Reducing the dependence on pesticides: a matter of transitions within the whole agri-food system

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Abstract: *This paper, built as a synthesis of the sociological part of the Endure European Network of Excellence (2007-2010) analyses the conditions of transition towards more sustainable crop protection practices at different levels of the agri-food system: farmers' practices, interactions between farmers and advisors, retailers strategies, governance of research and extension, and involvement of civil society.*
Within Endure, different components of agri-food systems (farmer's practices, extension services strategies, retailers guidelines, research governance and involvement of civil society) have been studied in France, Italy, Switzerland, the Netherlands, the UK, Denmark, Poland and Hungary. The confrontation of National situations allows identifying common obstacles and conditions for achieving robust transitions towards more sustainable crop protection practices. These transitions are not only a the responsibility of farmers but involve the larger socio-technical system, its interdependencies and/or lack of coordination. In this perspective this paper intends to be a contribution to current debates within transition theories and also to characterise the different national context specificities to which these obstacles and conditions can be related.

Keywords: *transitions, low-input practices, IPM, agri-food systems, pesticides*

Introduction

This paper is based on different complementary studies achieved within the sociological work package of Endure, a Network of Excellence on pesticide reliance reduction (2007-2010). It analyses the conditions of transition towards more sustainable crop protection practices at different levels of the agri-food system. Based on a path-dependency analysis, the paper will first demonstrate (section 1) how the current agri-food system has embraced the "paradigm of intensification" on the long run following a convergence of innovations (homologation of new pesticides, selection of cultivars, changes in farming practices, etc.) and of actor strategies, which has led to a change from a curative use of pesticides to a more systematic one. Second, from a variety of qualitative interviews in France, Switzerland, the Netherlands, the UK, Denmark, Poland, Italy and Hungary, we will present the complementarities of our results with respect to different components of this agri-food system: evolutions in cereal and fruit growers practices, interactions between farmers and advisors, retailers guidelines regarding fruit production, governance of research and extension in the current context of the revision of European regulations regarding crop protection issues, and the involvement of the civil society through the evolution of public debates (section 2).

This confrontation of results from different national settings will lead us to identify common obstacles and conditions for robust transitions towards more sustainable crop protection practices (section 3). Also it will allow us to show that these do not only involve farmers' practices but the larger socio-technical system and its interdependencies and/or lack of coordination. From this perspective the paper intends to be a contribution to current debates within transition theories. Studies of technological transitions and system innovations have developed a multi-level perspective which understands transitions as outcomes of changes at the three main levels which are niche-innovations, sociotechnical regimes and landscape. (Smith et al., 2005, Geels and Schot, 2007). The notion of sociotechnical regime refers to the set of rules, knowledge and technologies with respect to a given sector, i.e., food production, processing, distribution and consumption in our case. Changes at the landscape level, i.e., the exogenous environment (macro-economics, cultural patterns and macro-politics), create pressure on the sociotechnical regime and its destabilisation creates in turn windows of opportunity for niche-innovations. In this paper we choose to use the notion of "agri-food socio-technical system" and define it as the ensemble of interrelated social and economic actors and institutions involved in food production, processing, distribution and consumption.

The "paradigm of intensification": a path-dependency analysis

The *path dependency* theory, developed within evolutionary economics, suggests that an innovation trajectory may become dominant and strengthened by the feedback of its implementation, despite the existence of alternative innovations which could have offered a better sustainability on the long run (Dosi, 1982). Possas et al. (1996) have adapted it to the case of agriculture and shown how the convergence of the main sources of innovation (suppliers, public institutions, agro-industry, collective organisations) have led to the reinforcement of the productivist regime. Despite its recent questioning, strong uncertainties about future technologies and paradigms hamper the apparition of a new technological regime. Several authors have analysed the difficulties to shift from current crop protection practices towards IPM due to lock-in effects (Cowan and Gunby, 1996; Wilson and Tisdell, 2001; Vanloqueren and Baret, 2009).

