# Final Report

| Project title (Acronym) |
|---|
| Building an international network of collections for reference of regulated and other important plant viruses and viroids (VirusCollect II) |

**Project duration:**

| | |
|---|---|
| **Start date:** | 16-10-01 |
| **End date:** | 18-10-01 |

# Contents

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# 2. Short project report

## 2.1. Short executive summary

The aim of the VirusCollect II project was to establish and extend an international network of collections of plant viruses and viroids (hereafter referred to as viruses) thereby making virus isolates available for reference at diagnostic and research laboratories in Plant Health. At present access to isolates of regulated viruses is limited and only the plant virus collection at DSMZ is officially accredited as reference producer.

Strengthening the infrastructure of plant virus collections is required because diagnostic tests on regulated organisms have to be accredited under the new Plant Health rules of the European Union that apply from December 14th 2019. The ability of laboratories of National Plant Protection Organizations (NPPOs) to fulfil this requirement will depend on public access to well-characterised virus isolates.

The collaboration between partners of the Euphresco projects NGS-detect and VirusCollect II and especially their joint meetings offered a fruitful platform for exchanging practices in characterisation and safeguarding of virus isolates for reference. Discussions on practices in High-throughput sequencing (HTS) and analysis, and on quality criteria for reference materials contributed to a common understanding of procedures, as well as to identify future needs and functions of plant virus collections.

Within the project more than 150 isolates of regulated and (related) non-regulated viruses have been made available. However, since identification of many isolates was based on only one technique, and/or sequence data were lacking or limited, not all of them qualify as reference material yet. Whether these isolates will be included in Q-bank depends on the criteria imposed on completeness of data and certainty of identification. The transfer of Q-bank to EPPO ensures the continuity of a platform for sharing data on availability and location of virus isolates for diagnostics and research.

Two successive VirusCollect projects have made clear that plant virus collections are not on the priority list of policy makers and researchers. Only those partners that benefited from allocated budgets were able to contribute substantially to Q-bank by characterising isolates and making them publicly accessible and available. In addition, the implementation of the Nagoya protocol appeared to increase administrative obligations of both curators and users of collection materials. Therefore, governments need to allocate specific budgets for the characterisation and maintenance of virus collections to enable NPPO laboratories to perform their official tasks.

## 2.2. Project aims

The aim of the VirusCollect II project was to establish and extend an international network of collections of plant viruses (hereafter referred to as viruses), thereby making virus isolates available for reference at diagnostic and research laboratories in Plant Health.

In the field of plant virology there is only one official ISO 17034 accredited collection of viruses: the German collection of Microorganisms and Cell cultures (DSMZ) of the Leibniz institute in Braunschweig. This collection includes only part of the currently regulated species. Many (regulated) viruses, if publicly available at all, are scattered over different collections hosted by National Plant Protection Organizations (NPPOs), research institutes and universities. Obtaining reference materials in plant virology, therefore, is a challenging task (Roenhorst *et al*., 2013).

The VirusCollect I and II projects were initiated to improve the public accessibility of isolates of (regulated) viruses in collections of individual institutions by:

1. providing locally available virus isolates by making them accessible via Q-bank Comprehensive databases on quarantine plant pests and diseases[1]
2. extending Q-bank by providing data and safeguarding virus isolates characterised within research projects and regular diagnostics.

Strengthening the infrastructure of plant virus collections is becoming even more important when diagnostic tests on regulated organisms have to be accredited under the new Plant Health Regulation of the European Union coming into force December 14$^{th}$ 2019. Public access to well-characterised virus isolates for development and validation of tests will determine the ability of NPPO laboratories to fulfil this requirement.

## 2.3. Activities and Results

**Quality criteria for collection materials**

To guarantee the authenticity of virus isolates in a collection the minimum requirements as described by Roenhorst *et al*. (2017) should be applied. Preferably, these requirements are met for all isolates included in Q-bank. However, when applied too strictly, it appears that only few of the available virus isolates qualify for inclusion in Q-bank.

In the VirusCollect II project, partners provided data either for re-authenticated isolates from existing local collections, or for isolates from diagnostics or research projects. All isolates for which data were provided will be included in Q-bank, despite the fact that not all of them qualified as reference material; as it was agreed that it was important to ensure accessibility despite the fact that the isolates lack a full characterisation.

