Ecological, technical and social innovation processes in conservation agriculture research position and first results of the ANR funded program PEPITES

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ECOLOGICAL, TECHNICAL AND SOCIAL INNOVATION PROCESSES IN CONSERVATION AGRICULTURE

RESEARCH POSITION AND FIRST RESULTS OF THE ANR FUNDED PROGRAM PEPITES

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Résumé — Les techniques culturales sans labour et l'Agriculture de Conservation (AC), fondées sur une perturbation minimale du sol, le maintien d'une couverture végétale en surface et une diversification des rotations et associations de cultures, se développent rapidement au nord et au sud. Leur émergence procède souvent d'un processus d'innovation original, fondé sur un apprentissage permanent et adaptatif au sein de réseaux sociotechniques novateurs, qui bouscule les schémas linéaires de conception et transfert des innovations. Les modifications du fonctionnement de l'agrosystème en AC sont susceptibles de fournir des services écosystémiques mais la mise en œuvre délicate de ces techniques peut en diminuer les performances, notamment en augmentant la dépendance aux pesticides. L'objectif général du projet PEPITES est de produire des connaissances sur les processus écologiques, les processus d'innovation technique et sociale et leurs interactions, pour évaluer et concevoir des systèmes techniques et des dispositifs d'accompagnement plus durables. Nous construisons pour cela une approche interdisciplinaire articulant les sciences biophysiques, l'agronomie des systèmes de culture et des systèmes de production et la sociologie de l'innovation, en partenariat avec les acteurs professionnels sur quatre terrains d'étude : France grandes cultures, France agriculture biologique, Brésil et Madagascar petite agriculture familiale. Après un an d'opération, nous présentons les réponses apportées aux défis du projet en termes de posture de recherche autour de deux questions clé : comment construire une approche interdisciplinaire et en partenariat pour accompagner un processus d'innovation et produire des connaissances ? Comment construire une approche comparée entre terrains, au nord et au sud ?

Mots clés : non labour, plante de couverture, Brésil, Madagascar, agriculture biologique, services écologiques, réseaux sociotechniques, interdisciplinarité, approche participative, partenariat.

Abstract — No-tillage techniques and conservation agriculture (CA), based on minimal soil disturbance, the maintenance of plant cover and a diversification of rotations and intercropping, are developing rapidly in both the North and South. The emergence of these techniques often involves an original process of innovation based on continuous and adaptive learning within innovative socio-technical networks, which overturn the traditionally linear process of innovation design and transfer. Changes in the functioning of the agrosystem associated with CA are likely to supply ecosystem services, but the difficult implementation of these techniques may decrease the performance of the agrosystem, in particular by increasing dependence on pesticides. The general objective of the PEPITES project is to generate knowledge concerning ecological processes, technical and social innovation processes and their interactions, for the evaluation and design of more sustainable technical and support systems. We are working towards this objective by constructing an interdisciplinary approach combining biophysical sciences, cropping system and production system agronomy and the sociology of innovation, in partnership with professionals in four study terrains: conventional field crops in France, organic farming in France and small-scale family farms in Brazil and Madagascar. After one year of operation, we present here the progress made towards answering the questions posed in this project, in terms of the positioning of research with respect to two key questions: first concerning the construction of an interdisciplinary approach in partnership to assist the innovation process and the generation of knowledge, and second the construction of an approach for comparing terrains in the North and South.

Key words : no-tillage, cover crop, Brasil, Madagascar, organic farming, ecological services, sociotechnical networks, interdisciplinarity, participatory approaches, involvement of stakeholders

INTRODUCTION

The development of sustainable forms of agriculture valorising the use of ecological processes whilst responding to the demands and constraints of farmers and society poses challenges of several types. What knowledge do the various actors involved require to understand and valorise these ecological processes? How are these ecological processes modified by crop management practices, and how can they be optimised? Are any innovations (technical, social or organisational) required to generate or to facilitate the necessary associated change in practices, technical systems and professional social networks? How can these innovations be incorporated into production systems that are themselves rapidly changing, whilst best meeting the professional and personal objectives of farmers ? How can research, in a functional manner, best develop the acquisition of knowledge and accompany change, to contribute to sustainable agricultural development?

