Fruit Resistance to *Colletotrichum acutatum* in Strawberries

B. Denoyes-Rothan, M. Lafargue, and G. Guerin, INRA, Unité de Recherches sur les Espèces Fruitières et la Vigne, BP 81, 33883 Villenave d'Ornon, France; and **M. Clerjeau**, INRA, Station de Phytopathologie, BP 81, 33883 Villenave d'Ornon, France

ABSTRACT

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Evaluation of strawberry resistance to anthracnose is generally limited to the crown rot phase of the disease. The major objective of this study was to develop a screening test for resistance to anthracnose fruit rot (*Colletotrichum acutatum*) using detached strawberries under controlled-environment conditions. Inoculation was carried out on detached fruits harvested at the stage when they were turning white-pink. Lesion diameter and percentage of diseased fruits (disease incidence) were measured. An incubation temperature of 18°C allowed a better discrimination between resistant and susceptible genotypes than 25°C. At 18°C and 8 days after inoculation, 26 genotypes differed greatly in susceptibility to anthracnose fruit rot, and lesion size ranged from 0 to 17 mm with disease incidence of 10 to 100%. A relationship between lesion size and disease incidence was established. The 26 genotypes were classified into three groups of susceptibility according to lesion size and percentage of diseased fruits. The susceptible group included nine genotypes with lesion sizes of 8.2 to 14.4 mm and 81 to 100% diseased fruits. In this group, Pajaro and Elsanta were the most susceptible. The four genotypes belonging to the resistant group, Dover, Capitola, US159, and US438, showed small fruit lesion sizes of 0.4 to 1.0 mm and a limited disease incidence (10 to 17%). The resistance of two genotypes to anthracnose fruit rot was evaluated under field conditions (plastic tunnel). The relatively resistant genotype, Sequoia, displayed reduced incidence of anthracnose fruit rot in the sections closest to the source of inoculum compared with the susceptible genotype Elsanta.

Additional keywords: *Fragaria* × *ananassa*

Strawberry anthracnose, caused by *Colletotrichum acutatum* J.H. Simmonds, is one of the most important diseases of strawberry in France (8). Lesions can occur on all parts of the plant, including the crown, fruit, stolon, petiole, leaf, flower, and root (4). Losses caused by fruit rot are particularly damaging economically. No chemical disease control methods are available to effectively control the disease. In France, chemical control for anthracnose is limited to preventive treatments applied before fruit production (1). Among cultural techniques employed, drip irrigation and culturing under plastic tunnels considerably limit inoculum dispersal and therefore reduce fruit losses (17,18,29). The use of pathogen-free plants usually provides a sufficient level of disease control (20,21). Nevertheless, latent infection may occur in apparently healthy plants, leading to anthracnose symptoms in production fields (19). Hence, the selection of resistant cultivars appears to be the most efficient and practical control strategy for

limiting or suppressing anthracnose epidemics.

Current screening methods evaluate the whole plant reaction and select for foliage, stolon, and crown resistance (5,8,16,26). Therefore, breeding programs for anthracnose resistance focus on seedlings or plants rather than on fruit (9,11,13,23,24). Using those screening methods, apparently resistant genotypes, particularly everbearing types, still show anthracnose fruit lesions in production fields. Therefore, in breeding programs, fruit rot resistance should be considered in addition to whole plant resistance for limiting anthracnose incidence. The fruit rot resistance could be evaluated directly on fruit.

Strawberry fruit inoculation methods with *Colletotrichum* spp. have been developed mainly to study the virulence of *Colletotrichum* spp. (16,25) or *C. acutatum* epidemiology (4,14,28,29). The only study concerning a screening method for resistance to anthracnose fruit rot was reported by Maas (15), although among 19 strawberry cultivars, no resistance was shown following wound inoculation.

The objective of this study was to develop a screening test for resistance to anthracnose fruit rot using detached strawberries. The effect of incubation temperature on fruit rot was determined in order to find the temperature that best revealed fruit resistance to anthracnose. Then anthrac-

nose resistance was evaluated on a wide range of genotypes in detached fruit in a controlled environment.

A second objective was to determine whether the variability in fruit rot susceptibility observed in a controlled environment was similar under field conditions. This study was conducted under a plastic tunnel with two genotypes that differed in susceptibility to fruit rot.

