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Rain Splash Dispersal of *Colletotrichum acutatum* from Infected Strawberry Fruit

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ABSTRACT

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A rain simulator was used to investigate the influence of rain intensity (15 and 30 mm/hr), rain duration (15-60 min), and ground cover on splash dispersal of *Colletotrichum acutatum* from infected strawberry fruit. Potted strawberry plants were held in two concentric circles (30- and 60-cm radii) by a wood frame which was levelly exposed to a uniform zone of generated rain. Infected fruits with sporulating lesions were placed in the center of the circles. Studies were conducted with three ground covers: soil, soil covered with fresh straw (6-8 cm deep), and plastic. With plastic cover, 100% disease incidence was obtained at both distances and all times. With soil and straw, disease incidence was generally less in the outer compared with the inner circle, but increased in both circles over time only with soil. With 60 min of rain at 30 cm from the source, mean disease incidence was ≥90%. Rain intensity, however, did not have a consistent effect on dispersal. Influence of number (source strength) and distribution of infected fruit on resultant dispersal was evaluated, with one, five, or nine infected fruits clustered in the center of the circles, or five or nine fruits uniformly scattered over the frame. Neither source fruit number nor its spatial distribution, however, was found to significantly affect disease incidence. A simple wind tunnel also was incorporated into the study to evaluate the effect of horizontal air flow. With a flow of ≈2.3 m/sec, differences in disease incidence between up- and downwind locations were significant at 60 cm from the source but not at 30 cm. At 60 cm, disease incidence downwind (≈60%) was triple the incidence upwind (≈18%).

Additional keywords: quantitative epidemiology, disease spread, *Fragaria* × *ananassa*.

Anthracnose of strawberry (*Fragaria* × *ananassa* Duchesne) is becoming one of the most economically important diseases in the major strawberry production regions of the southeastern United States and California (10,23). The disease is caused by several species of *Colletotrichum* and *Gloeosporium*, including *Colletotrichum acutatum* Simmonds (24). In addition to causing

a fruit rot, *C. acutatum* can infect the crown, leaves, stolons, and petioles of strawberry. Anthracnose of strawberry was first found in Ohio in 1985 (9,38).

The association of rain with diseases caused by *Colletotrichum* spp. has been well established (8,18). Conidia are embedded in mucilage in acervuli, a characteristic of rain-splash dispersed fungi (15). Very little, however, is known about the splash dispersal of *C. acutatum*. In fact, rain splash dispersal has been studied in detail only recently (14,16,22,28-31,33-36). An understanding

of the mechanisms of rain splash dispersal requires knowledge of characteristics of natural rain (20,26,28), inoculum source (33), plant canopy (3,21,27,34), ground surface (28,34), and weather conditions, including wind (5,6,11,29), in addition to processes of rain drop impact (2,20), transportation (25,31), and inoculum deposition (13,16,31).

With a newly developed rain simulation system, Reynolds et al (28) conducted studies on the effect of rainfall intensity, distance from the inoculum source, fruit position within plant canopy (on ground or elevated), plant barrier, and straw mulch on the percentage of fruit infected by *Phytophthora cactorum* (Leb & Cohn) Schroet., the causal organism of strawberry leather rot. Their results indicated a significant effect of rain intensity, distance from the inoculum source, and fruit position on the plant, whereas the effects of straw mulch and plant barrier were not significant.

The purpose of this study was to demonstrate the dispersal of *C. acutatum* by rain splash. Specific objectives were to: 1) quantify the influence of rain intensity, rain duration, and ground cover on horizontal dispersal of conidia within a synthetic strawberry canopy; 2) determine the effect of number (source strength) and distribution of infected fruit on resultant dispersal; and 3) evaluate the effect of air movement at a single velocity on dispersal of the pathogen.

