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Integrated Pest Management

Fanleaf degeneration/decline disease of grapevines

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Introduction

Fanleaf degeneration/decline disease is one of the most severe viral disease complexes of grapevine worldwide. It is also one of the oldest known viral diseases of *Vitis vinifera* with descriptions of symptoms being reported in Europe as early as 1841. This disease is now known to affect grapevines in all temperate regions where *Vitis vinifera* and hybrid rootstocks are grown. Within the United States, fanleaf degeneration/decline is widespread in California, but has also been observed in Washington State, Maryland, Pennsylvania, New York and Missouri.

Causal Agents

Fanleaf degeneration/decline disease is caused by several different virus species (Table 1). Viruses causing fanleaf degeneration/decline are nepoviruses (acronym for ne = nematode-borne; po = polyhedral particle) (Figure 1). *Grapevine fanleaf virus* (GFLV) is the most well-characterized nepovirus, and is by far the most widespread and important cause of the disease worldwide. In the United States, GFLV, *Arabis mosaic virus* (ArMV), *Tomato ringspot virus* (ToRSV), *Tobacco ringspot virus* (TRSV), *Peach rosette mosaic virus* (PRMV), and *Blueberry leaf mottle virus* (BLMoV) have been reported in fanleaf-affected vines. However, only ToRSV, TRSV, and BLMoV have been found in New York State vineyards.

Table 1. Nepoviruses that can cause fanleaf degeneration/decline disease. Nepoviruses in bold are found in USA vineyards; those within a blue field are found in NY vineyards.

ArMV	*Arabis mosaic virus*	**GFLV**	***Grapevine fanleaf virus***
AILV	*Artichoke Italian latent virus*	GTRSV	*Grapevine Tunisian ringspot virus*
BLMoV	***Blueberry leaf mottle virus***	**PRMV**	***Peach rosette mosaic virus***
CLRV	*Cherry leafroll virus*	RpRSV	*Raspberry ringspot virus*
GARSV	*Grapevine Anatolian ringspot virus*	SLRSV	*Strawberry latent ringspot virus*
GBLV	*Grapevine Bulgarian latent virus*	**TRSV**	***Tobacco ringspot virus***
GCMV	*Grapevine chrome mosaic virus*	TBRV	*Tomato blackring virus*
GDefV	*Grapevine deformation virus*	**ToRSV**	***Tomato ringspot virus***

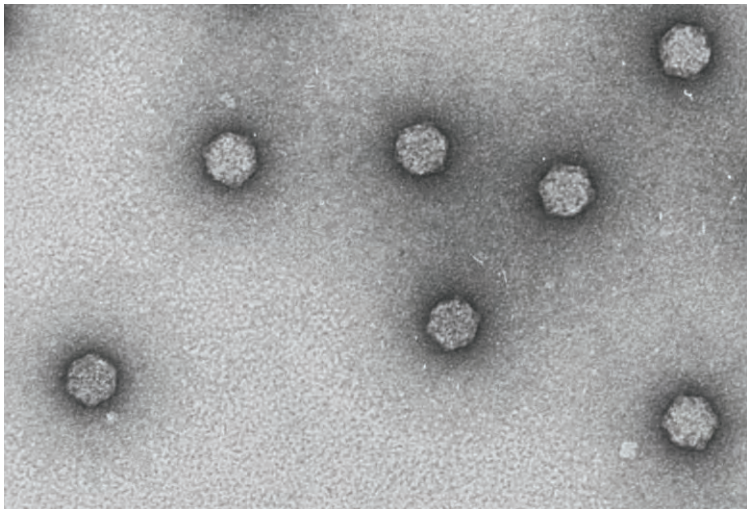

Figure 1. Electronmicrograph of purified *Grapevine fanleaf virus* particles of 28 nm in diameter. Photo by M. Fuchs.

Figure 2. Missing, dead vines of *Vitis vinifera* cv. Pinot noir alongside other declining vines in a naturally GFLV-infected vineyard. Photo by M. Fuchs.

