



## Worldwide view of breeding for disease resistant grapevine varieties

**Not an exhaustive presentation !  
Only few examples and challenges to face**

Laurent Audeguin

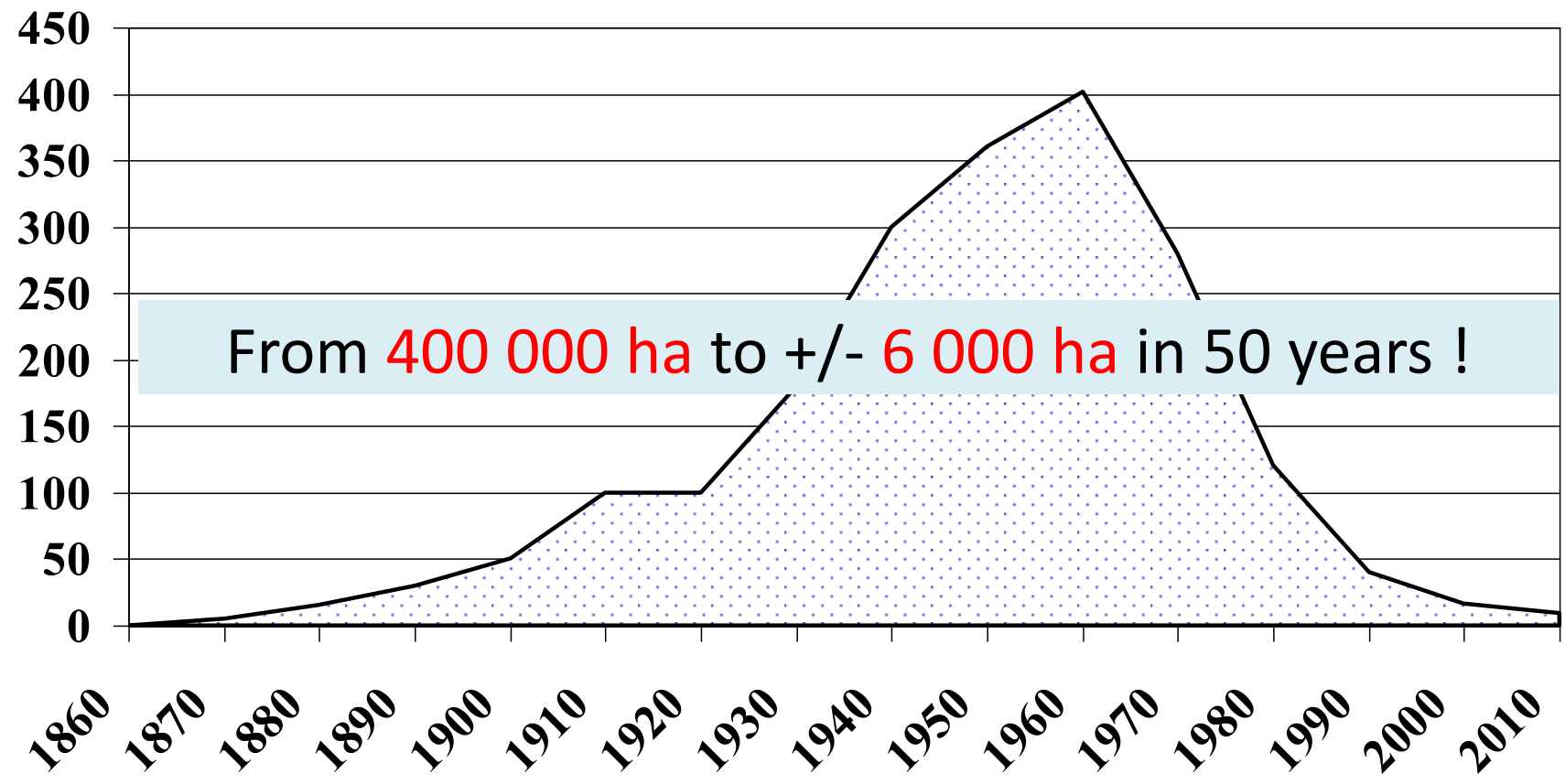
*IFV, UMT Geno-Vigne®, F-34060 Montpellier, France*

Geno  Vigne®

- What do we mean by Resistance ?
  - Biotic stresses (PM, DM, PD, phylloxera, nematodes...)
  - Abiotic stresses (cold hardiness, drought, lime...)
- A bit of History
- For : Wine industry , Table Grape, Juice, Rootstocks...
- Current programs : kind of 360° but not an exhaustive one!
- « Go » vs « No go » ? What's next ?