In line with these approaches, we draw on the case of winter wheat in France and demonstrate through a socio-historical analysis the coherence of the agri-food socio-technical system and the irreversibilities created by the specific and interdependent trajectories of its different components. From the 1960s onwards, this socio-technical system has progressively stabilised itself around the "paradigm of intensification", creating "lock-in" and "path dependencies" (Cowan and Gunby, 1996), because of the convergence of innovations (homologation of new pesticides, changes in fertilisation methods, earlier sowing, etc.) and actors strategies. This progressive evolution towards intensification, with a shift in the years 1978-1984, can be sketched along a time line going from the 1960s until today:

The modernisation period		**The intensification turn**			**The period of questioning**
First insecticides and growth regulators	First fongicides First systemic herbicides	From curative to systematic treatments Changes in practices : early fertilization, early and dense sowing Adapted equipment	First resistances to fungicides	First productive multi resistant varieties First studies on low input strategies	Period of low prices Agro-environmental measures Works on low input strategies and rustic varieties Development of good agricultural practices schemes
1960s	**1970s**	**1978-1984**	**1983**	**1985-1993**	**1993-2006**

Pesticides used to deal with an unexpected problem* => *pesticides used as an insurance

This evolution shows a convergence of innovations and strategies from the 1960s to the present, regarding breeding, pesticides, farming practices, research and advice etc. The homologation of new pesticides in the 1970s and 1980s (insecticides, growth regulators, fungicides, herbicides) led to a change from a curative use of pesticides to a more systematic one. Pesticide use became even preventive in various aspects as can be analysed when studying technical arguments which were prevalent at that time as can be seen in a special issue of the main arable crop growers' journal (Effland, 1981). It is also linked to the evolution of fertilisation methods (early fertilisation) and in the dates and modes of sowing (earlier, higher density). In this model, the main aim is to maximise the yields. The professional identity was centred on this criteria: a professional network created around 1980 was called "Club des 100 quintaux" (100 quintal/ha Club), a level of production that some farmers began to reach. Research in genetics was organised around this demand of high yields, and developed high yielding varieties that were however diseases and pest sensitive. Several official events and dissemination strategies also spread out this paradigm especially in the advisory sector, in which input suppliers were increasingly involved at the same time.

The high coherence of these evolutions and their consequences in terms of "lock-in" appear when we look more precisely at the different system levels: cropping systems, farming systems, advisory system, and breeding and seed market (Meynard and Girardin, 1991):

-**at the level of cropping systems**, there is a strong coherence between practices, i.e. varieties choice, sowing, fertilisation and the use of chemicals. The yield objective is determined by the potential of local soil and climate. Reaching it involves the maximisation of the interception of light energy by early sowing, high density and a non-limiting supply of nitrogen. These three factors result in strong risks of weed growth, aphids and fungal diseases, which make a preventive crop protection necessary. Likewise, early sowing, high density and a large and early nitrogen supply lead to strong risk of lodging and therefore in the systematic application of growth regulators. With regards to the maximisation of yields, cultivars are chosen for their productivity while resistances to diseases are poorly used.

-**at farming system level**, there is a strong coherence between intensive crop management, work organisation and equipment. The possibility of very early sowing is associated with the use of preceding crops that allow early field release. It also requires efficient farm machinery (because of the risk of lodging and diseases, an efficient sprayer must be available at all times). Finally, similar intensive practices are likely to be adopted for other crops on the farm.

-**at the level of advisory systems**, there is a strong coherence between the dominance of intensive cropping systems, the origin of technical advice and the content of information. Farmers need advice on new products and on their use. The cooperatives and firms which sell them pesticides are gradually becoming their major technical advice providers and staff bonuses are often related to pesticide sales. The maximisation of production matches the objective interest of both collecting firms and technical institutes the budget of which depends on the production level. Despite the fact that a few agronomists (e.g., Meynard, 1985) and a few producer networks[1] explore low input-strategies, references to these are hardly found in scientific and technical publications or displayed by "public" advisory services.

