

## *LES VIROSES*

# Virus Diseases: Summary of the answers from interviewed scientists & professionals

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# 1. Quelle est la situation des maladies de type viral de la vigne dans votre pays?

Which is the situation of virus diseases in your Country ?

## European Countries :

France: soilborne diseases (infectious degeneration complex including fanleaf etc. ) are very important in particular for the prestigious cultivar and areas (Champagne, Bourgogne...etc). LR spread in Northern part of the Country.

Germany: Grapevine Fan Leaf Virus (GFLV), Arabis Mosaic Virus (ArMV), and Raspberry ringspot virus (RpRSV) (Cherry strain) in Palatinate and other areas.

Spain: Very low is the presence and the effect of GFLV in where the most important disease is Leafroll, that is spreading quite rapidly probably due also to the presence of efficient vectors.

Italy Grapevine leafroll-associated virus 1 and Grapevine leafroll-associated virus 3 (GLRaV-1 and GLRaV-3) are prevalent even if GFLV and ArMV are increasing, in particular in the commercial vineyards.

Hungary: Spread of *Grapevine leaf roll virus* (mainly Type 3), Rugose wood and recently of *Grapevine chrome mosaic virus* has accelerated.

Romania : GFLV+ArMV, GLRaV-1and GLRaV-3, GLRaV-2, GFkV, GVA on Fetească neagră, Fetească regală, Tămâioasă românească, Victoria, Augusta

Israel: Leaf-roll disease, caused by GLRaV-3. Most (probably all) vineyards planted until 2007 were infected. GVA, more in table grapes than in wine but the effects are not severe

## Other Countries :

Australia: important viruses are GLRaV-3, GVA (associated with Australian Shiraz Disease), GLRaV-1, GFkV and RSPaV (both are considered as minor)

USA : no different than in other countries with viruses present wherever grapes are grown.

South Africa: Grapevine leafroll is a greater problem. Grapevine fanleaf virus is restricted to only some parts of the wine production area but is well controlled.

Chile: GFLV, GLRaV-1, GLRaV-2, GLRaV-3, GLRaV-4, GLRaV-5, GLRaV-7, GLRaV-9, GVA, GVB, GRSPaV, GFkV, GSyV-1.

**2. Quel est l'objectif principal de votre programme de recherche en termes de virose de la vigne?**

Which is the main objective in your research program on grapevine virus diseases?

- 1 - **development of new diagnostic tools** are the common objective of many research groups in Europe and in other Countries (USA, Australia and Chile).
- 2 - **containment of the virus spread in vineyard** since most of the most relevant grapevine viral diseases are propagated by vectors such insects and mites. The recent tendency for the low impact management on plant protection implies the development of new tools for the vector population control, possibly based on pesticide free, or lower input, strategies.

Here below are summarized the main topics and the related Countries:

- **The Next Generation Sequencing (NGS)** (Italy, France and USA) and **Microarray technology** (USA) as innovative and powerful detection methods are developed mainly for **the detection of viruses** associated with diseases at unknown aetiology. Interesting results have been obtained for the detection and identification of GPGV in Italy and other new viruses such as GSyV-1 in France and USA.
- **The cell and molecular interaction** in the system **plant (grapevine)-virus and vector**: in particular for fanleaf and leafroll diseases (France, Germany and Italy ).
- **Virus elimination by tissue culture** are developed in Australia, Romania and USA (macro shoot tip and meristem culture).
- **Improvement of the control strategies to contain spread of airborne diseases** caused by *Ampeloviruses* (GLRaV-1 and GLRaV -3) and *Vitiviruses* (GVA). In France due to the relevant importance of nepoviruses studies of **integrated management of nematode** vector/s are carried out by mean of chemical treatments and agronomic measures.
- Studies on **virus resistance** and set up of suitable strategies for the virus control by means of **biotechnology tool** such as RNA interference and **transgenic plants** (France).

### **3. Avez- vous estimé le dommage économique que la virose provoque sur la production totale de vin dans votre pays?**

Did you have a crop losses data and the economic impact of the virus diseases on enological production?

The best data obtained from this question comes from Marc Fuchs that reports the values of **economic impact of leafroll disease the United States: from** \$25,000 to \$40,000 per hectare in New York, \$81,000 to \$202,000 per hectare in Napa Valley in California, \$41,000 to \$102,000 per hectare in Sonoma in California and \$26,900 to \$67,900 per hectare in San Joaquin Valley in California over a 25 year vineyard lifespan.