**Accreditation**

Regarding accreditation of (virus) collections, the following ISO standards are considered relevant:

- ISO Guide 34:2009 General requirements for the competence of reference material producers; https://www.iso.org/standard/50174.html
- ISO 17034:2016 General requirements for the competence of reference material producers; https://www.iso.org/standard/29357.html
- ISO 17025:2017 General requirements for the competence of testing and calibration laboratories; https://www.iso.org/standard/66912.html
- ISO 20387:2018 Biotechnology -- Biobanking -- General requirements for biobanking; https://www.iso.org/standard/67888.html
- ISO/WD Guide 85 Guidance for the production of reference materials having one or more assigned qualitative property values (under development); https://www.iso.org/standard/75538.html?browse=tc

At present, only the plant virus collection at DSMZ is officially accredited according to an ISO Standard as reference material producer (https://www.dakks.de/en). Accreditation requires compliance with two ISO Standards, i.e. ISO Guide 34 outlining the general requirements for the production of reference materials and ISO 17025 focusing on the requirements of testing and calibration laboratories. This combination will be replaced by the new ISO 17034, which

[1] In 2019 Q-bank will be accessible via EPPO Global Database.

combines both requirements in one Standard. Even if ISO 17025:2017 is implemented in most NPPO laboratories, the implementation of the Standard for reference material producers will not be possible for most of them. Therefore, the new ISO 20387 and/or ISO/WD Guide 85 might provide suitable alternatives, when the main focus of reference materials concerns qualitative characteristics.

**Authentication and/or characterisation of virus isolates from existing local collections**
Within this project, a few partners got the opportunity to work on virus isolates already present in their collection. For many ‘old’ isolates, sequence data had to be generated, since the isolates date back to before the molecular era. Conventional Sanger sequencing or high throughput sequencing (HTS) technologies were applied, which resulted in data ranging from short sequences to almost complete genome sequences. In total, more than 150 virus isolates have been made available. However, since identification of many isolates was based on only one technique, and/or sequence data were lacking or limited, not all of them qualify as reference material yet.

**Virus isolates from research**
In the VirusCollect project several virus isolates became available through the diagnostic activity of laboratories. It was noted that the increased use of HTS technologies in research is yielding almost complete genome sequences of known as well as unknown viruses. Safeguarding the corresponding isolates in a collection, therefore, seemed an obvious way of extending collections to support diagnostic activities.

**Ownership and Nagoya protocol**
The ratification of the Nagoya Protocol on access to genetic resources and the fair and equitable sharing of benefits arising from their utilization (Convention on Biological Diversity, 2011) has consequences for access to and exchange of reference materials in Plant Health. Since 2014, date when the Nagoya protocol came into force, a prior informed consent (PIC) and mutually agreed terms (MAT) have become a prerequisite for access to plant virus isolates in many cases. These requirements already appear hampering access to collection materials, especially for isolates of ‘new’ and emerging viruses encountered after this date. Moreover, the implementation of the Nagoya protocol also triggered discussions on the ownership of virus isolates in collections. At present, not all researchers and/or curators decided on the status of their collection materials and, therefore, not all of the virus isolates characterised during the NGS-detect project were available for sharing via Q-bank.

**Q-bank and transfer of data to EPPO Global Database**
Q-bank Comprehensive databases on quarantine plant pests and diseases (http://www.q-bank.eu/ ) started as a Dutch initiative to strengthen the infrastructure in Plant Health (Bonants *et al*., 2013). To emphasise the international position of Q-bank and guarantee its continuity, it was desirable to transfer the database to EPPO. In September 2018 the EPPO Council agreed on inclusion of parts of the database in EPPO Global Database (EPPO-GD; https://gd.eppo.int/), in particular information on the availability of specimens/isolates and sequence data. The way information and data will be included in EPPO-GD depends on both the type of organism and the intended use. For example, barcodes do not apply to viruses, implying that sequence data are used in a different way for identification than for other organisms. Furthermore, the number of virus isolates to be included will depend on the criteria imposed on the certainty of identification. If isolates only qualify for inclusion when (almost) complete genome sequences have been determined, the number of isolates available for reference might be limited. If inclusion criteria are less stringent, more isolates will be available for potential users, who then should decide if additional characteristics have to be determined, based on their specific needs. It is clear that the transfer of Q-bank to EPPO Global Database will demand further discussions in different expert groups.

**Quantification of reference materials**
One-step reverse transcription droplet digital PCR can be applied for absolute quantification of viral RNA amounts. Quantification of reference materials allows their use as a reference tool for evaluation of the performance of tests. Furthermore, they can be used for the calibration of instruments in diagnostic laboratories. In the frame of the VirusCollect project the National Institute of Biology deployed droplet digital PCR for strains of *Potato virus Y* (Mehle *et al*., 2018) and for different genotypes of *Pepino mosaic virus* (Mehle *et al*., 2019; manuscript in preparation).

