

Long-term historical characterization of French vineyard exposure to pests and diseases: a case study of the Bordeaux and Champagne regions

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Abstract: The French agricultural warning service has historically published weekly reports and annual summaries of key pest and disease pressures (grouped and named “pests” hereafter). The summaries were based on a large number of plots, notably vineyards, monitored in different regions, with different local editions for each region. They constitute a highly valuable corpus of literature on pests' presence and overall damage in vineyards. We used this literature to develop a textual analysis and build an integrative grading system for annual pest occurrence over a long period (1961 to 2020) in the Bordeaux and Champagne regions. To reconstruct the pest occurrences over time in the two regions, we then established a long-term database of annual grades, including various grapevine diseases (mildews, rots, trunk diseases, etc.) and phytophagous or disease vector animals (moths, mites, scale insects, leafhoppers). In this paper, to present and illustrate the new methodology, we focus on two contrasting types of pests, i. e., two grape berry moth species (*Lobesia botrana* and *Eupoecilia ambiguella*) and two fungal diseases (rotbrenner and black rot). This tool can be very useful for characterizing the epidemiological status of various years and analysing long-term trends *versus* isolated events. This will allow us to better understand past pest evolutions and link them to biotic and/or abiotic contexts. This will help anticipate the necessary evolution of grapevine protection against quantitative and/or qualitative losses and adapt to global changes and regulatory or marketing evolutions.

Key words: grapevine, crop protection, history, grading system, warning services database

Introduction

Most published epidemiological studies are based on a few seasons and/or intra-seasonal data. This is important for assessing the long-term historical biotic exposure of a crop to better understand and assess past evolutions of key pests and/or diseases (grouped and named “pests” hereafter). Such studies have been carried out on potatoes (Zwankhuizen and Zadoks, 2002) and wheat (Huerta-Espino et al., 2011). However, to our knowledge, this has not been investigated thoroughly in grapevine. The difficulty with this type of approach is finding a coherent dataset that is sufficiently detailed and suitable for such an analysis. For this study, we used the collection of phytosanitary warning bulletins drawn up by French regional authorities (Journet and Touzeau, 1980; de La Rocque, 2010). The advantage of these historical sources is that the pieces of information were consistent over a long time period at the wine-growing region scale. They were designed to provide regulatory information, to help monitor plant

protection and to help growers correctly apply pesticide treatments (Jacquin et al. 2003). The bulletin content was based on observations, trapping and/or modelling (Jacquin et al., 2003; Journet and Touzeau, 1980). For each pest, the information corresponded to the frequency of occurrence (prevalence), often according to some defined sub-regions, and the associated severity level. These essentially qualitative textual data needed to be transformed into categorical variables to be further analysed (Zwankhuizen and Zadoks, 2002). Thus, as one of our major goals, we devised and developed a new annual grading system to assess, over time, the natural regional pressure exerted yearly by key vineyard pests (considered individually).

Materials and methods

Selection of the study regions and the study period

The French regions to be analysed were defined by using three major criteria: i) of viticultural importance, ii) corresponding to contrasting situations in terms of types of wine production and climate, and iii) with warning documents available over several decades. The wine-growing regions of Bordeaux and Champagne emerged as those that met all these criteria. From the outset, the regional stations issued regional reports that were sent to growers at intra-seasonal intervals and completed by annual synthesis. The authors offered strategic and practical advice. Before the Second World War, the first bulletins were sent out in concise sentences mainly advising on the need for vineyard treatment. Gradually, the content of the reports was enriched to reach a more complete and analysable format of several pages. In the two regions, the common study period ranged from 1961 to 2020.

Data analysis

The main principle was to convert the qualitative written information into numerical grades. Careful reading of the bulletins revealed the need to translate it into a semi-quantitative scale, allowing analyses and comparisons and rarely accepting some arbitrariness of classification. Zwankhuizen and Zadoks (2002) used a five-grade scale to address the overall, annual, intensity of potato disease, and we used a similar scale in grapevine for a multi-pest damage indicator (Fermaud et al., 2016). However, this grade scale did not allow us to characterize most of the epidemical cases encountered in the warning literature. Thus, a new seven-grade scale was designed to distinguish low- and high-pressure years, including exceptional/extreme vintages for every pest considered (Table 1). In both regions, a total of 26 species of pathogens and arthropods (mites, leafhoppers, moths, etc.) were studied.

Results and discussion

Both regions are characterized by a long-standing and regular presence of downy mildew (*Plasmopara viticola*) and powdery mildew and gray mold (*Botrytis cinerea*). Concerning insect pests, leafhopper occurrences have increased over the past three decades, while some historical species, e. g., the long-palped tortrix, (*Sparganothis pilleriana*) have been on the decline since 2000. Things were very different for the four species that we focus on in this paper: two grape berry moths (*Lobesia botrana* and *Eupoecilia ambiguella*) and two fungal diseases, rotbrenner (*Pseudopezicula tracheiphila*) and black rot (*Guignardia bidwellii*).

Table 1. Rationale for the new semi-quantitative grading scale of annual overall pest intensity. 0, no epidemics; grades 1 to 3, local epidemics; grades 4 to 6, general epidemics.

