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EVALUATING THE LEVEL OF INTEGRATION BETWEEN LIVESTOCK AND CROPS ON FARMS TO PROMOTE THE BENEFITS OF INTEGRATED FARMING

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Abstract: Organic farming aims at closing biogeochemical cycles. On farms combining livestock and crops, this aim should be achieved by increasing interactions between both. However, there is a lack of methodology for measuring these interactions from farm's management databases. To assess the level of integration (LI) between crops and livestock, we built a tool based on 10 indicators concerning food self-sufficiency, fertilizers autonomy and land use. This tool differentiates farms in three LI: low, medium and high. We compared the economic and environmental performances of each LI. Organic farms are mainly found in the high LI group. As the LI increases, environmental performances increase and economic performances are more resilient. Monitoring the evolution of the LI score while implementing changes in farming practices could help assess their sustainability and identify innovative practices.

Introduction: Two terms are used to name farms combining livestock and crops: "mixed crop livestock systems" and "integrated crop livestock systems". “Mixed” focuses on the diversity of productions, whereas “integrated” underlines the flows between productions. Most of the assumed interests of combining crops and livestock are related to the integration: facilitation of nutrient cycle completion, increase of farm resilience to economic and climatic hazards and promotion of productive agriculture (Lemaire et al., 2014). Organic farming rules ban chemical fertilization and pesticides but also GMO feed and then promote integration by producing organic manure to fertilize crops and own cereals and straw to feed and bed the animals (IFOAM, 2008). However, we lack tools to assess the level of integration (LI) between livestock and crop productions that is the strength of flows between both productions. We aim at i) building a tool to assess the LI, ii) comparing LI scores of organic and conventional farms, iii) assessing environmental performances and economic resilience of farms in respect of their LI score.

Material and methods: We selected ten criteria available in farms management databases to represent three dimensions of crops and livestock integration (use of arable land, feed and straw autonomy and fertilization autonomy). Each criteria

is related positively (the highest the better, +) or negatively (the less the better, -) to the integration. For ‘use of arable land’, the criteria selected are “proportion of utilized agricultural area (UAA) used for animals” (+), “proportion of maize in forage area” (-), “proportion of crops used for feeding the animals” (+), “intercropping area used for animals” (+). The criteria selected to represent feed and straw autonomy are “concentrate self-sufficiency” (+), “euros spent for fodder purchases” (-), “frequency of straw purchases in the three last years” (-). Criteria selected for fertilization autonomy are “euros spent for crop fertilization” (-), “euros spent for grass fertilization” (-), “proportion of protein crops in the UAA” (+).
All data were available for 1190 farms including 119 organic farms and were submitted to a principal component analysis. The three first axes have been retained and linked to integration. The LI score of farms was then calculated from their coordinates on these axes. Each farm is distributed to one class of LI (low, medium or high) in order to obtain 30% of farms considered as low, 40% as medium and 30% as high.
Environmental and economic performances were assessed through seven criteria: nitrogen balance per ha, fuel consumption per ha, treatment expenses per ha of crops - for environmental aspects - income per labor unit, ratio between Earnings Before Interest and Taxes and Amortization (EBITA) and gross product, ratio between operating costs and gross product and ratio between subsidies and EBITA - for economic aspects. We used a GLM procedure to test the effects of LI, organic farming, part of crop in UAA and type of livestock production on each of these criteria. We also analyzed the variability of these criteria over the last 15 years.
We also monitored the LI score of the Saint-Laurent de la Prée experimental farm engaged in an agroecological transition to organic farming between 2009 and 2017.

Results: Farms had LI scores varying from -23.2 to 8. The upper limit of low integration class is -2.8 (mean -6.3) and the lower limit of high integration class is 2.15 (mean 3.8). Medium integration class had a mean score of -0.2. Organic farms had a mean score of 4.2 vs. -1.3 for conventional ones. Consequently, organic farms were mostly in high LI class (101 out of 119) and rarely found in low level class (1 out of 119) (Table 1).
Figure 1 shows the LI score evolution of the experimental farm during its agroecological transition. From 2009 to 2014, the score increased with the transition progress of the farm. It started with the mean score of the conventional farms (-1.3) to reach a value greater than the mean of organic farms (4.6). In 2012, the consequences of a major storm which destroyed crops and impacted grassland productivity resulted in large purchases of fodders, decreasing the integration score (- 2.2). In 2013, the farm was able to produce some of its food concentrates and its LI score increased. In 2015 and 2016, the experimental farm introduced some practices rarely found in the databases used to calibrate the score: use of intercropping to feed the animals and cultivation over 20% of the UAA in protein crops. As the LI score did not progress despite the implementation of new agroecological practices, it sets out a limit of validity of our method. Despite this limitation, the LI score remained among the higher of the studied farms. In 2017, the farm started its conversion to organic farming and the LI score increased as purchased inputs decreased.
Farms with a high LI score had the higher environmental performances for the three selected criteria (Table 1). In addition, organic farming had also lowest nitrogen balance and treatment expenses. On economic performances, income per labor unit and subsidies seems unrelated to the level of integration or organic farming despite large differences between means’ groups. This is due to the other factors tested (crop proportion in UAA and type of livestock) which explain most of the variation of these criteria. However, EBITA / Gross product and operating cost are lower for high level of integration and for organic farming. The analysis of income/labor unit evolution over 15 years revealed a better resilience of farms with high LI (variation coefficient over the period: 18%) compared to farms with low LI (variation

