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Are crop sequence evolutions influenced by farm territory dynamics?

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1 Introduction

Crop sequence can be defined as the temporal arrangement of crops and is influenced by four major types of constraint: the timing of agricultural operations, the minimum area of each crop, the minimum return period between the same crop, and the benefits or risks associated to preceding-following crop pairs (Castellazzi *et al.*, 2008).

Crop sequence is a key factor for assessing the environmental impact of farming systems (Leteinturier *et al.*, 2006). Thus, analyzing the evolution of crop sequences and its drivers (*e.g.* European regulations or changes in farm size) is essential to understand farming system dynamics. The aim of this work was to analyze the link between farm territory dynamics and crop sequence evolutions. We specifically analyzed the evolutions of crops preceding winter wheat on cereal farms with contrasted dynamics of their territory (growth or stability of their Used Agricultural Area (UAA)).

2 Materials and Methods

Our study was carried out in the Niort Plain in western France (53,000 ha). We used the spatially explicit data from the French Land Parcel Identification System (LPIS), called RPG, available from 2007 to 2012.

In the RPG, each mapped parcel is associated with a farm identifier which differs from one year to another. So, we established a link between the farm identifiers of two successive years by intersecting chronologically the RPG geo-referenced layers. We thus identified farms in which no change of the UAA has occurred over the 2007-2012 period (stable farms) and farms which have known an increase of their UAA in 2009, 2010 or 2011 (growing farms). We focused on 203 cereals farms, *i.e.* farms cultivating winter wheat and holding more than 50% of cereals or less than 5% of grasslands in their cropping plan. Among them, we identified 61 stable farms and 30 growing farms.

For these 91 cereal farms, winter wheat represents about 45% of the cropping plan. Therefore, crops preceding winter wheat play a key role in the lengthening and the diversification of crop sequences. We analyzed the evolution of the number (lengthening indicator) and the proportion of each crop preceding winter wheat (diversification indicator) on stable and growing farms between 2007-2008 and 2011-2012 (*i.e.* before and after the potential growth in farm size). The preceding-following crop pairs were determined by intersecting RPG layers too (Leteinturier *et al.*, 2006).

In addition, the evolutions of crops preceding winter wheat observed in the RPG were compared with those of 20 surveyed cereal farms (10 stable farms and 10 growing farms). Interviews were conducted to collect information about the composition and the allocation of crop sequences on the farm territory and to determine the drivers of changes.

3 Results – Discussion

On stable and growing farms, the average number of preceding crops remained quite the same between 2007-2008 and 2011-2012 (*resp.* 2.8 and 2.5 crops in stable farms; *resp.* 3.7 and 3.5 crops in growing farms). Nevertheless, we observed that the proportion of stable farms with more than 3 preceding crops before winter wheat decreased between 2007-2008 and 2011-2012 (Fig. 1). This highlights a potential slight shortening of crop sequences on stable farms. On growing farms, no specific behavior towards shortening or lengthening of crop sequences was identified: the proportion of farms with 4 preceding crops drastically decreased, but at the same time, both the proportion of farms with 3 or less preceding crops and the proportion of farms with 5 or more preceding crops increased. Besides, it appears that the crop sequence lengthening was often limited on the UAA of stable and growing farms. Actually, even when farms had 5 or more crops preceding winter wheat, two of them represented on average 70% of the farm area in winter wheat.

Rapeseed, sunflower and winter wheat were the 3 more frequent crops preceding winter wheat in 2007-2008 and in 2011-2012. Each of these preceding crops represented 15% to 40% of winter wheat area (Fig. 2). Between 2007-2008 and 2011-2012, the proportion of winter wheat preceded by rapeseed and winter wheat decreased (*resp.* -11.8% and -7.5% on stable farms; *resp.* -12.1% and -11.0% on growing farms) whereas the proportion of sunflower/winter wheat area substantially increased (+20.4% on stable farms; +16.7% on growing farms). Over the same period, we also observed an increase of preceding crops with agronomic benefits (*e.g.* legumes/winter wheat). According to these changes, our results highlight a diversification of crop sequences with an expansion of crops whose crop management is less intensive (reduced needs in pesticides and nitrogen) in the Niort Plain.

