

NOV 11-13, 2019

SUSTAINABLE AG EXPO
&
**INTERNATIONAL SUSTAINABLE
WINEGROWING SUMMIT**

SAN LUIS OBISPO, CALIFORNIA

Inra-ResDur

The French grapevine breeding program for durable resistance to downy and powdery mildew

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France





- **Introduction**
- **History of breeding for resistance to pathogens in France**
- **The Inra-ResDur breeding program**
- **Summary and perspectives**

Alsace region



4,000 wineries
15,621 hectares
907,000 hl

Organic vineyard
281 wineries
2,230 ha
14,2%



The Inra research center of Colmar

A research institute dedicated to grapevine



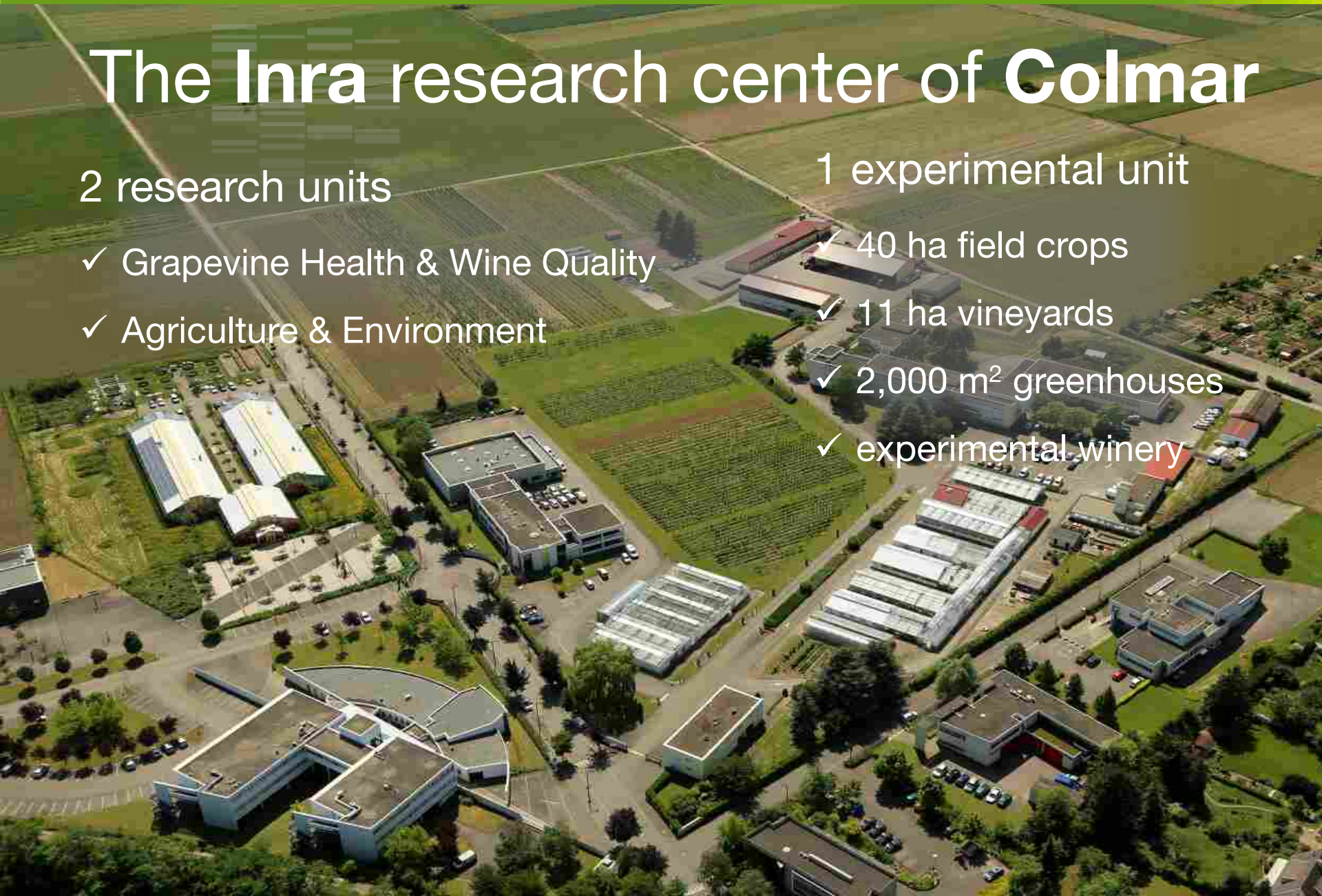
The Inra research center of Colmar

2 research units

- ✓ Grapevine Health & Wine Quality
- ✓ Agriculture & Environment

1 experimental unit

- ✓ 40 ha field crops
- ✓ 11 ha vineyards
- ✓ 2,000 m² greenhouses
- ✓ experimental winery



Strengths and weaknesses of **French viticulture**

Wine sector generates an annual turnover of over **14 billion €**

Grapevine represents **3%** of the cultivated area

Viticulture uses **30%** of the fungicides used in agriculture

Reduce the use of fungicides

- 16 treatments per year
- 300-400 million euros
- **Impact** on human health and the environment
- Pathogen resistance to fungicides
- Obligation to **reduce** the use of pesticides





An alternative to the intensive use of
fungicides
is the development of
varieties resistant to pathogens

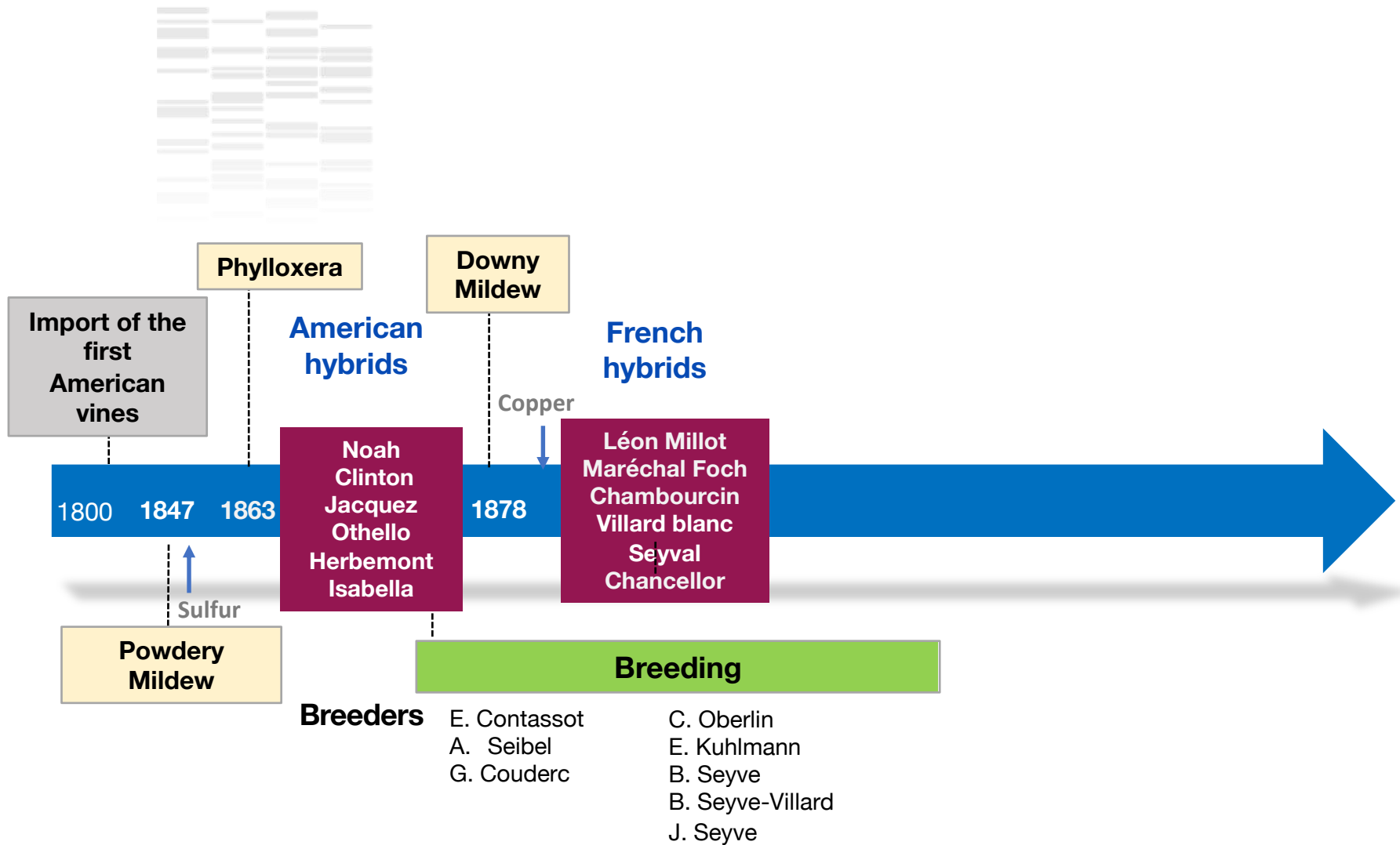


In France and until 2018, **resistant varieties**
with high wine quality
weren't available

