Experimentation in the vineyard of an insurance protocol to cover the harvest's risk of damage due to cryptogamic diseases linked to the reduction of phytosanitary inputs.

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1 Introduction

To answer to the strong societal demand for a better consideration of human health and environmental risks, the French wine industry engaged in an ambitious agroecological transition aiming at strongly reducing the use of phytosanitary treatments. However, plant protection products are an integral part of current production systems, which have been built for decades on the selection of grape varieties based on their organoleptic qualities rather than on their ability to resist to losses caused by pests. Phytosanitary expenses thus represent less than 5% of production costs; it is not very costly to protect against the risks of crop losses, which can sometimes be total when meteorological conditions are favorable to diseases. The unexpected suppression of a treatment can easily lead to a 30 to 50% loss of crop. Awaiting the deployment of new production systems (less sensitive grape varieties, effective biocontrol products or prophylactic methods), a significant and massive reduction in the use of phytosanitary products can only be envisaged by optimizing techniques to make them more efficient at the scale of the winegrowing operation and associating them with insurance-type mechanisms to encourage winegrowers to take this risk while securing their earnings: Crop insurance, supported by the European policies (Agricultural Fund for Rural Development, EAFRD), only covers climatic hazards, but could be extended to cover damage due to diseases.

As part of the regional VitiREV project supported by the New Aquitaine region and financed by the French government, the French Vine and Wine Institute (IFV) proposed to experiment an Insurable Treatment Process (PTA) (Aubert, 2020). This test is now carried out since 2019 with the insurance group Groupama and two winegrowers cooperatives from Buzet and Tutiac, each one respectively located 100 km south east and 60 km north east from Bordeaux. This PTA aims to reduce the use of unnecessary phytosanitary treatments according to our best technical knowledge while guaranteeing a satisfactory level of protection of the vineyard and ensuring crop losses in case of failure. The two wineries allow us to verify the adaptability of the proposed measures to the different production contexts and to the different types of structures representative of the wine production methods in the New Aquitaine region.

MONITORING SYSTEM:
The two wineries of "Vignerons de Buzet" and "Vignerons de Tutiac" established an experimental insurance contract with Groupama to cover the areas involved in the experiment. The experiment was so carried out on 60 ha in 2019 to 80 ha in 2021. The experimentation includes a weekly monitoring of Untreated Controls displayed on these surfaces (5 consecutive vines covered during treatments or 4 entire rows located at the edge of some plots. Each monitoring block (almost 10 ha) includes a repetition of control of a whole rows and 2 to 3 covered vines, in order to be able to qualify the level of damages without any treatment an natural variability of the attacks.

The main cryptogamic vine diseases (downy and powdery mildews, black rot and botrytis) are monitored every week from budburst to ripening stage. Physiological and sanitary observations are carried out applying an IFV protocol to assess the production level of the vine, the estimated leaf surface, and level of attack: on each vine and for each disease, the incidence and severity of destruction are estimated on leaves and bunches.

Monitoring is also carried out on treated rows selected by aerial image analysis in order to cover the heterogeneity of the plots. It aims to monitor the sanitary state resulting from the treatment strategies applied and to ensure that the level of protection generated by the PTA is correct.

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INSURABLE TREATMENT PROCESS (PTA)

PTA is a protocol defining the management of production practices that saves on phytosanitary substances, taking into account our current epidemiological knowledge. This protocol is designed for both conventional and organic growing practices. The objective is to implement a strategy that will reduce the Treatment Frequency Indicator (TFI) as much as possible, eliminating the supposed unnecessary treatments.

The protocol is based on the use of a Decision Support System developed by IFV (Fig. 1): the Epicure software allows the consultation of meteorological data maps that are used to calculate and simulate epidemic risks in the vineyard (Raynal, 2010); Optidose® and DéciTrait® DSSs provide recommendations on treatment doses and optimal dates for treatments (Davy, 2020) : Optidose® calculates the percentage of possible dose reduction according to modelled risk of epidemics, sensitive stage of the vine and volume of biomass; DéciTrait® uses the outputs of the Potential System models and the results of the monitoring to determine an adapted strategy to cover heavy contamination periods for which the plots should be treated.

Downy and powdery mildews are the main cryptogamic diseases requiring phytosanitary treatments in France : downy mildew treatments represent an average of 40% of the phytosanitary treatments applied (Chen et al, 2020). The decision guidelines defined in the PTA so focus on these two diseases. The first treatments are activated according to susceptible stage of the vine, risks of epidemics and first symptoms observed. The end of the protection adds sanitary state of the plots to these data.

A rule of maximum TFI per treatment is settled, stipulating that the limit of one should not be exceeded for a single treatment. The French registered doses that can be applied to control downy or powdery mildews are settled by hectare and should not be exceeded: a full dose of treatment applied on the canopy so constitute a TFI of value 1. A full dose treatment against both Downy and Powdery mildews gives a TFI of 2. Since Downy and Powdery mildews favorable weather conditions are antagonists the PTA define the maximum TFI of one for each treatment : For example, if the Optidose downy mildew dose is 80% of the registered dose, then the powdery mildew dose applied cannot exceed 20% of the registered dose even though if the Optidose recommended dose is higher, 40% per example.