Other data are narrower and related to particular varieties such those of Mannini and colleagues in Italy for Nebbiolo cultivar (Mannini et al., 2012) and Pinot gris for GPGV (Malossini et al., 2012). No recent data are available from France and according to Marc Fuchs data, **previous estimates of the economic impact of Grapevine fanleaf virus indicated \$1.0 billion annual losses in France.**

In Spain and Israel specific large scale evaluation are in progress and the data will be published in the next months (Caballeiro *et al.*, in press).

In general reliable and significant data are not available or they are too old (i.e. Germany). This is probably due to the fact that no better incoming are expected from a better quality berry yield.

#### **4. Avez- vous identifié de nouvelle virose pour la vigne dans votre pays ?**

**Did you have recently identified new virus diseases in your Country?**

The answer of the question number 4 is representative of the real state of the art concerning the major emergent problems for the healthy grapevine propagating material.

**In France**, Tomato black ring virus (TBRV, Nepovirus) has been found in the Bordelais area (Laveau et al., 2013) and Grapevine Syrah virus 1 (GSyV-1, Marafivirus) (Beuve et al., 2013). Recently also GPGV (Colmar group)

**In Germany** Grapevine Pinot Gris Virus and Grapevine Rupestris Stem Pitting Virus (by NGS, to be confirmed) have been identified.

**In USA (New York, California and Washigton) Red blotch**, a newly recognized, virus disease in North America has been found by the groups in Geneva (Cornell University) and in Davis (UC - California). The economic impact of GRB disease is very high and its causal agent (GRBV a DNA virus) has been fully sequenced. No information are so far available concerning the epidemiology even if critical has been found the role of the propagating material.

**In Italy** as mentioned above a new virus disease was discovered in the Trentino Region. Unusual symptoms of chlorotic mottling, leaf deformation and stunting were observed since 2003 on the cultivar Pinot gris and Traminer. The disease affects yield and qualities of the productions and it is associated with **Grapevine Pinot Gris virus** (Giampetruzzi et al., 2012). The virus was also reported in several other Italian Region (Friuli Venezia Giulia, Veneto, Emilia Romagna, Puglia and Lombardia) (Martelli, 2014, Casati et al., 2014), Korea (Cho et al. 2013), on the table grape Tamnara inducing a necrosis of the berries; Slovak and Czech Republics (Glasa et al., 2014) on different cultivars; Slovenja (Plesko et al., 2014), on the cvs Pinot gris, Sauvignonasse and Muscat blanc, associated with a similar symptomatology.

No other available information are coming so far from other Countries. **It is reasonable to expect a great increase of the virus findings in the next years in the view of the a larger use of this new technique (NGS).**

## 5. Est-ce qu'il y a une urgence phytosanitaire liée aux viroses dans votre pays?

Are there emergent phytosanitary problems for grapevine in your Country?

The major concerns according to the scientist answers are quite different:

- **Leafroll spread** is an emergent problem for **France, Germany, Israel and USA and northern Italy**. This is probably due to the reduced (and conceivable) use of insecticides and the consequent increase of the insect vector populations.
- For **France, USA** and some areas of **Italy** the major concern is the persistent presence of **fanleaf** and its probably spreading in particular where and when preventing measures are not applied.
- For **Italy**, as above reported, the new grapevine disease associated with **Grapevine Pinot gris virus** is clearly an emergent phytosanitary problem in several premium viticultural areas in the Northern of Italy. Similar symptoms were described on several wine varieties, cvs Traminer and Pinot noir in Trentino, Friuli Venezia Giulia cv Glera, in Veneto, Chardonnay, in Lombardy and recently in the table grapes Black magic and Supernova in Apulia.
- **In Chile** there are not yet phytosanitary emergencies, but there are problems with GFLV (and vector management: *X. index*), GLRaV-1, -2, -3, and with Syrah Decline.

