Experiments on the use of knowledge management tools for agriculture

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Abstract: Agriculture must be both sustainable and economically viable. Sustainable agriculture requires new knowledge and expertise. However, knowledge management is not sufficient in current sustainable agriculture. To overcome this, we have made the assumption that the knowledge management practices used in industry can be transferred in agriculture. In this paper, we propose to apply to agriculture, the methodological tools developed by the French knowledge management group. These tools are based on theoretical approaches for the transformation of explicit and tacit knowledge within an organization. These tools are generic and suitable for any knowledge. We have tested the tool CFK for knowledge criticality in order to identify the knowledge to make explicit within a farm. This knowledge is critical because they are valuable, rare, complex and difficult to formalize. They must therefore be managed. We have determined the criticality of knowledge in a farm for organic agriculture field crops, in prairies and on various flora grain legumes. In the French research project TATABOX related to the agro-ecological transition study in a land between Tarn and Aveyron in France, we also have experimented another methodological tool (TRACO) for characterizing the most appropriate knowledge transfer tools to use between an agricultural cooperative and farmers. Among 16 knowledge transfer methods proposed, TRACO allow highlighting supervised self-education but also traditional teaching courses, communities of practices and workshops. Our conclusion is that the proposed knowledge management tools seem relevant to manage knowledge in agriculture, but they still require training and adaptation to agricultural fields.

Keywords : Agro-ecology, knowledge management tool

1. Introduction

Agriculture must become more environmentally sustainable while being economically viable. Taking better account of ecosystems, this type of agriculture called agro-ecology is the inverse of an intensive agriculture. The production and the acquisition of knowledge by farmers are one of the strategic conditions to develop this sustainable (but productive) farming. Currently, knowledge for productivity improvement is available, but knowledge that meets requirements for environment, territory and economic viability must be developed. Therefore, agro-ecology requires new knowledge and expertise. The diversity of the stakeholders and the difficulty to perform experiments because of the long duration of the production cycles constitute obstacles to knowledge capitalization. Thus, knowledge management is not sufficient in agro-ecology (Meynard, 2012; Guichard, 2015 Ballot et al.).

To remedy this problem, we make the assumption that knowledge management methods applied in the industrial world can be transposed in agriculture (Soulignac, Ermine et al. 2012). This paper focuses on the methodological tools developed by the French knowledge management group (“Le club de gestion des connaissances" - http://www.club-gc.asso.fr/accueil_gc). These tools are based on the transformation of explicit and tacit knowledge within organizations (Nonaka and Toyama 2003; Ermine 2008). They are generic and usually suitable for any type of organizations. In this paper, we present the use of two of these tools in real cases in agriculture. The first tool is used to identify the "critical" knowledge on which organizations should focus. The second tool allows the organizations to better define the knowledge transfer to implement.

2. Knowledge management

The creation of explicit knowledge in an organization is a complex task. The knowledge management process involves a first step for the identification of the most important knowledge (called critical knowledge). The second step is the definition of an action plan to reduce risks related to a poor control of knowledge. There are two main action types. The first type of action plan is a skill management. Knowledge is transferred by people, with learning processes or through recruitment. The second type of action is indirect. It requires a phase in which explicit knowledge is written, before a step of knowledge appropriation. Since the early 2000s, the French knowledge management group has developed a methodology for knowledge management. At each step of this methodology, the group proposes the use of a software tool, as indicated in Figure 1. Each of these tools uses the results of surveys conducted among stakeholders in the studied areas. It is not always necessary to use all the tools. For example, an organization can choose to successively use the following tools:

- The tool called CKF for evaluating the criticality of knowledge,
- The decision support system TRACO to identify the most relevant knowledge transfer methods,
- The RPC guide for writing knowledge, if the indirect knowledge transfer is an appropriate solution.

All these tools have been extensively used in industry in France, by private companies or public institutions. Their interest was proven in industrial and service activities. These tools are generic, as they are suitable for any of these areas, but a question arises about the usability of these tools for knowledge management in agro-ecology; this latter area having certain particular characteristics. For example, agro-ecology implies an anticipation strategy to manage pests. In this context, a crop rotation over a long period, more than five years, can be considered and implemented in order to limit the occurrence of plant diseases or weeds. Local characteristics are very important, in particular the soil and climatic conditions make it complex the production of knowledge to design a rotation taking into account different issues (pests, production, etc.). Efficient solutions to be implemented locally are often the result of a combination of both empirical and scientific knowledge. The challenge is to determine if these tools also provide a solution for complex cases in which different types of knowledge must be combined, according to their origins (e.g., operational and scientific knowledge) .

