Available online at www.centmapress.org

INTERNATIONAL JOURNAL ON FOOD SYSTEM DYNAMICS

Int. J. Food System Dynamics 9 (2), 2018, 197-206

DOI: http://dx.doi.org/10.18461/ijfsd.v9i2.927

Knowledge Management for Sustainable Agro-systems: Can Analysis Tools Help us to Understand and Support Agricultural Communities of Practice? Case of the French Lentil Production

Lola Leveau and Vincent Soulignac

TSCF Research Unity, Irstea, Centre des Cézeaux, 63170 Aubière, France
lola.leveau@gmail.com; vincent.soulignac@irstea.fr

Received October 2017, accepted April 2018, available online May 2018

ABSTRACT

Grain legumes are often mentioned as one of the levers available for the transition to sustainable agro-food systems. Unfortunately, several socio-technical lock-in, including a serious lack of technical knowledge, are currently limiting their integration in French agriculture. We evaluated the utility of two operational tools developed by the French *Club Gestion des Connaissances* for the establishment of a diagnosis concerning the knowledge management strategy of agricultural communities. The results of the survey we conducted in seven major French lentil production areas show that those two tools are useful for analysing knowledge management practices and needs in an agricultural field.

Keywords: Knowledge management; agricultural community of practice; critical knowledge; lentils

1 Introduction

Recently, grain legumes have been in the spotlight of agronomic research since their introduction in cropping systems is considered as one of the levers available for the transition to more sustainable agro-food systems (Magrini et al., 2014). However, studies on grain legumes identified several socio-technical "lock-in" (Liebowitz and Margolis, 1995) currently limiting their integration in French agriculture, including a serious lack of technical knowledge and references available for the farmers (Magrini, Thomas and Schneider, 2015). Two complementary actions can address this lack of knowledge: providing new technical references through scientific research and improving the knowledge management (KM) strategies used by the actors of this agricultural sector, notably by providing them adequate tools to capitalize and access knowledge, as discussed by Thomas et al. (2014). Since the results from leading either of these actions strongly depends on the accurate vision of the concerned sector they are based on, a good field diagnosis is an essential preliminary step.

During the last 20 years, the French KM organization Club Gestion des Connaissances (Club-gc, 2017) developed a set of operational tools helping communities of practice (CoP), defined as auto-organized

groups of persons sharing their expertise on a common domain in order to circulate good practices and to create new knowledge about it, to implement a KM plan*.

The main purpose of this study was to evaluate whether two of those operational tools, initially developed by and for industrial and services sectors, were suitable for an application in an agricultural domain. Those two tools are questionnaires that respectively help to identify, for a given CoP, what knowledge exactly is critical (Critical Knowledge Factors, CKF), and how the knowledge already present in the CoP is managed (Community Maturity Model, CoMM). In order to assess these questionnaires, in-depth interviews were conducted with them in seven major CoP of the French lentil production sector (Tab. 1, Fig. 1), well-known for the instability of its crop yields and for its lack of technical references (Metayer and Denhartigh, 2016; Jeuffroy et al., 2015). In each lentil production CoP, one to three members having a good global vision of their community (renowned farmers or technical advisors) were interviewed.

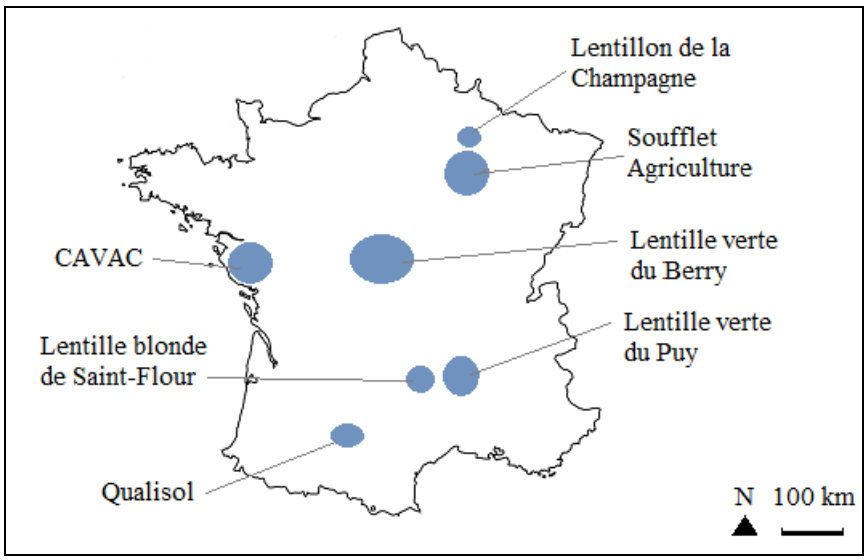

Figure 1. France map with the location of the seven lentil production communities analysed during the study

Table 1.
Description of the seven communities analysed during the study. DMO = Defence and Management Organization; *AOP* = Protected Designation of Origin, *Label Rouge* = Red Label; *IGP* = Protected Geographical Indication; CKF = Critical Knowledge Factors questionnaire; CoMM = Community Maturity Model questionnaire.