Information from scientists from **Spain and South Africa** gives a prominent concerns to **phytoplasma diseases**, respectively for Flavescence doée and Aster Yellows (AY)



# Safeguarding Fruit Crops in the Age of Agricultural Globalization

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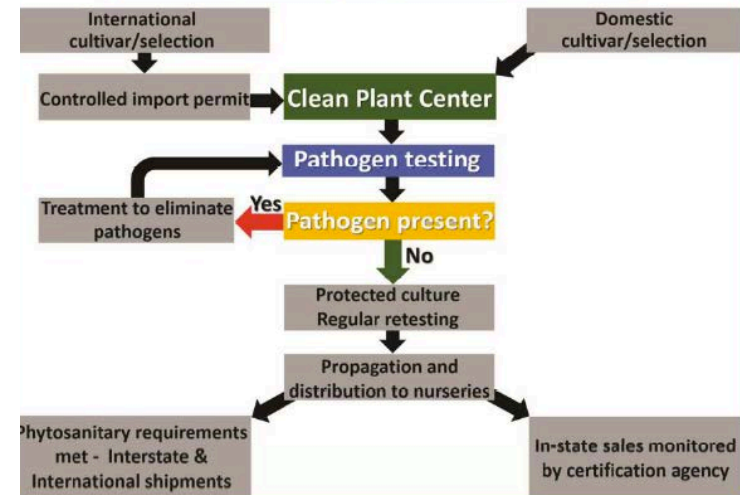
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## Idealized journey for plants to producers



\* for laboratory testing, bioassays, therapy, and meristem tip culture at a Clean Plant Center.

Plant Disease / February 2015

## NCPN centers as of 2014



Cooperator Institution	Crops
Auburn University, Alabama (AU)	Citrus
Clemson University, Clemson, SC (Clemson)	Fruit trees
Cornell University, Geneva, NY (CU)	Grapevine
FL Dept. of Agric. & Consumer Svc. Gainesville, FL (FL DACS)	Citrus
FL Dept. of Agric. & Consumer Svc. Winter Haven, FL (FL DACS)	Citrus
Florida A&M University Tallahassee, FL (FAMU)	Grapevine
Louisiana State University, Baton Rouge, LA (LSU)	Citrus
Missouri State University, Mountain Grove, MO, (MOSU)	Grapevine
North Carolina State University, Raleigh, NC (NCSU)	Berries
Texas A&M University Kingsville, TX (TAMU)	Citrus
University of Arizona Yuma, AZ (UAZ)	Citrus
University of Arkansas Fayetteville, AR (UARK)	Berries
University of California Davis, CA (UC-D)	Fruit and nut trees, grapevine and strawberry
University of California Riverside, CA (UC-R)	Citrus
University of Hawaii, Honolulu, HI (UH)	Citrus
USDA/ARS, Corvallis, OR (USDA/ARS HCRL and OSU)	Berries
Washington State University, Prosser, WA WSU	Fruit trees, grapevine and hops

Fig. 5. Map indicating the location and identity of the 19 National Clean Plant Network (NCPN) centers

## 7. Quelles sont selon vous les choses à faire? Quels sont les obstacles pour bien comprendre en profondeur les maladies de type viral ?

Which are the main constraints for the improvement of the knowledge of virus diseases?

- 1) **shortage of funding** and insufficient network between scientists from different Countries that are facing the similar problems.
- 2) **lack of consciousness** (and correct information) about the economic impact of viral diseases such as fanleaf and leafroll and then suggests to set up novel and more efficient strategies for their control in particular for fanleaf.
- 3) some of the answers deserve to be reported integrally, as supplied by the scientists.  
Pasquale Saldarelli and G.P. Martelli (Italy): ... Differently from what we observe in other continents (i.e. several Countries in the Americas, Australia), **Europe gave up research in grapevine virology**, which is mainly linked to the emergence of new diseases (see the GPGV case) and/or regionally funded. In parallel, new viruses, also belonging to **new taxa with a DNA genome** (see GRBV) were described in the **USA**, whose presence in Europe is completely unknown. In addition, important questions in basic **grapevine virology**, mainly related to the etiology of single viruses alone and in synergy, **did not meet any reception in recent EU funding programs**. Because of this, the European scenario is made by an always more limited number of grapevine virologists which, occasionally and independently, continue to work in this field.
- 4) Marc Fuchs (USA): **Limited financial resources** and **limited interest of the industry leadership in Europe** are major constraints to research on viruses and viral diseases.

