Natural regulations and agricultural practices in organic vegetable production

Favre Martial[a], Tchamitchian Marc[a], Bellon Stéphane[a], Priac Amandine[a].
[a]INRA, Unité Ecodéveloppement, UR 767, Domaine Saint Paul, site Agroparc 84914 Avignon Cedex 9, France; mfavre@avignon.inra.fr

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Abstract

Through the conventionalization thesis, many authors question organic farming (OF) dynamics. A possible alternative option would be an ecologization of OF, albeit without compromising productivity. This turn to an ecologization could be more marked in intensive systems, namely for vegetable farming systems under shelters. Fertility maintenance and crop protection enhancing natural biological activity seem to be a tangible option for such systems. However it may be difficult in some systems to answer these goals. In this scope, a survey was conducted in 29 vegetable farms in the south of France to understand the relationships between farmers' practices and the integration of natural regulations (NR) in their systems. It showed an important diversity of agricultural practices. A cleavage, under what can be defined as a conventionalised OF and a canonical OF could be shown. Concerning the integration of NR processes in practice by the farmers, it appeared a predominance of farmers not seeking to promote NR in the choice of their practices. The analysis of independence between practices and farmers' perception of their own system with the integration of NR (χ^2) was made: it shows a not significant association ($p = 0,6$). With this study, we argue that the clusters related to the perception and the integration of NR do not match groups of practices, either canonical or conventionalizing. However, all practices developed by farmers to promote NR were not informed. Finally it seems important to analyze farmers' practices with the monitoring of pest populations and beneficial insects to understand the links they may have.

1. Introduction

Through its practices, farming may very negatively impact on the environment (Matson et al., 1997). It has been shown that agriculture contributes to the fragmentation of the landscape (Tscharntke et al., 2005) and has an impact on plant biodiversity (Culman et al., 2010) by reducing the floristic diversity in cultivated fields and their borders (Armengot et al., 2011), but also by reducing the abundance and diversity of birds (Donald et al., 2001), wild bees (Le Féon et al., 2010)...

Faced with this, organic farming (OF) seems to be a good model of green agriculture. Indeed, OF is often shown as a prototype for sustainable agriculture in that it maintains many environmental qualities (Lotter, 2003) and more widely due to its beneficial effects on various features of the agroecosystem (Bengtsson et al., 2005 ; Sandhu et al., 2010). Several studies have demonstrated the beneficial effects of this mode of production on the abundance or diversity of predators and parasitoids of crop pests (Garratt et al., 2011). Through this we can consider that OF can be based on productive natural processes, such as pest control through these beneficial effects on biodiversity. This is also a proposed guidance on eco-functional intensification of Niggli et al. (2009).

However, other studies have shown that some organic farmers practices may comply with the regulations while moving away from the principles of OF (IFOAM, 2005). This has been called a "conventionalization" trend of OF. Buck et al. (1997) describe it in organic California market garden practices, with large scale production units, specialization at farm and regional scale, a high degree of mechanization, significant use of hired labor, a vertical integration, the adoption of production contracts, and mass marketing. In this context, organic agriculture should be re-examined alder its principles and its contribution to sustainable agriculture (Darnhofer et al., 2010).

Some authors have shown that environmental concerns of farmers was linked to the practices they developed, especially in this conventionalization thesis (Goldberger, 2011). And conventionalization may also depend on the civic engagement of farmers, referring to deliberate, thoughtful, action-oriented participation in civic life. Therefore, it seems interesting to understand in ecologically-based systems as appearing in some versions of OF (Francis, 2009), which links are established between the practices developed by farmers, their perception of pests and their level of Integration of NR in their choice of practices.

In southern France, organic vegetable production under shelters is widely used and by its high level of artificialisation leaves a wide discretion as to how to maintain or enhance productivity. Such shelters, due to hot and humid climatic conditions are particularly conducive to the development of pests and diseases (Pralavorio et al., 1983). Furthermore, a study has shown that organic systems in this region exhibit various degrees of specialization (Navarrete, 2009), which could reveal a conventionalization trend in these horticultural systems. Thus, in this part of France such systems were studied in order: (i) to see if this organic market garden systems can be referred to the conventionalization of OF (ii) to understand farmers' perception of their systems and their degree of integration of NR, and (iii) to observe whether links exist between farmers' practices and their perception of their shelter system.