Name of the CoP	Legal form	Certification of quality and/or origin	Approximate cultivated area (ha)	Major type of lentil cultivated	Number of actors interviewed
Lentille verte du Puy	DMO	*AOP*	4000	Green spring lentil	3 (CKF) 1 (CoMM)
CAVAC	Agricultural cooperative	/	2000	Green spring lentil	3
Soufflet Agriculture	Trading company	/	2000	Green spring lentil	3
Lentille verte du Berry	DMO	*Label Rouge* *IGP*	750	Green spring lentil	3
Qualisol	Agricultural cooperative	/	250	Green spring lentil	3 (CKF) 1 (CoMM)
Lentillon de la Champagne	DMO	Applying for *AOP*	150	Red winter lentil	1
Lentille blonde de Saint-Flour	DMO	Applying for *AOP*	50	Brown spring lentil	3

* The operational tools are only accessible to the adherents of the Club Gestion des Connaissances. However, a KM Handbook explaining on what concepts each tool is based and when it may be used during a KM action plan will soon be available to all on their website (Club-gc, 2017) under a Creative Commons license (CC BY-NC-SA).

While both of the tools provided interesting results, the second one (CoMM) seems to be the most useful for a preliminary KM diagnosis since it allowed us to construct, via a principal components analysis (PCA), a clear typology of the different CoP analysed in terms of KM.

2 CKF: a tool for measuring the criticality of different knowledge domains

2.1 Methods of use

CKF is a questionnaire used to rate the criticality of different knowledge domains associated to a particular practice. The criticality of each domain is rated by 20 questions related to four main characteristics of the knowledge: its scarcity, its utility for the CoP, its difficulty to be acquired and its difficulty to be exploited. For each question, the answer is a number between zero and four, four corresponding to the higher level of criticality.

For the lentil production sector, twelve fields of knowledge like pest management, fertilization practices or harvest and storage techniques were identified. Since each of the 20 questions must be asked for each field of knowledge, a complete CKF interview takes a considerable time and may be really burdensome for the respondent. For this reason, the complete version of CKF was only carried out in one CoP, Qualisol in Midi-Pyrénées. In the other CoP, the ranking of Qualisol and the four major criticality factors it was based on were presented to the respondent, who had to establish a new criticality ranking for its own CoP.

2.2 Results: a geographical ranking of criticality for the twelve lentil production knowledge domains

The results of the CKF questionnaire show that the most critical domains of knowledge are pretty homogeneous between the CoP, particularly concerning insect management and weed control (Tab. 2). Still, variations can be observed from a production area to another, which is not surprising considering the wide range of climates, soils, farming models and commercial strategies constituted by the seven regions we studied. The most striking examples are the varying prevalence of airborne and soilborne diseases and the result expected from varietal selection, which varies a lot depending on the area's marketing strategy: differentiated quality production based on one long renowned variety, production of lentil with thick teguments for the agro-industry etc.

Table 2.

Results of the Critical Knowledge Factors (CKF) questionnaire: ranking of criticality, in decreasing order, for the twelve knowledge domains of the French lentil production in the seven communities of practice (CoP) analysed. The complete version of the CKF was used in the CoP Qualisol, while a short version was used in the six other CoP. The domains in red are cited as very critical by a majority of the members of the CoP interviewed. The domains in green are considered as non critical by all the members interviewed.

Complete vers.	**Short version**					
Qualisol	**Lentille verte du Puy**	**CAVAC**	**Soufflet**	**Lentille verte du Berry**	**Lentillon de la Champagne**	**Lentille blonde de Saint-Flour**
Insects	Weeds	Weeds	Weeds	Insects	Airborne diseases	Weeds
Weeds	Soilborne diseases	Insects	Insects	Weeds	Harvest and storage	Climate and soil
Harvest and storage	Insects	Harvest and storage	Soilborne diseases	Climate and soil	Weeds	Insects
Climate and soil	Crop rotation	Commercial outlets	Varieties	Varieties	Insects	Crop rotation
Crop rotation	Airborne diseases	Varieties	Airborne diseases	Crop rotation	Varieties	Harvest and storage
Commercial outlets	Varieties	Soilborne diseases	Harvest and storage	Airborne diseases	Crop rotation	Commercial outlets
Varieties	Climate and soil	Crop rotation	Climate and soil	Commercial outlets	Climate and soil	Soilborne diseases
Soilborne diseases	Fertilisation	Airborne diseases	Crop rotation	Soilborne diseases	Commercial outlets	Airborne diseases
Airborne diseases	Harvest and storage	Climate and soil	Commercial outlets	Harvest and storage	Soilborne diseases	Varieties
Irrigation	Irrigation	Slugs	Fertilisation	Fertilisation	Irrigation	Fertilisation
Fertilisation	Commercial outlets	Fertilisation	Irrigation	Irrigation	Fertilisation	Irrigation
Slugs	Slugs	Irrigation	Slugs	Slugs	Slugs	Slugs