These issues are at the heart of the rapid development of conservation agriculture (CA), which, in its various forms, already covered nowadays more than 100 million hectares worldwide (Derpsch et al., 2010). CA is based on the application of three major principles of agrosystem management: (1) minimal soil disturbance, (2) protection of the soil through the permanent maintenance of plant cover at the surface, (3) the diversification of rotations and intercropping (FAO, 2010). The diversity of production conditions and of farmers' needs has led to a considerable diversification of practices in the application of these three principles. CA thus corresponds to a family of cropping systems rather than to a single technology or system. In some cases, seeds are sown directly through the crop residues (direct drilling through stubble), while in others, the soil is still lightly prepared to facilitate crops installation.. In all cases anywhere, changes related to the introduction of CA goes beyond a mere change in soil tillage techniques, and must be considered in a broader context including other innovations, such as the use of cover crops and intercropping for example.

The adoption of CA depends on different determinants in different situations but, in most cases, it is developed in response to two main types of constraint: agroenvironmental constraints on the one hand (in particular, the need to combat erosion and declining soil fertility) and/or economic constrains on the other (the need to increase profitability by decreasing working time and the use of fossil fuels). In the current context, these two driving forces are very powerful, both in the North and in the South, stimulating processes of technical and organisational innovation that differ considerably between different contexts (Coughenor, 2003; Ekboir, 2003; Triomphe and Sain, 2004, Bolliger *et al.*, 2006, Triomphe *et al.*, 2007).

The introduction of CA leads to substantial changes in the functioning of the agrosystem. It can contribute to increases in the physical productivity of cropping systems and their profitability, and may also increase the provision of many ecological services, such as the conservation of soils and biodiversity, carbon sequestration, plant biomass production and the control of certain pollutants. Conversely, CA is associated with a risk of failure linked to the difficulty of learning how to apply the new technologies involved, the cost of this learning process and the required changes in production systems, which may be particularly problematic in highly constrained situations. In addition, CA may, in some cases, increase dependence on pesticides (mostly herbicides), jeopardising the long-term sustainability of these systems. Finally, the development of CA in many instances is based on an original process of innovation, involving continuous, adaptive learning within a sociotechnical network in which farmers play a key role. This participatory, multi-stakeholder process completely overturns the linear flow of the design and transfer of innovations which has been typical of the green revolution model.

The problem posed is thus that of how to assist the process of innovation in CA, which is rapidly developing due to its economic profitability, and for which the use of ecological processes seems to be a key point for increasing productivity, supplying ecological services and reducing inputs. The PEPITES project (*Processus Ecologiques et Processus d'Innovation Technique et Sociale en Agriculture de Conservation*; Ecological Processes and Processes of Technical and Social Innovation in Conservation Agriculture) funded since January 2009 by the French ANR (Systerra call) aims to address this issue.

1. IMPORTANT ISSUES AND OBJECTIVES OF THE PEPITES PROJECT

1.1. Understanding and making the best use of ecological processes

Minimal and no tillage systems, involving minor or no mechanical disturbance of the soil and the presence of crop residues at the soil surface, are leading to two major changes in the functioning of the agrosystem:

- A vertical gradient in organic matter content is gradually established, with the accumulation of organic inputs at the soil surface. This modifies the biological and geochemical processes underlying the functions of element recycling, storage and transformation, contributing to the quality and fertility of soils and fulfilling ecological functions. Several studies have investigated the effects of the distribution of plant residues on their decomposition (Douglas *et al.*, 1980), CO_2 emissions (Curtin *et al.*, 1998), mineralisation (Corbeels *et al.*, 2003) and microbial activity (Holland & Coleman, 1987). The residues remaining at the surface also increase water infiltration and slow the initial evaporation from the soil, thereby modifying soil moisture conditions (Bond & Willis, 1969).
- The habitat becomes much more favourable to soil organisms, which often increase in number, diversity and activity. Many studies have shown that the communities of living organisms in the soil (i) differ between conventional farming and CA systems; (ii) vary according to the age of the CA system and (iii) vary as a function of intercropping practices and the quality of the residues provided (Kladivko, 2001; Holland, 2004; El Titi, 2003a, b; Blanchart *et al.*, 2006; Blanchart *et al.*, 2007; Rabary *et al.*, 2008). These changes to soil-dwelling communities and their biological activities lead to changes in organic matter and soil structure dynamics, resulting in changes to the overall functioning of the soil, but without the clear demonstration of a causal relationship (Coq *et al.*, 2007).

However, it is often difficult for farmers to decrease soil tillage, because this requires a re-assessment of all practices in their cropping systems, to take into account the modifications of the functioning of the agrosystem. In particular, increases in biodiversity generally lead to an increase in the pressure exerted by bioaggressors, including, in particular, weeds, which are no longer ploughed under (Debaeke & Orlando, 1991). This may lead to some farmers increasing their use of herbicides or even introducing these chemicals for the first time, as has been reported in some developing countries (Boahen *et al.*, 2007; Baudron *et al.*, 2007). This may jeopardise the sustainability of these systems, due to potential environmental effects, problems relating to social acceptability and costs. Conversely, the use of cover crops may decrease weed pressure, through competition or alleopathic effects (Holland, 2004; Carof *et al.*, 2007 ; de Tourdonnet *et al.* 2006, 2007), and may make it possible to maintain a biotope favourable for the predators of bioaggressors (Symondson *et al.*, 1996 : Rodriguez *et al.*, 2006). It may thereby be possible to decrease the use of chemicals to control the cultivated field, favouring instead the use of biological control.

2.2. Understanding and facilitating the processes of individual and collective innovation

The changes to agrosystems resulting from the introduction of CA also involve significant changes in the production system at farm level: planting calendar, work organisation and the mobilisation of funds, equipment, land use and relationships between crops and livestock activities, for example (Do Prado, 2004, Fontaneli *et al.*, 2000, Boahen *et al.*, 2007, Shetto & Owenya, 2007). Due to the diversity of the processes modified by CA introduction, a comprehensive assessment of the performance(s) and impact(s) of these systems requires indicators multiple and diverse (Loyce & Wéry, 2006; Meynard *et al.*, 2001). Evermore, different standpoints can be used for evaluation purposes, each defined in terms of a hierarchical list of criteria linked to the diverse components of sustainability retained as important and to the weighting of their relative importance (Dogliotti *et al.*, 2003; Loyce *et al.*, 2002). The evaluation models used may thus differ in terms of how the perceptions of the various key actors involved in the process of technical, social and organisational innovation are being accounted for (Jodelet, 1984; Leeuwis *et al.*, 2002). The participation of farmers in the definition of the various criteria is thus essential because, they will be the end-users of any modified techniques developed (Altieri, 2004). It is important to provide farmers and/or technicians with tools enabling them to consider possible changes to their own production systems (McCown, 2002) through the ex-ante evaluation of the various impacts of innovations.