Breeding by hybridization started in the 19th century



History of breeding for resistance



The first French breeders

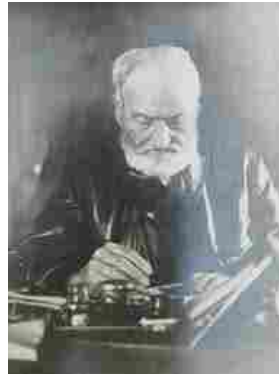
E. Contassot (1846-1922)



1874

Introduction of
Jaeger 70

A. Seibel (1844-1939)



1886

2000 hybrids
Seibel 7053 = **Chancellor**

G. Couderc (1850-1924)



M. Georges COUDERC

1887

Bayard



The first breeders in Alsace



1895 Institut Oberlin



C. Oberlin (1831-1916)



E. Kuhlmann (1858-1932)



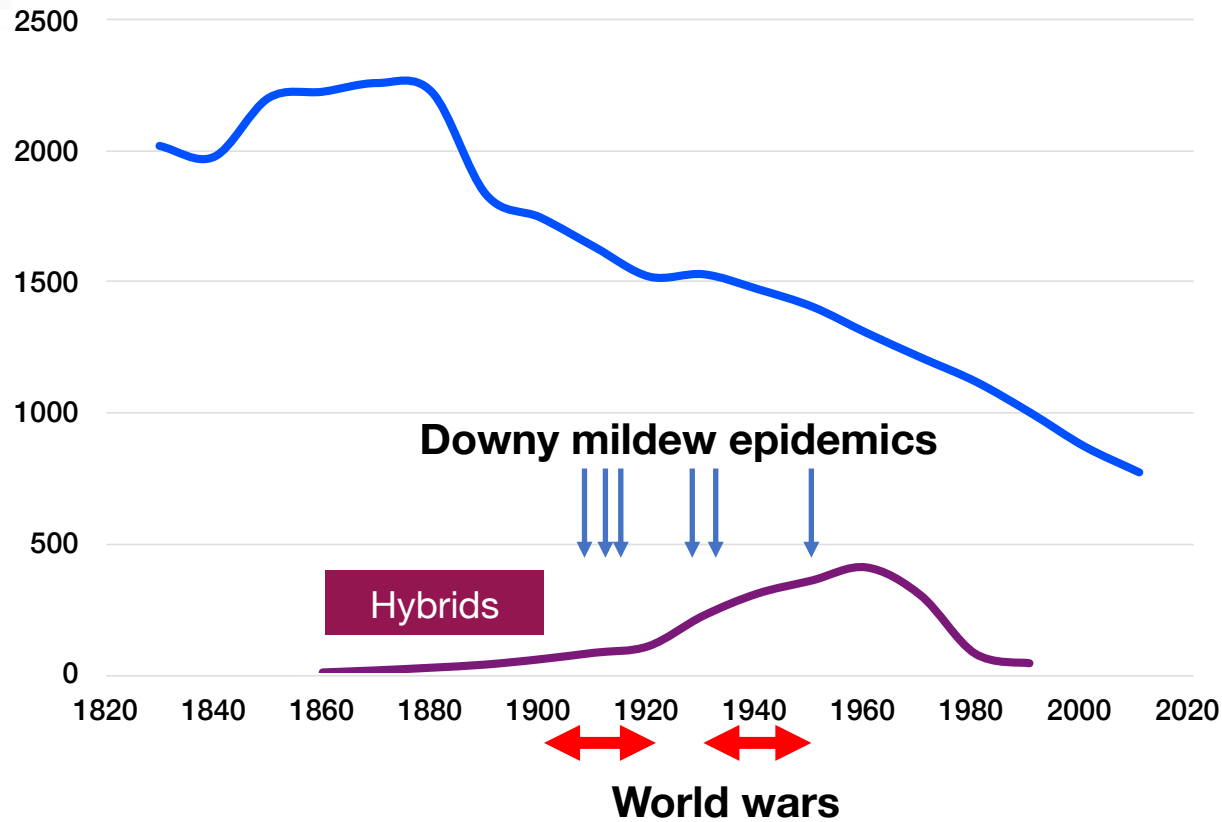
Oberlin noir



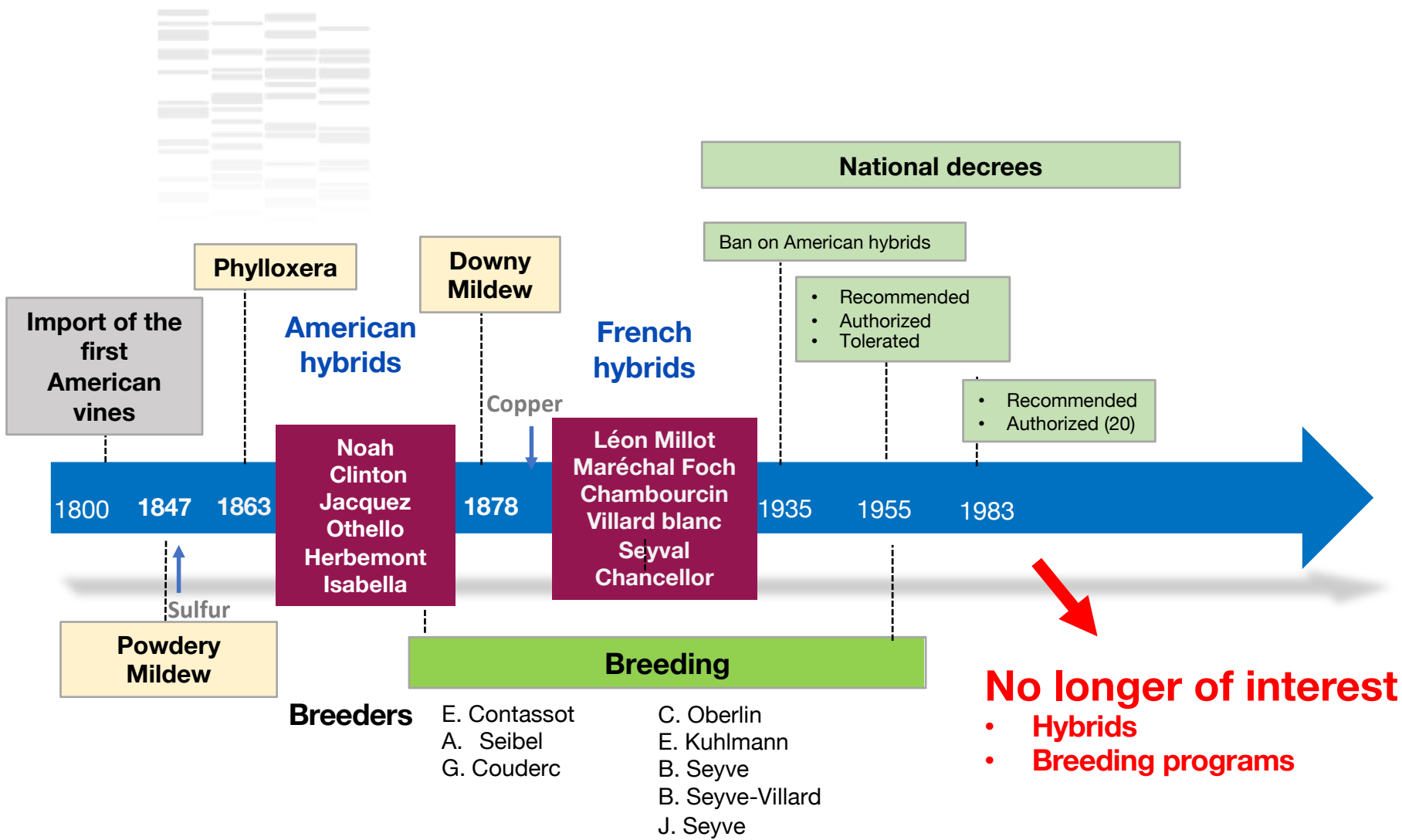
Maréchal Foch

Evolution of vineyards in France

Thousands of hectares



History of breeding for resistance



After 1983, breeding was continuing in Europe



- Julius Kuhn Institut Geilweilerhof (JKI)
- Staatliches Weinbauinstitut (WBI)



