Assessment of biodiversity and agronomic parameters in two Agroforestry vineyards

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Abstract. Sustainability of agricultural production systems is nowadays considered as a major challenge to face. Viticulture is particularly affected by environmental issues, especially because of its consumption in pesticides. Besides, the social demand in environment-friendly products is increasing, and the reputation of wines produced under Protected Denomination of Origin (PDO) is also built on the specificity of natural characteristics and resources such as soil, which has to be preserved. Biodiversity loss is largely admitted among the scientific community, and landscape simplification is known as a major driver in this process. Agroforestry, which combines trees with crops, could be a seducing response to biodiversity loss in agro-ecosystems, but the possibility of negative interactions between trees and vines (competition for water, nutrients, light) has to be considered. The Vitiforest project aims to assess south west of France agroforestry vineyard plots by spatializing different parameters in the domain of agronomy, ecology, micro-climate and economy. Field measurements were undertaken at different distances from the intercropped lines of trees in two agroforestry vineyard plots, in order to test potential effects of the trees. Arthropods were collected periodically with pitfall traps (for ground-dwelling individuals) and with D-vac system (aspiration of vine leaves). Pest insects (Empoasca vitis) were collected by specific yellow sticky traps. Data collected to describe biodiversity in these agroforestry systems was total arthropods abundances, abundances per order, carabidae richness and abundances. Nitrogen status was assessed by using Greenseeker® device, through the NDVI index. Our observations show that intercropped trees have no direct effects on vine nutrition. Slight effects on pests insects repartition were found, but these effects are inconstant according to experimental site and year of observation. The same trend is observed for arthropods abundances in the plots.

1 Introduction

Wine sector has currently several issues to face, particularly for products under DOC which are claiming their typicity and strong link to terroir specificities. Indeed, some parameters are changing, such as climate, biodiversity, and social demand of consumers. Climate change is currently known as a major factor which will impact the wine sector in the future [1]. Biodiversity has declined dramatically during the five past decades. The loss of natural habitats for the benefit of agricultural or urban land, and the pollution are identified as the main drivers of this global loss [2]. This worrying trend is still maintained nowadays, and jeopardizes the capacity of ecosystems to provide services which are necessary to human wellbeing (food production, pollination, climate regulation, etc.). The agricultural sector is particularly sensitive to this issue since it both provides and depends on EcoSystem Services (ESS) [3]. Moreover, general public (including wine consumers) has been more and more informed about these issues for the past

two decades, and is demanding food and drink produced in the respect of environment [4]. Consequently, the wine sector has to find how to conciliate the production of grapes either in quality and quantity, considering the environmental issues of biodiversity, use of inputs, and anticipating the climate change consequences. In this context, a discipline known as agroecology has emerged in the 80's, and has been translated in terms of political line in France with the "Loi d'avenir pour l'Agriculture" in 2014. Agro-ecology is defined as "a way of thinking production systems which take advantage of ESS" (French Ministry of Agriculture and Food). Among the diverse aims of agro-ecology, such as the preservation of natural resources or the limitation of the use of inputs, the diversification of production systems is a major challenge [5]. Agroforestry (AF), defined by ICRAF as a land use system involving trees combined with crops and/or animals on the same unit of land, seems to satisfy at least this last point (diversification of production systems and landscape). But risks linked to the introduction of

trees in agricultural plots have also to be considered. The LUCAS land use and land cover survey indicates that AF represents about 15,4 million hectares in Europe, the largest area being occupied by livestock AF with 15,1 million hectares [6]. Other kinds of agroforestry remain therefore poorly represented, and references or feedbacks in French vineyards are very scattered. The Vitiforest project aims to describe the effects of introducing trees in vine plots in a south-west viticulture context. It allowed to explore parameters such as agronomy, ecology, micro-climate and economy. The results obtained for biodiversity and agronomic measurements are presented here. They were obtained in two AF vineyards in the Bordeaux and Côtes de Gascogne areas in 2015 and 2016.

2 Material and method

2.1 Experimental sites

Two vineyards were tested in this study. Vineyard 1 is located in the Bordeaux area (Lapouyade, Gironde), on a 3.5 hectares plot, planted in 2002 with *Vitis vinifera* cv Merlot, 6600 vines/ha. Fruit trees have been planted in 2009 in 2 of the rows to replace missing vines. The distance between trees is 5 to 9 meters. The two tree lines are about 50 meters apart from each other. This farm operates in certified organic practices. Vineyard 2 is located in Gascony area (Lagardère, Gers), on a 2.2 hectares plot, planted in 2008 with *Vitis vinifera* cv Sauvignon Gris, 4000 vines/ha. Trees, *Sorbus domestica, Sorbus pyralis* and *Pyrus pyraster* have been planted in 2008 on 3 specific inter rows.