8. Comment faites- vous pour informer les producteurs/vignerons des résultats de votre travail scientifique?

COUNTRY	ACTIVITIES
AUSTRALIA	Articles on growers' magazines: Australian Viticulture or Aust. New Zealand <u>grapegrower</u> and winemaker. University linked website: <a href="http://www.agwine.adelaide.edu.au/facilities/wdiag/">http://www.agwine.adelaide.edu.au/facilities/wdiag/</a>
CHILE	Through seminars, field days, extension articles. Providing technical advisory services and analyzing plant material.
FRANCE:	Seminars, brochures, trade shows, open days (open doors), meetings, articles in the professional press.
GERMANY:	<u>Advisory</u> service, meetings Open doors day at institute, publications in journals for professionals
ISRAEL	Growers meeting – regional, national and at wineries at which we lecture about the work. Annual and final reports of the researches are published in <u>web-sites</u> of the wine board and the local research organizations (all in Hebrew). The final results are also published as articles in our local grower's journal " <u>Alon Hanotea</u> ". Field days to teach about symptomatology, vectors and the ways to control them.
ITALY	Presentation and <u>reports</u> to General Assembly of the " <u>Associazione Costitutori Viticoli Italiani</u> ". Regional and district meeting for winemakers and growers. Meetings with extension service (i.e. Phytosanitary service) personnel.
ROMANIA	Television and newspapers reportages inform the farmers.
SPAIN	Meetings, roundtables, and field <u>visits</u> with vine growers/winemakers organized by territorial agricultural institutions and extension services
SOUTH AFRICA	Contacts with Wine –industry based organization, <u>Vinpro</u> , who do the technology transfer tasks, or co-ordinate them with relevant researchers.
USA	Regular contact <u>with growers, vineyard managers, vintners and industry leaders through onsite visits, participation at grower's conventions and personal extension responsibilities</u>

## The project in all of the World: a summary....

- in **Israel** specific programs are carried out in order to evaluate the effects of agronomic practices on performance of virus infected vines. Also, field trials for control of the mealybug (*Planococcus ficus*) using chemicals, male disruption and/or biological control with *Cryptolaemus montrouzieri* are carried out.
- studies on new viruses and undefined disease aetiology researches for the **GPGV**, **GSyV-1** and other *Marafiviruses*, **Grapevine ruspestris stem pitting virus**, **Grapevine Rupestris vein feathering virus in Italy** as well as GPGV. Several studies are in progress in order to evaluate the role of this virus and/or its strains in the symptom expression (mottling and deformation of the leaves).
- Studies on the **GLRaV transmission**, epidemiology (by monitoring mealybug leafroll) and symptomatology are carried out in **Spain**. Also, damage evaluation of leafroll on yield and production and the effect of rootstocks on the diseased vines are conducted.

**9. Est-ce que vous seriez intéressé à participer à une future collaboration multinationale de recherche et quels sont pour vous les aspects à rechercher?**  
**Would you be interested to collaborate at possible future international research project and could you suggest the main issues that should be investigated?**

Total support to the idea of a **common project of grapevine virus diseases** has been supplied by the interviewed scientists. The major topics for the possible program of investigation are here below listed:

1. applying and evaluating techniques of next generation sequencing for the diagnosis of grapevine virus and virus-like diseases
2. evaluating the aetiological role of widely diffused viruses and their strain diversity.
3. studying the molecular interactions among Grapevine fanleaf virus and/or Grapevine leaf roll associated viruses and the grapevine
4. studying the aetiological role and the molecular evolution of the recently discovered and emergent viruses such as Grapevine Pinot gris virus and Grapevine Syrah Virus -1
5. Studies of genomic and metagenomic of viral diseases.+
6. Investigation of the phenomenon of tolerance or resistance against viral infection
7. Development of quick and cheap diagnostic tools.
8. Evaluation of economic impact of the main grapevine virus diseases also considering the diversity of involved virus strains and grapevine growing regions





## Geographical Distribution of Grapevine Pinot Gris Virus Infections



Geographical Distribution of Grapevine Pinot Gris Virus Infections

A new grapevine virus discovered by deep sequencing of virus- and viroid-derived small RNAs in *Cv Pinot gris*

Annalisa Giampetruzzi<sup>a,1</sup>, Vahid Roumi<sup>a,1</sup>, Roberta Roberto<sup>a</sup>, Umberto Malossini<sup>b</sup>, Nobuyuki Yoshikawa<sup>c</sup>, Pierfederico La Notte<sup>a</sup>, Federica Terlizzi<sup>d</sup>, Rino Credi<sup>d</sup>, Pasquale Saldarelli<sup>a,\*</sup>

