EPPO Datasheet: *Sadwavirus citri*

Last updated: 2022-04-19

IDENTITY

Preferred name: *Sadwavirus citri*
Taxonomic position: Viruses and viroids: Riboviria: Orthornavirae: Pisuviricota: Pisoniviricetes: Picornavirales: Secoviridae
Other scientific names: *Natsudaidai dwarf virus, Navel orange infectious mottling virus, SDV, Satsuma dwarf nepovirus, Satsuma dwarf sadwavirus, Satsuma dwarf virus*
Common names: Oleocellosis-like symptoms of Satsuma orange, Summer orange dwarf, dwarf disease of satsuma
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EPPO Categorization: A2 list
view more categorizations online...
EU Categorization: Quarantine pest ((EU) 2019/2072 Annex II A)
EPPO Code: SDV000



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Notes on taxonomy and nomenclature

Satsuma dwarf virus (SDV) is a positive-sense single-stranded RNA (+ssRNA) virus with a bipartite genome encapsidated in polyhedral virions (Iwanami *et al*., 1999). The reference sequences of the genomic RNAs 1 and 2 of SDV are available in GenBank (NC_003785.2 and NC_003786.2, respectively) (Iwanami *et al*., 1999). The virus was initially associated with a severe disease of satsuma (*Citrus unshiu*) (Usugi and Saito, 1979). Viruses identified in other hosts and/or associated with different symptoms, initially named differently [i.e. citrus mosaic virus (CiMV) (Iwamani and Ieki, 1996), navel orange infectious mottling virus (NIMV) (Iwamani *et al*., 1998), natsudaidai dwarf virus (NDV) (Tanaka, 1972) and hyuganatsu virus (HV) (Ito *et al*., 2004)], share over 75% amino acid sequence identity with SDV and do not fulfil the species demarcation criteria established for members of the family *Secoviridae*. They are thus considered to be strains of SDV (Le Gall *et al*., 2007; Iwanami, 2010), which is the unique species in the subgenus *Satsumavirus*, genus *Sadwavirus* (Family *Secoviridae*). SDV has also been reported as citrus mosaic virus in the literature (Iwamani and Ieki, 1996), a name initially used to designate another unrelated DNA virus identified on *Citrus* in India (Dakshinamurti and Reddy, 1975; Ahlawat *et al*., 1985; Pant and Ahlawat, 1997) which was later characterized as a badnavirus and named citrus yellow mosaic virus (Pant and Ahlawat, 1997).

HOSTS

The principal host is satsuma (*Citrus unshiu*), on which the symptoms have most commonly been observed. However, SDV may naturally infect a range of *Citrus* species in the family *Rutaceae*, generally inducing symptoms . *Viburnum odoratissimum* (China laurestine, sweet viburnum), a woody plant used as hedge in satsuma orchards in Japan, and *Daphniphyllum teijsmannii*, are the only two non-rutaceous natural hosts identified so far (Koizumi *et al*., 1988; Nakazono-Nagaoka *et al*., 2014) and are symptomless hosts. The virus has been experimentally transmitted by grafting to a very broad range of *Citrus* species and their hybrids (Miyakawa, 1969, Tanaka & Yamada, 1972; Iwanami *et al*., 1993) so that most *Citrus* species are considered as susceptible. It is thought that this will also be the case for related *Rutaceae* species (*Fortunella* spp., and *Poncirus* spp.) (Miyakawa, 1969; Tanaka, 1972; Iwanami *et al*., 1993a; Iwanami, 2010). Some susceptible *Citrus* (*Citrus latifolia, C. medica, Citrus reticulata* x *C. paradisi* cv. Orlando) may not develop obvious symptoms. Several non-*Citrus* rutaceous species were also found to be susceptible to SDV (Iwanami *et al*., 1993a; Miyakawa, 1969).