In a first section, we introduce our approach for on-farm surveys and data analysis. We then present the results obtained in various classifications. Finally we discuss our results confronting them with state of the art, and conclude on the limits and prospects of our results.

2. Materials and methods

2.1 On-farm surveys: location and selection of organic farmers choice

After defining the three departments to study (13, 30, 84) in the South of France, we have built a data base for all farms with organic label or a special brand (Nature et Progrès, Demeter), such brands were assumed to reveal a higher commitment in organic principles. With the farms addresses, we realized the density of farms per administrative municipality. This map enabled us to select three areas with both different agroecological contexts and a high density of organic farms, for repetitions or comparisons in a same zone. Subsequently, 11 farms in Bouches-du-Rhône department (13), 7 in Gard (30) and 11 in Vaucluse (84) were investigated.

To approach farming practices and their arguments, we realized semi-directive interviews among the farmers. The questionnaires were filled during spring 2011, including about the following topics: structure and practices in vegetable production under shelter, level of recognition of the NR in practices reasoning, perception of pests and use traps for reasoning pesticide management.

2.2 Data analysis: clustering and statistical treatments

To characterize the diversity of famers' practices and perceptions, a multiple correspondence analysis (MCA) was performed on two data tables, built on the basis of our on-farm surveys. The first data table, called "practical", is built from 22 variables defining the practices selected to analyze the diversity of practices, totaling 60 different modalities. Then another table was built, called "perception", based on farmers' statements related to the adaptation of their management of : shelter climate, semi-natural inter-shelter or crop associations to increase NR of aerial pests, weed control (e.g. preserving specific species favourable for pollinator or beneficial), considerations of aerial pests (by a number of aerials pests concern), and the use of reasoning tools of pesticides. As a result, six variables were indicated, for 16 different modalities.

As for the MCA, the quantitative variables were changed in qualitative variables with groups with a same number of data. For qualitative variables, "how" variables were created based on farmers' answers. To explain the construction of the ACM, we focus on modalities correlated with over 30% within the ACM axes.

In order to determine homogenous groups of farmers' practice and perception, an Ascending Hierarchical Classification (AHC) was performed according to Ward's algorithm. In order to observe the link between groups of practices and groups of perceptions a Chi 2 independence test (X^2).

The link between groups of practices and purposes was tested with a Chi 2 test of independence with a Correspondence analysis (CA) to define the distribution. All these tests were performed using the R software (version 2.12.2) and packages FactoMineR (Lê et al., 2008) and ADE4 (Chessel et al., 2004).

3. Results

3.1 Practices: a large diversity, and an interesting cleavage

The first axis 1 represents 15% of the total inertia (Figure 1). In this axis, we see an opposition between (i) negatively correlated farmers who cultivate a species once or twice a year in the same place and do not have permanent grass cover under their shelter; (ii) positively correlated farmers who combine several species and varieties in the same shelter, do not use plastic to limit the development of weeds, cultivate more than 11 different species and have a permanent grass cover under shelter.

With the second axis (2) representing 11% of the total variance there is an opposition between (i) farmers who use mineral treatments systematically, sometimes with local applications and lower doses, use 4 or 5 different organic and mineral products for pest control, and apply fertilizers during crop cultivation; and (ii) farmers who don't use mineral or biological treatments, grow the same species in the same place every 2 or 3 years and do not apply fertilizers during crop cultivation.

The third axis (3), representing 8% of total variance contrasts (i) farmers who release over three species of beneficial insects and use relays crops; and (ii) farmers who apply more fertilizers than amendments and not use relays crops.