We experimented the use of the methodology described in Figure 1 in several projects in organic farming or in agro-ecology. In this paper, we report the experience feedback on two knowledge management tools described above i.e. the tool for critical knowledge CKF and decision support tool TRACO for knowledge transfer.

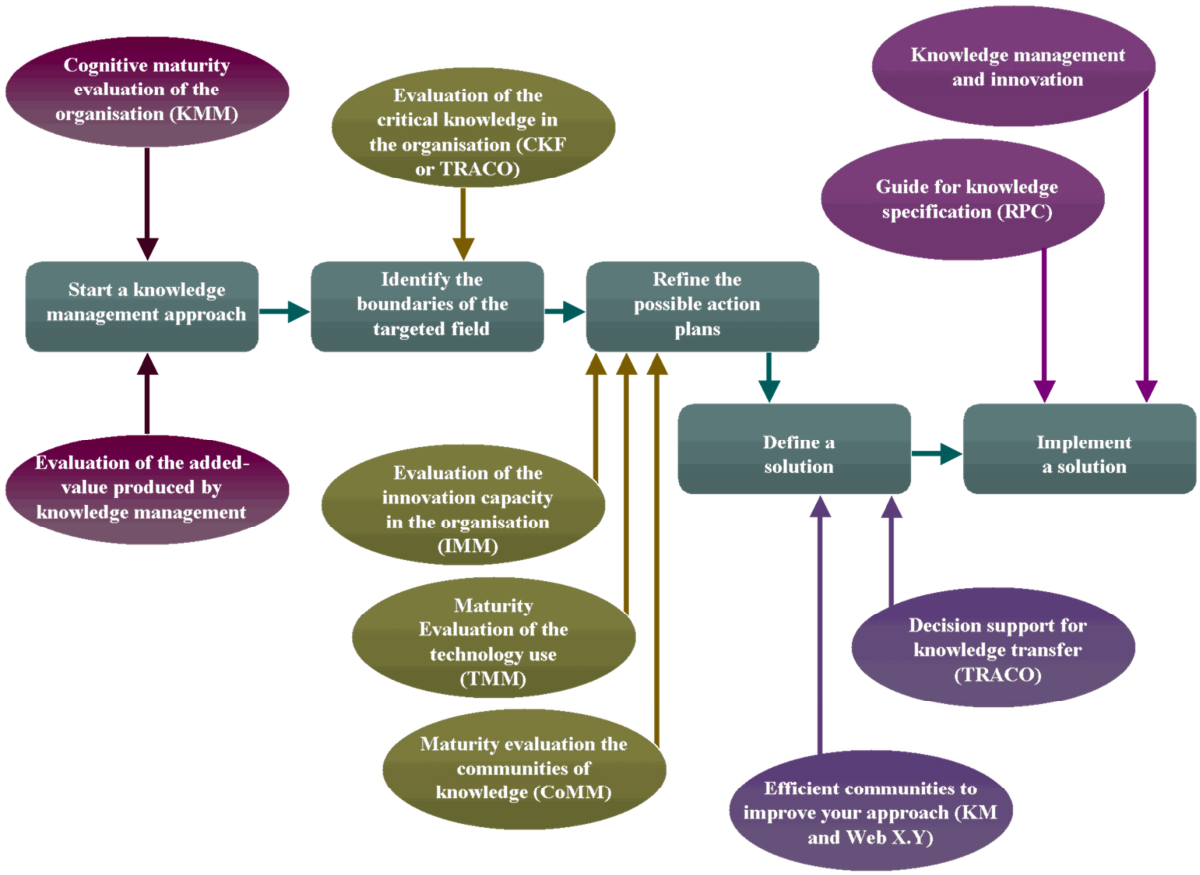

Figure 1. Methodology for knowledge management (by the French knowledge management group – "club de gestion des connaissances" - http://www.club-gc.asso.fr)

3. Use of knowledge management tools in agriculture

3.1 CKF – a tool for knowledge criticality

CKF allows identifying critical knowledge (Club de gestion des connaissances, 2004). Factors having impacts on this criticality are the knowledge usefulness, its rarity, its complexity and its difficulty to be implemented. We tested CKF in multiple environments including the Melibio project led by the Organic Agriculture Centre for Massif Central in France. This research and development project aims at the enhancement of the diversity of species, forage varieties and farming practices in organic farming in order to secure food systems of ruminants in Massif Central in France. This project involves researchers,

agricultural advisors, experts and teachers. In this paper, we illustrate the use of CKF on an example of research work related to the varied plant prairie management, conducted in the Melibio project. The CKF method includes several steps:

- Agricultural advisors and researchers having knowledge in varied plant prairies in organic farming were chosen. We also could involve farmers.
- The knowledge areas are defined collectively. They are disjoint as possible in order to facilitate their analysis. Thus, 23 knowledge areas on varied plant prairie management have been identified related to pest management or nutritional needs of animals, etc. The complete list is in table 1.
- Each of these areas is rated by an expert according to the four criteria (usefulness, rarity, complexity, implementation difficulty). A high score means that the knowledge area is highly critical.

The knowledge areas are ranked from #1 (the most important) to #23 (the less important). The results are presented in Table 1:

N°	Topics	Knowledge fields
1	Development strategy of the forage system	Varied flora prairie destruction
2	Technical action	Fertilizers
3	Development strategy of the forage system	Socio-economical factor
4	Development strategy of the forage system	Role of varied flora prairie in crop rotations
5	Technical action	Control of bioagressor and disease
6	Development strategy of the forage system	Pedoclimatic knowledge
7	Development strategy of the forage system	Animal needs
8	Technical action	Harvesting and storage method
9	Environment	Water
10	Technical action	Agricultural seeding
11	Plant dynamics	Dry matter
12	Environment	Landscape
13	Technical action	Control of bioagressor and weed
14	Technical action	Control of bioagressor and pest
15	Technical action	Location
16	Environment	Carbon footprint
17	Plant dynamics	Quality
18	Environment	Biodiversity
19	Development strategy of the forage system	Floristic composition of varied flora prairie
20	Development strategy of the forage system	Forage system adaptation
21	Development strategy of the forage system	Role of varied flora prairie in forage system
22	Plant dynamics	Diversity
23	Plant dynamics	Sustainability

Table 1. Criticality knowledge ranking related to the management of varied plant prairie (5-10 year plant) in organic agriculture

The project Melibio committed since 2011 and will finish in 2018. The methodological tool CKF was applied to the varied plant prairie management from the beginning of the project. The result analysis highlights the priority areas, but also those in which cognitive investment is not needed. Thus, subjects such as fertilization or disease treatment will not be studied in Melibio because these technical processes are well controlled. Subjects related to plant dynamics such as varied plant prairie diversity and sustainability are preferred. Detailed analysis of the results facilitates the creation of an action plan. The rating of the four factors (usefulness, rarity, complexity, implementation difficulty) is analysed, but also the differences between the opinions of researchers and agricultural advisors:

- Each CKF rating of factors refer to an action plan:
    - When the usefulness factor rating is low, even if the overall score is high, the question about the relevance of the field study is raised. Consequently, the pest control is not taken into account.
    - When a domain is rare, i.e. only little knowledge is associated with it, then a scientific research work or an empirical knowledge collection is started, as was the case with plant dynamics.
    - When a domain is complex but its implementation is relatively well controlled, a wiki web server is a possible solution to explain and disseminate knowledge.
    - When the difficulty factor has a high rating, a pilot plot is used to identify good practices over a long period and for their dissemination through farmer meetings.
- The level of knowledge in a domain between agricultural advisors and researchers is sometimes different. Consequently, the ratings can be different. In our analysis of ratings, we distinguish agricultural advisors and researchers. For a researcher, information is rare when there is a limited number of scientific publications about the topic. For an agricultural advisor, information is rare when they cannot be found in practical cases. This point can explain some differences in ratings. In that case, the knowledge transfer is possible. For instance, concerning the carbon footprint issue, courses can be created to transfer knowledge related to carbon footprint. Knowledge transfer can also be produced by technical actions. In this case technical skills can be transferred to researchers. It can be for example the case for the methods used in practice for varied plant prairie harvesting and storage.

3.2 TRACO – a decision support tool for knowledge transfer

The methodical tool TRACO allows choosing the best approaches. TRACO offers 16 knowledge transfer methods (Club de gestion des connaissances, 2009), classified into four types:

- “Classroom” training courses where the trainer and the trainees are physically in the same room,
- Methods mixing practical and theoretical knowledge such as block-release training,
- Knowledge transfer media such as knowledge server software dedicated to knowledge dissemination,
- knowledge networks in which people can share and enrich their practices (such as communities of practices).

