

Anthracnose of Pepper Caused by *Colletotrichum* Spp.*

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Abstract

Anthracnose of pepper incited by *Colletotrichum* spp. causes severe losses in *Capsicum* spp. due to pre- and postharvest fruit decay. Four *Colletotrichum* species (*C. gloeosporioides*, *C. capsici*, *C. acutatum*, and *C. coccodes*) have been identified as causal agents of pepper anthracnose in Louisiana. The major incitants are *C. gloeosporioides* and *C. capsici*. Potential sources of inoculum in cayenne pepper were evaluated in field studies using various combinations of 'clean seed', 'infected seed', 'clean field', and 'infested field' treatments. Throughout the two seasons the clean seed-clean field combination averaged 9% infected pods, whereas the use of infected seed or planting in an infested field resulted in 66% and 62% infected pods, respectively. Detached mature red bell pepper and tomato fruits were inoculated with 22 *Colletotrichum* isolates from pepper and tomato representing *C. gloeosporioides*, *C. capsici*, *C. acutatum*, and *C. coccodes*. The fruits were inoculated with a conidial suspension (25 μ l, 10^6 conidia/ml) and were incubated at 24°C for nine days after which the percentage of fruits showing lesion development was recorded and lesion diameters were measured. All isolates, regardless of their original host, caused characteristic anthracnose symptoms on fruit of both hosts. Field applications of chlorothalonil (Bravo 500 at 3.8 ml/liter) and maneb (Manex 4F at 1.9 ml/liter) were made to cayenne and bell pepper to determine the efficacy of these fungicides for the control of anthracnose. Spray applications were made to the point of runoff at time intervals ranging from one to four weeks. A significant reduction in the incidence of pod infections was obtained with both fungicides applied at one- and two-week intervals. Seventy-six percent of the pods were diseased in the unsprayed check treatments, while only 25% and 37% of the pods were diseased in the weekly sprayed chlorothalonil and maneb treatments, respectively.

Introduction

Anthracnose caused by *Colletotrichum* spp. is an economically important disease of pepper (*Capsicum* spp.). Under conditions favorable for disease development, pre- and postharvest fruit losses of up to 50% have been reported (Higgins. 1930; Smith and Crossan. 1958). This disease is mainly a problem on mature pepper pods; however, symptoms on the foliage and immature pods have been reported by some investigators (Dastur. 1921; Halsted. 1890; Higgins. 1926;

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Smith. 1958). Typically, symptoms first appear on mature pods as small, water-soaked, yellow or dark sunken lesions which rapidly expand. The lesions may enlarge to 3 or 4 cm in diameter and sometimes coalesce, encompassing a large portion of the fruit (Figure 1). Fully expanded lesions are sunken and range from dark red to light tan in color with varying amounts of visible dark stromatic fungal tissue. Generally, numerous setose or glabrous acervuli-bearing pale buff to salmon spore masses occur scattered or in concentric rings on the lesions (Dastur. 1921; Halsted. 1890; Halsted. 1891; Higgins. 1923; Smith. 1958).

