

Success of organic and biodynamic system experiment to produce high quality wines

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Abstract. Reducing input use and in particular pesticide use is very important in OIV 2018 new resolutions. Also Europe and France promote research and co-design with winegrowers in more sustainable viticulture according to a combination of climate change. It is also very important to take into account soil diversity and Protected Designation Areas constraints to make sure that new wines will ensure the sustainability of the wineries. This study explores design, experiment and assess of new realistic viticulture production systems located in Protected Designation of Origin (PDO) areas and with already organic or biodynamic certification for six consecutive years, in winery production conditions. It also discusses the chosen assessment indicators and the adoption of such new production systems by winegrowers. Eleven cases were studied in a system experiment network in Alsace (France) and in six consecutive production years. Contrasted production years, PDO areas combined to organic or biodynamic certification allow testing the resilience of experimented systems over time. Combination of new practices are tested to drastically reduce input and in particular pesticide. Assessed performances of the systems deal with 14 main indicators: social acceptability (1) and economic viability (1), agronomy (yield (1), harvested berries quality (2), fungi damage (3), soil quality (1), and wine sensorial analysis (1) and environment (Frequency Treatment Index (1), Copper rate (1), INDIGO[®] method (2)). Several innovations were selected by co-design with winegrowers: adding essential oil and Propolis to copper spraying; total grass cover of the vine site; new decision rules for rate and time pesticide spraying; decision aid tool; resistant grape varieties planted. The assessment results support that the performance of the 14 indicators is very good for most of the eleven systems during the six assessed years. Combinations of tested innovations are neither dangerous nor difficult to enforce in the field by the vineworkers. Innovations do not increase the cost of grape production. The yield ratios were satisfactory the 6-year-old of observation because calculated yield match with targeted yield. Harvested berries quality support that the 7 vine sites succeed in targeted total acidity and sugar rate according to the different PDO conditions every years. Wines were Alsace or Grand Cru PDO labelled and successful marketed. At least, the Treatment Frequency Index is reduced by an average of 40% for all vine sites and assessed years. TFI can be reduced at a maximum of 89% and TFI median is 38%. Copper rate can be reduced at a maximum of 97% and Copper rate median is 54%. I-pest from INDIGO[®] method indicate a minimal risk taking for groundwater, surface water, air and beneficial organisms contamination. And finally, flora richness indicator is stable or steadily increases during the 6 study years. In this study, we demonstrated that drastically monitoring reduction of pesticide and other inputs is possible. Chosen indicators allow a exhaustive assessment, but could also be aggregated all together to give a synthetic information to winegrowers and make them easier to adopt the innovative systems. Introduction of innovation combinations in highly sustainable organic and biodynamic systems are validated to produce high quality wines. Now, it is possible to serenely promote and disseminate these highly sustainable innovative systems, taking into account of course vineyard diversity.

1. Introduction

Reducing inputs, and in particular pesticide use, is one of the most important challenges in global viticulture (Saint-Ges and B elis-Bergouignan, 2009). The vine is a perennial crop planted for a few decades. One way to reduce the use of inputs in existing wine systems

or new-planted vineyard is to introduce combinations of innovations into these production systems (Deli ere et al., 2014) and design system experiment (Metral et al., 2012; Thiollet-Scholtus et al., 2016). These wine-growing systems are often subject to constraints such as climate change, the diversity of soil conditions, certification by Protected Designation of Origin (PDO) specifications

Table 1. PEPSVI systems description. (PDO: Protected Designation of Origin).

Site	CHAT	ING	RIBEAU	WINTZ
System	Biodynamic since 2009		Organic since 2010	Organic since 2014
Variety	Riesling			Pinot blanc
Root-stock	SO4	3309	161-49	SO4
Vine age	10	41	22	5
Area	0.25 ha	1.6 ha	0.37 ha	0.35 ha
Soil	Brown soil	Granit alluvium	stony and silty-claey soil	Loamy sandy soil
Slope	10%	0%	15%	10%
Winter pruning	double Guyot			
PDO	Alsace	Alsace	Alsace Grand cru	Alsace
Yield target (hL.ha ⁻¹)	60	50	60	–

Table 2. PEPSVI innovation description.

Site	CHAT	ING	RIBEAU	WINTZ
Innovations				
1. Sowing cover crop		X	X	
2. Decision Aid Tool				X
3. Decision rules “If, then, else”			X	X
4. Hardwood mulching under vine rows			X	X
5. Plant protection alternative products	X	X	X	
6. Essential oils and Propolis	X			
7. Blowing the floral caps	X	X		

or environmental specifications (organic or biodynamic agriculture).

In this study, we analyse the multi-criteria performance of organic and biodynamic wine-growing systems to which we have added combinations of innovations that drastically reduce pesticide use.

2. Material and methods

2.1. Material

There are two organic and two biodynamic systems in PEPSVI system experiment. They are all in different soil and climate conditions, in **Alsace**, located in the northeast of France.

The temperature and rainfall conditions of the 2 studied years, **2017 and 2018**, were such that this reduced average pest pressure.

CHAT and ING are in wine-growing farms; RIBEAU and WINTZ are in INRA experiment stations. The four systems reflect a variety of production situations: biodynamic or organic, grape variety and root-stock, vine age, soil type, low to steep slopes, Alsace or Grand Cru PDO and targeted yield by the winegrower (Table 1).

Tested innovations to reduce pesticide use are technical (innovations 1, 4, 5, 6, 7), organizational (innovations 2, 3). Innovations are not tested alone. Combinations of 2 to 5 innovations are tested (Table 2).