The biodiversity monitoring occurred in these two plots during the years 2015 and 2016. Figure 1 shows their configuration.
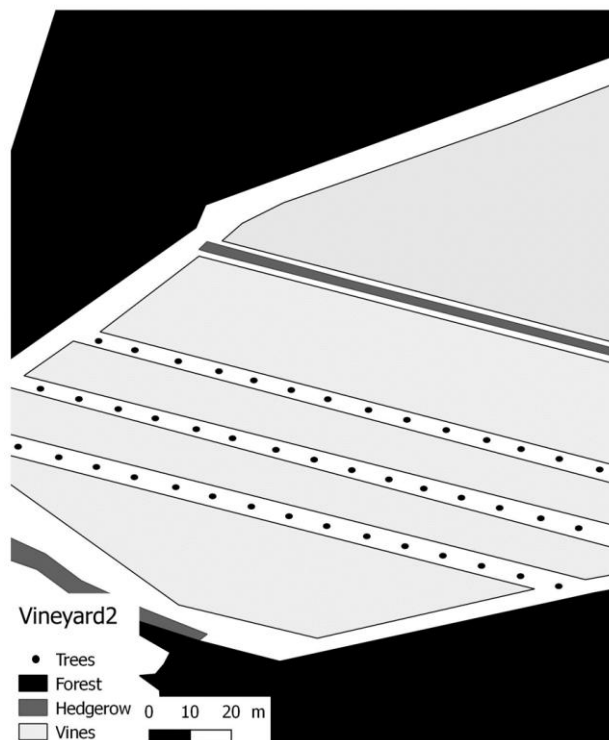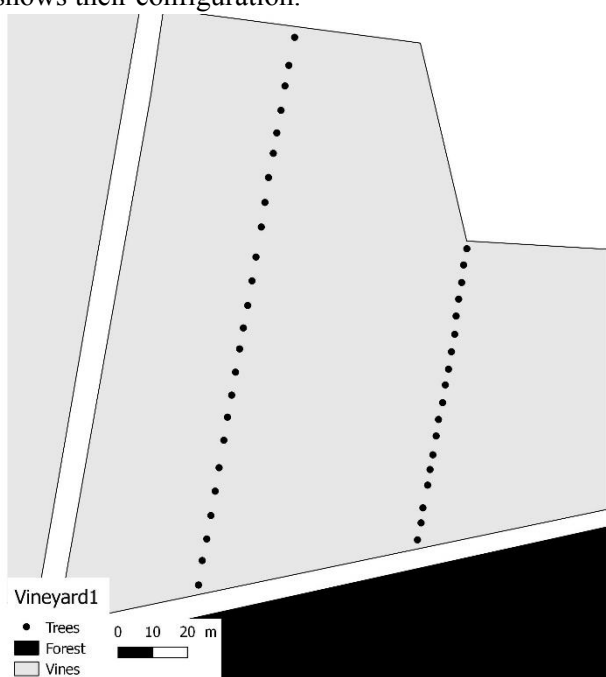

Figure 1 : Configuration of the two plots

These two vineyards were described by photo-interpretation in order to geo-localize AF trees (lines inside the vineyard plots) and surrounding trees (forests edges). Sampling points have been located and also geo-localized at different distances from either side of the trees lines, in order to test the effect of these distances on biodiversity parameters. It has previously been shown that trees seem to not influence NDVI index on these two plots [7]. Then, the potential effect of vigour on E. vitis repartition has been tested, as it has been demonstrated that E. vitis aggregates in areas with the most vigourous vine plants [8].

2.2 Biodiversity assessment

Different taxa were selected to describe biodiversity and biological communities associated with vines. Green leafhopper (*Empoasca vitis*) populations were observed and quantified all along the season thanks to yellow sticky traps (YST) [8]. Dimensions of YST were 5cm x 10 cm. These traps were settled in early may each year, between two vines, attached to the lower wire. YST were changed and adults of E. vitis counted every second week, until beginning of September.