- Agroscope
- Valentin Blattner



Szőlészeti és Borászati
Kutatóintézet (SZBKI)

Since 2000

- 
- Institut National de la Recherche Agronomique (INRA)
 - Institut Français de la Vigne et du Vin (IFV)



- Julius Kuhn Institut Geilweilerhof (JKI)
- Staatliches Weinbauinstitut (WBI)



- Agroscope
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Szőlészeti és Borászati
Kutatóintézet (SZBKI)

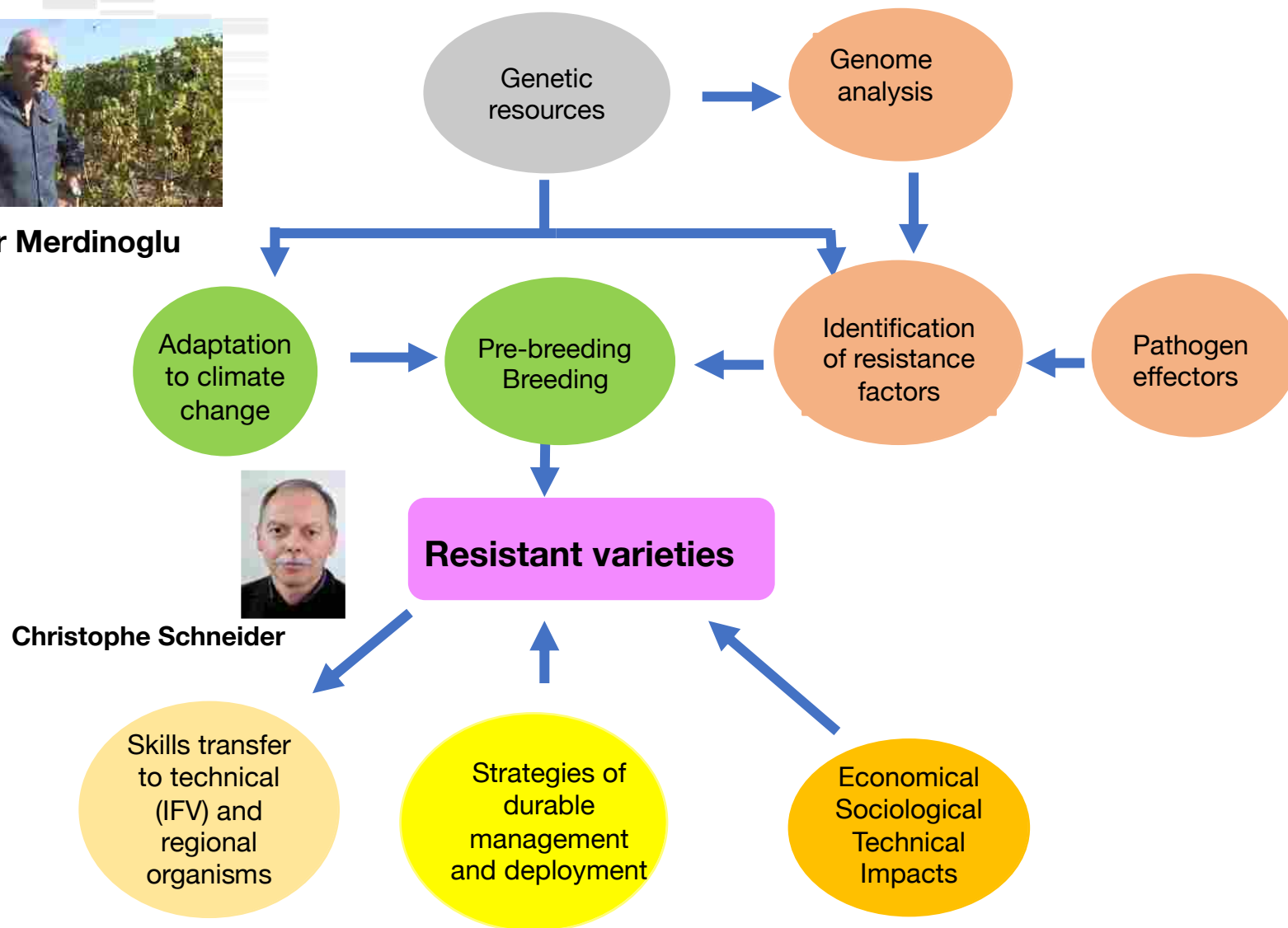


Instituto di Genomica Applicata (IGA)

