had at least 6 years of practice in reduced tillage, permanent soil cover and complex cultural successions. We chose this time lapse because of previous studies (Pittelkow et al. 2014) indicating that the transition toward conservation agriculture usually includes a deterioration of the soil conditions around the third year, and that it takes about 5 years for the benefits of the practices to be effective.

Our qualitative data was gathered through face-to-face semi-structured interviews, always conducted by the same person. Because we had no *a priori* hypothesis to be tested, these interviews were largely exploratory, and were thus conducted in a rather loose way to follow the line of thought of the farmer and enable new topics to emerge (Blanchet and Gotman 1986). However, even though a certain freedom was given to the interviewee, we made sure that the three main aspects of conservation agriculture (reduced tilling practices, soil cover, and crop succession) were discussed at some point, as well as the relationships and knowledge exchange with other farmers, scientists and extension agents.

3.3 Data analysis: qualitative structuration of interviews through inductive coding

The interviews were integrally transcribed and a qualitative analysis of content was then performed using the Nvivo® software. We constructed separately the grids of the mechanisms and objects of learning; for the grid of objects of learning, we proceeded as follows.

Taking one interview after the other, in random order, we coded the objects of learning in the inductive way characteristic of "*conventional coding*" (Hsieh & Shannon 2005). Our strategy was close to the grounded theory (Glaser and Strauss, 2009), and consequently there was no previously defined list of nodes to be used.

Each time the interviewee talked about something he learned, we coded this excerpt of the text with a short expression describing "what the farmer learned about". We used words that were as close as possible to the farmer's, while also trying to choose an expression not too specific to one particular excerpt, so that it could be re-used to code other parts of interviews dealing with the same object. We observed that saturation (or the absence of apparition of any new object) was reached around the end of the fourth interview.

The data thus structured into smaller units through coding was then used for "*gradual construction of a system of categories*" (Langley 1999) encompassing the various discourses of interviewed farmers. Because the categories of mechanisms and objects of learning had to be sufficiently general to include elements of discourse from different farmers, we could not strictly keep the words used by each interviewee: consequently, the labels of the categories of objects and mechanisms of learning are often scientific terms, chosen because they were large enough to encompass the diverse specific expressions used by different farmers.

The resulting set of objects of learning will be presented hereafter. The same method was then applied again to the 5 interviews to obtain the grid of mechanisms of learning.

4. Results

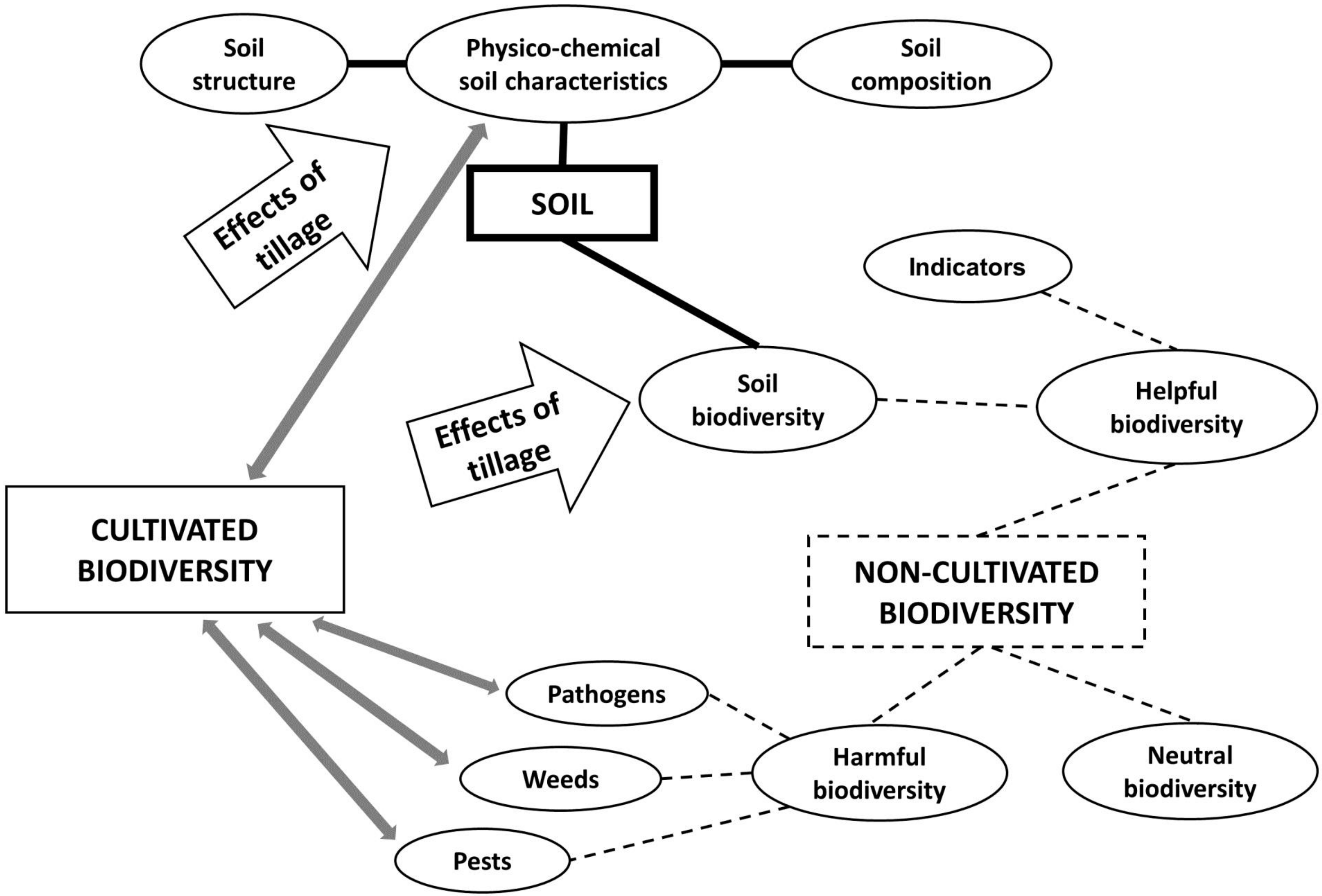
4.1. Objects of learning of farmers experienced in conservation agriculture