-finally, **at the level of the breeding and seed markets**, there is a strong coherence between intensive management (high-input strategies) and the prevalence of varieties which are disease sensitive on the seed market. The breeders who developed multi-resistant varieties suffer commercial setbacks, as it goes against the financial links between pesticide companies and some plant breeding companies. Regulations forbid the sale of population cultivars and combinations of varieties. A recent socio-historical study (Bonneuil and Hochereau, 2008) also demonstrates that the seed inscription process and criteria prevented the development of resistant varieties.

-we could add that at the level of milling industry, technological criteria linked to industrial processes such as the protein content, which is directly linked to the level of fertilization, do not facilitate evolution towards low-input practices (Wiskerke, 2003, Lamine et al., 2010).

[1] Such as the Cedapa network in the west of France, with his quite well known leader André Pochon.

However, there are minor deviations in this general development, and they highlight the conditions for a global transition towards more sustainable crop protection strategies. From 1993 until 2006, cereal prices were decreasing, while environmental problems were increasing. This led some producers to change their practices in order to reduce their costs, but also for environmental and ethical reasons. Some chose to convert to organic farming, others reduced their use of inputs. Those transitions were sometimes strengthened by the existence of public subsidies such as in the agri-environmental schemes from 1992 onwards. In the same period, several scientific studies assessed the technical and economical feasibility of more extensive farming practices (Meynard, Girardin, 1991; Rolland et al., 2003). However, these trends have remained relatively isolated and occurred mainly in social and geographical contexts where collective dynamics could develop and where a good support could be offered to producers.

Current lock-in effects in the agri-food system

188 interviews with a variety of stakeholders led by sociologists in France, Switzerland, the Netherlands, the UK, Denmark, Italy, Poland and Hungary, have allowed exploring five major components of the agri-food socio-technical system:

- evolutions in growers practices (n= 42), in France and Switzerland,
- interactions between farmers and advisors (n=52) in France, the Netherlands, Denmark, Italy and Hungary,
- governance of research and extension in the current context of the revision of European regulations regarding crop protection issues (n=28) in France, the Netherlands, the UK, Denmark and Poland,
- retailers guidelines regarding fruit production (n=54), in France, Switzerland, the Netherlands, and the UK,
- the involvement of civil society through the evolution of public debates (n=12 interviews, and a press corpus analysis of about 1000 articles) in France and the Netherlands.

These five components have been chosen because they represent main sources of both lock-ins and changes within the agri-food system and because they allow addressing the interdependencies within this system.

Evolutions in cereal and fruit growers practices

In France, apple growers and wheat producers have been interviewed with the objective of studying the processes of diffusion of IPM strategies and knowledge in regions where there is some institutional support (even though often very limited) in favour of IPM. Regarding wheat producers, three types of trajectories have been identified:

- Farmers who turned to IPM through a rather robust conversion, and would not come back to conventional agriculture,

- Farmers who turned to IPM mainly for economic reasons (to reduce costs) in a period of low prices and have or could come back to conventional production,

- Farmers who do not turn to IPM because they are interested but remain hesitant or simply because they are reluctant.

These categories and the changes in practices they involve can be discussed in reference to the ESR (for Efficiency - Substitution – Redesign) framework proposed by agricultural scientists to distinguish three approaches of the evolution of crop protection practices (Hill and MacRae, 1995). In the Efficiency paradigm, farmers try to make the best choice and use of pesticides in order to reduce their overall use, in the Substitution paradigm they would replace chemical pesticides with biological ones or with other alternative techniques and in the Redesign paradigm they would reorganize production systems according to ecological principles. Can this ESR framework be applied to our farmers' trajectories in order to identify the presence of the different paradigms along these trajectories? In arable crops and especially wheat production, the (input) Substitution paradigm which would be characterized by the introduction of biological pesticides or biological control is hardly present, because such innovations are not much developed. The distinction we can observe is mainly between the Efficiency paradigm and the system Redesign paradigm. It can be assessed by the degree of application of the set of IPM principles (resistant cultivars, later sowing, less density, lower and later fertilization, lower doses of fungicides, no growth regulator, longer rotations) in the regions studied; especially in IPM farmer groups.

