A prototyping method for the re-design of intensive perennial systems: the case of vineyards in France

Raphaël Métral *±[1], Bruno Rapidel [2], Laurent Delière [3], Morgane Petitgenet [3], David Lafond [4], Christel Chevrier [5], François-Michel Bernard [6], Eric Serrano [7], Marie Thiolet-Scholtus [8], Jacques Wery [1]

[1] Montpellier SupAgro, UMR 1230 System, F-34060 Montpellier, France
[2] CIRAD, UMR 1230 System, F-34060 Montpellier, France
[3] INRA, ISVV, UMR 1065 Santé & Agroécologie du Vignoble, F- 33883 Villenave d'Ornon, France
[4] IFV, F-49071 Beaucouzé, France
[5] Chambre Régionale d'Agriculture de Languedoc-Roussillon, F-34875 Lattes, France
[6] IFV Unité Charentes-Cognac F-16130 Segonzac, France
[7] IFV Pôle Sud-Ouest F-81310 Lisle sur Tarn, France
[8] INRA-SAD-UEVV-1117, F-68021 Colmar, France

* Speaker
± Corresponding author: raphael.metral@supagro.fr

1 Introduction

Vineyards are typical of perennial-based cropping systems, with low agrobiodiversity, intensive use of labor, pesticides and energy, and high ambitions of product quality and profitability. Their technical systems are based on a high number and a large diversity of techniques applied to the plant or soil components of the agrosystem (in average 20 technical interventions per year). There is an increasing societal and market pressure to re-design these systems in order to reduce this intensity and related impact on the environment. This paper presents the first results of the french EcoViti network where several prototypes of grapevine agrosystems are experimented in many regions. The prototyping method is used with the main goals of reducing pesticide uses without reducing production and economic performances.

2 Materials and Methods

Re-designed systems imply to combine agro-ecology and socio-economic sustainability and specificities of each regions and farm types. To reach these objectives, we developed and implemented a prototyping method combining (i) conceptual modelling (Lamanda *et al*, 2012), (ii) prototype experiments (Lançon *et al*., 2007) and (iii) a set of analysis, management and assessment indicators, in French wine regions (Metral *et al.*, 2012).
The theoretical prototypes for each set of objectives and constraints (SOC) are produced by experts in prototyping workshops and then adapted for field experiments. A list of decision rules (DR) defines every tactical and operational action on the system. This form of representation allows integrating, in a testable form, the effect of several techniques on key processes of the agrosystem. After field experiment of these prototypes, they can be assessed and adjusted using relevant indicators (Rapidel *et al*., 2009).

3 Results - Discussion

Since 2012, six platforms gathering 45 fields for experimented prototypes have been operating in French wine regions. 19 prototypes are based on high level of reduction in pesticide use, while maintaining yield, harvest quality, working time and production costs. The changes of existing practices in the re-designed systems mainly concern soil management without herbicides, and pesticides spraying strategies according to dose reductions and crop monitoring). Some prototypes also test new (powdery and downy) mildew resistant varieties.

With regards to the agro-ecological intensification (AEI) and eco-efficiency frontier (Keating *et al*., 2010), very few of the tested prototypes have achieved the environmental and the production performance (Fig. 1). We can use the thresholds of 50% TFI reduction and 20% yield increase to consider to have a high eco-efficient agrosystem (Fig. 1). Only two situations on twelve in Languedoc are in this « AEI area » (Integretad Pest Management (IPM) strategies with decision support systems to reduce spraying). By consequence, we can extend the « AEI area » to a no yield decrease (ie. 0% of yield variation) for denomination of origin vineyards which have a maximum level of yield allowed. With this new definition, prototypes with resistant varieties and some IPM strategies (ie. cover crops without herbicides) satisfy the expected targets of AEI.

However, grapevine systems face a high annual variability of the performances (TFI) due to bioclimatic context (i.e. pests pressure). The TFI reductions are very variable. For instance we have measured cumulative reduction of TFI lower than 50% on three years experiments in Languedoc.

The analysis must take into account the multiannual and multidimensional aspect of the overall sustainability and at least, others objectives of the SOC than pesticide pressure (TFI) and production (yield) (Blazy *et al*., 2011).