- US Hybrids : > 1800
- > 1860: Phylloxera, Powdery Mildew, Downy Mildew... :
  - Rootstocks
  - Hybrids : « HPD »
  - Private breeders +++
- 20th Century > 1950
  - Rootstocks +
  - Varieties +++ : production (+++), quality : intra-specific breeding programs mainly (eg : Marselan, Dornfelder...)
  - Public breeders +++

- French vineyards : evolution of « HPD »



Source : Jean-Michel Boursiquot

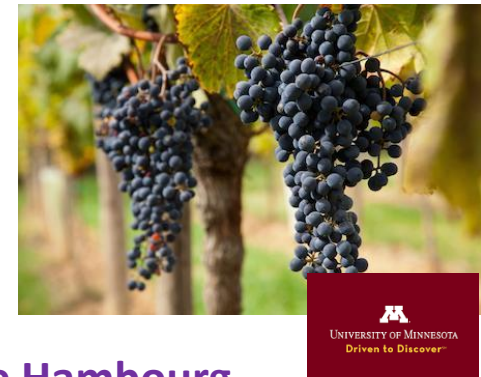
# “Legacy” of 1<sup>st</sup> generation of Hybrids ! Specific characteristics and Use

## Frontenac : *V. riparia* 89 x Landot 4511

University of Minnesota

Cold hardiness : -30°C

Very disease resistant, with near-immunity to downy mildew



## La Crescent : St. Pepin x Swenson selection from *V. riparia* x Muscat de Hambourg

University of Minnesota

Cold hardiness : -30°C

Moderately disease resistant



## Vidal 256 : Ugni blanc x Rayon d’Or

Canada (Ontario +++)

Cold hardiness

Production of ice wines



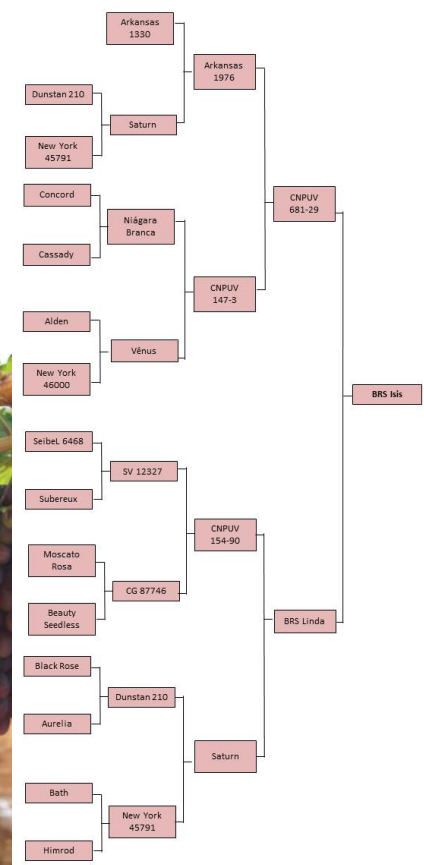
## Brazil : Table grape and Juice



**Niagara :**  
Concord X Cassady  
*V labrusca* x *V vinifera* (1868)



**BRS Isis :**  
Red seedless table grape  
Tolerant to downy mildew  
High yields, berries of natural big size and uniform color, even without chemical treatments.



- “Second generation ” of breeding programs ~ 70’s – 80’s

*Vitis amurensis* – Hybrids x *V Vinifera*

Germany :

eg : WBI Friburg : Bronner, Solaris (1975), Souvignier gris (1983), Prior (1987)....

