Tomato Black Ring Virus

a. Virus/pathogen name, including accepted acronyms and synonyms

Tomato black ring virus, TBRV - Genus *Nepovirus*, Family *Secoviridae,* Order *Picornavirales*.

b. Host range, including resistance or tolerance within the crop hosts, alternate hosts

TBRV has a host range as wide as those of the other nematode-transmitted viruses. Some of the hosts are *Fragaria* spp. (strawberry), *Rubus* spp. (raspberry), *Ribes* spp.(currants), *Prunus* spp., cherry, almond, peach, grapevine (*Vitis* sp.), artichoke, asparagus, bean, cabbage, celery, leek, swede, lettuce, onion, potato, sugarbeet, cucumber, carrot, turnip, daffodil and tomato. In strawberry, cultivar 'Huxley', is known to be immune to TBRV. In red raspberry, resistance to TBRV has been reported and cultivars differ in susceptibility; for instance cultivars 'Burnetholm', 'Glen Clova', 'Glen Isla', 'Mailing Delight', 'Mailing Exploit', 'Mailing Leo' and 'Norfolk Giant' are susceptible to the type strain, whereas 'Lloyd George', 'Seedling V', 'Mailing Admiral', 'Mailing Enterprise', 'Mailing Jewel' and 'Mailing Landmark' among others are immune to it (Jones & McGavin, 1998, Stace-Smith R, 1987).

TBRV infect nearly all commonly used herbaceous indicator plants, infecting more than 29 dicotyledonous families, such as *Chenopodium amaranticolor*, *Chenopodium quinoa, Petunia hybrida, Phaseolus vulgaris, Nicotiana rustica, Nicotiana clevelandii* and *Nicotiana tabacum*. *N. clevelandii* and *Petunia hybrida* are the best hosts for propagation and *C. amaranticolor* is the most reliable local lesion host. Some indicators used as "bait" plants for nematode transmission experiments are *C.quinoa* and *Petunia hybrida*.

c. Symptoms on crop host including varietal differences with images of symptoms when available

TBRV is often found in association with *Raspberry ringspot virus* (RpRSV), as they are both transmitted by nematodes in the genus *Longidorus*. The viruses cause few or no symptoms in the early stages of Infection. In mixed infection, TBRV and RpRSV cause “raspberry leaf curl disease”; with symptoms including brittle, downward curling leaves. Other symptoms in raspberry may include chlorotic ringspots, yellow leaf blotches, chlorotic mottling and stunting. Leaf symptoms may fade or disappear in summer but return later in in the season. Reduced yields and increase in fruit crumbling are observed. TBRV by itself can cause a severe disease in the old red raspberry cultivar ‘Seedling V’, affected plants produce many short, spindly, and brittle young shoots with chlorotic ringspots on the leaves. Other raspberry cultivars seem to be more tolerant, showing only mild symptoms when infected with the virus. The cultivar ‘Mailing Exploit’ develops faint chlorotic ringspots on the leaves, stunting of the canes and fruit deformation, due to abortion of some of the drupelets. The cultivar Norfolk Giant develops leaf-curling symptoms.

Symptoms in *Fragaria vesca* indicator clones may vary from being asymptomatic to leaf blotching. In some strawberry cultivars, leaves develop yellow blotching, ring spots, crinkling, stunting, and eventually plants may die. The cultivar ‘Royal Sovereign’, develops local necrotic lesions, cultivar ‘Talisman’, ‘Early Cambridge’ and ‘Merton Princess’, develops well defined chlorotic spots and rings, the whole leaf may become chlorotic; the plants become progressively dwarfed and eventually die. Outbreaks of disease caused by RpRSV and TBRV occur in patches due to the horizontal distribution of the vector in the soil. If the infection occurs due to infected planting material, infected plants are distributed randomly throughout the crop. Most hosts show milder symptoms in summer than in Winter.