**Future project VirusCurate**
It was proposed by A. Fox (Fera, GB) to continue the efforts of the VirusCollect projects on sharing information and data on virus isolates and making them publicly accessible. A topic for collaboration was submitted through Euphresco: the topic (identified as VirusCurate) aims at using HTS to gain insights from virus collections and strengthening the infrastructure of plant virus collections. The use of HTS in Plant Health is revealing large numbers of previously unknown virus sequences, which in some case may concern viruses that are held in existing collections and have been previously characterised biologically and serologically. Sequencing of these 'old' virus isolates might provide the key to benefit from knowledge gained and published (long) before. Moreover, these efforts will strengthen the infrastructure of plant virus collections by providing public access to well-characterised isolates for reference purposes. VirusCurate may start in the Autumn 2019/Spring 2020.

## 2.4. Conclusions and recommendations

**Transfer of Q-bank to EPPO Global Database**
The transfer of Q-bank to EPPO Global Database is crucial for the public accessibility of virus isolates. In contrast to other plant pests, for viruses there is only one official collection at DSMZ in Braunschweig, Germany. Therefore, Q-bank provides an additional platform for sharing data on available isolates and their location. The transfer of Q-bank to EPPO ensures the long-term sustainability of this platform.

**Nagoya protocol increases administrative obligations**
The implementation of the Nagoya protocol increased the administrative obligations of both curators and users of collection materials. To enable easier access to collection materials for NPPO laboratories, simplified and tailored requirements for their specific uses of collection materials would be desirable.

**Public plant virus collections require funding by governments**
Two successive VirusCollect projects have made clear that plant virus collections are not on the priority list of policy makers and researchers. Only those partners that benefited from allocated budgets were able to contribute substantially to Q-bank by characterising of isolates and making them publicly accessible and available. Improving collections by aiming to share knowledge and safeguard virus isolates encountered during diagnostics or being part of research, failed because limited budgets did not allow people to spend time on these tasks.

To enable NPPO laboratories to fulfil future demands of the Official Controls Regulation (EU) 2017/625 and Plant Health Regulation' (EU) 2016/2031 of the European Union, it is recommended to strengthen the infrastructure for plant virus collections by providing allocated budgets for the characterisation and maintenance of virus isolates by governments (Overmann, 2015).

## 2.5. Benefits from trans-national cooperation

**Euphresco projects as platform for exchanging practices in plant virology**

The collaboration between partners of the Euphresco projects NGS-detect and VirusCollect and especially their joint meetings offered a fruitful platform for exchanging practices in characterisation and safeguarding of virus isolates for reference. Discussions on practices in High-throughput sequencing (HTS) and analysis, and on quality criteria for reference materials contributed to a common understanding of procedures, as well as to identify future needs and functions of plant virus collections. Moreover, these meetings provided opportunities for looking ahead and enhancing the coherence between upcoming and future Euphresco projects, such as 'Phytosanitary risks of newly introduced crops' (2018-A-293 PRONC), and 'Using HTS to gain insights from virus collections and strengthening the infrastructure of plant virus collections' (VirusCurate).

Benefits from trans-national cooperation include:

- Providing public access to isolates in plant virus collections by sharing information in Q-bank
- Sharing experiences and practices of characterisation and maintenance of virus isolates in collections for reference
- Stimulating harmonisation of quality requirements on collection materials for reference
- Providing opportunities to back-up valuable collection materials
- Decreasing expenses on maintenance of local collections by enabling easy access to other collections
- Expanding expert networks and improving collaboration over projects

**References**

- Bonants P, Edema M, Robert V (2013). Q-bank, a database with information for identification of plant quarantine plant pest and diseases. EPPO Bulletin 43: 211-215.
- Convention on Biological Diversity (2011). Nagoya protocol on access to genetic resources and the fair and equitable sharing of benefits arising from their utilization to the convention on biological diversity (https://www.cbd.int/abs/doc/protocol/nagoya-protocol-en.pdf [accessed on 21 November 2018]).
- Mehle N, Dobnik D, Ravnikar M, Pompe Novak M (2018). Validated reverse transcription droplet digital PCR serves as a higher order method for absolute quantification of Potato virus Y strain. Analytical and Bioanalytical Chemistry 410: 3815–3825. DOI: 10.1007/s00216-018-1053-3
- Overmann J (2015). Significance and future role of microbial resource centres. Systematic and Applied Microbiology 38: 258–265.
- Roenhorst JW, Boonham N, Winter S, Menzel W & Van der Vlugt RAA (2013). The plant viruses and viroids database and collections of Q-bank. EPPO Bulletin 43: 238–243.
- Roenhorst JW, Lacomme C, Nisbet C, Leichtfried T, Menzel W, Winter S *et al*. (2017). Euphresco project VirusCollect – Fulfilling the need for a common collection of plant viruses and viroids for reference. EPPO Bulletin 47: 41–47.