Organization of the Inra-Resdur breeding program



Didier Merdinoglu



Christophe Schneider

V. rupestris



V. lincecumii



V. berlandieri



V. amurensis

26 Asian *Vitis* species



V. riparia



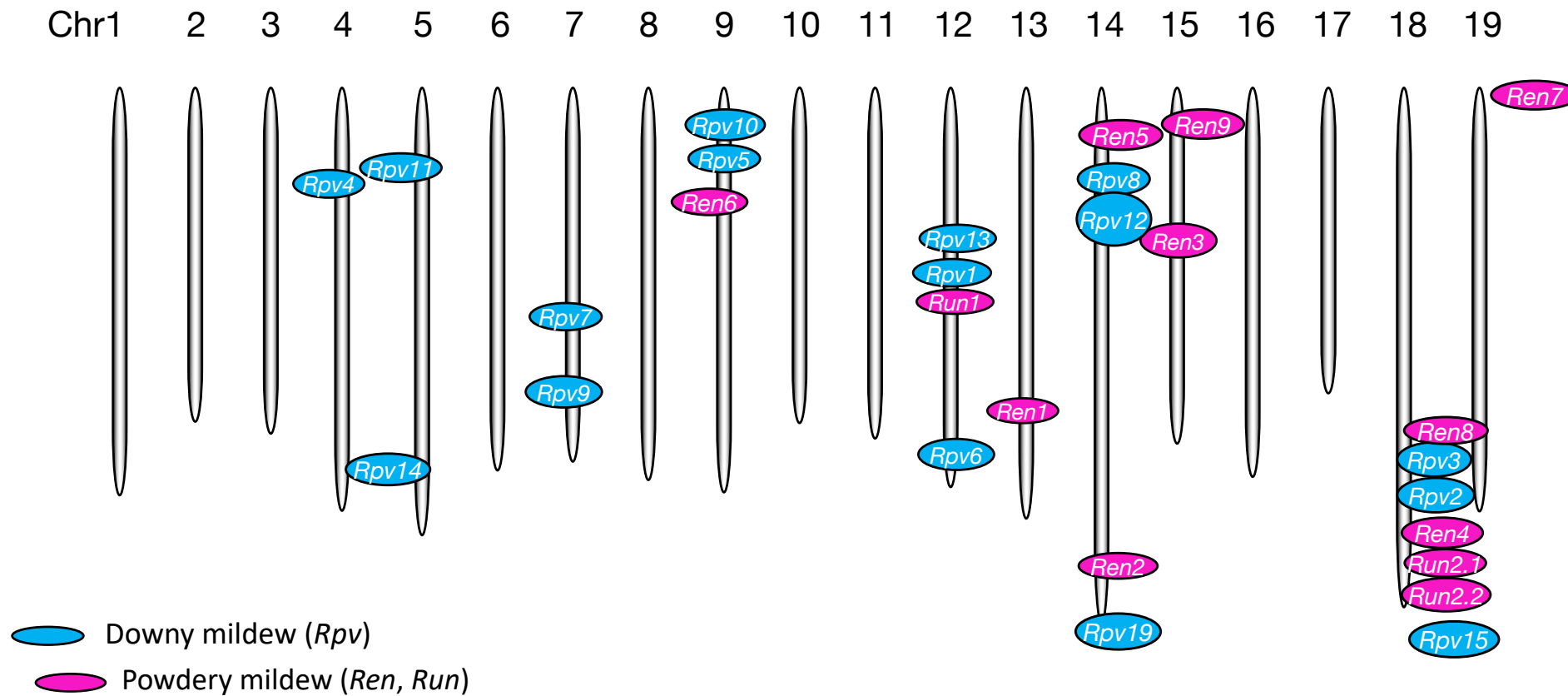
V. rotundifolia

33 American *Vitis* species

Vitis vinifera
ca 2000 varieties

Sources of resistance to downy and powdery mildews among *Vitis* species

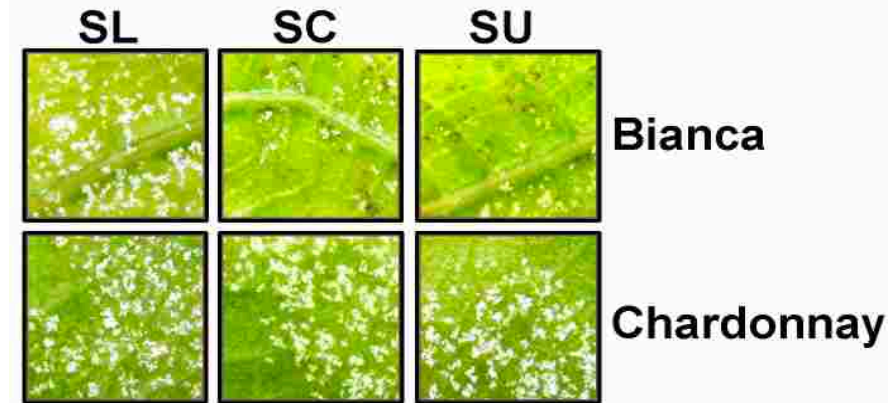
Identified resistance factors to downy and powdery mildew



Resistance breakdowns in *Vitis*

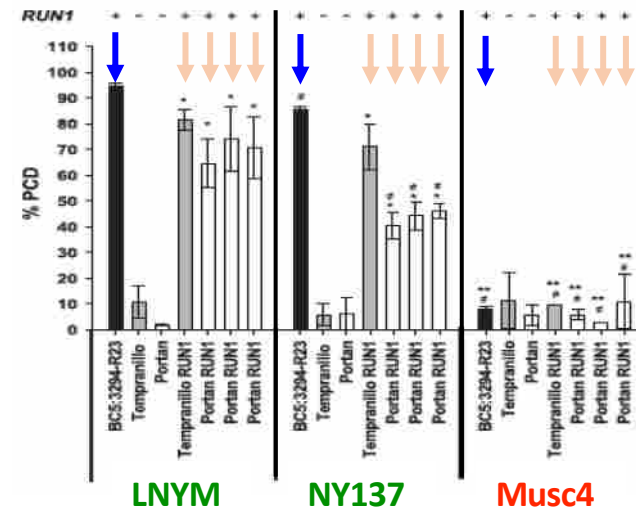
Breakdown of *Rpv3.1* downy mildew resistance from the Bianca variety

(Peressotti et al, 2010, BMC Plant Biol)

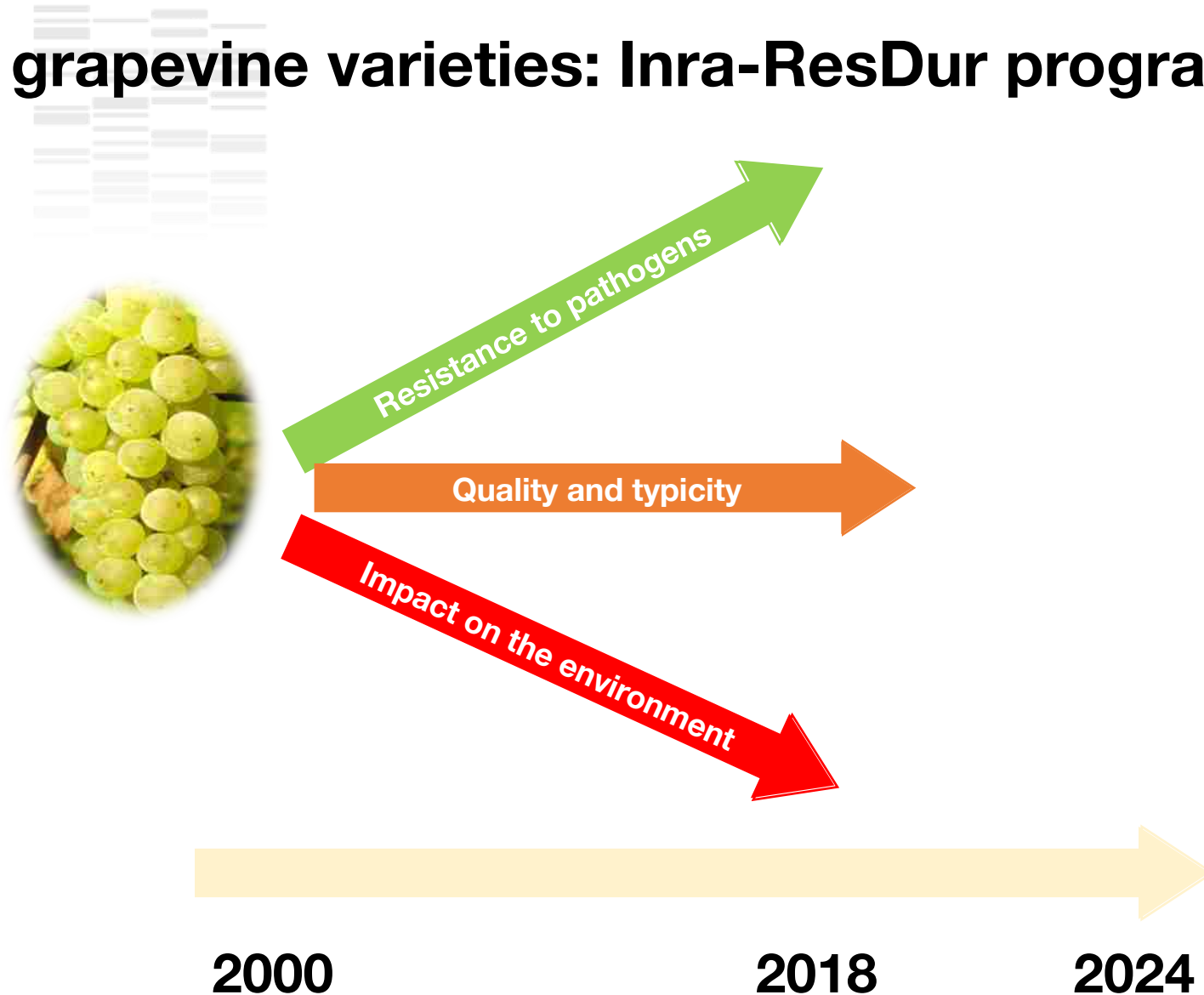


Breakdown of *Run1* powdery mildew resistance from *Muscadinia rotundifolia*

(Feechan et al 2013, Plant J; Feechan et al 2015, Phytopathology)



