Potyvirus Leek Yellow Stripe Virus

Scientific Name:
Potyvirus Leek Yellow Stripe Virus (Bos, 1978)

Synonyms:
Garlic mosaic virus, garlic yellow stripe virus, garlic yellow streak virus

Common Name(s)
Leek Yellow Stripe Virus (LYSV)

Type of Pest
Plant pathogenic virus

Taxonomic Position
Class: Not assigned, **Order:** Not assigned, **Family:** Potyviridae

Reason for Inclusion in Manual
Additional Pest of Concern

Pest Description
Allium species (garlic, onion, and leek) are grown commercially all over the world for consumption or ornamental decoration. *Leek yellow stripe virus* (LYSV) is the causal agent of yellow stripe disease in leek and mosaic disease in garlic. Severe epidemics of yellow stripe disease on leek in Germany in the 1950s, and twenty years later in the Netherlands catalyzed more intensive research into the viral causal agent of the disease (Bos, 1983). These investigations proved difficult, as the causal agents of yellow striping occurred in virus complexes that were challenging to characterize. The first official report of LYSV in commercial garlic was in 1987, but later investigations demonstrated the presence of the virus in New Zealand as early as 1981 (Lot et al., 1998)

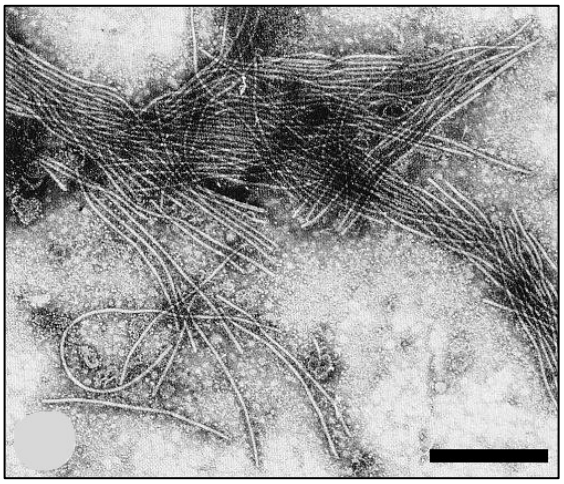

Figure 1. Electron micrograph of LYSV viral particles from infected leek. Photo courtesy of the Association of Applied Biologists.

The virus is a positive-sense single stranded RNA virus that houses its genetic material in a non-enveloped capsid (Davis, 2008a). The virus particles (Fig. 1) are flexuous (rod-like and bendable) particles 815 to 820nm long that aggregate end-to-end. The protein coat of the virus is 34 kDa with a buoyant density in a cesium chloride gradient of 1.326 g/cm^3 (Bos, 1981).

Biology and Ecology

Leek Yellow Stripe Virus is a potyvirus specific to *Allium* species (Bos et al., 1978). The *Allium* potyviruses rarely cross over to infect new hosts, which eases the threat of contamination and spread to neighboring non-*Allium* hosts. LYSV is commonly found in nature in viral complexes with other *Allium* potyviruses and carlaviruses, such as onion dwarf yellow virus and garlic common latent virus. The appearance of LYSV in these viral complexes made initial identification and classification difficult (Barg et al., 1997).

Symptom expression is rare and haphazard in the field during summer months, but becomes increasingly apparent in the fall months. Autumn and winter crops can be completely infected (Bos et al., 1978). In the late 1970s, there was a shift from lighter-colored cultivars to darker-colored, "less sensitive" cultivars in commercial production. This led to a decrease in the incidence of LYSV in autumn crops. This apparent resistance has been credited to the thicker cuticular wax layer on the darker leek cultivars (Vandijk, 1993).

Figure 2. Infected garlic leaves with chlorotic striping. Photo courtesy of Dr. Hanu Pappu.

Symptoms and Signs

Leek: In leek, LYSV causes irregular yellow striping on the leaves (Fig. 2), particularly near the base, but not confined to this area. In certain instances, entire leaves can turn yellow (Bos et al., 1978). Diseased plants are drier with soft, limp, and/or deformed leaves (Barg et al., 1997). Symptoms observed in the field could be replicated in the greenhouse, and usually appeared within 14 days of inoculation (Lot et al., 1998).

