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Bockstaller

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Assessing impacts of cropping systems on biodiversity: comparison of indicators for four systems along an intensity gradient

T. Denoirjean¹, V. Tosser¹, F. Angevin², C. Bockstaller^{3*}

¹ Arvalis-Institut du Végétal, 91720 Boigneville, France

² Inra, Eco-Innov, 78 850 Thiverval – Grignon, France

³ Université de Lorraine, Inra, LAE, 68000 Colmar, France

* Speaker

± Corresponding author: christian.bockstaller@inra.fr

1 – Introduction

The design of sustainable innovative cropping systems (SICS) requires assessing their impacts on a set of sustainability criteria, among them biodiversity and, more recently, the provision of ecosystems services. Until now, two types of indicators have been proposed in most of the sustainability assessment methods: direct measurements, resulting from field observations on taxonomic or functional groups, or indirect causal indicators derived from management variables (Bockstaller *et al.*, 2011). An alternative to these indicators is the use of predictive indicators based on outputs from models more or less elaborated. Such indicators make possible an *ex ante* assessment of sustainability which is an important step in the design of SICS (Angevin *et al.*, 2017).

Any implementation of indicators requires characterizing their strong and weak points, especially the relevance of their outputs, which can be performed by comparison of their results with those of other indicators (Bockstaller *et al.*, 2008). Here we compared the results of a set of predictive and causal indicators with the ranking - regarding biodiversity- of four cropping systems from a system experiment.

2 – Materials and methods

A literature review and author expertise has led to the selection of six relevant causal indicators (Table1), and four qualitative models using the DEXi tools: DEXi Auximore, MASC 2.0 (Craheix *et al.*, 2012) DEXiPM v1 (Pelzer *et al.*, 2012) and v2 (Demade, 2014). Data from a system experiment at the Boigneville station (France) of the technical Institute Arvalis-Institut du Végétal were used to calculate the indicators for 3 years (2009-2011), from four cropping systems with decreasing intensification level: an intensive non-tilled (MACH) an optimized conventional (CONV), an integrated (INT), and an organic (ORG) system.



3 – Results – Discussion

The calculation of causal indicators confirmed the intensification gradient: ORG<INT<CONV<MACH for four out of six indicators (Table 1). Rotations between these systems are relatively similar, especially for the number of crops, and the systems, having a relatively common environment, do not differ for the indicator “diversity of semi natural habitats in one km buffer”.

Table 1: Average indicator rating from 3 years (2009-2011) with respect to biodiversity for four cropping systems (from most intensive to less: MACH: intensive non-tilled, CONV: optimized conventional, INT: integrated ORG: organic system; pink= less favorable, yellow=intermediate, green= more favorable, white=no difference).

Indicator	MACH	CONV	INT	BIO
Average N rate				
% cropped area with > 150 kg N/ha				
Number of crops in the rotation				
Diversity of crop families				
% of semi natural habitats in 1 km buffer				
diversity of semi natural habitats in 1 km buffer				

For the two versions of the DEXiPM model, the agreement between results was in general good and the ranking of the systems confirmed the intensity gradient, excepted for the weed component (Table 2). In most cases, MASC 2.0 method delivered results with an inconsistent system ranking. For flying natural enemies, the Auximore DEXi model was less sensitive than DEXiPM models to distinguish systems.

Table 2: Ranking of four cropping systems (see table 1) by indicators of four biodiversity assessment methods (pink=inconsistent, yellow=intermediate, green=consistent, white=no concerned).

Criterion	Indicator	Auximore DEXi	MASC 2.0	DEXiPM v1	DEXiPM v2
Global biodiversity			Inconsistent with gradient	Consistent with the gradient	
Flying insects	Flying insects		CONV and INT are not distinguished		
	Flying natural enemies	Two consistent groups: (MACH, CONV) and (INT, BIO).		Consistent with the gradient	
Soil fauna	Soil macro fauna		Only MACH is distinguished		
	Soil natural enemies			Consistent with the gradient	
	Crawling natural enemies				
Flora	Weeds			Consistent with the gradient	Inconsistent with gradient
	Semi natural flora		Only BIO is distinguished		
Micro organisms	Soil micro organisms		Only BIO is distinguished		

4 – Conclusions

Causal Indicators as well the two versions of DEXiPM delivered consistent results with the intensity gradient of the four systems tested, excepted for the flora criteria that require more investigation. The former indicators are easier to calculate but do not provide information about the effect of CISs on biodiversity and its components, the latter make *ex ante* assessment possible in a cropping system design process. Such study should be repeated with other dataset, including biodiversity measurements.

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