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Field Resistance of 20 Strawberry Cultivars to Black Root Rot[1]

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Abstract

Black root rot (BRR), a non-specific disease typified by blackening of roots, with associated poor growth and yield, is common in perennial strawberry plantings worldwide. Although the causal agent of blackening is often unknown, *Pythium* spp., *Rhizoctonia fragariae* Husain & McKeen and *Pratylenchus penetrans* (Cobb) Filip. and Stek. have been identified in association with BRR. Distinct cultivar differences in tolerance to BRR can be observed in commercial fields, suggesting the possibility that management can be achieved by cultivar selection. Twenty cultivars from various breeding programs throughout North America were planted in the spring at two field sites (with and without a history of BRR) in western New York and root health was assessed during harvest the following year. The cultivars most resistant to BRR were 'Tristar,' 'Earliglow,' and 'Midway,' while 'Allstar,' NY113 and 'Selva' were least resistant. When cultivar rankings at these sites were compared with those of two other studies, correlations were nonexistent to negative. These data suggest that the causes of BRR can differ among locations, and cultivar selection will be of no value unless the causal organism at a particular site is known. Chemical names used: *N*-(2,6-dimethylphenyl)-*N*-(methoxyacetyl) alanine methyl ester (metalaxyl).

Introduction

Blackening of plant roots with associated poor growth and yield is common among strawberry plantings worldwide. In many cases the causal agent of blackening is unknown, and the disease is referred to as "black root rot" (BRR) (11). A large number of factors have been reported to be associated with BRR: the root lesion nematode, *Pratylenchus penetrans* (Cobb) Filip. & Stek.; *Rhizoctonia* spp.; *Pythium* spp.; and various abiotic soil factors (12, 13). There is no single, generally effective control for this complex disease. However, distinct cultivar differences can be observed in commercial plantings, suggesting that cultivar selection may be one tool that can be employed to manage BRR.

As early as 1932, Zeller (14) reported that commercial cultivars of strawberry showed differential susceptibility to *Rhizoctonia*, a pathogen causing blackened roots. Unpublished data cited by Wilhelm et al. (10) indicated that differences in susceptibility to injury by *Ceratobasidium* sp. (*Rhizoctonia fragariae*) were related to inherent root vigor and fruitfulness of the cultivars. Small field trials conducted in western Massachusetts and in eastern New York found significant varietal differences in susceptibility to BRR as well (3, 8).

The objectives of the study described here were 1) to rank a large number of cultivars from breeding programs throughout North America for BRR resistance under carefully described field conditions and 2) to compare these results with those of other studies to determine whether rankings were consistent from site to site.

Materials and Methods

On 19 May 1992, a planting was established at Ithaca, NY in soil (Col-

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lamer silt loam, typic Hapludalf, pH 6.1, organic matter 4.8%) with no history of BRR. On the same day, another planting was established 8 km away in Brooktondale at a site where BRR first had been noted in 1987; strawberries had been grown on the site continuously for over 8 years. The soil at Brooktondale was a gravelly loam, pH 5.9 organic matter 4.7%. Neither soil was fumigated prior to planting, nor were fungicides likely to influence root pathogens (e.g. metalaxyl) applied subsequently. At each site, dormant runner plants of 20 strawberry cultivars obtained from a commercial nursery were planted in plots of 6 plants, with 4 replicates of each plot. The summer of establishment and the following spring were cool and wet (May through September 1992 precipitation 57 cm, 13 cm above normal and mean temperature 16C, 7C below normal; February through June 1993 precipitation 48 cm, 11 cm above normal and mean temperature 5C, 4C below normal) conditions which have been, reported to be favorable for BRR development (11). One replicate at Brooktondale was disrupted by cultivation and was therefore excluded from the study. Two replicates at Ithaca failed to establish evenly due to field wetness on a lower slope and were likewise excluded.

In the middle of the first harvest season, 2 July 1993, when it was anticipated that symptoms would be most apparent, mother plants were rinsed free of soil and each plot was assigned scores for feeder and perennial root rot severity. The scoring scales were as follows:

Perennial root scale
1 = perennial roots entirely black
2 = > 90% of perennial roots black
3 = moderate perennial root decay
4 = < 10% of perennial roots black
5 = perennial roots abundant, fleshy and white.

Feeder root scale
1 = feeder roots non-existent
2 = very few feeder roots
3 = some feeder roots present
4 = many feeder roots
5 = feeder roots abundant, fleshy and white.