The resolution of these difficulties in the design and assessment of the agrosystem requires individual and collective learning processes involving different combinations of the appropriate actors (Béguin, 2005), the comparison of experiences and the generation of knowledge, often leading to the establishment of a network of concerned stakeholders. This process is guided by instrumental rationality (acquisition of knowledge and know-how) and by axiological rationality, guided by values and a shared passion. This makes it possible to break the technical and even social isolation within local advisory or dialogue networks or communities of practice (Wenger, 1998, Triomphe *et al.*, 2007, Goulet *et al.*, 2008), sometimes leading to the establishment of a strong dimension of identity (Goulet and Chiffoleau, 2006). These communities of practices or, more generally, networks that could be viewed as innovation systems (World Bank, 2006), also provide opportunities for collaboration between many different stakeholders interested in diverse aspects or issues linked to CA (soil, biodiversity, plant cover etc.). The relationship to science is renewed in two opposing directions that can coexist: recognition of the essential role played by scientists in sociotechnical networks, thereby promoting approaches based on a partnership between research and action; and contestation of the division of knowledge production between the erudite and the uninformed, who call into question the role of research in an ascending process of innovation (Lahmar *et al.*, 2006 ; de Tourdonnet *et al.*, 2006, 2007 ; Labreuche *et al.*, 2007). In the North, these aspects often take the form of distributed organisations (Dodier, 1997), based on informal networks of practitioners. These organisations contribute to technical learning processes, by facilitating the sharing of experience and providing advice at distance. In the South, these networks and a strong driving role of farmers and their associations in the process of innovation for CA play a variable role. This role was clearly substantial in southern Brazil (Ekboir, 2003), but in many other cases, it is research that has played a key role in the emergence and structuring of support for the innovation process (Triomphe *et al.*, 2006). Such projects do not necessarily adopt a participatory approach (Baudron *et al.* 2007, Boahen *et al.*, 2007). However, when this is the case, particular challenges are raised: ensuring equitable negotiations and shared governance of the mechanisms in place (Faure *et al.,* 2010), and identification of steps at which true co-operation and partnership is possible between researchers, agricultural advisors and farmers (Mischler *et al.*, 2008).

2.3 Combining the analysis of ecological processes with sociotechnical innovation processes

CA thus appears to be the vector of two dynamic processes operating in interaction (Figure 1): a process of agrosystem transformation to ensure the provision of ecosystem services and a process of sociotechnical innovation to ensure that the objectives of farmers are met and to contribute to sustainable development. Changes to the agrosystem are dependent on the actions generated by the process of innovation: changes and adjustments to practices, cropping systems and production systems. Conversely, the innovation process is fed by the perception that the various stakeholders have of the changes to the agrosystem: changes in the state of the environment and indicators used to evaluate it, attention to new processes or new ecosystem functions (such as soil conservation and biodiversity).