Biodiversity was estimated using pitfall traps, specialized in ground-dwelling arthropods. Three sessions of trapping were done in 2015 and 2016, in May, June, and July. Pitfall traps were installed between two vines at each sampling point, and left for minimum three days before being taken away. Their content was transferred in jars containing 70% ethanol, in order to conserve arthropods trapped

until identification at laboratory. Two sessions of aspiration (to catch arthropods in the vine leaves) were done each year, one in June and one in July. Aspiration of vine leaves was performed on four consecutive vines with a D-vac system, arthropods caught (called "foliage arthropods" in the following lines) were immediately transferred in plastic zipped bags and stored in a freezer until identification. For both samples got from pitfall traps and aspiration, identification consisted in sorting out and quantifying arthropods up to the order level. Among coleoptera order, carabids (family: carabidae) encompass a wide range of ecological functions, included predation. They were set apart, and specimens were sorted out up to the species level and counted.

2.3 Agronomic characterization

GreenSeeker® (N-Tech, USA) is an integrated optical sensing system that measures the Normalized Difference Vegetative Index (NDVI). It is mounted on a quad bike. GreenSeeker sensor uses light emitting diodes (LED) to generate red and near infrared (NIR) light. The light generated is reflected off the crop and measured by a photodiode located at the front of the sensor head. NDVI measured on a plant can vary between 0 and 1. A value of 1 represents a maximum coverage of surface by vegetation. The value 0 represents an absence of vegetation. We use a white board (NDVI value around 0) positioned behind the row measured. Thus, the GreenSeeker values vary between 0 and 1 depending on foliage porosity and leaves chlorophyll content. One session of measurements was performed per plot : in August 2015 in vineyard 1, and in August 2016 in vineyard 2.

3 Data processing and analyses

Distances between sampling points and the nearest trees (AF trees or forest edges) were calculated. Extraction of values for the plant vigor index produced by GreenSeeker sensor in a buffer zone of 2,5m radius around each sampling point was performed. These data were obtained by using the ArcGIS 10.0 software. We tested this main question : do the trees, inside the plot or forest border, have an effect on arthropods populations ? In arthropods populations, we include the following variables : E. vitis abundances, total foliage arthropods abundances, total ground-dwelling arthropods abundances, generalist predators (arachnids) abundances, carabids diversity and abundances. Number of arthropods were counts data and they were analysed using a GLM with a log link and

Poisson errors. Overdispersion was checked by comparing residual deviance and residual degrees of freedom (R software; R Development Core Team 2010).

4 Results and discussion

4.1 Global results

The table 1 shows the total abundances trapped per site and per year for the five biodiversity variables monitored.

Table 1 : General abundances obtained for E. vitis, ground-dwelling arthropods and foliage arthropods

Mean +/- standard deviation per sampling point		Empoasca vitis abundance	Foliage arthropods abundance	Ground-dwelling arthropods abundances
Vineyard 1	2015	111,7 (±35,9)	174,8 (± 65)	117,6 (± 61,8)
	2016	78,1 (± 24,9)	134,5 (± 76,3)	111 (± 53,1)
Vineyard 2	2015	307,2 (± 88,4)	105,4 (± 40,0)	63,3 (± 19,2)
	2016	60,1 (± 24,9)	122,2 (± 37,7)	202 (± 60,8)

Arthropods trapped in the vines foliage belong to the following orders : Hemiptera (leafhoppers, true bugs, aphids, …) are the most abundant with 48,9% of the individuals caught, Diptera (flies, mosquitoes), Arachnids (spiders), collembola and hymenoptera (parasitoids, wasps, bees, …) represented respectively 15,8%, 14,5%, 7,8% and 7,3% of the total abundance. Ground-dwelling arthropods trapped mainly belong to hymenoptera (ants in majority) (36,2%), arachnids (19,2%), diptera (10,2%), Acarii (mites) (8,9%).

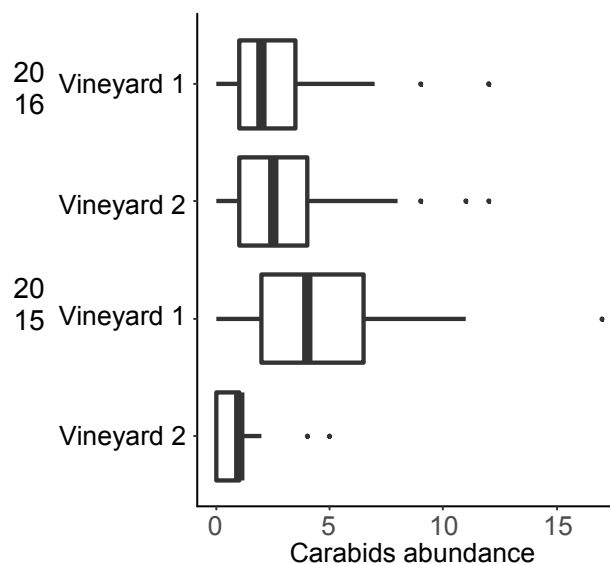Focusing on carabids, their abundances and richness were very low (figure 2).