Farmers who only apply part of these principles (for example who use resistant cultivars and/or decision support systems for their treatments, but without any major changes in their sowing and fertilization methods and in their rotations) can be related to the Efficiency paradigm. They often adopt IPM in a reversible way as in the second type of trajectory above: they might eliminate a fungicide one year and reintroduce it the next year. They mainly speak about reducing inputs in order to reduce costs, mostly through the use of precision agriculture methods such as decision support systems.

Farmers who implement all these principles can be said to be undertaking a systemic change in their practices and therefore can be characterised by the paradigm of system Redesign. They are also characterized by progressive and robust transitions as in the first type of trajectory above. Often before even having heard of IPM, all of them had initially experienced the reduction of pesticide use on plots with less potential for economic reasons, in order to reduce costs in a context of low prices for cereals. But in opposition to the previous category, their motivations have progressively involved also environmental and technical aspects. A few ones had also led proper trials with the help of an advisor. Most of these farmers belong to an IPM study group and meet every month with their local advisor who is an expert in IPM (sometimes at National level). It also appears, as was demonstrated for organic farming (Lamine et al., 2009), that trajectories and changes are by no way linear: even though most farmers who are today close to a Redesign paradigm have generally gone through an Efficiency phase, these phases often overlap.

This confrontation of our trajectories to the ESR grid leads to two important results. The first one deals with the importance of collective dynamics and learning processes among farmers, the second one deals with the importance of conditions of change which go far beyond the farm level. These two results show that changes in farming practices need to be thought and situated within wider socio-technical system changes.

Belonging to a group helps farmers to overcome technical problems through the collective construction of solutions adapted to their situations, with the help of the group advisor and sometimes of researchers. Belonging to an IPM study group also help them building a collective identity in a professional world that is mainly sceptical. Indeed, farmers' professional identity is highly challenged by the adoption of IPM techniques, especially in terms of risk conceptions. These changes go hand-in-hand with changes in the conception of what is a good farmer – the main criteria of professional excellence remaining yield (Burton, 2004) and crop aspect: integrated farmers have to accept a crop that looks more irregular and clearer than their conventional neighbours' wheat at the beginning of the cycle. Besides, the systemic vision of IPM leads farmers to lengthen their crop successions and introduce new crops in order to reduce the use of fertilizers and control the weeds. Thiss is confronted with lack of storage capacities and of transforming and marketing capacities for these crops within the food supply chain.

In Switzerland, where apple growers have been studied, the situation is quite different, as IPM is not the matter of individual or small groups' trajectories but rather defines the trajectory of a whole professional world, legitimized by public policies and accompanied by research and advisory systems. IPM has been put into practice since around 1960 in IPM groups of growers, in strong collaboration with researchers and advisors, through similar learning processes that could be observed in the case of arable crops above. The main difference is that in the Swiss case, the institutional environment of farming practices has also been taken into account and changed: IPM is taught in agricultural schools since around 1980, and the turn towards IPM has been institutionalised in the mid 1990s through a reform of the agricultural policy which now requires IPM for access to direct payments. IPM that was once explored by the pioneers soon became something “natural” for the younger growers, who see it as the “standard” way of producing (Paratte, 2008).