*Muscadinia rotundifolia* (Run1, Rpv1)

INRA Alain Bouquet, > 1970

From Malaga x *M rotundifolia* to BC5 (and now BC6) using different *V vinifera* at each generation. INRA UE Pech Rouge



- **Western Europe :**

- Italy 10 000 ha
- Portugal 8 000 ha
- Spain 4 000 ha
- Germany 3 000 ha
- Switzerland 400 ha

- **Eastern Europe :**

- Romania 90 000 ha
- Ex USSR 80 000 ha
- Hungary 20 000 ha
- Ex Yugoslavia 20 000 ha
- Bulgaria 15 000 ha

- **Asia :**

- Japan 15 000 ha
- Korea 15 000 ha
- China 10 000 ha
- India 5 000 ha

- **America :**

- USA 50 000 ha
- **Brazil 45 000 ha**
- Canada 5 000 ha
- Uruguay 4 000 ha



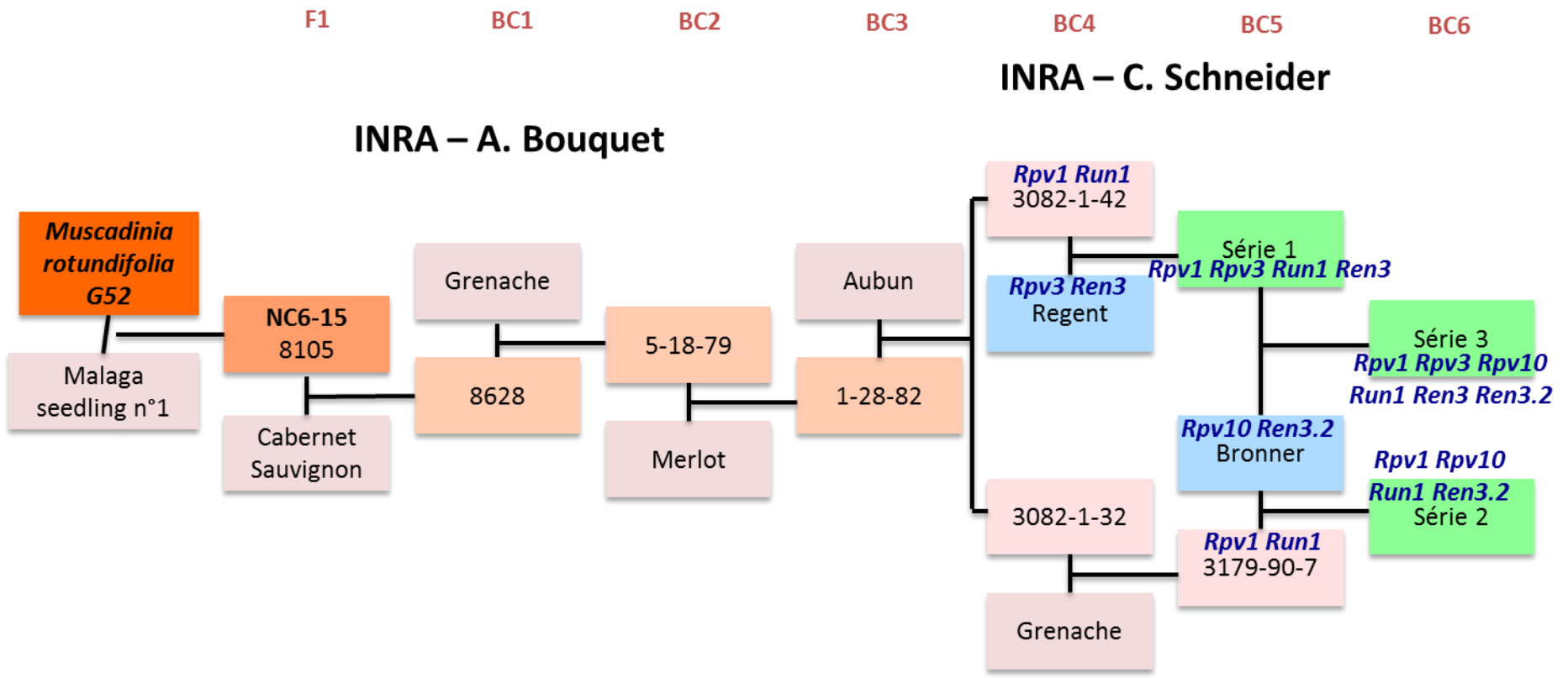
- **To sum up :**

- Juice production : Brazil +++
- Table grape : Brazil and United States of A.
- Cold hardiness : United States of A. (NE) and Canada
- Other specific productions : Ice wines (Canada)
- “Old” vineyards (Eastern Europe)

- **“Third generation” of breeding programs since 2000**
  - Identification of traits and alleles relevant for breeding  
<http://www.vivc.de> (PM : 10 +/-, DM : 15+/-)
  - Genome sequence in 2007
  - Introgression
  - Selection assisted by markers (MAS)
  - Pyramiding



# Example of INRA Resdur Programs



# INRA RESDUR 1 : Submission for 2017 registration



**INRA BC4 Muscadinia x Regent**

# INRA RESDUR 1 : Submission for 2017 registration



**INRA BC 4 Muscadinia X Regent**

# INRA RESDUR 1 : Submission for 2017 registration



**INRA BC 5 Muscadinia X Villaris**

# INRA RESDUR 1 : Submission for 2017 registration



**INRA BC 5 Muscadinia X Villaris**

# Breeding programs in Australia



Mark Thomas, Ian Dry, Peter Clingeleffer

- CSIRO AGRICULTURE AND FOOD





## CSIRO : main (only) research institution in Australia breeding new grapevine varieties

- Scions and rootstocks for 3 industries
  - wine
  - table grape
  - dried fruit

### Industry focus :

- Reduced inputs & costs
- Quality product
- Resilience to climate change
- Environmental sustainability



Research supported by industry:  
Wine Australia  
Horticulture Innovation Australia (HIA) – table and dried fruit industries