Figure 2 : Abundance of carabids trapped in the two vineyards in 2015 and in 2016.

Moreover, 80% of samples collected in the two vineyards in each sampling session of 2015 and 2016 contained 0 or 1 individual. For this reason, abundances only were taken into account for the study of carabids repartition according to the distance from the trees.

4.2 E. vitis repartition

When grouping total E. vitis abundances overall years of observation, no significant effect of AF trees or forest edges is noticed. A slight effect of AF trees

and forest edge is measured on Vineyard 1 in 2015, which is balanced by an opposite effect found in 2016 (table 2). No significant effects of trees on E. vitis repartition were found in the vineyard 2.

Table 2 : Effects of distance from the nearest tree (AF, forest and/or hedgerow) on E. vitis abundances

	Distance from AF trees		Distance from forest edge		Distance from hedgerow	
	t value	p value	t value	p value	t value	p value
2015 Vineyard 1	**3,73**	**<0,001**	**2,91**	**0,007**	/	/
2016 Vineyard 1	1,22	0,23	**-2,54**	**0,02**	/	/
2015 Vineyard 2	-0,23	0,82	-0,67	0,51	-0,22	0,83
2016 Vineyard 2	1,12	0,27	-0,56	0,58	-0,15	0,88

E. vitis abundances were positively linked to NDVI index in Vineyard 1 in 2015 (t = 2.60, p-value = 0.02). No significant effect was found in vineyard 2 in 2016.

4.3 Ground-dwelling and foliage arthropods

No effects of trees on ground-dwelling arthropods abundances was noted in the vineyard 1. Foliage arthropods were more abundant when the distance from the line of trees was big in 2015, but an opposite result was found in 2016 (Figure 3).
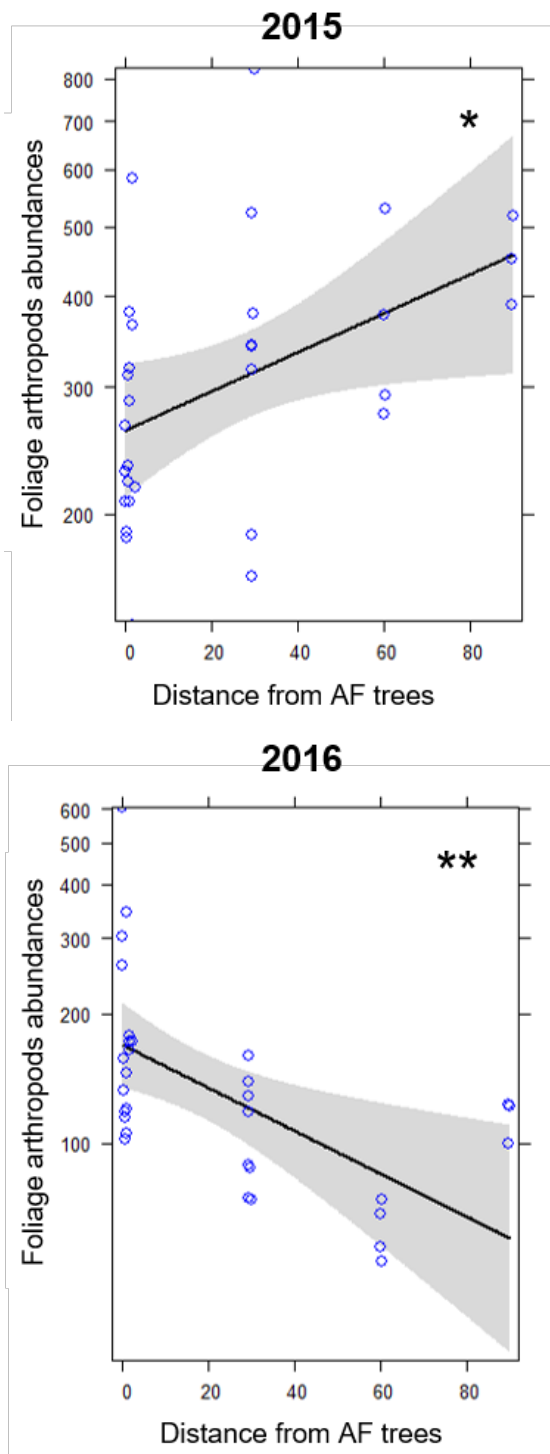

