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Field Reactions of Strawberry Cultivars and Selections to Anthracnose Fruit Rot, Leather Rot and Gray Mold in Arkansas

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Abstract

Three strawberry field trials, conducted for two years each, revealed differing levels of field susceptibility to three fruit rots among cultivars and selections. 'Earliglow' consistently displayed among the lowest levels of anthracnose fruit rot (incited by *Colletotrichum gloeosporioides* (Penz.) Penz. & Sacc.) and gray mold (caused by *Botrytis cinerea* Pers.:Fr.), and moderate to low levels of leather rot (incited by *Phytophthora cactorum* (Leb. & Cohn) Schrot.), in all three trials over both years. 'Vantage' exhibited low levels of all three rots during two seasons in one trial, and NC4052 and USB301 appear promising as rot-resistant selections after one season's data in one trial. 'Guardian' and 'Cardinal' proved susceptible or very susceptible to all three rots, 'Allstar' demonstrated high susceptibility to leather rot and gray mold, 'Lateglow' was very susceptible to anthracnose and gray mold, and 'Badgerglo' exhibited high susceptibility to anthracnose. 'Fairfax' and 'Tristar' appeared resistant to gray mold during seasons with low gray mold pressure but fully susceptible during seasons with high gray mold pressure, and exhibited moderate levels of anthracnose and leather rot. 'Chandler' exhibited less of all rots than the other California cultivars, 'Fern,' 'OsoGrande,' 'Pajaro' and 'Yolo,' which were very susceptible to anthracnose and leather rot and moderately susceptible to gray mold.

Introduction

Several fruit-rotting fungi attack strawberries, often causing severe pre- and postharvest losses. Chemical control of fungal rots often proves ineffective, may pose human health risks, and has induced development of fungicide-resistant strains of several strawberry pathogens (8, 15). Variation exists within cultivated strawberry germplasm for reactions to several fruit rots, although field rot ratings are highly influenced by environmental conditions including region, weather, and season (3, 5, 9). Field trials over several years could enable selection of cultivars and breeding lines with greater rot resistance within a region, and commercial and breeding use of these genotypes could minimize losses and the need for fungicides.

Three strawberry fruit rots are prevalent in Arkansas and much of the eastern United States: anthracnose, leather rot and gray mold. Several

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Colletotrichum species may cause anthracnose (11), but only *C. gloeosporioides* (Penz.) Penz. & Sacc was isolated from anthracnose-infected fruit collected from University of Arkansas fields. *Phytophthora cactorum* (Leb. & Cohn) Schrot., a common soil inhabitant, incites leather rot, while *Botrytis cinerea* Pers.:Fr. causes gray mold (11). Warm, wet weather favors anthracnose development, cooler wet weather encourages gray mold, and soils that remain wet for several days favor leather rot development (11).

Strawberry cultivars have been tested most often for reaction to gray mold, the most common fruit rot worldwide. Most trials measured postharvest rot occurrence (2, 3, 4, 6, 13), which is often poorly correlated to preharvest resistance to gray mold (1, 5, 9, 16). 'Earliglow,' from the U.S. Dept. of Agriculture (USDA) breeding program in Beltsville, Md., demonstrated good pre- and postharvest resistance to gray mold in Maryland (13). A Russian gray mold trial revealed preharvest (but not postharvest) resistance in 'Troubador' from Scotland, and postharvest (but not preharvest) resistance in 'Badgerglo' from Wisconsin (16). 'Holiday,' a very firm-fruited New York cultivar, exhibited preharvest (but not postharvest) gray mold resistance in Russian trials (16) and postharvest resistance in Maryland trials (13). 'Cardinal,' a firm-fruited University of Arkansas cultivar, displayed general postharvest rot resistance in Oklahoma trials (Ben Bruton, personal communication). 'Allstar,' 'Fairfax,' 'Lateglow' and 'Tristar,' all USDA cultivars, exhibited intermediate gray mold reaction in Maryland (Gene Galletta, personal communication), where 'Guardian' and 'Sunrise' proved very susceptible to postharvest gray mold (13).

