Efficiency of ruminant organic farming systems: Specialised grass systems perform better than mixed crop-livestock

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Abstract

The efficiency of the production system can be approached by comparing the results obtained (agricultural production) and the means employed (factors of production). We calculated the techno-economic efficiency of 70 organic ruminant livestock farms in the French Massif Central for 2014 and 2015. Multivariate data analyses were used to explore sample variability and identify determinants of farm efficiency. Specialised livestock and grass-based production systems appear to be the most efficient. Crop diversification, mixed crop-livestock farming seems to limit efficiency.

Introduction

The French Massif Central (MC) is a mountainous area accounting for 30% of the national herd of Organic Farming (OF) certified ruminants. MC professional stakeholders express a strong need for references to accompany farmers towards less vulnerable (Bouttes et al., 2019) and/or more efficient systems (Veysset et al., 2015). The BioRéférence project (2015-2020), led by the “Pôle AB Massif Central”, aims to produce structural, technical and economic references for ruminant livestock farms in the MC. This project relies on about twenty local partners (development, research, R&D, teaching, associations) and a network of 70 ruminant OF livestock farms. The objective of this study is to identify an overall indicator to measure and evaluate the efficiency of ruminant farming systems. This work is carried out using data from the BioRéférences farms’ network. Using multivariate data analyses methods, we explored the determinants of this indicator. Then, based on a typology of farms, we will determine whether there are different strategies to reach a good level of efficiency.

Material and methods

The livestock farms’ network

The BioRéférence project's support farms cover the entire Massif Central territory and integrate the three ruminant species (cattle, sheep and goats) and the two main productions (milk and meat) of the MC. The willingness of local actors was to have data from specialised, professional farms with good production levels. Farms are monitored each year according to the INOSYS-Réseaux d'Elevage methodology (Institut de l’Elevage, 2014). Structural, technical and economic data from 70 farms were recorded in the Diapason database for 2014 and 2015 (constant sample): 20 dairy cattle, 16 beef cattle, 12 dairy sheep, 13 meat sheep and 9 goats. Half of these farms have been certified organic for more than 10 years, and only 15% have been certified for less than 5 years. The main structural and economic characteristics of these 70 farms, on average over 2014 and 2015, are shown in Table 1. Beyond the average values, there is great variability within the sample. The detailed annual techno-economic results for each year's production are available on the Pôle AB MC website (Pôle AB Massif Central, 2019).

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Efficiency of the production systems

The efficiency of a production system can be approached by comparing the result obtained (agricultural production) and the means employed (factors of production), i.e. by factor productivity (Veysset et al., 2015). The amount of input used for a given production system is a strong determinant of the economic and environmental sustainability of the system (Lebaq et al., 2015). Therefore, we calculated the techno-economic efficiency by the ratio:

Gross output excluding aids (€) / (intermediate consumption + use of equipment) (€)

Intermediate consumption is the consumption of goods and services acquired from a third party to obtain the output. Equipment use is the annual depreciation charges for equipment, buildings and land improvements. This techno-economic efficiency is calculated for each of the 70 farms for 2014 and 2015.

Data analyses

Data analyses should highlight the links, if any, between the variability of structures, systems, practices and techno-economic efficiency.

First, in order to explore and summarise the variability of our sample of 70 farms, we conducted a principal component analysis (PCA) with 43 active variables: 18 structural variables (labour, area, capital), 20 system organisation variables (intensification of production factors, diversification, crop destination), and five technical variables (food self-sufficiency, animal productivity). Three economic performance variables (value-added/gross product, gross farm income/gross product, farm net income/worker) and five partial factor productivity variables (labour, land, equipment, intermediate consumption and techno-economic efficiency) are used as additional variables. To overcome the "type of production" effect, all data have been standardised by production and year, and individuals have been weighted by the production system to establish an equivalent weight for each production. Finally, the data from both years are combined into a single sample of 140 observations (70 farms x 2 years) and processed together.

Based on the results of the PCA, we performed a hierarchical cluster analysis (HCA). It allows us to construct a typology of farms by grouping individuals with relatively similar characteristics into groups that are significantly different from each other.

Results

Variability analysis and correlations

Three axes explain 42.2% of the total variability of our sample of 140 observations: (A1) the first axis discriminates farms according to their size (ha UAA, LU) and their diversification (number of crops). These variables are positively correlated with self-sufficiency in concentrates, the quantity distributed per LU and animal productivity; (A2) the second axis discriminates large grassland and specialised farms (ha main forage area, LU, forage area/UAA, share of permanent grassland), with high labour productivity (ha UAA/worker, LU/worker) and low intensification of production factors (stocking rate, capital employed per ha); (A3) the third axis discriminates small-scale farms with factors of high intensification production (quantity of concentrate per LU, animal productivity, capital employed per ha and per worker, intermediate consumption per ha). These variables are negatively correlated with size and feed self-sufficiency.

The net farm income per worker is positively correlated with A2 (large grassland farms with high labour productivity) and negatively correlated with A3 (opposite to intensification of production factors). Techno-economic efficiency is significantly and negatively correlated with A3 (opposite to intensification of production factors).