Garlic: In garlic, LYSV causes light yellow striping on the distal part the leaves, which can lead to dwarfing of the entire plant (Fig. 3). The virus also causes bulbs to be smaller and malformed, which results in yield loss.

Figure 3. Severely dwarfed garlic with necrosis on the leaf tips. Photo courtesy of Dr. Mike Pearson.

Allium crops infected with LYSV are more susceptible to weather conditions like frost, and do not keep well post-harvest (Bos et al., 1978).

Pest Importance

Potyviruses rarely infect in isolation, and complexes of different strains and species are common. Infections of LYSV in the field can be devastating, sometimes approaching 100% on leek plots (Bos, 1983). Yield loss in garlic bulbs can approach 60% and climb to 84% when doubly infected with another potyvirus. Germination rate in garlic is also affected and can decline to 60% of normal when doubly infected with another potyvirus (Lot et al., 1998). Garlic exports in the United States were valued at approximately $8.8 million in 2008, and world-wide production was valued at $187 million. Significant losses are a possibility if the disease becomes widely established in the United States (NPAG, 2009).

Known Hosts

Major hosts:

Allium ampeloprasum var. *holmense* (great-headed garlic), *A. ampeloprasum* var. *porrum* (leek), *A. aperloprasum* var. *sectivum* (pearl onion), *A. longicupis* (wild garlic), and *A. stavium* (garlic) (Bos, 1981; Vandijk, 1993).

Minor hosts:

Allium cepa var. *cepa* (onion) and *A. cepa var. ascalonicum* (shallot) (Bos, 1981; Vandijk, 1993).

Experimental/Indicator Hosts:

Chenopodium amaranticolor (tree spinach), *C. quinoa* (quinoa), and *Celosia argentea* (silver cock's comb) (Bos, 1981; Vandijk, 1993).

Known vectors (or associated organisms)

Common aphid vectors of LYSV are the green peach aphid (*Myzus persicae*) and the black bean aphid (*Aphis fabae*) (Fig. 4, 5) (Lunello et al., 2002). Both species are found on every continent except Antarctica, and in over half of the 50 United States (CIE, 1963). These aphids are mono- or polyphagous depending on the growth stage. The youngest stages have a single primary host during the winter and spread to other hosts in the summer months as the nymphs grow. They both spread numerous plant viruses in addition to LYSV in a non-persistent manner during feeding (Blackman and Eastop, 2000).

Figure 4. (Left to right) Young nymph, adult wingless, and winged green peach aphids. Photo courtesy of Rothamsted Research.

Other aphids used to experimentally inoculate host plants include: *Rhopalosiphum maidis* (corn aphid, corn leaf aphid)*, R. padi* (bird cherry oat aphid)*, Schizaphis graminum* (greenbug)*, Aphis gossypii* (melon aphid,

cotton aphid) , *A. nerii* (oleander aphid), *Uroleucon sonchi* (sowthistle aphid), and *Hyperomyzus carduellinus* (Asian sowthistle aphid) (Lunello et al., 2002).

LYSV is also commonly associated with other *Allium* viruses, *i.e.*, it has a synergistic relationship with onion dwarf virus. Multiple investigations have demonstrated that plants express aggravated symptoms when infected with LYSV and one or more other viruses (Vandijk, 1993; Lot et al., 1998). Reverse transcriptase polymerase chain reaction (RT-PCR) and immunocapture reverse transcriptase polymerase chain reaction (IC-RT-PCR) methods are available to distinguish LYSV from onion yellow dwarf virus in single and mixed infections (Dovas et al., 2001b; Lunello et al., 2005).

Figure 5. Adult and juvenile black bean aphids. Photo courtesy of Dr. Jim Hardie.