Maryland field observations suggested that 'Robinson,' 'Shuksan,' and MdUS 3575 possessed moderate resistance to anthracnose fruit rot caused by a *Colletotrichum* (=*Gloeosporium*) species later identified as *C. gloeosporioides* (10, 12). When harvested fruit were wound-inoculated and placed in plastic boxes at 25 C, however, all cultivars tested—including 'Earliglow,' 'Fairfax' and 'Guardian'—became 100% infected within 3 days (10). Fruit of 26 genotypes, inoculated with *C. acutatum* Simmonds in a California postharvest test for susceptibility to anthracnose fruit rot, displayed significant differences in lesion diameter after 7 days, but fruit of all cultivars—including 'Chandler,' 'Fern' and 'Pajaro'—were susceptible (18). All cultivars appeared equally susceptible to leather rot, based on field symptoms and percentage of infected fruit, in a survey of commercial strawberry fields in Ohio (7, 14).

These studies were initiated to compare various strawberry cultivars and selections for reactions to anthracnose fruit rot, leather rot and gray mold in northwest Arkansas over several seasons, in several fields with varying amounts of disease pressure from each pathogen.

Materials and Methods

Three strawberry fields were established on Taloka silt loam soil at the University of Arkansas Experimental Farm in Fayetteville, and harvested for two years. Each field was spray-inoculated several times each season with *B. cinerea* conidial suspensions (3 to 5 x 10^5 conidia/ml), to provide sufficient and uniform gray mold pressure. A *B. cinerea* isolate was collected from the University Farm, stored in a cryofreezer until needed, and increased on pea agar medium. Each liter of this medium contained 20 g gelidium agar, the liquid from two cans of no-salt canned peas, and distilled water, with 0.1 mg/liter streptomycin added after autoclaving. Inoculum was prepared from 7- to 21-day-old cultures of the pathogen, and inoculum density was determined with a hemocytometer.

Table 1. Incidence of three fruit rots and total rot at harvest of nine strawberry cultivars in Study 1, harvested three times per week, from 1 May to 31 May, 1991.[z]

Cultivar	Percent of fruit with rots at harvest			
	Anthracnose fruit rot	Leather rot	Gray mold	Total rot
Yolo	27.8 a	8.6 bc	0.1 e	36.5 a
Fern	17.1 b	14.2 a	1.0 cd	32.2 a
Guardian	11.0 bc	13.1 ab	1.1 bc	25.2 b
Lateglow	14.5 b	5.5 cd	0.8 cd	20.8 bc
Allstar	5.8 cd	11.5 ab	1.9a	19.3 bc
Cardinal	10.6 bc	3.4 cd	1.7 ab	15.7 cd
Tristar	3.9 cd	5.6 cd	0.7 cd	10.3 de
Sunrise	4.9 cd	2.5 d	0.3 de	7.6 e
Earliglow	1.6 d	1.9 d	0.4 de	3.9 e

[z]Each percentage listed is a mean of percentages from eight plots, with a mean of 647 fruit per plot. Means within each column followed by different letters differ significantly according to Duncan's multiple range test, $P = 0.05$.

Inoculum was applied to runoff on all plots using a backpack sprayer with a microjet nozzel, on cloudy, humid days or in the evening.

Abundant anthracnose fruit rot and leather rot occurred naturally and fairly uniformly in each field, as indicated by block means for incidence of each disease. After leather rot pressure appeared excessive during 1991 harvests, metalaxyl (Ridomil™) fungicide was applied to all fields in September 1991 and 1992 to suppress that disease only. This fungicide acts only against Oomycetes such as *Phytophthora*, not against Ascomycetes such as *Botrytis* or *Colletotrichum*.

