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Farm machinery cooperatives: a new arena for agroecological innovation?

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Abstract: *In France, new agroecological policies demonstrate a movement of collective innovation experienced by farmers within machinery cooperatives. The present paper aims at understanding how French farmers recompose machinery- and labour-sharing arrangements by developing agroecological practices. Our methodology is based on six case studies, by combining a farming system and a sociological approach. Farmers implement new practices that reconfigure more diversified farming systems with fewer inputs. The collective organisation provided by the machinery cooperative and its associated labour-sharing arrangements shape a niche of innovation conducive to agroecology. These results provide a better identification of the current lock-ins that limit agroecological transition at the farm level.*

Keywords: *farm machinery cooperative, agroecology, transition, agricultural cooperation, niche of innovation*

Introduction

Since 2013, the French Ministry of Agriculture has launched initiatives and a new law to develop agroecology. The government encourages collective approaches by introducing into French legislation new provisions to strengthen agroecological projects by groups of farmers (Branderburg et al., 2015).

In France, the current socioeconomic and ecological context (rising costs of animal feed, price volatility, droughts, new public regulations and private specifications, etc.) is increasingly leading farmers to innovate. To do so, conventional farmers are implementing new practices such as legume integration, no-tillage, etc. Thus, different elements out of a broader agroecological strategy are being implemented by French farmers. Although they do so without referring to the concept of agroecology, they develop more diversified farming systems with fewer inputs by making better use of the ecological functionalities of the agroecosystem. Simultaneously, they may maintain key features of the conventional mode of farming such as high yields or automation.

The French National Federation of farm machinery cooperatives is particularly affected by this phenomenon. 11 000 farm machinery cooperatives exist in France, comprising one third of all French farms. The new farm policy encouraging collective projects for agroecology makes visible a movement of collective innovation experienced by farmers within their machinery co-ops, conducive to the development of agroecological practices.

This paper aims at questioning the collective reconfiguration of farming work interlinked with the development of agroecological practices by conventional farmers. Indeed, little attention has been paid in agroecological studies to reconfigurations occurring within machinery- and labour-sharing arrangements between neighbour farmers. How do farmers reshape work organisation by developing agroecological practices? How does the agroecological transition change cooperation between neighbour farmers? To deal with these issues, the paper will present the main results of a current research-action program aiming at understanding the phenomenon of collective innovation in the network of machinery co-ops which facilitates the practical implementation of agroecological practices at farm level. We particularly propose to examine how French farmers recombine the arrangements between peers within machinery co-ops by developing agroecological practices. Although innovation in agriculture is generally considered as affecting the work on the farm, we show how the work organisation and its reconfiguration can produce innovation.

After a brief literature review regarding the issues of farming work and agroecological innovation, we describe the functioning of the French machinery co-ops before explaining our methodology and case studies. We then examine the development of new practices by the farmers studied, as well as the modes of cooperation they rely on to do so. Finally, we discuss the potential of the machinery co-ops and labour-sharing arrangements for agroecological innovation.

Agroecological innovation: work and niche issues

Novelties as seeds of transition developed in niches

Sustainability oriented innovation and technology studies have received increasing attention over the past 15–20 years, with the emergence of a new field dealing with “sustainability transitions” (Markard et al., 2012). In this field, first works regarding agriculture were carried out by the Dutch Rural sociology group of Wageningen University in collaboration with the pioneer researcher Arie Rip (Wiskerke and Ploeg, 2004). Rip contributed to highlighting the strong path dependencies and lock-ins derived from the intertwining of established technologies with user practices, business models, organisational structures, regulations, and even political structures. Together, these elements shape a socio-technical regime that undergoes incremental rather than radical changes. Such incremental changes do not suffice to cope with the prevailing sustainability challenges (Rip and Kemp, 1998; Vanloqueren and Baret, 2009; Meynard et al., 2013). The niche is another key concept in transition studies, due to its pivotal role in the emergence of novel practices. Niches have been conceptualized as protected spaces, i.e., specific places in which radical innovations, called novelty, can develop without being subject to the selective pressure of the prevailing regime.

