Grapevine Yellows vectors: a threat for viticultural areas worldwide

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Phytoplasma associated diseases are persistently transmitted by leafhoppers, planthoppers and psyllids. Phytoplasmas infect a huge number of plant species, both wild and cultivated. Grapevine Yellows (GYs) are among the most dangerous phytoplasma diseases worldwide, and their presence has been reported in Central and Southern Europe, Middle East, Northern Africa, South Africa, Northern and Southern America and Australia. The area where GYs have been reported is almost coincident with the area of grapevine growing. Moreover, many phytoplasmas, including some of those associated with GYs, are quarantine organisms in several countries. GYs are caused by several different phytoplasma strains (belonging to the genetic groups 16Sr-I, -III, -V, -VII, -X, -XII) but grapevine reacts with very similar symptoms to different phytoplasmas. The different GYs are transmitted by different vector species of leafhoppers (Cicadellidae) and planthoppers (Cixiidae), but for some GYs vectors are still unknown. Because plants with phytoplasma diseases cannot be satisfactorily cured, control strategies are directed towards prevention and rely on an integrated approach, combining the use of healthy propagation material, early detection and eradication of infected plants, and finally, vector control. This latter measure is always difficult because it is hard to prevent colonisation of crops by mobile insects and it is even harder to prevent phytoplasma transmission that may occur with short feeding periods. Moreover, the insecticide treatments against vector hoppers in vineyards interfere with the IPM strategies designed to control other grape pests, such as berry moths.

Two main case studies, *Scaphoideus titanus* Ball and *Hyalesthes obsoletus* Signoret, vectors of Flavescence dorée (FD) and Bois Noir (BN), respectively, are provided as examples of invasive and potentially invasive vector species.

FD (16Sr-V, elm yellows group, *Candidatus* Phytoplasma vitis) was first reported in France in the 50's by Caudwell (1957) and has been named Flavescence Dorée (= Golden Flavescence) because of the bright yellow colour induced by the disease on the leaves of white grape varieties. Later, FD was observed in Northern Italy in late 1960s, then in Corsica (France), in new areas of Northeast and Northwest Italy, in Spain and, very recently, in Switzerland, Serbia and central Italy. The Nearctic vector species, *S. titanus* (Schvester et al., 1963), was first identified in Southern France in 1960. Within the following 10 years *S. titanus* was found in Northern Italy, then in Corsica during the 70's, in Slovenia, Croatia (former Yugoslavia) and Switzerland during the 80's. During the 90's, *S. titanus* also invaded the Iberian Peninsula and was found both in Spain and Portugal. In very recent years the leafhopper has moved south and has been recorded in spots in Central, Southern Italy (across the 40th parallel) and Serbia. Studies on active movement and dispersal of *S. titanus* showed that the species flies over a very short distance, especially in the absence of grapevine plants. Therefore, the active movement capability of *S. titanus* can hardly explain the relative speed of diffusion in an area of about 3,000 Km, especially if we consider that the species, under field conditions, is monophagous on grapevine and that viticultural areas are discontinuous. Moreover, high mountains areas, like Pyrenees and Alps, represent further geographic barriers. It is then likely that marketing of nursery material, cuttings and rootstocks, spread the leafhopper vector as well as the FD phytoplasma. The egg stage of *S. titanus* overwinters in the bark of two-year old branches. In Southern France, Corsica, and Northern Italy the introduction of *S. titanus* has resulted in severe outbreaks of FD that led to great alarm among vine growers, so that eradication programs of infected plants and mandatory insecticide treatments against *S. titanus* have been carried out. In other areas more recently colonised by the vector the disease is not yet present or has not yet established noticeable epidemics, probably because *S. titanus* is still present with very low populations and in localized distribution or/and because severe phytosanitary measures and controls have hampered the diffusion of infected propagation material. If we compare the climographs of the North American regions that comprise the reported range of *S. titanus* (Barnett, 1977) with those of the areas of viticultural interest all over the world, we can see that many zones fall within the area of potential *S. titanus* spread. The exceptions are areas characterized by a dry warm climate (in Greece, Spain and Australia) or by high rainfalls (in Portugal and Australia). Thus *S. titanus* and FD have the potential to widen their current geographic distribution.

BN (16Sr-XII, stolbur group) is a GY largely spread in viticultural areas of Europe and Middle East. The disease presumably has been present for a long time but, due to the lack of molecular tools for the identification of phytoplasma strains, it has been reliably identified only in the last 15 years. The disease was first described by Caudwell *et al*. (1971) as a GY non-transmissible by *S. titanus*. Later, the phytoplasma associated with the disease was identified as belonging to the stolbur group, which also infects a number of other plant species, mainly horticultural. The vector species, *H. obsoletus* (*Cixiidae*) was identified recently by Maixner (1994). While FD has a "closed" cycle, from grapevine to

grapevine, the cycle of BN is "open". In fact *H. obsoletus* is not a grapevine feeder and develops on the roots of herbaceous hosts, mainly *Urtica* and *Convolvolus* where it can acquire the phytoplasma that can be later transmitted to grapevine during occasional feedings. Since its identification, BN has been reported with variable incidences from France, Germany, Switzerland, Hungary, Slovenia, Serbia, Croatia, Macedonia, Greece, Ukraine, Spain, Northern and Southern Italy, Israel, Palestine and Morocco. The vector *H. obsoletus*, which is a Palaearctic hopper found in Europe, the Middle East, Asia Minor and Afghanistan, is also present in the same area. The importance BN has been underestimated because the disease spreads more slowly compared with FD. Recent surveys have shown that BN is widespread over a large area, wider than that of FD. The stolbur phytoplasma is very common in weeds (e.g. *Urtica, Convolvolus, Calystegia, Ranunculus*) and in natural populations of *H. obsoletus* (more than 20% of plant samples positive for stolbur have been repeatedly reported and sometimes more than 60% of the samples were positive). Therefore, the disease now spreads faster in vineyards so that high incidences of BN (up to 30% of the plants) are now not uncommon. Moreover, other planthoppers, besides *H. obsoletus,* are potential vectors: eleven hopper species tested positive by DAS-ELISA with a stolbur-specific monoclonal antibodies in France, *Pentastiridius beieri* (Wagner) transmits stolbur to sugar beet. *Reptalus panzeri* (Löw) samples collected in Hungarian vineyard were found by PCR to be stolbur-infected, and even a leafhopper, *Goniagnathus guttulinervis* (Kirschbaum), collected in Sardinian (Italy) vineyards, tested positive for stolbur phytoplasma. If BN phytoplasma is introduced in new areas, the presence of *H. obsoletus* will be a threat to the existing viticulture. So far there is no evidence of introduction of this planthopper into new areas. *H. obsoletus* cannot be introduced with grapevine propagation material since it does not oviposit on grapevine and only herbaceous host-plants could eventually carry nymphs on their roots. Following an eventual introduction, the polyphagy and plasticity of this cixiid vector, whose geographic range covers a wide area with different climates, could enable it to invade and establish in new areas. Moreover, if other planthoppers can vector the disease, then the introduction of BN (stolbur) phytoplasma alone would be potentially dangerous because indigenous cixiid species could act as vectors.

Other GY diseases

GY diseases, associated with phytoplasmas belonging to other genomic groups-subgroups, are spreading in the same areas of FD and BN as well as in Australia, US (Virginia and New York), Chile and South Africa; particularly in US and Australia the disease can cause damages of economic importance. For these latter GY, no vector species have been identified, but at least 15 leafhopper species tested positive for the phytoplasmas associated with Australian and North American GYs. We can not exclude that some of these species could be further potentially invasive vector species.

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