Perennial and feeder root scores for a given cultivar were averaged to yield an "entire root score" (Table 1).

To characterize the disease complex as it occurred at these sites, nematode analyses were performed on root and soil samples, and fungal pathogens from a total of ten randomly selected root systems were isolated and identified. Nematode samples from each site consisted of five full root systems and 20 soil cores, bulked (2). Nematode population densities were estimated from extractions of 100 cm^3 of soil by flotation and centrifugation, and by shaking fresh roots for 48 hr in water (7). Nematodes were identified to genus (5). Fungi were isolated from lesions on representative plants by plating on both Difco potato dextrose agar (Difco Laboratories, Detroit, MI) amended with 250 $mg \cdot liter^{-1}$ of sodium ampicillin and 10 $mg \cdot liter^{-1}$ of rifampicin (PDA-RA) and on Difco corn meal agar amended with 250 $mg \cdot liter^{-1}$ sodium ampicillin, 10 $mg \cdot liter^{-1}$ rifampicin and 5 $mg \cdot liter^{-1}$ of pimaracin (CMA-PAR).

The cultivar rankings obtained from field evaluations were compared with published rankings from eastern NY and western MA. The rankings obtained from eastern NY were from a field planting of strawberries in a soil (Hamlin silt loam, Dystric Fluvenic Eutrochrept) with a history of BRR (8). The rankings from western MA were from a field planting of 11 cultivars in soil artificially infested with a highly virulent strain of *R. fragariae* (AG-1, isolate number B-43) (3). Rankings of all trials were compared to published cultivar ratings for verticillium wilt and red stele resistances (4) and fruit ripening date (1).

Table 1. Root scores for 20 strawberry cultivars in 1993 black root rot resistance trial at two western New York sites.[z]

Cultivar	Ithaca, NY			Brooktondale, NY			Combined Mean[v]
	Perennial Root Score[y]	Feeder Root Score[x]	Entire Root Score[w]	Perennial Root Score[y]	Feeder Root Score[x]	Entire Root Score[w]	
Allstar	1.5	1.5	1.5	1.0	2.0	1.5	1.5
Blomidon	2.5	2.5	2.5	1.7	2.3	2.0	2.3
Cavendish	2.5	2.0	2.3	2.0	2.7	2.3	2.3
Chandler	2.0	3.0	2.5	1.3	1.7	1.5	2.0
Earliglow	3.0	3.0	3.0	1.7	2.3	2.0	2.5
Honeoye	3.0	2.0	2.5	2.0	2.0	2.0	2.3
Jewel	3.0	2.5	2.8	1.7	1.7	1.7	2.2
Kent	2.0	2.5	2.3	1.7	1.3	1.5	1.9
Lateglow	3.0	2.0	2.5	2.0	1.7	1.8	2.2
Lester	3.0	3.0	3.0	1.3	1.7	1.5	2.3
Midway	2.5	3.0	2.8	2.0	2.3	2.2	2.5
NY113	1.5	1.5	1.5	1.3	1.7	1.5	1.5
Raritan	1.5	2.5	2.0	1.7	2.3	2.0	2.0
Redchief	2.0	2.5	2.3	1.0	2.5	1.8	2.0
Scott	1.5	2.5	2.0	1.0	1.5	1.3	1.6
Selva	2.0	2.0	2.0	1.0	1.0	1.0	1.5
Settler	3.0	2.5	2.8	2.0	2.0	2.0	2.4
Sparkle	3.5	2.0	2.8	1.0	1.3	1.2	2.0
Surecrop	3.0	2.0	2.5	1.0	1.7	1.3	1.9
Tristar	3.0	4.0	3.5	2.3	2.7	2.5	3.0
Mean	2.5	2.4	2.4	1.5	1.9	1.7	2.1

[z]Scores assigned 2 July 1993.
[y]Scale: 1 = roots entirely black, to 5 = roots fleshy and white.
[x]Scale: 1 = feeder roots non-existent, to 5 = feeder roots abundant.
[w]Mean of perennial root score and feeder root score.
[v]Mean of entire root scores at Ithaca and Brooktondale.

Results

None of the three major nematode genera associated with diseases of strawberry roots, *Meloidogyne, Pratylenchus,* and *Xiphinema,* were recovered from root or soil samples at either test site. *Pythium* species were isolated from over 80% of the root systems. The only other known pathogenic fungus, *Phytophthora cactorum* (Leb. & Cohn) Shroet., was isolated from one plant. No *Rhizoctonia* species were found on roots from either site.

