Strawberry Parent Clones US 4808 and US 4809 Resistant to Bacterial Angular Leafspot Disease Caused by *Xanthomonas fragariae*

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The strawberry (*Fragaria ×ananassa* Duch.) genotypes described herein were identified during a series of studies conducted at Beltsville, Md., to identify sources of resistance to bacterial angular leafspot disease (BALD), caused by the bacterium *Xanthomonas fragariae* Kennedy and King. Typical symptoms of BALD begin as small, water-soaked lesions on the lower leaf surface. The lesions enlarge but are delimited by small veins, which gives them an angular outline. Lesions are translucent when viewed by transmitted light. In later stages of infection, lesions may coalesce to cover large portions of the leaf. Bacterial exudate (ooze) also may be produced on the leaf surface under moist conditions. Sepals as well as leaves may become infected, reducing marketability of fruit. The disease can cause serious reductions in production and sale of strawberry fruit and has become a disease of international quarantine significance (Maas, 1998). This disease affects only *Fragaria* species and cultivars. To our knowledge, this is the first known release of strawberry germplasm that is highly resistant to this disease. The two clones described here should prove useful for breeding strawberry cultivars resistant to BALD.

Bacterial angular leafspot disease of strawberry, first documented from Minnesota in 1960, now occurs in many strawberry-growing areas of North America, Europe, South America, Africa, and Australasia. To date, no commercial cultivars have been found to be resistant to infection (Maas et al., 1995). Resistance to *X. fragariae* has been reported in *Fragaria* species. Kennedy and King (1962a, 1962b) found that the diploid *F. vesca* L. ('Alpine') had low disease severity ratings compared to the others in greenhouse and field

inoculation tests. Hazel (1981) reported that of several *Fragaria* species evaluated by inoculation, only *F. moschata* Duch. (hexaploid) was immune and some *F. virginiana* Duch. (octoploid) clones displayed moderate degrees of tolerance. More recently, Maas et al. (2000) reported that two genotypes, a native *F. virginiana* and an *F. virginiana* × *F. ×ananassa* hybrid (octoploid), were highly resistant to two differentially pathogenic strains of *X. fragariae*. These data suggest that angular leaf spot resistance can be incorporated into cultivars by recurrent selection.

The incorporation of resistance to *X. fragariae* from nonoctoploid species would involve complex manipulations and bridging crosses involving different ploidy levels (Bors and Sullivan, 1997, 1998). Therefore, availability of resistant octoploid germplasm would speed the resistance breeding process. In addition, such crosses would also serve to broaden the germplasm base of *F. ×ananassa* for disease resistance and resistance to biotic and abiotic stresses and could enhance plant and fruit traits as recommended by Luby et al. (1991) and Sjulín and Dale (1987).

In our earlier study (Maas et al., 2000), we observed two *Fragaria* genotypes that were resistant to two differentially pathogenic strains representing two of the four genotypic strain groups of *X. fragariae* reported by Pooler et al. (1996). The genotypic groups were identified by repetitive element PCR-based assays. In subsequent work, we have tested these genotypes against representatives of the other two genotypic strain groups (Maas et al., unpublished data). The four strains used in these studies were: strain ATCC 33239 from Minnesota (American Type Culture Collection, Rockville, Md.), the type strain of *X. fragariae*; Xf-3 from North Carolina and Xf-6 from California (D. Ritchie, North Carolina State Univ., Raleigh, N.C.); and Xf-1425 from Florida (J. Jones, Univ. of Florida, Bradenton). All strains were isolated from, and are pathogenic to, strawberry (Maas et al., 2000; Milholland et al., 1996; Pooler et al., 1996). Bacterial culture, plant inoculations, and disease scoring were done as previously described (Maas et al., 2000). Plants of the two resistant clones rated 0 on a standardized scale of 0 to 5 (0, no leaf necrosis or other symptoms of infection; 5, leaf necrosis, bacterial ooze production, and secondary spread of infection) following re-

peated inoculations in replicated trials with each strain of *X. fragariae*. Plants of the susceptible standard, 'Sweet Charlie', always developed severe leaf symptoms and were rated 5 in each test.

US 4808. Tested as SG-89, US 4808 was collected by M. Stahler in 1986 from a wild population of *F. virginiana* in Minnesota. This clone appears typical of native populations in terms of morphology, runnering, flowering responses, and fruit development (J. Luby, pers. comm.). US 4808 has a high degree of resistance to infection by highly virulent strains of *X. fragariae*. It was tested against *X. fragariae* strains Xf-3, Xf-6, Xf-1425, and ATCC 33239, each representing one of the four recognized differentially pathogenic strain groups of *X. fragariae*. US 4808 was not tested or selected for resistance to other diseases. In a cross with 'Sweet Charlie', a highly susceptible cultivar, US 4808 transmitted resistance to 8% to 12% of its progeny, depending on the challenge *X. fragariae* strain used (Maas et al., unpublished data). This clone should be a suitable disease-resistant parent for breeding disease-resistant varieties adapted to different cultural systems and environments.

US 4809. Tested as 80-4-38, US 4809 originated from a 1979 cross between *F. virginiana* clone SG-26 and *F. ×ananassa* 'Earliglow'. US 4809 was selected in 1980 and maintained as a potential parent for additional crosses. Clone SG-26, received in 1976 and entered in the USDA Plant Introduction system as PI 414129, was collected in Georgia where it had been in cultivation by the same family since 1900. Presumably it was of either pure *F. virginiana* lineage or a chance seedling resulting from a cross between native and cultivated strawberry clones. This clone appears typical of native populations in terms of morphology, runnering, and flowering responses, but its fruit is somewhat larger than most wild clones of *F. virginiana*. US 4809 has a high degree of resistance to infection by highly virulent strains of *X. fragariae*. It was tested against *X. fragariae* strains Xf3, Xf6, Xf1425, and ATCC 33239, each representing one of the four recognized differentially pathogenic strain groups of *X. fragariae*. US 4809 was not tested or selected for resistance to other diseases. In a cross with 'Sweet Charlie', a highly susceptible cultivar, US 4809 transmitted resistance to 4% to 18% of its progeny, depending on the challenge *X. fragariae* strain used (Maas et al., unpublished data), and should be a suitable disease-resistant parent for breeding disease-resistant varieties adapted to different cultural systems and environments.

The manner of inheritance of resistance to *X. fragariae* in strawberry has not been determined. The form of resistance displayed by US 4808 and US 4809 is not due to a hypersensitive host reaction, but may be similar to a host reaction in pepper (*Capsicum annum* L.) genotype ECW 12346 to *X. campestris* pv. *vesicatoria*. In that pathosystem, the bacterial population growth is inhibited without typical tissue necrosis occurring, and the bacteria infused into host tissues remain viable but neither multiply nor cause disease symptoms

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(Jones et al., 2001). In effect, bacteria become trapped in the host tissue. In pepper, this reaction is conditioned by two recessive genes. Work is currently under way to characterize this disease-resistance reaction in strawberry.

Availability

Limited numbers of in vitro plants of one or both of these clones are available to interested parties from Dr. J.L. Maas, USDA-ARS Fruit Lab, Bldg. 010A, 10300 Baltimore Avenue, Beltsville, MD 20705 (phone: 301/504-7653; e-mail: maasj@ba.ars.usda.gov). The in vitro stocks were produced from virus- and phytoplasma-tested nuclear stock and may be regarded as free of fungus and bacterial contaminants and presumably free of viruses. Voucher specimens of each clone have been deposited with the USDA, ARS National Clonal Germplasm Repository, Corvallis, Ore.

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