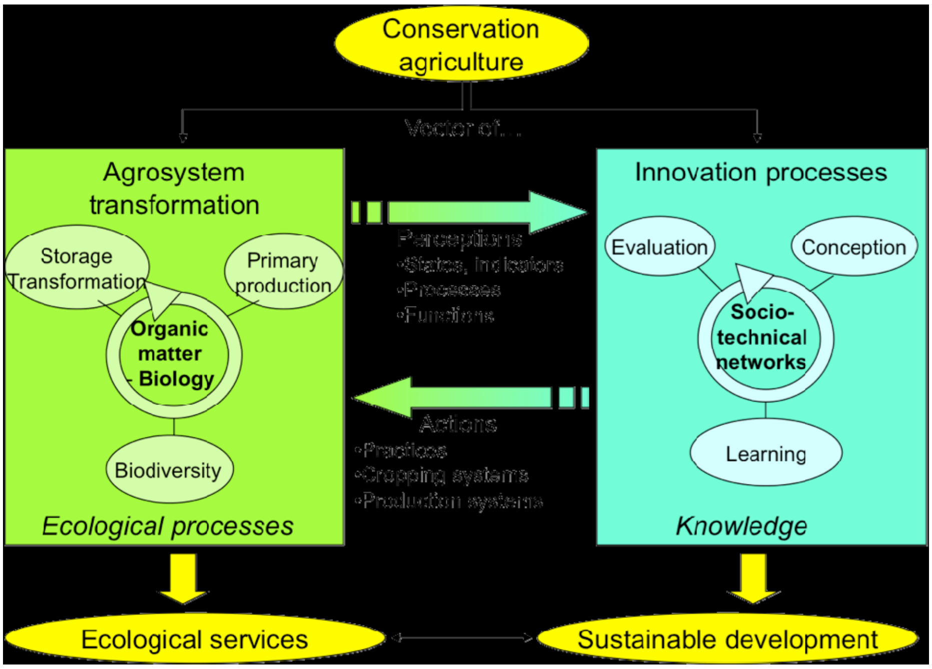

Figure 1: Ecological and innovation processes in CA

This project aims to combine the analysis of these two processes and their reciprocal dependence. We believe that such analysis is essential for an understanding and facilitation of changes in practices and is also original with respect to previous work on CA. Indeed, studying changes to the agrosystem independently of the innovation process means that we consider that practices will not be modified in response to these biophysical changes, or as if it is possible to pass directly from conventional systems to CA systems, without transition. This is clearly not the case in reality because the stakeholders adjust their ways of doing things (farmers) and their proposals (technicians and researchers) according to what they perceive to be the changes in the environment due to CA. Conversely, studying the process of innovation without considering, in detail, the transformations of the agrosystem would neglect the importance in the social exchanges of objects such as the soil, cover crops or specific equipment, which nonetheless provide an important contribution to individual and collective learning.

The general aim of the PEPITES project is to generate knowledge concerning ecological processes, innovation processes and their interactions in conservation agriculture, for the evaluation and design of technical systems through innovative support structures.

2. POSITIONING OF THE PEPITES PROJECT RESEARCH

2.1. Application of activities to four terrains in the North and South

CA is developing worldwide, but the innovation processes used and the ecological processes valorised are highly diverse and context-dependent. For this reason, we decided to carry out studies on four very different sites, to make our findings more generic.

Site 1: Field crops in north France, where no-tillage techniques have been developed since the 1990s, under the impetus of groups of farmers wishing to decrease production costs and labour requirements (Goulet, 2008). These farmers were inspired by the Brazilian experience involving exchanges at several levels: the factors of production, cropping practices and the establishment of advisory systems based on farmers' associations (the BASE association, NouriciAgrossol Club etc.). The learning process, initially firmly focused on equipment and soil, gradually shifted to the use of cover crops. There has been a general drift away from no-tillage practices towards conservation agriculture, through the construction of sociotechnical networks combining a number of objectives and stakeholders, associated with technical, agronomic and environmental questions, through multiple clusters (Goulet, 2008).

Site 2: Organic farming in Rhône-Alpes region (France), in which the reduction of tillage is more recent and driven by economic, environmental and agronomic concerns (Peigné *et al.*, 2007). However, it is more difficult to reduce soil tillage in organic farming, as any attempt to do so is confronted by two major technical obstacles: weed control and nitrogen nutrition (Watson *et al.* 2002). The use of leguminous cover crops to fix nitrogen is of particular interest in organic farming (Hauggaard-Nielsen & Jensen 2005). Given the difficulty of controlling weeds mechanically (Teasdale *et al.* 2007), it is important to determine whether the environmental conditions in organic farming lead to a spontaneous change in the flora present (Peigne *et al.* 2007) or whether the presence of a mulch or cover crop can modify weed emergence (Hiltbrunner *et al.* 2007).

Site 3: Family farms from agrarian reform sector in the Cerrados and in the Amazon Bioma (Humid tropics of Brazil). Despite Brazil being one of the birth places of the development of CA since the 1970s (Bolliger *et al.* 2006), these techniques have only recently filtered down to small producers subject to the strong constraints, such as those of the agrarian reform sector. The aim here is to stabilize Maize grain yield and to increase total biomass production to contribute to the intensification of grazing production currently underway and to break the classic slash and burn/agriculture/extensive pasture cycle responsible for deforestation. In this context, CA has several advantages: the use of a animal-drawn no-till seed drill overcomes the costs and risks associated with tractor-based tillage subcontracting; CA also combats erosion on fragile lands and increases soil fertility in the medium and long term. CIRAD, EMBRAPA, universities, farmers' associations and diverse development and training partners have been working together since 2004 on the development of research-action partnership projects for CA (Triomphe *et al.*, 2008: Bastos da Veiga et al., 2007, Barbosa et al. 2008).