2.3 Conclusions on CKF suitability for an agricultural sector

For establishing a general diagnosis about the lack of knowledge existing in different CoP of an agricultural sector, the application of the short version of the CKF appears to be sufficient. This is mainly due to the fact that in agriculture, knowledge available in each domain is so central in the everyday work of an actor that he can easily produce an intuitive criticality ranking of it. Indeed, during a crop season, each technical decision is based on almost all the domains of knowledge implied in the production: the work is not divided into successive and independent steps managed by different actors, as it could be for an industrial process.

The complete version of the CKF, on the other hand, is worth carrying out in a CoP that decides to improve its KM strategy and needs to establish priorities by precisely identifying what knowledge and which actors are critical for its development. Indeed, the complete version of the CKF gives a deeper insight of the knowledge lacking in a CoP than the short version since it provides not only a ranking but also a score of criticality (from 0 to 4) for each of the 20 questions in each domain.

In any case, a particular attention must be taken to interview members having different roles in a CoP since these roles may influence the domains considered as critical. For example, when the farmers deliver lentils to a cooperative immediately after the harvest, the storage techniques are only a subject of concern for the technical advisors. Similarly, the members implied in the commercial organisation of a CoP tend to consider the research of market opportunities as more critical than the others. Beyond the question of the domains “felt” as critical, carrying out the CKF questionnaire on members having different roles in an agricultural production sector (farmers, technical advisors, researchers etc.) is a good way to identify knowledge detained by some actors but not efficiently spread through the sector. The same applies to the use of CKF in multiple isolated CoP, which can lead to the realization that knowledge missing in a given CoP is well mastered in another one. For example, our study revealed that the CoP Lentille blonde de Saint-Flour could learn a lot from other CoP such as Lentille verte du Berry or Soufflet concerning storage techniques, which are not well mastered by its members and cause considerable losses every year.

In conclusion, depending on the complexity of the version used, the application of the CKF questionnaire in an agricultural sector provides results going from a general insight into the lack of knowledge hampering a community to a precise report about the degree of criticality and the inequalities of distribution of a given domain of knowledge. Consequently, it helps to decide what actions to lead in order to reduce knowledge criticality, as well in terms of new references production via scientific research as in terms of knowledge transfer actions (between CoP, from researchers to technical advisors, from farmers to researchers, between farmers etc.).

3 CoMM: a tool for assessing the KM strategy of a community

3.1 Method of use

CoMM is a questionnaire evaluating the maturity of a CoP in terms of KM. Its main purpose is to establish the complete inventory of a KM strategy by exploring the CoP’s advancement concerning different KM topics, in order to identify the points where progress can be made. The first step of the interview is to correctly define the limits of each CoP: who belongs to it? With which external organizations does it collaborate and share knowledge? Once the CoP is delimited by the respondent, the questionnaire consists in eighteen questions related to the following four themes, inspired by the works of Wenger (1998) on CoP: joint enterprise, mutual engagement, shared directory and collaborative work (Tab. 3). For each question, the answer is a number between zero and four, four corresponding to the higher level of maturity.

3.2. Results: a new typology to understand the KM strategy of lentil production CoP

Some comments about the results obtained with the CoMM are interesting to make before doing any statistical analysis. Firstly, all the actors interviewed agreed with the CoP delimitation we presented them (Tab. 1). Secondly, few relations between the different CoP were cited by the actors, except for the four CoP Soufflet, CAVAC, Lentille verte du Puy and Lentille verte du Berry, that recently began to communicate about technical knowledge since they associated through the newly-created French grain legumes inter-professional association (ANILS). Thirdly, while the scores vary from one to four for most of the questions, all the CoP display very low scores (between one and two) for the last question of the CoMM, which concerns the KM tools used by the members (Tab. 3).

Table 3.
Community Maturity Model (CoMM) questionnaire. For each question, the answer is a number between zero and four, each number being illustrated with an example to ease and homogenize the answers of the members interviewed. The answer four always corresponds to the higher level of maturity.

Themes	Questions
Joint enterprise	1. What is the legitimacy of your community? Do you receive help from external actors? 2. Did you identify the major knowledge domains of mutual interest? 3. Did you commonly decide tasks corresponding to those knowledge domains? 4. Does your community create knowledge exchanges opportunities and does it produce new collective knowledge?
Mutual engagement	5. Do you have criteria for membership? 6. Do you have rules of conduct? 7. Are the members motivated by the objectives of the community? 8. What is the degree of involvement of the members (active/passive ratio)? 9. What is the degree of reciprocal trust between the members?
Shared directory	10. How renowned is the history of your community? 11. Is your community strengthened by shared values? 12. How big is the sense of belonging of the members? 13. How do you capitalize knowledge? 14. Did you establish a common frame of reference from the capitalized knowledge?
Collaborative work	15. How organized is the communication between the members? 16. How coordinated are your knowledge exchanges and creation activities? 17. Is there regular collaboration and does it involve a majority of the members? 18. Which communication, sharing and problem-solving tools do you use?

