



SEMINÁRIO

Variedades resistentes,
alternativa aos fungicidas?

REFLEXÃO

Vineyards without pesticides for quality wines: results and perspectives for the world's vineyards. French approach

Hernán Ojeda

INRA

Unité Expérimentale de Pech Rouge,
Unité Expérimentale du Domaine de Vassal

hernan.ojeda@inra.fr



Unité Expérimentale de PECH ROUGE
INNOVATION, DIVERSIFICATION et DURABILITÉ
en VITICULTURE et ŒNOLOGIE
<http://www.montpellier.inra.fr/pechrouge>





French context for the use of pesticides in viticulture :

- ☑ Almost all of the French vine is *Vitis vinifera*
- ☑ 259 varieties registered in the French catalog
- ☑ 15 varieties represent 85% of all the vineyard
- ☑ Viticulture uses 3% of the agricultural surfaces and 20% of pesticides, of which 80% corresponds to fungicides
- ☑ Ecophyto (I and II) plans which aim to reduce the use of pesticides by 25% in 2020 and 50% in 2025.



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French context for the use of pesticides in viticulture :

- ✓ Almost all of the French vine is *Vitis vinifera*
- ✓ 259 varieties registered in the French catalog
- ✓ 15 varieties represent 85% of all
- ✓ Viticulture uses 30% of pesticides and 20% of

For the vine, these objectives will not be achieved only by changes in agricultural practices!

and II) plans which aim to reduce the use of pesticides by 25% in 2020 and 50% in 2025.



Strategy options for reducing the use of agrochemicals in viticulture

| Level | Situation | Types of viticulture |
|-------|---|---|
| L0 | Without limitation of use of agrochemicals | Intensive Viticulture |
| L1 | Agrochemicals limitation using models to establishing risk thresholds | Reasoned Viticulture |
| L2 | L1 more the use of prophylactic and alternative methods | Integrated Viticulture |
| L3 | No synthetic plant protection products (copper and sulfur authorized) | Organic Viticulture Biodynamic Viticulture |
| L4 | Without any pesticides or fungicides (use of resistant varieties) | Smart Viticulture ? Sustainable viticulture? |



Strategy options for reducing the use of agrochemicals in viticulture

| Level | Situation | Types of viticulture |
|---|--|---|
| L0 | Without limitation of use of | Intensive Viticulture |
| <p>“Phylloxera was defeated by the use of American vines and not by the carbon disulfide; chlorosis by rootstocks resistant to calcareous rather than iron sulphate; downy mildew will be overcome, in the short or long term, by resistant hybrid varieties and not by the copper”</p> <p><i>Georges Couderc (nurseryman), Montpellier Congress 1911</i></p> | | |
| L3 | Without synthetic plant protection products (copper and sulfur authorized) | Organic viticulture Biodynamic Viticulture |
| L4 | Without any pesticides or fungicides (use of resistant varieties) | Smart Viticulture ? Sustainable viticulture? |



The varietal resistance as a sustainable solution

- ☑ first generation of hybrids called "direct producers" (HPD) strongly tolerant to downy and powdery mildew (end of XIXth)
- ☑ second generation of HPD called "French Hybrids"
(400.000 ha in 1958 (30% of the vineyard) → 6000 ha in 2017)
- ☑ improving the quality of Franco-American hybrids in Germany, Switzerland, Hungary, Italy...



Main resistant / tolerant varieties created since 1950 in Europe

| | |
|--------------------------------|--|
| Germany, Geilweilerhof | Regent, Phoenix, Sirius, Staufer, Orion, Villaris, Felicia, Calandro, Reberger |
| Germany, Freiburg | Merzling, <u>Johanniter</u> , <u>Bronner</u> , <u>Solaris</u> , <u>Cabernet Cortis</u> , <u>Monarch</u> , Cabernet Carol, Cabernet Carbon, Helios, <u>Prior</u> , <u>Muscaris</u> , <u>Sauvignier Gris</u> |
| Germany, Geisenheim | Rondo, Prinzipal, <u>Saphira</u> |
| Hungary | Bianca, Zalagyöngye, Kunleány, Kunbarat, Refren, Fanny, Hongrie Lilla, Jasmine... |
| Switzerland, ACW Chavignin | Gamaret, Galotta, Garonnoir, Diolinoir, Mara, Carminoir, <u>Divico</u> |
| Switzerland, Blatter y Borioli | <u>Cabernet Jura</u> , <u>Pinotin</u> , <u>Cabertin</u> , <u>Cabernet blanc</u> , <u>Cabernet Noir</u> ... |
| Austria | Aromera, Vinett, Rathay, Roesler, Donauriesling, <i>Vinera</i> , <i>Vinore</i> |
| Czech Republic | Malverina, Jolanka, Nativa, Cerason, Laurot, Savilon, Sevar.... |
| Romania | Admira, Andrevit, Brumariu, Purpuriu, Radames, Valeria.... |
| Moldova | Alb de Laloveni, Apiren roz, Arkadia, Fesztivalnyj, Lyana, Moldova.... |
| Serbia | Aranka, Evita, Kozmopolita, Mila, Panonia.... |
| Italy, Udine Uni. /IGA | <u>Sauvignon Kretos</u> , <u>Fleurtai</u> , <u>Julius</u> , <u>Soreli</u> , <u>Cab. Volos</u> , <u>Merlot Kanthus</u> , <u>Merlot Khorus</u> , <u>Sauvi. Nepis</u> , <u>Sauvi. Rytos</u> , <u>Cab. Eidos</u> ... |



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- ☑ second generation of HPD called "French Hybrids"
(400.000 ha in 1958 (30% of the vineyard) → 6000 ha in 2017)
- ☑ improving the quality of Franco-American hybrids in Germany, Switzerland, Hungary, Italy
- ☑ the new hybrids from INRA France from *Muscadinia rotundifolia* (Bouquet varieties) and *M. rotundifolia* x other *Vitis* (Resdur varieties)



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The varietal resistance as a sustainable solution



