SCIENCE & POLICY
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RESISTANT GRAPE VARIETIES

TOWARDS INNOVATIVE SOLUTIONS FOR SUSTAINABLE AND QUALITY WINE GROWING

INRA
SCIENCE & IMPACT

01

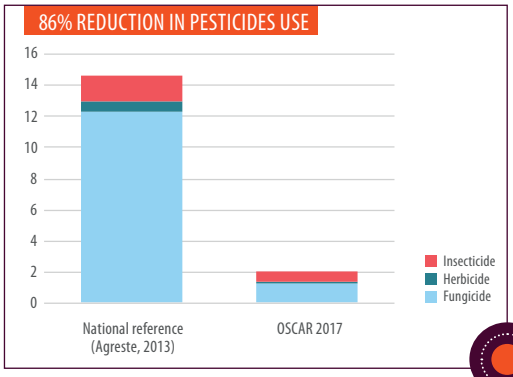
CREATING MILDEW-RESISTANT GRAPE VARIETIES:
A RESPONSE TO ECONOMIC, ENVIRONMENTAL, AND HEALTH CHALLENGES TOWARDS IMPROVED PRODUCTION PERFORMANCES

The French national plan to reduce the use of pesticides ("Ecophyto 2") aims for a 50% reduction in the use of chemical plant protection products (PPPs) by 2025 to protect the environment and public health. **Alongside governmental policy, French public research in agricultural sciences focuses on reducing PPP use to improve performance of the agricultural sector in economic, environmental, health and social terms. The winegrowing sector is of particular concern** because French vineyards account for 20% of total PPP annual uses while covering 3% of arable land in France. In the same vein, the heavy reliance on copper sulphate in organic systems is raising concerns because of its consequences for the environment and health. Both chemical fungicides and copper sulphate are sprayed to control fungal pathogens, namely powdery mildew and downy mildew.

MORE EFFECTIVE DISEASE CONTROL

The whole purpose of Inra is to create sustainable agricultural production systems that respect the environment and do not threaten human health. To this end, INRA has been developing resistant grape varieties for years, to serve as an alternative to PPPs and copper sulphate in the fight against widespread fungal pathogens. Indeed, powdery and downy mildew represent a major threat to French vineyards.

Powdery mildew infections on sensitive (A) and resistant (B) *Vitis vinifera* varieties. © Inra



First results (2017) obtained on 30 vine plots of the participatory research device "OsCaR" – the national observatory for resistant grape varieties [see part 3 for more details] showing a 86% reduction in PPP use. © Inra

BETTER ENVIRONMENTAL PERFORMANCE WHEN REDUCING CHEMICAL PESTICIDES USE

Over the last years, INRA carried out fundamental and experimental research on grape varieties that are resistant to powdery and downy mildew (namely at Bordeaux, Colmar, Montpellier and Gruissan)**. The results show that such varieties greatly reduce the need for fungicide treatments.**

BETTER ECONOMIC PERFORMANCE

Mildew-resistant varieties make it possible for wine-producers to reduce PPP use and are thus **an effective tool for lowering the operating costs of the vineyards**. In France, the winegrowing sector spends €300 million/year on fungicides with an average of 12 treatments per year. More generally, the industry must continue to meet markets expectations for product quality and excellence while dealing with rising consumer concerns over pesticide use. Mildew-resistant varieties are one of the key responses to this challenge.

