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Resistance of Strawberry Cultivars and Advanced Selections to Anthracnose and Botrytis Fruit Rots

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Strawberry (*Fragaria ×ananassa* Duch.) cultivars and advanced selections were evaluated for resistance to anthracnose fruit rot (caused by *Colletotrichum acutatum*) and botrytis fruit rot (caused by *Botrytis cinerea*) in field trials in west-central Florida during the 2004–05, 2006–07, and 2007–08 seasons. Fruit were harvested twice weekly and anthracnose and botrytis fruit rot incidence were evaluated each season. The incidence of anthracnose fruit rot ranged from 1% to 10% in 2004–05, <1% to 9% in 2006–07, and 1% to 54% in 2007–08. For anthracnose, 'Sweet Charlie', 'Ruby Gem', 'Florida Elyana', and 'Florida Radiance' were the most resistant cultivars tested; 'Strawberry Festival' and advanced selection 99-117 were intermediate in susceptibility; and 'Albion', 'Camarosa', 'Camino Real', 'Ventana', 'Candonga', and 'Treasure' were susceptible/highly susceptible. The incidence of botrytis fruit rot ranged from 5% to 38% in 2004–05, 0.3% to 8% in 2006–07, and 1% to 6% in 2007–08. Assessment of cultivars for resistance to botrytis fruit rot was more difficult due to low disease incidence. However, 'Camarosa', 'Florida Radiance', 'Florida Elyana', and advanced selections 99-117 and 99-164 showed good levels of resistance, whereas 'Camino Real', 'Ventana', 'Treasure', 'Candonga', 'Strawberry Festival', and 'Sweet Charlie' were more susceptible.

In the Florida annual winter strawberry production system, botrytis fruit rot (caused by *Botrytis cinerea*) and anthracnose fruit rot (caused by *Colletotrichum acutatum*) are the most important preharvest fruit diseases (Legard et al., 2003). Commercial growers apply fungicides regularly to control or delay the onset of these diseases. Fungicide recommendations (i.e., product, rate, and frequency) have not traditionally incorporated knowledge of cultivar resistance, but that will be done in the future (Mertely and Peres, 2004). Developing cultivar-specific recommendations should result in reduced fungicide applications and/or improved disease control.

Maas (1978) suggested that results from multi-year yield trials (where all fruit are harvested and the relative number of rotted fruit is determined) were more broadly applicable than results derived from other methods of assessing fruit rot resistance. Maas' advice has been largely disregarded, probably because of the time and expense required to test strawberry germplasm in this manner. However, Barritt (1980) used this method to determine the relative resistance of Pacific Northwest cultivars and selections to botrytis fruit rot, and Olcott-Reid and Moore (1995) used this method to determine the relative susceptibility of various strawberry clones to several fruit rot diseases. In Florida, a study using this method determined that 'Sweet Charlie' was highly resistant, 'Strawberry Festival' was moderately resistant, 'Camino Real' was susceptible, and 'Treasure' and 'Camarosa' were highly susceptible to anthracnose (Chandler et al., 2006). In the same study, botrytis fruit rot data were less clear, but the disease incidence was relatively low on 'Camarosa', two to three times higher on 'Sweet Charlie', and intermediate on 'Strawberry Festival'.

The purpose of this study was to determine the resistance of new cultivars currently grown in Florida and advanced selections from the University of Florida's breeding program to botrytis fruit rot and anthracnose fruit rot, and compare them to current and past industry standards with known disease susceptibility.

Materials and Methods

Field trials were conducted at the University of Florida's Gulf Coast Research and Education Center in Dover, FL, during the 2004–05 and in Wimauma, FL, during 2006–07 and 2007–08 strawberry growing seasons. In the 2004–05, 2006–07, and 2007–08 trials, six, eleven, and nine cultivars/advanced selections, respectively, were tested. The trials were initiated on 21 Oct. 2004, 12 Oct. 2006, and 19 Oct. 2007 by transplanting freshly dug runner plants with intact leaves (commercial cultivars) or plug plants (advanced selections) into standard two-row raised beds previously treated with methyl bromide/chloropicrin fumigant and covered with black polyethylene mulch. Plants were spaced 38 cm apart within rows, and 30 cm apart between rows. The beds were 1.2 m apart, center-to-center. Four plots of each cultivar were arranged in a randomized complete-block design, with each replication on a separate bed. Plots on the same bed were separated by 1.1 m. Plots contained 14, 12, and 10 plants during the 2004–05, 2006–07, and 2007–08 seasons, respectively. Transplants were irrigated by overhead sprinklers for 10 to 14 d to aid establishment, then irrigated and fertilized through drip tape. In order to ensure that anthracnose and botrytis fruit rot incidences could be evaluated in the same plots, the lowest label rate of captan (1.5 lbs a.i./acre) was applied weekly during the 2004–05 and 2006–07 seasons to prevent the incidence of either disease from reaching extremely high levels. During the 2007–08 season, however, a "La Niña" year (drier, warmer, and