This is due to the fact that face-to-face meetings, phone calls or emails are still the most used communication and knowledge sharing tools, even if some CoP complement that with private-access websites or sharing softwares. Finally, some respondents showed a real interest in the CoMM questionnaire, which obliged them to assess their KM strategy by answering questions they usually do not take the time to ask themselves, even if they are crucial.

Normally, the *Club Gestion des Connaissances* recommends employing a radar (or Kiviat) diagram to observe the results of the CoMM questionnaire. However, the application of a PCA to the results is a more effective way to obtain a clear representation of the results per individual and per community. Consequently, for greater readability but also for statistical validity evaluation, a PCA was conducted with the results of the CoMM questionnaire, each question being an explicative variable.

Several observations can be made from the plan formed by the first and the second principal axis of the PCA (Fig. 2, Fig. 3), which summarizes a significant proportion of the information obtained with the survey (54,45%), as well as from the third principal axis of the PCA.

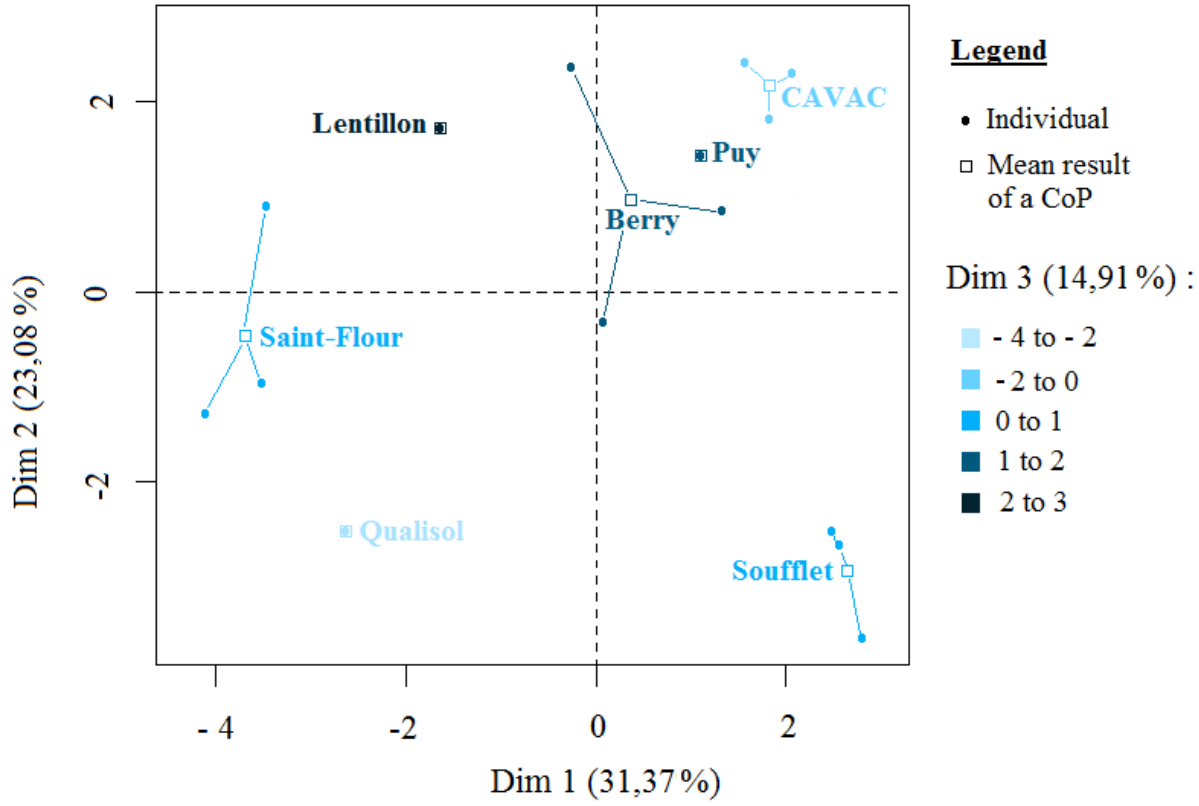

Figure 2. Graph of the individuals obtained via a principal components analysis (PCA) of the CoMM questionnaire results. The coordinates of each individual are represented on axes for the first and second principal dimensions (Dim 1 and Dim 2) of the PCA, and via a colour chart for the third principal dimension (Dim 3) of the PCA. The percentage next to each axis represents the portion of the individuals' variance synthetized by this axis. For each community of practice (CoP), the dots represent individuals, while the square represents the mean result of the CoP. For readability, individuals from a same CoP are connected to the mean result of their CoP by a line which has no statistical meaning.