# 3. Publications

## 3.1. Article(s) for publication in the EPPO Bulletin

Roenhorst JW, Lacomme C, Nisbet C, Leichtfried T, Menzel W, Winter S *et al*. (2017). Euphresco project VirusCollect – Fulfilling the need for a common collection of plant viruses and viroids for reference. EPPO Bulletin 47: 41–47.

## 3.2. Article for publication in the EPPO Reporting Service

None.

## 3.3. Article(s) for publication in other journals

Mehle N, Dobnik D, Ravnikar M, Pompe Novak M (2018). Validated reverse transcription droplet digital PCR serves as a higher order method for absolute quantification of Potato virus Y strain. Analytical and Bioanalytical Chemistry 410, 3815–3825. DOI: 10.1007/s00216-018-1053-3.

## 3.4. Publication by other means

**Posters**

- Mehle N, Dobnik D, Ravnikar M, Pompe Novak M. Droplet digital PCR serves as a higher order method for absolute quantification of Potato virus Y strains. Power of Viruses, Poreč, Croatia,16-18 May 2018.
- Mehle N, Dobnik D, Kutnjak D, Pompe Novak M, Ravnikar M. One-step RT-ddPCR for quantification of Potato virus Y. 16th Triennial Meeting of the Virology Section of the European Association of Potato Research & 8th Annual Meeting of PVYwide Organization, Ljubljana, Slovenia, 31 May-3 June 2016.

# 4. Open Euphresco data

**Information on virus isolates**

Information on virus isolates characterised within this project, including their location, will be made accessible via the EPPO Global Database. Details on the contribution of each partner are provided in the tables in Appendix 1.

# Appendix 1. Overview of virus isolates provided by each partner

Note that the following tables give an overview of isolates available for sharing. At present, not all isolates qualify as reference material.

**Table 1 Virus isolates provided by ANSES, France (Partner 2)**

| Virus species | Acronym | Original host plant | Original code | Q-bank code |
|---|---|---|---|---|
| Beet mosaic virus | BtMv | *Beta vulgaris* | | BtMV_2016_005 Spinach beet |
| Bean common mosaic virus | BCMV | *Phaseolus vulgaris* | | BCMV_2017_013 Bean |
| Bidens mosaic virus | BiMV | *Alstroemeria* | 2016PL05012 | BiMV_2016_001 Alstroemeria |
| Canna yellow streak *virus* | CaYSV | *Canna indica* | 2013CA0P0071 | CaYSV_2013_001 Canna |
| Clover yellow vein *virus* | ClYVV | *Phaseolus vulgaris* | | ClYVV_2017_001 Bean |
| Daphne mottle virus | DapMV | *Daphne* | | DapMV_2016_001 Daphne |
| Impatiens necrotic spot *virus* | INSV | *Nemesia* | | INSV_2017_002 Nemesia |
| Lettuce mosaic virus | LMV | *Lactuca sativa* | LMV0 | LMV_2015_001 Lettuce |
| Moroccan watermelon mosaic virus | MWMV | *Cucurbita pepo* | | MWMV_2015_001 Zucchini |
| Onion yellow dwarf virus | OYDV | *Allium cepa* | H00329816 | OYDV_2014_001 Onion |
| Ornithogalum mosaic virus | OrMV | *Gladiolus* | | OrMV_2016_001 Gladiolus |
| Papaya ringspot virus | PRSV | *Cucurbita pepo* | DSMZ PV-0401 | PRSV_2014_001 Zucchini |
| Potato virus A | PVA | *Solanum tuberosum* | | PVA_2014_011 Potato |
| Potato virus Y | PVY | *Solanum lycopersicum* | 2017PL05173 | PVY_2017_013 Potato |
| Squash vein yellowing virus | SqVYV | *Citrullus lanatus* | 1297112-12GU27B | SqVYV_2012_001 Watermelon |
| Tomato spotted wilt virus | TSWV | *Solanum lycopersicum* | | TSWV_2016_003 Tomato |
| Watermelon mosaic virus | WMV | *Cucurbita pepo* | 2017PA0P0365 | WMV_2017_001 Zucchini |
| Zucchini yellow mosaic virus | ZYMV | *Cucumis melo* | GO-8-16-COU | ZYMV_2016_001 Melon |