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less conducive to anthracnose and botrytis fruit rot) was predicted. Therefore, the captan applications were eliminated and plants were inoculated with *C. acutatum* on 13 Dec. 2007 by applying 10,000 conidia/plant to each crown in 2 mL of water using a manual sprayer. Fruit were harvested and graded for disease twice weekly from 21 Feb.2004 to 31 Mar. 2005, 12 Dec. 2006 to 30 Mar. 2007, and 11 Dec. 2007 to 14 Mar. 2008. Marketable fruit were counted and weighed to determine yield. Small fruit weighing less than 10 g, diseased fruit, and other unmarketable fruit were also enumerated. Disease incidence was expressed as a percentage of the total number of marketable and unmarketable fruit. Percentage disease data were transformed to square roots (if all incidences were <30%) or an arcsine square root transformed (all other data sets) prior to analysis. Non-transformed means are presented.

Results and Discussion

In the 2004–05 season, anthracnose fruit rot incidence ranged from 0.5% to 9.7%. Cultivars tested clustered statistically into three clear groups. The California cultivars 'Ventana' and 'Camino Real' and the Spanish cultivar 'Candonga' were susceptible (9.7%, 6.3%, and 6.2%, respectively). University of Florida advanced selection 99-117 was moderately resistant and similar to 'Strawberry Festival' (2.1% and 3.6%, respectively), whereas 'Sweet Charlie' was resistant (0.5%) (Table 1).

In the 2006–07 season, overall anthracnose levels were low, as previously mentioned. The new California cultivar 'Albion' grouped with the susceptible/highly susceptible cultivars 'Camino Real', 'Camarosa', and 'Treasure' (5.0%, 3.7%, 6.6%, and 8.9%, respectively). The Australian cultivar 'Ruby Gem', the new Florida cultivars 'Florida Radiance' and 'Florida Elyana', and the advanced selections 99-164 and 99-117 all had very low disease incidence (0.2%, 0.6%, 0.4%, 1.1%, and 0.5%, respectively) and were not significantly different from one another, the moderately resistant 'Strawberry Festival' (0.7%) or the highly resistant 'Sweet Charlie' (0.3%) (Table 1).

In the 2007–08 season, eliminating fungicide applications and inoculating with *C. acutatum* led to higher disease incidence (0.9% to 54.0%) and better separation of cultivars. For the second season, 'Albion' was highly susceptible and grouped with 'Treasure' (45.2% and 54.0%, respectively). The advanced selection 99-164 was as susceptible as 'Albion' but not as susceptible as 'Treasure' with an anthracnose incidence of 34.3%. For the third season, advanced selection 99-117 grouped with the moderately resistant 'Strawberry Festival' (10.8% and 16.9%, respectively). Ruby Gem' (5.4%) was intermediate between 'Strawberry Festival' and 'Sweet Charlie' (0.9%). The new cultivars 'Florida Radiance' (3.9%) and 'Florida Elyana' (3.4%) grouped with 'Sweet Charlie' and were considered resistant to anthracnose fruit rot (Table 1).

In earlier trials, 'Sweet Charlie' was resistant, 'Strawberry Festival' was moderately resistant, 'Camino Real' was susceptible, and 'Treasure' and 'Camarosa' were highly susceptible to anthracnose fruit rot (Chandler et al., 2006). Results of the current trials were consistent with the previous work. That is, cultivars in these four resistance categories were significantly different in all three seasons, with the exception of 2006–07. Disease levels were so low in that season (0.2% to 8.9%) that the resistant 'Sweet Charlie' (0.3%) and the moderately resistant 'Strawberry Festival' (0.7%) were not significantly different (Table 1).

In the 2004–05 season, botrytis fruit rot incidence ranged from 4.6% to 37.5%. Cultivars tested clustered into three distinct groups. The most susceptible cultivars were 'Camino Real' and 'Ventana' (37.5% and 32.4%, respectively). 'Sweet Charlie', 'Candonga', and 'Strawberry Festival' were slightly less susceptible (17.5%, 13.8%, and 13.3%, respectively). The most resistant was advanced selection 99-117 (4.6%) (Table 2).

In 2006–07, overall disease incidence was low but the range (0.3% to 7.8%) allowed statistical separation of cultivars. 'Camino Real' was the most susceptible cultivar tested (7.8%). Advanced selections 99-164 and 99-117 were the most resistant with the lowest disease incidence (0.3% and 0.9%, respectively). The rest of the cultivars were of intermediate susceptibility. 'Treasure' (3.5%), 'Sweet Charlie' (3.4%), and 'Strawberry Festival' (3.1%) were more susceptible than 'Camarosa' (1.8%), 'Florida Radiance' (1.4%), and 'Florida Elyana' (1.8%). 'Albion' (2.2%) and 'Ruby Gem' (2.3%) were intermediate and not significantly different from either group (Table 2).

Botrytis fruit rot incidence was not significantly different between any of the cultivars in 2007–08. Disease incidence was low (1.3% to 6.3%) despite a lack of fungicide applications that season. The low botrytis fruit rot incidence in 2006–07 and 2007–08 allowed for little separation of cultivars (MacKenzie et al., 2003). Additionally, strawberry fruit is primarily susceptible

Table 1. Incidence of anthracnose fruit rot among 13 strawberry cultivars/advanced selections.