MATERIALS AND METHODS

Rain generation system. A rain simulator developed previously at The Ohio State University, Ohio Agricultural Research and Development Center (28), was used to investigate rain splash dispersal of conidia of *C. acutatum* on strawberry. The system used wide-angle spray nozzles (Spraying Systems, Inc., Wheaton, IL) to produce conical spray patterns that assured generation of a 1.2- × 1.2-m area of uniform rain at ground surface. The height of drop-fall was 4.0 m at 68.95 kPa water pressure at the nozzle orifice, which was maintained constantly with a precision flow valve. Two spray nozzles, 27W and 35W, were used in this study. The cumulative distribution of generated raindrop volume and the distribution of raindrop kinetic energy produced by 27W and 35W nozzles were in agreement with empirical distributions associated with natural rainfall intensities of 15 and 30 mm/hr, respectively (28).

Inoculum source. The isolate of *C. acutatum* used was obtained from a naturally infected strawberry fruit collected near Mt. Vernon, OH, in 1985. To maintain pathogenicity, fruits were inoculated with the fungus every 2 wk and the fungus was then reisolated from infected fruits. Conidia were scraped from infected fruit and streaked on potato-dextrose agar (PDA), and cultures were incubated in the dark at 25 C for 2–4 days (32). Inoculum was prepared by scraping conidia from culture plates and suspending them in deionized water. Conidial concentration was determined using a hemacytometer. All inoculations were made with a conidial suspension of 5×10^4 conidia per milliliter.

To prepare infected source fruit for each treatment, various numbers of detached, immature (green stage) fruits from greenhouse-grown plants were washed with distilled water, surface sterilized in 70% ethanol for 60 sec, rinsed with distilled water, and placed on elevated screens (6-mm mesh) contained in 5-L plastic containers. Each fruit had its stem placed through the mesh of the metal screen. The containers were filled with 700 ml of deionized water. The stem tips of detached fruits were immersed in the water, which slowed desiccation of the fruit. Fruits were then sprayed with a conidial suspension (5×10^4) until runoff. The containers were closed and incubated at 25 C for 24 hr. After 24 hr the container lid was removed and fruit remained at 25 C for 6–8 days for lesion development and sporulation.

To determine the consistency of conidia production on infected fruits, assessment of inoculum density was made for two sets of five fruits. Each fruit was placed in one 100-ml beaker containing 60 ml of sterilized deionized water. Fruits were soaked for 30 min, then gently brushed with a fine-tip paintbrush for 2 min; then conidia were collected in the deionized water. The conidial suspension was agitated for 30 sec. Conidia production was expressed as the mean number of conidia per fruit and was estimated by counting the number of conidia with a hemacytometer.

Rain intensity, rain duration, and ground cover. Strawberry plants (cultivar Midway) were grown from transplants in soil/sand/peat mixture (1:1:1, by volume) in 15-cm plastic pots in a greenhouse for 5–7 wk. New plants were planted weekly to assure the supply of fruit. Twenty plants with immature fruit in green-to-white stage of development were used in each treatment to simulate the crop canopy. Potted plants were held in two concentric circles by a wood frame that was levelly exposed to the uniform zone of generated rain (28). Radii of the two concentric circles were 30 and 60 cm, respectively. Positions of the strawberry plants in the frame were radially aligned so that the plants in the inner circle served as canopy barriers to those in the outer circle when inoculum source fruits were placed in the center. The wood supporting frame was completely covered with sterilized soil mix (soil/peat/sand, 2:2:1, by volume), straw over sterilized soil mix, or new plastic mulch. The depth of soil mix was about 6 cm for bare soil cover and 4 cm for treatments with soil under fresh straw. The depth of straw was 6–8 cm. Twenty-five drainage holes were punched in the plastic mulch with a knife to reduce free water accumulation. The average length of the holes was about 2 cm.