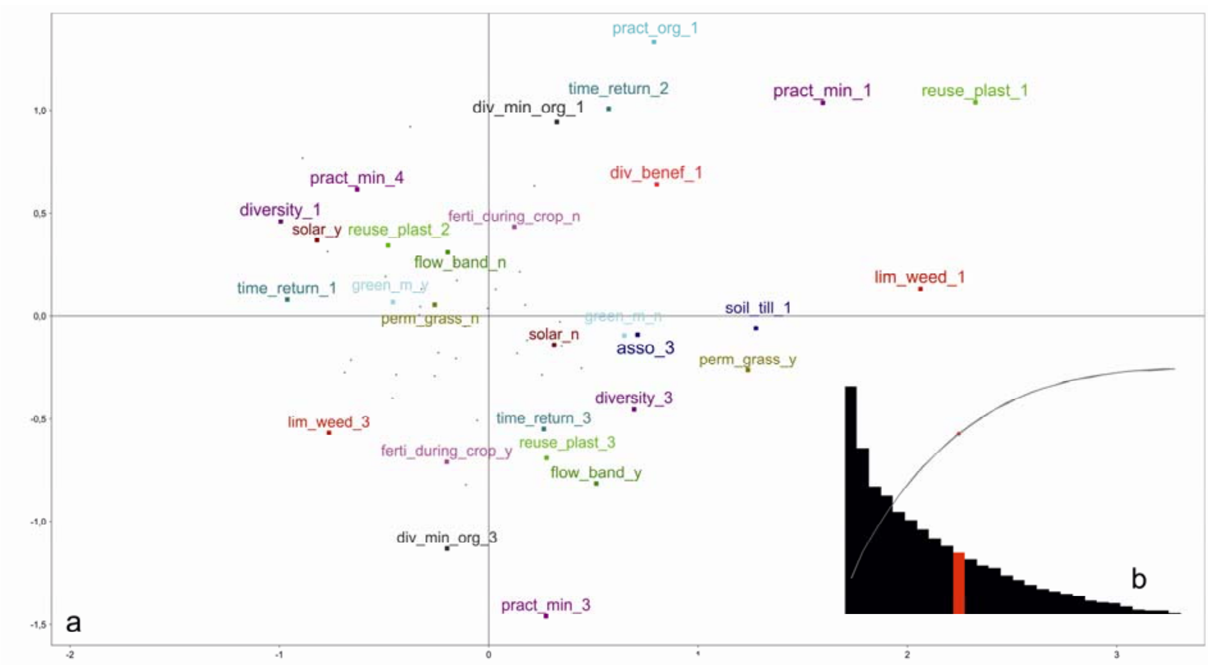

Figure 1: a) plan 1-2 of ACM realize on practices of farms (22 variables, 60 modalities). Every plot is a modality of one variable. Plot with a same color is the same variable. Size of plot is proportional of cos² in this plan. b) Contribution to the variability of each of the 28 axes. In red, it a number of axe use for CAH, 10 axes for 73% of total variability.

3.2 Classification of practices, conventionalized vs canonical

The AHC, performed on the first 10 lines of the ACM (73% of the total variability) enabled to identify five types of farms:

- Group 1 (in black in **Fejl! Henvisningskilde ikke fundet.**) includes 8 of the 29 farms surveyed. It was significantly correlated to a small number of crop species (2-4); a short period of time to return ; the practice of solarization; non-systematic mineral treatments, without localized applications, or lower doses; the non-reuse of plastics, non-association of species or variety within the same shelter ;
- Group 2 (red) was significantly correlated to the association of crop species and varieties under the same shelter and return of same species every 2 or 3 years. This group includes seven farms ;
- Group 3 (green), with 7 farms, is significantly correlated with a high diversity of released beneficials (3 or more), systematic export of crop residues, unsystematic and sometimes localized mineral treatments , and a medium pressure on the soil tillage ;
- Group 4 (blue) was significantly correlated with the use more fertilizers than amendments, adoption of flower strips, systematic use of phytosanitary products , sometimes with site-specific location of treatment and lower doses, a high variety of products of biological and mineral treatment, and a return of same specie greater than 4 years. This group includes 5 farms;
- Group 5 (light blue) is significantly correlated with the absence of use of plastic for the limitation of weed population and non-use of mineral treatments. This group includes two farms.