By applying this framework to agriculture, sociologists of Wageningen University have detailed the various features of the novelty in agriculture. According to Ploeg et al (2004), the emergence of sustainable forms of agriculture is not only based on the creation of new products or alternative food chains, but also involves the construction of different socio-technical configurations and requires new patterns of learning. In this sense, novelty production is a key term for describing the emergence of something new: a new practice, a new insight, new artefacts, innovative socio-technical arrangement, etc. In agriculture, a novelty emerges as a specific response to face a problem, a new opportunity or concern, and may spur another one required from the first novelty. So novelty production is a highly localised process, embedded in the organisation of the labour process (p.2-3).

The agroecological turn requiring new organisation of farming work

Ploeg (2008) highlights how the agroecological transition involves some backward moves with regard to two entrepreneurial farming trends: specialisation and externalisation. This has consequences for work organisation.

The use of external inputs may be considered as an externalisation process of the needed resource production. Entrepreneurial farms may reach a considerable degree of externalisation. This means that several parts that once belonged to the labour process as located in the farm may become externalized to outside agencies. In the case of livestock farms, cattle-feeding may be grounded in the acquisition of industrial feed, whilst the on-farm production of fodder may be delegated to contractors. Reproduction of soil fertility may be grounded in the use of chemical fertilizer, manure becoming a waste product. Finally, the reproduction of the herd (raising and selecting young animals) might be externalized as well (Ploeg, 1985). The process of externalisation allows for considerable increases in the ratio between the total volume of production and labour input. The mirror-side, though, of this same process is that high and relatively rigid levels of input use are necessary (Ploeg et Lucas, *in press*). This constitutes a lock-in to developing agroecological practices.

Specialisation of crops and productions allows management of the farm with a restricted set of equipment, i.e. machinery that is specific to a few crops or products.

Thus, specialisation and externalisation tend to involve encapsulation in complex networks resulting from social and spatial divisions of labour (Ploeg, 2008). Developing self-provisioning or diversifying by introducing a new crop may involve in turn, a new work organisation on farm to include new required tasks, new socio-technical relationships with outside actors, and new material needs, such as processing equipment, storage infrastructures, adapted machinery, etc.

Finally, agroecological farming is based on locally available resources and on the capacity and skills to use these resources in the most adequate and sustainable way. This is why Ploeg (2011) highlights how labour is strategic in agroecology, just as the knowledge carried by the labour force.

To conclude, the turn to low external input and more diversified farming systems may face difficulties due to “path dependency” resulting from the dominant socio-technical regime that locks-in possibilities for agroecological transition. The collective organisation of the farmers, by setting in niches of innovation, may lead to efficient ways to overstep the socio-technical lock-ins. This allows novelty production, knowledge production and reconfiguration of the labour and material processes. Thus, examining the potential of machinery co-ops and labour-sharing arrangements for agroecological transition appears as a relevant issue.

Methods and materials

The machinery co-op embedded in a socio-technical network of farmers' sharing arrangements

In France, the agricultural policies of 1960 and 1962 have framed the modernisation process, by strongly valuing farmers' collective organisation and action. As a result, farmer organisations have become driving forces to implement a family productivist farm model in France (Nicolas, 1988; Nicourt, 2013). This explains the widespread machinery co-op network with more than 11,000 units throughout the French regions.

On average, a French machinery co-op includes 25 farmers, and the smallest are composed of 4 farmers, which is the authorised minimum membership. It is based on the commitment contract. For each member, the contract implies the commitment to use a minimum amount of one or several pieces of equipment for a multi-year period.

To share machinery in the best conditions, co-op members often set machinery-sharing arrangements to avoid the constraints induced by the cooperative organisation. For instance, to limit the time needed to pass a piece of shared equipment among the requiring farmers, the first farmer who uses it may keep his tractor attached to the equipment and pass them both to the following user. This avoids repetition of the coupling and uncoupling task. Farmers also organise labour-sharing arrangements, which may be the following: joint organisation of tasks, delegating to common paid employees, mutual aid, etc. The machinery co-ops network promotes the organisation of “labour banks” between farmers to facilitate labour exchanges between peers.

The habit of sharing equipment and working together may create a trust level that triggers other kinds of machinery-sharing arrangements between some members (often in a bilateral way), such as co-ownership. Some other resource-sharing arrangements may emerge or other kinds of collective arrangements, such as coordinated purchases pools to buy inputs (Lucas et al, 2014).