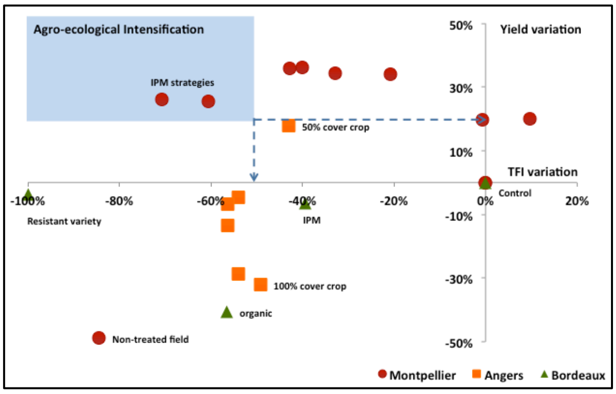

Fig. 1. Treatment Frequency Index (TFI) and yield performances of grapevine prototypes (% variation with the local reference or the control agrosystem). Partial results from the national EcoViti experimental network.

Table 1. Number of experimented prototypes which have achieved the objectives of pesticides reduction, yield and quality, and financial results, in two regions.

Number of situations	Rate of achieved objectives		
	100%	More than 75%	Less than 75%
Bordeaux ***(Year 2014)***	3	1	7
Languedoc ***(Year 2013)***	4	2	6

Table 1 presents how experimented prototypes achieve the expected objectives defined by the SOC. The recorded performances indicate that less than 30% of the prototypes reached the main goals of agronomic and economic performances (100% of achieved objectives). Before acceptance by the farmers, performances must be confirmed in the next years. In perennial crops, technical decisions (ie soil management, training system) can have consequences on the following years. If the re-adjustement of the prototypes is needed, some objectives may have to be re-adjusted too in the SOC, especially on harvest quality. Wine-makers could accept some harvest damages if they do not have any impact on wine quality when using the proper technique of wine making.

4 Conclusions

The results of our re-design and experimentation of grapevine agrosystem, as well as on the other crops (Lançon *et al*., 2007 and Wery & Langeveld, 2010) show promising perspectives of the prototyping method to achieve high goals for performance and innovation. The complexity of the grapevine agrosystem (ie the number of technical interventions and their potential interactions) requires a strong systemic approach at the interface between the technical and biophysical dimensions of cropping systems (Rapidel *et al*., 2009). The approach must implement agro-ecological processes to greatly limit inputs. It also required a high innovation and significant changes in the grapevine agrosystem genetics, structure and management. Our results point out the need to re-design grapevine systems from the crop plantation with new varieties, new training systems and with intercrops aiming to improve ecosystem services and maintain a very high level of sustainability criterias.

Acknowledgements: The authors thank the funders of these research programs: ONEMA and the ECOPHYTO program of the French Department of Agriculture.

References

Blazy J.M., H. Ozier-Lafontaine, T. Doré, A. Thomas, & J. Wery (2011). « A methodological framework that accounts for farm diversity in the prototyping of crop management systems. Application to banana-based systems in Guadeloupe ». Agricultural systems 101, no 1 2: 30 41.

Keating B. A., P. S. Carberry, P. S. Bindraban, S. Asseng, H. Meinke, et J. Dixon (2010). « Eco-efficient Agriculture: Concepts, Challenges, and Opportunities ». Crop Science 50, no Supplement 1: S 109 S 119. doi:10.2135/cropsci2009.10.0594.

Lamanda N., S. Roux, S. Delmotte, A. Merot, B. Rapidel, M. Adam, & J. Wery (2012). « A protocol for the conceptualisation of an agro-ecosystem to guide data acquisition and analysis and expert knowledge integration ». European Journal of Agronomy 38: 104 116. doi:10.1016/j.eja.2011.07.004.

Lançon J., J. Wery, B. Rapidel, M. Angokaye, E. Gérardeaux, C. Gaborel, D. Ballo, & B. Fadegnon (2007). « An improved methodology for integrated crop management systems ». Agronomy for Sustainable Development 27, no 2: 101 110. doi:10.1051/agro:2006037.

Metral R., Lafond D., Gary C., Mero A., Metay A., Wery J., 2012. “How to design and experiment new cropping systems with low pesticide inputs for perennial crops: framework development and application to vineyards”. ESA Congress 2012 (Helsinki) 2p

Rapidel B., B. S. Traoré, F. Sissoko, J. Lançon, & J. Wery (2009). « Experiment-based prototyping to design and assess cotton management systems in West Africa ». Agronomy for Sustainable Development 29, no 4: 545 556. doi:10.1051/agro/2009016.