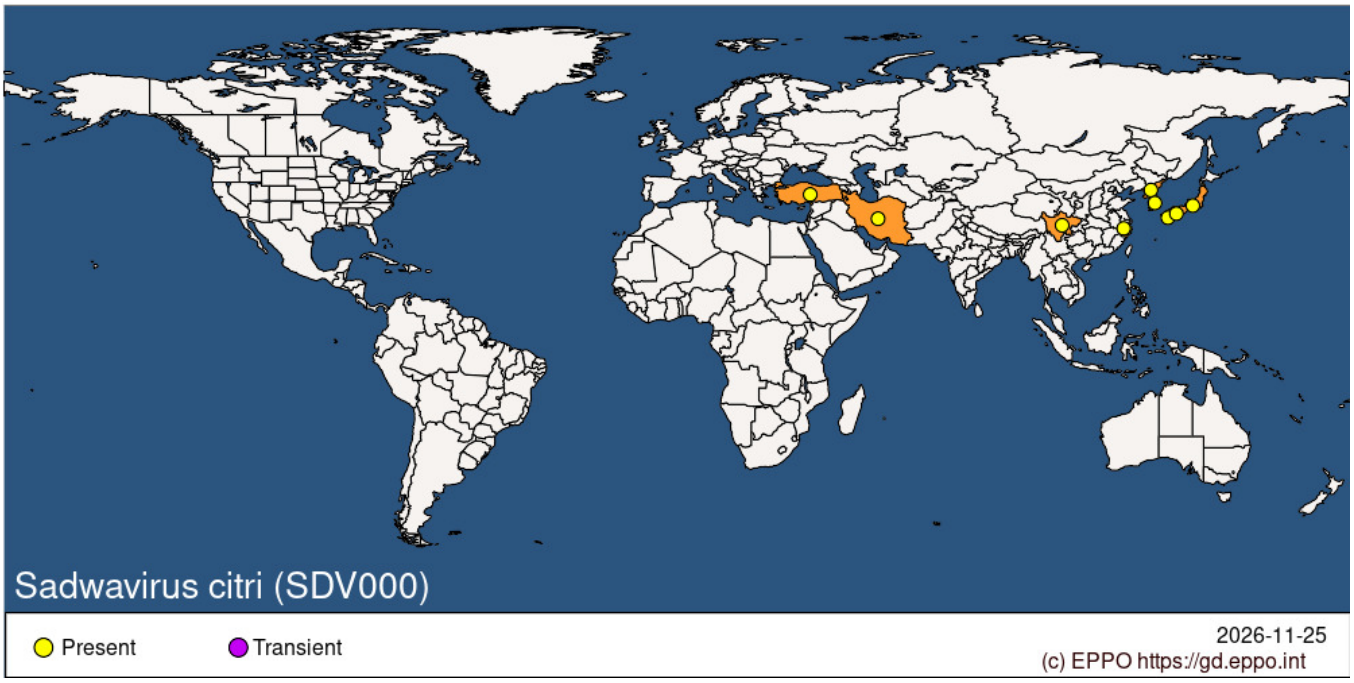
The literature is somewhat confusing, with sometimes contradictory reports, when it comes to herbaceous, non-rutaceous experimental hosts of SDV identified upon artificial mechanical inoculation. Causes for these discrepancies may include the use of different viral isolates, co-infection with other viral agents, the use of different varieties/genotypes of herbaceous hosts or differences in experimental inoculation conditions. In particular, SDV strains may vary in their experimental herbaceous host range, but most isolates are able to systemically infect *Sesamum indicum*

and *Physalis floridana* (Iwanami *et al*., 1993a). The majority of these experimental hosts have been reported in the *Fabaceae* family, including *Phaseolus vulgaris* and *Vigna unguiculata.* Outside of this family, two *Nicotiana* species (*N. clevelandii*, *N. tabacum*), *Chenopodium quinoa* and *Gomphrena globosa* have been reported as hosts (Tanaka & Imada, 1974).

Host list: *Citrus natsudaidai*, *Citrus tamurana*, *Citrus trifoliata*, *Citrus x aurantium var. sinensis*, *Citrus x aurantium var. unshiu*, *Citrus x tangelo*, *Daphniphyllum teijsmannii*, *Viburnum odoratissimum*

GEOGRAPHICAL DISTRIBUTION

Satsuma dwarf virus is present in China, Iran, Japan and the Korean peninsula. It has a restricted distribution in Turkey where it is presumed to have been introduced with budwood imported from the Far East (Onelge and C?nar, 2010). One report from Peru (IOCV website, 2017) has been retracted its author (Iwanami, 2010).