No other fungicide or insecticide sprays were applied, but metaldehyde slug-bait pellets were scattered around plants (5g/m2) early in each harvest season to control slugs. Napropamide (Devrinol™) and sethoxydim (Poast™) herbicides were applied as needed during summers, as was sprinkler irrigation for low soil moisture. Commercial 10-10-10 (N-P_2O_5-K_2O) fertilizer was applied at recommended rates (56 kg/ha actual nitrogen) to each field each July, except that the Study 3 field was fertilized instead in March 1992 at 17.6 kg/ha actual nitrogen, because it was planted in late summer. Plants were mulched with straw for winter protection in late December, and the mulch was removed and placed around plants in mid-March of each year. Fields were renovated after the

Table 2. Incidence of three fruit rots and total rot at harvest of seven strawberry cultivars in Study 1, harvested twice per week, from 1 May to 29 May, 1992.[z]

Cultivar	Percent of fruit with rots at harvest			
	Anthracnose fruit rot	Leather rot	Gray mold	Total rot
Guardian	23.2 b	22.9 a	9.2 a	55.3 a
Lateglow	33.8 a	10.7 bc	7.0 abc	51.5 a
Allstar	8.8 cd	13.9 b	8.6 ab	31.3 b
Sunrise	17.3 bc	8.6 bc	5.1 bcd	31.0 b
Tristar	15.0 bcd	10.0 bc	3.4 d	28.3 b
Cardinal	14.5 bcd	7.2 c	5.6 bcd	27.3 b
Earliglow	7.1 d	12.3 bc	3.8 cd	23.2 b

[z]Each percentage listed is a mean of percentages from eight plots, with a mean of 311 fruit per plot. Means within each column followed by different letters differ significantly according to Duncan's multiple range test, $P = 0.05$.

first harvest season by mowing off old leaves and narrowing rows to 0.25 m with a rotary cultivator, then allowing plants to runner within the 0.6-m wide rows.

Study 1, planted in 1990, was the only field fumigated with methyl bromide before planting to control weeds and soil-borne diseases such as verticillium wilt. This was also the only field that received sprinkler irrigation for frost protection during bloom, due to its proximity to a yield evaluation trial of strawberry advanced selections. This study included eight replicated blocks of nine strawberry cultivars chosen to provide various levels of susceptibility to fruit rots as cited above: 'Allstar,' 'Cardinal,' 'Earliglow,' 'Guardian,' 'Lateglow,' 'Sunrise,' 'Tristar,' 'Fern' and 'Yolo.' The last two are day-neutral University of California cultivars and were presumed to possess high fruit rot susceptibility due to low disease pressure for fruit rots where these cultivars were developed. The randomized block design contained 72 matted-row plots, each 3.0 m x 0.6 m long and slightly raised about 10 cm, and each originally planted with five plants which filled the plot with runner plants. Guard rows, one of 'Cardinal' and one of 'Allstar,' were planted along outside rows of the field. The two California cultivars, 'Fern' and 'Yolo,' died out after a sudden freeze in late October 1991, so the 1992 trial contained only the remaining seven cultivars.

Plots were harvested three times per week, the most common harvest interval for commercial strawberries, over 13 harvest dates in 1991, from 1 May to 31 May. All fully red fruit were harvested on each date. All fruit with visible signs or symptoms of gray mold, leather rot, or anthracnose were counted for each plot during each harvest. Early in the season, each fruit rot pathogen was positively identified by observing thin cross-sections of lesions under a light microscope, and keying the fruiting structures and spores to genus and species. Diagnostic signs and symptoms used to identify each disease in the field included the fuzzy, gray "mold" (conidiophore growth) of gray mold; the discrete, sunken lesions with orange-brown spore masses of anthracnose; and the tough, discolored (lilac to maroon to brown) mass of decay and distinctive odor of leather rot. Almost all rotten fruit ex-

Table 3. Incidence of three fruit rots and total rot at harvest of 12 strawberry clones in Study 2, harvested twice per week, from 4 May to 26 May, 1992.[z]