The following figure (**Figure 2**) aims at representing in a systemic way the major objects of learning emerging from our interviews. We distinguished three kinds of objects of learning: biological objects (such as pests or cover crops), relationships between biological objects (such as the effect of some crops on weeds), and relationships between a practice and a biological object (such as the effect of tillage on soil micro-fauna). These diverse objects of learning revolve around three large themes, in other words three main aspects managed by the farmers, namely soil, cultivated biodiversity and non-cultivated biodiversity.

The farmers interviewed expressed learning about both the physico-chemical and the biological characteristics of the soil. The physico-chemical properties encompass elements regarding the structure and the composition of the soil: soil structure includes the characteristics of the soil layers at a given time as well as the propensity to erosion; while soil composition covers chemical content and micro-geological characteristics. These physico-chemical characteristics of the soil are deeply affected by agricultural practices, and farmers repeatedly talked about observed effects of different tillage practices on soil structure (compaction of the soil, reduced water retention). The biological properties of the soil –its microfauna, microflaura…- were also frequently evoked, as well as their response to practices such as tillage.

This leads us to the second theme, namely non-cultivated biodiversity. We decided to divide it according to the roles farmers said it played for them, which led to three categories: harmful biodiversity, helpful biodiversity, and neutral biodiversity. “Helpful biodiversity” includes species that present an intrinsic advantage for agricultural production (for instance, any bacteria or worms participating in organic matter recycling), and species that are used by the farmer as indicators (e.g., birds used as a way to know whether or not insects are present). We call “neutral” the biodiversity which does not, according to the farmers, explicitly play a direct role in the production system. Harmful biodiversity includes pathogens, pests and weeds, all of which affect, and are affected by, the cultivated biodiversity, i.e. crops.

Effects of crops on weeds may happen through a diversity of ecological processes managed by farmers, such as competition (with the implantation of a cover crop to make it harder for weeds to start growing) or allelopathy (“Because oat […] hampers weeds a lot. You have barley, oat, but oat is maybe one of the most...It has allelopathic virtues, or I don't know what, that are quite exceptional”). Along the same lines, the choice of crops may affect pathogens and pests by disrupting their life cycles and depriving them of a suitable habitat. Regarding cultivated biodiversity, farmers also mentioned learning about seed selection and effect of climate on crops. Finally, the effects of cultivated biodiversity on soil structure often appeared in farmers’ discourse, for instance through the use of cover crops to mitigate soil erosion, or the choice of specific crops such as sorghum to alleviate soil compaction.