Known Distribution

Asia: Bangladesh, China, Japan, Indonesia, Iran, Thailand, Turkey, Vietnam, and Yemen. **Europe:** Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece**,** Italy, Netherlands, and Sweden. **Oceania:** Australia and New Zealand. **North America:** Mexico and United States (Oregon, Washington). **South America:** Argentina, Brazil, Chile, Colombia, Uruguay, and Venezuela (Lunello et al., 2002; Pappu et al., 2005; Takaki et al., 2005; Perez-Moreno et al., 2006; Wei et al., 2006; CABI/EPPO, 2007; Gieck et al., 2007; Fidan and Baloglu, 2009a, b).

Potential Distribution within the United States

LYSV has been reported in garlic in Washington and Oregon (Pappu et al., 2005; Gieck et al., 2007). Although the virus is considered to be of restricted distribution in these states, the virus was found in the garlic germplasm maintained by the USDA-ARS Western Regional Plant Introduction Station in Washington (~15%) (Pappu et al., 2005; 2008). It was reported in 2006 that California led the way in garlic production in the United States, followed by Oregon and Nevada (Boriss, 2006). If LYSV travels south unchecked from where it has been reported in Oregon and Washington, it could spread to major commercial garlic producers in those states. Leek is not a common commercial product in the United States.

Pathway

LYSV can spread locally through aphid vectors (*M. persicae, A. fabae*) in a non-persistent manner, meaning that the virus does not replicate in the host, and stays localized on the

piercing stylet of the aphid. During feeding, the stylet breaks through plant tissue, and deposits the virus. Typically however, aphid vectors move the virus into the plot too late in the growing season to cause economic losses in that same season (Davis, 2008a).

Propagative plant material is the most important long-distance transmission pathway, since "the United States allows peeled garlic cloves from all countries without a permit…[and] imports *Allium* sp. for propagation from a wide variety of countries, including Mexico" (NPAG, 2009). The virus can also be transmitted in sap inoculation, a common practice in experimental settings.

Survey

CAPS-Approved Method*: The CAPS-approved survey method is to collect symptomatic plant tissue by visual survey.

Survey Sample Collection:
Leaves: Remove leaf tip samples from the second youngest leaf on symptomatic plants.

Bulbs: Remove bulb from the symptomatic plants of interest.

*For the most up-to-date methods for survey and identification, see Approved Methods on the CAPS Resource and Collaboration Site, at http://caps.ceris.purdue.edu/.

Literature-Based Methods:
In areas where the disease is known to occur it is recommended that at least 100 leaf samples (not necessarily symptomatic) per crop be collected if possible (Smith et al., 2006). From bulbs, remove one clove from the bulb, and cut a cube of approx. 1.0 x 0.5 x 0.5 cm from the basal region (Conci et al., 2002). The leaf tip and bulb cubes samples should be used in diagnostic analysis.

Key Diagnostics/Identification

CAPS-Approved Method*:
Enzyme Linked Immunosorbent Assay (ELISA): Agdia and AC diagnostics have commercially available double antibody sandwich (DAS) ELISAs for LYSV available using polyclonal antisera (https://orders.agdia.com/InventoryD.asp?attribute_Size=1000&collection=SRA+20301&loc=IN; http://www.acdiainc.com/lysv.htm). Neither of the commercial ELISA tests have been validated for regulatory purposes at this time, however. This test is to be used for screening only. Positive results will need to be verified using molecular methods.

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Literature-Based Methods:
Indicator Hosts: (Bos, 1981)

- *Allium porrum*: Yellow leaf stripes are observed with infection of LYSV.

- *Chenopodium amaranticolor* and *C. quinoa*: Diagnostic symptoms of LYSV include chlorotic local lesions that become green rings when leaves senesce.
- *Celosia argentea*: brown necrotic local lesions are observed with infection of LYSV.

ELISA: Wei et al. (2006) extracted sap from the affected plant and tested for LYSV with general potyvirus monoclonal antibodies from Agdia Inc. (Elkhart, Indiana). They also used an ELISA with polyclonal antibodies (not known to be commercially available). The authors measured optical density of the ELISA plates at 405 nm. Positive readings are defined as any sample with an A_{405} of at least three times the mean of the negative control. Use healthy sap of non-host plants as the negative control. This diagnostic should be verified with RT-PCR or sequencing to confirm it is LYSV and not another potyvirus.