coefficient: 43%). Identically, Nitrogen balance/ha remains almost constant over the period in farms with high LI, whereas it increased for farms with low LI. The gap between the two groups has thus increased from 31 units/ha to 74 units/ha over the period.

Table 1: Number of farms, environmental and economic performances according to the level of integration.

Level of integration	Number of farms		Environmental performances			Economic performances			
	Conventional	Organic	Nitrogen Balance / ha	Fuel / ha	Treatment expenses / ha of crops	Income / labor unit	EBITA/ Gross Product	Operating costs/ Gross Product	Subsidies /EBITA
Low	356	1	104	124L	127	29500	30.8%	38.3%	55%
Medium	459	17	60	91L	103	23300	33.2%	34.1%	78%
High	256	101	30	75L	69	20500	36.1%	30.4%	91%
Effect*			I / O	I	I / O	n.s.	I / O	I / O	n.s.

*Letter I indicates a significant effect of integration level on performance (p<0.05), letter O indicates a significant effect of organic farming on performance (p<0.05), n.s.: not significant.

EBITA: Earnings Before Interest and Taxes and Amortization.

Discussion: Our methodology allowed discriminating farms according to their level of integration from a limited number of criteria. Contrary to the majority of farm descriptor in agricultural statistic, this methodology stress out the operation of the farms. Organic farms are mainly found to be with high LI, which confirm the importance of integrating crops and livestock in organic farms. The analysis of farms' performances according to their LI confirm the high interest of integration practices for environment and economic resilience. Moreover, these results have been achieved in a favorable prices context for crops and livestock production. Our results also confirm those of Offermann and Nieberg (2000) who found similar profitability between organic and conventional farms. On the environmental performances, we were able to found a positive effect of LI and organic farming. This is in line with the results of Gomiero et al. (2011) that report several studies showing the better environmental performances of organic systems.

Our methodology used in the case study of a farm involved in an agroecological transition shows that it could be a useful to monitor processes of changes of farms' management. The methodology has been implemented in a diagnostic tool (NICC'EL) which can be used in farms or during training courses for advisers to help farmers and advisers to assess the level of integration and identify levers for improving practices.

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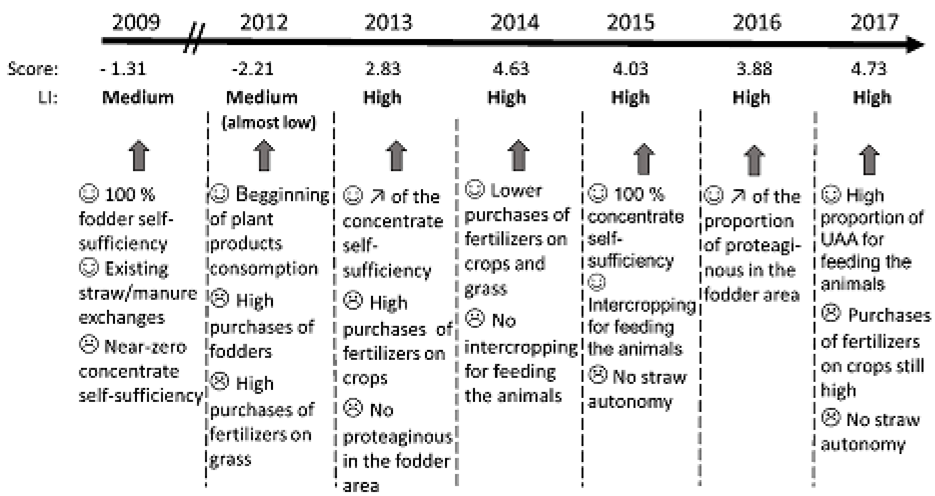
Image:



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