The symptoms produced by TBRV in the herbaceous indicators are similar to the ones induced by other nepoviruses. In *C. amaranticolor* and *C. quinoa* symptoms consist in chlorotic or necrotic local lesions; systemic necrosis or chlorotic mottle may also develop. In *N. tabacum*, *N. rustica* and *N. clevelandii* the virus causes local necrotic spots and rings and systemic chlorotic and necrotic spots, rings, and line-patterns. When infected during winter *Phaseolus vulgaris* may develop dark-brown local lesions; while in summer the plant may not develop symptoms or if so mild chlorotic lesions are observed. *Petunia hybrida* when infected with TBRV shows chlorotic local lesions, sometimes with brown necrotic margins and systemic veinal chlorosis or necrosis. Generally, most hosts show milder symptoms in summer than in winter. The herbaceous test plants rarely become systemically infected or show symptoms following inoculation of the roots by nematodes.

d. Geographic distribution:

TBRV is a European virus and has a limited extent spread to other continents. It has been detected in Sweden, Finland, United Kingdom, Germany (Brown et al., 1989), Belgium, Belarus, Switzerland, Slovakia, Moldova, Croatia, Serbia, Bulgaria, Albania. The virus is Widespread in France (Laveau et al., 2019) and is locally established in Norway, Ireland, Netherlands, Poland (Rymelska et al., 2013), Czech Republic (Spak et al., 1997), Hungary (Lehoczky & Burgyan, 1986), Greece, Turkey and Russia. Outside from Europe, the virus has been detected in Asia (India (Madhusudan & Govindu, 1985) and Japan (Iwaki & Komuro, 1973) and has been intercepted in infected imported material in North and South America (Canada, The United States and Brazil) (Harper et al., 2011). The vector *Longidorus elongatus* has been reported in Canada, United States and New Zealand (Yeates et al., 2008), although TBRV is not established in any of those countries. Susceptible cultivars are widely grown in the United States.

e. Means of spread:

Natural transmission is by nematodes of the genus *Longidorus*, *L. elongatus* and *L. attenuatus*. Both larvae and adults are able to transmit the virus, nematodes

acquire the virus from infected plants after feeding for about 1 h. Different TBRV isolates often have different vector species. The virus particles adsorb to regions within the nematode esophagus and may be retained and able to be transmitted for long periods; in the case of *L. elongatus* the virus is retained up to 8 weeks. The virus is lost when the nematode molts and is not passed through the eggs to juveniles. Outbreaks in the field as a result of the vector presence, have a slow expansion and oval or circular patches of affected plants can be observed. Long-distance spread of TBRV can be a direct consequence of transportation of infected plants or soil which contains viruliferous nematodes. TBRV can also be spread through vegetatively-propagated cuttings. TBRV is known to be seed and pollen-transmitted in some hosts.

f. Recognized diagnostic tests with cited references:

TBRV can be detected by serological tests such as enzyme-linked immunosorbent assays (ELISAs) (Laveau et al., 2019, Clark & Adams, 1977). Given its broad host ranges it can be detected by mechanical transmission to a number of herbaceous hosts (Stace-Smith, 1987). There days, reverse transcription polymerase chain reaction (RT-PCR) and by real-time one-step RT-PCR (Harper et al., 2011, Wei & Clover, 2008) are the prefered methods for deection of the virus due to their sensitivity.

g. Sampling recommendations for each pathogen including timing and tissue to be sampled

Spring and early summer (May to June) is the ideal time for sampling nepoviruses. Preferably, the samples should be taken from leaves that are symptomatic and young (3/4 expanded leaves). Sampling from different sites of the same plant increases chances of detection since the pathogen propagules are not evenly distributed within a plant. As this virus can be transmitted through pollen, precaution needs to be taken during flowering periods as pollen from infected

material may land on TBRV-free material which would test positive for the virus. A thorough wash with water before extraction is recommended

h. Management strategies for the pathogen and the vector(s) of the pathogen:

The main management strategy is the use of certified virus-tested planting material, the virus may be distributed in infected planting material especially because few or no symptoms are visible in tolerant cultivars or in the early stages of infection in sensitive cultivars. Fumigating soil with nematicides prior to planting and keeping the field weed free, is essential for removing potential reservoirs of the viruses. Crop rotation can be a measurement as well, not all plants are equally good hosts of vector nematodes, for example, populations of the vector nematodes increase rapidly on strawberry, but decrease on raspberry, so infection can be minimized by not planting raspberry after strawberry. Also, maintaining a cover crop between rows helps minimizing soil movement in the field. Additionally, using cultivars that support lower levels of the nematode vector populations or have resistance or tolerance to the virus is recommended. This virus spread very slowly from an infection source and can be controlled by removing infected plants plus several additional plants around the infection focus, taking care to remove as much of the root system as possible, followed by a spot treatment with a nematicide. Another cultural control measure that is effective decreasing the numbers of *L. elongatus*, is the practice of pulverizing old raspberry canes and returning them to the soil.