Clone	Percent of fruit with rots at harvest			
	Anthracnose fruit rot	Leather rot	Gray mold	Total rot
Aberdeen	2.8 cd	34.7 a	4.5 bc	42.0 a
A7313	3.2 cd	27.2 ab	8.5 ab	38.9 a
A7531	9.3 ab	23.8 abc	2.2 bc	35.4 a
Fairfax	4.5 bcd	16.3 bcd	12.1 a	32.9 ab
Guardian	6.6 abc	21.3 abc	4.1 bc	31.9 ab
A7556	3.0 cd	23.4 abc	5.0 bc	31.4 ab
A7580	9.3 ab	18.5 a-d	3.1 bc	30.9 ab
Cardinal	4.4 bcd	18.1 a-d	2.6 bc	25.2 abc
A6724	11.1 a	11.8 bcd	1.8 c	24.8 abc
Earliglow	1.9 cd	16.1 bcd	3.2 bc	21.2 abc
A7614	1.4 cd	8.9 cd	2.0 bc	12.3 bc
Vantage	0 d	4.0 d	0 c	4.0 c

[z]Each percentage listed is a mean of percentages from four plots, with a mean of 105 fruit per plot. Means separation within columns by Duncan's multiple range test, $P = 0.05$.

Table 4. Incidence of three fruit rots and total rot at harvest of 26 strawberry clones in Study 2, harvested once per week, from 21 May to 11 June 1993.[z]

Clone	Percent of fruit with rots at harvest			
	Anthracnose fruit rot	Leather rot	Gray mold	Total rot
A7531	38.4 ab	11.6 ab	1.8 cd	51.8 a
OsoGrande	32.8 abc	13.6 ab	2.5 cd	48.9 ab
Pajaro	33.4 abc	9.9 ab	3.3 bcd	46.5 abc
Badgerglo	40.3 a	6.1 ab	0 d	46.3 abc
USB312	20.8 b-f	18.9 a	6.5 ab	46.1 abc
Guardian	31.4 abc	6.5 ab	3.0 bcd	40.9 a-d
Cardinal	23.7 a-e	12.6 ab	1.6 cd	38.0 a-e
A6742	31.0 a-d	2.9 b	1.3 cd	35.1 a-e
Allstar	21.1 b-f	11.6 ab	1.5 cd	34.2 a-f
A7614	16.3 c-g	12.5 ab	3.8 bcd	32.5 a-f
USB310	16.7 c-g	11.9 ab	3.9 bcd	32.5 a-f
A7580	17.2 c-g	10.8 ab	0.7 cd	28.6 b-g
A7313	10.2 efg	8.5 ab	8.1 a	26.8 c-h
Chandler	19.7 c-f	6.6 ab	0 d	26.3 c-h
USB298	17.4 c-g	4.4 b	0.4 cd	22.1 d-h
A7556	6.6 efg	13.4 ab	1.8 cd	21.8 d-h
Fairfax	11.0 efg	10.5 ab	0.1 cd	21.5 d-h
USB303	6.4 efg	11.0 ab	3.0 bcd	20.4 d-h
Holiday	13.0 d-g	3.7 b	1.7 cd	18.4 e-h
Sunrise	11.3 e-g	4.1 b	2.6 cd	18.0 e-h
Aberdeen	7.2 e-g	9.9 b	0.9 cd	18.0 e-h
USB320	12.1 efg	1.7 b	0 d	13.8 fgh
Vantage	6.1 efg	4.4 b	0.6 cd	11.1 gh
NC4052	5.2 efg	3.7 b	0.9 cd	9.9 gh
USB301	0 g	4.6 b	2.7 cd	7.3 h
Earliglow	3.3 fg	2.9 b	0.9 cd	7.0 h

[z]Each percentage listed is a mean of percentages from four plots, with a mean of 187 fruit per plot. Mean separation within columns by Duncan's multiple range test, $P = 0.05$.

hibited only one of the three diseases, but the rare berry that displayed two of the diseases was counted for both.