New grapevine varieties: Inra-ResDur program

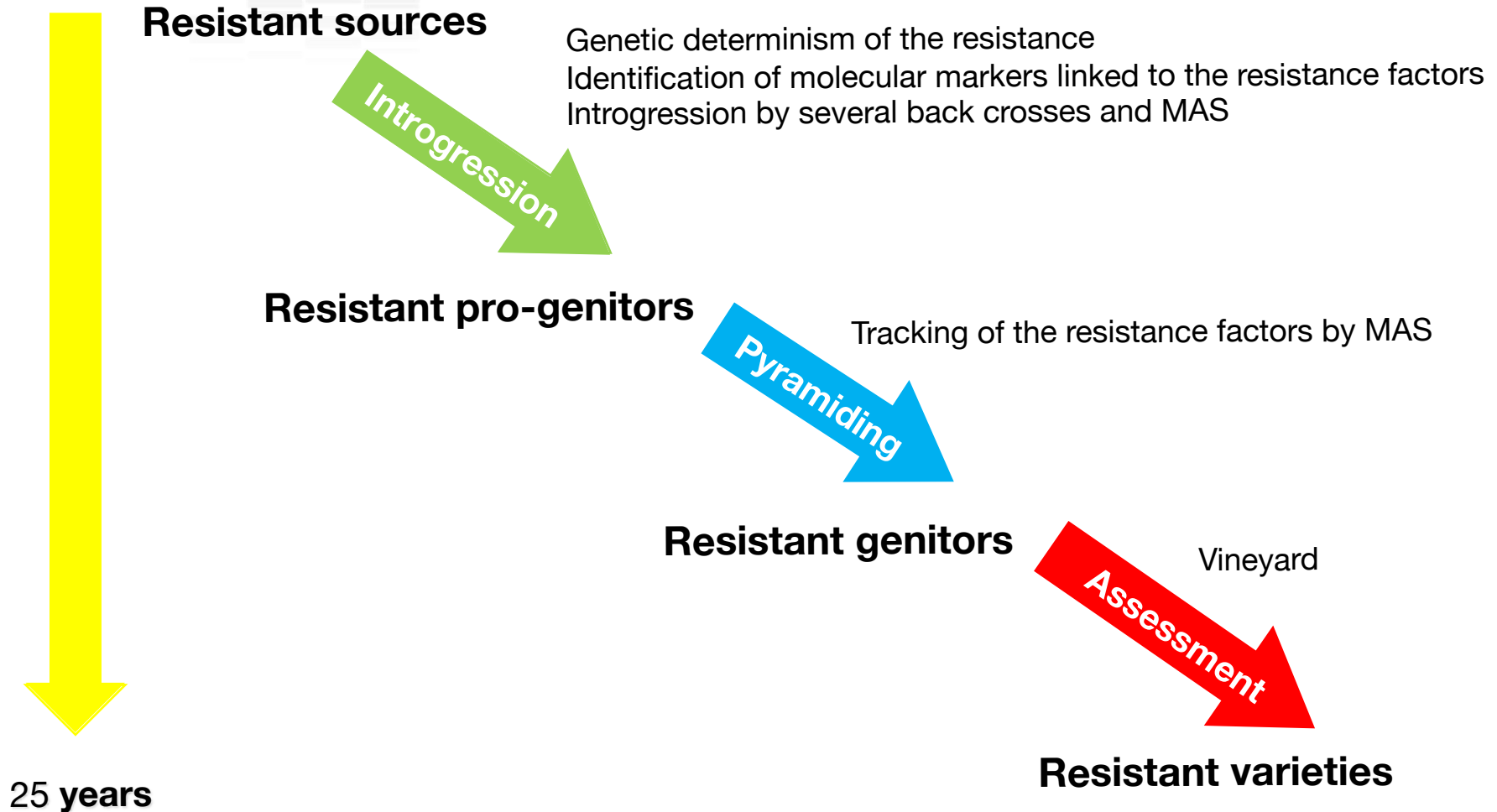


Durable management of resistance

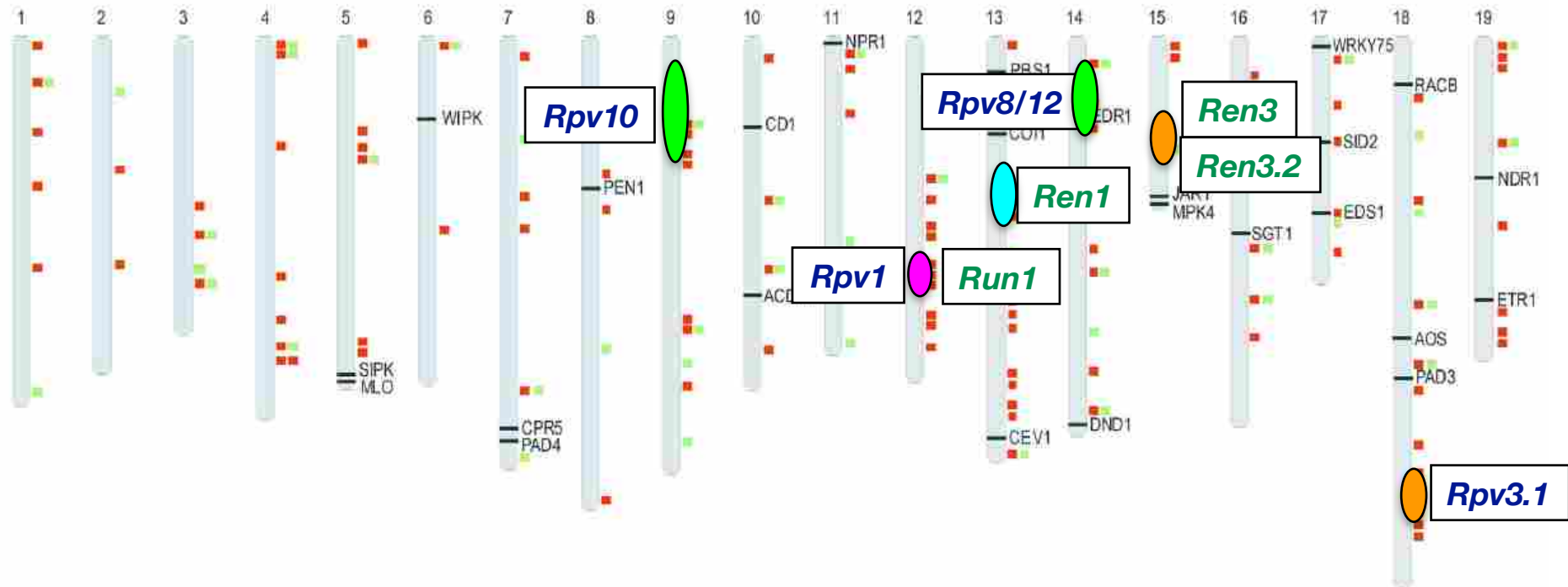
- Resistance genes are a **limited resource**
- Resistance gene **breakdowns** have already been observed
- A breeding program is a **long-term and costly process**
- The question of the management of **resistance durability** is crucial, particularly, in the case of a **perennial species**

- ✓ **Pyramiding** resistance genes is an efficient strategy to increase resistance durability
- ✓ Appropriate **cultural practices** and **monitoring of variety deployment** also contribute to the durability of resistance

Breeding is a **three-steps** process



Resistance factors to downy and powdery mildew (probably) used in the European breeding programs