i. References:

Brown D.J.F, Murant A.F, Trudgill D.L. Differences between isolates of the English serotype of tomato black ring virus in their transmissibility by an English population of *Longidorus attenuatus* (Nematoda : *Dorylaimoidea*), *1989*.

Clark M.F, Adams A.N, 1977. Characteristics of the microplate method of enzymelinked immunosorbent assay for the detection of plant viruses. *Journal of general virology,* 475–83.

Harper S.J, Delmiglio C, Ward L.I, Clover G.R.G, 2011. Detection of Tomato black ring virus by real-time one-step RT-PCR. *Journal of Virological Methods* 171, 190-4.

Harrison B.D, 1958. Further studies on raspberry ringspot and tomato black ring, soil-borne viruses that affect raspberry. *Annals of Applied Biology* 46, 571-584.

Iwaki M, Komuro Y, 1973. Viruses Isolated from Narcissus (*Narcissus* spp.) in Japan. *Japanese Journal of Phytopathology* 39, 279-87.

Jones At, Mcgavin Wj, 1998. Infectibility and sensitivity of UK raspberry, blackberry and hybrid berry cultivars to Rubus viruses. Annals of Applied Biology 132, 239-51.

Laveau Cd, Mary S, Darrieutort G, Audeguin L, Van Helden M, Van Leeuwen C, 2019. Impact of Tomato Black Ring Virus (TBRV) on quantitative and qualitative features of Vitis vinifera L. cv. Merlot and Cabernet franc. *Oeno One* 53, 161-9.

Lehoczky J, Burgyan J, 1986. Occurrence of tomato black ring virus in Hungary. *Kertgazdasug* 18, 47-57.

MacFarlane S, Mcgavin W, Tzanetakis I, 2015. Virus Testing by PCR and RT-PCR Amplification in Berry Fruit. In: Lacomme C, ed. *Plant Pathology.* New York, NY: Humana Press, 227-48. (Methods in Molecular Biology; vol. 1302.)

Macfarlane S.A, Martin R.R, 2017. Nematode-Transmitted Viruses. In: Robert R. Martin Mae, Brian Williamson, Roger N. Williams, ed. Compedium of raspberry and blacberry diseases and pests. APS press.

Madhusudan T, Govindu Hc, 1985. Identification of virus diseases of tobacco in South India. *Indian Journal of Virology* 1, 163-73.

Martin R.R, Macfarlane S, Sabanadzovic S, Quito D, Poudel B, Tzanetakis I.E, 2013. Viruses and Virus Diseases of Rubus. *Plant Disease* 97, 168-82.

Rymelska N, Borodynko N, Pospieszny H, Hasiow-Jaroszewska B, 2013. Analysis of the biological and molecular variability of the Polish isolates of Tomato black ring virus (TBRV). *Virus Genes* 47, 338-46.

Spak J, Kubelkova D, Honetslegrovafranova J, 1997. Occurrence of nepoviruses in Rubus species in the Czech Republic. *Acta Virologica* 41, 177-9.

Stace-Smith R, 1987. Virus and virus-like diseases of Rubus (Raspberry and Blackberry). In: Converse Rh, ed. *Virus Diseases of Small Fruits.* U.S. Government Printing Office, Washington, D.C.

Wei T, Clover G, 2008. Use of primers with 5 ' non-complementary sequences in RT-PCR for the detection of nepovirus subgroups A and B. *Journal of Virological Methods* 153, 16-21.

Yeates G.W, Mercer C.F, Newton P.C.D, 2008. Populations of *Longidorus elongatus* (Nematoda: *Longidoridae)* in two New Zealand soils under grazed pasture. *New Zealand Journal of Zoology* 35, 287-96.

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