02 WHAT ARE MILDEW-RESISTANT GRAPE VARIETIES?

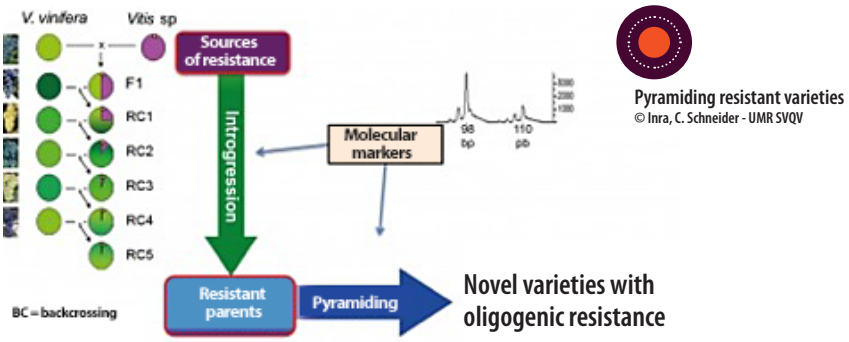
Fungal pathogens, and notably powdery and downy mildew, are extremely common in vineyards, especially in France. At present, the control of these pathogens largely involves the extensive use of chemical fungicides or copper sulphate. Such pesticides have serious impacts on the environment and health. **For more than 40 years, INRA researchers have been working to develop alternative solutions based upon resistant varieties.**

A BRIEF HISTORY OF INRA'S RESEARCH

The very first research worldwide searching for resistance sources in related species was initiated in the US in the early 20th century. Since the mid-1970s, INRA has been crossing grape varieties and related species, and developing breeding programs to enhance mildew resistance in the European grape *(Vitis vinifera)*. The targeted resistance factors were found in wild North American or Asian grape varieties (*Muscadinia rotundifolia* and other *Vitis* species, such as *Vitis amurensis, Vitis piasezkii, Vitis rupestris, Vitis riparia,* and *Vitis cinerea*). As a result of a 25 years long breeding program, researchers created the **Bouquet varieties**, named after the scientist who carried out the first rounds of breeding. **Each variety carries one gene conferring resistance to each of the two pathogens** (displaying monogenic resistance). In the 2000s, INRA began the 'Resdur' breeding programme. The aim was to incorporate new resistance genes against the two pathogens into Bouquet varieties to **generate novel varieties with longer-lasting or "durable" mildew resistance due to their higher number of resistance genes. This programme resulted in the creation of the Resdur varieties, which display polygenic resistance to both mildews.**

THE CHALLENGE OF GENERATING DURABLE RESISTANCE

In 2011, INRA decided to **focus on varieties displaying polygenic resistance obtained via pyramiding** (i.e., associating several resistance genes). In such varieties, pathogens are less likely to evade resistance mechanisms, preventing them from permanently undermining the protection afforded by resistance genes.



Pyramiding resistant varieties
© Inra, C. Schneider - UMR SVQV

INRA is constantly looking for new resistance genes in wild grapes and landraces that could be incorporated into cultivated varieties using marker-assisted selection*. In this way, new information is continually being collected on resistance genes (gene function and location on the plant genome). This research leads to **genotypes with new resistance genes to powdery and downy mildew. The ultimate stage will be to incorporate those genes into the main commercial grape varieties without affecting their organoleptic properties.**

*Marker-assisted selection: a standard selection method that uses markers (which function as labels) to identify genes that encode traits of interest (in this case, in an agricultural setting) and that are transmitted over the course of successive crosses. This technique is a significant time saver because it allows crosses to be quality checked

PHENOTYPING PLATFORM AT INRA COLMAR

Unique in Europe, the INRA Colmar phenotyping platform was launched in 2012. It has three main functions: to characterise available genetic resources for grape varieties and its wild relatives, to identify and map the genes controlling plant resistance to mildew, and to develop new resistant varieties via marker-assisted selection.

03 FOCUS ON INRA RESEARCH:
TOWARDS THE DEVELOPMENT AND DISSEMINATION OF VARIETIES WITH DURABLE DISEASE RESISTANCE AND DISPLAYING REGIONAL VINEYARDS TYPICALITY

INRA and its partners - winegrowers associations and other stakeholders in the field of agricultural advisory services - are facing major research challenges. These include **creating varieties with more durable resistance to pathogens as well as adapting such varieties to the climate and soils met in the different wine-growing areas and the grape/wine production conditions and oenological practices**. This process involves a **testing phase that takes place in real farm conditions**. The new varieties must also be **socially and technically adopted by the industry**.