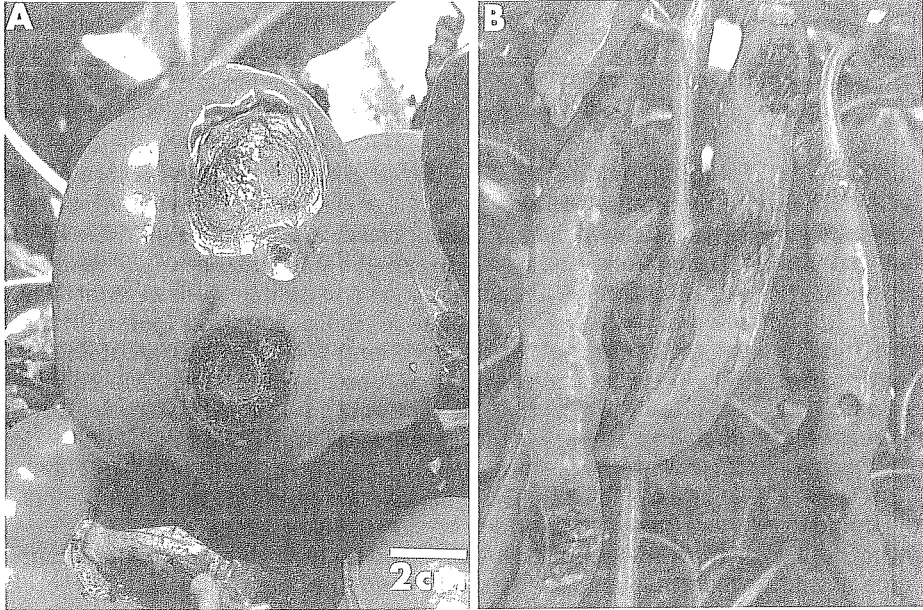


Figure 1. (A) Bell and (B) cayenne pepper (*Capsicum annuum*) showing symptoms of anthracnose caused by *Colletotrichum* spp.

Four species, *C. gloeosporioides* (Penz.) Sacc., *C. capsici* (Syd.) Butl. & Bisby, *C. acutatum* Simmonds, and *C. coccodes* (Wallr.) Hughes, were shown recently in this laboratory to incite anthracnose of pepper (Hadden and Black. 1987). These species also are reported to cause tomato anthracnose (Barksdale. 1972; Mordue. 1967; Miller et al. 1984; Simmonds. 1965). In a survey of pepper-growing areas in south Louisiana, all species except *C. coccodes* were isolated from pepper pods exhibiting symptoms of anthracnose (J.F. Hadden. 1987. unpublished). *Colletotrichum gloeosporioides* and *C. capsici* were the most frequently isolated species in the present study, but *C. acutatum* predominated in some fields. Although *C. coccodes* was not isolated from infected pepper fruit, a previous study in this laboratory showed that isolates from tomato were capable of producing typical anthracnose symptoms on pepper fruit (Hadden and Black. 1987). Other *Colletotrichum* spp. such as *C. piperatum* (Grover and Bansal. 1968; Smith. 1958; Smith and Crossan. 1958), *C. dematium*, *C. graminicola*, *C. nigrum*, and *C. atramentarium* (Halsted. 1891; Verma. 1973) as well as *Gloeosporium*-spp. (Halsted. 1890; Higgins. 1923; Higgins. 1926) have been reported to cause similar symptoms on peppers. Considerable confusion exists in the literature as to the proper naming of these organisms and their possible synonymity (Smith. 1958; Smith and Crossan. 1958; Sutton. 1980) with the species included in the current study.

Colletotrichum piperatum (Grover and Bansal. 1968; Smith. 1958; Smith and Crossan. 1958) and *Gloeosporium piperatum* E. & E. (Higgins. 1926; Higgins. 1930), which now appear to

be synonymous with *C. gloeosporioides*, along with *C. capsici* (Dastur. 1921; Grover and Bansal. 1970; Verma and Krishi. 1974) are reported to be seedborne by way of both infected and infested seed. In a study of seed extracted from cayenne (*Capsicum annuum* L.) pepper pods coinfecting with *C. capsici* and *C. gloeosporioides*, *C. capsici* was found to infect the seed coat and occur as a surface contaminant, while *C. gloeosporioides* occurred only as a surface contaminant (J.F. Hadden. 1984. unpublished).

It is generally believed that seeds and crop debris from infected plants provide inoculum that leads to development of anthracnose on pepper pods. However, little work has been done to establish a link between these sources of inoculum and the fruit rot phase of the disease. In fact, Chowdhury (1957) stated that *C. capsici*-infected seed plays little part in development of riperoth of chillies in India. Several workers (Grover and Bansal. 1968; Grover and Bansal. 1970; Smith. 1958) have shown the importance of seedborne inoculum in pre- and postemergence damping-off of pepper seedlings. Halsted (1896) and Higgins (1926) stated that *G. piperatum*-infested field debris is of little importance in the development of anthracnose, but Smith and Crossan (1958) have shown more recently that *C. piperatum*-infested crop debris is an important source of inoculum.

