# Participative design of conservation agriculture cropping systems in organic agriculture

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## 1 Introduction

New forms of agriculture have emerged aiming at addressing challenges such as improving food production, while minimizing environmental impacts and maintaining economic viability. Among them, organic farming bans the use of synthetic inputs and emphasizes the conservation of soil fertility based on closed farming systems including plants and animals to recycle nutrients. Nevertheless, the number of stockless organic farms specialized in crop production is increasing in Europe. In order to cope with soil fertility problems, some organic farmers are interested in conservation agriculture practices. Conservation agriculture (CA) aims at addressing the problems of soil degradation by improving soil organic matter content, limiting soil erosion, and improving soil structure and fertility. It relies on three principles: minimum or no soil disturbance, permanent soil cover, and diversified crop rotation. Organic farmers are facing technical constraints to combine organic farming and conservation agriculture (e.g. weed infestation that cannot be controlled by herbicides, delay in spring mineralization, or lower yield) and factor-based experimental studies are still insufficient to explore the range of possible solutions and conclude on the possible implementation of conservation agriculture on organic farms (Peigné et al., 2015). Designing organic cropping systems including conservation practices is thus very challenging. Prototyping methods (Vereijken, 1997) have been proved to be efficient to design innovative cropping systems based on limited and dispersed knowledge. Two studies used participative workshops to design organic cropping systems including conservation practices. Lefèvre *et al.* (2013) involved French farmers in a prototyping process to design cropping systems tailored to the local conditions of the participant farms. On the other hand, researchers of the TILMAN-org project (www.tilman.net) designed cropping systems for five pedoclimatic conditions in Europe. The objective of the present study is to analyze the two co-design processes. What are the characteristics of the designed prototypes? What is the impact of the prototyping method and participants on the designed prototypes?

## 2 Materials and Methods

We compare two methods respectively developed in (i) Lefèvre *et al.* (2013) and (ii) TILMAN-org project that are summarized in Table 1. In case of Lefèvre *et al.* (2013), existing knowledge and data on innovative situations were presented and discussed between step 2 and 3. In case of TILMAN-org project, results from a European farmers' survey (Peigné *et al.*, 2015) were presented during the first workshop to pick the objectives of the prototypes among the ones of the farmers (step 1).

**Table 1.** Comparison of the two methods

| | **Lefèvre et al. (2013)** | **TILMAN-org Project** |
|---|---|---|
| Location of the design | France | Europe |
| | 2 pedoclimatic zones | 5 pedoclimatic zones[1] |
| Facilitation | 3 researchers | 2 researchers |
| Participants | 14 French farmers | 17 European researchers |
| **Step 1** | **Defining and ranking objectives (collective workshop)** | |
| **Step 2** | **Designing prototypes (collective workshop)** | |
| | 7 exploratory prototypes (no constraints) | 5 prototypes tailored to the 5 zones |
| **Step 3** | **Designing prototypes with constraints (collective and individual workshops)** | - |
| | 14 prototypes tailored to the 14 farms | - |
| **Step 4** | **Assessing the prototypes (MASC 2.0.)** | |
| **Step 5** | **Redesigning the prototypes** | |
| | 14 prototypes | 5 prototypes |

[1]Northern, Nordic, Western, Atlantic, and Mediterranean zones.

As the prototypes were designed to follow conservation principles, we compared the characteristics of the prototypes with regard to (i) soil cover, and (ii) soil disturbance (Fig. 1.). Soil cover depends on (i) ley management (1: all cuts are exported, 2: some cuts are exported other are returned to the field, 3: all cuts are returned) and (ii) cover crops (1: occasional or frequent, 2: systematic, 3: permanent). Soil disturbance depends on: (i) soil tillage (1: reduced tillage and occasional ploughing, 2: systematic reduced tillage and no ploughing, 3: 0, 1 or 2 reduced tillage operations (including direct seeding)) and (ii) mechanical weed management (1: systematic, 2: frequent or occasional, 3: no weeding).