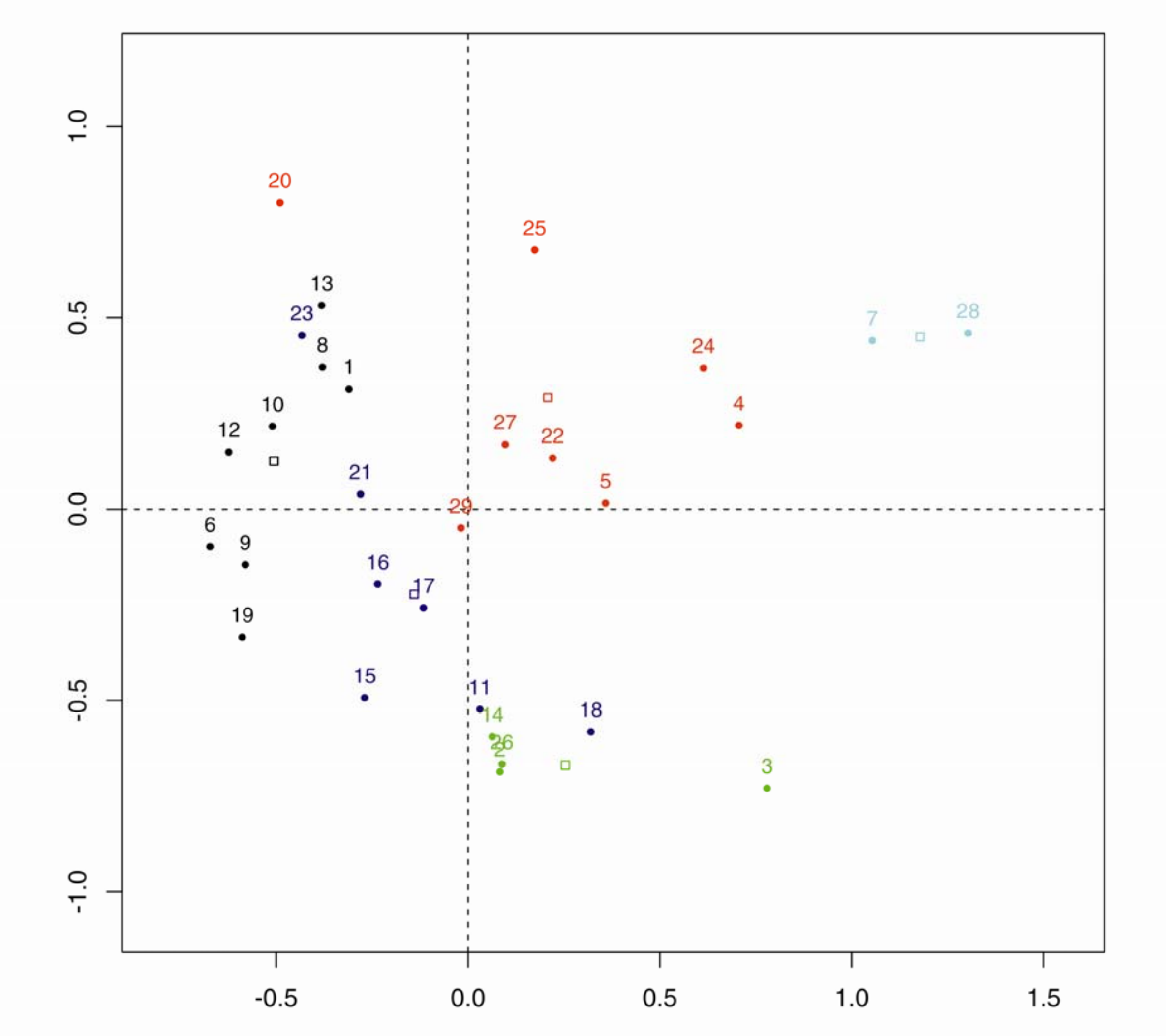

Figure 2: plan 1-2 of ACM realize on practices of farms (22 variables, 60 modalities). Every plot is exploitation. A color is a statistical group after ACH, group 1, 2, 3, 4 and 5, is respectively a color black, red, green, blue and light blue.

3.3 Contrasting perceptions and finality of practice

The ACM opposed on axis 1 (19% of total variability) of (i) farms which do not adjust the climate control to maintain the NR, saying one or to two pests of concern, not practicing association and managing inter-shelter to promote the natural regulation ; (ii) to farms declaring three pests concern, and don't managing inter-shelter to promote the NR.

Axis 2 (16%) opposes (i) farms practicing some associations but not for to promote the NR, manager climate shelter to promote RN and not using the tool for guiding treatment; (ii) to farms practicing often associations but not to promote RN and using tools for guiding treatments.