Inoculated source fruits were wetted with a light water mist for 60 min before each test. Ten source fruits were then placed in a tight cluster on the ground surface in the center of the wood frame. In all cases, percentage of fruit infection was used as the measure of conidia dispersal. To maintain the consistency of number and location of the sample fruits for each treatment, healthy strawberries were detached from plants immediately before each test and placed under the inner part of the plant crown in the two circles. After each test, fruits were collected and placed on elevated wire-mesh screens in 5-L containers. All fruits were lightly misted with sterile distilled water and placed in an incubator at 25 C with container lids on. After 24 hr, the container lids were removed for 60 min of natural drying. Stem ends were cut afterwards and the fruits were placed back into the containers by sticking their stems through the wire-mesh screens into deionized water. Containers were placed back in the incubator and assessment of fruit infection was made by visual examination of each fruit at 7 days after each rain simulation. With this incubation regime, lesions are relatively large and unambiguous by 7 days (38).

Four rain durations were evaluated for each combination of ground cover and rain intensity. At the end of 15, 30, 45, and 60 min, 25 fruits were collected from each circle and incubated as described above.

Inoculum source strength and distribution. For testing the effect of source strength and distribution on splash dispersal of *C. acutatum*, either one, five, or nine inoculated fruits were used to produce different levels of source strength. Inoculated fruits were either clustered in the center of the frame or spread uniformly over the sampling area (for the five and nine fruits). The general methods were the same as those described for the first experiment, except that simulated rainfall of only 15-min duration with a sterile soil cover was evaluated.

Wind simulation. A simple wind tunnel was incorporated into the study to evaluate the effect of a horizontal air flow on rain splash dispersal. The wind tunnel consisted of three 51-cm square circulators (fans) (Model 4C510A, Dayton Elec. Manuf. Co., Chicago, IL) and a constraining tunnel, as shown in Figure 1. This structure was not designed to provide a vertical profile of air movement similar to natural wind, but to supply a fairly uniform horizontal air flow across the strawberry canopy. Air flow pattern over the sample area was measured three times from 25 evenly spaced locations in the frame with hot-wire anemometers (Model 1650, TSI Inc., St. Paul, MN). The data were then used to check the uniformity and strength of the horizontal air flow.

Experimental methods were similar to the first experiment. However, only 15-min rain durations were applied and plastic

mulch was not evaluated. Ten inoculum source fruits were placed in the center of the frame. One hundred detached healthy fruits were placed in four rows (25 fruits in each row) perpendicular to the direction of air flow, with two rows located upwind and two rows downwind. The distances of the inner and outer rows in each upwind and downwind direction from the inoculum source were 30 and 60 cm, respectively. After each test, fruits were collected in four 5-L containers, incubated, and examined as previously described.

Statistical analyses. The experimental design for the three experiments was a repeated measures factorial. In the first experiment, ground cover and rain intensity were randomized (crossed) factors, and rain duration and distance from the inoculum source were repeated measures. In the second experiment, source strength and distribution was the randomized factor and distance from the source was the repeated measure. The third experiment had ground cover and rain intensity as randomized factors and row location (two rows upwind or downwind) as the repeated measure. All treatments were repeated at least twice. The dependent variable for all experiments was the arcsine square-root transformation of the percentage of infected fruit. Data were analyzed with analysis of variance (ANOVA) followed by orthogonal polynomials using the BMDP statistical software (2V) (4). The Waller-Duncan, Bayesian, least-significant difference (BLSD) test also was used to separate means in some cases (37). For duration and the interactions of duration with the other factors, linear, quadratic, and cubic polynomials (contrasts) were evaluated for significance (4).