In contrast to this Swiss case, in most European countries larger evolutions towards IPM are impeded by the lack of recognition of IPM practices and the looseness of IPM definitions. In some cases farmers are called IPM when they merely document and record their practices, in other cases when they adopt one environmental friendly technique such as pheromone traps in orchards (which can be imposed by some supermarkets guidelines, as we will see) while they might maintain a high level of pesticide use. In the most extensive definition, IPM is considered as the implementation of a range of complementary and coherent techniques allowing a sharp input reduction, and involves a systemic approach. However, even in those cases, such a systemic definition of IPM implies the existence of conditions that go beyond the farm scale: transitions in farmers’ practices cannot be seen in isolation from other components of the socio-technical system, which we will address in the next sections.

Changes in the extension sector

The results about farmers and growing practices highlight the importance of learning processes, both at the individual and at the collective scale. The most extensive and robust transitions were those of farmers involved in IPM study groups led by advisors who were independent from input supply. More generally, the type of advisor (“public” system, cooperatives, input suppliers or private independent advisors) seems quite determining in the crop protection strategies adopted by farmers.

Therefore, in a second step of our work, we looked at the recent changes in the advisory sector and at their consequences. Public involvement is decreasing regarding extension systems in the 5 countries under study (France, the Netherlands, Denmark, Italy and Hungary). In many countries, public extension services have almost disappeared and financial support to extension services has strongly decreased. Some commentators argue that the broad transformations occurring in the organization of extension services throughout Europe may lead to important failures regarding the implementation of a more sustainable agriculture (Rivera and Alex, 2004).

Indeed, as advisory systems become market led, farmers are clients that the various extension services do not want to lose. This situation has important consequences for the type of advice given to farmers. Against a background where farmers tend to assess the advisor work according to the yield (and income) they contribute to generate, advisors become risk-adverse and reluctant to promote alternative strategies. They will be heavily criticized by competitors when it happens that their “alternative” advice (towards a reduction in pesticides) leads to failures in a given year (Lamine, 2009).

However, our interviews with different types of advisors show that some actors that are often said to provide advisory indentured to their “sale and purchase” business interests (input suppliers, farmers’ cooperatives and trade partners) have started to change tracks and – to some extent – have more positive attitudes towards low-input pest management practices.

Governance of research and extension

In the last decades, drastic changes have occurred in the public sector, which have impacted on the governance of research and extension in most EU countries. The general trend is that research like extension is less (or not) public driven and/or funded anymore. There are, of course, nuances in each country. For instance, in the NL and in the UK, public extension services have been dismantled and public research is less funded as well, with the consequence that the orientation of research activities is more and more towards short-term and practical problem solving issues. Even in countries like France where agronomic research is still mainly public driven, this sector has recently been submitted to big structural changes, such as the transformation of the subsidies system for agricultural research and extension.

Moreover, life sciences are evolving towards new challenging frontiers of research that are not directly related to environmental matters or agricultural concerns such as biomolecular biology. In such a context, agronomic research dealing with long term stakes for environmental impacts of agricultural practices is not receiving enough attention and funding, as has been shown in a recent study which compares the place of genetic engineering and agro-ecology in terms of research funding and priorities (Vanloqueren and Baret, 2009).

Our interviews with institutional and research actors show that these endorse the economic constraints that seem dictated by the current production system and focus on the improvement of techniques (e.g. precision agriculture) which is presented as the best way to tackle the pesticide issue and reach the objectives given by the new European regulation on pesticides which must be translated in National Action Plans.

In contrast, our study of farmers' transitions to IPM showed the importance - in the regions under study - of both applied research programs devoted to IPM and of interactions between researchers, advisors and farmers. These interactions take place in situations that we have analysed in our fieldwork such as participation of farmers to IPM groups or regular meetings of a network of researchers and advisors. For example in France, for about 10 years, series of trials on resistant varieties and low-input practices have been coordinated and analysed collectively in a group of researchers, advisors and growers.