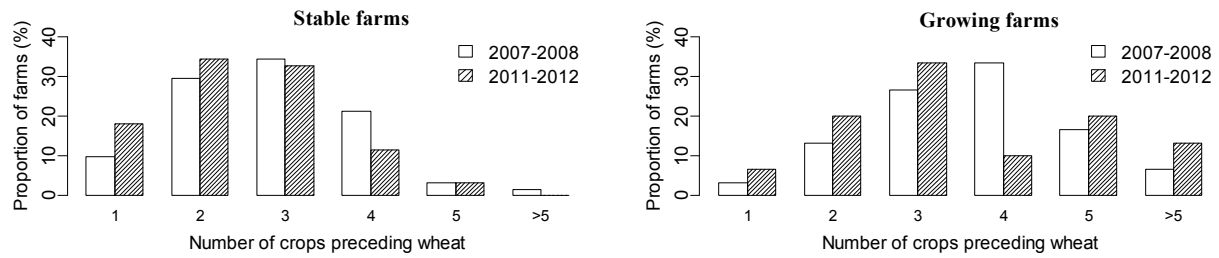


Fig. 1. Proportion of farms according to the number of crops preceding wheat on stable farms (n=61) and growing farms (n=30) (1 - 2: short sequence / 4 - >5: long sequence). Sources: RPG (2007-2008 and 2011-2012).

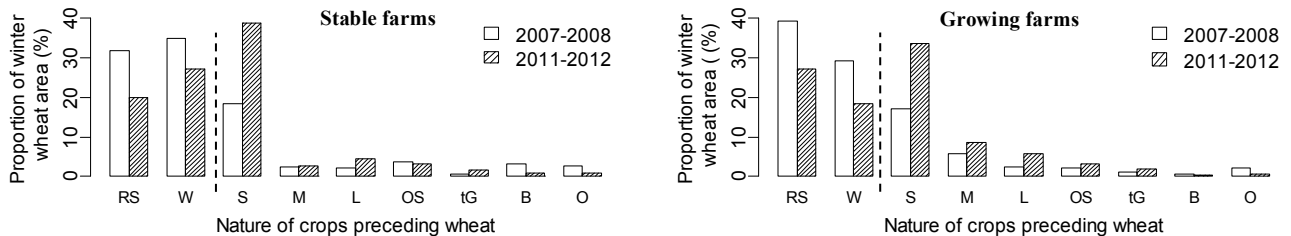


Fig. 2. Proportion of winter wheat area associated to each type of preceding crops on stable farms (n=61) and growing farms (n=30) (RS, W: intensive preceding crops / S, M, L, OS, tG, B: extensive preceding crops). Sources: RPG (2007-2008 and 2011-2012).

RS: rapeseed, W: winter wheat, S: sunflower, M: maize, L: legumes, OS: other oilseed-crop, tG: temporary grassland, B: barley, O: others.

Farm interviews confirmed the evolutions observed on preceding crops of winter wheat (rapeseed, sunflower and winter wheat). Drivers of changes were similar on both stable and growing farms and can be classified as economic or environmental drivers. On the economic point of view, farms tended to lengthen their rotations with new break crops (sunflower, oilseed-linen, legumes or maize) in order to limit the economic risk related to a large area in one crop (mainly rapeseed). This was especially the case when the farm size increased between 2007 and 2012. However, the lack of irrigation can limit this diversification of crop sequences on shallow soils when irrigation is requested by downstream supply-chain for specific contract (e.g. seed contracts). On the environmental point of view, new break crops were often introduced in crop sequences to delay the return period of rapeseed and winter wheat and reduce the pest pressure and nitrogen requirement. According to interviews, Agro-Environmental Schemes (AES) could both contribute to lengthening and diversification of crop sequences (introduction of legumes to reduce nitrogen use) or limit it (suppression of rapeseed to reduce pesticide use). Alongside Schaller (2011), interviews showed that new crop pairs were introduced systematically or according to an opportunistic management. The latter was linked to the subscription to an AES or to the evolution of the collection area of a supply-chain. Duration of these opportunistic management strategies without CAP subsidies is a new challenge for policy makers and raises the question of the durability of crop sequence changes on an agricultural territory.

4 Conclusions

Our results based on database analysis and interviews showed that farm enlargement was not the main driver of crop sequence changes: the number and the nature of crops preceding winter wheat changed on both stable and growing farms between 2007-2008 and 2011-2012. A slight shortening of crop sequences was observed on stable farms but no fixed orientation towards shortening or lengthening was identified on growing farms. On both stable and growing farms, the main observed evolution was the introduction of new preceding crops in order to replace or delay the return period of rapeseed and winter wheat. Strategies of crop sequence changes did not differ on stable and growing farms due to common environmental and economic drivers. These results might well be of importance either in identifying relevant crop sequence changes for environmental issues at large scale and in determining policy to deal with this issue.

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