Vitis sp

Muscadinia rotundifolia





List of QTL and resistance genes for downy mildew published ***(S. Blanc 2012, Merdinoglu 2016)***

| Gen | Origin | Chromosome localization | Resistance level | Reference |
|---------------|----------------------------------|-------------------------|------------------|--|
| <i>Rpv 1</i> | <i>M. rotundifolia</i> | 12 | Partial high | Merdinoglu et al 2003 |
| <i>Rpv 2</i> | <i>M. rotundifolia</i> | 18 | Total | Wiedemann-Merdinoglu et al 2006 |
| <i>Rpv 3</i> | <i>V. rupestris</i> (cv Bianca) | 18 | Partial | Bellin <i>et al.</i> 2009, Welter et al 2007 |
| <i>Rpv 4</i> | Am. <i>Vitis</i> (cv Regent) | 4 | Partial weak | Fisher <i>et al.</i> 2004; Welter <i>et al.</i> 2007 |
| <i>Rpv 5</i> | <i>V. Riparia</i> G.M. | 9 | Partial weak | Marguerit <i>et al.</i> 2009 |
| <i>Rpv 6</i> | <i>V. Riparia</i> G.M. | 12 | Partial weak | Marguerit <i>et al.</i> 2009 |
| <i>Rpv 7</i> | American <i>Vitis</i> | 7 | Partial weak | Bellin <i>et al.</i> 2009 |
| <i>Rpv 8</i> | <i>V. amurensis</i> | 14 | Partial high | Blasi <i>et al.</i> 2011 |
| <i>Rpv 9</i> | <i>V. Riparia</i> G.M. | 7 | Partial weak | Moreira et al 2011 |
| <i>Rpv 10</i> | <i>V. Amurensis</i> (cv Solaris) | 9 | Partial high | Schawander <i>et al.</i> 2011 |
| <i>Rpv 11</i> | American <i>Vitis</i> | 5 | Partial weak | Fischer et al 2004 |
| <i>Rpv 12</i> | <i>V. amurensis</i> | 14 | Partial high | Venuti et al 2013 |
| <i>Rpv 13</i> | <i>V. Riparia</i> | 12 | Partial weak | Moreira et al 2011 |
| <i>Rpv 14</i> | <i>V. cinerea</i> | 5 | Undetermined | Ochssner et al 2016 |

Rpv by resistance to *Plasmopara viticola*



List of QTL and resistance genes for powdery mildew published (S. Blanc 2012, Merdinoglu 2016)

| Gen | Origin | Chromosome localization | Resistance level | Reference |
|---------|---|-------------------------|------------------|---|
| Run 1 | <i>M. rotundifolia</i> | 12 | Total | Pauquet <i>et al</i> 2001; Donald <i>et al</i> 2002; Barker <i>et al</i> 2005 |
| Run 2.1 | <i>M. rotundifolia</i> | 18 | Partial | Riaz <i>et al</i> 2011 |
| Run 2.2 | <i>M. rotundifolia</i> | 18 | Partial | Riaz <i>et al</i> 2011 |
| Ren 1 | <i>V. vinifera</i> cv Kishmish vatkana | 13 | Partial | Hofmann <i>et al</i> 2008 |
| Ren 2 | <i>V. cinerea</i> | 14 | Partial | Dalbo <i>et al</i> 2001 |
| Ren 3 | Am. Vitis (cv Regent, Villard B) | 15 | Partial | Fisher <i>et al</i> 2004; Akkurt <i>et al</i> 2007; Welter <i>et al</i> 2007 |
| Ren 4 | <i>V. romanetii</i> | 18 | Partial | Ramming <i>et al</i> 2010; Riaz <i>et al</i> 2010 |
| Ren 5 | <i>M. rotundifolia</i> | 14 | Total | Blanc <i>et al</i> 2012 |
| Ren 6 | <i>V. Piasezkii</i> | 9 | Total | Pap <i>et al</i> 2016 |
| Ren 7 | <i>V. Piasezkii</i> | 19 | Partial | Pap <i>et al</i> 2016 |
| Ren 8 | American Vitis | 18 | Partial | Zyprian <i>et al</i> 2016 |

Run by resistance to *Uncinula necator* and later **Ren** by resistance to *Erysiphe necator*

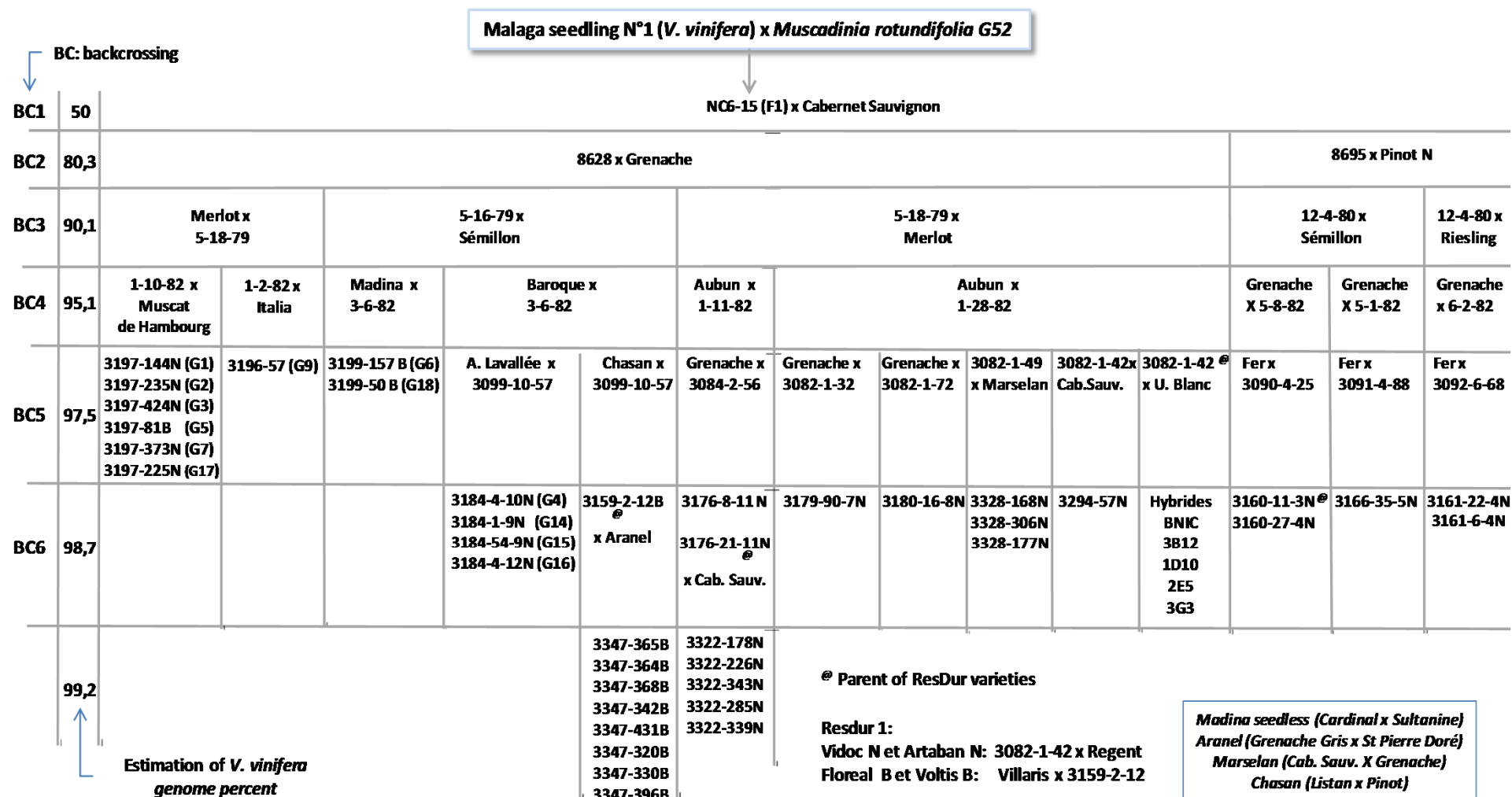


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Diagram for the creation of powdery and downy mildew tolerant varieties from inter-specific crosses between *Vitis vinifera* x *Muscadinia rotundifolia* by Alain Bouquet.