<u>Figure 2:</u> Objects of learning of farmers experienced in conservation agriculture. *The three rectangles indicate the main themes of learning, while the circles represent biological objects included in those themes. The thinner grey arrows represent relationships between biological objects, while the larger arrows represent the effect of a practice on biological object.*

4.2. Learning mechanisms of farmers experienced in conservation agriculture

The following table (**Table 1**) presents the mechanisms of learning emerging from our interviews. We organized them into five categories corresponding to different steps in the learning process: these possible steps are not always present for each farmer, nor do they represent a logical sequence which is necessarily followed. They are merely larger categories which we defined to cluster more specific learning mechanisms.

Get an idea of a new practice. This may happen on one's own, or it may result from exchanges with peers, either directly (i.e., getting the idea from another farmer) or indirectly (i.e., on the basis of exchanges with peers, getting inspiration to personally conceive a new practice). It may also come from scientific sources, this time again, directly or indirectly.

Implement a new practice. Farmers talked about implementing new practices at a variety of spatial scales (for instance, trying a cover crop on a smaller area first, or on a whole field at once) and time scales (e.g., trying direct seeding of corn just one year, or try it over several years to see whether the specific climatic conditions of the first year made a difference or not). New practices may also be implemented more or less progressively: some farmers try stopping tillage altogether, whereas others go through gradual change, from a 50cm ploughing to 30cm, 15cm and so on, assessing the results as they proceed.

A farmer may implement a new practice in a more or less planned way, and we here suggest to distinguish three types of experiments: planned experiments, that are willingly foreseen and conducted by a farmer, opportunistic experiments, that happen when some mishap puts a farmer in an unexpected situation, prompting him to try something new which he would not otherwise have tried, and fortuitous experiments, that are not decided by a farmer but happen anyway, for instance when a mistake leads to interesting results (because this last category is wholly unplanned, it can happen simultaneously to a group of peers, but it cannot include any scientific input, hence the exclusion of the "scientific inputs" column in the table).

A farmer may implement a new practice on his own, but exchanges with peers may also affect how he decides to go about experimenting. Scientific documents or extension agents may also provide methodological inputs to plan an experimental design.

Monitor the state of the system. Farmers may monitor their system or parts of it in a qualitative or quantitative way, at different frequencies and spatial scales, with a variety of indicators (coming from scientific sources, co-developed with peers, and/or personally developed).

The analysis of such monitoring may also be more or less formal (from a very rough guess to a computer-aided statistical analysis including a diversity of independent variables).

Get standards/points of comparison. Farmers form an idea of what their system or parts of it should be like and what its performances should be, either on their own or based on exchanges with peers leading to the construction of a common ideal, comparison with other farmers' systems, and/or scientific standards.

Assign a certain degree of validity to a principle. Farmers expressed to different degrees their needs to understand the cause of an observed phenomenon in order to consider it as generally true. Such an explanation may come directly from peers or scientific sources, or be more indirectly inspired from such sources.

<table>
<tr><th></th><th>Personal experience</th><th>Peers’ inputs</th><th>Scientific inputs</th></tr>
<tr><td>Get an idea of a new practice</td><td>Conceive a new possible practice</td><td>Find an idea of a new practice together with peers
Imagine a new practice, by getting inspiration from peers' practices</td><td>Find an idea of a new practice from a scientific source
Imagine a new practice, based on a similar phenomenon scientifically understood</td></tr>
<tr><td rowspan="4">Implement a new practice</td><td colspan="3">Choose a time scale
Choose a spatial scale
Choose a degree of intensity of change</td></tr>
<tr><td colspan="3">Experiment in a planned way
Experiment in an opportunistic way</td></tr>
<tr><td colspan="2">Experiment in a fortuitous way</td><td></td></tr>
<tr><td>Implement a new practice individually</td><td>Implement a new practice collectively</td><td>Rely on scientific methods to conceive an experimental design

Be comforted in a decision already taken thanks to a scientific input</td></tr>
<tr><td>Monitor the state of the system</td><td colspan="3">Monitor the system in a quantitative or qualitative way
Monitor a specific experiment, or monitor the system in a more general way
Choose a frequency and spatial scale for monitoring activities
Find indicators for the information desired

Analyze the information obtained through monitoring in a more or less formal, quantitative way
Choose a time and spatial scale for analyzing the information obtained through monitoring
Take into account independent variables</td></tr>
<tr><td>Get standards</td><td>Reject peers' standards</td><td>Compare one's system with peers' systems
Construct and share common ideals</td><td>Judge the state of the system with respect to scientific standards</td></tr>
<tr><td>Elaborate a principle of action</td><td>Confirm or disprove an information coming from a scientific source