RESULTS

Inoculum density. The mean number of conidia per fruit was 4.0×10^8 (standard error = 0.7×10^8) and 4.5×10^8 (standard error = 0.7×10^8) for the first and second replication, respectively, indicating consistent inoculum production. A 95% confidence
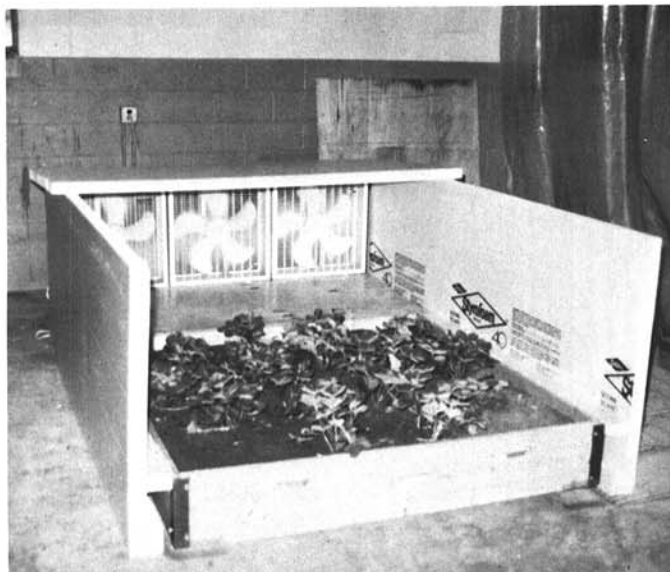

Fig. 1. Simple wind tunnel structure and synthetic strawberry canopy.
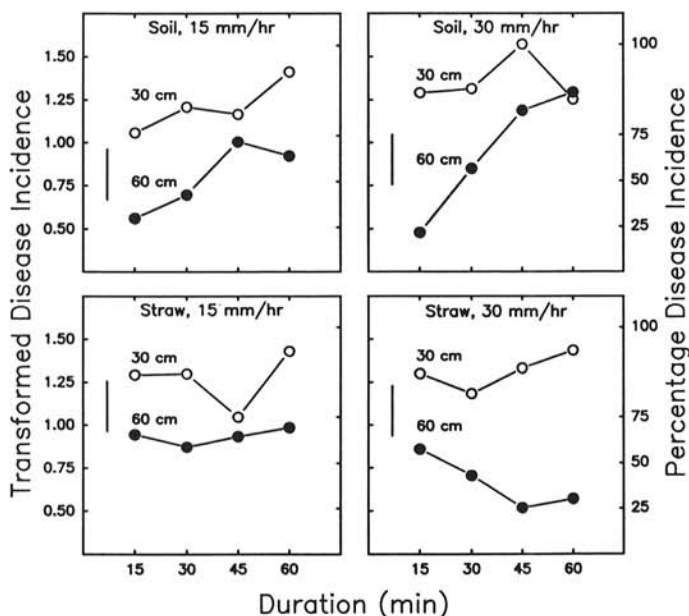

Fig. 2. Variation of mean (transformed) incidence of strawberry anthracnose (caused by *Colletotrichum acutatum*) with rain duration for soil and straw subjected to 15 and 30 mm/hr rain intensities. Open and filled symbols are for 30 (inner circle) and 60 cm (outer circle) distances from the inoculum source, respectively. Vertical line segments represent the value of the Waller-Duncan, Bayesian, least-significant difference ($P \approx 0.05$). Minimum value of the left-hand ordinate is 0.25.

TABLE 1. Linear contrasts for evaluating the effect of ground cover, rain intensity, and distance from inoculum source on the change in (transformed) incidence of strawberry anthracnose (caused by *Colletotrichum acutatum*) over time

Contrast number	Ground cover Intensity Distance	F Statistic	
	Soil		
	15 mm/hr		
1	30 cm[a]	7.92	**[b]
2	60 cm	12.71	***
3	30 × 60 cm[c]	0.28	NS
	30 mm/hr		
4	30 cm	0.76	NS
5	60 cm	48.79	***
6	30 × 60 cm	18.68	***
	15 × 30 mm/hr		
7	30 cm	3.76	NS
8	60 cm	11.69	**
	Straw		
	15 mm/hr		
9	30 cm	0.02	NS
10	60 cm	0.10	NS
11	30 × 60 cm	0.02	NS
	30 mm/hr		
12	30 cm	2.33	NS
13	60 cm	6.48	**
14	30 × 60 cm	8.30	**
	15 × 30 mm/hr		
15	30 cm	1.98	NS
16	60 cm	8.19	**
	Soil × Straw[d]		
	15 mm/hr		
17	30 cm	7.25	*
18	60 cm	10.56	**
	30 mm/hr		
19	30 cm	0.43	NS
20	60 cm	90.85	***