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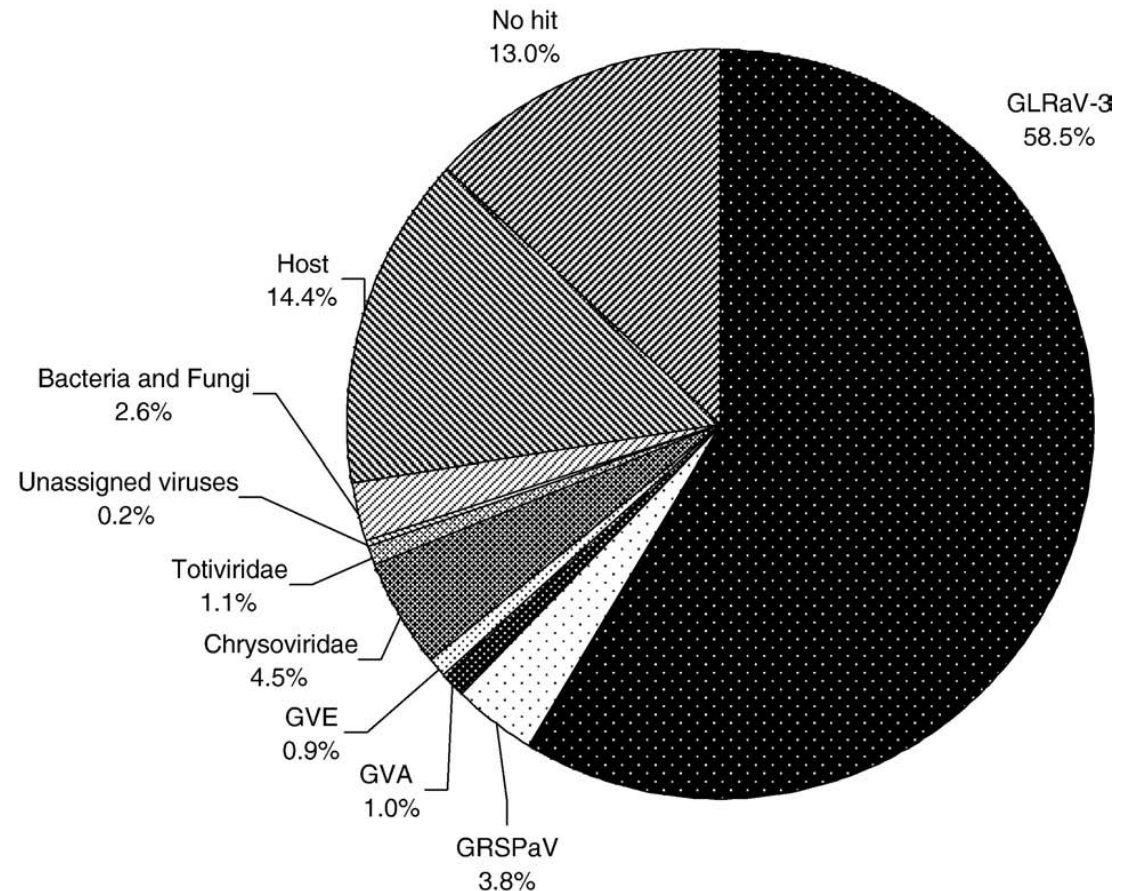
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Studies are in progress with the aim to clarify the role of GPGV on the disease aetiology, to understand the virus biology and epidemiology and to develop fast diagnostic tools.



# La NGS (Next Generation Sequencing) will take place of the PCR for routine analyses ?

Deep sequencing analysis of viruses infecting grapevines: Virome of a vineyard (Coetzee et al., 2010)



*Le “virome” – The Metagenome of a vineyard*

February, 2015

Al Rwahnih, 1 Phytopathology

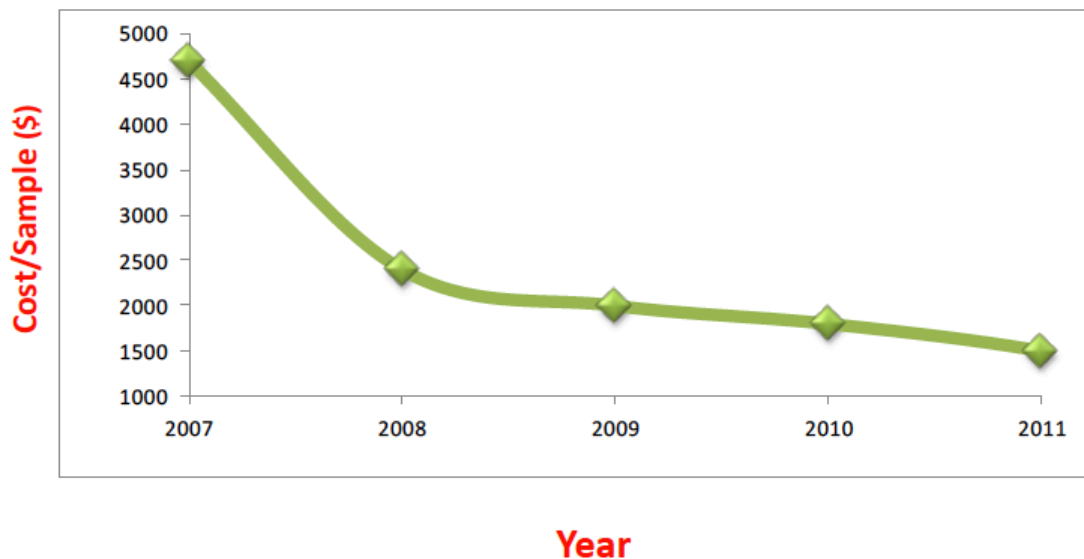
# **Comparison of Next Generation Sequencing vs. Biological Indexing for the Optimal Detection of Viral Pathogens in Grapevine**