Losses due to pepper anthracnose in Louisiana are minimized by numerous hand harvests to remove fruit of cayenne and tabasco (*C. frutescens* L.) from the field as soon as it matures, followed by immediate processing of the harvested fruit. These procedures effectively reduce disease losses because the fruit is removed and processed before symptoms have a chance to develop on the pods. With the trend towards mechanical harvesting, anthracnose has the potential of becoming a limiting factor in the production of pepper, because mature pepper pods would have to remain in the field for much longer prior to harvest. Under these circumstances, serious disease losses can be expected unless other control strategies are employed.

Dithiocarbamate fungicides, such as maneb, have been shown to provide some protection (Chowdhury. 1957; Narain and Panigrahi. 1971; Smith. 1958) and are recommended for control of the disease in Louisiana (Whitam et al. 1988). Chlorothalonil, in addition to the dithiocarbamate fungicides, is recommended for control of tomato anthracnose (Whitam et al. 1988), a disease which appears to be caused by the same organisms that cause pepper anthracnose. Although not yet approved for use on peppers, this fungicide is fairly stable over a wide range of environmental conditions (Fry. 1982) and may offer pepper growers an alternative material for management of the disease when and if it is approved for this use.

The objectives of this paper were: (a) to determine the role of inoculum sources in disease development, (b) to evaluate two fungicides at various application intervals for their efficacy in controlling anthracnose, and (c) to examine the pathogenicity and virulence of *Colletotrichum* spp. isolates from pepper and tomato in cross-inoculation studies.

Materials and Methods

Inoculum Source Studies

A study was initiated to determine the importance of seed and crop debris as sources of inoculum which contribute to the development of anthracnose on mature pepper pods. Three treatments consisting of 'clean seed' in a 'clean field' (CS-CF), 'clean seed' in an 'infested field' (CS-IF), and 'infected seed' in a 'clean field' (IS-CF) were employed.

Seed for the 'infected seed' treatment was extracted from pods of cayenne, selection LSU 16, coinfecting with *C. capsici* and *C. gloeosporioides*. Seed of the same selection produced in an arid area without overhead irrigation was used in the 'clean seed' treatments. The 'clean field' treatments were located in fields in which there had been no pepper production for more than 20 years. The 'infested field' treatment was located in an area in which pepper heavily infected with *C. capsici* and *C. gloeosporioides* had been grown the previous year.

Six-week-old pepper transplants were produced in the greenhouse in model 200 'TODD' planter flats (Speedling Inc., Sun City, Florida) using Jiffy Mix-Plus (Jiffy Products of America, West Chicago, Illinois) as the growing medium. The plants from 'infected seed' treatments and the plants from 'clean seed' were maintained on separate greenhouse benches. The plants were transplanted into the field with a 38 cm in-row spacing on rows which were on 1.2 m centers. The rows were raised, shaped beds covered with aluminum-painted plastic film mulch. Treatments were replicated four times. Each replication consisted of two rows 30.5 m in length. Treatments were located in different fields physically separated by a minimum of 150 m. The experiment was repeated once.

The effect of the treatments on disease incidence was evaluated on two harvest dates in 1984 and on three harvest dates in 1985. The percentage of diseased pods was determined by counting a 50-pod subsample of the total harvest of each replication. At least 15 lesions from each subsample were examined microscopically to determine the species of *Colletotrichum* involved.

Fungicide Studies

A fungicidal spray study was conducted to evaluate two fungicides and the frequency of their application for anthracnose control in bell pepper (Bell Boy) and cayenne pepper (selection LSU 16). Two fungicides, maneb (Manex) and chlorothalonil (Bravo 500), were applied at 1.9 ml/liter and 3.8 ml/liter, respectively. Fungicides were applied at a pressure of 7 kg/cm² (100 psi) to the point of runoff with a tractor-drawn drop-boom spray system using three to five TX26 hollow cone nozzles (Spraying Systems Co., Wheaton, Illinois). Applications of fungicides at one to four-week intervals began on June 26 when a majority of the plants were at the first bloom stage, and continued throughout the season, ending on November 2. A treatment which received no spray application was maintained as a control for each fungicide studied.