MATERIALS AND METHODS

Screening test on detached fruit for fruit rot resistance. *Fruit material.* Fruits used for investigating the effect of incubation temperature and for the screening test were kindly provided by CIREF (The Interregional Centre for Strawberry Research and Experimentation, 24130, Prignonrieux, France). They were harvested at the stage when they are turning white-pink (stage 82 according to Risser and Navatel [22]). After removal of the calyx, fruits were surface-sterilized in a 60% ethanol solution for 90 s, rinsed once in sterile water, and then surface-sterilized in a sodium hypochlorite solution (400 µg/ml) for 6 min, followed by two rinses in sterile water. The effect of incubation temperature was studied on four genotypes, Dover, Honeoye, US159, and US438. The experiment was conducted twice. Screening for fruit rot resistance was studied on 26 genotypes. Each genotype was tested at least twice and up to six times, depending on the quantity of white-pink fruits available for inoculation.

Inoculum preparation. In all experiments, the strain of *C. acutatum*, 1267b, was used and the conidial suspension was prepared from the same stock culture in order to reduce intra-isolate variation. Conidial suspension was prepared as described before (6). The suspension was diluted with distilled water to give a final concentration of 2×10^4 conidia per ml (6).

Detached fruit inoculation technique under controlled environment. Twenty detached fruits per genotype were randomly placed in 30 × 40 cm plastic boxes on moist paper. Fruits were inoculated by depositing a 15-µl drop of the conidial suspension on each fruit. Four fruits per genotype were used as noninoculated controls in order to visually verify that the fruits did not have anthracnose infection when harvested. In order to maintain high humidity, plastic boxes were closed with a glass cover, and the fruits were sprayed regularly with sterile water throughout the

Corresponding author: B. Denoyes-Rothan
E-mail: denoyes@bordeaux.inra.fr

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experiment. Plastic boxes were maintained in a controlled environment chamber with a 12-h photoperiod. Two incubation temperatures were tested, 18 and 25°C ± 1°C.

Disease response. Lesion diameters were measured at 2-day intervals from 4 to 8 days after inoculation. The percentage of fruit showing an anthracnose lesion (disease incidence) was calculated for each genotype and experiment. Data are presented at 8 days after inoculation.

Statistical analysis. An analysis of variance (ANOVA) of the square root of the lesion diameter of detached fruits recorded 8 days after inoculation was performed after checking the data for normality of distribution of error, adequacy of the model, and homogeneity of residual variances. In order to meet assumptions of normality of disease incidence, data were transformed using the square root of the arcsine (27). ANOVAs were conducted using the general linear models procedure of the Statistical Analysis System (SAS Institute, Cary, NC). Since treatment sizes were unequal, a least squares means (LS means) test ($P = 0.001$) was used to separate the lesion diameter means and the disease incidence. In addition, a non-parametric approach was used on disease incidence. The likelihood ratio chi-square test, G^2 test (2), was performed on the distribution of fruit number in two classes according to the presence or absence of

anthracnose rot lesions. Statistical significance was considered at $P = 0.001$. The relationship of lesion diameter size to disease incidence was studied using linear and quadratic models.

Evaluation of fruit rot resistance under field conditions. Genotypes Sequoia, relatively resistant, and Elsanta, very susceptible (6,8), were chosen in order to determine their levels of susceptibility to anthracnose fruit rot and the spread of the fungus under a plastic tunnel culture. Genotypes were planted in two separate 1 × 11 m plots in a plastic tunnel of 4-m width and 13-m length. The experiment was conducted twice. Plots were covered with black plastic. Both plantings were carried out following soil treatment with a methyl bromide-chloropicrin mixture (98:2, vol/vol) (1). Four rows in the first experiment and three rows in the second experiment were planted in each plot, at an interrow spacing of 25 cm (four rows per plot) or 30 cm (three rows per plot). The intrarow spacing was 33 cm in both experiments. The central 9 m of each plot was divided into nine sections, with an average length of 1 m for the first experiment and 12 sections (0.75 m long) for the second experiment (Fig. 1).

The source of inoculum was infected fruits with large sporulating lesions. Fruits were inoculated in our laboratory with *C. acutatum* strain 1267b. Two plants of each

genotype located in section 1 were inoculated by placing one infested source fruit on each plant's crown. Inoculations were performed in mid-October. After 7 days, fruits were removed and then replaced with newly infected fruits for another 7 days. During these 14 days, plants were watered manually every other day, avoiding water splashes between the two genotypes. After the removal of inoculating fruits, plants were watered by drip irrigation until 2 weeks before harvesting, when sprinkler irrigation was used twice a week until midharvest.