		OVERALL SEVERITY			
		Null	Low	Medium	High
PREVALENCE/DISTRIBUTION	Null	0: The pest/disease not present in the vineyard	-	-	-
	Local	-	1: Localized, almost non-existent, very weak and/or low damage	2: Localized, medium severity/damage (ex in susceptible sites/untreated areas only)	3: Localized, severe, high intensity/damage (ex in susceptible sites/untreated areas only)
	General	-	4: Widespread, low intensity/damage (very few areas may be without the pest/disease)	5: Generalized or high pest/disease pressure or high pressure/widespread damage	6: Widespread, very high/exceptional pressure, very important damage

First, the Bordeaux vineyards are characterized by the very regular presence, nearly every year, of *L. botrana* (Figure 1 A), which has been a historical occurrence since its well-studied introduction in France at the turn of the 19th-20th centuries. This pest is rarely generalized in the whole region, although it is often severe locally. In contrast, *E. ambiguella* (Figure 1 B) is always present locally but is never actually a risk. Concerning the two selected diseases, our analysis confirmed that rotbrenner has been absent, never recorded, near Bordeaux (Figure 1 C). However, black rot disease was constantly present (Figure 1 D), showing high overall severity associated with a widespread epidemiological distribution within the region in some years (notably 1963, 1971, 1979, 1983, 2014, 2015, 2019 and 2020). Then, after a phase of regression, this disease became more widespread and severe over the past decade.

Second, in Champagne, widespread and regular populations of *E. ambiguella* were present over the whole studied period (Figure 1 B). Regularly, significant and heavy damage due to this pest was observed. However, *L. botrana* has always been present locally, but with an increasing severity in recent years, from approx. 1990 onwards (Figure 1 A). Regarding disease, rotbrenner has always been present but causes local damage only (Figure 1 C). The disease is currently declining or even disappearing. On the other hand, black rot, which appeared in 1996 in Champagne, is now observed regularly, but locally and with low severity (Figure 1 D).

In conclusion, the development of the new grading system allowed us to easily assess and compare the prevalence and local/general epidemics for every key pathogen or pest considered. This allowed us to distinguish low-pressure *versus* high-pressure years, notably by considering the scale extrema of great interest. By also considering the other key pests and pathogens, such long-term results will be further investigated for being related to changes in viticulture practices over time and to agroclimatic parameters. This effort will be aimed at better i) explaining fluctuations in long-term epidemics and infestations, ii) characterizing the potential evolution of pathogens and pests according to different scenarios of future climatic evolution, and iii) anticipating the impact of cultural and/or regulatory changes.

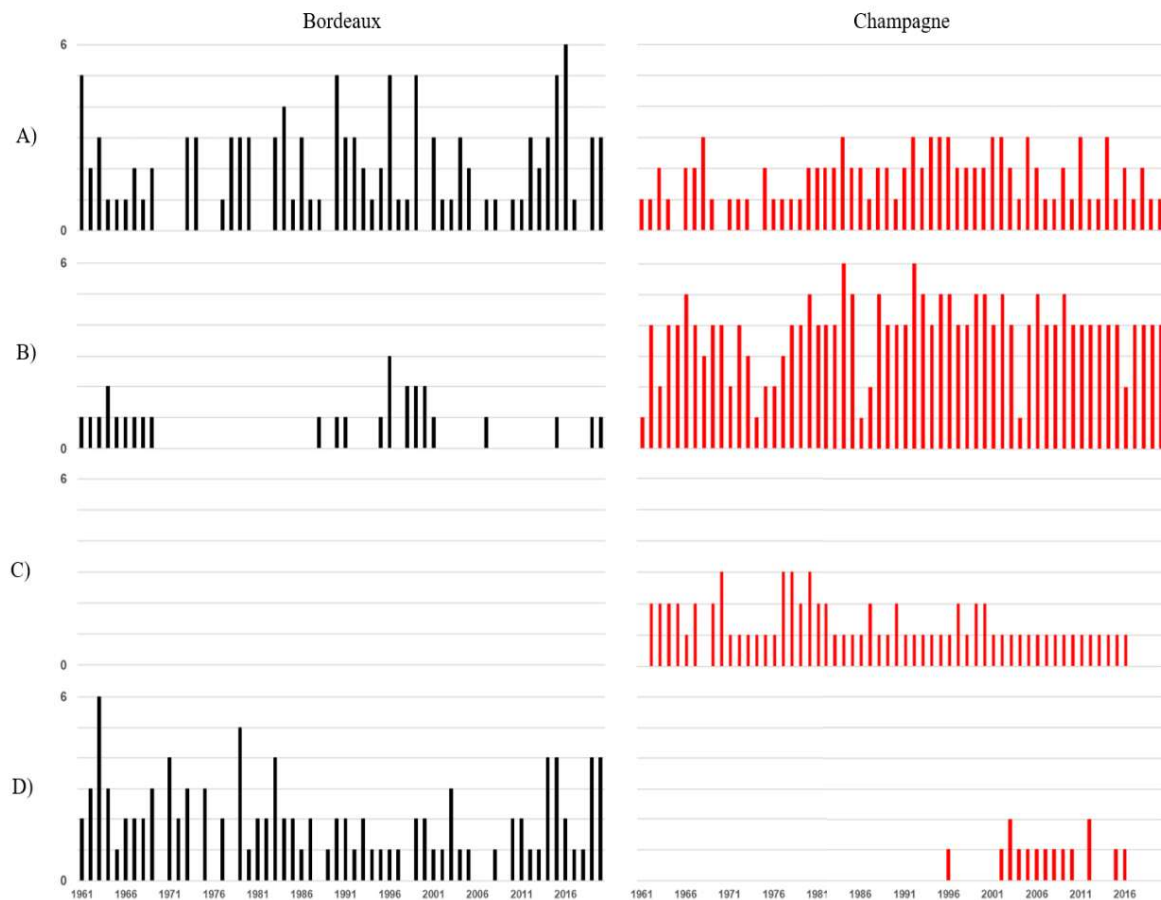


Figure 1. Prevalence/severity grades near Bordeaux (black) and in Champagne (red) from 1961 to 2020: A) *Lobesia botrana*, B) *Eupoecilia ambiguella*, C) rotbrenner and D) black rot.

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