EPPO Region: Türkiye
Asia: China (Sichuan, Zhejiang), Iran, Islamic Republic of, Japan (Honshu, Kyushu, Shikoku), Korea, Democratic People's Republic of, Korea, Republic of

BIOLOGY

SDV is transmitted by grafting (Ushiyama, 1981), but also mechanically under artificial conditions (Tanaka & Imada, 1974; Usugi and Saito, 1979; Iwanami, 2010). Mechanical transmission does not seem to play a role in the natural spread of the virus (EFSA, 2017 and references therein). Field observations suggest that the disease is slowly transmitted from tree to tree, presumably through soil. Although no vector has been identified so far, involvement of fungi or nematodes cannot be excluded (EFSA, 2017). It is thought that *V. odoratissimum* and *D. teijsmannii* may act as a reservoir for infection (Koizumi *et al*.,1988; Nakazono-Nagaoka *et al*., 2014). Seed transmission, reported experimentally in *Phaseolus vulgaris* (kidney bean) (at a rate of 8.6%), was not observed in *Citrus* or in *Sesamum indicum* (white sesame) (EFSA, 2017 and references therein). Considering the natural spread pattern in the field, pollen transmission is considered unlikely (EFSA, 2017).

DETECTION AND IDENTIFICATION

Symptoms

On *Citrus*, SDV typically causes dwarfing and small boat or spoon-shaped leaves. General symptoms are enations, multiple flushing, stunting or dwarfing, reduction in number and size of leaves and shoots, shortened internodes, and small-sized fruits with thick peel. Fruit production can be seriously reduced both in quality and yield (Iwanami and Koizumi, 2000).

The CiMV strain is characterized by the particular symptoms it causes on fruits. On satsumas, these are green blotches or ring-shaped spots on the rind at colour break and delayed colouring of the spotted area. Fruit symptoms also appear on lemons, but not typically on oranges, although fruit quality is reduced on this host. However, some isolates do not induce symptoms on fruits of satsuma (Iwanami *et al*., 1993a), while others have been associated with specific symptoms, i.e. CiMV with dapples on rinds of satsuma mandarin fruits, NDV with mottling and curling of new leaves of *Citrus natsudaidai*, NIMV with chlorotic spots on navel oranges, and HV with brown growth rings on hyuganatsu (*Citrus tamurana*). Severity of symptoms has also been correlated with low temperature environmental conditions (Kitajima *et al*., 1972).

Some host plants are known to be symptomless (e.g. *V. odoratissimum* and *D. teijsmannii*).

Morphology

SDV is an isometric virus approximately 26 nm in diameter, with particles containing two capsid proteins with a molecular weight of about 42 and 22-23 kilodaltons (Iwanami *et al*., 1993b). The virions encapsulate the two genomic RNAs (RNA1 and RNA2) of respectively about 7.0 kb and 5.4 kb. Both RNAs have a poly(A) sequence at their 3' end. For more information on characteristics of SDV, see Usugi and Saito (1977, 1979).

Detection and inspection methods

Visual inspection may allow the detection of symptoms but is not considered reliable enough since symptoms are not highly specific and are not always obvious in infected plants.

White sesame is the best herbaceous indicator plant for detecting SDV through biological assays based on mechanical inoculation of homogenates from *Citrus* plants (EPPO, 1998; Tanaka *et al*., 1965). Blackeye cowpea, 'Satisfaction' kidney bean and *Physalis floridana* can also be effectively used as indicators (Tanaka and Kishi, 1963; Tanaka *et al.*, 1965). Bioassays can also rely on graft inoculation of *Citrus* indicator seedlings [*Citrus natsudaidai*, citron (*C. medica*), sour lemon (*C. limon*), Dweet tangor, mandarin (*C. reticulata*) or satsuma (*C. unshiu*)] (EPPO, 1998) however the possible interference of citrus tristeza virus, if present in the plants to be tested, must be considered (Roistacher, 2004). SDV, including the CiMV strain, can be detected by ELISA using polyclonal antibodies produced against SDV and extracts from young tender leaves from the spring flush (Usugi & Tsuchizaki, 1982; Koizuimi *et al*., 1988). ELISA is extremely helpful in large-scale detection. However, it should not be used as the only method for the testing of mother trees because it sometimes gives false negative results, in particular with some strains of SDV. ELISA can be used in conjunction with mechanical transmission to white sesame or with other method(s) to ensure that important budwood or mother trees are free from SDV. ELISA with monoclonal antibodies can be used to distinguish the CiMV strain from other SDV strains (Nozu *et al*., 1986). Reliable molecular tests, based on reverse-transcriptase polymerase chain reaction (RT-PCR) (Iwamani, 2010), multiplex RT-PCR (Hyun *et al* ., 2017), QuantiGene Plex-Luminex-based test (Dang *et al*., 2016) are available to detect SDV alone or in mixed infections.