Figure 3 : Effects of distance from AF trees on foliage arthropods trapped in vineyard 1

In vineyard 2, a positive effect of the distance from the hedgerow on ground-dwelling arthropods (less abundances near the hedgerow) was found in 2015 and in 2016. Similar effects of distances from other trees have been partly observed: trees of forest edge in 2015, and intra-plot trees in 2016. Regarding foliage arthropods, except for a negative effect of the distance from the hedgerow in 2016 (i.e., number of arthropods decreasing when the distance

from the hedgerow increased), the intra-plot trees and forest edge had no effect (table 3).

Table 3 : Effects of distance from the nearest trees (AF, forest and/or hedgerow) on arthropods trapped in vineyard 2

	Distance from AF trees		Distance from forest edge		Distance from hedgerow	
	t value	p value	t value	p value	t value	p value
2015 Ground-dwelling arthropods	1,91	0,06	**2,42**	**0,02**	**2,09**	**0,04**
2016 Ground-dwelling arthropods	**2,24**	**0,03**	0,95	0,34	**2,77**	**0,009**
2015 Foliage arthropods	-1,51	0,14	-0,37	0,71	-0,88	0,37
2016 Foliage arthropods	-1,50	0,14	-1,31	0,20	**-3,18**	**<0,01**

Arachnids abundances were analysed separately, only one significant effect is noted in vineyard 2 in 2015 : abundances are bigger near the forest edge than inside the vineyard (t= -2.02, p-value = 0.05). Regarding carabids, a slight effect exists in vineyard 2 in 2016 : carabids seem to be more numerous near the AF trees and their abundance decreases with the distance from the AF trees (t = -2,00, p-value = 0.05).

5 Conclusion

Some effects of trees on biodiversity (arthropods) have been observed, but they remain punctual and inconstant, so they cannot be generalized, even at the small scale of this trial. Our results show that AF practices only (introduction of trees in or around agricultural plots) seem not to be sufficient to explain arthropods repartition inside a vineyard. Other factors, like ground cover in the inter-rows for instance, could interfere. This potential effect could explain some contrasting results found in vineyard 1 between 2015 and 2016. In fact, ground coverage was established by the farmer in 2016 (the plot - excepted the two rows from either side of the trees lines - was kept under soil tillage until 2015). The combination of biodiversity-friendly practices (such as ground cover in the inter-rows associated with AF trees for instance) could therefore be considered as a promising solution to slow biodiversity loss in agricultural lands. If our study, run on two eight-years-old French AF vineyards, did not allow us to present AF as a key factor to solve the biodiversity issue, it does not seem to impact negatively grape production so far [7].

References

[1] N.Ollat, J. Touzard, C. Van Leeuwen, Journal of Wine Economics, 11(1), 139-149 (2016)

[2] Millennium Ecosystem Assessment, Island Press, Washington, DC. (2005).

[3] W. Zhang, T.H. Ricketts, C. Kremen, K. Carney, S.M. Swinton, EcolEcon 64, 253–260 (2007)

[4] H. Assael, Consumer Behavior and Marketing Action (Kent Pub. Co., 1984)

[5] M. Duru, O. Therond, G. Martin, R. Martin-Clouaire, M. A. Magne, E. Justes, E. P. Journet, J. N. Aubertot, S. Savary, J. E. Bergez, J. P. Sarthou, Agron. Sustain. Dev. 35, 1259–1281, (2015)

[6] M. den Herder, G. Moreno, M.R. Mosquera-Losada, J.H.N. Palma,.A. Sidiropoulou, J.J. Santiago Freijanes, J. Crous-Duran, J. Paulo, M. Tomé, A. Pantera., V. Papanastasis, K. Mantzanas, P. Pachana, A. Papadopoulos, T. Plieninger, P.J. Burgess, Current extent and trends of agroforestry in the EU27. Deliverable Report 1.2 for EU FP7 Research Project: AGFORWARD 613520. (2016)

[7] T. Dufourcq, F. Lopez, M. Vergnes, L. Gontier. , *20th International GiESCO Symposium, Mendoza, Argentina*, 868-872. (2017)

[8] D. Decante, C. van Leeuwen, M. van Helden, Agricultural and Forest Entomology 11, 377–387 (2009)