The PTA also includes a possible additional reductions of the TFI according to the performance of the sprayer and its settings.

Since the first version of the protocol in 2019, adjustments have been made based on the feedback from the partners. For example, the maximum doses for copper and sulphur treatments are those used by the partners because they are already lower than the registered doses. The objective of the PTA is to propose a homogeneous protocol for all the products but consistent with the various dose reductions already implemented.

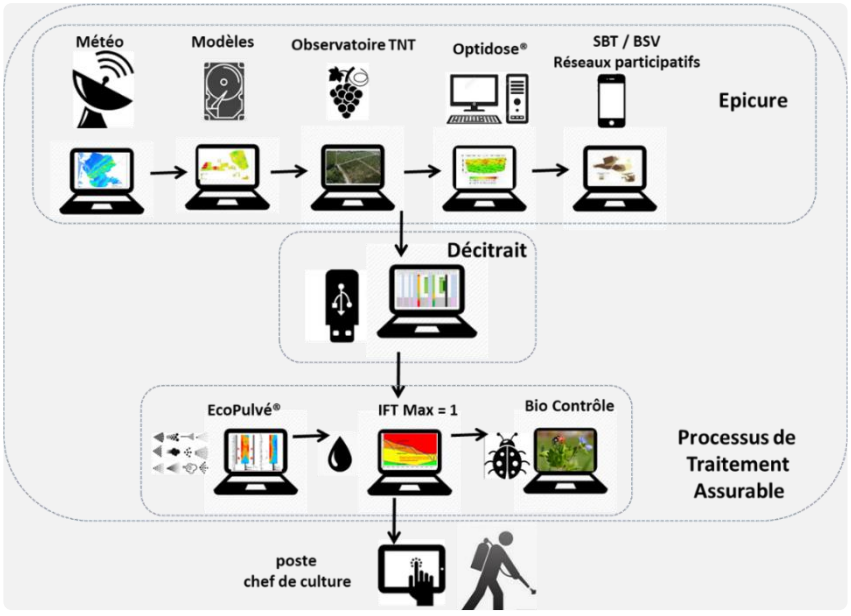


Figure 1: representation of the insurable treatment process and its interaction with the IFV DSS elements.

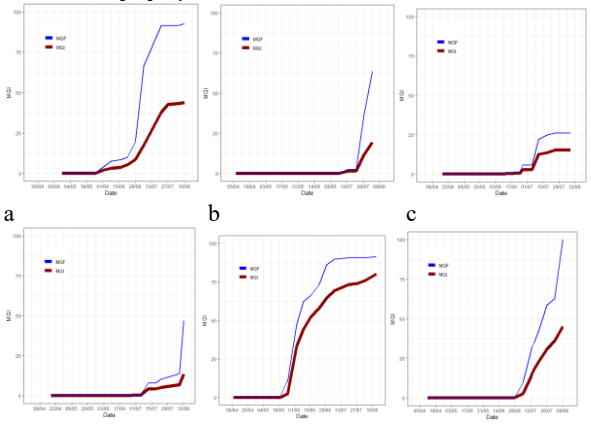
2 Results

The epidemic pressure of downy mildew for the 2019 to 2021 vintages is shown in Figure 2.

The 2019 vintage is characterized by a low pressure. The first symptoms of downy mildew appeared in the second half of June both on leaves and clusters. The destruction of the crop on untreated control is on average of 35-40%. Black rot and powdery mildew pressure was very low, causing no damage on bunches.

Downy mildew pressure for the 2020 vintage was very high. The first symptoms appeared on the leaves of untreated at the beginning of May, before flowering stage. The first mildew symptoms on bunches appeared at the end of May. Very few black rot symptoms appeared on leaves and none on clusters. The powdery mildew pressure was low, with very low damages. Crop destruction due to downy mildew reached an average of 70% with part of the controls completely destroyed.

The 2021 vintage is very unusual with a late but very strong downy mildew pressure: The first symptoms appeared on leaves at the end of June, which is very unusual. The bunches were affected a few weeks later with a very strong progression of damage during July. The black rot pressure also contributed to this particular vintage. The first symptoms appeared on leaves at the beginning of June and a strong contamination on bunches was observed at the beginning of July. The destruction of bunches due to these two diseases at veraison stage averaged 50-60% on the controls. Powdery mildew pressure was extremely low, with an average of less than 1% bunch destruction and the majority of controls did not show any symptoms.



a b c

d e f

Figure 2: Development of downy mildew on bunches in the untreated controls of:
- Buzet winery in 2019 (a), 2020 (b), 2021 (c)
- Tutiac winery in 2019 (d), 2020 (e) and 2021 (f).
The blue curves represent the incidence on bunches; the bold dark red curves show severity of DM destruction of the harvest.