Confirm or disprove an information coming from peers

Put together different personal experiences</td><td>Confirm or disprove an information coming from a personal observation

Confirm or disprove an information coming from a scientific source

Find among peers a direct explanation for an observed phenomenon
Elaborate an explanation of a phenomenon based on an analogy with an explanation of a similar phenomenon heard from peers

Put together different opinions from peers

Take a piece of information coming from a peer as true without further inquiry, based on credit given to this peer</td><td>Confirm or disprove an information coming from a personal observation

Confirm or disprove an information coming from peers

Find in a scientific source a direct explanation for an observed phenomenon
Elaborate an explanation of a phenomenon based on an analogy with a scientific explanation of a similar phenomenon

Put together different scientific sources

Take a piece of information coming from a scientific source as true without further inquiry, based on credit given to this source</td></tr>
</table>

Table 1: Learning mechanisms of farmers experienced in conservation agriculture. *The left-side column indicates the main possible steps of the learning process, and the upper line presents the different sources that a farmer may mobilize when going through these different steps.*

5. Discussion

These results show an extensive diversity of objects and mechanisms of learning for farmers experienced in conservation agriculture practices. However, we do not claim that these grids are exhaustive; quite the contrary, we suggest that they could be taken as a starting point to better qualify the full diversity of objects and mechanisms of learning. Although our sample already presented fairly diverse approaches to learning, it is important to note that because our interviews were conducted with farmers belonging to a same conservation agriculture association and same geographical area, it is possible that part of their discourse is more homogeneous than it would otherwise be. As a result, we are currently interviewing a broader sample of farmers, taken out this specific context, to complete the grids. In the same lines, in order to better approach the learning mechanisms and objects which may not be easily verbalized, our further work will include more observation and interviews in the fields.

It will also be interesting to explore the relationships between objects and mechanisms of learning. Indeed, our interviews suggest that a diversity of learning mechanisms may be linked with one same object, but these relationships remain to be clarified. In particular, if some mechanisms are more specifically mobilized by farmers to learn about a given object, then knowing this could help intermediaries in better tailoring their actions towards farmers to support them in learning to develop their own practices. These grids may also be used as a first step to investigate the interconnection of the learning mechanisms and their succession over time, or in other words, the learning process as a whole. The learning process may also involve changes in objects of learning, and further work would help identify the modalities of such changes, that is to say, how a succession of learning mechanisms related to one object may result in another sequence of learning mechanisms linked with another object.

We focused here on objects of learning directly related to production practices (biological objects, relationships between biological objects, and effect of a practice on a biological object), however learning may also occur for other types of objects. More specifically, we suggest that developing agroecological practices such as conservation agriculture may induce changes of pragmatic judgements about such objects as oneself, one's role in society as a manager of natural resources, one's desired relationship with nature and so on. These objects and their role in the learning process as a whole could be envisioned through the theory of double-loop learning (Argyris 1982): learning about objects directly related to production practices could be considered as first-loop learning, which may in turn induce a second-loop learning dealing with those broader objects. Such a learning process seemed to appear in our interviews, for instance when a farmer explained how learning to change his seeding technics (from a conventional method to direct seeding) made him reconsider the whole technical orientation of his system and try to develop new methods based on ecological processes through a diversification of crops and so on.

Understanding in more details how learning happens for farmers experienced in agroecology is crucial to better tailor extension services and agricultural support generally. For instance, if we can identify more clearly which kind of evidence (a scientific explanation of the phenomenon, an observable example at a neighbor…) are required by farmers to consider something as a rule of action, then it may be easier for intermediaries to efficiently search for and expose such evidence. Along the same line, having a clearer idea of the objects that farmers feel a need to think about, and how they relate these objects to each other, may help in defining the focus of extension services.

6. Conclusion

Our study enabled us present a diversity of objects and mechanisms of learning for farmers experienced in conservation agriculture, and to propose organized, although non exhaustive, sets of these objects and mechanisms. This analytical framework may be used as a starting point towards a more comprehensive characterization of the multiple-loop learning processes of agroecological farmers. The learning processes may well be very varied, and consequently, a promising research path would consist in highlighting some steadier aspects, or try to establish a typology of of learning styles, based on an understanding of the learning process as a whole, for farmers experienced in agroecological practices. A deeper understanding of the diversity of learning processes may then be mobilized by intermediaries to better tailor their support for farmers engaged in agroecological practices.

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