The power of retailers: fruit production guidelines and marketing criteria

Since the mid 1990s, retailers have started to impose private standards. Some of these include the whole retailer procurement of a given product, e.g. EurepGap – GlobalGap – GAP for Good Agricultural Practices, which is a "business- to-business" scheme mostly devoted to products traceability and safety. Others which we will call here private quality schemes distinguish part of a category of products, e.g. apples, within specific marketing strategies and product lines such as in "quality chains" like Engagement Qualité Carrefour in France and also in Poland. Even this second type of guidelines is often perceived by producers as a commercial condition for being able to supply the supermarket with the rest of their production, as our interviews show. In both cases, retailer guidelines are much more commercial tools imposed on producers as a condition to market access than tools for the support of a different agriculture.

The first kind of standards (GlobalGap type) does not go much further than the general regulations, as producers merely have to document and record their practices. There is also an emphasis on the respect of pesticides residues limits (MRLs, Maximum Residue Limits) because those standards are inserted within food assurance schemes.

Actually, few retailer guidelines and certification schemes go beyond the documentation and traceability demand as in the second type of guidelines, i.e., private quality schemes. Those which do so would either emphasise the environmental impact standards (such as some British supermarkets schemes do), a positive list of authorized pesticides, compulsory monitoring procedures and thresholds for pesticide use, or, in the case of a French certification scheme, the use of alternative techniques such as biological control (e.g. pheromone traps for fruit production).

Our interviews with producers organizations (devoted to marketing their products) show that these private quality schemes, despite their limited and sometimes even inaccurate - in the sense that some criteria might be inefficient - ambitions in terms of changes in agricultural practices, might have led some growers to implement more environment-friendly practices. This is the case regarding biological control for apple growers: the collective organization of producers, initially mainly for marketing purposes, provide these producers with professional advice. This can be considered as a positive effect of such guidelines.

Within and beyond these retailers guidelines, the quality criteria, most often defined by the regulation, are a major bottleneck for increasing the sustainability of farming practices. For fruit production, part of the pesticides use is linked to the criteria of size (minimum and regular size) and visual aspect (perfect aspect, with given colours and no spots or irregularities). These criteria are considered by most actors of the fruit supply chain, included farmers themselves, as part of the consumer demand for fruit. More generally, among producers, producers' organisations and food retailers, consumer demand is used as the justification for action. However, both consumer demand and food quality are socially constructed (Nicolas and Valceschini, 1993, Lockie 1998). Consumers buy what is available and cannot buy what they are not offered… If products with less perfect aspect were to be found easily at the same price or cheaper with information on their sanitary and superior environmental quality, it is well possible that consumers would progressively adopt these products. The so-called consumer demand is the result of a balance between the respective weights of the different actors involved in the agri-food system, such as retailers, regulators and the civil society. Indeed, some alternative systems such as community supported agriculture box schemes show that this balance can be negotiated and that consumers can accept product irregularities when this helps reducing or abolishing pesticide use (Lamine, 2005). However, these systems also eliminate all intermediaries between producers and consumers, and given the current state of agriculture but also of food diets, with their part of transformed and/or distant products involving intermediaries, such a radical simplification of the agri-food chain can not be imagined at a large scale.

The involvement of civil society and the evolution of public debates

Pesticides and more generally agricultural issues have long remained debated in relatively closed arenas (Jas, 2007). While civil society used to remain outside the main arenas of discussion and decision, progressively new stakeholders got involved in these debates and today we have to acknowledge that civil society has now a determining role to play in pesticide issues through the construction of the environmental impact of agriculture as a public issue. In many countries the institutionalization of specific forums (the pesticide forum in GB, the Grenelle de l'Environnement in France[2], The Covenant Crop Protection[3] in the Netherlands) has brought together representatives of the agri-food chain, NGOs and also water boards and local authorities. These forums allow the inclusion of new stakeholders but we must keep in mind that they also allow the authorities to frame the debate and its participants.