This is why the functioning of a machinery co-op cannot be understood without considering the whole socio-technical network of farmers' sharing arrangements in which it is embedded (Dodier, 1995).

Methodology

The innovation approach of the Rural Sociology Group of Wageningen provides the theoretical framework for our work, especially their adaptation of transition theories to agriculture (Wiskerke et Ploeg, 2004). Following this approach, we consider the farm machinery cooperative as a niche, i.e. as a protected space for novelty production.

Our methodology combines a farming system and a sociological approach. We carried out in-depth research on six farm machinery co-ops, whose members are engaged in legume introduction or no-tillage practices on their farms.

Indeed, data of the national network of machinery co-ops currently reveal that investments in no-tillage machinery have been increasing in recent years: nowadays, 20% of the machinery co-ops own this kind of equipment (50% own machinery for cultivation), with an annual increasing rate of more than 30%. Similarly, investments in haymaking machinery better adapted for legumes are increasing (FNCuma, 2015). Indeed, farmers who wish to develop alfalfa or clover face problems of excessive

mechanical leaf loss. To avoid it, they have to use expensive adapted machinery in specific weather conditions.

Finally, the six co-ops studied cover different geographical contexts and farming systems, whose details are briefly presented in table 1 below.

Thirty-six semi-structured individual interviews were conducted with farmer members of the six co-ops. We focused on the change process experienced by each farmer on the farm and the mode of their involvement in the machinery co-op and the associated labour-sharing arrangements. The results of the interviews were recorded. The analysis has allowed us to draw the socio-technical determinants of farmers' individual and collective strategies.

Tab 1. Case studies

N°	Geographical area	Number	Collective activities	Practices developed
1	<u>French Basque Country</u> (area of origin-based sheep cheese)	2 milk sheep farms, 1 milk sheep and goat farm	Design of a collective barn hay drying	Development of legumes in meadow areas
2	<u>Tarn</u> (Toulouse north-eastern region)	2 dairy farms, 1 cattle farm, 3 arable farms	Sharing of no-tillage and direct seeding machinery, mutual help, seeds sharing	No-tillage, direct seeding, development of winter cover crops based on legumes (mostly for fodder production)
3	<u>Ain</u> (area of origin-based butter & cream) (Lyon north-eastern region)	4 dairy farms, 1 milk goat farm, 1 arable farm	Sharing of a collective barn hay drying, with a common paid employee	Development of legumes in meadow areas
4	<u>Aube</u> (Paris south-eastern region)	2 sheep farms, 1 cattle farm, 3 arable farms	Sharing of no-tillage and direct seeding machinery, labour bank, seeds sharing,	No-tillage, direct seeding, development of winter cover crops with legumes (mostly grazed by sheep)
5	<u>Touraine</u> (area of origin-based goat cheese)	2 milk goat farm, 7 dairy farms, 1 cattle farm	Sharing of hay-making machinery adapted for legumes, collective program of on-farm experiments	Development of legumes in meadow areas, development of winter cover crops with legumes (mostly for fodder production)
6	<u>Brittany</u>	3 dairy farms, 1 arable farm	Sharing of no-tillage machinery	No-tillage, development of winter cover crops with legumes (mostly for fodder production)

The majority of the farms studied are characterized by high yields. Half of the dairy farms have automatic milking. Two farms of the machinery co-op n°2 are organic (one being a dairy farm with automatic milking).

New practices and farming logics

A whole series of circumstances has occurred over about fifteen years in France that has triggered initiatives from farmers to implement new practices. These tend to engage them in new specific farming logics.

New agronomic and fodder practices

The farmers interviewed implement new practices to face a diversity of problems and requirements. Each new practice generally responds to several concerns.