CHEMICAL REDUCTION DUE TO THE PTA

Modeling of the epidemic risks, monitoring of the diseases on the controls, and PTA decision rules allowed significant reductions of the IFTs applied against DM and PM on each vintage compared to the average practices of the winegrowers of the two wineries as shown in tables 1 to 3 for both conventional and organic protection.

For the Tutiac winery (Table 1), where all the plots in the experiment were managed in conventional agriculture over the three years, the average reduction in the TFI for mildew was close to 37% and for powdery mildew 58% compared to the winery's conventional practices. The global reduction of the TFI against these two diseases is 47%.

	2019			2020			2021		
	Mean	Exp.	Red.	Mean	Exp.	Red.	Mean	Exp.	Red.
DM	3.1	2.2	-30%	10.5	4.0	-60%	7.2	5.8	-20%
PM	3.4	2.4	-30%	7.5	2.4	-70%	5.5	1.4	-75%
Tot.	6.5	4.6	-30%	18.0	6.4	-65%	12.7	7.2	-45%

Table 1: average TFIs for conventional plots of TUTIAC for downy mildew (DM), powdery mildew (PM) and both DM and PM (Tot.) of the winegrowers (Mean), the experimental PTA (Exp.) and relative percentage of reduction of the TFI (Red.) due to the PTA

The Buzet winery has integrated conventional and organic farming areas into the experiment. On the organically managed plots (table 2), the average reduction of the TFI for downy mildew was 47% and 35% for powdery mildew compared to the practices of the winery, i.e. a global reduction of the TFI of 42% against these two diseases.

	2019			2020			2021		
	Mean	Exp.	Red.	Mean	Exp.	Red.	Mean	Exp.	Red.
DM	5.8	3.3	-40%	6.0	2.7	-55%	6.1	3.3	-45%
PM	4.1	2.9	-30%	4.0	2.1	-45%	3.7	2.5	-30%
Tot.	9.9	6.2	-35%	10.0	4.8	-50%	9.8	5.8	-40%

Table 2: average TFIs for organics plots of BUZET for downy mildew (DM), powdery mildew (PM) and both DM and PM (Tot.) of the winegrowers (Mean), the experimental PTA (Exp.) and relative percentage of reduction of the TFI (Red.) due to the PTA.

On the Buzet plots conducted over the three years of experimentation with conventional protection (Table 3), the average reduction in the TFI for downy mildew was 37% and 55% for powdery mildew compared to the winery's conventional practices, i.e. an overall reduction in the TFI of 45% against these two diseases

	2019			2020			2021		
	Mean	Exp.	Red.	Mean	Exp.	Red.	Mean	Exp.	Red.
DM	5.8	4.0	-30%	6.1	3.1	-50%	6.1	4.4	-30%
PM	4.1	2.0	-50%	2.7	1.5	-45%	3.7	1.2	-70%
Tot.	9.9	6.0	-40%	8.8	4.6	-50%	9.8	5.6	-45%

Table 3: average TFIs for conventional plots of BUZET for downy mildew (DM), powdery mildew (PM) and both DM and PM (Tot.) of the winegrowers (Mean), the experimental PTA (Exp.) and relative percentage of reduction of the TFI (Red.) due to the PTA.

The coverage rate of the phytosanitary protection against downy or powdery mildews can be calculated over the whole

vegetative period from April 1st to August 31st. Our calculation takes into account the reduction of the applied dose and the type of chemical used (contact, penetrating, systemic). The PTA reduces the average coverage rate to 25% in 2019, 30% in 2020 and 35% in 2021. Figure 3 presents a synthesis of the protection strategy respecting the PTA in 2021 on the Buzet site managed in conventional protection.

The orange curve shows the average daily temperatures and the blue bars the daily rainfalls. The red flashes indicate the days when the risk of mildew contamination is very high and requires protection. The red arrows represent the days when the treatments against downy mildew were carried out and the red bars the period covered. The yellow and green bars correspond respectively to the protection against powdery mildew and black rot.
Figure 3 shows that one to two treatments could be saved at the beginning of the season while the model predicted contaminations from the beginning of May.

Few crop losses on sensitive plots or on rows located near some of the untreated controls have been observed during the experiment. Crop weighing have been done on these limited areas to evaluate these damages. It appeared actually very difficult to precisely evaluate these crop losses and the exact surfaces concerned: some of the affected areas sometimes showed higher level of harvest than on the healthy reference zones. This difficulty (10% of bunch severity observation does not systematically lead to 10% of crop loss, due to natural compensation) is currently the main factor limiting the eventual transfer of this experiment into practice,

3 Conclusions

The three years of experimentation show very enthusiastic results in reducing the use of phytosanitary treatments while maintaining a good level of protection. Crop protection insurance against diseases really is a significant lever to motivate winegrowers to adopt more environmentally friendly practices while limiting their financial risks. The insurable treatment protocol will be further modified during the coming years of experimentation, to better integrate the disease pressure evaluation systems (e.g. airborne spores) in the decision making processes.

Figure 3: Summary of the phytosanitary protection strategy applied on 8 ha in 2021 on the Buzet conventional protection.

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