[a] Example: Contrast to determine if there is a significant change in (transformed) disease incidence over rain duration (15–60 min) for the inner circle (30 cm), 15 mm/hr rain intensity, and soil ground cover. All analyses based on arcsine square-root transformation of disease incidence.
[b] Asterisks *, **, and *** indicate the significance of each treatment combination at $P = 0.05$, $P = 0.01$, and $P = 0.001$, respectively. NS = not significant ($P > 0.05$).
[c] Interaction of distance and duration at the specified ground cover and intensity. A significant interaction indicates that the change in (transformed) disease incidence over rain duration is not the same for the two distances from the source.
[d] Interaction of ground cover and duration on (transformed) disease incidence. A significant interaction indicates that the change in (transformed) disease incidence over rain duration for the specified treatment combination (e.g., 15 mm/hr rain intensity and 30 cm distance) is not the same for soil and straw ground cover.

interval for the combined data was $3.2 \times 10^8 - 5.3 \times 10^8$ conidia per fruit.

Effect of ground cover, rain intensity, rain duration, and distance from inoculum source. Disease incidence was generally less in the outer circle (60 cm) compared with the inner one (30 cm) and varied with rain intensity, rain duration, and distance from the inoculum source for soil and straw covers (Fig. 2). With plastic cover, however, 100% incidence was observed for both distances, both rain intensities and all durations. In analysis of variance, the main effects of ground cover, rain duration, and distance from inoculum source were all significant ($P < 0.01$, < 0.05, and < 0.01, respectively), whereas the main effect of rain intensity was not ($P > 0.05$). There were several significant interactions of duration and intensity and the other factors, including the four-way interaction ($P < 0.05$). This indicated that conclusions could not be drawn on the main effects alone.

When rain duration and the interactions of rain duration with the other factors were partitioned into orthogonal polynomials, only the linear contrasts were significant ($P < 0.05$). Therefore, duration of rainfall had a major (positive or negative) impact on disease incidence, depending on the other factors. Results for individual linear contrasts of (transformed) disease incidence over rain duration for selected levels of the other factors are given in Table 1. For instance, there was a significant increase in (transformed) disease incidence over time with a soil cover at both distances for 15 mm/hr rain and at 60 cm for 30 mm/hr rain (Fig. 2 and Table 1 [contrast numbers 1, 2, 5]). Conversely, there was a decrease over time with straw cover for 30 mm/hr rain at 60 cm from the source (Fig. 2 and Table 1 [contrast number 13]). There was no change with the other treatments with rain duration. The observed difference between distances in change in disease incidence over time was confirmed by the significant interaction of distance and duration within each ground cover and rain intensity combination (e.g., soil and straw at 30 mm/hr [contrast numbers 6, 14]). The general increase in disease incidence with soil and stable or declining incidence with straw was confirmed with the interaction of ground cover (soil × straw) and duration at both distances at 15 mm/hr and 60 cm at 30 mm/hr intensity (Table 1 [contrast numbers 17, 18, 20]). Linear contrasts for plastic cover were not calculated because 100% incidence was found for all durations and distances. Pairwise comparison of individual means can be made with the Waller-Duncan BLSD bar in Figure 2.

Effect of source strength and distribution over the sample area. Source fruit number and distribution did not have a significant effect on disease incidence ($P > 0.05$). One infected fruit in the center gave the same results as five or nine (Table 2). In contrast, a significant effect ($P < 0.01$) of distance from the center was found. No significant interaction occurred between distance and

source fruit number/distribution ($P > 0.05$).