## 3 Results - Discussion

In Lefèvre et al. (2013), the method combined collective and individual workshops and led to the design of 14 prototypes, tailored to each farm conditions. In TILMAN-org project, the method, based on the participation of European researchers produced 5 prototypes, adapted to 5 pedoclimatic conditions. In both cases, the overall objective of the prototyping was to preserve and promote soil fertility. In Lefèvre et al. (2013), all prototypes were designed with the same objectives and same ranking, combining expectations of the researchers and farmers. In TILMAN-org project, based on the results of a previous farmers' survey (Peigné et al., 2015), for each pedoclimatic zone, the sub-groups of researchers ranked the objectives before designing each prototype. Thus objectives and their ranking were different for each prototype.

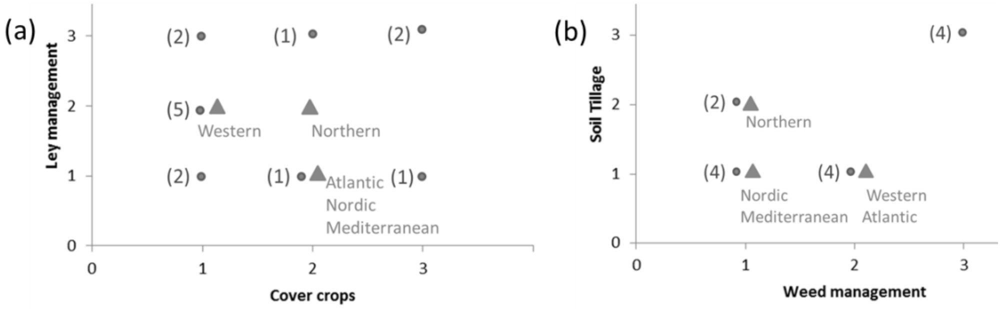


**Figure 1.** Distribution of prototypes according to their compliance with (a) soil cover and (b) soil disturbance. Dots refer to the prototypes from Lefèvre et al. (2013), and the number in brackets stand for the number of prototypes. Triangles refer to the TILMAN-org prototypes with the corresponding pedoclimatic zones below.

When designed exclusively by researchers (TILMAN-org project), the prototypes of the cropping systems systematically included soil cover (Fig. 1.a.), achieving one of the conservation principle. Nevertheless, ley is often exported and soil is highly disturbed because of mechanical weed management and quite intensive soil tillage (occasional ploughing for 4 prototypes out of 5, Fig. 1.b.). When designed by farmers (Lefèvre et al., 2013), prototypes cover a larger range of situations (Fig 1.), reaching better levels of conservation principles. Indeed, 5 farmers' prototypes return all the ley cuts to the field and 3 farmers' prototypes apply permanent cover crops (Fig 1.a). Moreover, 4 farmers' prototypes combine no weeding and much reduced tillage (Fig. 1.b.).

The farmers' prototypes (Lefèvre et al., 2013) were more innovative than the researchers ones (TILMAN-org) (Fig. 1). The method of Lefèvre et al. (2013) was carried out on a longer period, with more steps (Tab. 1), fostering the creativity of the participants. Ongoing experiments and their scientific knowledge might also have restrained researchers' creativity. The sub-groups of participants (TILMAN-org project) were made of researchers of different countries. They had to find compromise prototypes that were adapted to larger range of conditions (a pedoclimatic zone) compared to the tailored farm prototypes designed by the farmers. In addition, researchers groups included specialists of different disciplines with diverging interests and focus (e.g. soil fertility vs weed control). As researchers aimed at designing prototypes that would be applicable by farmers, they ranked economic objectives among the first objectives of each prototype (even if the farmers of the survey did not rank them uppermost). This lead to prototypes applying quite intensively soil tillage and weed control to avoid risky management (Fig. 1.b.). In case of farmers (Lefèvre et al., 2013), the designed cropping systems detailed the decision-making rules for crop management. This shows that farmers anticipated variable conditions and dealt with risk during the prototyping phase.

## 4 Conclusions

This comparative paper shows that depending on the objective of the study, the participants and the method should be carefully defined. When looking for innovation and creativity, one would better select farmers and use a long term method with a "no constraints" step. When looking for capitalizing and operationalizing existing knowledge and experiments, involving researchers and/or experts is relevant, but the designed prototypes might lack of creativity. Contrary to conventional thinking, when using adequate method, farmers could put things into perspective and design cropping systems that are very different from their own systems and contribute to address research front issues.

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