All fruit from each plot that appeared uninfected were weighed on each harvest date, as was a 25-berry sample of sound fruit from each plot. During data analysis, the total weight of sound fruit was divided by the 25-berry weight and multiplied by 25 to estimate the number of sound fruit. Subsamples of six sound berries per plot (a total of 48 berries per cultivar) were also placed in closed plastic boxes on moist paper towels on three harvest dates (6 May, 13 May, and 21 May 1991) to determine incidence of postharvest rot. All fruit in plastic boxes rotted within three days at room temperature (25 C), mainly from leather rot, anthracnose or *Rhizopus* rot. Since this postharvest test did not distinguish rot susceptibility among cultivars while the harvest test did, the postharvest test was not repeated in 1992 or for the other field trials. The harvest interval was extended in 1992 by harvesting twice per week on eight dates from 1 May to 29 May, to increase amounts of rots seen in the field. The mean number of total fruit per plot was 647 in 1991 and 311 in 1992, with 1992 yields reduced by the Oct. 1991 freeze.

Study 2, planted in 1991, contained four randomized-block replications of 26 strawberry breeding selections and cultivars, with one guard row of 'Cardinal' and one of 'Earliglow' planted

along outside rows of the field. Each matted-row plot was 1.8 m x 0.6 m long, slightly raised about 10 cm, and originally planted with three plants which filled the plot with runner plants. Genotypes included six promising University of Arkansas selections with unknown rot susceptibility (designated by selection numbers preceded by A); six promising selections from the USDA strawberry breeding program for *Botrytis* resistance at Beltsville, MD (designated by selection numbers preceded by USB); NC 4052, an apparently rot-resistant selection from North Carolina; three commercial cultivars from California: 'Chandler,' 'Pajaro,' and 'Oso Grande'; and the cultivars 'Aberdeen,' 'Allstar,' 'Badgerglo,' 'Cardinal,' 'Earliglow,' 'Fairfax,' 'Guardian,' 'Holiday,' 'Sunrise,' and 'Vantage.'

Many of the selections were received late in the 1991 season and did not bear sufficient fruit until the 1993 season. Sound fruit and those with gray mold, leather rot, and anthracnose were counted for each plot during seven twice-weekly harvests of all fully-red fruit from 4 May to 26 May 1992, and four once-weekly harvests from 21 May to 11 June 1993 (an unusually late season). The mean number of total fruit per plot was 105 in 1992 and 187 in 1993.

Study 3, planted in 1991, contained progeny of crosses between seven parent cultivars, along with the parents, in four randomized blocks in a 0.4-ha field. The field was cross-cultivated to keep individual plots separate, and each plant was allowed to runner within a 0.6 m x 0.6 m square plot that was slightly raised about 10 cm. Eight plants of each parent cultivar—'Allstar,' 'Cardinal,' 'Earliglow,' 'Fairfax,' 'Fern,' 'Guardian,' and 'Tristar'—were planted in each of the four randomized blocks, and data from these parent cultivars were analyzed separately for this report, to provide further information about the reactions of these cultivars to these three fruit rot diseases. Sound fruit and those with gray mold, leather rot, and anthracnose were counted for each plot during four once-weekly harvests of all fully-red fruit each year, from 5 May to 27 May 1992, and from 19 May to 8 June 1993. The mean number of total fruit per plot was 35 in 1992 and 62 in 1993.