BREEDING NEW VARIETIES DISPLAYING LOCAL TYPICALITY, IN SYNERGY WITH THE FRENCH WINE AND VINE TECHNICAL INSTITUTE (IFV) AND REGIONAL INTERPROFESSIONAL ORGANIZATIONS

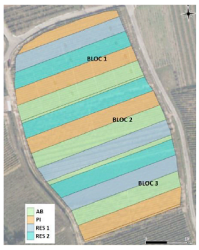
More than 10 programmes seeking to cross **ResDur varieties and traditional varieties** are currently implemented. The goal is to develop new mildew-resistant varieties that display typicality of local varieties of key French wine-growing areas (Cognac, Bordeaux, Provence, Alsace, Rhône, Languedoc, Bourgogne, etc.).

RESINTBIO FACILITY AT BORDEAUX

- Variety: LJ134 (red)-ResDur1
- Planting year: 2011
- Field size: 3 x 0.2 ha
- Planting density: 6,500 plants/ha
- Pruning method: Cordon
- Other system features:
  - Soil managed without herbicides
  - Preventive (suppress fungal inocula)
  - Supplementary treatments with fungicides (as of 2015)
- Systems compared:
  - Conventional low input (INT; Merlot)
  - Organic viticulture (BIO; Merlot)

PEPSVI ALSACE FACILITY AT COLMAR

- Variety: Col-2383L (white)-ResDur2
- Planting year: 2014
- Field size: 3 x 0.1 ha
- Planting density: 4,850 plants/ha
- Pruning method: Double Guyot
- Other system features:
  - RES 1: standard soil management (mechanical + chemical), miminal fungicide treatments (two treatments targeting black rot)
  - RES 2: no pesticides, mechanical weed control
- Systems compared:
  - Integrated Production (PI; Pinot Blanc)
  - Organic viticulture (AB; Pinot Blanc)



EXAMPLES OF EXPERIMENTAL RESEARCH FACILITIES FOCUSING ON REDUCING PPPS: RESINTBIO (INRA BORDEAUX) AND PEPSVI ALSACE (INRA COLMAR)

INRA, IFV, agricultural schools and colleges, chambers of agriculture, and local and regional representatives of winegrowers mobilize theses experimental research facilities. They come together to define and carry out field trials of low-input wine-growing practices. The aim is to **compare, under real conditions, different production systems, including those based upon mildew-resistant varieties**. The ResInt-Bio and PEPSVI designs are part of the DEPHY-Expé network, which was set up as part of the French national plans to reduce the use of pesticides (Ecophyto 1 and 2). **The first results showed that the use of mildew-resistant varieties can reduce significantly the need for chemical pesticides in conventional systems and the use of copper sulphate in organic systems**. Only two treatments (instead of 12) are kept to control secondary pathogens such as black rot and parasites.

OSCAR: THE NATIONAL OBSERVATORY FOR RESISTANT GRAPE VARIETIES

Observatoire national du déploiement des cépages résistants

OsCaR is a participatory research design implemented across all the French wine production areas. **Interested winegrowers are invited to evaluate resistant varieties on their land while contributing to ongoing research**. It has an inclusive approach: it includes all resistant varieties, including those bred by INRA. Established in 2017 by INRA and IFV, it is a unique participatory research scheme and aims at creating strong and direct links between winegrowers and researchers. **It has several goals: to carry out biological and sociological research, to monitor disease and agronomic features, to offer demonstrations, to share experiences and results, and to promote adoption of new practices**. It aims at **characterising the durability of mildew resistance** by monitoring populations of powdery mildew and downy mildew and scoring secondary pathogens. It is also designed for **data collection** and **the evaluation of agricultural and oenological practices** across different agro-climatic conditions. This will make it possible to determine the **optimal conditions for the use of resistant varieties. To this end, a modelling approach incorporating the collected data is being used**. OsCaR also **assesses production and quality of wines** produced from resistant grape varieties.