**Table 2 Virus isolates provided by DSMZ, Germany (Partner 3)**

| Virus species | Acronym | Original host plant | Original code | Q-bank code* |
|---|---|---|---|---|
| Iresine viroid 1 | IrVd-1 | *Portulaca* | DSMZ PV-1179 | IrVd-1_2015_ Purslane |
| Eggplant mottled dwarf virus | EMDV | *Hydrangea macrophylla* | DSMZ PV-1127 | EMDV_2014_ Hydrangea |
| Pepino mosaic virus [Peruvian] | PepMV | *Solanum muricatum* | DSMZ PV-0554 | PepMV_1970_ Pepino |
| Pepino mosaic virus [Ch2] | PepMV | *Solanum lycopersicum* | DSMZ PV-0716 | PepMV_2001_ Tomato |
| Pepino mosaic virus [US1] | PepMV | *Solanum lycopersicum* | DSMZ PV-0975 | PepMV_2009_ Tomato |
| Pepino mosaic virus [EU] | PepMV | *Solanum jasminoides* | DSMZ PV-1110 | PepMV_2013_ Jasmine |

| | | | | |
|---|---|---|---|---|
| | | | | nightshade |
| Pepino mosaic virus [Peruvian] | PepMV | *Solanum lycopersicum* | DSMZ PV-1125 (56A) | PepMV_2014_ Tomato |
| Physostegia chlorotic mottle virus | PhCMoV | *Physostegia virginiana* | DSMZ PV-1182 | PhCMoV_2014_ Physostegia |
| Potato virus A | PVA | *Solanum tuberosum* | DSMZ PV-0760 (B11) | PVA_2002_ Potato |
| Potato virus A | PVA | *Solanum tuberosum* | DSMZ PV-0768 (M) | PVA_2002_ Potato |
| Potato virus A | PVA | *Solanum tuberosum* | DSMZ PV-0772 (CAN) | PVA_2002_ Potato |
| Potato virus S | PVS | *Solanum tuberosum* | DSMZ PV-0758 (Chile 31) | PVS_2000_ Potato |
| Potato virus S | PVS | *Solanum muricatum* | DSMZ PV-0739 | PVS_2001_ Potato |
| Potato virus S | PVS | *Solanum tuberosum* | DSMZ PV-0757 (Chile 28) | PVS_2002_ Potato |
| Potato virus S | PVS | *Solanum curtilobum* | DSMZ PV-1186 (P2) | PVS_2003_ Solanum curtilobum |
| Potato virus S | PVS | *Solanum tuberosum* | DSMZ PV-1200 (E1) | PVS_2003_ Potato |
| Potato virus S | PVS | *Solanum tuberosum* | DSMZ PV-1201 (B11) | PVS_2003_ Potato |
| Potato virus S | PVS | *Solanum phureja* | DSMZ PV-1203 (CO1) | PVS_2003_ Solanum phureja |
| Potato virus S | PVS | *Solanum tuberosum* | DSMZ PV-0838 (CH1) | PVS_2004_ Potato |
| Potato virus X | PVX | Unknown | DSMZ PV-0847 | PVX_2004_ Unknown |
| Potato virus X | PVX | *Solanum jasminoides* | DSMZ PV-1152 | PVX_2015_ Jasmine nightshade |
| Pelargonium zonate spot virus | PZSV | *Solanum lycopersicum* | DSMZ PV-1183 | PZSV_2015_ Tomato |
| Wild potato mosaic virus | WPMV | *Solanum muricatum* | DSMZ PV-1194 | WPMV_2016_ Pepino |

* Q-bank codes will be assigned as soon as Q-bank is included in EPPO Global Database.

**Table 3 Virus isolates provided by SASA, United Kingdom (Partner 4)**

| Virus species | Acronym | Original host plant | Original code | Q-bank code* |
|---|---|---|---|---|
| Potato mop top virus | PMTV | *Solanum tuberosum* | C1665-3 | PMTV_2016_ Potato |
| Potato mop top virus | PMTV | *Solanum tuberosum* | C1671-1 | PMTV_2016_ Potato |
| Potato mop top virus | PMTV | *Solanum tuberosum* | RD1701-4 | PMTV_2017_ Potato |
| Potato virus Y [NA-Wilga] | PVY | *Solanum tuberosum* | 5467 | PVY_2015_ Potato |
| Potato virus Y [NA-Wilga] | PVY | *Solanum tuberosum* | 6392 | PVY_2015_ Potato |
| Potato virus Y [EU-NTN] | PVY | *Solanum tuberosum* | 10088 | PVY_2010_ Potato |
| Potato virus Y [N-Wilga] | PVY | *Solanum tuberosum* | 4388 | PVY_2010_ Potato |
| Potato virus Y [N-Wilga] | PVY | *Solanum tuberosum* | 6409 | PVY_2010_ Potato |
| Potato virus Y [NA-NTN] | PVY | *Solanum tuberosum* | 9561 | PVY_2010_ Potato |
| Potato yellow blotch virus[1] | PYBV | *Solanum tuberosum* (breeding line 99m-022-026) | | PYBV_2008_ Potato |
| Tobacco rattle virus | TRV | *Solanum tuberosum* | C1632 | TRV_2016_ Potato |