Percentages of fruit with each disease and with total rots were calculated for all plots in all studies. Data from each study for each year were subjected to analysis of variance, and means were separated by Duncan's multiple range test, using the Statistical Analysis System (SAS) general linear model procedure (17). Arcsine transformations, commonly used for percentage data, were computed for percentages of each rot, but analyses of variance and mean separations using transformed data yielded the same results as those

Table 5. Incidence of three fruit rots and total rot at harvest of seven strawberry cultivars in Study 3, harvested once per week, from 5 May to 27 May 1992.[z]

Cultivar	Percent of fruit with rots at harvest			
	Anthracnose fruit rot	Leather rot	Gray mold	Total rot
Fairfax	8.2 c	20.3 a	34.2 a	62.7 a
Guardian	14.1 bc	19.6 a	27.2 a	60.9 a
Cardinal	21.8 a	4.4 c	32.2 a	58.4 a
Allstar	9.0 c	18.3 ab	30.3 a	57.6 a
Tristar	16.9 ab	9.9 bc	30.0 a	56.8 a
Fern	12.2 bc	17.0 ab	11.2 b	40.4 b
Earliglow	7.5 c	7.8 c	14.2 b	29.5 b

[z]Each percentage listed is a mean of percentages from 18 to 28 plots, with a mean of 35 fruit per plot. Mean separation within columns by Duncan's multiple range test, $P = 0.05$.

using untransformed percentages. Only the untransformed percentages are reported.

Environmental and within-clone correlation coefficients (r values) between field expression of pairs of individual fruit rot diseases, and between each disease and total fruit rots, were calculated for each study and season using the SAS nested procedure (17). Environmental variation, which includes random error, designates the variation not accounted for by clone, block or clone x block in the large Study 3, and the variation not accounted for by clone in the smaller Studies 1 and 2, where variation due to blocks was not significant. The nested procedure also revealed the percent of total variation due to genotypes for each fruit rot in each study and year.

Results and Discussion

Only low levels of gray mold occurred in 1991 in Study 1, but losses to anthracnose and leather rot reached fairly high levels (Table 1). 'Yolo' proved very susceptible to anthracnose, 'Fern' and 'Lateglow' were susceptible, and 'Guardian' and 'Cardinal' were moderately susceptible, while the other four cultivars exhibited less anthracnose. 'Fern,' 'Guardian,' 'Allstar,' and 'Yolo' displayed the most leather rot. 'Earliglow' had the lowest levels of both anthracnose and leather rot and the lowest total rot, followed by 'Sunrise' and 'Tristar.' The two California cultivars had the most total rot.

A cool, wet, and very humid harvest season during 1992 produced more gray mold, and the lengthened interval between harvests allowed more of all rots to develop on the seven remaining cultivars in Study I (Table 2). 'Lateglow' suffered significantly more anthracnose and 'Guardian' had significantly more leather rot than the other cultivars, causing these two cultivars to have significantly greater total rot than the others. These two and 'Allstar' also displayed the most gray mold. 'Earliglow' again exhibited the lowest levels of anthracnose and total rot and among the lowest gray mold levels, but had moderate leather rot.

'Earliglow' also displayed moderate leather rot, low anthracnose, and low gray mold in Study 2 during 1992 (Table 3). Leather rot predominated in this field, and 'Aberdeen' displayed the most leather rot and total rot, while 'Fairfax' exhibited the most gray mold. One Arkansas selection, A7614, and 'Vantage' displayed less of each rot than 'Earliglow.'

After a fall metalaxyl spray to reduce the disease pressure from leather rot, anthracnose predominated when Study 2 was harvested once a week in 1993, but gray mold levels were low (Table 4). That year, A7614 had moderate levels of all rots, but 'Vantage' still had low levels, although not better than

Table 6. Incidence of three fruit rots and total rot at harvest in seven strawberry cultivars in Study 3, harvested once per week, from 19 May to 8 June 1993.[z]

Cultivar	Percent of fruit with rots at harvest			
	Anthracnose fruit rot	Leather rot	Gray mold	Total rot
Guardian	39.8 ab	15.6 a	5.1 a	60.5 a
Cardinal	44.8 a	7.9 b	2.5 b	55.1 ab
Fern	42.2 a	6.4 b	1.4 b	49.9 b
Tristar	34.2 bc	5.3 b	0.5 b	40.0 c
Fairfax	28.2 cd	4.6 bc	0.6 b	33.4 c
Allstar	24.2 d	7.3 b	1.5 b	33.0 c
Earliglow	14.5 e	1.6 c	1.6 b	17.6 d

[z]Each percentage listed is a mean of percentages from 26 to 32 plots, with a mean of 62 fruit per plot. Mean separation within columns by Duncan's multiple range test, $P = 0.05$.