04 HORIZON 2030:
USE OF MILDEW-RESISTANT VARIETIES IN FRENCH VINEYARDS

MOVING TOWARDS THE COMMERCIALISATION OF RESISTANT GRAPE VARIETIES

Around 30 ResDur and 7 Bouquet wine-grape varieties are under evaluation for entering the official catalogue of species and varieties of cultivated crops in France. Registrations of the first Resdur varieties occurred in late 2017, and their first classifications at the beginning of 2018.

July 2016, meeting in the field at Châtenois.
© Inra - M. Thiollet Schoitus

A REMINDER OF THE PROCEDURE FOR REGISTERING, CLASSIFYING, AND PLANTING GRAPE VARIETIES

STEP 1: a variety must meet various criteria—it must be distinct, uniform, and stable (DUS) and have agricultural, technological, and environmental value (VCUS test results)—**to be included within the official catalogue**. Its registration is formalised via governmental order upon the recommendation of the Technical Committee for Plant Breeding (CTPS) - vine section, and then stock/plants may be sold within the EU. Based upon DUS test, the breeder may apply for protection through Plant Breeder Rights.

STEP 2: based on its VCUS result, a registered variety is then **classified as a table grape** or a wine grape. This classification is formalised via governmental order, upon the recommendation of the relevant FranceAgriMer committee and of the Technical Committee for Plant Breeding (CTPS) - vine section.

STEP 3: Authorisation for planting* may be granted for classified varieties only. Winegrowers must receive such an authorisation before they are allowed to plant their vines. It is part of the French management system of the total national vine production potential, which benefits everyone.

* *Under the planting authorisation system, there is a way to request a temporary classification so that winegrowers can experiment with varieties under controlled conditions.

CURRENT REGULATIONS MAY CONSTRAIN THE PRODUCTION OF PDO WINES

To bear the protected designation of origin (PDO) seal or the protected geographical indication (PGI) seal, wines must meet PDO or PGI standards, respectively. Extensive discussions have already taken place with the National Institute of origin and quality (INAO) and the representatives of the wine-growing sector. This dialogue must be pursued in the future to ensure widespread support for the adoption of resistant varieties within the sector, notably about certified wines. **So far, it has become clear that regulations as they stand may seriously impede the future adoption of such varieties as far as PDO wines are concerned. Indeed, EU regulations state that PDO wines must be produced exclusively from varieties of *Vitis vinifera*. However, all of INRA's mildew-resistant varieties are the result of crosses between *Vitis vinifera* and other grape species**, such as *Muscadinia rotundifolia* or *Vitis amurensis* even though several backcrosses towards *Vitis vinifera* were performed after the initial crosses. Yet, PDO wines, which display typicality and high quality, could clearly benefit qualitatively, environmentally, and economically from the use of resistant varieties and the achieved reduction in the use of chemical pesticides. It is therefore necessary to set adapted regulations taking into account scientific innovations already used by producers and that respond to societal concerns. **Indeed, such regulations have to be modified in a timely manner, before difficulties arise, to allow economic stakeholders to benefit fully from major research-based innovations targeting clear public goods (environment, human health).**

For example, it would make sense to **take advantage of the reform of the Common Agricultural Policy post-2020 to modify article 93 - 1.a) iv) of Regulation (EU) No. 1308/2013 of the European Parliament and of the Council, which addresses the common organisation of the markets in agricultural products (single CMO). One of its stipulations is that a wine product benefiting from a "designation of origin" has to be "obtained from vine varieties belonging to *Vitis vinifera*". This constraint needs to be removed via regulatory modifications following exchanges with winegrowers' representative organisations and in such a way as to combine benefits from innovative varieties and PDO wine typicality.**

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