Site 4: extremely poor family farms (Madagascar). CA has been promoted in Madagascar through many projects over the last 15 years or so, during which research has played a key role, in partnership with local stakeholders (NGOs, agricultural development agencies), and with the support of political decision-makers and international funding bodies. The key issue for this country is the sustainable improvement of agricultural production, with great emphasis placed on the prevention of erosion, through CA techniques in particular (Chabersky *et al.*, 2005; Muller *et al.*, 2005, Douzet *et al.*, 2007). The focus has been on developing CA cropping systems for rainfed rice, including a forage/cover crop used for animal feed, and diffusing them at large-scale among farmers (Chabaud *et al.*, 2007; Durand *et al.*, 2007). The process of innovation is based on the introduction of large amounts of knowledge and know-how from outside, supported by training activities and demonstrations for farmers and agricultural advisors.

2.2. Development of a pluridisciplinary approach

Achieving the objectives of PEPITES requires an approach bringing together biophysical sciences, the agronomy of cropping and production systems and the sociology of innovation (table 1). The analysis of innovation processes (task 6) focuses on studies of the production and transformation of knowledge within socio-technical networks and the modes of co-operation between actors. Particular attention is paid to the dynamics of changes in farmers' practices, indicators and the knowledge used during the learning process. The structural and functional approach to farm systems (task 5) facilitates comprehension and makes it possible to simulate the diversity of these systems; it also involves testing, with farmers and agricultural advisors, tools for prospective reflection concerning the transformations that could be envisaged in these production systems. The transformation of cropping systems (task 3) is addressed by studies at research stations combining experimentation and modelling of the functioning of innovative systems combining no-tillage techniques and the use of cover plants in an intercropping system. The emphasis is on the use of ecological processes (facilitation, competition), which are amplified by the use of cover plants and could be improved in terms of their agronomic and environmental performance. A more detailed study of the ecological processes resulting from interactions between organic matter and living organisms (tasks 1 and 2) is being carried out to provide information and useful indicators for the rational adaptation of practices to changes in the environment and for evaluation of the ecological services supplied. The indicators and the specifications arising from these activities at different scales (plot, cropping system, production system, socio-technical network) are used for *ex ante*, multicriteria and multi-actor evaluations of the performances of innovative cropping systems in CA (task 4).

2.3. Developing an interdisciplinary transverse approach

Interdisciplinarity is ensured, in part, by the connections between the various disciplinary tasks (1 to 6) of the project (see www.projet-pepites.org for more information). Three tasks (7, 8 and 9) go beyond disciplinary topics and contribute strongly to interdisciplinarity (Table 1). These tasks address the following questions:

- Which methodological developments, particularly in terms of modelling, are required to increase the capacity of research to assist the process of innovation (task 7)?
- How can we implicate research in the approaches and partnership systems, to accompany changes in farmers' and stakeholders' thinking and practices (task 8)?
- How can we contribute to training and knowledge transfer (task 9)?

Table 1. Tasks and activities of the PEPITES project

Task 1:	**Biological functioning of soils in CA** • Biological indicators of soil functions in CA • Role of the soil fauna in soil functions in CA
Task 2:	**Dynamics of organic matter in soil** • Characterisation of the physical and biochemical components of mulches • Study of the effects of mulches on the fate of C (mineralisation, humification), mineralisation-organisation of the major elements (N,P) and transport (soluble C, nitrate, pesticide) • Adaptation of C-N models and validation based on the experimental data obtained
Task 3:	**Study of the functioning of innovative systems valorising ecological processes in CA** • Experimental study of the processes of facilitation and competition