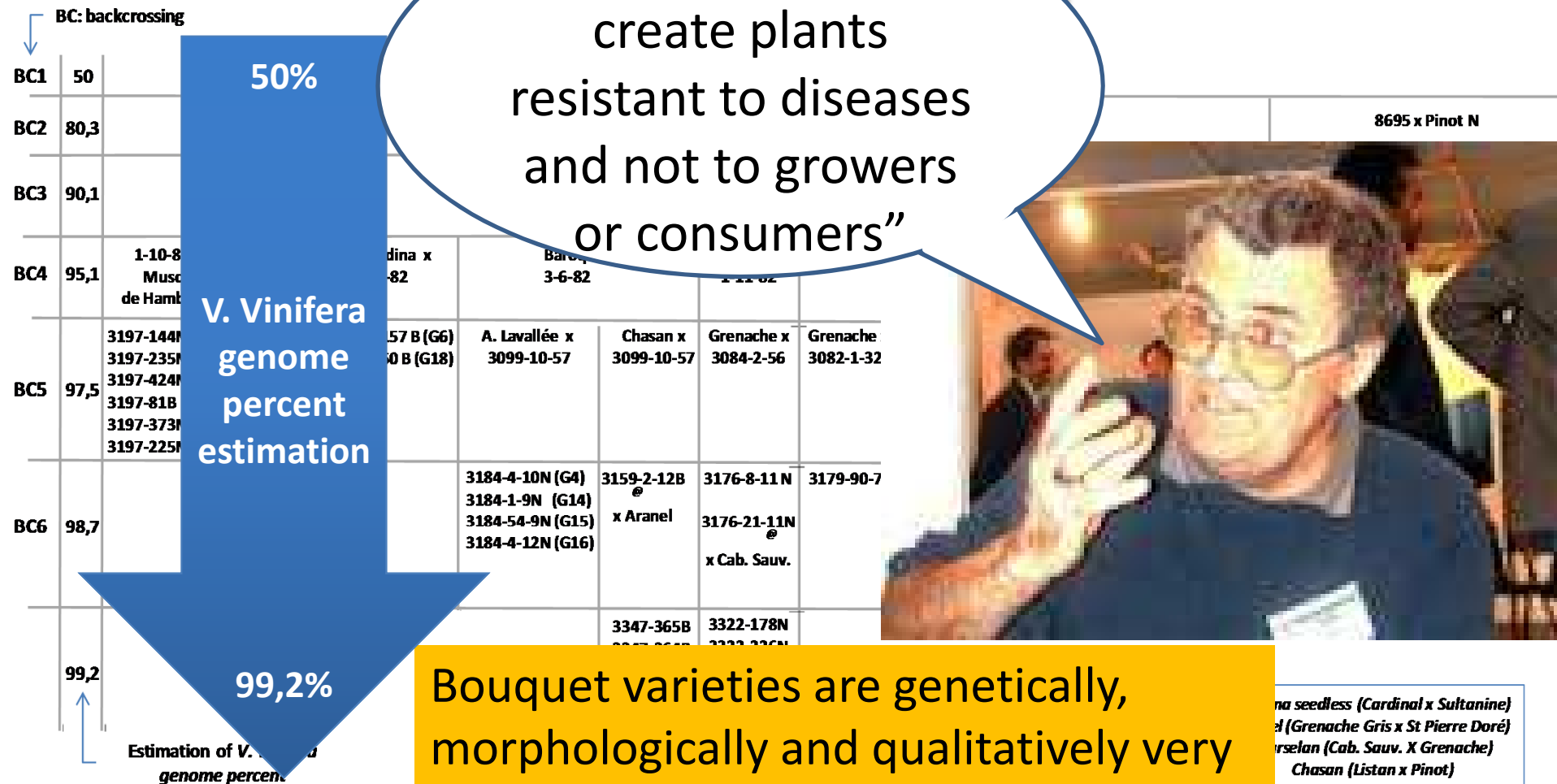


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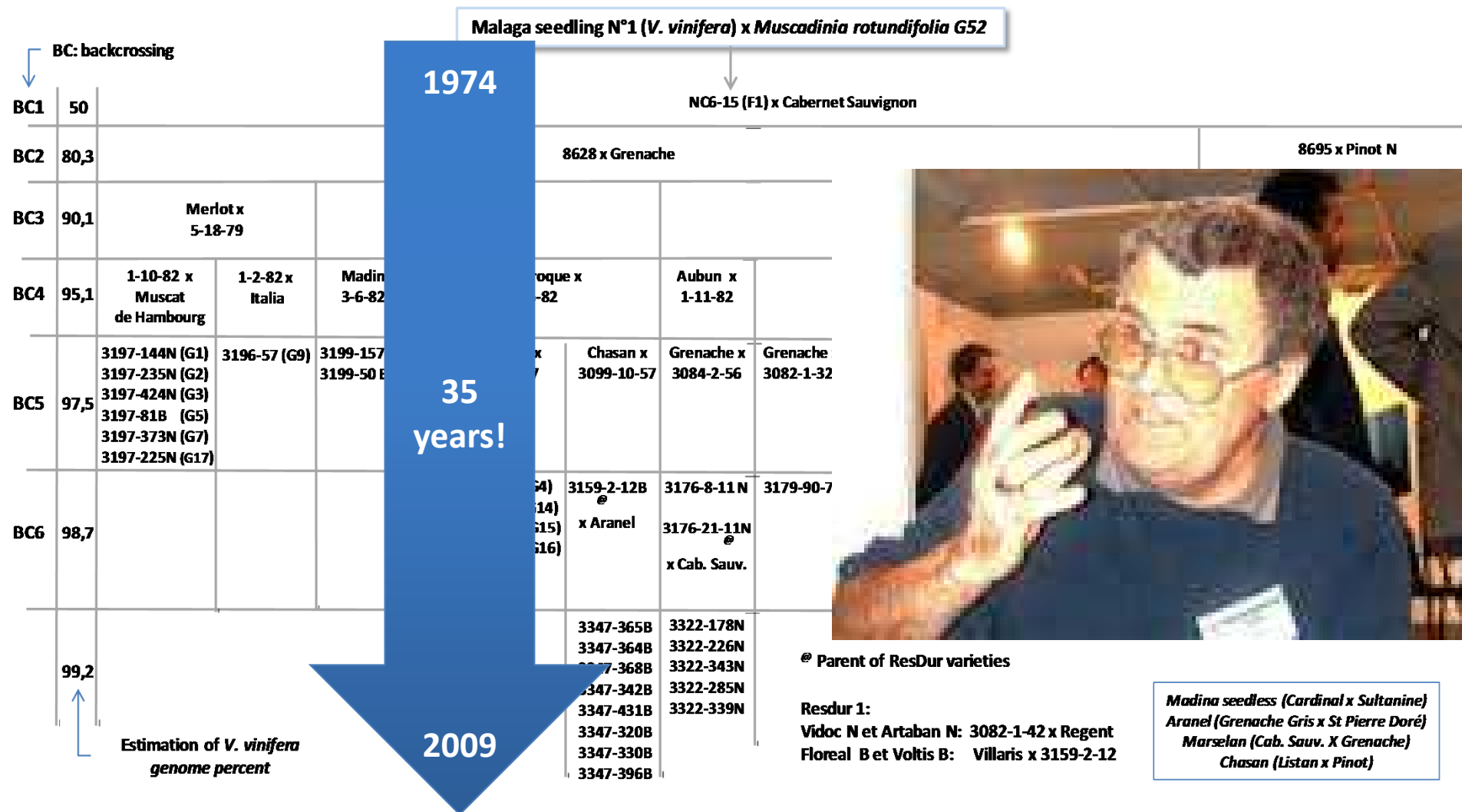