## Scions (wine, table, dried fruits), Traits of Interest

- Powdery Mildew and Downey Mildew resistance
- Yield
- Fruit composition and wine quality
- Better suited to Australian conditions (climate change)

## Origin of new traits

### Biotic resistance and abiotic tolerance :

- American species
  - *Muscadinia rotundifolia* (mildew resistance, e.g. RUN1)
  - *Vitis amurensis* (mildew resistance)
  - *Vitis cinerea* (root pest resistance)
  - *Vitis berlandieri*
  - Complex hybrids
- Asian species
  - *Vitis romanetti* (mildew resistance)
  - *Vitis piasezkii* (mildew resistance)



Long-term focus is durable resistance – trait stacking from different species

## Strategy for scions and rootstocks

Changed from traditional breeding to marker-assisted selection (MAS) to improve the process



**Stage 1:** Breeding of new selections

**Stage 2:** Field performance, fruit and wine evaluation of new selections and existing varieties ( >5,000 since 2010 )

**Stage 3:** Identification of superior selections for further evaluation and regional trials ( >800 )

**Stage 4:** Small scale testing with interested companies

**Stage 5:** Commercial release

## Wine industry challenges for new scion adoption

### How to market new varieties?

- variety label or non-varietal label (winery, region)
- no marketing, just use in blending

### Timeframe for adoption?

- May depend on enterprise size and risk versus benefits
  - slow with increasing scale to reduce risk (20-30 years)?
  - fast with higher risk (10-20 years)?

## Breeding programs in USA

- Resistance to **PM&DM**, Cornell University



Cornell University

- Released 2013
- First identified 2001
- Tested in “no-spray” vineyards
- Highly disease resistant – PM, DM, Botrytis
- Harbors *Ren2*
- Cold hardiness : 25 C
- Upright growth habit
- Wines : densely colored, light to moderate tannins

## Breeding programs in USA

- Resistance to PM&DM, Cornell University



Disease resistant red wine grape

Highly resistant to downy mildew, powdery mildew and black rot

It harbors loci Rpv1, Run1, and Ren2.