Immunoelectromicroscopy: Virus particles are trapped from crude leaf extracts on copper grids in 0.1 M phosphate buffer at pH 7.0 for 15 minutes. Grids are washed with 1:50 dilution of LSYV antiserum for 15 minutes. Decorated virus particles are then stained with 1% (weight/volume) of uranyl acetate (Dovas et al., 2001a).

Molecular:

RT-PCR: RT-PCR was performed using specific primers designed from the consensus regions of the coat protein genes of *Leek yellow stripe virus* Fajardo et al., 2001). Viral RNA is extracted from purified virus samples or total RNA from infected plants. The cDNA is synthesized from the RNA using a “Time Saver cDNA Synthesis Kit” (Pharmacia Biotech). To amplify viral cDNA, add 10 µL of the RT reaction to “50 µl polymerase reaction mixture containing 20 mM Tris-HCl, pH 8.4, 50 mM KCl, 1.5 mM MgCl2, 200 µM each dNTPs, 2.5 U of Taq DNA polymerase” and 100 ng each of 1LYSV (5’ TCA CTG CAT ATG CGC ACC AT 3’) and 2LYSV (5’ GCA CCA TAC AGT GAA TTG AG 3’)” (Fajardo et al., 2001).

Run the reaction in a PCR protocol of “94°C for 5 min, followed by 35 cycles (94°C / 1 min, 50°C / 2 min and 72°C / 2 min) and a final amplification at 72°C for 7 min.” (Fajardo et al., 2001). The expected fragment is approximately 1000 base pairs (Fajardo et al., 2001). Pappu et al. (2008) also provide specific details on RT-PCR and primers for *Leek Yellow Stripe Virus*.

Figure 6. Diamond-shaped chlorotic lesions on onion seed stalkes (top) and on onion leaves (bottom). Photos courtesy of Lindsey J. du Toit and Gary Q. Pelter.

Easily Confused Species

Leek Yellow Stripe Virus could be confused with *Iris Yellow Spot Virus* (IYSV) depending on the expression of symptoms (Pappu et al., 2005). Both of these viruses infect leek, but IYSV is a tospovirus, not a potyvirus. The main hosts of IYSV are onion and shallot, but the virus has the capacity to infect leek as well (Smith et al., 2006). IYSV is not known to infect any variety of garlic.

IYSV also causes chlorotic (yellow) lesions on unfurled leaves, but the lesions are distinctly diamond-shaped instead of continuous down the lamina as with LYSV (Fig. 6) (Schwartz et al., 2002). *Iris yellow spot virus* typically only infects leaves, compared to LYSV which infects bulb tissue with ease. IYSV is also established in many states, and is not considered an exotic pest (Smith et al., 2006).

IYSV vector transmission also differs from LYSV. Iris yellow spot virus is vectored by the onion thrips (*Thrips tabaci*) (Fig. 7) larvae in a persistent and propagative manner, meaning that the virus passes into the insect's salivary glands, and multiplies inside the vector. Transmission of IYSV therefore depends on the life stage of the vector and the success of replication inside that vector (Kritzman et al., 2001; Srinivasan et al., 2012).