Axis 3 (13%), opposes (i) farms with non-specific weed management; (ii) to farms practicing associations for to promote the NR and management weed specifically.

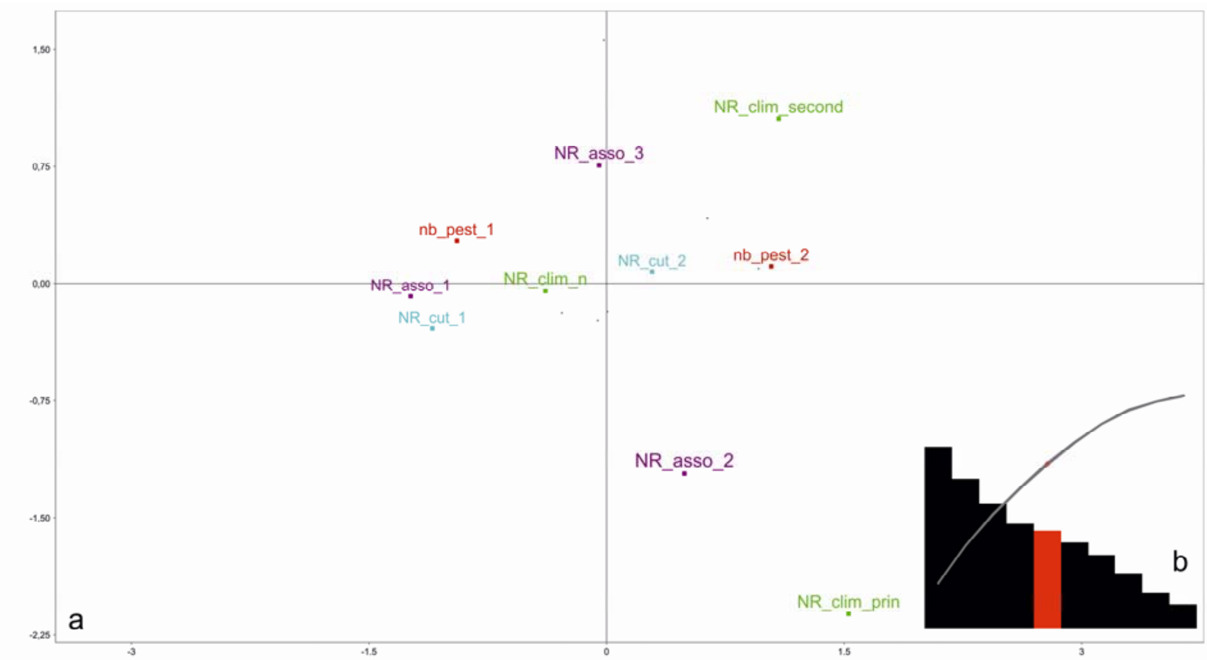

Figure 3 : a) plan 1-2 of ACM realize on perception of farms (6 variables, 16 modalities). Every plot is a modality of one variable. Plot with a same color is the same variable. Size of plot is proportional of cos² in this plan. b) Contribution to the variability of each of the 10 axes. In red, it a number of axe use for CAH, 10 axes for 73% of total variability.

3.3 Unexpected composition of perception groups

The ACH, performed on the first 5 axes of the ACM (80% of the total variability) identified four types of group:

- Group 1 (black), with 14 farms, is significantly characterized by not adapting to climate management for maintaining NR, have low pest concern (1-2), not practice associations for maintaining NR;
- Group 2 (red) is significantly characterized by adapt secondarily climate management for the maintaining NR. This group includes 4 farms;
- Group 3 (green), with 8 farms, is significantly characterized by practice association but not for the promoting NR. This group includes 8 farms;
- Group 4 (blue), 3 farms, is significantly characterized by practice associations to promote NR.