Typology: six groups of farms

The HCA makes it possible to distinguish six groups of farms. Only four groups with the most "extreme" characteristics are presented below and in Table 1.

1. "Small and thrifty farms, with workforce": this group consists of farms that are smaller than the average size of the total sample (-36%) but with almost the same number of workers. 16% of the UAA is allocated to crops, which allows for very good feed self-sufficiency (92%). These farms show slightly above-average techno-economic efficiency mainly due to good equipment productivity (because of their small size with a sufficient number of workers, they have chosen not to invest too much in equipment). Despite labour productivity being 26% lower than average, the net farm income per worker is only 16% lower.

2. "Intensive farms, high labour productivity": these farms, with the highest labour productivity of the six groups, are very intensively managed. They are medium-sized but have the smallest number of workers. In value terms, they use 38% more intermediate consumption per ha of UAA than the average. These high labour productivity farms tend to substitute labour with capital and/or intermediate consumption, but the product does not increase in proportion to the inputs. The techno-economic efficiency is the lowest of the six groups. Despite high labour productivity (+40% compared to the average), the net farm income per worker in this group is 17% lower than the average.

3. "Large grassland farms with high labour productivity": this group includes large grassland farms (ha UAA +60% compared to the average) with high labour productivity. Contrary to group 2, these farms do not seek to increase productivity through the intensification of inputs but to limit expenses. These farms use few inputs per ha of UAA (-28% compared to the average) and have the best techno-economic efficiency of the six groups. A large size associated with good techno-economic efficiency allows this group to obtain the best net farm income per worker (+43% compared to the average).

4. "Large mixed crop-livestock farms, with high labour productivity": this group is made up of large farms with high labour productivity, which devote 21% of their UAA to annual crops (80% for animal feed and 20% for sale). Crops allow the best self-sufficiency in concentrates of the six groups. Due to the high equipment need for the crop, the techno-economic efficiency is slightly lower than the whole sample average. Net farm income per worker remains in the average range due to the relatively high labour productivity.

The two undescribed groups are made up of grassland farms medium-sized, specialized (group 5), and "small", intensive, with low labour productivity (group 6). It should be noted that all production is found in all groups, except for goats, which are not found on large farms (groups 3 and 4).

Discussion and conclusion

Labour productivity and maximization of the output have always been seen as the main drivers of good farms economic performances. These two strategies do not seem the most efficient for OF ruminant farms in the French Massif Central. The productive specialisation, the feed self-sufficiency and input savings are positive determinants of the systems techno-economic efficiency.

Crop diversification and mixed farming seem to limit the techno-economic efficiency of these farms. However, the mixed crop-livestock farms are generally large with high labour productivity. Even so, farm size and labour productivity impact economic efficiency, but either positively or negatively, depending on the combination of other factors. A large grassland specialised farm can be very efficient, while a similarly sized farm in a mixed system has some probability of being less efficient. Smaller farms seeking to increase production by intensifying see their efficiency degraded; in these cases, the additional quantity of inputs, services and equipment used does not lead to a proportional increase in agricultural production, resulting in lower efficiency.

Suggestions for research and support policies to develop further organic animal husbandry

Mixed cropping-livestock farming is generally seen as a system enabling the construction of eco-efficient production systems. Diversification often entails enlarging farms. Farmers' choices in terms of work organisation, equipment investment on these large, diversified farms should be studied to objectively assess the trade-offs made and their impact on the sustainability of the systems.

Table 1: Main characteristics of the 70 farms in the BioRéférence network and 4 of the 6 groups from the hierarchical cluster analysis (HCA)

Average values for the 2 years 2014 and 2015 cumulated	70 farms x 2 years (n=140)	1. Small and thrifty farms, with work-force (n=27)	2. Intensive farms, high labour productivity (n=13)	3. Large grassland farms with high labour productivity (n=11)	4. Large mixed farms, high labour productivity (n=29)
Annual Work Units (AWU)	2,1	2,0	**1,6**	2,4	**2,6**
Agricultural Area (UAA) ha	89	**57**	76	**142**	**145**
Forage Area (MFA) % UAA	88	84	84	**95**	**79**
Livestock Units (LU)	78	**52**	67	**141**	**112**
Stocking rate, LU/ha MFA	1,03	1,09	1,08	1,04	0,95
Crop diversity, Shannon index	1,26	**1,48**	1,49	**1,12**	**1,65**
UAA ha/AWU	46	31	**50**	61	**61**
LU/AWU	39	**28**	**44**	**61**	45
Intermediate consumption €/ha UAA	1160	1150	**1600**	840	890
Concentrate self-sufficiency, %	45	**59**	**23**	23	**74**
Feed self-sufficiency, %	87	**92**	**77**	85	90
Net farm income k€/AWU	29,0	**24,3**	24,0	**41,8**	29,3
Labour productivity	88	**65**	**124**	**114**	95
Land productivity	2,3	2,3	2,6	1,9	**1,8**
Intermediate consumption productivity	2,1	2,1	**1,7**	**2,9**	2,0
Equipment productivity	7,6	**9,6**	6,5	9,8	7,2
Techno-economic efficiency	1,57	1,60	**1,26**	**2,14**	1,52

In bold: significantly discriminating variables

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