Each plot was assessed approximately twice weekly by harvesting ripe fruits and recording disease incidence and distance from the source of inoculum as section number. Fruits were recorded as diseased when lesions were visible, and as healthy when no symptom was visible. Whenever there was any doubt concerning the pathogen that caused the lesion, diagnosis was confirmed by observing conidia using a dissecting microscope. To avoid cross-contamination during harvesting, hands were disinfected with alcohol between sections. Disease incidence was determined as the percentage of the total number of diseased fruits relative to the total number of ripe fruits harvested throughout the fruiting season. These percentages were calculated for each section and genotype.

The likelihood ratio chi-square (G^2) test was performed on the distribution of fruit in two classes according to the presence or absence of fruit rot lesions. Statistical significance was considered at $P = 0.05$.

RESULTS

Screening test for fruit rot resistance on detached fruit. A typical dark brown, circular, sunken, firm-rot lesion caused by *C. acutatum* developed on fruit where the inoculum drop was deposited. On the most susceptible genotypes, such as Honeoye, lesions were observed 3 days after inoculation at the incubation temperature of 25°C, while at 18°C, lesions appeared 4 to 5 days after inoculation. No lesions were observed on control fruits. Fruits showing symptoms caused by *Rhizopus stolonifer* or *Botrytis cinerea* were removed from the plastic boxes to avoid contaminating other fruits and were excluded from the analysis.

Effect of temperature. ANOVAs were carried out on fruit lesion diameter and on disease incidence scored from the four genotypes tested at both temperatures (i.e., 18 and 25°C). The effects of temperature and genotype were highly significant ($P = 0.001$), while the effects of experiment, genotype × experiment, and temperature × genotype interactions were not significant ($P = 0.76$, 0.07 , and 0.11 , respectively) (data not shown). Disease on Honeoye was statistically different from that on Dover, US159, and US438, except for lesion size

Fig. 1. Percentage of harvested ripe fruits obviously infected by *Colletotrichum acutatum* (strain 1267b) in tunnel experiments in relation to the anthracnose fruit rot susceptibility of two genotypes (Elsanta, susceptible, and Sequoia, relatively resistant) and to the distance from source of inoculum. Results of X^2 or G^2 tests comparing the two genotypes, Elsanta and Sequoia, are reported for each section: NS means no significance, * and ** mean significant with $P < 0.05$ and $P < 0.01$, respectively.

at 25°C (Table 1). In addition, ranges of lesion size and disease incidence were greater in genotypes incubated at 18°C than at 25°C (Table 1). The incubation

temperature of 18°C is therefore more discriminating than 25°C.

Screening test on 26 genotypes using the lesion size. Genotypes displayed continu-

ous values of lesion size ranging from 0 to 17 mm. ANOVA was carried out on fruit lesion size scored from the 26 genotypes tested in six experiments at 18°C. The effects of genotype, experiment, and genotype × experiment were significant (Table 2). Since the genotype × experiment interaction was significant, we carried out ANOVAs by experiment, followed by an LS means test (Table 3). Although variability within the data exists from one experiment to another, results of LS means allow the classification of the 26 genotypes into three groups of susceptibility according to lesion size in the six experiments. Among them, nine could be distinguished from the others by their larger lesion size (5.2 to 17.0 mm). Within this susceptible group, Honeoye, Valeta, Darestival, Fern, Selva, Darselect, and Darline were not significantly different, in at least one experiment ($P = 0.001$), from the most susceptible genotypes, Pajaro and Elsanta. The four most resistant genotypes, Capitola, Dover, US438, and US159, displayed the smallest lesion sizes of 0.0 to 2.1 mm. The 13 remaining genotypes, Seascape, Gariguette, Pandora, Chandler, Arking, US292, Dorit, Mamie, Sequoia, Milsei, Belrubi, Addie, and Mara des Bois, composed a large intermediate group of susceptibility. Their lesion size varied from 2

Table 1. Fruit lesion diameters and disease responses of plants of four strawberry genotypes inoculated with *Colletotrichum acutatum*, strain 1267b, at two temperatures, 18 and 25°C

Genotypes	18°C			25°C		
	Freq ^x	Diam. ^y (mm)	Diseased fruit (%)	Freq	Diam. (mm)	Diseased fruit (%)
Honeoye	40	10.7 a ^z	98 a	23	23.0 a	100 a
Dover	40	0.7 b	15 b	19	6.7 b	64 a
US159	39	0.4 b	5 b	22	5.0 b	75 a
US438	40	0.5 b	18 b	16	9.9 b	74 a

^x Number of measured fruits.