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Diag
spec

f pow
itis vir

y tolerant varieties from inter-
undifolios



Malaga seed

G52

16-79 x
émillon

Baroque
3-6-82

bun x
8-82

30 x
ng

che
32

68

| | | | | | | | | | | | |
|------------------|------------|--------------|------------|------------|------------|------------|----------|-------------|------------|------------|--|
| B (G6) | Lavallée x | Chasan x | Grenache x | Grenache x | Grenache x | 3082-1-49 | 3082-1- | | | | |
| 3 (G18) | 3099-10-57 | 3099-10-57 | 3084-2-56 | 3082-1-32 | 3082-1-72 | x Marselan | Cab.Sauv | | | | |
| 3184-4-10N (G7) | 3159-2-12B | 3176-8-11 N | 3179-90-7N | 3180-16-8N | 3328-168N | 3294-57N | Hybrides | 3160-11-3N® | 3166-35-5N | 3161-22-1N | |
| 3184-1-9N (G14) | @ | @ | | | 3328-306N | | NIC | 160-27-4N | | 3161-6-4N | |
| 3184-54-9N (G15) | x Aranel | 3176-21-11N | | | 3328-177N | | 3B12 | | | | |
| 3184-4-12N (G16) | | x Cab. Sauv. | | | | | 1D10 | | | | |
| | | | | | | | 2E5 | | | | |
| 3347-365B | 3322-178N | | | | | | | | | | |
| 3347-364B | 3322-226N | | | | | | | | | | |
| 3347-368B | 3322-343N | | | | | | | | | | |
| 3347-342B | 3322-285N | | | | | | | | | | |
| 3347-431B | 3322-339N | | | | | | | | | | |
| 3347-320B | | | | | | | | | | | |
| 3347-330B | | | | | | | | | | | |
| 3347-396B | | | | | | | | | | | |

Resdur 1:
Vidoc N et Artaban N: 3082-1-42 x Regent
Floreale B et Voltis B: Villaris x 3159-2-12

Traditional wines

Madina seedless (Cardinal x Sultanine)
Aranel (Grenache Gris x St Pierre Doré)
Marselan (Cab. Sauv. X Grenache)
Chasan (Listan x Pinot)

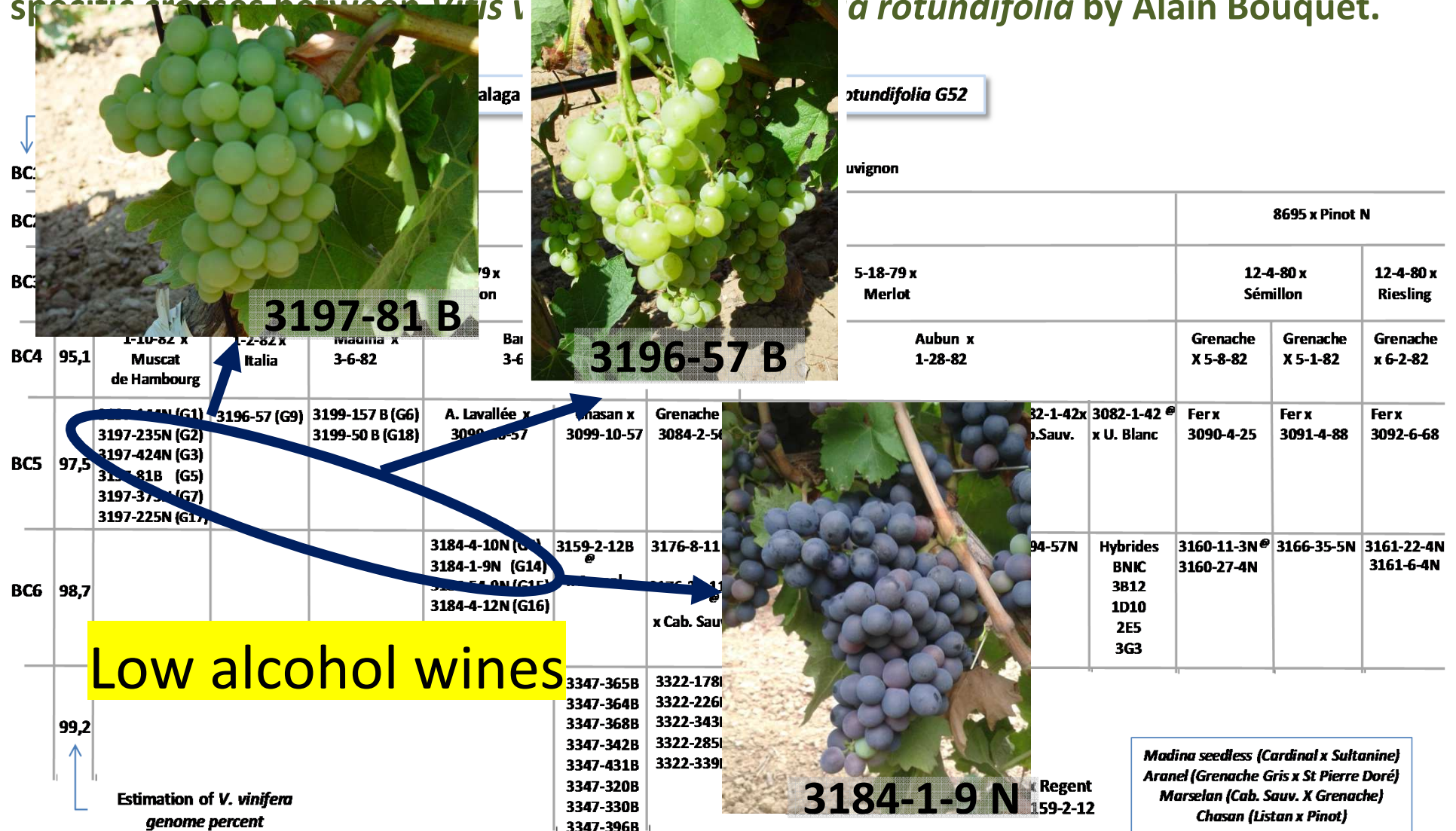


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Vineyards without pesticides for quality wines: results and perspectives for organic vineyards. French approach

Diagram
specific

powdery a
s vinifera

tolerant varieties from inter-
difolia by Alain Bouquet.