There were no above ground symptoms except for a somewhat thinner than normal stand at both sites. Root decay was moderate at Ithaca and severe at Brooktondale, with mean entire root system scores of 2.4 and 1.7 (where 5 = healthy), respectively (Table 1). Spearman's coefficient of rank correlation, rho (10, 6), was used to test whether cultivars performed similarly at Brooktondale and Ithaca. The correlation between entire root scores at the two sites was positive and significant at the 90% confidence level, indicating that cultivars that resisted decay at Ithaca tended to do well at Brooktondale as well. On the basis of entire root scores from Ithaca and Brooktondale, the cultivars most resistant to BRR were 'Tristar,' 'Earliglow' and 'Midway.' The least resistant cultivars were 'Allstar,' 'NY 113,' and 'Selva' (Table 1).

There was no agreement between cultivar ratings for BRR resistance from our western New York study and results of field trials conducted elsewhere

Table 2. Comparison of cultivar rankings from several strawberry black root rot resistance trials.[z]

Cultivar	Trial Site and Year			
	Ithaca N.Y. 1993[y]	Brooktondale, N.Y. 1993[y]	New Paltz, N.Y. 1991[x]	Amherst, Mass. 1990 91[w]
Tristar	3.5	2.5	-	-
Earliglow	3.0	2.0	2.3	2
Midway	2.8	2.2	-	1
Settler	2.8	2.0	-	-
Cavendish	2.3	2.3	-	-
Lester	3.0	1.5	5.5	1
Honeoye	2.5	1.0	1.2	2
Blomidon	2.5	2.0	1.1	3
Jewel	2.8	1.7	3.9	3
Lateglow	2.5	1.8	3.2	3
Raritan	2.0	2.0	6.0	-
Redchief	2.3	1.8	2.0	1
Chandler	2.5	1.5	-	-
Sparkle	2.8	1.2	5.3	-
Surecrop	2.5	1.3	4.0	2
Kent	2.3	1.5	-	2
Scott	2.0	1.3	3.9	-
Allstar	1.5	1.5	2.5	3
NY113	1.5	1.5	4.2	-
Selva	2.0	1.0	-	-

[z]Cultivars are listed in descending order of mean western N.Y. root scores (average of Ithaca and Brooktondale). (Table 1).
[y]Rating scale: 1 = complete root decay, 5 = healthy roots. Values are means of feeder and perennial root scores.
[x]Rating scale: 1 = all roots significantly rotted with no root hairs, 10 = no root lesions. Reference: Pritts, 1991.
[w]Rating scale: 3 = tolerant, 2 = variable, 1 = most susceptible, based upon Wing's interpretation of 1990 and 1991 survival and shoot growth averages reported by Cooley et al. (1991).
"-" = cultivar not rated.

(Table 2). When Spearman's coefficient of rank correlation was used to measure the closeness of the relationship between the rankings of pairs of studies, all comparisons of sites showed negative correlations, with the exception of the Brooktondale and Ithaca sites (Table 3). Similarly, there were no significant correlations between each trial's rankings and cultivar ratings for verticillium wilt or red stele resistance (data not presented). Correlations between ripening date and BRR rankings were insignificant for all trials except Cooley's Massachusetts trial (rho = 0.66).

Discussion

Under the cultural and environmental conditions tested here, certain cultivars displayed less severe root decay than others. However, damage was extensive for all cultivars and the differences between the best and worst performers were subtle. It is unlikely that even the most resistant of these cultivars would provide sufficient field resistance to be a useful means of disease control to growers under conditions favorable for BRR development.

The lack of agreement among studies ranking resistance or tolerance of strawberry cultivars to BRR indicates that the expression of this trait is highly variable. Possibly, pathogen mixes varied from site to site so that each study was testing for resistance to a different cause or causes of the same general symptoms. Indeed, our rankings could be interpreted as ratings of field resistance to *Pythium* spp., since that was the dominant pathogen group recovered, while those of Cooley et al. (3) were presumably a measure of resistance to *R. fragariae;* however, the latter authors did not report any isolations from their field grown plants which would have confirmed this assumption. Similarly, no fungal isolations or nematode identifications were performed in Pritts' 1991 cultivar trial. Clearly, if variable cultivar performance is a function of resistant or susceptible reactions to specific pathogens, the rankings from any study are useful in predicting cultivar performance only in sites infested with the same pathogens under similar grow-

Table 3. Spearman's rank correlation between ratings of resistance to strawberry black root rot conducted at four sites.