Maher Al Rwahnih, Steve Daubert, Deborah Golino, Christina Islas and Adib Rowhani

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## **Next generation sequencing cost**

(FPS data)



### **NEXT GENERATION SEQUENCE: NGS**

A quick modality to obtain a full set of information of the sanitary status of the vineyard





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## Will **Red Blotch** Change the Way the Industry Propagates Vines?



**Map of red leaf blotch disease detections in North America.**

**TABLE 2** Dormant 2014 vine lots from California nurseries tested prior to shipment to the East Coast

Scion	Rootstock	% samples positive		CDFA-certified
		GRBaV	LR3	
Chardonnay 70 (96)	101-14MG	22%		CERT
Petit Verdot 02	Riparia Gloire	33%		no
Cabernet Sauvignon 47 (337)	101-14MG		13%	CERT
Pinot Noir 667	3309C	13%		no
Pinot Noir 667	101-14MG	13%		no

- AVF funded \$388,700 in research in 2013 and 2014. An additional \$29,500 was funded by the CA Rootstock Commission.

**9. Est-ce que vous seriez intéressé à participer à une future collaboration multinationale de recherche et quels sont pour vous les aspects à rechercher?**  
**Would you be interested to collaborate at possible future international research project and could you suggest the main issues that should be investigated?**

Total support to the idea of a **common project of grapevine virus diseases** has been supplied by the interviewed scientists. The major topics for the possible program of investigation are here below listed:

1. applying and evaluating techniques of next generation sequencing for the diagnosis of grapevine virus and virus-like diseases
2. evaluating the aetiological role of widely diffused viruses and their strain diversity.
3. studying the molecular interactions among Grapevine fanleaf virus and/or Grapevine leaf roll associated viruses and the grapevine
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5. Studies of genomic and metagenomic of viral diseases
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7. Development of quick and cheap diagnostic tools
8. Evaluation of economic impact of the main grapevine virus diseases also considering the diversity of involved virus strains and grapevine growing regions

Sofia 8-9 May 2012

# VALIDATION OF DIAGNOSTIC PROTOCOLS FOR THE DETECTION OF GRAPEVINE VIRUSES COVERED BY PHYTOSANITARY RULES

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## Validation of Diagnostic Protocols for the Detection of Grapevine Viruses Covered by Phytosanitary Rules

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# UE Regulation



- Directive n. 77/93/CEE – 21/12/976
- Directive n. 91/683/CEE – 19/12/1991
- Directive n. 92/98/CEE – 16/11/992
- Directive n. 93/48/CEE – 23/06/1993
- Directive n. 93/64/CEE – 05/07/1993
- Directive n. 2005/43/CE – 23/06/2005



- D.M 24 giugno 2008
- D.M. 31 maggio 2000
- D.M 14-04-97
- D.M. 23-02-06 (AP)
- D.M. 28 -07-09 (PPV)
- D.M. 31.01.96 (PD-ESFY)
- D.M. 27-03-97 (E. amylovora)



- D.M 7 juillet 2006
- D.M. 9 juillet 2003
- D.M. 22 novembre 2002
- D.M. 27 novembre 2008