The following practices were introduced by the interviewees, often in an articulated way:

- Some of the arable and mixed crop-livestock farmers develop no-tillage. This practice may serve to face soil problems (loss of organic matter, erosion) or/and to reduce costs and workload.
- Most of the interviewees seek to produce more protein and legume crops and grass on farms. If they are arable farmers, they do it to enrich the soil. If they are livestock farmers, they do it to feed their animals. The latter may provide origin-based livestock product markets or be involved in direct selling with consumers. This new trend has especially emerged after important campaigns organised by environmental NGO (Greenpeace, WWF, etc.) during the 2000s against GMO soybean imported by the European livestock sector (Escobar, 2014).
- Many interviewees have developed winter cover crops. In so doing, some of them seek to improve the soil conditions to develop no-tillage. Others respond to the various agri-environmental schemes requiring to cover the soil during winter. Many livestock farmers make the most of cover crops to produce additional fodder.
- Some farmers try to integrate new crops for longer and more diversified rotations to face resistance to pesticides or soil problems. This motive also triggers the strengthening of crop/livestock interfaces by a few interviewees. Crop diversification may also respond to climatic change.

Most of the farmers seek to decrease the use of external inputs to reduce costs, especially because of the current price volatility context that has set in since 2007. Some also face difficulties in accessing certain external inputs. For instance, farmers who have to buy external fodder explain they experience irregular quality problems (especially with purchased hay). That is why they seek to improve their on-farm fodder production by developing means to limit the losses. Finally, farmers of case study n°4 are encouraged by their agricultural marketing cooperative to use less external inputs for a strategy of environmental differentiation within product markets. To receive a premium in addition to the basic price of wheat and barley, they have to follow specifications to ensure their practices have less negative impacts on water quality and low level of greenhouse gas emission and energy consumption (Villemaire, 2016).

Most of the interviewees who seek to introduce legumes face difficulties in accessing seeds. Input suppliers do not always offer the right diversity of seeds of legumes at the right moment with a good price. To face this difficulty, many interviewees have decided to organise seed production on the farm.

Specific farming logics

The farmers' narratives regarding the implementation of these various practices reveal several logics that guide the management of the farm. The development of self-provisioning strategy makes it possible to reduce external inputs, by introducing new production activities, or by recycling some outputs within the farming system to be used as productive resources. The best use of the internal resources also reduces external inputs, for instance by purchasing haymaking equipment better adapted for legumes to limit leaf loss. Diversification appears as a way to enhance the agronomic, economic and climatic resilience of the farming system. Finally, to better master the system owing to new knowledge or self-provisioning is a step-by-step strategy to improve the farm management.

Progressing towards agroecological practices

The on-farm change process is strongly based on the striving and the resources of the farmers rather than on mobilisation of external techniques or inputs. So some of the farmers express the satisfaction they get by seeing the successful results of their own work and creativity. This encourages them to undertake new initiatives. This appears as a self-propelling dimension of agroecological practice development.

The current development of agri-environmental state policies and schemes may encourage farmers to engage in reducing external inputs. Moreover, as reducing external inputs may be a way to make agriculture more environmentally-friendly, some of them have the feeling of meeting current general socio-political expectations. This does not appear as the starting motivation, but much more as an additional convincing factor. Indeed, the narratives of the interviewees reveal the paramount technical and productive norms and values in relation to their professional identification.

Most of the new practices, such as legume introduction, no-tillage and winter cover crops, are considered to contribute to climate mitigation by expert assessment (Pellerin et al., 2013). Moreover, some of the interviewees, especially those engaged for more than ten years in a change process to develop their autonomy, nowadays reach a low level of external inputs, even to the extent of converting to organic farming.

The cooperation to develop agroecological practices at farm level

The network of arrangements associated with the farm machinery cooperative make the practical integration of new practices feasible at farm level. In so doing, the cooperation between farmers shapes a niche by creating conducive conditions at an aggregated level to overstep the farm level limitations.

New material needs derived from diversification and self-provisioning

New material needs are induced by diversification and self-provisioning strategies. Indeed, dealing with a wide set of adjustable equipment to be able to diversify, to develop self-provisioning and/or to better ground the farming practices on their specific ecological conditions becomes a substantial challenge for farmers. For instance, the farmers interviewed who multiply seeds on farm need appropriate storage facilities and specific equipment to separate and clean them, even to dry them. This is why the machinery co-op newly becomes a significant asset in facing this material challenge by reducing equipment costs owing to the shared investment.

Moreover, farmer members with mechanical skills contribute to developing tailored technological solutions, even self-built or self-designed equipment like in case study n°2. Farmers also seek to strengthen the “multifunctionality” of each piece of equipment. For instance, farmers of case study n°3 nowadays dry new products (corn, wood-chip) with their collective barn hay drying in addition to alfalfa. This enables them to make the equipment more profitable.