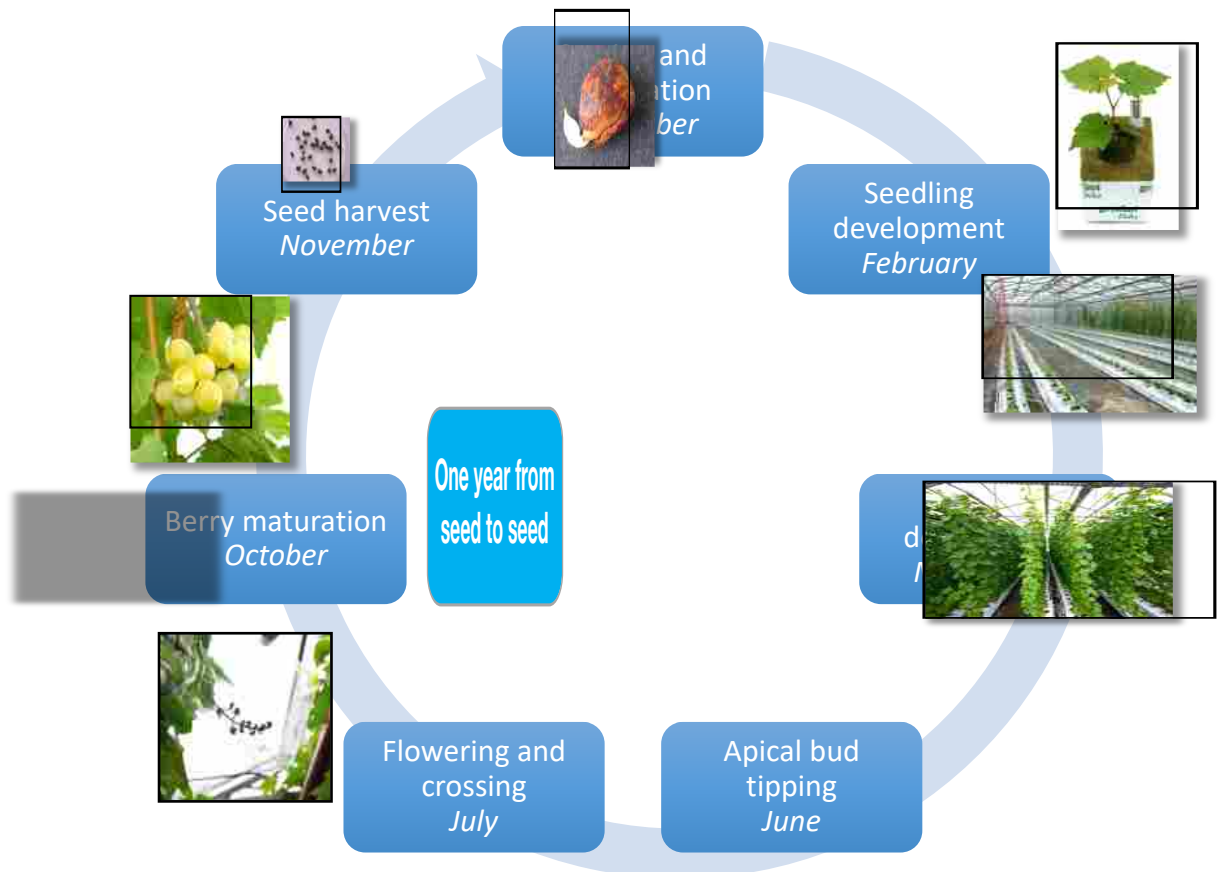
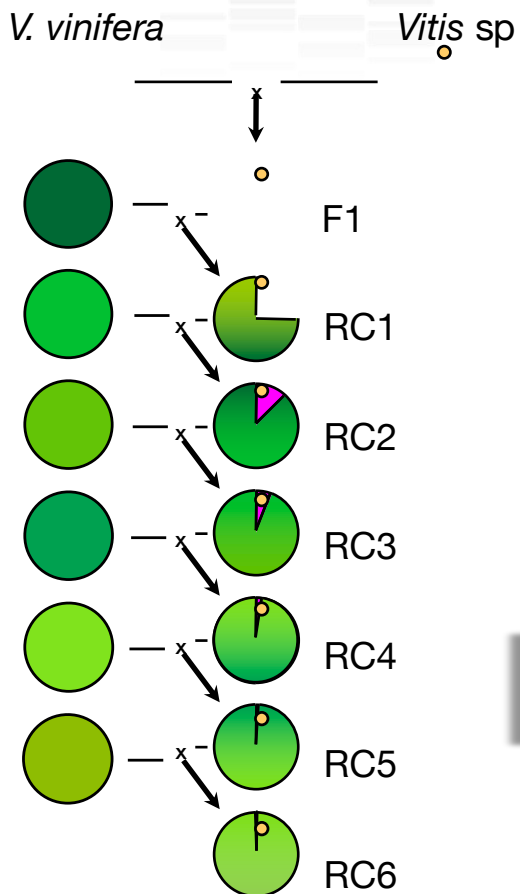


● *V. rotundifolia*
 ● American *Vitis*
 ● *V. amurensis*
 ● Kishmish Vatkana

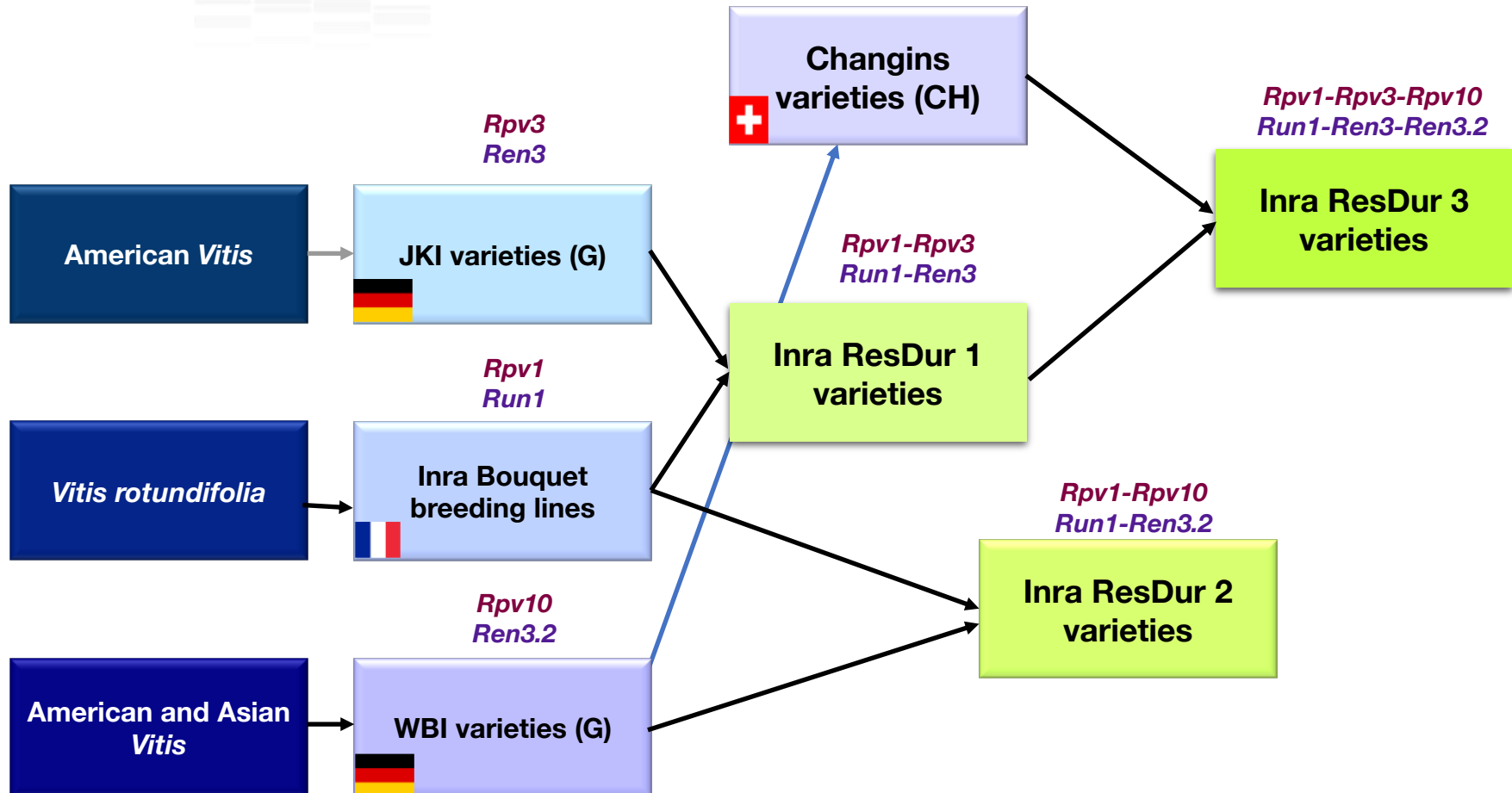
Downy mildew (*Rpv*) Powdery mildew (*Run*, *Ren*)