| | | | | |
|---|---|---|---|---|
| Tobacco rattle virus | TRV | *Solanum tuberosum* | C1657 | TRV_2016_ Potato |
| Tobacco rattle virus | TRV | *Solanum tuberosum* | TRV-Spey | TRV_2016_ Potato |

* Q-bank codes will be assigned as soon as Q-bank is included in EPPO Global Database.
[1] New species (Nisbet C, Monger WA, Ross S, Holmes RF, Nova Y, Thomson C, Goodfellow HA, Lacomme C, Jeffries CJ (2019) Biological and molecular characterization of Potato yellow blotch virus, a new species of the genus Potyvirus. Plant Pathology 68, 251-260.

**Table 4 Virus isolates provided by NEBIH, Hungary (Partner 5)**

| Virus species[1] | Acronym | Original host plant | Original code | Q-bank code* |
|---|---|---|---|---|
| Plum pox virus [M] | PPV | *Prunus persica* cv. Mariska | PPV 10/4-5-6 | |
| Pum pox virus [D] | PPV | *Prunus armeniaca* cv. Gönci magyar kajszi | PPV 10/25-27 | |
| Plum pox virus [D] | PPV | *Prunus persica* cv. Meystar | PPV 10/61-62-63 | |
| Pum pox virus [D] | PPV | *Prunus domestica* cv. President | PPV 11/1-3 | |
| Plum pox virus [M] | PPV | *Prunus armeniaca* | PPV 11/67-68-69 | |
| Pum pox virus [M-Rec] | PPV | *Prunus domestica* cv. Besztercei Nm 122 | PPV 12/61-62-63 | |
| Plum pox virus [M] | PPV | *Prunus domestica* cv. Besztercei NM 122 | PPV SK 68 | |
| Pum pox virus [M] | PPV | *Prunus persica* | PPV SK 278 | |
| Plum pox virus [M] | PPV | *Prunus armeniaca* cv. Bergeron | PPV SK 292 | |
| Pum pox virus [D] | PPV | *Prunus persica* | PPV SK 302 | |
| Plum pox virus [D] | PPV | *Prunus dulcis* | PPV SK 304 | |
| Plum pox virus [M-Rec] | PPV | *Prunus armeniaca* cv. Ceglédi óriás | PPV SK 321 | |
| Prune dwarf virus | PDV | *Prunus cerasus* cv. Érdi bőtermő | PDV 13 | |
| Prune dwarf virus | PDV | *Prunus cerasus* cv. Érdi bőtermő | PDV 48/1 | |
| Prune dwarf virus | PDV | *Prunus spinosa* cv. Plena | PDV 223 | |
| Prunus necrotic ringspot virus | PNRSV | *Prunus domestica* | PNRSV 28 | |
| Prunus necrotic ringspot virus | PNRSV | *Prunus avium* | PNRSV 57C | |
| Prunus necrotic ringspot virus | PNRSV | *Prunus dulcis* cv. Grosse tendre rigorose | PNRSV 63 | |
| Prunus necrotic ringspot virus | PNRSV | *Prunus persica* cv. Elberta 603 | PNRSV 66 | |
| Prunus necrotic ringspot virus | PNRSV | *Prunus domestica* cv. Besztercei | PNRSV 147 | |
| Prunus necrotic ringspot virus | PNRSV | *Prunus cerasus* cv. LPP4/1L | PNRSV 208 | |

* Q-bank codes will be assigned as soon as Q-bank is included in EPPO Global Database.
[1] Isolates are available from natural hosts, but since sequence data are lacking, these will not be included in Q-bank yet.