Host Range, Impact, and Symptoms

The natural host range for most of the nepoviruses involved in fanleaf degeneration/decline disease includes *Vitis* species (*V. vinifera,* rootstocks and interspecific hybrids). While GFLV has a narrow host range, other nepoviruses have a wider host range. ToRSV, TRSV, BLMoV, PRMV, ArMV, CLRV, RpRSV, and TBRV can infect small fruit crops such as strawberry, raspberry, blueberry, currants (black and red), or black elderberry. ToRSV, PRMV, CLRV, and RpRSV can infect fruit trees including peach, apricot, almond, cherry, plum, walnut and apple. Furthermore, ToRSV, TRSV, ArMV, and CLRV can infect other crops, including hop, soybean, tobacco, birch, and ornamentals. In addition to these important crop hosts, many of these viruses have also been found to infect common weed species. Some of these weeds include dandelion (for ToRSV and PRMV), broadleaf plantain (for TRSV), Bermuda grass, knotweed, and wild raspberry (for GFLV), and a much wider range of weed species for ArMV, AILV, and TBRV.

Infected vines exhibit a progressive degeneration or decline, which leads to a shortened productive lifespan of the affected vineyards by reducing yield (up to 80%) and quality, often ending in vine death (Figure 2). Fruit clusters are often smaller and fewer in number and exhibit irregular ripening and poor berry set (Figure 3). All nepoviruses involved in fanleaf degeneration/decline can cause similar symptoms.

Fanleaf degeneration disease gets its name from the fan-like leaf shape that may be exhibited on infected vines and the gradual decline in growth and vigor of infected vines over time. The fan-shaped leaves are caused by abnormally gathered primary veins and widely open petiolar sinuses (Figure 4A). In addition to this symptom, which may not be present in all infected vines, leaves may also show yellowing, puckering, deep lobes, bright chrome yellow coloring or mosaics with mottling (Figure 4B and C). Yellow and distorted leaf symptoms often occur in the spring and fade as the summer progresses. Shoots of affected vines may have shortened internodes and abnormal branching (Figure 4D). Infected vines may also exhibit a decreased resistance to adverse climatic factors such as drought or freeze events. Infected propagation materials may show reduced ability to root or poor graft take.

Figure 3. Small clusters with shot berries of (A) GFLV-infected *Vitis vinifera* cv. Savagnin rose (center) compared to healthy clusters on the left and right, (B) ToRSV-infected interspecific hybrid Geisenheim 26, and (C) TRSV-infected interspeciic Bertille Seyve 2862. Photos by M. Fuchs and P. Bass.