BC: backcro

BC1 50

BC2 80,3

BC3 90,1

BC4 95,1

BC5 97,5

BC6 98,7

99,2

Estimation of *V. vinifera*
genome percent



2E5

aga seedling N°1 (

8628 x Gren

Baroque
3-6-82



3G3

Aubun x
1-11-82

Aubun x
1-28-82

8695 x Pinot N

12-4-80 x
Sémillon

12-4-80 x
Riesling

Grenache
X 5-8-82

Grenache
X 5-1-82

Grenache
x 6-2-82

3197-144N (G1)
3197-235N (G2)
3197-424N (G3)
3197-81B (G5)
3197-373N (G7)
3197-225N (G17)



3B12

Grenache x
3084-2-56

Grenache x
3082-1-32

Grenache x
3082-1-72

3082-1-49
x Marselan

3082-1-42x
Cab.Sauv.

3082-1-42 @
D. Blanc

Fer x
3090-4-25

Fer x
3091-4-88

Fer x
3092-6-68

3176-8-11 N

3179-90-7N

3180-16-8N

3328-1-18N
3328-306N
3328-177N

3094-1-7N

Hybrides
BNIC
3B12
1D10
2E5
3G3

316-11-3N @
316-1-27-4N

3166-35-5N

3161-22-4N
3161-6-4N

@ Parent of ResDur varieties

Resdur 1:

Vidoc N et Artaban N: 3082-1-

Floreale B et Voltis B: Villaris

Madina seedless (Cardinal x Sultanine)

nache Gris x St Pierre Doré)

(Cab. Sauv. X Grenache)

san (Listan x Pinot)

Brandy



Reclia

Madina seedless (Cardinal x Sultanine)
Aranel (Grenache Gris x St Pierre Doré)
Marselan (Cab. Sauv. X Grenache)
Chasan (Listan x Pinot)



Characteristics of Bouquet resistant varieties in the process of inscription to the French official catalog

| Identification code | Color of berry | Number of back crossing | Last crossing with | Target | Convention Partner |
|---------------------|----------------|-------------------------|--------------------|-------------------|----------------------------|
| 3176-21-11 | red | 5 | Grenache N | Traditional wines | CIVL and IGP Sud de France |
| 3160-11-3 | red | 5 | Fer Servadou | | |
| 3159-2-12 | white | 5 | Chasan | | |
| 3322-339 | red | 6 | Cabernet-Sauvignon | | |
| 3197-81(G5) | white | 4 | Muscat de Hamburg | Low alcohol wines | |
| 3196-57 (G9) | white | 4 | Italia | | |
| 3184-1-9 (G14) | red | 5 | Alfonse Lavallée | | |
| 3197-424 (G3) | red | 4 | Muscat de Hamburg | Grape jus | Foulon-Sopagly |
| 3184-4-10 (G4) | red | 5 | Alfonse Lavallée | | |
| 3199-50 (G18) | white | 4 | Madina | | |
| 3B12 | white | 5 | Ugni blanc | Brandy | BNIC |
| 1D10 | | | | | |
| 2E5 | | | | | |
| 3G3 | | | | | |



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Diagram for the creation of powdery and downy mildew tolerant varieties from inter-
Sauvignon x Muscadinia rotundifolia by Alain Bouquet.



Vidoc N

N°1 (*V. vinifera*) x *Muscadinia rotundifolia* G52

NC6-15 (F1) x Cabernet Sauvignon

| Grenache | | | 8695 x Pinot N | | |
|------------------|-----------------|----------------|----------------------|--------------------|-------------------|
| 5-18-79 x Merlot | | | 12-4-80 x Sémillon | 12-4-80 x Riesling | |
| Aubun x 1-11-82 | Aubun x 1-28-82 | | Grenache X 5-8-82 | Grenache X 5-1-82 | Grenache x 6-2-82 |
| 3197-144N (G1) | 3196-57 (G9) | 3197-424N (G3) | 3082-1-42 x Regent | 3090-4-25 | 3091-4-88 |
| 3197-235N (G2) | | | 3082-1-72 x Marselan | | 3092-6-68 |

3082-1-42 x Regent



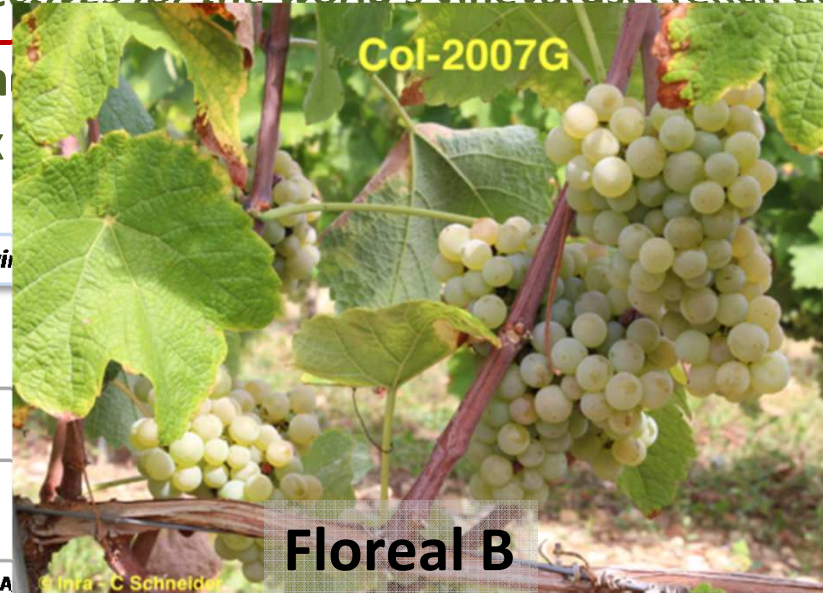
Artaban N

Resdur 1

ResDur for “Resistance durable”
(sustainable resistance)
target: reinforce resistance with
the gene pyramiding