^y Lesion diameter size. Fruits were inoculated by depositing a drop of inoculum containing 150 conidia.

^z Least squares means test was carried out for each experiment. Values in a column followed by different letters are different at $P = 0.001$.

Table 2. Effects of genotypes, experiments, and their interaction on the lesion diameter size of fruits inoculated by *Colletotrichum acutatum* strain 1267b

Source of variation	df	MS ^y	$P > F^z$
Genotypes	25	6.14	0.0001**
Experiments	5	2.58	0.0001**
Genotypes × experiments	56	0.21	0.0001**
Error	1,392	0.11	
Total	1,478		

^y Mean squares.

^z **, significant at $P < 0.01$.

Table 3. Fruit lesion diameters (Diam.) and disease incidence (DI) in 26 strawberry genotypes of inoculated with *Colletotrichum acutatum*, strain 1267b

Cultivars	No. ^s	Freq. ^t	Experiment 1		Experiment 2		Experiment 3		Experiment 4		Experiment 5		Experiment 6		Diam. mean	DI mean
			Diam.	DI	Diam.	DI	Diam.	DI	Diam.	DI	Diam.	DI	Diam.	DI		
Pajaro	4	73	17.0 ^u a ^v	100 ^w	...	^x	12.0 a	100	13.1 a	100	15.3 a	100	...	...	14.4	100 a ^y a ^z
Elsanta	6	86	15.8 ab	95	16.0 a	100	11.8 a	100	12.4 a	100	11.6 ab	100	9.5 a	94	12.9	98 a ab
Honeoye	4	56	...	...	...	...	8.9 a	100	12.6 a	95	12.7 ab	100	10.0 a	100	11.1	98 a ab
Valeta	4	67	...	...	9.2 a	91	...	...	10.1 ab	100	11.9 ab	100	7.2 ab	88	9.6	96 ab a-c
Darestival	2	20	...	...	...	...	...	...	7.6 a-c	88	12.9 ab	100	...	...	10.3	95 a-c a-d
Fern	2	35	...	...	...	...	...	...	8.9 ab	100	7.5 b-d	81	...	...	8.2	91 a-d a-d
Selva	4	72	8.2 bc	94	...	...	...	...	8.7 ab	85	8.7 a-c	89	7.4 a	88	8.3	89 a-d b-d
Darselect	3	58	...	...	...	...	...	...	9.3 ab	95	11.7 ab	95	6.4 a-c	70	9.1	86 a-e b-d
Darline	3	53	13.8 ab	100	...	...	...	...	7.1 bc	79	...	...	5.2 a-c	65	8.7	81 a-e c-e
Seascape	4	75	...	...	3.6 b	63	...	...	6.1 bc	90	6.5 b-d	79	2.7 b-d	50	4.7	71 b-f d-f
Gariguette	2	54	12.0 ab	95	...	...	2.5 bc	40	...	...	...	...	2.0 c-e	53	5.5	63 b-f e-g
Pandora	2	38	...	...	...	...	...	...	...	...	4.2 c-e	61	3.5 b-d	55	3.9	58 c-g e-g
Chandler	4	86	...	...	3.2 bc	37	2.7 b	68	3.0 c-e	55	...	...	4.3 a-c	75	3.3	57 c-g e-g
Arking	3	50	...	...	3.1 bc	44	...	...	...	...	7.9 bc	84	2.5 c-e	33	4.5	56 c-g e-g
US292	3	43	...	...	...	...	...	...	3.0 de	45	7.4 b-d	69	3.7 b-d	29	4.6	51 d-h e-h
Dorit	3	55	4.0 de	44	...	...	...	...	2.3 de	42	3.7 de	61	...	...	3.3	49 d-h f-h
Mamie	3	59	6.6 cd	70	...	...	1.2 b-d	32	1.9 de	30	...	...	...	...	3.2	44 e-h f-h
Sequoia	2	23	...	...	1.0 bc	10	...	...	...	...	1.3 e	53	...	...	1.2	43 e-h f-i
Milsei	3	53	...	...	2.7 bc	27	1.2 b-d	32	4.7 cd	55	...	...	...	...	2.9	40 e-h g-i
Belrubi	3	52	2.8 de	50	...	...	0.5 cd	19	2.3 de	40	...	...	...	...	1.9	37 f-h g-i
Addie	3	49	4.7 c-e	46	...	...	0.2 d	12	2.6 de	42	...	...	...	...	2.5	33 f-h g-i
Mara des Bois	4	78	...	...	0.6 bc	6	...	...	1.4 de	33	1.7 e	30	0.9 c-e	32	1.1	27 f-h h-j
Capitola	4	53	0.4 e	8	0.0 c	0	...	...	...	...	2.1 e	36	0.7 c-e	27	0.8	17 gh ij
Dover	4	58	...	...	...	...	0.0 d	0	1.4 de	25	0.8 e	18	1.9 c-e	14	1.0	16 gh ij
US438	3	60	...	...	...	...	0.5 cd	0	0.5 e	11	...	...	0.2 e	5	0.4	13 gh ij
US159	4	73	...	...	...	...	0.0 d	0	0.7 e	10	0.8 e	21	0.3 de	7	0.5	10 h j