# Grapevine Regulation in Europe: the example of Ita there are some c

Italy					
Reference rules	Ministerial decree 24th June 2008 - Modifications on the technical protocol for the clonal selection of grapevine				
Vineyards for the clonal selection of grapevine					
Initial propagation material	GFLV+ArMV+GLRaV1-2-3+GVA+GVB+GFkV - serological and molecular tests		every 5 years	-	
Basis propagation material	GFLV+ArMV+GLRaV1-2-3+GVA+GVB - analytical methods	after 3 years	every 6 years		
Reference rules	Ministerial decree 7th July 2006 - Commercialization of propagation material of grapevine				
Vineyards for the commercialization of propagation material					
Certified propagation material	GFLV+ArMV+GLRaV1-3+GVA - serological and molecular tests	after 5 or 10 years	every 10 years	5%	
Reference rules	D.M. 31 maggio 2000: Mandatory struggle to Flavescence Dorée				5%
France					
Reference rules	Ministerial decree 7th July 2006 - Commercialization of propagation material of grapevine				
Vineyards for the clonal selection of grapevine					
Initial propagation material	GFLV+ArMV+GLRaV1-3+GFkV - serological and molecular tests		every 5 years	-	
Basis propagation material	GFLV+ArMV+GLRaV1-3 - analytical methods	after 3 years	every 6 years		
Reference rules	Ministerial decree 7th July 2006 - Commercialization of propagation material of grapevine				
Vineyards for the commercialization of propagation material					
Certified propagation material	GFLV+ArMV+GLRaV1-3 - serological and molecular tests	after 5 or 10 years	every 10 years	5%	
Standard propagation material	GFLV+ArMV+GLRaV1-3 - visual, serological and molecular tests			10%	
Reference rules	Arrêté ministériel du 9 juillet 2003 : Mandatory struggle to Flavescence Dorée				5%

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8. Evaluation of economic impact of the main grapevine virus diseases also considering the diversity of involved virus strains and grapevine growing regions

## Results from the questionnaires sent to the winegrowers

- 1 – generally speaking, **winegrowers are not sufficiently informed about research programs** about virus disease, only the technicians of bigger farms know about them and, even then, they don't know their results in detail.
- 2 – winegrowers state that they know thoroughly the main virus diseases of grapevine, that they notice some problems related to them but **they are not fully conscious of their economic damage.**
- 3 – winegrowers generally **use certified propagation material** for establishing new vineyards and consider this measure to be safe enough. **Only in two cases additional sanitary analyses** were carried out on the plant material before using them in the field.
- 4 – most winegrowers are **not adequately informed about the new virus diseases** that are spreading in vineyards of different countries (Pinot gris virus and Red Blotch), **and consider the divulgation** about such diseases **to be insufficient.**
- 5 – in general, **winegrowers** in different countries **are not informed** about the presence of a action plan to follow whenever they find virus infected plants in their vineyards.



## **In summary some “row” but shared ideas for the discussion**

- To intensify the control of saplings for the new plantations
- To correctly manage the cases of coexistence of asymptomatic and asymptomatic strains
- To develop new diagnostic technologies and protocols for early detection by image analysis in robot assisted systems and/or by mass scale molecular assays (RT-PCR , realtime PCR etc.)
- To uniform the certification procedures and harmonize the different diagnostic protocols
- Development of Resistant plants by conventional (Marker Assisted Breeding) or/and biotechnological tools (GMO)
- To transfer information and technology/ies at the stakeholders:
- To set up and establish a reliable modality for evaluation of the economic impact of grapevine virus diseases
- Cooperation among scientists and then with the winemakers and public offices/functions (phytosanitary services, public consortia, etc.)