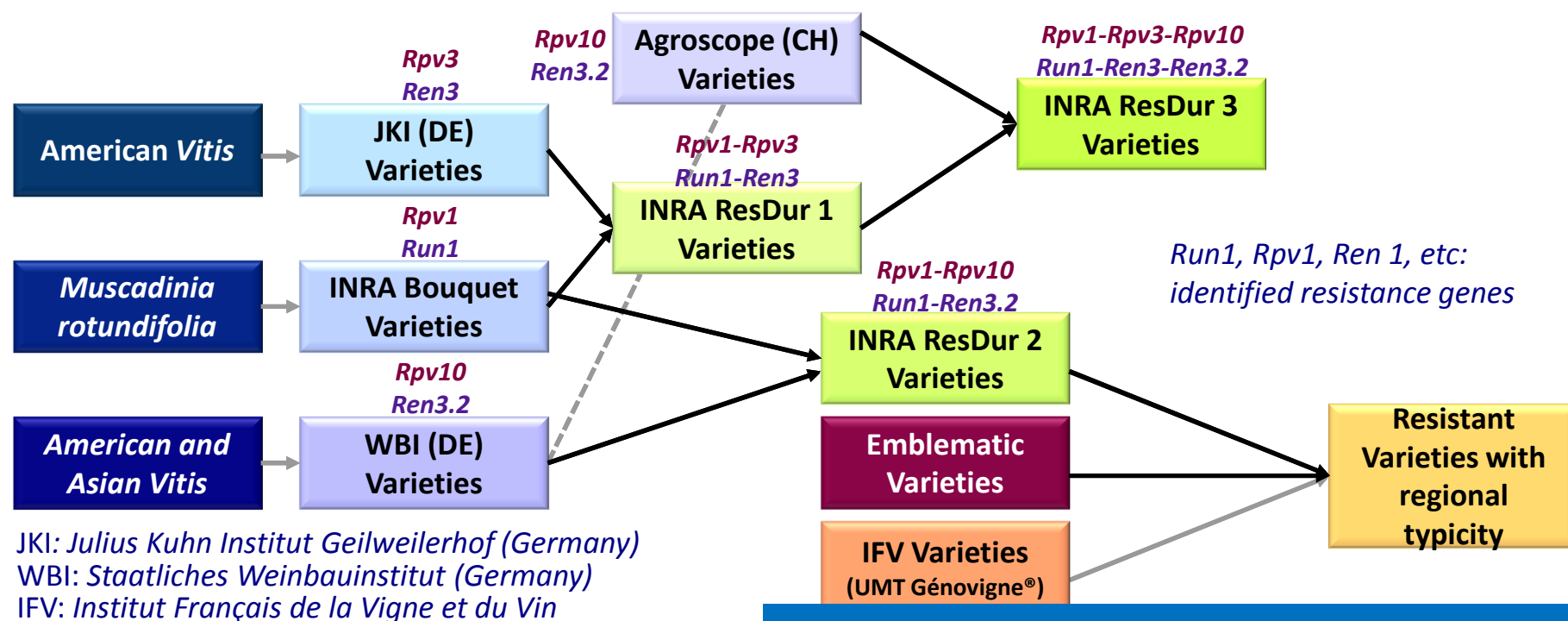
om inter-
quet.



ResDur for “Resistance durable”
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Scheme of crosses of INRA RedDur program (Merdinoglu, 2017)



ResDur for “Resistance durable”
(sustainable resistance)
target: reinforce resistance with
the gene pyramiding

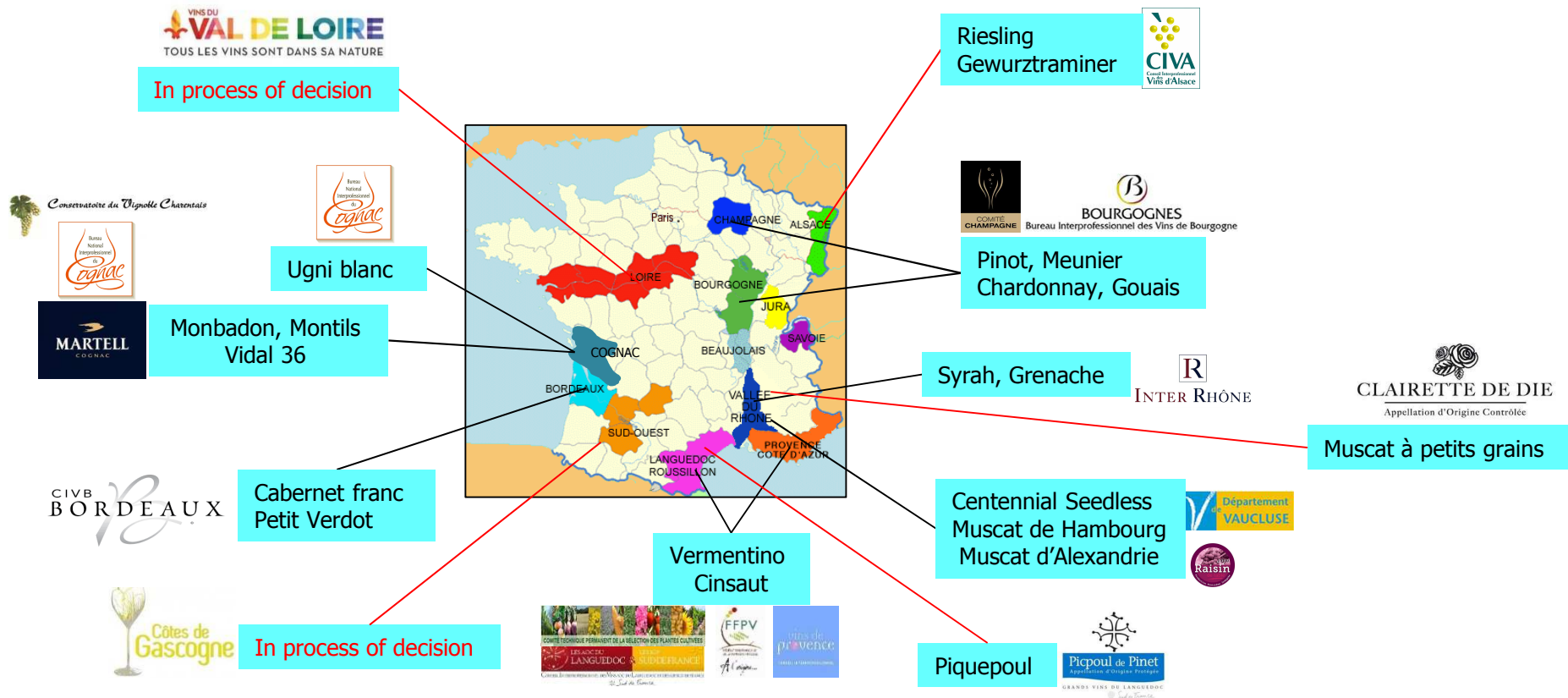


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Looking for diseases resistance and quality