^s Number of experiments.

^t Number of measured fruits.

^u Mean size of lesion diameter. Fruits were inoculated by depositing a drop of inoculum containing 150 conidia.

^v Least squares (LS) means test was carried out for each experiment on lesion diameter. Values in a column followed by different letters are different at $P = 0.001$.

^w Disease incidence is the percentage of fruit showing a lesion.

^x Not tested.

^y LS means test was carried out on mean of diseased fruit percentage. Values in the column followed by different letters are different at $P = 0.001$.

^z Likelihood ratio chi-square test, G^2 test, was performed on the distribution of fruit in two classes according to the presence or absence of lesions. Values with the same letters do not differ significantly ($P < 0.001$).

to 12 mm. Variability within the experiment does not allow clear ranking within the intermediate group.

Relationship of lesion diameter to disease incidence. Mean lesion size for a given cultivar was highly correlated with disease incidence in the same cultivar ($P = 0.001$) (Fig. 2). For the regression of mean lesion diameter as a function of disease incidence, a quadratic model fit better than a linear model, $r^2 = 0.89$, $r^2 = 0.79$, respectively.

Screening test on 26 genotypes using disease incidence. In the ANOVA carried out on disease incidence scored from the 26 genotypes, the genotype effect was highly significant ($P = 0.001$) (data not shown). Whether a parametric test (LS means) or a nonparametric test (G^2) was performed, the results were similar (Table 3). Indeed, using disease incidence, three groups, which overlapped with the three groups described before, can be distinguished. The nine susceptible genotypes, which had the largest lesions, also showed higher percentage of diseased fruits, ranging from 81 to 100%. The four resistant genotypes displaying the smallest lesions showed the lowest percentage of diseased fruits, from 10 to 17%. The 17 remaining genotypes had a large range of disease incidence, from 27 to 71%.

Fruit disease incidence under the plastic tunnel. During the two experiments performed under a plastic tunnel, no anthracnose symptoms were observed in aerial vegetation except for a few lesions on the leaves of inoculated plants of the susceptible genotype, Elsanta. In experiment 1, diseased fruit were detected in both genotypes as far as 9 m from inoculum source; while in experiment 2, disease fruit were found as far as 6.75 m from the source. Disease incidence of Elsanta was significantly higher ($P = 0.05$) than that of Sequoia in 6 of 9 sections in experiment 1 and in 3 of 12 sections in tunnel experiment 2 (Fig. 1). In Elsanta, the closest to the source of inoculum showed the highest disease incidence (32 to 35% diseased

fruit). In contrast, disease incidence of Sequoia was uniformly low (<3%) regardless of location relative to inoculum except in experiment 2, where 10% of fruits in the section nearest the inoculum showed lesions.

DISCUSSION

As a first step in evaluating susceptibility to anthracnose fruit rot on strawberry, it was necessary to develop a standard protocol. The age of the fruit, which plays an important role in susceptibility (4,28), has to be clearly defined in order to compare susceptibility among genotypes. In our experiments, the phenological selected stage, i.e., fruit turning white-pink, has several advantages. This stage is brief and distinct, which makes it easy to identify in the field. In addition, fruit at this stage do not decompose as rapidly as more mature fruit (28), and evaluations can be made for up to 8 days after inoculation.