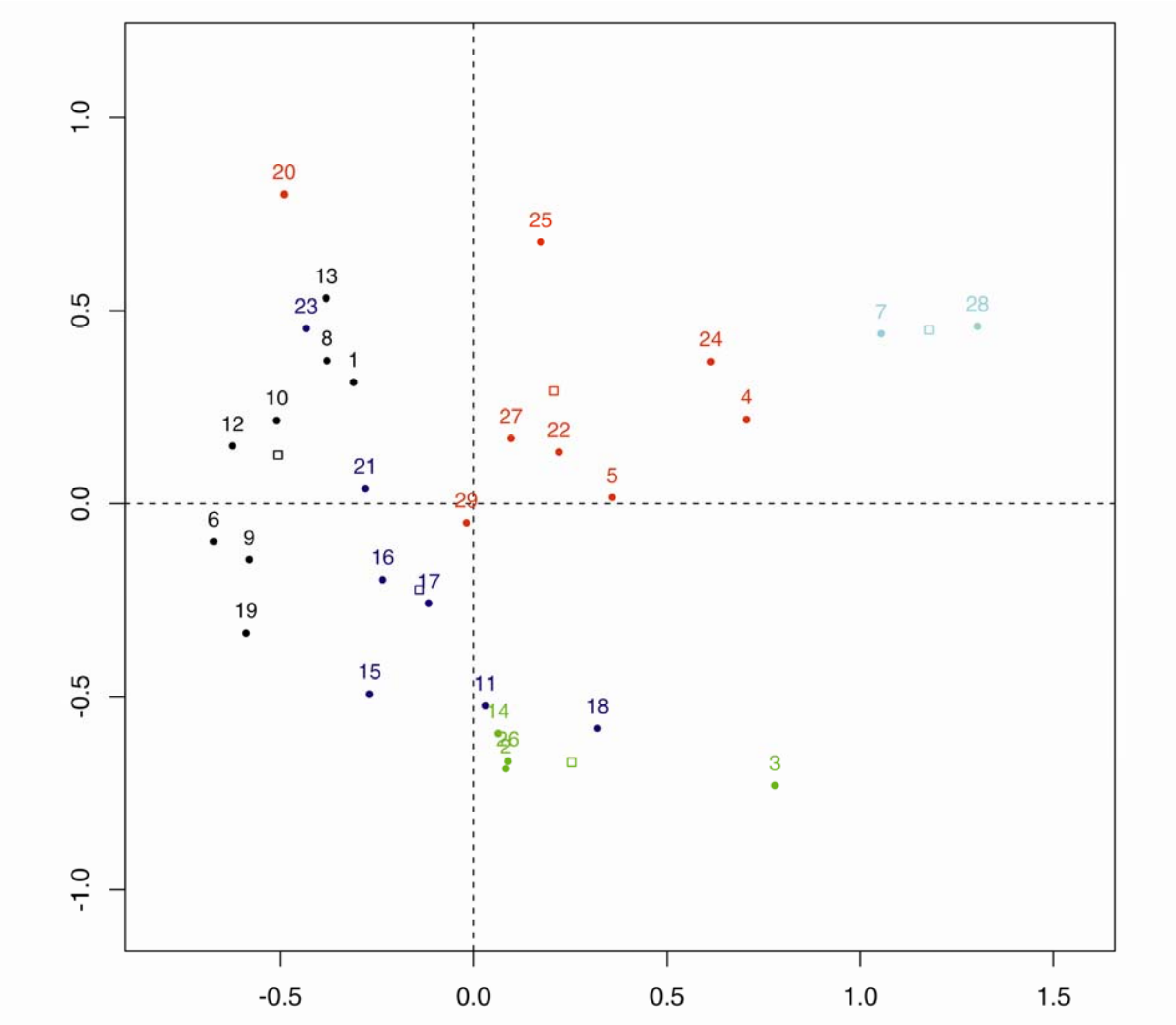

Figure 4 : plan 1-2 of ACM realize on perception of farms (6 variables, 16 modalities). Every plot is exploitation. A color is a statistical group after ACH, group 1, 2, 3, and 4, is respectively a color black, red, green, and blue.

3.4 Do perceptions translate into practices?

The independence test (Chi-2) made between the different groups of farms from the ACM is not significant ($X^2 = 6.47$, pvalue = 0.60).

We can therefore conclude that there is no link between the ends sought by farmers and practices they develop. This suggests that a given perception may translate into different sets of practices and conversely.