**NY06.0514.06**

## Breeding programs in USA

- Resistance to **PM&DM**, Cornell University



NY12.0107. (2012)

Selected with markers for **Run1, Rpv1 and Ren2**

Cluster and vine characteristics suitable  
**Flavor free of wild species characteristics**

To be propagated for wine trials in the next future

**NY12.0107**



## Breeding programs in USA

**07355-075**



Source : Andy Walker

- Resistance to **Pierce Disease**, UC Davis

Source : PDR1 (*Vitis arizonica*)

50% Petite Sirah, 25% Cab-Sauvignon

Early bloom, early ripening

Relatively large berries, medium large clusters

Medium productivity

## Breeding programs in USA

- Resistance to **Pierce Disease**, UC Davis

Source : PDR1 (*Vitis arizonica*)

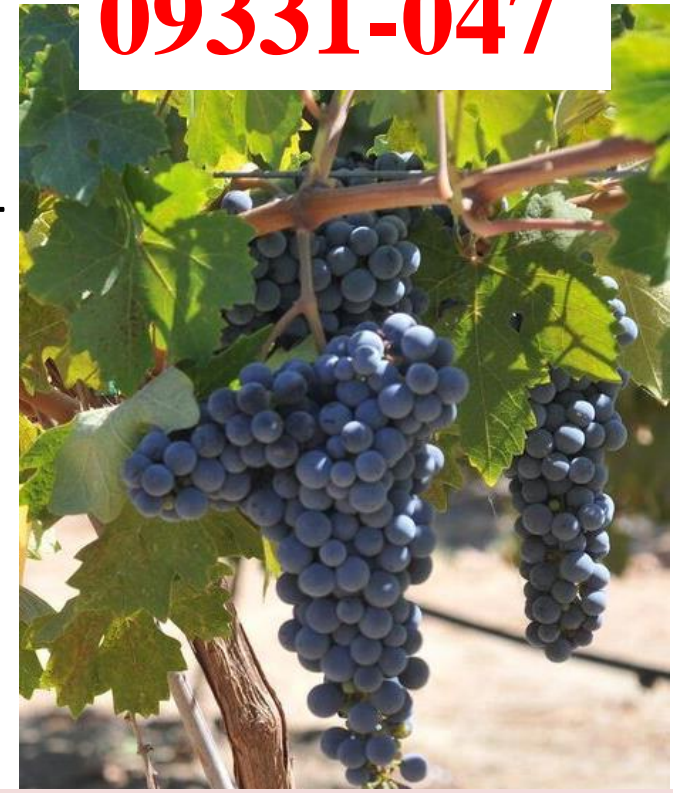
50% Zinfandel, 25% Durif, 12.5% Cab-Sauvignon

Late bloom, mid-season ripening

Relatively large berries, large clusters

Moderate-low productivity

**09331-047**



Source : Andy Walker

## Breeding programs in USA

- Resistance to DM, Botrytis, MSU, Chin-Feng Hwang

Downy mildew, Botrytis Bunch Rot, Rooting ability

Sources of resistances: *Vitis aestivalis*-derived 'Norton'

Agenda : ?

Number of genotypes under evaluation :  
~250 F1 of Norton x Cabernet-Sauvignon

Release Norton-based cultivars for wine industry



## Breeding programs in USA

- **Private sector**

Continuous improvement of fruit and wine quality, including **wine grape sector (Gallo)** and **table grape sector (IFG)**.

Schedule for the introduction or adoption of improved plant material : **challenging to delineate**. Because of continuous improvement !

Shared aspects for disease resistance breeding and clonal improvement : selection and evaluation for **freedom from bunch diseases, such as botrytis bunch rot and sour rot**.

*“Compact clusters = bunch diseases. Strong interest of new plant materials with loose clusters”*. P Cousins. Gallo



## Breeding programs in South Africa

### Mainly Table grape, just starting for wine industry

Mostly focused on Downy and Powdery mildew.