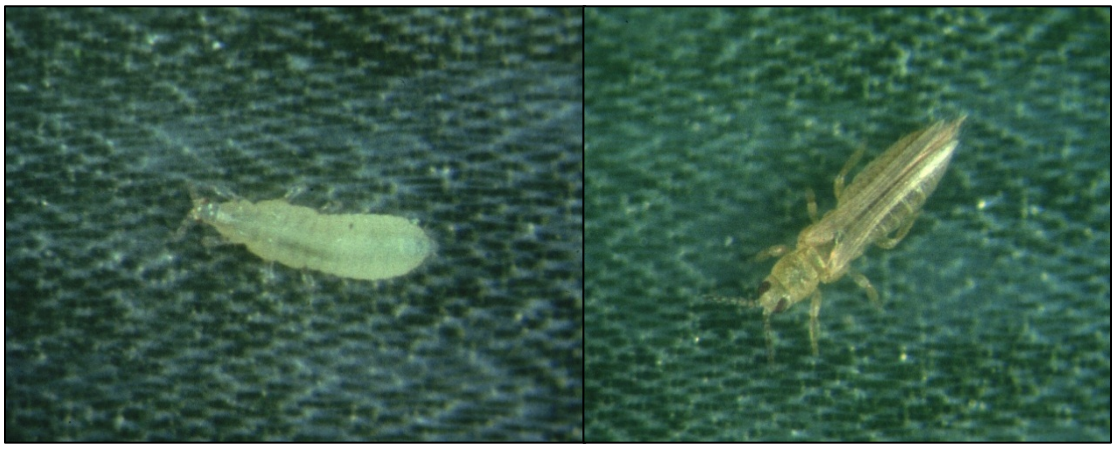

Figure 7. *Thrips tabaci* larvae (left) and adult (right). Photos courtesy of Joe Ogrodnick.

Another easily confused virus is *Onion Yellow Dwarf Virus* (OYDV). OYDV is also a potyvirus with similar symptoms to LYSV. Like LYSV, streaking starts at the base of the leaf and can spread to complete yellowing of the entire leaf. Leaves are sometimes flattened and fall over often. OYDV is transmitted by the same two species of aphids and via vegetative propagation, and is often found in complex with LYSV. The OYDV virus forms thread-like particles about 722 to 820 nm long (Davis, 2008b). To distinguish which virus is present in a symptomatic plant, it is best to use molecular diagnostics.

References

Barg, E., Lesemann, D.E., Vetten, H.J., and Green, S.K. 1997. Viruses of Alliums and their distribution

in different *Allium* crops and geographical regions. First International Symposium on Edible Alliaceae. J. L. Burba and C. R. Galmarini (eds.) 607-616.

Blackman, R.L., and Eastop, V.F. 2000. Aphids on the world's crops: an identification and information guide. Chichester, John Wiley & Sons Ltd.

Boriss, H. 2006. Commodity Profile: Garlic. Davis, Agricultural Issues Center, University of California Davis.

Bos, L. 1981. Leek yellow stripe virus. Descriptions of Plant Viruses. Association of Applied Biologists.

Bos, L. 1983. Viruses and virus diseases of Allium species. Acta Horticulturae 127: 11-29.

Bos, L., Huijberts, N., Huttinga, H., and Maat, D.Z. 1978. *Leek yellow stripe virus* and its relationships to *Onion yellow dwarf virus* - characterization, ecology, and possible control. Netherlands Journal of Plant Pathology 84(5): 185-204.

CABI/EPPO. 2007. *Leek yellow stripe virus*. Distribution Maps of Plant Diseases. Wallingford, CAB International. 999.

CIE. 1963. Distribution Maps of Pests. Wallingford, UK, CAB International.

Conci, V.C., Lunello,P., Buraschi, D.,Italia, R.R., and Nome, S.F. 2002. Variations of *Leek yellow stripe virus* concentration in garlic and its incidence in Argentina. Plant Disease 86(10): 1085-1088.

Davis, R.M. 2008a. Garlic Mosaic. Compendium of Onion and Garlic Diseases and Pests. H. F. Schwartz and M. K.S. St. Paul, American Phytopathological Society.

Davis, R.M. 2008b. Onion Yellow Dwarf. Compendium of Onion and Garlic Diseases and Pests. H. F. Schwartz and M. K.S. St. Paul, American Phytopathological Society.

Dovas, C.I., Hatziloukas, E., Salomon, R., Barg, E., Shiboleth, Y., and Katis, N.I. (2001a). Incidence of viruses infecting *Allium* spp. in Greece. European Journal of Plant Pathology 107(7): 677-684.

Dovas, C.I., Hatziloukas, E., Salomon, R., Barg,E., Shiboleth, Y., and Katis, N.I. (2001b). Comparisonof methods for virus detection in *Allium* spp. Journal of Phytopathology 149: 731-737.

Fajardo, T.V.M. Nishijima, M., Buso, J.A., Torres, A.C., Avila, A.C, and Resende, R.O. 2001. Garlic viral complex: identification of Potyviruses and Carlavirus in Central Brazil.Fitopatologia Brasileira 26(3): 619-626.