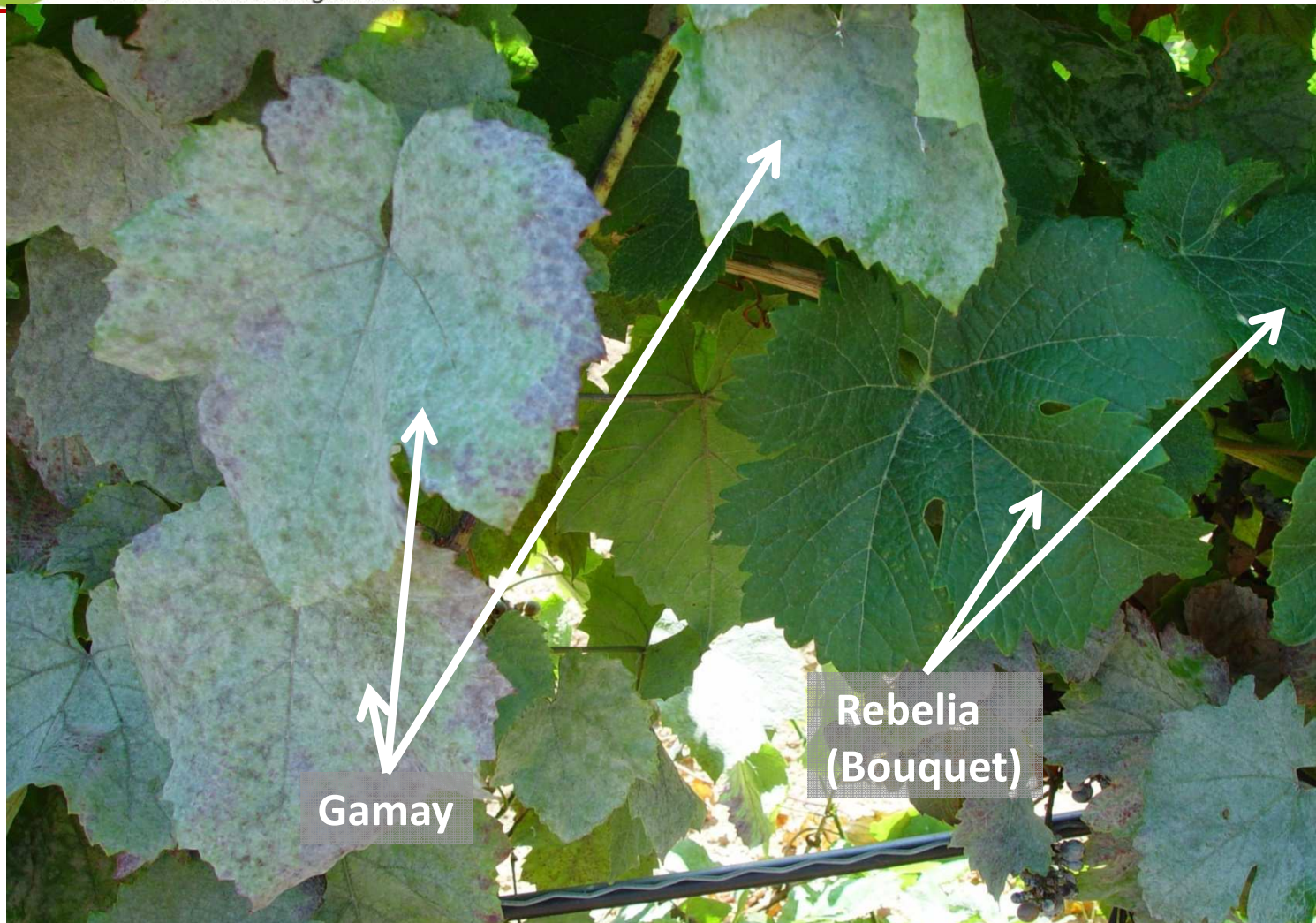
Some figures : ~ 100000 seeds produced, 1320 genotypes in stage 2



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Pre-selection plot of Bouquet varieties (FIJUS project) in the complete absence of treatments against powdery mildew and downy mildew since 2008. Effects of powdery mildew on leaves.



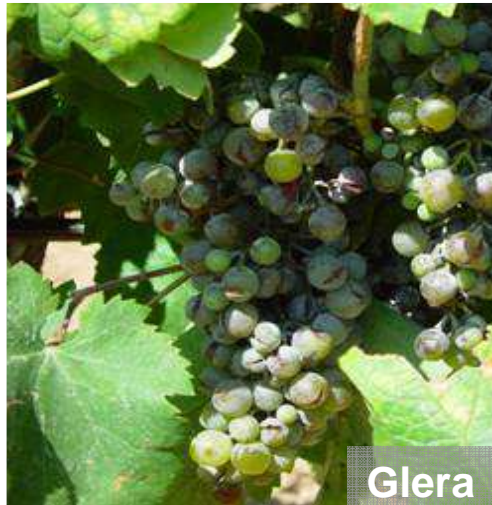
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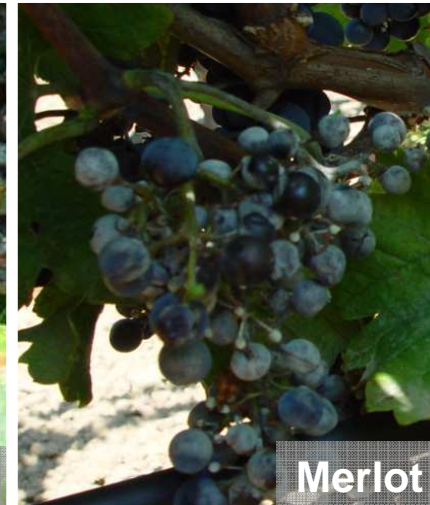
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Gamay



Glera



Merlot



G5



G9



G14

Pre-selection plot of Bouquet varieties (ANR VDQA project) in the complete absence of treatments against powdery mildew and downy mildew since 2008. Effects of powdery mildew on clusters.