PATHWAYS FOR MOVEMENT

Movement and trade of contaminated propagation materials is considered the most significant mode of spread since SDV is readily transmitted by grafting. SDV may also move locally, probably through soil with the possible contribution of unidentified vector(s) (Isoda & Gyoutoku, 1990). In international trade, SDV is most likely to be carried in infected propagation material, but soil should also be considered as a potential pathway.

PEST SIGNIFICANCE

Economic impact

Trees of satsuma mandarin infected by SDV are generally stunted, with reduced yield. Fruits on trees severely affected by the CiMV strain are of poor quality and low commercial value. Detailed data on yield losses caused by SDV are not available. However, a field infection rate of 31% has been reported in Turkey (Ç?nar and Önelge, 2010), showing the potential for severe impact on satsuma mandarin and some other *Citrus* cultivations.

Control

The most efficient control strategy appears to be the development and use of SDV-free propagation material, as described in EPPO Standard PM 4/12 *Pathogen-tested citrus trees and rootstocks* (EPPO, 1998). No control measures are known in the field, besides the destruction of infected plants. Though field observation suggests the transmission of SDV through soil, soil fumigation is not effective to control disease progression in *Citrus* groves (Isoda *et al*., 1991).

Phytosanitary risk

The virus typically infects and has its main impact in satsumas (*C. unshiu*) compared to other *Citrus*. Satsumas are not widely grown in the EPPO region. In Turkey, where satsumas are grown in the Aegean region, the virus has only been reported on this species and does not appear to have spread to other *Citrus* species, or to other regions of Turkey, or elsewhere in the EPPO region. Even if no vector is known, SDV natural infection has already been reported from other *Citrus* species elsewhere in the world, in particular for CiMV, NIMV, NDV and HV; most Citrus species have been experimentally shown to be susceptible. There are no ecoclimatic constraints for SDV affecting establishment, except those affecting its hosts; and *Citrus* cultivation occurs widely in the Mediterranean part of Europe (EFSA, 2017). It was therefore considered justified by EPPO to prevent further spread of SDV and, in particular, introduction of new strains from the Far East.

PHYTOSANITARY MEASURES

Appropriate phytosanitary measures to import plants for planting (excluding seeds and pollen) of *Citrus*, other rutaceous hosts, as well as the natural non rutaceous hosts of SDV into the EPPO region could require that these plants are produced in a pest free area, in a pest free place/site of production (e.g. established according to EPPO Standard PM 5/8 *Guidelines on the phytosanitary measure 'Plants grown under physical isolation'* (EPPO, 2016)), or shown to be free from SDV by appropriate diagnostic methods. A number of EPPO countries already ban the import of *Citrus*, *Fortunella*, *Poncirus* and their hybrids (other than fruits and seeds) (EU, 2019).

SDV already occurs in the EPPO region (i.e. in Turkey). So, within the EPPO region, *Citrus* planting material should be certified free from SDV (EPPO, 2018).

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Datasheet history

This datasheet was first published in 1997 in the second edition of 'Quarantine Pests for Europe', and revised in 2022. It is now maintained in an electronic format in the EPPO Global Database. The sections on 'Identity', ‘Hosts’, and 'Geographical distribution' are automatically updated from the database. For other sections, the date of last revision is indicated on the right.

CABI/EPPO (1997) *Quarantine Pests for Europe (2nd edition).* CABI, Wallingford (GB).

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