Effect of horizontal air flow. The wind tunnel supplied a fairly uniform horizontal air flow over the sample area. Figure 3 shows an air flow pattern near the top of the strawberry canopy. The data shown were averages of three replicates taken in three tests. The air speed along the left edge of the frame was consistently lower than elsewhere, which was believed to be caused by the clockwise rotation of the circulators. Because the left edge was not occupied by fruits, the low air velocity probably did not influence results. The average horizontal air speed over the sample area encompassing the rows was 2.28 m/sec with a standard error of 0.08 m/sec. The maximum difference of air speed measurements between replicates for a single location was 0.58 m/sec.

Horizontal air flow across the canopy had a pronounced effect on rain splash dispersal of *C. acutatum* as evidenced by the significant ($P < 0.01$) row location effect. However, ground cover, rain intensity, and all interactions were not significant ($P > 0.05$). At 60 cm downwind, fruits had higher disease incidence than at 60 cm upwind. As shown in Figure 4, disease incidence at
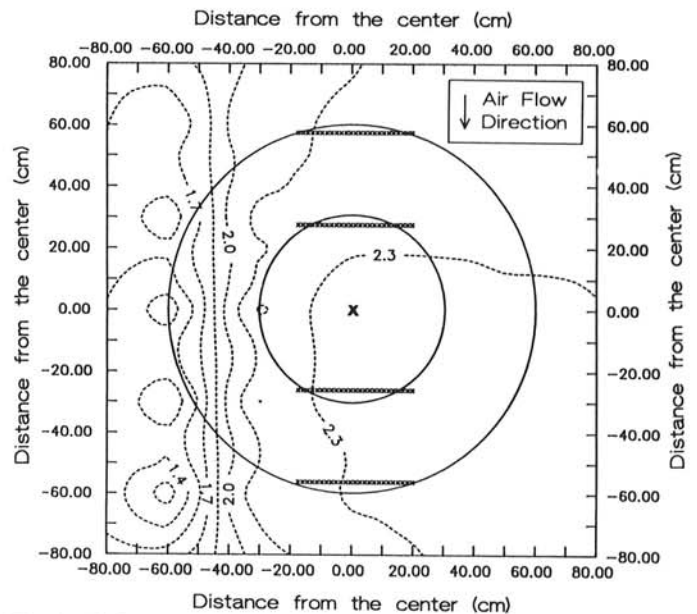

Fig. 3. Air flow pattern (dashed line) over the sampling area in meters per second. Solid circles encompass locations of the strawberry plants and the four parallel lines indicate places of the rows of sample fruits. Source fruits were in the center of the circles (X).
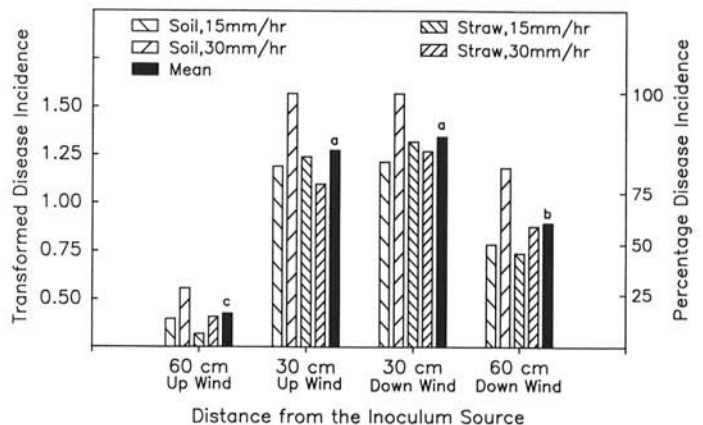
TABLE 2. Average percentage and transformed (arcsine square-root) incidence of strawberry anthracnose (caused by *Colletotrichum acutatum*) for evaluating the effect of source strength and distribution

Source fruit, Distribution	Disease incidence		
	30 cm	60 cm	Mean
Nine, Scattered	42.20	50.00	46.10
	(0.707)[a]	(0.785)	(0.746)
Nine, Clustered	66.80	35.67	51.24
	(0.957)	(0.640)	(0.798)
Five, Scattered	57.83	39.30	48.57
	(0.864)	(0.678)	(0.771)
Five, Clustered	57.40	23.93	40.67
	(0.860)	(0.511)	(0.691)
One	57.97	16.13	37.05
	(0.865)	(0.413)	(0.654)
Mean	56.44	33.01	44.72
	(0.850)[b]	(0.612)[b]	(0.733)