The technical dialogues for learning and local knowledge production

The socio-technical network associated with the machinery co-op often functions as a network of technical dialogues between farmers. These allow for learning processes and local knowledge production between peers.

Indeed, the technical dialogues allow farmers to share their experiences, to compare their results and to confront their practices. In so doing, they can better draw valid conclusions from their on-farm observations. Labour-sharing arrangements tend to strengthen technical dialogues, because they allow each farmer to improve their knowledge of the on-farm conditions and practices of his peers. This deepens the content and the quality of the dialogues. An interviewee from machinery co-op n°1 illustrates this point with the following words: *“I owe a lot to the co-op because we exchange very much: I rub shoulders with colleagues with their own experience, and each time we collect good and bad things. We really are a good group, and I would not have experienced all the development on my*

farm without the co-op. We need to get information around, and the co-op is really a good place to have discussions”.

The local network of technical dialogue triggered from the machinery co-op functions better if some farmer members are connected to other networks or study groups, or interact with other sources of knowledge. In machinery co-ops n°s 2, 4 and 5, some farmers are connected to a study group or a regional peer-to-peer network devoted to no-tillage farming. This allows them to regularly participate in activities, such as training sessions, lectures, study trips, etc. Other farmers may benefit from the knowledge drawn from these activities through the technical dialogues with the “connected” farmers. In the areas of co-ops n°s 1 and 6, no study group exists. But these machinery co-ops applied for special funding for agroecology provided by the French Ministry of Agriculture in 2013 that has allowed them to organise specific study trips and training sessions with technical experts for their members.

All the socio-technical networks associated with the machinery co-op do not provide equal conditions for taking part in the technical dialogues. In some cases, the technical dialogues tend to be more concentrated on a few farmers associated through multiple sharing arrangements.

Moreover, few study groups and networks exist in France devoted to legume improvement and integration in farming systems. As a result, the interviewees from machinery co-op n°3 face difficulties in mastering and improving the practices regarding this topic. This appears as an “orphan topic” in research programs. Similarly, farmers who practise no-tillage tend to be dependent on herbicides to terminate winter cover crops. Some interviewees seek to reduce herbicide applications, but they cannot find the appropriate knowledge to do so. This obliges them to experiment by their own means, which can be a risky situation. This point has already been examined by Landel (2015), who shows that no-tillage is also an “orphan topic” that does not benefit from many public research activities. As a result, farmers depend on solutions provided by private research by the agricultural supply industry, who do not care about herbicide dependence.

Facing the challenge of work organisation

Many labour-sharing arrangements are organised through the socio-technical network associated with the machinery co-op. We identify the following arrangements: joint organisation of the tasks to be carried out, individual specialisation within farmers' groups, labour banks and mutual aid. These allow farmers to re-arrange the work organisation on-farm. Indeed, the changes may involve additional operations at the farm level, such as experimental activities, observation and improvement of ecological processes, and coordination tasks (especially if the new practices lead to the integration of a new crop or activity). Machinery co-op n°3 employs a paid employee to manage the collective barn hay drying. Two farmers of machinery co-op n°4 have recently created a pool of employers to hire someone who works on both farms (in this case, he is a son of one of them). For one of the farmers involved, this allows him to dedicate more time to experimental activities and to participate in a study group in order to access adequate knowledge to improve his practices.

Seed-sharing may be organised between farmers to avoid individual farmers having to multiply a wide set of the required seeds. In co-op n°2, the preparation of the seed mixing to sow winter cover crops may be jointly organised to facilitate seed exchange between farmers. This also allows them to anticipate this task by collectively scheduling it in their calendar, which avoids “botching” it at the last moment. By creating this common obligation, the task turns into a pleasant moment instead of being done in an isolated and tedious way. This is also a strategic opportunity for technical dialogues.

The labour-sharing arrangements appear as means to compromise between the strategy of diversification induced by the new implemented practices and the constraint to maintain the same level of labour productivity. Indeed, the interviewees introduce new practices on the farm in a global context of labour shortage and economic uncertainties.