Indeed, perception group 2, for which NR is secondary in the selection of practices, is mainly found in the practice group 2 (3 out of 4 farms) which is characterized by specific and varietal intra-shelter associations and a low diversity of beneficial insects used. Perception group 3, which is characterized by the practice of association but not to promote NR is predominantly found in practice group 1 and 4 (Table I).

The links between perceptions and practices are much more diffuse in the other groups. As for the perception group 1, which have little consideration for NR in the choice of practices, the mainly found practices group is 1 (4 out of 14 farms), with less diversification and interventionism. However, this same perception group is found in all practices groups (Table I). This shows a poor integration of NR in the choice of practices, regardless of the practice group.

Table I : Number of farms in the groups of each of the two clustering, according to the practices and the perception tables.

		Practice group					
		1	**2**	**3**	**4**	**5**	**sum**
Perception group	**1**	4	3	2	3	2	14
	2	0	3	0	1	0	4
	3	3	1	1	3	0	8
	4	1	1	1	0	0	3
Sum		8	8	4	7	2	

4. Discussion

A variety of practices has already been demonstrated in organic gardening in the south of France (Navarrete, 2009) or more widely in the world and on other biological systems (Guthman, 2004 ; Darnhofer et al., 2010 ; Oelofse et al., 2011). However, beyond the divisions advanced in these studies, specialized *vs* diversified, conventionalized *vs* canonical, complex sets of practices have been revealed. Indeed, the contrast between the A/B practices could be interpreted as an opposition between conventionalized (A) and canonical (B) farms (Figure 5). Thus, the first simplify their system (low diversity cultivated, no permanent grass) and adopt direct action (Bellon et al., 2006) to maintain fertility (preferential use of fertilizer) and limit pests (systematic treatments, not localized, solarization, coverage soil with plastic) while the latter tend to more complex systems (crop diversity more important, permanent grass cover) and indirect management of fertility (amendment only) and of pests (no use or low pecticide, no solarization...). However, this schematic cleavage should not prevent consideration of the farms of other dials of the MCA (B and D of Figure 1). Thus, the farms of the dial B have less pressure in the plant protection product but with a low cultivated diversity, while other farms (dial D) are more diversified, using alternative techniques (flower band, permanent weed) but with a systematic use of pesticides.