Low resistance in good quality table grapes then using wine grapes to introduce resistance in table grape program

Resistance donors : mainly “older” French-hybrids like Villard Blanc and Villard Noir, Chambourcin, etc) and newer cultivars like Regent and then also Kishmish Vatkana,...

Use of SSR markers

In process of pyramiding genes : off-spring in greenhouses being screened for Rpv3, Ren3 and Ren1. (Villard Blanc x Red Globe) times Kishmish Vatkana

Very recently : crosses for wine grapes, but no vines are in the fields yet.

Source : Phyllis Burger

## What's going on in New Zealand ?

Recent slight move toward research in Grapevine genetics mostly driven by **Plant and Food research**

Work driven by researchers rather than NZW.

Current work based around **creating a “Mutant population”** by exposing cell tissue to chemical stress and causing some mutations

Plan to grow **40,000** of these “mutant” plants most likely half Sauvignon Blanc and half Pinot Noir and screen these vines for desirable traits like disease tolerance

The researchers view this as fast forwarding clonal selection.

*“Pretty random and untargeted way” ?*

Source : Nick Hoskins, Riversun Nursery



## And Chile ?

No breeding program known for fungi resistance ?

**INIA La Platina in Santiago :**

**Working on Genome editing...**

Just setting up the technique aiming to work with table grapes mostly

Primary focus of the group : Botrytis



Source : Yerko Moreno, Universidad de Talca, CTV .

## And Europe ?

- **Main actors** : public institutes, semi-public institutes, private breeders
  - **Germany** : Geisenheim, Julius Kühn Institut, WBI
  - **Switzerland** : Agroscope Changins, V Blattner
  - **Italy** : Istituto de Genomica Applicata, CRA-VIT Conegliano
  - **France** : INRA, IFV
  - **Hungary** : Szőlészeti es Borászati Kutatóintezet (SZBKI) Pécs



**General strategy : Pyramiding** (sources : Vitis US, Muscadinia, Vitis amurensis, Kishmish vatkana)

Source : Les Cépages résistants, ICV



## New French programs

### Wild species

- ✓ Resistant to fungi diseases (2 QTLs PMDM)
- ✗ Defaults : growing aptitudes and wines -

### V. vinifera

- ✓ Quality and « Typicity »
- ✗ Susceptible to fungi diseases



### New genotypes

- ✓ Resistant to PM and DM
- ✓ Sustainable rsesistance
- ✓ Adapted to winegrowing regions
- ✓ Adaptated to Climate Change

### ➤ Champagne + Burgundy - CIVC-BIVB

Pinot, Chardonnay, Gouais X GENOTYPE RESISTANT (2 or + QTLs PM DM)

### ➤ Cognac - BNIC

Ugni blanc, Folle Blanche, Colombard, Folignan X GR

### ➤ Bordeaux - CIVB

Cabernet franc, Petit Verdot, Carmenère X GR

### ➤ Rhone Valley – Inter-Rhône

Grenache, Syrah X GR

### ➤ Rosés - CIVL CIVP Centre des rosés (EDGARR, Genomic selection)

Vermentino, Cinsaut X GR

### ➤ And also in 2016 : Alsace, Martell

### ➤ Raisin de Table

Muscat d'Alexandrie, Centennial Seedless, Alphonse Lavallée X GR

Starting in 2013/2014.....Official Releases = expected > 2028

- To conclude :
  - Faster changes and development for Table grape and Juice / Wine industry
  - Variable interest and involvement / countries (environmental conditions, market,....)
  - but +/- all wine countries involved now !
  - Recent growing demand in France
  - Health issues and economical issues
  - Public powers to encourage the movement

- What's next ?
  - Sources of resistance : non renewable resources ?
  - Nature vs Emptiness : other fungi diseases ?
- Recommendation for a minimum spraying / regions
- Observatory of sustainability (INRA UMR SAVE + IFV)
- Limited and controlled development of « Run Material » (Bouquet cultivars) for Juice and ...other use ?