28 criteria are used to choose an appropriate transfer method. These criteria are divided into four main types:

- The deadlines / urgency of knowledge transfer and the contextual information,
- The nature of knowledge,
- The source, i.e., the holders of the knowledge,
- The target, i.e., the receivers of these knowledge

For each of the 16 transfer methods proposed by TRACO, each 28 criteria is evaluated according to a colour code:

- The "red" colour is used when the method is not recommended,
- "Yellow" if the method is partially adequate,
- "Green" when the method is adequate,
- The “White” colour means that the criterion has no influence on the method analysis.

We take an example of the analysis of the classroom training course method for the factor of knowledge integration difficulty for one person. As shown in Figure 2, a classroom training course is appropriate when knowledge can easily be integrated in the practices.

We have 28 criteria to be applied to each of the 16 knowledge transfer systems. Consequently, we study 448 results to determine the most appropriate actions. Of course, the systems that have the greatest number of "green" colours will be preferred for the studied organization. In the French project called TATABOX (funded by the Research National Agency - ANR) on the agro-ecological transition, we experimented TRACO to determine the most appropriate knowledge transfer tools to use between an agricultural cooperative called Qualisol and its farmers. Qualisol is a pioneer cooperative in agro-ecology in the Southwest of France. The development of grain legumes (beans, lentils, chickpeas, etc.) completely complies with the objectives of Qualisol and this agro-ecological transition project. In addition to their nutritional qualities, grain legumes have also very good agronomic properties. Their cultivation provides nitrogen to the soil. The decrease in the use of fertilizers reduces health and environmental impacts of nitrogen inputs (Projets ANR LEGITIMES ET TATABOX, Ecole d'ingénieurs de PURPAN et al. 2015; Soulignac, Ferstler et al. 2015). The authors of (Magrini, Voisin et al. 2014) show that the development of grain legumes implies technological problems. The solutions are the definition of actions of knowledge capitalization and dissemination conducted by research, teaching and advisory organisations. To transfer knowledge on grain legumes, the Qualisol cooperative needs to use the most appropriate tools. Purpan engineering school students (France) conducted a survey of the Qualisol chief agronomist. The result is shown in Figure 3. Over the 16 transfer methods, TRACO allows us to highlight independent learning, but also “classroom” training courses, knowledge networks and workshops.

Difficulties to use these knowledge in practice: (1) Knowledge can be used without experience ; (3) Knowledge require experience	1 Easy to use in practice	2	3 Very difficult to use in practice

Figure 2. One example of a ranking proposed for the criterion « knowledge usability for one person » and for the method « classroom training course »