Discussion

These results show how cooperation between peers leads the farmers studied towards more diversified farming systems with fewer inputs and a better use of ecological functionalities. The discussed examples show how the incremental change process may result in a systemic change over the long term. Indeed, the new practices gradually impact the work organisation, the modes of feeding

the animals, the strategies of provisioning and investment, the ways to be involved in cooperation with peers, even strengthening logics of differentiation within output markets. Moreover, the cooperative principles of the machinery co-op also allow the practices to be made durable over the long term. Indeed, the commitment contract has engaged each member to a minimal level of equipment use for several years. This was also observed by Ploeg in other agricultural contexts, that through cooperation between farmers, the on-farm shifts tend to become enduring (2008). Finally, these results also echo other studies highlighting the role of experience- and knowledge-sharing in farmers' networks for efficient transition towards sustainability (Forney, 2016; Compagnone and Hellec, 2015, Coquil, 2014).

The niche, shaped by the machinery co-op and its associated network of sharing arrangements, facilitates agroecological innovation. It appears less as a protected space, but rather as providing additional room for manoeuvre. Indeed, it allows the organisational limitations and lock-ins existing at the farm level to be overcome and the lack of appropriate resources provided at the socio-technical regime level to be remedied. This niche is mainly based on organisational processes, such as labour-sharing arrangements and resource-sharing arrangements, as well as on learning processes.

Do these experiences contribute to a reversal of the prevailing socio-technical regime or to the emergence of a new regime? Facing the lack of appropriate resources provided by the prevailing regime, the national network of machinery co-ops seeks to network the existing niches to support their efforts. In the long term, if research institutions and agricultural suppliers evolve to provide appropriate resources for agroecological practices, we think that the niches shaped by the machinery co-ops would remain important tools for farmers for two reasons. First, the agroecological turn implies diversification and self-provisioning on farms, which encourage access to a range of appropriate equipment. Then machinery-sharing will still remain an important asset. Secondly, agroecology, as a knowledge intensive approach, also implies that farmers are expert in their own agroecosystem by relying on local and adapted knowledge. Then, learning processes and local knowledge production and sharing are essential to allow farmers to make continuous adaptations to face an ever-changing environment.

Conclusion

In the last fifteen years, different ecological and socioeconomic pressures have triggered initiatives from farmers to develop more diversified farming systems with fewer inputs owing to two kinds of cooperation. First, they are members of a farm machinery co-op embedded in a local socio-technical network of farmers sharing arrangements, which facilitates cooperation among peers. These arrangements enable farmers to better face material needs and to rearrange their work organisation. Secondly, some of the interviewed farmers belong to study groups or peer-to-peer thematic networks that connect them to different sources of knowledge. This allows them to get away from advisory services which fail to provide the required knowledge for agroecological transition. These "connected" farmers may share adequate knowledge and their vanguard experiences through the technical dialogues that occur in the labour-sharing arrangement network associated with the machinery co-op.

The experience of these farmers reveals work organisation as a possible niche for innovation. Indeed, they collectively re-arrange their farming work and equipment and thus, produce innovation. Labour-sharing and machinery-sharing arrangements shape a niche conducive for agroecological innovation in a multi-dimensional way: farming practices, organisation, knowledge and networks are designed and developed through this niche.

Finally, may we still consider these farmers as conventional? May we consider them as agroecological farmers? On the one hand, we notice that they increasingly search for more autonomy, especially with regard to input markets and the prevailing socio-technical regime (Lucas and Gasselin, 2016; Lucas et al., 2016). They tend to diversify their farming systems and to be involved in local knowledge production. Some of them pay increasing attention to natural objects, such as the "living soil". On the other hand, they still maintain high yields and the use of chemical inputs, even at a low level in some cases. Very few plan to turn their farming system into a state of dynamic equilibrium to allow its autonomous regulation. As Ploeg (2008) has already highlighted, we here meet farmers that we may position in the "extended grey zones" that link the clear empirical expressions of the peasant and agroecological constellation and the entrepreneurial constellation. Thus, the situations of these farmers "demonstrate the gradual nature of these linkages and the important fluctuations occurring" in

the in-between zones (p. 36). In the light of these situations, supporting agroecological innovation more than ever requires interpretive understanding processes.

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