**Table 5 Virus isolates provided by NVWA and WUR, the Netherlands (Partner 1 and 6)**

| Virus species | Acronym | Original host plant | Original code | Q-bank code* |
|---|---|---|---|---|
| Bell pepper mottle virus | BePMoV | *Capsicum annuum* | Path 0 | BePMoV_1979_ Pepper |
| Carrot mottle virus | CMoV | *Daucus carota* | Dc041 | CmoV_1982_ Carrot |
| Carrot mottle virus | CMoV | *Daucus carota* | DC108I | CMoV_1983_ Carrot |
| Cucumber green mottle mosaic virus | CGMMV | *Cucumis sativus* | K3 | CGMMV_1973_ Cucumber |
| Cucumber necrosis virus | CNV | *Daphne mezereum* | Dap1 | CNV_1971_ February daphne |
| Lettuce mosaic virus | LMV | *Lactuca sativa* | Ls1 | LMV_1987_ Lettuce |
| Odontoglossum ringspot virus | ORSV | *Odontoglossum* | NAKS | ORSV_1993_ Odontoglossum |
| Olive latent virus 1 | OLV1 | *Fragaria* | OLV1_2018_WUR_frag002 | OLV1_2018_ Strawberry |
| Pepper mild mottle virus | PMMoV | *Capsicum annuum* | Sp3 | PMMoV_1991_ Pepper |
| Pepper mild mottle virus | PMMoV | *Capsicum annuum* | Path1-2-3 | PMMoV_1978- Pepper |
| Pepper mottle virus | PepMoV | *Capsicum annuum* | PepMoV_2017_ WUR_001 | PepMoV_2017_ Pepper |
| Pepper veinal mottle virus | PVMV | *Capsicum frutescens* | CI | PVMV_1973_ Chili pepper |
| Potato aucuba mosaic virus | PAMV | *Solanum tuberosum* | Albion | PAMV_1968_ Potato |
| Potato virus X | PVX | *Solanum tuberosum* | 802 | PVS_1939_ Potato |
| Potato virus X | PVX | *Solanum tuberosum* | 805 | PVX_1986_ Potato |
| Potato virus X | PVX | *Solanum tuberosum* | 804 | PVX_1991_ Potato |
| Potato virus X | PVX | *Solanum tuberosum* | 951 | PVX_1954_ Potato |
| Potato virus X | PVX | *Solanum tuberosum* | 903 | PVX_1960_ Potato |
| Potato virus Y | PVY | *Solanum lycopersicum* | Tom5_4 | PVY_1989_ Tomato |
| Tobacco etch virus | TEV | *Nicotiana tabacum* | PV-308 | TEV_1996_ Tobacco |
| Zucchini green mottle mosaic virus | ZGMMV | *Cucurbita pepo* | 99907708 | ZGMMV_2009_ Zucchini |

* Q-bank codes will be assigned as soon as Q-bank is included in EPPO Global Database.

**Table 6 Virus isolates provided by VNIIKR, Russia (Partner 7)**

| Virus species | Acronym | Original host plant | Original code | Q-bank code* |
|---|---|---|---|---|
| Impatiens necrotic spot virus | INSV | *Streptocarpus* sp. | StI-6 | INSV_2013_ Streptocarpus |
| Plum pox virus [D] | PPV | *Prunus domestica* | D-007 | PPV_2013_ Plum |
| Plum pox virus [D] | PPV | *Prunus domestica* | D-899 | PPV_2012_ Plum |
| Apple chlorotic leaf spot virus | ACLSV | *Malus domestica* | StM-1 | ACLSV_2018_ Apple |
| Apple chlorotic leaf spot virus | ACLSV | *Malus domestica* | StM-2 | ACLSV_2018_ Apple |
| Apple chlorotic leaf spot virus | ACLSV | *Malus domestica* | StM-3 | ACLSV_2018_ Apple |

* Q-bank codes will be assigned as soon as Q-bank is included in EPPO Global Database.

**Table 7 Virus isolates provided by NIB, Slovenia (Partner 8)**

| Virus species | Acronym | Original host plant | Original code | Q-bank code* |
|---|---|---|---|---|
| Chrysanthemum stem necrosis virus | CSNV | *Chrysanthemum* sp. | NIB V38 | CSNV_2001_003 Chrysanthemum |
| Henbane mosaic virus | HMV | *Solanum lycopersicum* | D159/15 | HMV_2015_ Tomato |
| Potato virus Y | PVY | *Solanum tuberosum* cv Desiree | V 151 | PVY_2007_ Potato |

* Q-bank codes will be assigned as soon as Q-bank is included in EPPO Global Database.