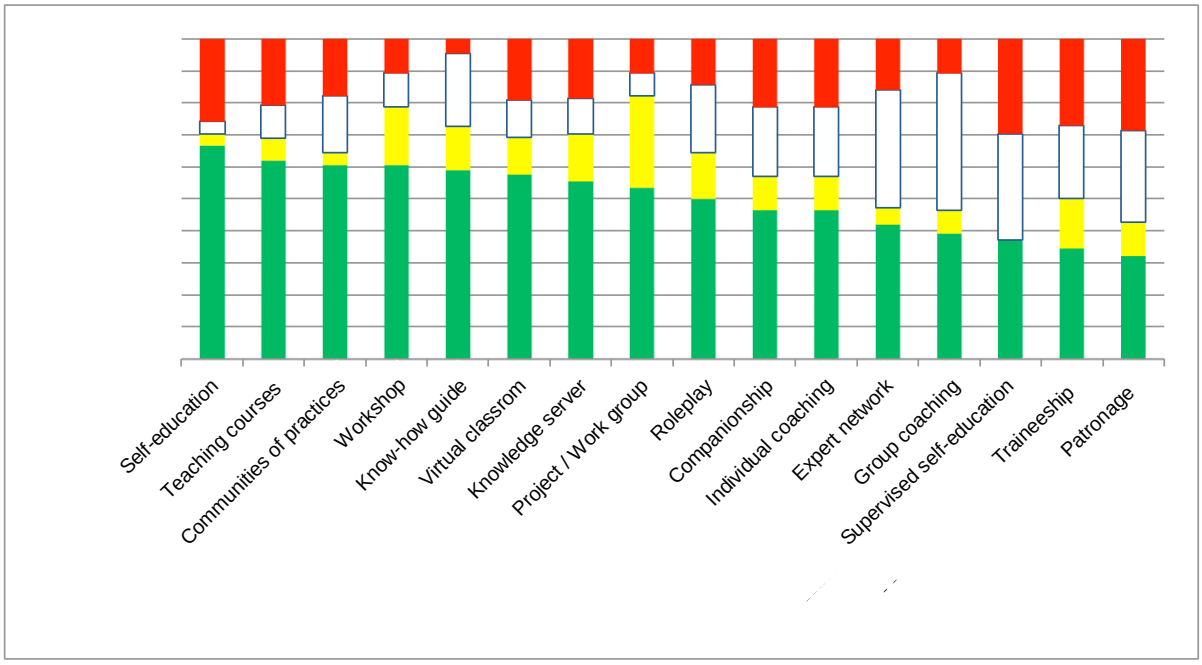

Figure 3. Results produced by the application of TRACO to the Qualisol environment related to grain legumes (Projets ANR LEGITIMES ET TATABOX, Ecole d'ingénieurs de PURPAN et al. 2015)

Our knowledge in the agricultural environment allows us to go further in the analysis of the approaches to develop. One of the methods proposed by TRACO is the use of knowledge networks. Their goal is to promote learning. This aspect has been described by (Wenger, 1998). It is highly developed in agriculture within the Local Professional Groups (LPGs) (Darré, 1999). LPGs allow grouping together farmers who are geographically close and who have the same cultural practices. These groups can produce practical knowledge during meetings. The soil and climate variability justifies the creation of LPGs; in agro-ecology, knowledge in crop management is particularly appropriate for a given soil and climate context. The construction of local knowledge is very important. In agro-ecology, soil and climate are two very important parameters. Only LPGs can correctly build local knowledge. The joint use of farmers' meetings and "classroom" training courses is relevant, as

highlighted by the TRACO method. LPGs have tacit knowledge based on their own experience. There are two additional advantages related to the use of “classroom” training courses for LPGs. First, feedbacks about the same crops can be exchanged between LPGs located in different small agricultural areas. Common knowledge can be capitalized. Second, during classroom trainings, the animator can provide important scientific knowledge. This exchange can result in the writing of technical reports produced by both empirical and scientific knowledge. Each report constitutes a common base of knowledge that can be adapted by LPGs depending on local soil and climatic conditions.

4. Discussion

The study of the application in agriculture of these two tools, CKF and TRACO, allows us to define a new method for crop management:

- For a given crop, the CKF tool highlights the lacks in knowledge about crop management,
- A collection of empirical knowledge from the best practitioners produces first technical report drafts,
- The “classroom” training course combines these empirical knowledge sources in order to produce more generic reports about crop management,
- Exchanges between LGP members (and with the animator) can provide technical solutions to various unsolved problems identified by CKF,
- Finally, in case of persistent lacks of knowledge, more information can be provided by researchers,
- If no solution can be provided by researchers, new research action plan must be started.

This new method must be validated in use cases.

5. Conclusion

Conceptual approaches - particularly the CKF method - have demonstrated that these tools can be used to integrate the spatial and temporal dimensions of agricultural production. The implementation criteria show that these tools can be used for explicit knowledge - those that people can write – and for tacit knowledge that must be transmitted by learning. These two types of knowledge are both important in agriculture. If knowledge management tools (such as the tools proposed by the French knowledge management) seem to be relevant to manage knowledge in agriculture, users need time to learn to use these tools. For some people, the use of these tools may seem a tedious and time-consuming task. To correctly analyse the survey results, it is very important to take into account the different professional categories and also the soil, climate and economic context.

In France, farming advice service is mainly provided by agricultural cooperatives and agri-business stakeholders. They provide technical recommendations (e.g., technical reports) to their members. These reports are based on the results produced by agricultural knowledge management system, but their writing is based on a top-down approach, from research

results to farmers. Thanks to the tools proposed by the French knowledge management, we have developed an alternative approach. Our method involves all the stakeholder types in the agriculture (Nagel, 1979), from farmers to researchers. This approach is based on the middle-up-down knowledge management proposed in (Nonaka, 1994). This organizational method improve the communication between the "hierarchy" and the professional stakeholders. It facilitates the creation of tacit knowledge and their external communication, whereas the “hierarchy” tends to combine knowledge and learning.

In our opinion, methods such as proposed in this paper, are important for a sustainable agriculture that must take into account environmental impacts. Research institutes have an important role in knowledge creation. Farmers and Local Professional Groups produces tacit knowledge. The challenge is to adapt this model to middle-up-down management, a model that seems relevant to agricultural knowledge management. Agricultural cooperatives could help to structure the operational knowledge in this new paradigm of agro-ecology.

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