VIEWPOINT

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Caution Required in Distribution of Plants of Red Stele *(Phytophthora fragaiae* Hickman) -Resistant Strawberries

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Red stele of strawberry *(Fragarin ×ananassa* Duch.), caused by *Phytophthora fragariae,* was first observed in Scotland in 1921 (Wardlaw, 1927; Wynn, 1968). The causal agent was named and described by Hickman (1940). The pathogen usually enters through root tips or wounds and invades the stelar root tissue, progressing up to, but not into, the crown of the strawberry plants. Latera1 roots are usually infected first and die, giving a "rat tail" appearance to the root system (Scott et al., 1984). The plants are killed when severely infected by the pathogen. The pathogen spreads mainly via infected roots and possibly field equipment. The disease is of major importance in most countries where temperature and soil moisture conditions are favorable (10 to 15C, wet soil), while it has become a limiting factor in some areas.

Pathogenic races of *P. fragariae* were first reported by Scott et al. (1950) and later by Hickman and English (1951). Subsequently, additional races of *P. fragariae* have been reported by other investigators (McKeen, 1958; Montgomerie, 1977; Scott et al., 1950), and the resistance of many cultivars to red stele has been evaluated (Khanizadeh et al., 1991, 1992; Maas, 1976; Maas and Galletta, 1989; Maas et al., 1989; Melville et al., 1980; Scott et al., 1984).

One effective control is the breeding of red stele-resistant varieties. Plant breeders in most strawberry-growing countries are using sources of red stele resistance derived from known genotypes, e.g., 'Sparkle', 'Aberdeen', 'MD683', and 'Stelemaster'. However, little is known of the genetic base of resistance to *P. fragariae* in strawberry. Van de Weg (1989a, 1989b) first identified individual resistance and virulence genes. He reported that the compatible and incompatible interactions between the American races Al to A6, A10, and a British isolate on one hand and the differentials 'Aberdeen', 'Blackemore', 'Climax', 'Del Norte', 'Md 683', 'Perle de Prague', 'Stelemaster', and 'Yaquina A' on the other hand can be described by a gene-for-gene model with five resistance and virulence genes.

Evaluation of strawberry genotypes for susceptibility to *P. fragariae* has been based almost exclusively on visual assessment i.e., reddening of stele in the root (Maas et al., 1989; McKeen, 1958; Melville et al., 1980; Montgomerie, 1966; Otterbacher et al., 1969; Scott et al., 1984), due to its simplicity. However, visual disease assessments for red stele are generally subjective and frequently inconsistent (Milholland et al., 1989). For example, Otterbacher et al. (1969) demonstrated that stelar reddening occurred in roots of both resistant and susceptible strawberry cultivars.

We have shown that resistant cultivars are not immune from infection, and relatively many oospores may be observed in the root tissues of resistant types as well as susceptible genotypes within 6 weeks of inoculation (Khanizadeh et al., 1992). Therefore, while reddening of the stele in field-grown plants may be used as a preliminary diagnostic feature, visual symptoms alone should not be used as a criterion to assess susceptibility (George and Milholland, 1986; Khanizadeh et al., 1992). Genotypes in which the pathogen sporulates to a limited extent in the root may be classified as resistant in genetic studies (Fulton, 1959; Khanizadeh, 1992), but it does not imply that they are not infected.

In many areas of the world, the growers are encouraged to plant runners that are certified as disease free. Despite these measures, outbreaks of disease occur. Difficulty in visually detecting slight infection of plants in propagation beds, and the planting of runners from infected but symptomless resistant cultivars (Fulton, 1959), may contribute toward these outbreaks. Examining the root for the presence of oospores may prove a valuable aid in *screening* certified strawberry stocks. Although sporulation of the pathogen on and within resistant genotypes is less than in susceptible plants, it may serve to maintain and disperse inoculum in the field and in the soil. This inoculum may be particularly dangerous, as it is produced on resistant plants. A mutant for pathogenicity at the appropriate loci would be ideally situated to spread and infect more tissues.

Strawberry genotypes should not be protected from infection by treating with fungicides, because fungicide residues on the root surfaces could suppress spore germination and infection, thus giving false negative results when the stocks are tested for red stele in the root tip (Duncan, 1985).

Grower's benefit. In breeding trials where infection has been evaluated, no seedling or variety has been found to be completely immune. Thus, the causal organism probably could be spread by infected symptomless roots. Planting stocks should be verified by careful examination of randomly selected roots for the presence of oospores. This relatively simple technique might well be used before planting to monitor the health of commercially distributed daughter plants or certified stocks, especially those of resistant cultivars. Attention should be paid to the term "resistant," which is used widely in horticulture and pathology, i.e., a cultivar described as resistant to *P. fragariae* may not show any symptoms of red stele even though it is infected by the fungus.

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