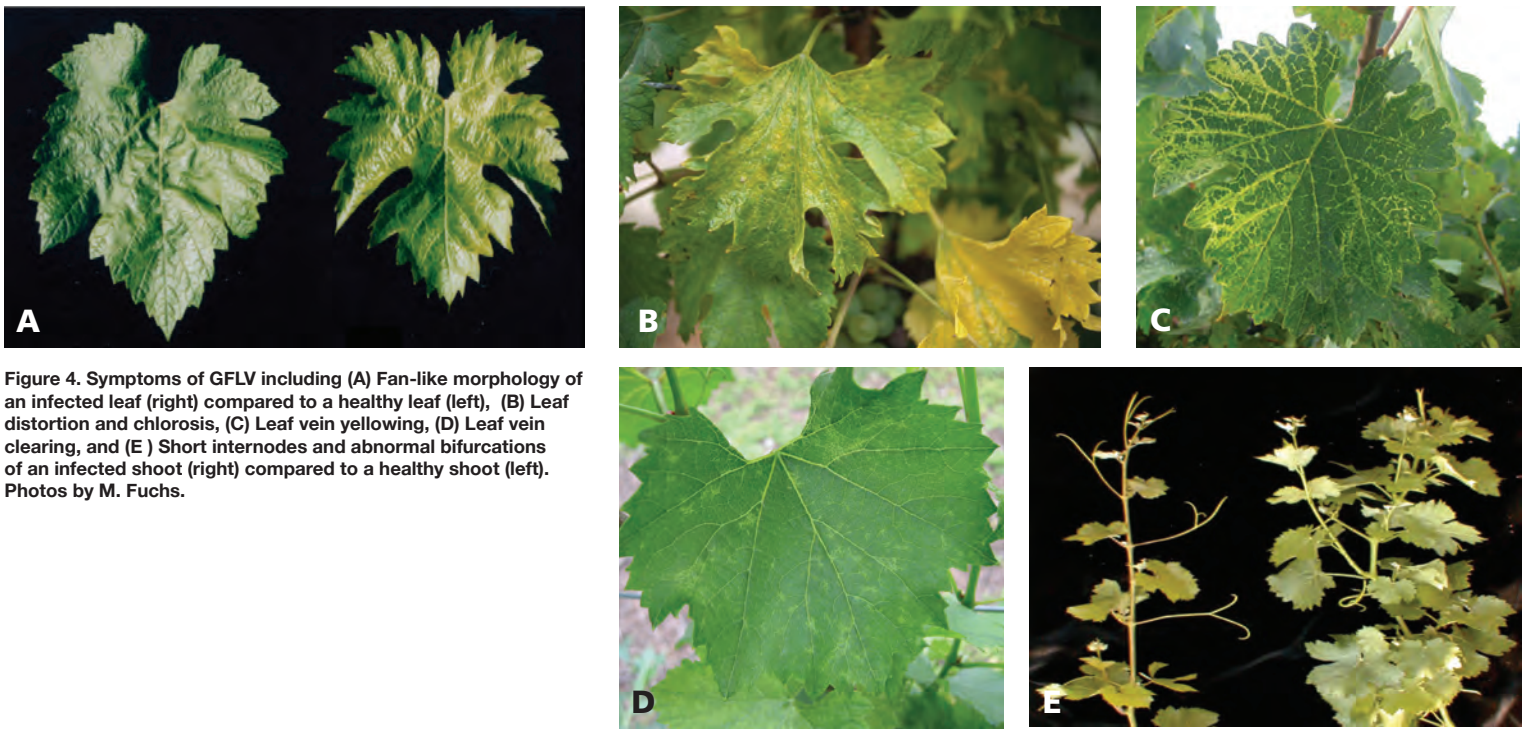

Figure 4. Symptoms of GFLV including (A) Fan-like morphology of an infected leaf (right) compared to a healthy leaf (left), (B) Leaf distortion and chlorosis, (C) Leaf vein yellowing, (D) Leaf vein clearing, and (E) Short internodes and abnormal bifurcations of an infected shoot (right) compared to a healthy shoot (left). Photos by M. Fuchs.

Transmission and Spread

Localized spread of the nepoviruses involved in fanleaf degeneration/decline disease occurs largely by dagger nematodes. Virus-infected vines often have a patchy distribution in vineyards (Figure 5A). ToRSV and TRSV are vectored by the dagger nematode *Xiphinema americanum* sensu lato, a large complex of related species. Nematode vector species of ToRSV include *X. americanum* sensu stricto (Figure 5B), *X. bricolensis, X. californicum, X. targanense, X. intermedium,* and *X. rivesi.* GFLV and ArMV are specifically transmitted by the dagger nematodes *X. index* (Figure 5C) and *X. diversicaudatum,* respectively, though neither of these nematode species has been found in New York State. Most of the other viruses that cause fanleaf degeneration/decline have nematode vectors also; however, no nematode vector is currently known for BLMoV, CLRV, GDefV, GARSV, GTRSV, or GCMV.

Seed transmission has been reported for most—but not all—nepoviruses, and BLMoV and CLRV are efficiently transmitted by pollen. However, since grapes are self-fertile and outcrosses are minimal, seed and pollen transmission are of only minor importance in grapevine, though these may be important mechanisms of transmission for virus spread between weed and alternate hosts.

Long distance spread of nepoviruses occurs primarily through movement of infected propagation materials and their subsequent careless use in propagation and grafting. Since the nematode vector of several nepoviruses, i.e. ArMV, AILV, RpRSV, AILV, and SLRV, has not been described in North America, and since the nematode vector of GFLV, X. index, has not been described outside of California, spread of these viruses via propagation and grafting of infected materials may be the only practical route of dissemination of fanleaf degeneration/decline disease in most North American grapevine-growing areas.

Management

To date, only ToRSV, TRSV, and (to a lesser extent) BLMoV have been reported in vineyards of New York State. Accordingly, only these viruses should be the focus of an active management program at this time. However, it is important that growers and vineyard managers be aware of the potential for other nepoviruses causing fanleaf degeneration/decline to become established in New York State vineyards.

Once a vine is infected, there is no cure for nepoviruses in a vineyard, and once infected vines and soilborne nematode vectors are established in a vineyard setting, control of fanleaf degeneration/decline can be extremely challenging. Management would require soil fumigation, deep plowing, cover crops with nematicidal properties, lengthy fallow periods (up to 10 years) and use of nematode-tolerant rootstocks.