We have described the framing of the pesticide debate in France and in the NL on the basis of interviews with leading NGOs (also at the European scale) and a press content analysis. Public debate at the European and national scale is mostly led by Environmental NGOs and has evolved in recent years from a concern about the environmental impacts of pesticides (in line with the debates over fertilizers) to a concern about the cumulative impacts of pesticides on human health. Such a concern is expressed in different ways in Europe but is common to the main European NGOs which adopt common strategies for lobbying the EU level – as industrial lobbies do. They have influenced changes in the pesticide risk regulation. Concerns about the long-term impacts of pesticide use on the health of the living beings have taken the lead in the public debates and been translated at regulatory level. For example, while the idea of controlling pesticide risks was prevailing in the past EU regulation (Directive 91/414/EEC); the 2009 EU "pesticide package" emphasizes the precautionary principle.

The NGOs' actions that we have analysed mainly focus on their involvement in debates on public policy. We could not find any examples of direct involvement of civil society groups (consumer or environmental NGOs) in IPM private certification schemes as can be found in the case of animal welfare (Lamine, 2006). However, the French "HVE" (for Haute Valeur Environnementale, High Environmental Value) future public certification of agricultural practices has been elaborated within a

[2] A debating process on environmental topics that was initiated by the French government in 2007 and which included NGOs, Unions, Government, Local authorities and "persons with moral authority".

[3] A covenant is an agreement whereby either party stipulates for the truth of certain facts, or promises to perform or give something to the other, or to abstain from the performance of certain things

working committee created after the Grenelle de l'Environnement in France, where actors from environmental NGOs and from the farming world established together the three levels of this scheme, the third and highest one corresponding to a quite extensive and systemic definition of IPM (see 2.1).

Obstacles and opportunities for robust transitions

The five aspects that we have developed inform us about the obstacles and opportunities for changes in agricultural practices: due to the complexity of interdependencies within the whole agri-food system, such changes have to involve the different systems levels.

Farmers may be favourable to changes towards pesticide reduction practices and IPM thanks either to some antecedents in their trajectories, to strong motivations at the individual level, to an efficient collective organisation allowing collective learning and/or to progressive changes in the definition of the professional standards. However, they may also be impeded to integrate new crops or new cultivars in their rotations because their clients do not want to buy them (Lamine et al., 2010).

Supermarkets certification schemes could be a way to foster changes but they have emerged in response to food scares and aim mainly at insuring corporate companies against possible sanitary affairs or claims; they are generally poor in terms of IPM and environmental aspects and focus mostly on record keeping of practices and Good Agricultural Practices. Therefore their current effects are probably more in terms of exclusion of non-competitive farmers more than inclusion of more environment friendly ones…

The growing concern for pesticide issues in the civil society should also legitimate environment-friendly practices but the civil society's main spokesmen (NGOs or some medical doctors and scientists) will mostly think in terms of zero pesticide rather than in low-input practices, and will claim a large evolution of European agriculture towards organic farming while it only represents today 4% of the arable land. Moreover, supermarket schemes and NGO claims will not necessarily take into consideration some key points of possible transitions towards more ecological forms of agriculture, such as the choice and selection of cultivars.

Seen from a more optimistic perspective, the different and interdependent aspects that we have studied define the main conditions for significant evolutions towards IPM: collective dynamics among farmers, translation of changes in farming practices into marketing strategies, involvement of research and extension, strong public policies, and the involvement of the civil society.