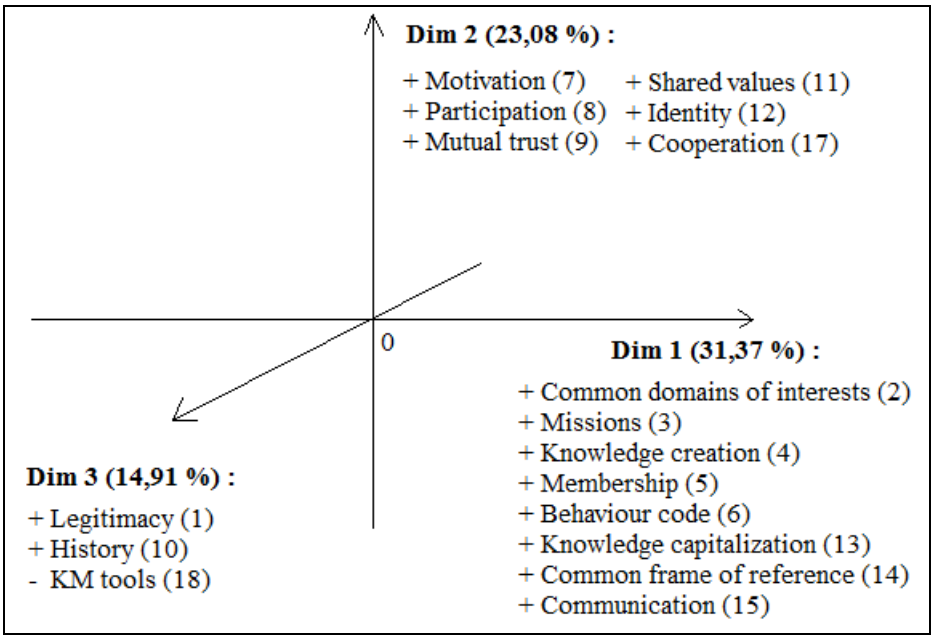

Figure 3. First (Dim 1), second (Dim 2) and third (Dim 3) axis of the principal components analysis (PCA) carried out with the results of the CoMM questionnaire.

In figure 3, the percentage next to each axis represents the portion of the individuals' variance synthetized by this axis. The explicative variables significantly correlated to an axis are cited bellow it, with a "+" if the correlation is positive and with a "-" if the correlation is negative. The number in brackets next to a variable refers to the number of the correspondent question in the CoMM questionnaire.

Firstly, it appears that the dots representing individuals belonging to the same CoP are systematically close to one another on the PCA plan (Fig. 2). Indeed, the qualitative explicative variable "CoP" explains significant proportions of the individuals' variance along the three first axes of the PCA (respectively 97,8%, 88,2% and 94,8%), even when the CoP containing only one individual are not considered (respectively 98,0%, 85,7% and 61,3%). This proximity is interesting since it shows that members of a same CoP often provide similar answers to the CoMM questionnaire, but also that the CoP delimited for the survey correspond to actual homogenous communities.

Secondly, the PCA highlights the many significant correlations existing between the eighteen questions of the CoMM, which were used as explicative variables (Fig. 3). It is interesting to observe that those correlations do not correspond to the classification by theme proposed in the CoMM questionnaire (Tab. 3). For example, some questions of the second theme, mutual engagement, are correlated with the first axis of the PCA (questions 5 and 6) while the others are correlated with the second axis of the PCA (questions 7, 8 and 9). A new typology of the CoP in terms of KM, different from the four themes of the CoMM, can therefore be proposed from the results of the PCA. The first classification criteria of this typology - the first axis of the PCA (Dim 1) - is significantly positively correlated with eight questions of the CoMM which all concern the technical and organizational maturity of the employed KM strategy. A CoP situated on the positive part of this axis tends to have membership criteria, clear organizational roles and strong, mutually-agreed research and development program. The second classification criteria of this typology - the second axis of the PCA (Dim 2) - is significantly positively correlated with six questions relative to the level of involvement and the sense of belonging reigning in a CoP. The communities with a high degree of reciprocal trust, a tendency to cooperate and many shared values tend to be positioned on the positive part of this axis. Finally, the third classification criteria of this typology - the third axis of the PCA (Dim 3) - is significantly positively correlated with two questions concerning the history of the CoP and the recognition and help it receives from external actors, and is significantly negatively correlated with one question about the complexity of the KM tools used by the CoP members.