'Earliglow.' 'NC4052' and 'USB301' both appeared promising for total rot resistance. 'Badgerglo' displayed no gray mold but had a high level of anthracnose. Several Arkansas selections, the California cultivars 'Pajaro' and 'Oso-Grande,' and 'Guardian,' 'Cardinal' and 'Allstar' exhibited high levels of all three rots, especially anthracnose. USB312 and USB310, both seedlings of 'Fairfax' x 'Allstar,' suffered high levels of gray mold and leather rot for this field in 1993, and had moderate anthracnose. 'Chandler' had moderate anthracnose and leather rot but much less than the other California cultivars, and displayed no gray mold.

Gray mold reached especially high levels in Study 3 during 1992 (Table 5). Many factors encouraged a gray mold epidemic in Study 3 in 1992: a very long infection period of about 38 hours occurred during and after a late March inoculation with *B. cinerea*, temperatures remained cool and humidity levels were high, this field was fertilized in early spring which can increase gray mold, and this field was harvested only once per week. The heavy gray mold pressure overcame the resistance of 'Tristar,' a cultivar that showed moderate resistance in Study 1 during 1991 and 1992, and negated any differences in susceptibility among it, 'Allstar,' 'Cardinal,' 'Fairfax' and 'Guardian.' 'Earliglow' and 'Fern' displayed significantly less gray mold, but 'Fern' was severely infected by leather rot and anthracnose.

Anthracnose predominated in Study 3 in 1993, and there was little gray mold (Table 6), just as in Study 2 during 1993. 'Cardinal,' 'Fern' and 'Guardian' had the most anthracnose, while 'Earliglow' had the least. 'Guardian' had significantly more leather rot and gray mold than all other cultivars, and the most total rots, followed by 'Cardinal' and 'Fern.' 'Earliglow' had significantly less total rots than all the other cultivars.

Genetic differences among genotypes accounted for from <10% to >50% of the total variation in percentages of each fruit rot, depending on the disease, study, and year (Table 7). Within-genotype and environmental correlations between the individual fruit rots were often positive, indicating that clones with greater amounts of one disease often had greater amounts of another (Tables 8, 9). When environmental correlations between individual fruit rots were negative, they were insignificant to low (r = -0.03 to -0.26). This suggests that high disease pressure for one rot does not greatly reduce field incidence of the other two rots, so field screening for all three rots simultaneously can be useful. Environmental and within-genotype correlations of individual rots with total rots demonstrate which diseases predominated in each study during each year (Tables 8, 9).

Storage tests of unwounded strawberries in humidity boxes have differentiated postharvest susceptibilities of

Table 7. Percent of variation in incidence of each fruit rot due to genotypes in each study in each year. Remaining variation is due to environmental or random factors.

		Variation due to genotypes (percent)			
Study	Year	Anthracnose fruit rot	Leather rot	Gray mold	Total rot
1	1991	38.6	43.8	47.3	54.0
1	1992	51.6	44.2	17.9	45.6
2	1992	47.9	28.8	29.1	25.3
2	1993	48.7	7.3	37.9	50.7
3	1992	9.3	11.1	24.6	27.3
3	1993	9.8	14.6	14.6	30.2

Table 8. Environmental correlations between individual rots and total rot in each study for each year.