[a] Number in parentheses is arcsine square-root transformed mean.
[b] Mean transformed incidence at 30 cm is significantly different from incidence at 60 cm (analysis of variance, Waller-Duncan Bayesian, least-significant difference = 0.19 in transformed scale, $P \approx 0.05$).

Fig. 4. Mean (transformed) incidence of strawberry anthracnose (caused by *Colletotrichum acutatum*) in response to horizontal air flow. Bars topped by same letter indicate that means are not significantly different according to the Waller-Duncan, Bayesian, least-significant difference ($P \approx 0.05$). Statistical comparisons are limited to the main effect of distance because ground cover, rain intensity, and interactions were not significant ($P > 0.05$). Minimum value of the left-hand ordinate is 0.25.

60 cm upwind was only about a third of that downwind. Disease incidence at 30 cm, however, was not different between upwind and downwind.

DISCUSSION

It was demonstrated in this study that *C. acutatum* is effectively dispersed by rain splash. Effects of ground cover, rain intensity, rain duration, distance from the inoculum source, source strength, and horizontal air flow on rain splash dispersal were quantitatively demonstrated. Because of the small spatial scale of splash dispersal (e.g., most splash dispersed spores travel less than 25 cm [11,15,31]), the 1.2- × 1.2-m sample area encompassed by the simulation system was considered large enough to evaluate a range of experimental factors. Additionally, because rain intensity or rain duration cannot be easily manipulated in the field, we feel that the rain simulator provides an ideal method for studying rain splash dispersal under a range of conditions. Results from the first experiment indicated that rain intensity and duration, ground cover, and distance all interact to influence dispersal as measured by infected fruit. Since the effect of the four-way interaction was significant, it was impossible to conclude any distinct quantitative relation between fruit infection and each experimental factor independent of the others.

Surface characteristics of ground cover played an important role in rain splash dispersal of *C. acutatum*. There were both qualitative and quantitative differences among effects of the covers. With plastic, no decline in disease incidence from the inner to outer circle was observed, and there was a rapid increase over time in incidence to 100% by the first assessment at 15 min. Presumably, few splash-transported spores were trapped or lost from the surface on which fruit were placed. Observed puddles of water also suggested that some inoculum was carried to the fruit in flowing (nonsplashed) water. For soil and straw cover, however, possible loss of spores through the ground cover may have reduced the effective dispersal of the pathogen. With soil and straw, except for a few instances, a significant disease gradient (decline in incidence over distance) was maintained over the 60-min rain duration of the study.

The total number of spores dispersed from the source fruit was assumed to increase over time until all spores were removed. The number actually being splashed at any single time or distance would depend on the number removed from the source, the number trapped or lost in the ground cover, and the number washed off of the target fruit. With disease incidence as the measure of dispersal, an increase in disease incidence over 15–60 min only occurred for soil cover. With plastic, a maximum incidence (100%) was reached by 15 min. With straw mulch, however, no increase in disease incidence was detected. In fact, incidence at 60 cm distance (outer circle) decreased at the higher rain intensity. This was considered to be caused by washing of spores directly through the straw or off of the fruits and into the straw. Wash-off effect has been recognized in other studies (35,36), although the association of wash-off with ground cover has not be adequately investigated. A loose layer of straw mulch allows water to freely drip down into the layer and may significantly reduce the spore number at the impacting surface. Loss of conidia to straw mulch thus could suppress the increase of conidia transported by splash droplets and reduce fruit infection. Although we do not have data on conidia in straw or soil, results of this study provide at least a conceptual significance of such wash-off effects. Our results may explain the nonsignificant effect of straw mulch on the dispersal of *P. cactorum* reported by Reynolds et al (28). In their study, only a single time was considered. With *C. acutatum*, individual differences between soil and straw cover depended heavily on duration since the beginning of the rain. At a single duration, the two ground covers could have similar results.