Introgression: a long process

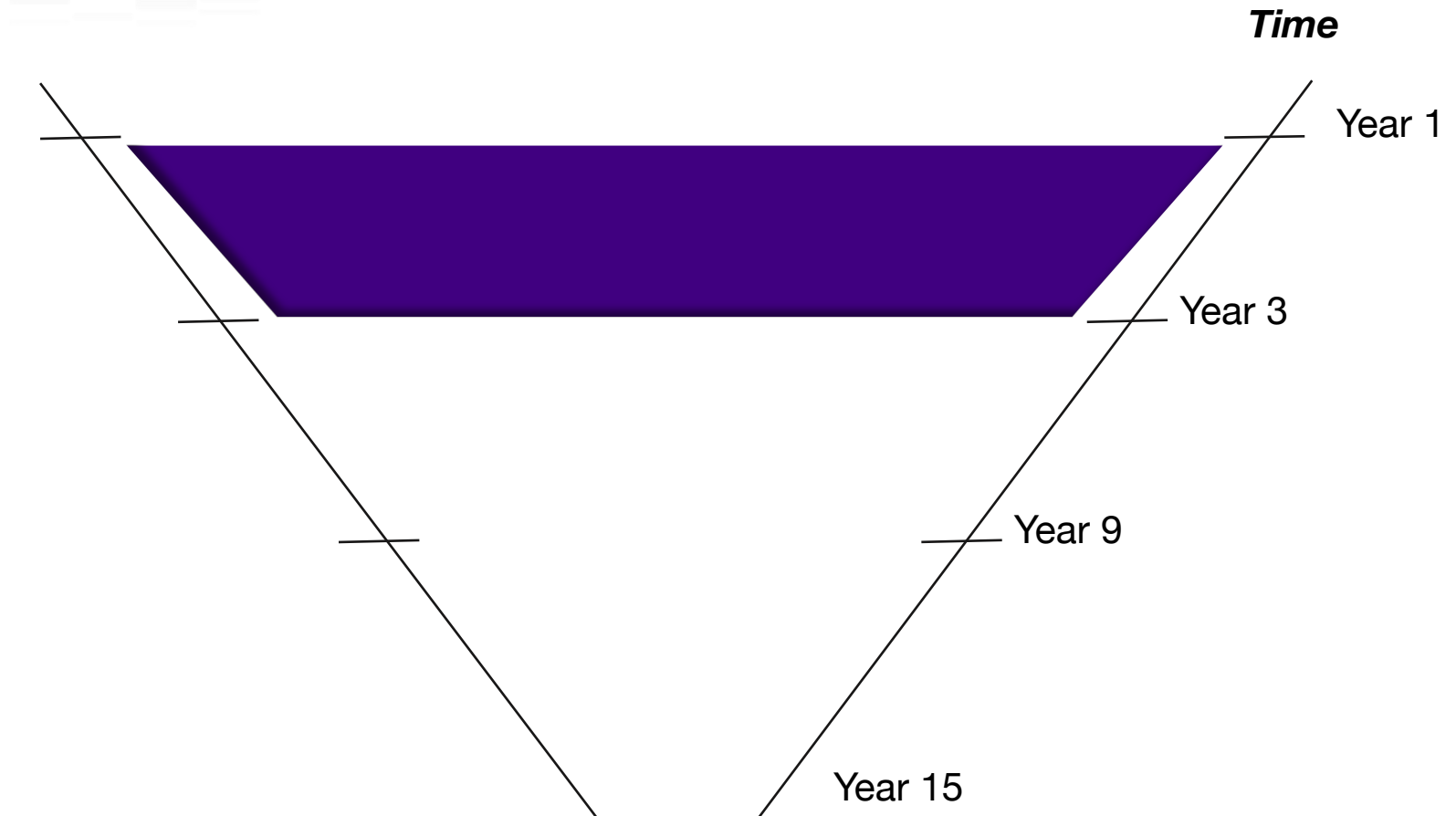
despite a short cycling method



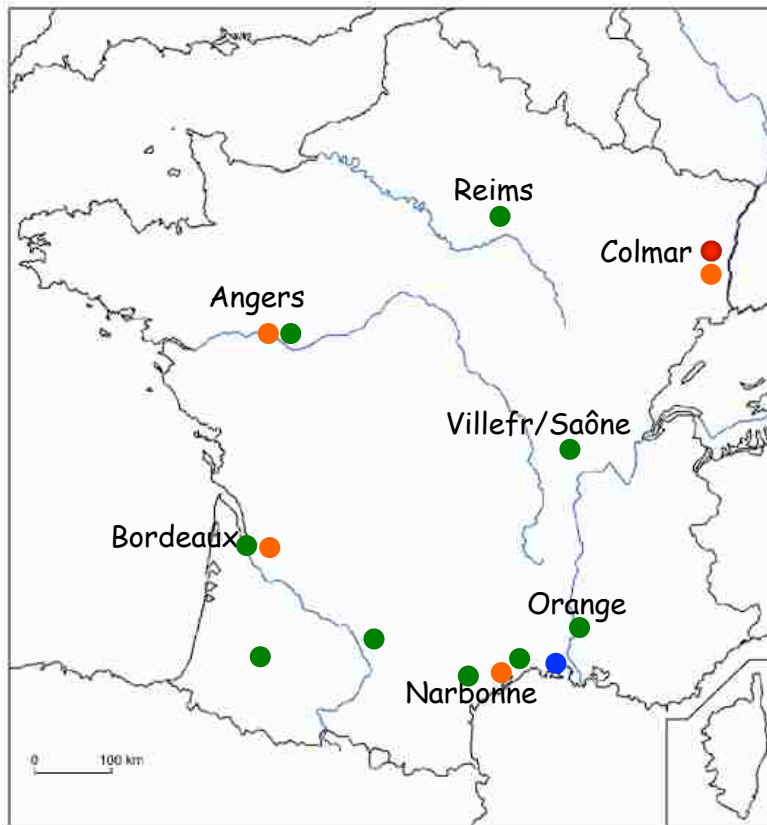
A sequential process developed in partnership and completed in 2025



15 years to select a resistant variety



The Inra-ResDur experimental network



- INRA research unit
- INRA experimental units
- IFV (National technical institute)
- Regional partners



Outcome of the Inra-ResDur program

50 crosses (in 3 series)

14,000 seedlings screened by MAS

700 progenies assessed in vineyard in intermediate selection

50 candidate varieties assessed in vineyard in final selection

30 varieties presented for registration

- **2-3 resistance genes** to PM and DM
 - **high wine quality**
 - a range of **phenology, sugar** content and **acidity**
-
- **First registrations in 2018**
 - **Deployment in partnership with IFV**

15 years to select a resistant variety



← ResDur3 varieties (35 candidates)
← ResDur2 varieties (24 candidates)

Registration in the Official Catalogue of Grapevine Varieties

January 2018

ResDur1 varieties: Artaban, Floreal, Vidoc, Voltis

2018: registration of 4 Inra-ResDur varieties

FLOREAL

- Total resistance to PM ; very high resistance to DM
- Moderate grape production
- Expressive, aromatic and pleasantly fresh wines
- Aromas dominated by notes of exotic fruits and boxwood

VOLTIS

- Total resistance to PM ; very high resistance to DM
- Moderate grape production
- Ample and persistent wines
- Quite strong acidity at low ripening level

VIDOC

- Total resistance to PM ; high resistance to DM
- Fairly high grape production
- Powerful and very robust wines, with intense colour
- Complex aromas dominated by fruity and spicy notes

ARTABAN

- Total resistance to PM ; high resistance to DM
- Fairly high grape production
- Light, silky and well-coloured wines
- Aromas dominated by fruity notes



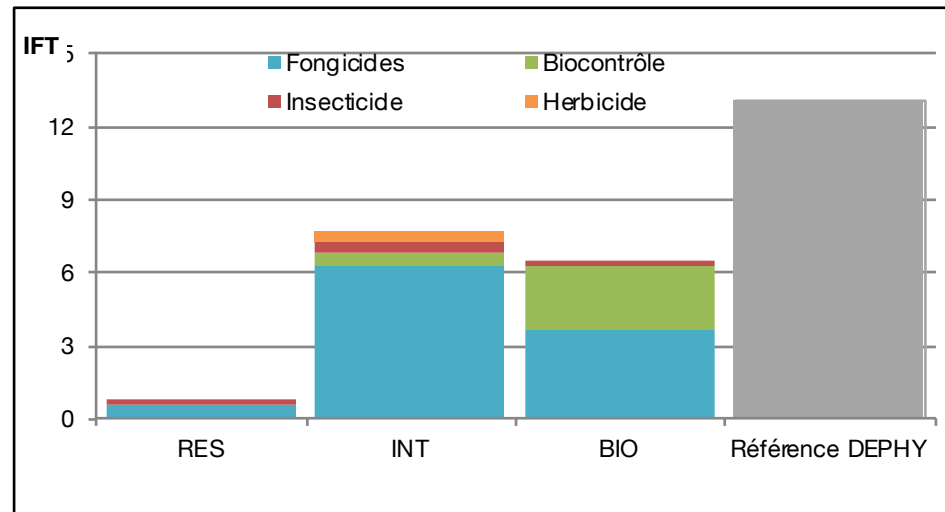
<http://www.colmar.inra.fr>

Impacts of the Inra-ResDur varieties

ResIntBio trial :