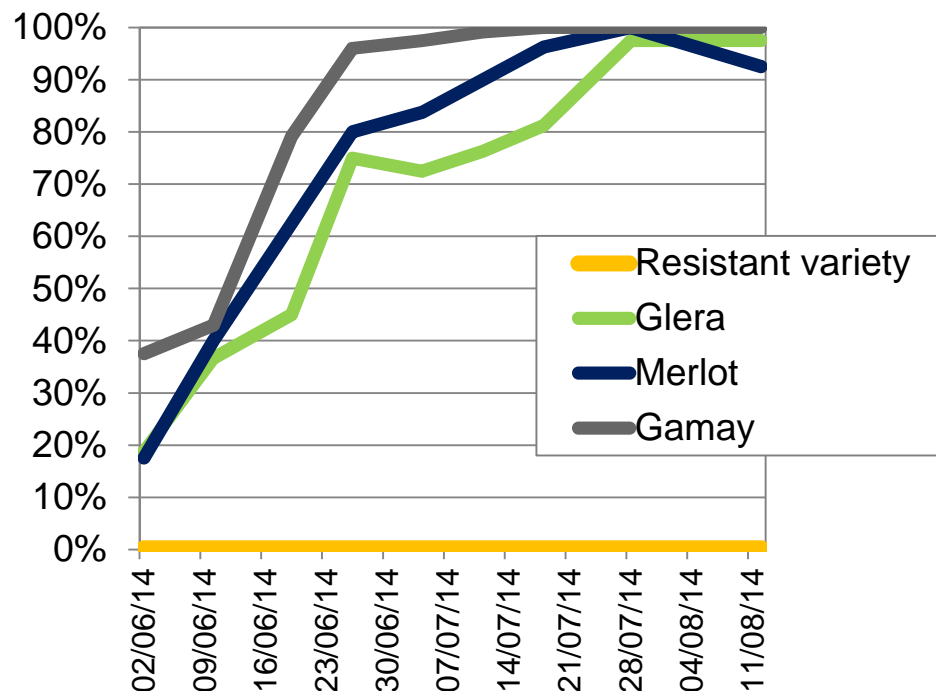


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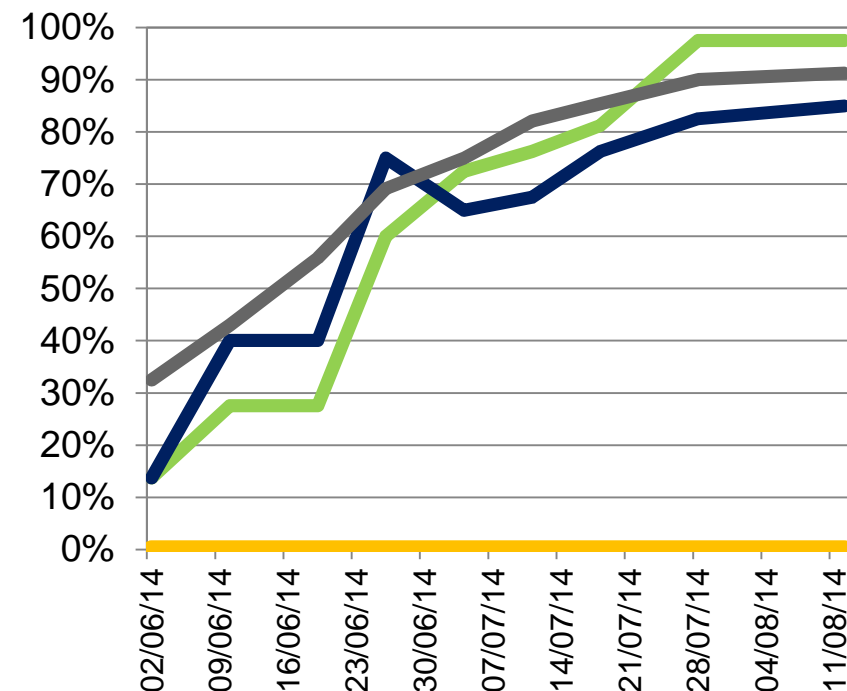
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percentage of berries
affected by powdery
mildew



percentage of leaves
affected by powdery
mildew



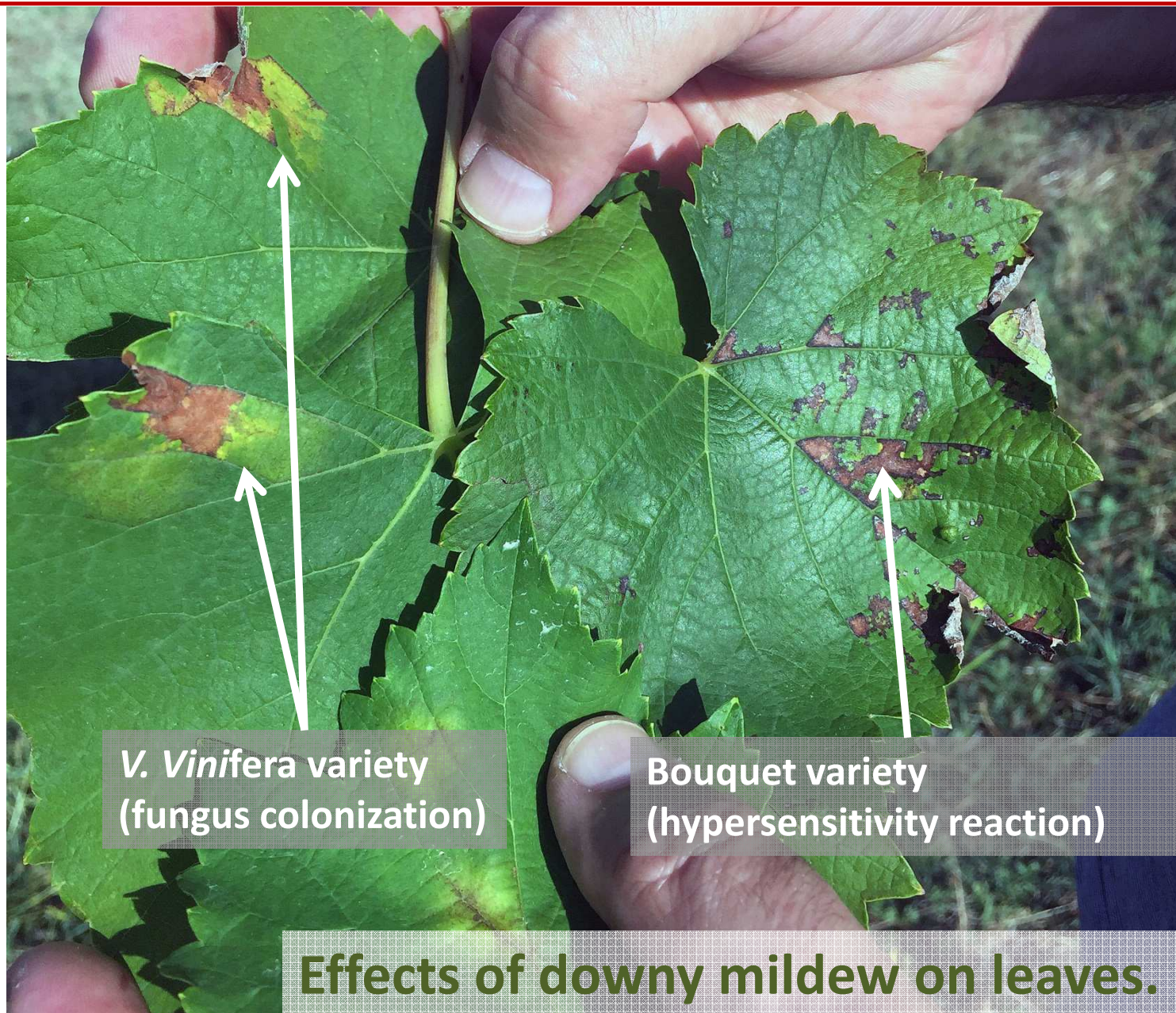
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V. Vinifera variety
(fungus colonization)

Bouquet variety
(hypersensitivity reaction)

Effects of downy mildew on leaves.



Questions by way of conclusions

- ☑ Polygenic or monogenic? Resistance sustainability?
- ☑ How far move away from the quality model by pyramiding genes?
- ☑ Is it possible to grow the vine under conditions of zero treatment ?
- ☑ Impact of "secondary" diseases and pests on resistant varieties?
- ☑ Winemaking technology adaptation to new resistant varieties?
- ☑ Consumer acceptance (willingness to pay)?

Perspectives

- ☑ National Observatory for the Deployment of Resistant Grape Varieties (OSCAR). Interdisciplinary approach piloted by INRA (UMR SAVE, Bordeaux) with active participation of growers