- Modelling of CA inter-cropped systems
- Identification of indicators of agronomic and ecological performance at the scale of the cropping system

Task 4: **Multicriteria, multi-actor *ex ante* evaluation of the performances of CA innovative cropping systems**

- Analysis of the specifications for the design of new cropping systems in CA
- Identification of indicators of the relevance or performance of cropping systems
- Multicriterion and multi-actor evaluation of the performance of systems in CA
- Comparison of the evaluation results with stakeholders in production

Task 5: **Assistance with the design of production systems incorporating conservation agriculture techniques**

- Analysis of the functioning of farms
- Modelling of the functioning of farms
- Use of simulation tools for problem-solving

Task 6: **Processes of innovation in CA: acquisition of knowledge, invention of practices and ofrms of co-operation between actors**

- Analysis of the processes of knowledge generation and transformation, combined with an analysis of the modes of co-operation between actors
- Analysis of the dynamics of changes in the practices of farmers at the level of their cropping systems and farms

Task 7: **Modelling**

- Systematic analysis of the adequacy of tools to tackle the questions asked
- Learning about the connections between models in the process for analysing the performance of CA systems
- Analysis of the use of these tools in a process of construction with the various stakeholders

Task 8: **Systems for intervention and for the joint construction of knowledge and practices for the innovation process in CA**

- Definition of means of intervention
- Implementation of the means of intervention
- Capitalisation and generalisation

Task 9: **Training and transfer**

- Writing of articles for transfer
- Construction or improvement of teaching modules
- Evaluation of these modes of intervention
- Construction of a website to capitalise on and make available teaching resources

Source: PEPITES project. For more information: www.projet-pepites.org

3. CHALLENGES AND PROGRESS AFTER ONE YEAR OF OPERATION?

3.1. Construction of an interdisciplinary approach involving partnership with professionals

One of the original features of the PEPITES project is our deliberate decision to move away from linear diffusion models proposing the production of knowledge and technologies by agronomists and other technical experts and its transfer to users, which currently dominate current approaches to CA development and diffusion internationally.

By contrast, in the PEPITES project, we aim to develop a non-lineal, iterative and more integrated approach to knowledge generation. This has led us to favour an interdisciplinary approach and the formalisation of an effective partnership involving stakeholders from different sites in the North and South. These two aspects (interdisciplinarity and partnership) require prolonged, detailed negotiations among project participants concerning the choice of subjects to be considered and of research approaches to be adopted. This applies as well to the choice of mulch to be incorporated in the controls, to the choice of cropping systems to be compared and the modes of experimentation, combining, to various extents, diverse trials in control environments and on farm plots, or to how best can research partner with other stakeholders in developing and disseminating CA systems and practices.

Another major consequence of this choice is the need for the researcher to find a balance between developing a detailed understanding of the (biophysical and social) processes and supporting changes in practices and approaches, for the design of innovations. One key element for resolving these tensions is an awareness that conducting what to some extent be called action-research on an on-going process (Faure et al; 2010) may reveal important aspects of the functioning of the corresponding systems and is thus quite compatible with a desire to understand them. However, the contrasted cultures of the various stakeholders involved with the PEPITES project at the various sites, whether researchers, development professionals or farmers, may not necessarily predispose them to spontaneously fruitful dialogue. The forum for dialogue promoted within the PEPITES project should gradually make it possible to overcome the difficulties experienced in achieving a mutual understanding. Beyond the classical issues of vocabulary and common definitions, there is also a need to acquire the capacity to understand the vision, perceptions and representations of others. Thus, biophysicists need to learn to appreciate the socially constructed nature of their research objects — such as a soil, a mulch — and this is not necessarily self-evident. Those working in the field must, for their part, learn to recognise that scientific approaches usually involve a simplification of, and taking a step away from, reality, and that the choice of objects, approaches, and tools, such as modelling — which certainly does not represent the reality in all its complexity and diversity —may nonetheless provide relevant insights into the influence of complex factors frequently not directly accessible through empirical observation alone.