Incubation at 18°C seems to be more useful than at 25°C for screening fruit resistance, because larger differences in disease incidence are seen at the lower temperature. We observed smaller lesions at 18°C than at 25°C, similar to previous studies (4,28). The temperature relationship of lesion size is consistent with observations that the optimum temperature for mycelium growth is 25°C, and growth of the mycelium at 18°C is slower (4,25,28). Measurement at 18°C was easier because the lesion diameter could be measured directly in plastic boxes, whereas at 25°C, it was necessary to take the fruit out of the boxes to measure the larger lesions.

When an inoculum concentration of 1×10^4 conidia per ml was used, disease incidence ranged from 10 to 100% diseased fruit according to genotype. This result agrees with previous data in which 2.5×10^4 conidia per ml was the lowest spore density to cause 100% fruit infection on cv. Midway (28). Earlier studies had shown that infection was influenced mainly by wetness duration, and disease development, by relative humidity (3,4,28). In our

screening tests, these conditions were achieved by not allowing the inoculum drop to dry for at least 24 h and by misting fruit with water and wetting the paper lining the incubation boxes.

Using this protocol, we showed highly significant differences in susceptibility to *C. acutatum* (strain 1267b) on detached strawberry fruits of 26 genotypes. The screening test allowed us to distinguish three classes of susceptibility based on lesion size and disease incidence. Since disease incidence is highly correlated with lesion size, we postulate that disease incidence may provide an easy and quick parameter to evaluate fruit rot resistance. The fruit rot resistance does not seem to be correlated to the crown rot resistance, which has been evaluated in previous studies by dipping cold-stored plants into a conidial suspension (8). Indeed, the crown rot-resistant group (7,10,12) was found to contain both fruit resistant cultivars, i.e., Dover, US159, US438, and Capitola, and fruit susceptible cultivars such as Honeoye and Selva.

When LS means analysis was conducted on lesion size data, the ranking of the genotypes in each experiment was similar. However, since there is a significant experiment effect, susceptible and resistant control genotypes have to be included in order to make a meaningful comparison of data. This study supplied susceptible control genotypes Elsanta, Honeoye, or Valeta and resistant control genotypes Capitola, Dover, US159, and US438.

The interest in identifying genotypes with limited lesion size was stimulated by a previous study (14) where a relationship was established between lesion size and conidia numbers. Selection for genotypes with small lesions would reduce sporulation and presumably reduce the rate of disease development. Obviously, cultivars showing a low percentage of diseased fruits also would reduce fruit losses directly.

The classification of Elsanta as susceptible and Sequoia as relatively resistant, according to tests carried out on detached fruits, was confirmed by the experiments conducted under the plastic tunnel. In the latter, Elsanta showed higher anthracnose fruit rot incidence within 5 m of the inoculum source compared to Sequoia.

A difference in anthracnose fruit rot incidence was detected between the susceptible Elsanta and the relatively resistant Sequoia in the tunnel experiment. However, the genotypes could not be distinguished by the distance over which the disease spread. In both experiments, a decline in disease incidence with increasing distance from the inoculum source was observed. The spread probably resulted from sprinkler irrigation and plastic mulch, which promoted the dispersal of the *C. acutatum* inoculum (17,29).

Screening tests in breeding programs have to consider variability in virulence.

Fig. 2. Relationship of lesion diameter and disease incidence at 8 days after inoculation for the 26 genotypes evaluated for fruit rot susceptibility on detached fruit. Data were pooled over all the 6 experiments. The regression was highly significant ($P = 0.001$).

Virulence of *C. acutatum* has been characterized using a test in which a number of host genotypes were tested against a number of pathogens (6,25). *C. acutatum* was classified into two groups distinguished by differences in virulences on a set of differentiating genotypes (6,7). The strain 1267b used in this study was representative of one of the two groups (7,8). Since some genotypes such as Chandler, which is resistant to strains of group 1, showed high susceptibility to strains of group 2 (7), further studies conducted on detached fruit are necessary to focus on race resistance. They will identify which strains have to be used in a screening test of fruit rot susceptibility.

Until now, differences in genotype susceptibility have been reported on vegetative organs such as petioles, leaves, or crowns (5,16,26). Detecting differences in susceptibility to *C. acutatum* in detached strawberry fruit would allow direct screening for fruit resistance in breeding programs. This trait is particularly interesting in everbearing cultivars, which produce fruit throughout the growth period, and in which lesions may serve as a significant source of inoculum.

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