Syndrome	Genus	Virus	Distribution
Infectious degeneration (Grapevine fanleaf virus)	Nepovirus	Grapevine fanleaf virus (GFLV)	Worldwide
Infectious degeneration (European and Mediterranean Nepoviruses)	Nepovirus	Arabis mosaic virus (ArMV)	Switzerland, Spain, Italy, Germany, Bulgaria, Yugoslavia, Hungary, Romania, Turkey, Iran, Israel, Canada, USA (California, New York), Japan
	Nepovirus	Artichoke Italian latent virus (AILV)	Bulgaria
	Nepovirus	Cherry leafroll virus (CLRV)	Germany, Poland, Chile
	Nepovirus	Grapevine anatolian ringspot virus (GARSV)	Turkey
	Nepovirus	Grapevine bulgarian latent virus (GBLV)	Bulgaria
	Nepovirus	Grapevine chrome mosaic virus (GCMV)	Hungary, Czech Republic, Croatia and Austria
	Nepovirus	Grapevine deformation virus (GDefV)	Turkey, Iran
	Nepovirus	Grapevine Tunisian ringspot virus (GTRSV)	Tunisia
	Nepovirus	Raspberry ringspot virus (RpRSV)	Germany, Switzerland
	Nepovirus	Tomato black ring virus (TBRV)	Germany, Yugoslavia, Greece, Israel, Turkey, Ontario (Canada)
Grapevine degeneration and decline (American nepoviruses)	Nepovirus	Strawberry latent ringspot virus (SLRSV)	Palatinate (Germany), northern Italy
	Nepovirus	Blueberry leaf mottle virus (BLMoV)	New York State (USA)
	Nepovirus	Peach rosette mosaic virus (PRMV)	USA
	Nepovirus	Tobacco ringspot virus (TRSV)	New York state and Pennsylvania (USA)
	Nepovirus	Tomato ringspot virus (ToRSV)	Great Lakes and Pacific regions (USA)
Leafroll	Ampelovirus, Closterovirus	Grapevine leafroll-associated viruses (GLRaVs)	worldwide
Rugose wood complex	Foveavirus	Grapevine rupestris stem pitting-associated virus (GRSPaV)	Worldwide
	Vitivirus	Grapevine virus A (GVA)	South Africa, Italy, Australia
	Vitivirus	Grapevine virus B (GVB)	Worldwide
	Vitivirus	Grapevine virus C (GVC)	Canada
	Vitivirus	Grapevine virus D (GVD)	Worldwide
	Vitivirus	Grapevine virus E (GVE)	Japan, China, South Africa, North America
	Vitivirus	Grapevine virus F (GVF)	California (USA)
Graft incompatibility	Closterovirus	Grapevine leafroll associated virus 2 (GLRaV-2) and its variants	Europe, Chile, Argentina, California (USA), New Zealand, Australia
Fleck complex	Maculavirus	Grapevine red globe virus (GRGV)	Italy, California (USA)
	Maculavirus	Grapevine fleck virus (GFkV)	Worldwide
	Marafivirus	Grapevine asteroid mosaic-associated virus (GAMaV)	California (USA)
	Marafivirus	Grapevine rupestris vein feathering virus (GRVfV)	Greece, Italy, California (USA)
Minor virus diseases			
Vein necrosis	Foveavirus	Grapevine rupestris stem pitting-associated virus (GRSPaV) strains	Worldwide
Grapevine yellow mottle	Alfamovirus	Alfalfa mosaic virus (AMV)	Germany, Switzerland, Hungary, Czech Republic, Bulgaria, Turkey
Grapevine line pattern	Ilarvirus	Grapevine line pattern vi-rus (GLPV)	Hungar y
Grapevine angular mosaic	Ilarvirus	Grapevine angular mosaic virus (GAMV)	Greece
Grapevine yellow line pattern	Idaeovirus	Raspberry bushy dwarf virus (RBDV)	Slovenia, Hungary, Serbia
Grapevine leaf mottling and deformation (Grapevine Pinot gris)	Trichovirus	Grapevine Pinot gris virus (GPGV)	North Italy, France, Slovakia, Slovenia, Czech Republic, Greece, Korea
Grapevine berry inner necrosis	Trichovirus	Grapevine berry inner necrosis virus (GINV)	Japan
Grapevine Ajinashika disease	Ampelovirus + Maculavirus	GLRaV + GFkV	Japan
Grapevine vein clearing	Badnavirus	Grapevine vein clearing virus (GVCV)	USA mid-west
Grapevine red blotch	Geminivirus-like	Grapevine red blotch virus (GRBV)	USA (New York, California, Washington), British Columbia (Canada)
Latent viruses			
Grapevine syrah virus 1	Marafivirus	Grapevine syrah virus 1 (GSyV-1)	USA, Chile, Italy, Greece
Grapevine cryptic virus 1	Alphacryptovirus	Grapevine cryptic virus 1 (GCV-1)	USA (Mississippi)
Summer Grape latent virus	Reovirus-like	Summer Grape latent virus (SGLV)	USA (Mississippi)
Petunia asteroid mosaic virus	Tombusvirus	Petunia asteroid mosaic virus (PAMV)	Germany, Italy, Czech Republic
Grapevine Algerian latent virus	Tombusvirus	Grapevine Algerian latent virus (GALV)	Algeria



Available online at [www.sciencedirect.com](http://www.sciencedirect.com)



# **The big unknown: plant virus biodiversity**

Marilyn J Roossinck

**Current Opinion in Virology** 2011, 1:63–67

*Thanks*