	Environmental correlation coefficients (r values)					
	Study 1		Study 2		Study 3	
Rot incidence	1991	1992	1992	1993	1992	1993
Anthracnose, gray mold	0.16	0.24	0.18	0.21	-0.23*	-0.05
Anthracnose, leather	-0.26*	0.19	0.48**	-0.23	-0.06	-0.25***
Gray mold, leather	0.31	0.44**	0.29	-0.03	-0.13	-0.07
Anthracnose, total	0.86***	0.80***	0.64***	0.78***	0.27**	0.87***
Gray mold, total	0.38**	0.65***	0.55***	0.34**	0.67***	0.15*
Leather rot, total	0.28*	0.68***	0.93***	0.40***	0.47***	0.19*
n-2	62	48	34	81	91	180

*, **, *** Significant at $P = 0.05, 0.01$, or 0.001, respectively.

genotypes to gray mold where it is the main fruit rot (1, 4, 5, 9). Such tests did not differentiate susceptibility to gray mold or the other rots among genotypes in this study, when anthracnose and leather rot were prevalent (data not shown). These results correspond to the uniform postharvest susceptibility of wounded strawberries of 19 cultivars to anthracnose fruit rot caused by *C. gloeosporioides* (10), and only slight differences in postharvest susceptibility of 26 strawberry genotypes to anthracnose fruit rot caused by *C. acutatum* (18). Field screening for fruit rot resistance is probably a better approach where several preharvest rot diseases occur.

The unique conditions of each season and study led to varying disease pressures and susceptibility rankings, but 'Earliglow' was always among the most rot-resistant. 'Earliglow' appears to offer some resistance to anthracnose fruit rot caused by *C. gloeosporioides*, and a moderate reaction to leather rot, in addition to its established resistance to gray mold. Preliminary evidence from two harvest seasons in one study indicates that 'Vantage' appears to be another rot-resistant cultivar, and data from one harvest season in the same study indicate NC4052 and USB301 are promising selections for use in breeding. Identification of additional sources of rot resistance in strawberries is needed, especially to leather rot.

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Table 9. Within-genotype correlations between incidences of individual rots and total rot in each study for each year.

	Within-geotype correlation coefficients (r values)					
	Study 1		Study 2		Study 3	
Rot incidence	1991	1992	1992	1993	1992	1993
Anthracnose, gray mold	-0.25	0.36	-0.12	0.01	0.27	0.38
Anthracnose, leather	0.42	0.14	0.08	0.16	-0.26	0.62
Gray mold, leather	0.34	0.68	0.36	0.49**	-0.53	0.87*
Anthracnose, total	0.91**	0.84*	0.25	0.91***	0.38	0.95**
Gray mold, total	0.01	0.72	0.56	0.31	0.93**	0.64
Leather rot, total	0.76*	0.64	0.90***	0.52**	0.68	0.83*
n-2	7	5	10	29	5	5

*, **, *** Significant at $P = 0.05, 0.01$, or 0.001, respectively.

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Call for Wilder Medal Nominations

The Wilder Medal Committee of the American Pomological Society (APS) invites nominations for the 1995 Wilder Silver Medal Award. All active members of APS are eligible to submit nominations. The Wilder Medal was established in 1873 by the American Pomological Society in honor of Marshall P. Wilder, the founder and first President of the Society. The award consists of a beautifully engraved medal which is presented to the recipient at the annual meeting of APS, held during the ASHS Annual Meeting.

The Wilder Medal is conferred on individuals or organizations which have rendered outstanding service to horticulture in the broad area of pomology. Special consideration is given to work relating to the origination and introduction of meritorious varieties of fruit. Individuals associated with either commercial concerns or professional organizations may be considered as long as their introductions are truly superior, and have been widely planted.

Significant contributions to the science and practice of pomology other than fruit breeding will also be considered. Such contributions may relate to any important area of fruit production such as rootstock development and evaluation, anatomical and morphological studies, or unusually noteworthy publications in any of the above subject areas.

Specific nomination guidelines can be obtained by contacting committee chairperson, Dennis J. Werner, Department of Horticultural Science, Box 7609, North Carolina State University, Raleigh, NC 27695-7609 (phone 919-515-1226). Please submit your nominations by May 1, 1995. Thank you.