Fitt et al (12), in a study on the effects of rainfall intensity and duration on splash dispersal of *Rhynchosporium secalis* (Oud.) Davis from infected leaves of barley (*Hordeum vulgare* L.), indicated that the numbers of splash-dispersed conidia increased with increasing rainfall intensity, provided that sufficient

conidia were available for dispersal. However, this could be offset by the rapid depletion of conidia under higher rain intensities over a longer duration. For a 30-min period, the difference between high and low rain intensities in total number of conidia became trivial. In general agreement with Fitt et al (12), we observed little effect of rain intensity (15 or 30 mm/hr) on resultant dispersal of *C. acutatum*. Our use of infected fruits rather than trapped spores may have caused rain intensity to have even less of an apparent effect.

Distribution and number of source fruit over the sample area had little effect on fruit infection. When source fruit were clustered in the center, plants on the inner circle had high probabilities of being infected. With uniformly scattered source fruit, the increase in probability for outer circle fruits to be infected was offset by the decrease for inner circle fruits. We believe the very high inoculum density per fruit was the main reason for the insensitivity of disease incidence to source fruit number and might have also contributed to the insensitivity to source position.

The effect of horizontal air flow on dispersal of *C. acutatum* over the sample area was demonstrated with the relatively simple wind tunnel. Griffiths and Hann (21) reported that splash dispersal patterns were mainly affected by wind near the top of the plant canopy but not near its base. Campbell (7) divided a typical plant canopy into different layers and pointed out that wind speed decreased exponentially at the top layer of the canopy; within the stem space, however, the wind was unrelated to both speed and direction of the air flow above the plant stand. According to Fitt et al (17), mean wind speed is often less than 0.5 m/ sec within crops and less than 2 m/sec just above the canopy, though it can be greater above a open field or in gusts. Thus the wind simulation in this study (about 2 m/sec at the top of the canopy) was considered sufficient to demonstrate the effect of wind on rain splash dispersal. In the present study, horizontal air flow was shown to have a strong effect on dispersal patterns. Whereas there was virtually no difference between infection levels in upwind and downwind direction at 30 cm (inner rows), three times the disease incidence was found downwind compared with upwind at 60 cm from the inoculum source. Although cover and rain intensity did not affect disease incidence in the wind experiment, this was not unexpected because only 15-min durations were considered. In one preliminary experiment, the large difference in disease incidence between upwind and downwind at 60 cm was maintained with 30 min of rain (X. Yang, *unpublished*). Fitt et al (17) reported that the trajectories of spores carrying splash droplets greater than 0.2 mm in diameter were little affected by wind below 3 m/sec. This indicates that the difference in fruit infection in our study at 60 cm distance may be caused by small airborne droplets.

In summary, fruit infection resulting from rain splash dispersal was found to be influenced by a range of factors, only some of which are under the control of a grower. Little can be done about rain intensity, rain duration, or wind, but ground cover and, to a lesser degree, distance from an inoculum source, can be controlled. Both straw and plastic mulch are commonly used in strawberry production (1,19). As shown in this controlled study, the difference in disease level between these two covers was great. Compared with straw, only a few infected fruits on top of plastic can result in a very high fruit disease incidence in the surrounding area. This is an important observation when one considers that plastic mulch is routinely used in the major production areas of Florida and California. The lack of a disease gradient over distance further demonstrates the great dispersal of the pathogen with a plastic ground cover. The nonincreasing incidence of anthracnose over time with straw and the general decline in disease incidence over distance suggests that this ground cover may be preferable to plastic for culturally controlling this disease, especially when an inoculum source is not near. Further studies are planned to determine the effect of ground cover on the dispersal of *C. acutatum* under field conditions.

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SUSTAINING ASSOCIATES