**Table 8 Virus isolates provided by CISTA, Czech Republic (Partner 9)**

| Virus species[1] | Acronym | Original host plant | Original code | Q-bank code* |
|---|---|---|---|---|
| Alfalfa mosaic virus | AMV | | | |
| Apple chlorotic leaf spot virus[1] | ACLSV | | | |
| Apple mosaic virus | ApMV | | | |
| Apple stem pitting virus | ASPV | *Malus* sp. | P322 | ASPV_2014_ Apple |
| Arabis mosaic virus | ArMV | *Vitis vinifera* cv. Ryzlink vlašský | 8702758 | ArMV_2004_ Grapevine |
| Bean yellow mosaic virus | BYMV | *Canna* sp. | 400497 | BYMV_2004_ Canna |
| Broad bean wilt virus 1 | BBWV-1 | | | |
| Calibrachoa mottle virus | CbMV | | | |
| Cherry green ring mottle virus | CGRMV | *Prunus avium* | 400554 | CGRMV_2004_ Cherry |
| Chrysanthemum stunt viroid | CSVd | *Chrysanthemum* sp. cv. Creamist | 903606 | CSVd_2009_ Chrysanthemum |
| Chrysanthemum virus B | CVB | | | |
| Citrus exocortis viroid | CEVd | *Solanum jasminoides* | 1001100 | CEVd_2010_ Jasmine nightshade |
| Columnea latent viroid | CLVd | Unknown | P352a | CLVd_2015_ Unknown |
| Cucumber msoaic virus | CMV | | | |
| Hop mosaic virus | HpMV | | | |
| Impatiens necrotic spot virus | INSV | *Cardamine hirsuta* | 1005501 | INSV_2010_ Hairy bittercress |
| Lettuce mosaic virus | LMV | Unknown | 8903791 | LMV_2004_ Unknown |
| Pepino mosiac virus | PepMV | *Solanum lycopersicum* | 400003 | |
| Pepino mosaic virus | PepMV | *Solanum lycopersicum* cv. Tricia F1 | 801839 | PepMV_2008_ Tomato |
| Pepper mild mottle virus | PMMoV | *Capsicum annum* cv. Stalagnit | 300005 | PMMoV_2004_ Pepper |
| Potato spindle tuber viroid | PSTVd | *Solanum rantonnetii* | 903671 | PSTVd_2009_ Blue potato bush |
| Potato virus M | PVM | | | |
| Potato virus S | PVS | | | |
| Potato virus X | PVX | | | |
| Prune dwarf mosaic virus | PDV | *Prunus avium* | P327 | PDV_2014_ Plum |
| Prunus necrotic ringspot virus | PNRSV | *Rosa* sp. | P223 | PNRSV_2010- Rose |
| Radish mosaic virus | RaMV | | | |
| Raspberry bushy dwarf virus | RBDV | | | |
| Tobacco mild green mosaic virus | TMGMV | *Capsicum annuum* | P245 | TMGMV_2011_ Pepper |
| Tobacco mosaic virus | TMV | *Petunia* x *hybrida* cv. | P101 | TMV_2011_ |

| | | | | |
|---|---|---|---|---|
| | | Rose Wein | | petunia |
| Tobacco rattle virus | TRV | | | |
| Tobacco ringspot virus | TRSV | *Impatiens walleriana* | 1104116 | TRSV_2011_ Impatiens |
| Tobacco streak virus | TSV | | | |
| Tomato apical stunt viroid | TASVd | *Solanum rantonnetii* | 1300148 | TASVd_2015_ Blue potato bush |
| Tomato aspermy virus | TAV | | | |
| Tomato black ring virus | TBRV | Unknown | P364 | TBRV_2015- Unknown |
| Tomato bushy stunt virus | TBSV | | | |
| Tomato chlorotic dwarf viroid | TCDVd | *Petunia* x *hybrida* | 906566 | TCDVd_2011_ Petunia |
| Tomato mosaic virus | TMV | *Solanum* sp. | 1404533 | ToMV_2014_ Solanum |
| Konjac mosaic virus | KoMV | | | |
| Lettuce mosaic virus | LMV | | | |
| Plum pox virus | PPV | | | |
| Potato virus A | PVA | | | |
| Potato virus Y | PVY | | | |
| Tomato spotted wilt virus | TSWV | | | |
| Turnip mosaic virus | TuMV | *Brassica rapa* subsp. *chinensis* cv. Wong Bok | 8904022 | TuMV_2007_ Turnip |
| Turnip yellow moaic virus | TYMV | | | |
| Watermelon mosaic virus | WMV | *Cucumis sativus* | 9206901 | WMV_2008_ Cucumber |
| Zucchini yellow mosaic virus | ZYMV | *Cucumis sativus* | 7508 | ZYMV_2000_ Cucumber |

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[1] Isolates are available, but since sequence data are lacking, these will not be included in Q-bank yet.