This new typology and the positions of the CoP along its three axes are of course dynamic, and a correlation between two variables does not imply a causal relation between them. However, the clustering of variables observed here seems pretty logical, except maybe for the opposition between the recognition a CoP receives and the KM tools it uses, that could easily disappear if some other CoP were interviewed. Besides, this classification is particularly useful to determine the needs and fears of each community concerning knowledge sharing and management tools, which was the purpose of this initial KM diagnosis. To illustrate this utility, a typological description of the seven lentil production CoP analysed is presented in the next paragraphs.

A first interesting observation concerns the four communities located on the positive part of the first axis (Fig. 2), described as the "technical and organizational maturity of KM strategy" axis (Fig. 3). These CoP have two things in common: firstly, they are the four French CoP cultivating the largest lentil surfaces, which naturally implies a good internal organisation. Secondly, they are the four CoP implied in the newly-created ANILS association. If it was not already done, the definition of this group's research and development program was the occasion for each of them to identify its most critical domains of interest and the technical trials needed to improve its knowledge capital.

A second interesting observation concerns the opposing positions of the communities CAVAC and Soufflet along the second axis (Fig. 2), described as the "level of involvement and sense of belonging" axis (Fig. 3). There are two main explanations for the significantly negative coordinate of Soufflet: Firstly, the CoP is a trading company buying lentils to farmers via annual contracts. This kind of relation between members does not implies to share values and does not characterize itself by a strong sense of identity, especially since the lentils produced do not have quality nor controlled origin label. Secondly, the company is conducting a very "top down" KM policy: while farmers easily adopt new knowledges produced by the technical advisors during strictly monitored trials, they do not tend (and are not encouraged) to take part in the knowledge creation via personal less-controlled trials. According to the technical advisor we interviewed, this top-down logic that concerns all the crop productions managed by Soufflet is justified by the fact that the CoP has to meet the high-quality standards of the food industry. At the opposite, the cooperative CAVAC, although it has to deal as well with strict food industry demands, distinguishes itself by a significantly positive coordinate on the second axis. All the interviewed members pointed out the excellent relations existing between the technical advisors and the farmers, and the two-way character of their exchanges. Besides, they share multiple values and have a strong sense of belonging to the CoP. The

differences observed with the company Soufflet probably have to do with the fact that CAVAC, as a cooperative, is characterized by the long-term implication of its members. These observations about the multiple forms of trust existing between members depending on their respective roles in the CoP (new farmer, renowned farmer, technical advisor, etc.) were not taken into account while constructing the CoMM questionnaire. This insufficiency can be related to the work of Roberts (2006) concerning the limits to the CoP approach in KM, as she mentions the weakness of this method concerning questions about "power" and "trust" within a community.

A third observation can be made about the threefold negative position of Qualisol (Fig. 2), which is due to the fact that despite its good experience in crop production, this cooperative began to manage lentil production really recently. Consequently, there is not yet a clear organisation of the knowledge capital concerning lentil, nor a powerful sense of identity amongst the members, nor a long shared history. Considering the good scores Qualisol would have obtained if the CoMM was about a crop production it manages since a longer time, we can predict that its position in the PCA plan will change a lot in the next few years.

The case of the CoP "Lentillon de la Champagne" is particular: contrary to Qualisol, it is not in development but rather in decline. Its long history, the multiple financial supports it received and the very good relation still existing between its members explain why the CoP is on the positive part of the second and third axes (Fig. 2). However, the CoP is currently in a "waiting" state concerning the organisation of its KM, mainly because its number of members - that are all farmers - has strongly decreased. While huge efforts were made a few years ago for collecting historical knowledge, this capital is not distributed anymore amongst the members, nor updated. The integration of new members and the acceptance of the Protected Designation of Origin (AOP) application of the CoP could unblock the current situation.

Finally, the CoP "Lentille blonde de Saint-Flour" distinguishes itself by a significantly negative coordinate on the first axis of the PCA (Fig. 2). This is due to the fact that until very recently, all the members of the CoP were farmers with very little time to dedicate to lentil production KM. This also explains their coordinate near to zero on the second axis: while all the members pointed out a strong identity, a good mutual trust and many shared values, the motivation and the level of participation to KM activities are pretty low since lentil production represents a minor part of their crop rotation. Besides, the main activity of the Cantal department where the CoP is located is cattle breeding, so the members' crop production skills are way less developed than in other areas. This situation could change since technical advisors from the Chamber of Agriculture of the Cantal department are now working with the CoP in order to develop sustainable lentil production techniques that will ease the acceptance of their application for an AOP label.