In the case of Switzerland we could demonstrate that if a major change towards IPM could be progressively achieved, it is precisely because all these conditions were present. It is commonly thought that the Swiss success in IPM has only to do with the link imposed on farmers between payments and ecological requirements. However, in the case of fruit growers which we have studied, they could operate these changes because they were inserted in a more global movement involving extension services *and* education *and* research *and* IPM groups of growers, from the 1960s onwards. Later on, it was translated in market strategies, with an early interest (1974) of the Swiss supermarket Migros for integrated production. Eventually, IPM was translated into public policies once the civil society confirmed - with the 1996 constitutional vote - that it was ready to support an extensive agriculture to the condition that it would be "in tune with nature". From the first groups of voluntary growers in the early 1960s to the generalisation of IPM as compulsory method in the late 1990s, we must recognize that the process has been progressive and well handled, for example by mixing old and new members in groups of growers or by integrating IPM as part of the teaching programs of agricultural schools.

In other countries, some alternative food systems such as community supported agriculture (Amap in France, GAS in Italy etc.) show that linkages with marketing channels can support progressive changes towards organic farming or pesticide use reduction. These cases also show the importance of consumers and producers collective organization, of technical support, and of public (often local) policies in order to extend the movement especially in terms of social accessibility. However, the changes induced by such systems will remain limited to a small category of farmer whose farm size (generally small) and competences allow shifting to direct marketing.

For other (often larger) farms, changes in regulations are probably the most efficient conditions of change. Indeed, the 2009 EU ban of several substances is an important element pushing farmers towards alternative strategies. Many would start to seriously consider alternative methods once conventional methods are no longer effective or available. However, changes in regulations have to be accompanied by changes of the agricultural advisory services and training. If not, there is a high risk to leave aside a whole range of farmers who could not adapt and to favour further concentrations in a sector already well concentrated.

Our studies show the importance of progressiveness in changes: how can this be taken into account in regulations and public policies? A suggestion is to work on a definition of IPM that could integrate the idea of transition and evolution in practices and give minimum but clear definitions of the different steps. Such work has already started at the EU level where the DG environment has commissioned a study to define those steps[4]. In France, the recent "HVE" regulation (see 2.5) also takes into account this idea of progressiveness (see Sainte Marie et al., 2010). However, only farmers and at best advisors practices are involved in these schemes and policies whereas we have demonstrated that the whole agri-food socio-technical system needs to be addressed.

This is why the notion of transition based on the idea of a progress path from to Substitution and then Redesign of cropping system following the ESR grid suggested by Hill and MacRae, 1995, initially conceived at farm level, has to be reformulated in order to involve the wider agri-food system as has been suggested by Gliesman (2007). Because of the interdependencies of the system's components on the long run, most evolutions that can be assessed in crop protection practices are orientated towards the "minimization" of the risks of pesticide use thanks to techniques defined in the Efficiency category, and not towards a larger Redesign of farming systems, which takes time and has to involve the different components of the socio-technical system.

Conclusion

Reducing the dependence on pesticides is not only a matter of changes at farm level. Where many actors and commentators would call upon the farmers' reluctance to consider non chemical alternatives, we have indicated that market conditions, governance of extension and research, public debates, as well as long lasting practices and habits in all these domains are framing current stakeholders' perceptions and actions and impeding some evolutions. Where farmers themselves talk of market and legislation as the most if not only determining factors of change (and no-change), often in a rather fatalistic way, we have showed that these factors can not play a role independently from others.

Changes in crop protection practices involve a large socio-technical system and make it necessary to tackle its interdependencies and need of coordination. In other words, nor the "invisible hand of the market" nor the power of the so-called consumer demand or of societal pressures, nor the organisation of knowledge and technical transfer, independently from one another, can lead to significant changes in practices. In this perspective, our studies at European scale provide a contribution to wider debates on innovations in agriculture and show the complementarities between path-dependency and transition theories: while the former allow showing that reducing the dependence on pesticides has been made difficult by the lasting interdependencies between the components of the agri-food socio-technical system, the latter help demonstrating that successful experiences leading to actual dependence reduction involve a good coordination between simultaneous changes in this socio-technical system.

[4] The BIPRO report (2009) which has been reviewed by ENDURE, see http://www.endure-network.eu/about_endure/all_the_news/endure_s_response_to_IPM _principles_now_online

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