3.2. Construction of an approach for comparing the different sites in the North and South

Our decision to carry out the PEPITES project on four different terrains arose from a desire to diversify the context in which the results were acquired, to make this project more generic. It also fits neatly into the history of CA, which may be seen as a transfer of innovation from the South towards the North, with its very frequent reference to the “Brazilian model” and the often frustrated desire to transfer the solutions that work. Finally, this choice also reflects a desire to bring together research teams (INRA, CIRAD, IRD) and teaching teams (AgroParisTech, ISARA Lyon, SupAgro) working in areas and using approaches that are complementary or similar, in the different contexts.

However, this diversity of situations in the field introduces an element of risk into the project: how can we make the most of this diversity to go beyond a collection of case studies and develop a comparative approach to biophysical, technical and social processes in the different sites? Preliminary studies in the PEPITES project have shown that the responses required differ as a function of the processes studied.

Biophysical processes are, by nature, generic: the decomposition of organic matter obeys the same laws in all contexts, regardless of the nature of the organic matter itself and of the organisms responsible for breaking it down. Thus, a consideration of the diversity of situations essentially equates to an enlargement of the range of variation of factors (temperature, humidity, pH etc.) and components (soil, mulch, organisms) involved in these processes. This requires the establishment of co-operations between the scientific and non-scientific partners in the project, to identify the most representative and relevant objects to be studied in the different terrains (which soil? which mulch? which organisms?) and to define the study conditions allowing exploration of the range of variation desired: choice of climatic conditions for following mineralisation in the laboratory, choice of simulation scenarios for a model, etc.

The technical processes seem to differ considerably between sites, as a function of the agro-environmental context, the objectives of the farmer, the resources at their disposal and the constraints imposed on their activities. For example, the use of cover crops in CA is subject to considerable diversity in terms of the services anticipated and the possibilities of action available. This leads to highly diverse practices: species chosen, dates and mode of sowing, management of the cover crop. Nevertheless, certain elements appear to be invariant on all sites: in all situations, the choice to grow a cover crop is, above all, based on a desire to control weeds by smothering them and to supply nitrogen through symbiotic fixation, without affecting the water resources available to the commercial crop. Whether or not these objectives are met depends on the control exerted over the same processes (competition, facilitation between species, element cycles), by highly different means, depending on the context. For example in developing country cover crop is also introduced as an additional forage resource, but in that case biomass exportation will directly affect weed control and N supply efficiency. The focusing of the PEPITES project on these common processes makes it possible to valorise the diversity of the situations studied.

Social processes depend on the human, institutional and historical context specific to each site. However, invariant elements can also be identified in innovation processes, particularly as concerns the objects dealt with in the socio-technical networks established in CA (seed drills, cover plants, herbicides, soil etc.) and the modes of knowledge generation. This finding led us to construct a transversal analysis grid for the four sites, describing the innovation process in terms of the following four processes:

- Positioning of the object “no tillage” in the collection of objects identified as important in the innovation system established;
- Retracing the history of the establishment of the innovation system and its changes, focusing on the major steps;
- Identification of the subjects chosen and discussed in each of the terrains and their possible impacts;
- Identification of the organised modes of knowledge generation.

CONCLUSIONS

The PEPITES project has taken up a major challenge, which it is addressing through several strong choices: a mixed approach combining efforts to understand ecological and social processes and efforts to facilitate the process of innovation, considerable interdisciplinarity extending from soil ecology to the sociology of innovation, studies at multiple scales, from soil organic matter to socio-technical networks and comparisons between contrasted situations in both the North and the South. After one year of operation, real progress has been made and dialogue is well established. As might be expected, there have also been some difficulties. Our approach, based on the construction of interdisciplinarity between partners and of an approach for comparing sites should, we hope, allow us to overcome these challenges to ensure that the PEPITES project will come to fruition.

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