Cultivar	Resistance classification	2004–05	2006–07	2007–08
Treasure	Highly susceptible	ND[z]	8.9 a	54.0 a
Camarosa	Highly susceptible	ND	6.6 ab	ND
Albion	Highly susceptible	ND	5.0 ab	45.2 ab
Ventana	Susceptible	9.7 a[y]	ND	ND
Camino Real	Susceptible	6.3 a	3.7 b	ND
Candonga	Susceptible	6.2 a	ND	ND
99-164	Susceptible	ND	1.1 cde	34.3 bc
Strawberry Festival	Moderately resistant	3.6 b	0.7 cde	16.9 d
99-117	Moderately resistant	2.1 b	0.5 cde	10.8 de
Ruby Gem	Moderately resistant	ND	0.2 e	5.4 ef
Florida Radiance	Resistant	ND	0.6 de	3.9 fg
Florida Elyana	Resistant	ND	0.4 de	3.4 fg
Sweet Charlie	Resistant	0.5 c	0.3 e	0.9 g

[z]ND = not determined.

[y]Mean separation within columns by Fisher's protected LSD test, $P \leq 0.05$.

Table 2. Incidence of botrytis fruit rot among 13 strawberry cultivars/advanced selections.

Cultivar	2004–05	2006–07	2007–08[z]
Camino Real	37.5 a[y]	7.8 a	ND
Ventana	32.4 a	ND	ND
Treasure	ND[x]	3.5 b	4.3
Sweet Charlie	17.5 b	3.4 bc	6.3
Candonga	13.8 b	ND	ND
Strawberry Festival	13.3 b	3.1 bc	2.6
Ruby Gem	ND	2.3 bcd	1.8
Albion	ND	2.2 cd	2.1
Camarosa	ND	1.8 de	ND
Florida Radiance	ND	1.4 def	1.9
Florida Elyana	ND	1.8 de	2.7
99-117	4.6 c	0.9 f	1.3
99-164	ND	0.3 g	2.0

[z]Cultivars/advanced selections were not significantly different in the 2007–08 season.

[y]Mean separation within columns by Fisher's protected LSD test, $P \leq 0.05$.

[x]ND = not determined

to botrytis infection at bloom; therefore, cultivars with differing peak bloom periods will experience varying weather conditions that may affect disease incidence as much as innate cultivar resistance (Mertely et al., 2002).

'Ventana' and 'Candonga' were only tested once and 'Ruby Gem', 'Albion', 'Florida Radiance', 'Florida Elyana', and 99-164 were only evaluated in one season with significant botrytis fruit rot; therefore, the level of resistance determined from these data must be considered preliminary.

'Strawberry Festival' is the predominant cultivar currently grown in Florida and has moderate levels of resistance to anthracnose and botrytis fruit rot. The newly released cultivars 'Florida Elyana' and 'Florida Radiance' showed even higher level of resistance to anthracnose fruit rot than 'Strawberry Festival' and should serve as an asset to Florida growers to reduce their fungicide applications for control of this disease. 'Florida Elyana' and 'Florida Radiance' also seem to have higher level of resistance to botrytis fruit rot than 'Strawberry Festival' but additional trials with higher disease pressure will be needed to confirm these results.

Literature Cited

Barritt, B.H. 1980. Resistance of strawberry clones to botrytis fruit rot. J. Amer. Soc. Hort. Sci. 105:160–164.

Chandler, C.K., J.C. Mertely, and N.A. Peres. 2006. Resistance of selected strawberry cultivars to anthracnose fruit rot and botrytis fruit rot. Proc. Vth Intl. Strawberry Symp. Acta Hort. 708:123–126.

Legard, D.E., M.A. Ellis, C.K. Chandler, and J.F. Price. 2003. Integrated management of strawberry diseases in winter fruit production areas, p. 111–124. In: N.F. Childers (ed.). The strawberry. Dr. Norman F. Childers Publications, Gainesville, FL.

Maas, J.L. 1978. Screening for resistance to fruit rot in strawberries and red raspberries: A review. HortScience 13:423–426.

MacKenzie, S.J., C.L. Xiao, J.C. Mertely, C.K. Chandler, and D.E. Legard. 2003. Uniformity of strawberry yield and incidence of botrytis fruit rot in an annual production system. Plant Dis. 87:991–998.

Mertely, J.C. and Peres, N.A. 2004. Strategies for early season disease control. Berry/Veg. Times Nwsl., July/August:2–3. <http://strawberry.ifas.ufl.edu>.

Mertely, J.C., S.J. MacKenzie, and D.E. Legard. 2002. Timing of fungicide applications for *Botrytis cinera* based on development stage of strawberry flowers and fruit. Plant Dis. 86:1019–1024.

Olcott-Reid, B. and J.N. Moore. 1995. Field reactions of strawberry cultivars and selections to anthracnose fruit rot, leather rot, and gray mold in Arkansas. Fruit Var. J. 49:4–13.