Fidan, H. and Baloglu, S. 2009a. First report of *leek yellow stripe virus* on leek in Turkey. Journal of Plant Pathology 91(1): 234-234.

Fidan, H. and Baloglu, S. 2009b. First Report of *Onion yellow dwarf virus* and *Leek yellow stripe virus* in Garlic in Turkey. Plant Disease 93(6): 672-672.

Gieck, S.L., Pappu, H.R., Hamm, P.B., and David, N.L. 2007. First Report of *Onion yellow dwarf virus*, *Leek yellow stripe virus*, and *Garlic common latent virus* in garlic in Oregon. Plant Disease 91(4): 461- 461.

Kritzman, A., Lampel, M., Raccah, B., and Gera, A. 2001. Distribution and transmission of *Iris yellow spot virus*. Plant Disease 85(8): 838-842.

Lot, H., Chovelon, V., Souche, S., and Delecolle, B. 1998. Effects of *onion yellow dwarf* and *leek yellow stripe viruses* on symptomatology and yield loss of three French garlic cultivars. Plant Disease 82(12): 1381-1385.

Lunello, P., Ducasse, D.A., Heiguera, M., Nome, S.F., and Conci, V.C. 2002. An Argentinean isolate of *Leek yellow stripe virus* from leek can be transmitted to garlic. Journal of Plant Pathology 84(1): 11-17.

Lunello, P., Ducasse, D.A., and Conci, V. 2005. Improved PCR detection of potyviruses in *Allium* spp. European Journal of Plant Pathology 112: 371-378.

NPAG (2009). New Pest Advisory Group Report. USDA-APHIS-PPQ-CPHST.

Pappu, H.R., Hellier, B.C., and Dugan, F.M. 2005. First report of *Onion yellow dwarf virus*, *Leek yellow stripe virus*, and *Garlic common latent virus* in garlic in Washington State. Plant Disease 89(2): 205-205.

Pappu, H.R., Hellier, B.C., and Dugan F.M. 2008. Evaluation of the National Plant Germplasm System's garlic collection for seven viruses. Plant Health Progress. doi: 10.1094/PHP-2008-0919-01-RS.

Perez-Moreno, L., Cordova-Rosales, Z., Barboza-Corona, E., Ramirez-Malagon, R., Ramirez-Lua, J., Ruiz-Castro, S., and Silva-Rosales, L. 2006. First report of *Leek yellow stripe virus* in garlic in the state of Guanajuato, Mexico. Plant Disease 90(11): 1458-1458.

Schwartz, H.F., Brown, W.M., Blunt, T., and Gent , D.H. 2002. *Iris yellow spot virus* on nnion in Colorado. Plant Disease 86 (5): 560.

Smith, T.N., Wylie, S.J., Coutts, B.A., and Jones, R.A.C. 2006. Localized distribution of *Iris yellow spot virus* within leeks and its reliable large-scale detection. Plant Disease 90(6): 729-733.

Srinivasan, R., Sundaraj, S., Pappu, H.R., Diffie, S., Riley, D.G., and Gitaitis, R.D. 2012. Transmission of *Iris Yellow Spot Virus* by *Frankliniella fusca* and *Thrips tabaci* (Thysanoptera: Thripidae). Journal of Economic Entomology 105(1): 40-47.

Takaki, F., Sano, T., Yamashita, K., Fujita, T., Ueda, K., and Kato, T. 2005. Complete nucleotide sequences of attenuated and severe isolates of Leek yellow stripe virus from garlic in northern Japan: Identification of three distinct virus types in garlic and leek world-wide. Archives of Virology 150(6): 1135-1149.

Vandijk, P. 1993. Survey and characterization of potyviruses and their strains of *Allium* species. Netherlands Journal of Plant Pathology 99: 1-48.

Wei, T., Pearson, M.N., and Fletcher, J.D. 2006. Molecular confirmation of New Zealand *garlic yellow streak virus* as *Leek yellow stripe virus*. Australasian Plant Pathology 35(3): 341-346.

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