3.3 Conclusions on CoMM suitability for an agricultural sector

The CoMM questionnaire provides a solid basis to implement a KM action plan in a CoP since it shows its main deficiencies in this field. Moreover, the application of a PCA to the results of the CoMM enlightens interviewers about the significant correlations existing between the questions they used and allows them to construct a relevant classification of the communities they studied. However, the comparison between the position each lentil production CoP has on the PCA plan and the complete conversation we had with their members highlighted two linked weaknesses of the CoMM questionnaire for an agricultural application. Firstly, the only question about mutual trust is based on the assumption that the degree of confidence existing between the members is homogeneous regardless of the role each member plays in the community, which was not always true during our study, particularly concerning the CoP Soufflet. Secondly, an additional question concerning the way new knowledge is validated by the CoP members would be interesting. Indeed, this subject is never addressed in the CoMM, while it is one of the main characteristics distinguishing the different CoP in terms of KM. The score obtained to this new question should depend more on the fact that the process of knowledge validation, called "procedural authority" in some French KM literature (Cohendet et al., 2003), is clear and well-known by the members, than on the kind of validation process applied since it would be very subjective to decide which process (strict scientific validation by the main technical advisor, experimental validation by a majority of the farmers, etc.) is more mature in terms of KM.

3.4 Use of the CoMM results in further studies on KM web tools

Besides the tool's utility evaluation, the application of the CoMM questionnaire in lentil production CoP, combined with the PCA, was the occasion to identify which CoP were the most suitable for the next step of our study, which will consist in an evaluation of the supporting role a semantic collaborative web tool can play in agricultural KM. This web tool - jointly developed by the National Research Institute of Science and Technology for Environment and Agriculture (Irstea) for the information technology side and by the

French National Institute for Agricultural Research (INRA) for the agronomic side - is notably designed to ease the access to attested knowledge concerning sustainable and less pesticide-dependent crop production techniques, and to allow networking and exchanges of experience beyond the borders of a CoP (Guichard et al., 2015; Soulignac et al., submitted for publication). The CoP Lentille blonde de Saint-Flour, characterized by a notable history and by good relations between its members, but hampered by important lacks of technical knowledge and KM tools, will be the starting point of our study. Agronomic institutes and other small CoP open to exchanges about sustainable techniques of lentil production should also be implied, for example the CoP Qualisol and communities participating to the French pesticide-reduction program, Ecophyto II (MAAF and MEDDE, 2015).

4 Conclusions and perspectives

The main objective of this study was to evaluate the relevance of the tools CKF and CoMM, initially designed for classical industries and services sectors, in an agricultural context. Our conclusions are that for a first general diagnosis, CKF could be replaced by a simpler and faster intuitive-ranking exercise based on the same four criteria (rarity, utility etc.) without too many information losses. The complete version of CKF, for its part, is useful to obtain a more thorough analysis of the knowledge and actors that are critical for the development of an agricultural community. On the contrary, the CoMM questionnaire is worth carrying out entirely even during a preliminary KM diagnosis since it provides useful results concerning the KM strategies of each CoP studied, especially when it is combined with a PCA. Though, several adaptations could make it more suitable to agronomic sectors, notably including a question concerning the way knowledge is validated within the CoP and dividing the question about mutual trust into multiple questions relative to the different relations of trust existing between members of a CoP (farmer to technical advisor, farmer to farmer, technical advisor to farmer, etc.).

Besides this main objective, the evaluation of these tools was the occasion to obtain a consistent diagnosis about the KM strategies of the main lentil production French CoP. This diagnosis will serve as a basis for the establishment of a KM action plan with some CoP interested in optimizing the management and the diffusion of sustainable agricultural knowledge, in particular via the use of a collaborative web tool.

Finally, the conduct of this survey brought to light a question that we did not anticipated and that is rarely addressed in studies about web collaboration in agriculture: the actor's reluctance to share knowledge beyond the borders of their own community. Indeed, during the interviews we sometimes faced pretty negative reactions about technical knowledge sharing, mainly because that knowledge is considered as a competitive advantage that must be kept internally. Understanding which actors of the French agricultural sector (farmers, CoP, technical institutes, fundamental research institutes, schools, etc.) consider knowledge exchanges as a positive innovation source and are ready to communicate with others is essential to develop web tools that will effectively support agricultural networking. Consequently, further studies on the social, political, agronomic and economic factors influencing the threatening or opportune character of knowledge sharing between CoP would be very valuable, as were the studies of Kühne et al. (2013) and Bertin et al. (2014), respectively for the farmer level in Flanders and for the public research level in Brazil.

Acknowledgements

The authors are grateful to the 19 members of the agricultural communities Qualisol, Lentille verte du Puy, CAVAC, Soufflet Agriculture, Lentille verte du Berry, Lentillon de la Champagne and Lentille blonde de Saint-Flour who accepted to answer to the CKF and CoMM questionnaires and to describe their working mode.

This research is supported by the French ANR (Agence Nationale de Recherche) – AAP GUI 006 Agrobiosphere / Project TATABOX ("Territorial Agroecological Transition in Action", 2014-2018).