Peppers were direct-seeded by the plug-mix method (Hayslip, 1974) with a 38 cm spacing between plants on raised rows on 1.2 m centers covered with aluminum-painted plastic film mulch. Unplanted alleys of 1.2 m were maintained between treatment replications. Each replication was 6.9 m long and consisted of approximately 18 plants. The experiment was arranged in a randomized complete block design with four blocks and five treatments per fungicide. The research plot was planted in a field in which a pepper crop severely affected by anthracnose had been grown the previous year.

Disease incidence was determined by counting the number of diseased pods in a 50-pod subsample from the total harvest of each replication. Bell peppers were hand harvested five times and cayenne peppers eight times. A pod was considered diseased if a single lesion was found. Diseased and symptomless pods in the 50-pod subsample were weighed to determine the percentage of the yield that was marketable in each replication. Only pods free of lesions were considered marketable.

Cross Inoculation Studies

Conidia of 22 isolates including representatives of *C. capsici*, *C. gloeosporioides*, *C. acutatum*, and *C. coccodes* that had been obtained from pepper or tomato were inoculated into both tomato and bell pepper fruit. Yolo Wonder pepper and Heinz 1350 tomato fruit were detached at the ripe red stage and inoculated to determine the pathogenicity and virulence of each isolate on both hosts.

The inoculation techniques were adapted from those used by others (Barksdale, 1970; Barksdale and Koch, 1969; Robbins and Angell, 1968; Robbins and Angell, 1970) in tomato anthracnose resistance studies. All cultures were single-spored and stored on silica gel (Perkins, 1962) immediately after isolation. Prior to each study, fresh cultures of each isolate were recovered from silica gel and grown on Difco potato dextrose agar (39 g/l) under continuous fluorescent light at room temperature (approx. 24°C). Seven-day-old cultures were washed with distilled

water to make a conidial suspension which was filtered through two layers of cheesecloth to remove mycelial and agar fragments. Spore suspensions were diluted and adjusted to approximately 10^6 conidia/ml using a hemacytometer. Three pepper and three tomato fruits were inoculated in three sites with each isolate by injecting 25 l of conidial suspension using a 1 ml syringe fitted with a 22 gauge hypodermic needle. The fruits were incubated for nine days at room temperature on a laboratory table, during which time they were examined for lesion development and lesion diameters were measured.

Results

Influence of Inoculum Source

Infected seed and crop debris were studied in 1984 and 1985 for their role as sources of inoculum for the development of pepper anthracnose. The three treatments compared for their influence on disease development were CS-CF, CS-IF, and IS-CF. Anthracnose developed in all three treatments, but occurred at a much lower incidence on pods in the CS-CF treatment (Table 1). The incidence of diseased pods ranged from 3 to 6% in the September and October harvests of both years. Pod infections examined in this treatment during both years were due to *C. gloeosporioides* with the exception of a single pod found to be infected with *C. capsici* (Table 2).

Table 1. Influence of inoculum source on the incidence of anthracnose in cayenne pepper, selection LSU 16.

Treatment ^y	Percent diseased pods ^z				
	9/27/84	10/5/84	9/11/85	10/2/85	11/1/85
Clean seed/Clean field	3 a ^x	4 a	6 a	5 a	27 a
Infected seed/Clean field	52 b	36 b	70 b	81 b	92 b
Clean seed/Infested field	64 b	46 c	44 ab	65 b	93 b

^zMean percentage of diseased pods was determined from a 50-pod subsample from each of the four replications at each harvest. ^yClean seed = western grown disease-free seed; infected seed = seed from pods infected with *C. capsici* and *C. gloeosporioides*; clean field = field with no past history of pepper production; infested field = field in which the previous year's pepper crop was infected with *C. capsici* and *C. gloeosporioides*. ^xMean separation within columns on harvest dates by Duncan's new multiple range test ($P = 0.05$).

Table 2. Influence of inoculum source on the prevalence of *C. capsici* and *C. gloeosporioides* causing anthracnose in cayenne pepper, selection LSU 16.