	Ithaca, NY	Brooktondale NY	New Paltz, NY
Brooktondale, NY	0.37		
New Paltz, NY	-0.01	-0.50	
Amherst, MA	-0.31	-0.08	-0.27

ing conditions. Alternatively, if BRR resistance is due to a general mechanism that depends on overall plant vigor (10), rankings from individual studies will simply reflect those cultivars best adapted to the local growing conditions.

The lack of any correlation between BRR resistance rankings and those for verticillium wilt or red stele offers some assurance that the BRR resistance rankings were not just mistakenly reflecting resistance to these other diseases in the evaluated trials. Cultivar rankings by Cooley et al. (3) tended to be higher for late ripening cultivars. Since root decay is most pronounced at the time of ripening (personal observation), it may be that any survey that compares cultivars which are at different stages of physiological maturity will underestimate the susceptibility of later maturing cultivars if data is collected during the early cultivar's harvest season.

Considered collectively, the four trials described here provide little evidence that some cultivars are generally more resistant to BRR than others. Thus, it is not possible to make general recommendations as to which cultivars will perform best for growers whose fields are affected with BRR, unless the underlying cause of the disease is known. The inconsistency of rankings also implies that breeders seeking to select for BRR resistance cannot rely on screening at a single site for the identification of genotypes with superior resistance.

Literature Cited

1. Anon. 1992. Brittingham Plant Farms, Inc. 1992 catalog. Salisbury, Md.
2. Barker, K. R. 1985. Soil sampling methods and procedures for field diagnosis. pp. 11-20. In B. F. Zuckerman, W. F. Mai, and M. B. Harrison (eds.). Plant nematology laboratory manual. Univ. of Mass. Agr. Exp. Sta., Amherst, Mass.
3. Cooley, D., D. Marchant, and S. Schloemann. 1991. Variations in strawberry cultivar tolerance to black root rot. Northeast LISA Small Fruits Newsletter. 2(2):8.
4. Maas, J. L. (ed.). 1984. Compendium of Strawberry Diseases. Amer. Phytopathol. Soc., St. Paul, Minn.
5. Mai, W. F., and H. H. Lyon. 1975. Pictorial Key to Genera of Plant-Parasitic Nematodes. Cornell Univ. Press, Ithaca, New York.
6. Mansfield, E. 1983. Statistics for Business and Economics. W. W. Norton, New York.
7. Niblack, T. L., and R. S. Hussey. 1985. Extracting nematodes from soil and plant tissue, pp. 201-206. In: B. F. Zuckerman, W. F. Mai, and M. B. Harrison (eds.). Plant nematology laboratory manual. Univ. Mass. Agr. Exp. Sta., Amherst, Mass.
8. Pritts, M. P. 1991. Cultivar tolerance to black root rot disease. Unpublished "Progress report: Evaluation of alternative strategies for small fruit production." Presented to U.S.D.A. LISA.
9. Sokal, R., and F. J. Rohlf. 1969. Biometry. W. H. Freeman Co., San Francisco.
10. Wilhelm, S., P. E. Nelson, H. E. Thomas, and H. Johnson. 1972. Pathology of strawberry root rot caused by *Ceratobasidium* species. Phytopathology 62:700-705.
11. Wilhelm, S. 1984. Black root rot, p. 90. In: Maas, J. L. (ed.). Compendium of Strawberry Diseases. Amer. Phytopathol. Soc., St. Paul, Minn.
12. Wing, K. B. 1994. The etiology of strawberry black root rot disease. MS Thesis, Cornell Univ., Ithaca, N.Y.
13. Wing, K. B., M. P. Pritts and W. F. Wilcox. 1994. Strawberry black root rot: a review. Adv. Strawberry Res. 13:13-19.
14. Zeller, S. M. 1932. A strawberry disease caused by *Rhizoctonia*. Ore. Agr. Exp. Stn. Bul. 295.

Field Resistance of Rootstocks to Collar Rot

Spur 'McIntosh' trees were innoculated with *Phytophthora cactorum* and evaluated for symptoms over 10 years. MM.111 remained healthy while MM.106 was very susceptible. M.4 and M.7a were similar to MM.111. Significant differences existed in the nursery that supplied the rootstocks and their field susceptibility. M.26 was similar in susceptibility to MM.106 from one of the nurseries tested. From Utkhede and Smith, J. Hort. Sci. 1994, 69:467-472.