## OIV resolution – June 2013

### Considering :

- PM and DM : +++ diseases at a world scale
- Efforts of introgression
- Risks of break down
- Recent improvement (ie : MAS)



### Recommends :

- Obtaining new material carrying more than one QTL
- Appropriated spraying programs to protect sources of resistance

## Taxonomy

### AOC EU regulation: *Vinifera* exclusively

- **Extrait du règlement européen 1308-2013, article 93 :**
- 1. Aux fins de la présente section, on entend par :
  - a) "appellation d'origine", .....
  - i) sa qualité et ses caractéristiques sont dues essentiellement ou exclusivement à .....
  - ii) il est élaboré exclusivement à partir de raisins provenant de .....
  - iii) sa production est limitée à la zone géographique considérée .....
  - iv) **il est obtenu exclusivement à partir de variétés de vigne de l'espèce *Vitis vinifera***

- What's next ?

- New “conditions” in France

Since **May 2016**, « opening » of Official Catalogue to new material for temporary registration

DUS done : 20 ha x 10 max in France

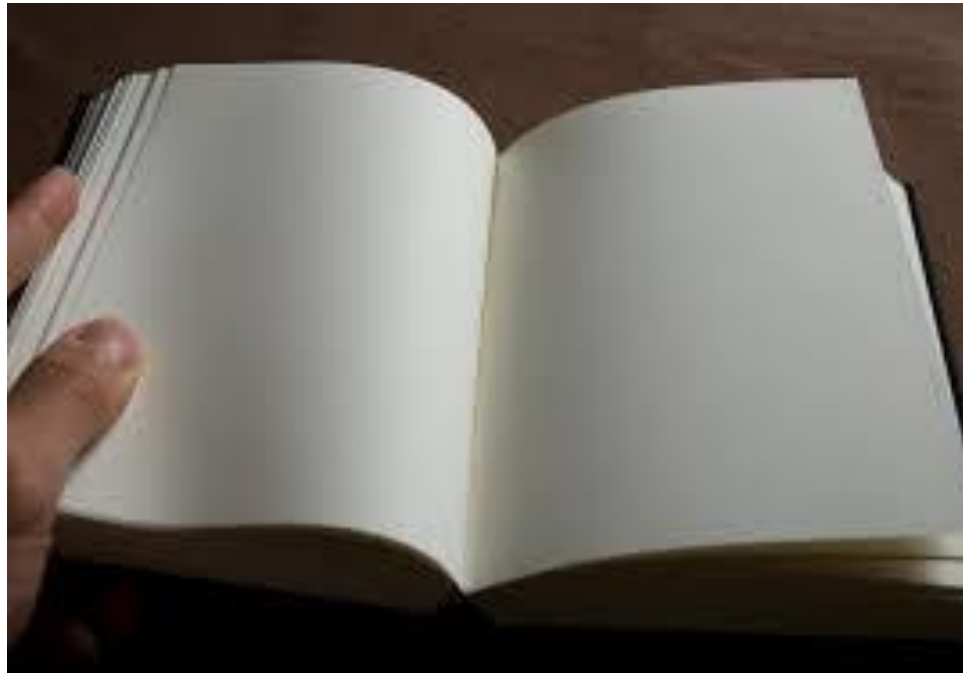
DUS not yet completed : 3 ha max in France

Demands being currently **evaluated** by Ministry of Agriculture for **25+ varieties**, eg : **Souvignier gris, Prior, Monarch (D), Divico, Pinotin (CH), Soreli, Fleurtaï (I)....**

- What's next ?
  - First round of new material : transitional, 85/15 ?
  - Climate change ?
  - Adoption by consumers ?
  - On the long run ? (eg : French program with winegrowers associations)
  - New technologies :
    - Routine use of screening with markers (MAS)
    - High throughput tools (genotyping + phenotyping), GBS
    - Genome Editing : Feasibility, GMOs or « hidden » GMOs or not ?



## Worldwide view of breeding for disease resistant grapevine varieties





Special thanks to :

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**And apologies for those I did not mention !**