However, as long as the vectors of a given virus are not known to be established in the eastern U.S., vine-to-vine spread of these viruses is limited or impossible, meaning that removal of infected vines is sufficient for control of most of the viruses that cause fanleaf degeneration/decline. Therefore, growers should take appropriate precautions to prevent the introduction of both the virus and its nematode vector.

In the case of ToRSV and TRSV, which have nematode vectors that are already widely distributed in eastern U.S. regions, management of these viruses relies on the following:

1. Prior to replanting, perform a soil test to determine the presence of dagger nematodes, which may harbor and spread the viruses of concern.
2. Devise the best preparation strategy for the vineyard replant site based on soil test results.
3. Plant only virus-tested, clean planting material originating from certified, clean mother stocks to ensure a healthy and high quality crop.
4. Eliminate alternate hosts—especially weed hosts—that can serve as a viral reservoir in vineyard settings.

At present, there are no sources of true resistance in either wild or cultivated grapevines toward most of the viruses that cause fanleaf degeneration/decline, so conventional breeding to develop fanleaf resistant material is not possible in most cases. *Vitis labrusca* is resistant to ToRSV and TRSV, and some interspecific hybrids (DeChaunac, Baco noir, Vidal blanc, Vincent, among others) show some resistance to TRSV but are susceptible to ToRSV. The rootstocks commonly used in the eastern U.S. (3309 C, SO4, Kober 5BB, St George, 44-53 Malegue, 110 Richter, 1616 C, among others) show field resistance to ToRSV and rootstocks O39-16, RS-3 and RS-4, among others, show field resistance to GFLV in California, but are not useful in the eastern U.S. since *X. index* is not currently found here. Rootstocks resistant to the nematode vectors of viruses causing fanleaf degeneration/decline are available, in particular for *X. americanum* and *X. index* but they do not prevent infection of scions with ToRSV and GFLV, respectively. Research is ongoing to develop virus-resistant grapevines, in particular GFLV-resistant rootstocks, through genetic engineering.

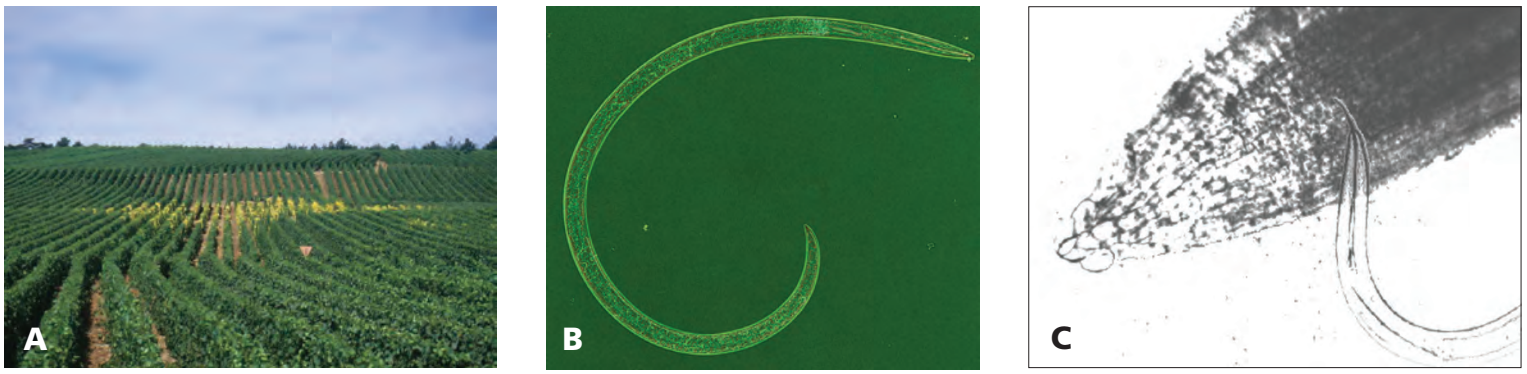

Figure 5. Dagger nematode vectors of viruses causing fanleaf degeneration/decline of grapevines. (A) Patchy distribution of GFLV-infected vines of *V. vinifera* cv. Chardonnay with chlorotic leaves in a naturally infected vineyard, as a result of *X. index*-mediated transmission, (B) *Xiphinema americanum* isolated from a vineyard replant site, and (C) *Xiphinema index* feeding on the root tip of a host plant. Photos by M. Fuchs, G. Abawi and C. Smart

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