2.2. Methods

2.2.1. Agronomic assessment

All measurements and notations are made on 10 plots of 10 vines. The means and standard deviations are then calculated to obtain a single value per innovative system and per year. **Yield** is calculated from the measurement of the weight of the plot harvest (in kg.vine⁻¹) and related to the surface (in kg.ha⁻¹ and/or hL.ha⁻¹ depending on the grape variety). The intensity and frequency rating of **fungi damage** due to grey rot (*Botrytis cinerea*) is made by visual observation.

2.2.2. Environmental assessment

The use pressure of plant protection products is assessed using the **Treatment Frequency Index** (TFI) for all treatments but also detailed for fungicides, herbicides and bio-control products used and compared to the Alsace regional reference (in 2013, TFI = 10.4), (Pujol, 2017).

Copper rate used per hectare per year is also calculated for each system and year. It is a useful indicator for winegrowers in the same way as the TFI for all used pesticides.

2.2.3. Social and economic assessment

During PEPSVI project, a method of evaluation using dashboards (SOECO) of the “social” and “economic” pillars was developed (Keichinger and Thiolllet-Scholtus, 2017). Social assessment focuses on risk of pesticide use,

Table 3. Agronomic, environmental, social and economic assessment of biodynamic innovative systems.

Biodynamic sites	CHAT		ING	
	2017	2018	2017	2018
Yield (comparing to PDO average)	-12%	-1%	-54%	8%
Fungi damage - <i>Botrytis cinerea</i> on cluster at harvest (comparing to regional year damage)	-100%	-100%	-82%	-100%
total TFI (comparing to regional average)	-88%	-89%	-54%	-69%
Copper use (comparing to regional average use)	-80%	-75%	-97%	-94%
Social (comparing to system without innovation)	+ 34%	-	0%	-
Economic (comparing to system without innovation)	+ 37%	-	+ 41%	-

Table 4. Agronomic, environmental, social and economic assessment of organic innovative systems.

Organic sites	RIBEAU		WINTZ	
	2017	2018	2017	2018
Yield (comparing to PDO average)	38%	191%	-36%	32%
Fungi damage - <i>Botrytis</i> on cluster at harvest (comparing to regional year damage)	-69%	-100%	-100%	-100%
total FTI (comparing to regional average)	-30%	12%	-30%	46%
Copper use (comparing to regional average use)	-23%	-53%	-23%	-63%
Social (comparing to system without innovation)	44%	-	-	-
Economic (comparing to system without innovation)	17%	-	-	-

hardness work and safety within the winery. Economic assessment is based on profitability of the winery. The originality of SOECO method comes from the possibility of being able to assess innovations in the light of what is usually done on the winery and therefore to know its level of adoptability (socio-economic) by winegrowers.

3. Results

The assessment results of the innovative systems make it possible to achieve the objectives of reducing the use of pesticides in vineyard. Each system results are presented below.

3.1. Assessment of biodynamic innovative systems

CHAT goals are (i) reducing yield, (ii) maintaining sanitary quality of grapes at harvest and finally (iii) reducing copper use. **Yield** is reduced in 2017 by 12% and stabilized in 2018 comparing to the reference, which is acceptable according to Chat goals. Sanitary quality is stable the two studied years regardless **fungi damage** is the same for CHAT and for the reference. Pesticide total use (**TFI**) and **copper** rate are reduced by at least 75% compared to reference. This allows the second objective of CHAT to be achieved. And finally, CHAT system improves **social** sustainability and even increases **productivity** compared to the system without innovation (Table 3).

ING goals are (i) stabilizing yield, (ii) maintain sanitary quality of grapes at harvest and finally (iii) reduce copper use. **Yield** drops sharply in 2017 by 54% and is little higher in 2018 than the reference. 2017 yield drop is

explain by the poor sanitary quality of clusters at harvest (18% of **fungi damage**). **ING** pesticide total use (**TFI**) is reduced by more than 54% compared to reference; and **copper** rate by more than 94% compared to reference. This allows the second objective of **ING** to be achieved, but not the first **ING** goal. And finally, introducing innovations in **ING** system does not change **social** sustainability of the system and even increases **productivity** compared to the system without innovation (Table 3).

3.2. Assessment of organic innovative systems

RIBEAU goals are (i) stabilizing Grand Cru yield, (ii) maintaining sanitary quality of grapes at harvest, and finally (iii) reducing pesticide use and working time. **Yield** is reduced in 2017 by 38% and astonishing increases in 2018 comparing to the reference. Sanitary quality is poor in 2017 because of drastic reduction of pesticide use that has led to strong **fungi damage**. **RIBEAU** pesticide total use (**TFI**) is reduced by more than 30% in 2017 but is higher of 12% than the reference in 2018. **Copper** rate is reduced by more than 23% both years compared to reference. And finally, **RIBEAU** system improves **social** sustainability and even increases **productivity** compared to the system without innovation. This allows the third objective of **RIBEAU** to be achieved, but not the two others (Table 4).

WINTZ goal is to have a system experiment implanted to get references for vineyard. **Yield** of the first year of cluster production is reduced in 2017 by 36% and astonishing increases in 2018 comparing to the reference. Sanitary quality is the same for **WINTZ** and for the

reference. WINTZ pesticide total use (**TFI**) is reduced by 30% in 2017 but is higher of 46% than the reference in 2018. **Copper** rate is reduced by more than 23% both years compared to reference. And finally, WINTZ **social** and **productivity** sustainability were not calculated because not comparable to reference data (Table 4).

4. Conclusion

Our results demonstrated that drastically reduction of pesticide use by introduction of innovations is possible in organic and biodynamic French vineyard. Our case studies demonstrate that agronomic, environmental, social and economic assessment is largely acceptable. Now, the combinations of innovations can be tested in a full-scale application.

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