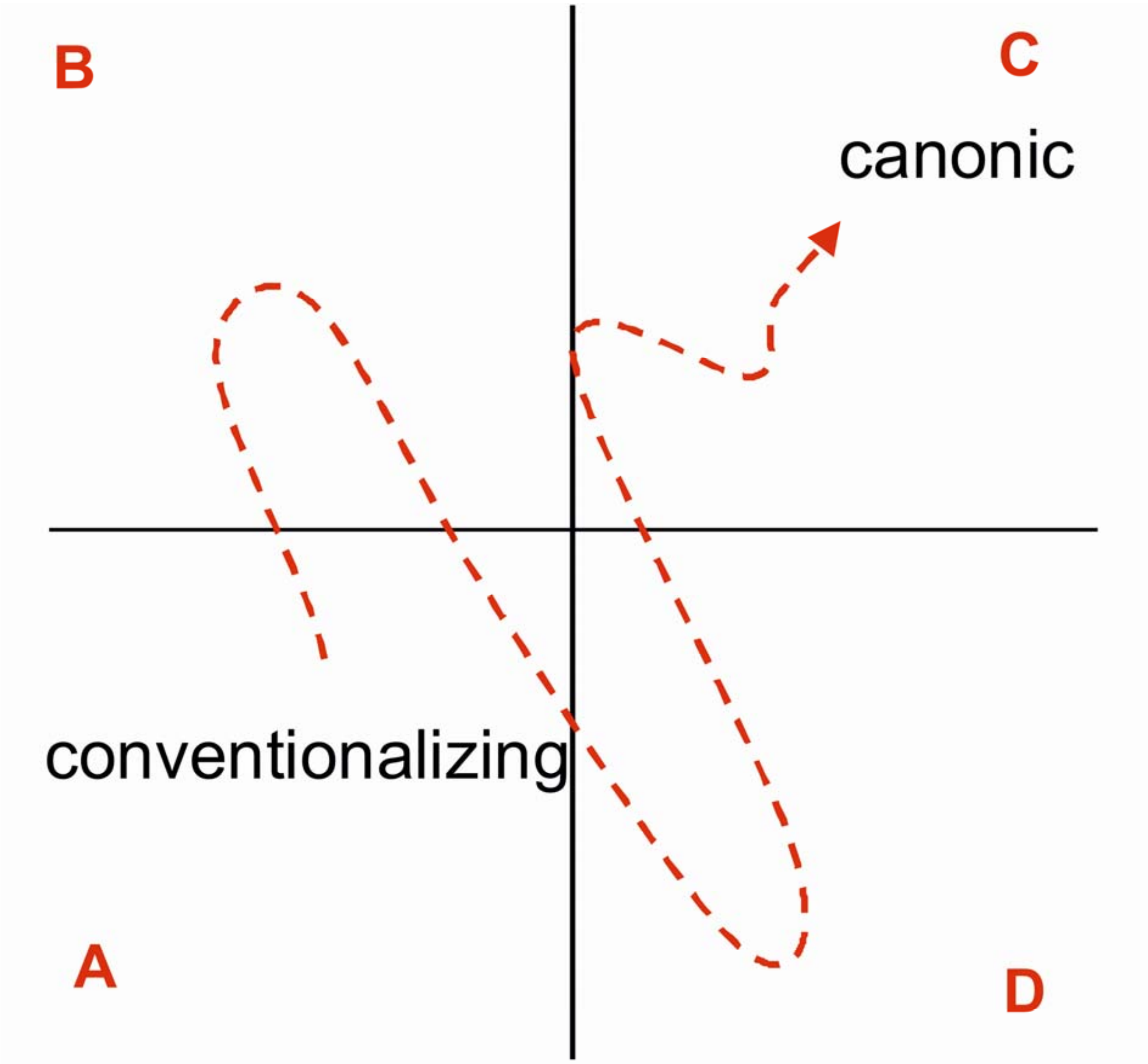

Figure 5 : schematic distributions of farmers' practices in plan 1-2 of the MCA and four type of system.

Our approach of the perception of farmers of their system (pest pressure, weed management), the integration of NR in practice reasoning and the use tool for guiding treatment, showed a wide variation depending on farmers. Indeed, a majority of farmers had little consideration for the NR in their practices choice (perception group 1). Moreover, these farmers seem to have no problem with pest air. It therefore seems that a majority of farms do not structure their practices to reduce the pressure of pests by natural enemies, without declaring a large number of pests. No other group combines all the goals in the choice of practices to promote the NR (association, climate management, inter-cutting of shelters) and has no particular orientation (NR in the shelter vs NR out of the shelter).

The first perception group covers all practices groups, it is impossible to say that this group of "finality" is linked to any type of practice. This fact is quite interesting. Indeed, it is generally admitted that the canonical organic farmers are prone to an ethical environmental conservation, while the conventionalized seek profit maximization (Goldberger, 2011). This study shows that farmers identified as reasoning their practices do not necessarily adopt canonical practices in terms of functional biodiversity to promote NR.

5. Conclusion

The practices of protected organic vegetable farmers are very diverse. A cleavage, under what has been defined as the conventionalization *vs* canonical has been demonstrated. However, a great disparity lies in the intermediate situations between the canonical organic and conventionalized organic. The variables included under the term “perception” have also showed a great diversity. They are more systems that have little considerations for NR in the choice of their practices. This fact is surprising because even the farmers belonging to the group of canonical organic are part of this group of perception. Finally, membership in a group of perception does not define the practice. Thus farmers with identical purposes may have different sets of practices and vice versa.

However, several questions remain unanswered. The questions asked to farmers on the fact of trying to promote NR in the choice of their practices were global and did not seek to know what specific practices were implemented to support this regulation. Furthermore, only the NR of airborne insects pests was targeted by these surveys, while some farmers seem more concerned with diseases, including soil borne ones. It might be interesting to understand what kinds of practices are developed by farmers in order to promote the NR emerge, for which systems of knowledge, network... Finally, this work is part of a larger work, which attempts to assess the interactions between the abundance and diversity of diseases and pests in connection with the auxiliary and landscapes. The inclusion of these variables appears to be essential to understand the interactions used in these agroecosystems.

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