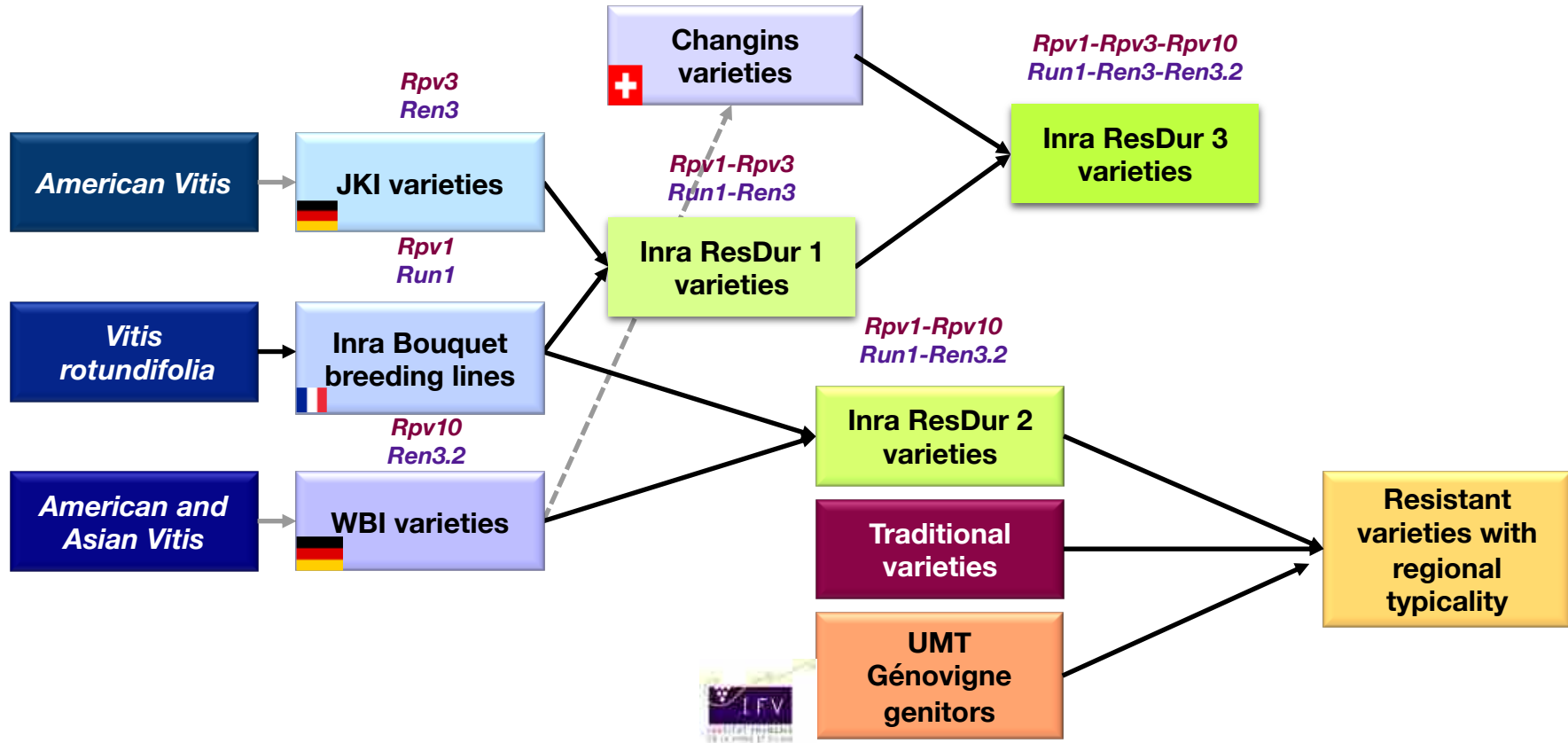
- **RES** : resistant variety - **Artaban**
- **INT** : low-input phytosanitary protection - **Merlot**
- **BIO** : organic winegrowing- **Merlot**

No damage on bunches with RES; damage caused by DM with BIO and INT
No pesticides residues with RES; very weak detection with INT and BIO
No organoleptic defects on wines

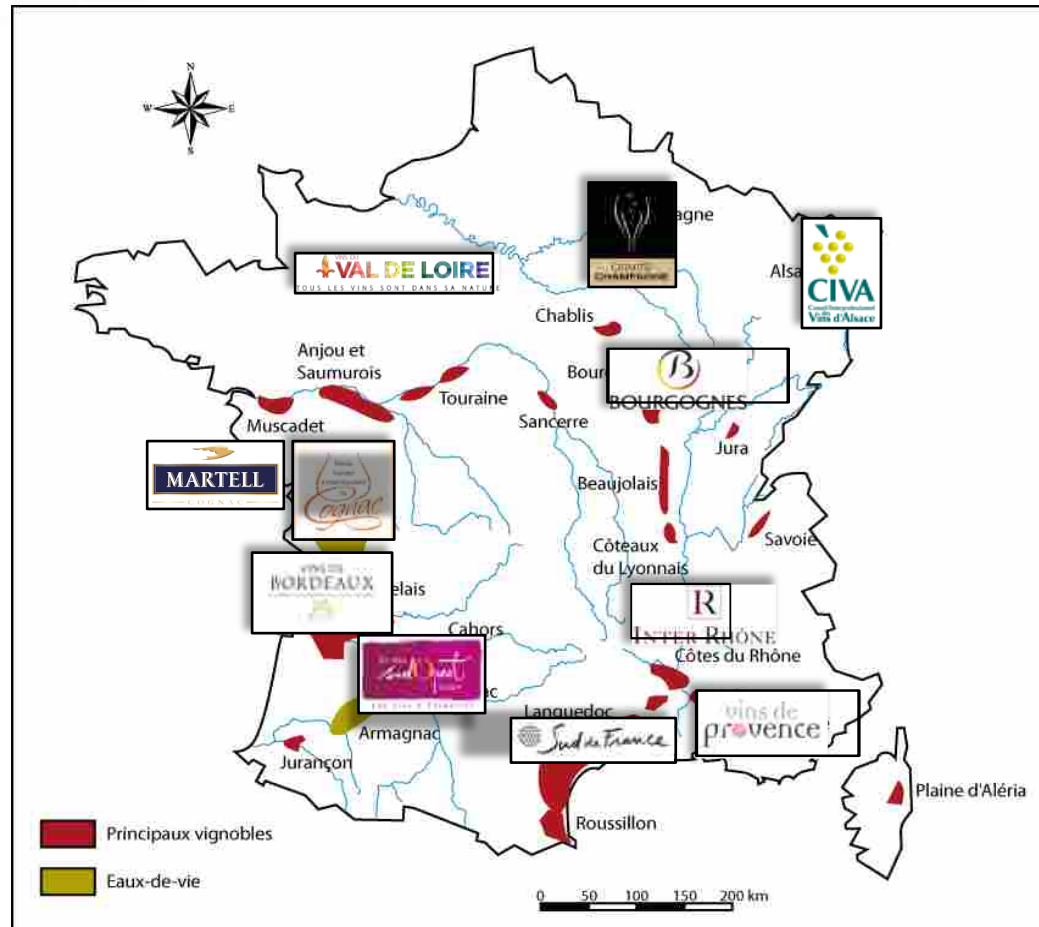


Toward breeding of resistant varieties with regional typicality

Developed in partnership with **regional wine committees**



Developed in partnership with the regional wine committees



- **Resistant varieties** to downy and powdery mildews are an alternative to the use of fungicides
- Resistance factors are **a limited resource**
- Resistance gene **breakdowns** have already been observed
- A breeding program is **a long-term and costly process**
- **Pyramiding** resistance factors is an efficient strategy to increase **resistance durability**
- Promotion and dissemination of these varieties will be ensured under **the ENTAV-INRA[®] trademark**



- **Improve** resistance durability
- **Improve the breeding methods** and the exploitation of genetic resources
- Integrate resistance **to other pathogens**
- Integrate traits for adaptation **to climate change**

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Thank you for your attention

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