References

Bertin, P., Fry, J., Ragsdell, G. (2014). The tension between competitive and collaborative forces in agricultural research: Impact on knowledge sharing within a public sector organization. Paper presented at the 15th European Conference on Knowledge Management, Santarem, Portugal, available at: https://dspace.lboro.ac.uk/dspace-jspui/bitstream/2134/17112/1/Bertin_Fry_Ragsdell_2014%20-%20Competitive%20and%20collaborative%20forces%20vs%20knowledge%20sharing.pdf.

Club-gc (2017). Club Gestion des Connaissances Home Page. 21 February 2017, Club Gestion des Connaissances. Available at: http://www.club-gc.asso.fr/.

Cohendet, P., Créplet, F., Dupouët, O. (2003). Innovation organisationnelle, communautés de pratique et communautés épistémiques : le cas de Linux. *Revue Française de Gestion*, **146**: 99-121. Available at : http://www.cairn.info/revue-francaise-de-gestion-2003-5-page-99.htm.

Guichard, L., Ballot, R., Halska, J., Lambert, E., Meynard, J.M., Minette, S., Petit, M.S., Reau, R., and Soulignac, V. (2015). AgroPEPS, un outil web collaboratif de gestion des connaissances pour Produire, Echanger, Pratiquer, S'informer sur les systèmes de culture durables. *Innovations Agronomiques*, **43**: 83-94.

Jeuffroy, M.H., Biarnès, V., Cohan, J.P., Corre-Hellou, G., Gastal, F., Jouffret, P., Justes, E., Landé, N., Louarn, G., Plantureux, S., Schneider, A., Thiébeau, P, Valantin-Morison, M., and Vertès, F. (2015). Performances agronomiques et gestion des légumineuses dans les systems de productions végétales. In Schneider, A. and Huyghes, C. (Eds), Les légumineuses pour des systèmes agricoles et alimentaires durables. Paris, Editions Quae: 139-186.

Kühne, B., Lambrecht, E., Vanhonacker, F., Pieniak, Z., Gellynck, X. (2013). Factors underlying farmer's decision to participate in networks. *International Journal on Food System Dynamics*, **4** (3): 198-213. Available at: http://centmapress.ilb.uni-bonn.de/ojs/index.php/fsd/article/view/434/345.

Liebowitz, S.J., Margolis, S.E. (1995). Path dependence, lock-in, and history. *Journal of Law, Economics and Organization*, **11**: 205-226. Available at: https://www.researchgate.net/publication/-5213887_Path_Dependence_Lock-In_and_History.

MAAF, MEDDE (2015). Plan Ecophyto II, agroécologie, produisons autrement. Available at: http://agriculture.gouv.fr/sites/minagri/files/151022_ecophyto.pdf.

Magrini, M.B., Thomas, A., Schneider, A. (2015). Analyses multi-enjeux et dynamiques socio-économiques des systèmes de production avec légumineuses. In Schneider, A. and Huyghes, C. (Eds), Les légumineuses pour des systèmes agricoles et alimentaires durables. Paris, Editions Quae: 339-413.

Magrini, M.B., Voisin, A.S., Anton, M., Cholez, C., Duc, G., Hellou, G., Jeuffroy, M.H., Meynard, J.M., Pelzer, E., Walrand, S. (2014). Which place for grain legumes in the transition to a sustainable agrofood system? Paper presented at the seminary "La grande transformation de l'agriculture, 20 ans après", Montpellier, France, available at: https://www.researchgate.net/publication/278804035_La_transition_-vers_des_systemes_agro-alimentaires_durables_quelle_place_et_qualification_pour_les_legumineuses-_a_graines.

Metayer, N., Denhartigh, C. (2016). Les legumes secs, quelles initiatives territoriales? Report ordered by the French ministries MEEM and MAAF and by the agency ADEME. Available at: https://www.rac-f.org/IMG/pdf/publi-leI_gumes_secs-web-finale.pdf.

Roberts, J. (2006). Limits to Communities of Practice. Journal of Management Studies 43 (3), 623-639. Available at: http://onlinelibrary.wiley.com/doi/10.1111/j.1467-6486.2006.00618.x/full.

Soulignac, V., Pinet, F., Lambert, E., Guichard, L., Trouche, L., Aubin, S. (2016). GECO, the French Web-based application for knowledge management in agroecology. *Computers and Electronics in Agriculture*, forthcoming.

Thomas, L.S., Alvarado, D.M., Araya, C.A., Ramirez, J.J.B., Ramirez, J.M.B., Viquez, G.B., Acuna, S.G., Redondo, F.V. (2014). The development of automated information systems to reduce the digital divide in agricultural communities: the case of the agricultural Information Service in Tierra Blanca (SIT), Costa Rica. *International Journal on Food System Dynamics*, **5** (4): 230-240. Available at: http://centmapress.ilb.uni-bonn.de/ojs/index.php/fsd/article/view/548/501

Wenger, E. (1998). Communities of practice: Learning, Meaning and Identity. Cambridge, Cambridge University Press.