Treatment ^y	Percentage of anthracnose lesions caused by <i>C. capsici</i> (Cc) and <i>C. gloeosporioides</i> (Cg) ^z									
	9/27/84		10/5/84		9/11/85		10/2/85		11/1/85	
	Cc	Cg	Cc	Cg	Cc	Cg	Cc	Cg	Cc	Cg
Clean seed/Clean field	5 a ^x	95 a	0 a	100 a	0 a	100 a	0 a	100 a	0 a	100 a
Infected seed/Clean field	41 b	59 b	60 b	40 b	77 b	23 b	100 b	0 b	97 b	3 b
Clean seed/Infested field	53 b	47 b	53 b	47 b	97 b	3 b	97 b	3 b	95 b	5 b

^zMean percentage of each pathogen was determined from 15 lesions on pepper in the 50 pod subsample from each of the four replications at each harvest. ^yClean seed = western grown disease-free seed; infected seed = cayenne seed from pods infected with *C. capsici* and *C. gloeosporioides*; clean field = field with no past history of pepper production; infested field = field in which the previous year's pepper crop was infected with *C. capsici* and *C. gloeosporioides*. ^xMean separation within columns on harvest dates by Duncan's new multiple range test ($P = 0.05$).

Incidence of infected pods in the CS-IF and IS-CF treatments ranged from 36 to 81% in September and October of 1984 and 1985. Numbers of lesions on the pods caused by *C. capsici* and *C. gloeosporioides* were about equal during 1984, but in 1985 they were caused predominantly by *C. capsici* even though both species were present in the fields throughout the harvest season (Table 2).

Fungicide Studies

Chlorothalonil or maneb applied at one- and two-week intervals significantly reduced the incidence of anthracnose in both bell and cayenne peppers when compared with the unsprayed control (Tables 3 and 4). Application of either chemical at three or four-week intervals had little effect on the incidence of anthracnose when compared with the control (Tables 3 and 4).

Cayenne pepper plants receiving applications of chlorothalonil and of maneb at one- and two-week intervals produced yields of 15.1, 11.4, 11.4, and 8.9 kg of marketable fruit per replication, respectively, while untreated plants produced only 4.0 kg per replication (Figure 2). Differences in yield of marketable fruit between treated and untreated plots were noted as early as the second harvest date. Cayenne peppers receiving these four treatments produced significantly higher yields of marketable fruit than the control, while yields of peppers receiving applications of chlorothalonil and maneb at three and four-week intervals were not significantly different from the control.

Accumulated marketable fruit yields of bell pepper followed a trend similar to that of cayenne pepper. Bell pepper plants receiving applications of chlorothalonil at one and two-week intervals produced the highest yields followed by those plants receiving one and two-week interval applications of maneb. Statistical differences in yield of accumulated marketable fruit of bell pepper were observed only on the September 11 harvest date. On this date treatments receiving applications of chlorothalonil at one and two-week intervals had produced significantly more marketable fruit when compared with the unsprayed control. Although statistical differences

Table 3. Effect of fungicides applied at various intervals on the control of anthracnose in cayenne pepper, selection LSU 16, during 1984.

Interval/fungicide	Percent diseased pods ²							
	8/23	9/7	9/11	9/19	9/26	10/2	10/17	11/9
1 week								
Chlorothalonil	18 a ^y	21 a	24 a	16 a	5 a	11 a	42 a	60 a
Maneb	25 a	44 b	46 b	18 a	10 a	11 a	61 b	86 b
2 week								
Chlorothalonil	22 a	30 ab	29 a	11 a	10 a	16 a	63 b	94 cd
Maneb	46 a	72 c	61 b	25 a	18 ab	17 a	79 b	95 cd
3 week								
Chlorothalonil	92 b	96 d	83 c	55 b	34 bc	39 bc	87 c	97 cd
Maneb	79 b	98 d	91 c	58 b	33 bc	40 bcd	91 c	94 cd
4 week								
Chlorothalonil	83 b	86 cd	86 c	53 b	32 bc	37 b	85 c	97 cd
Maneb	92 b	94 d	88 c	54 b	40 cd	61 d	89 c	96 cd
No spray								
Chlorothalonil - Control	85 b	92 d	79 c	54 b	43 cd	47 bcd	89 c	91 bc
Maneb - Control	82 b	94 d	89 c	62 b	55 d	59 cd	95 c	100 d

²Mean percentage of diseased pods was determined from a 50-pod subsample from each of the four replications at each harvest. ^yMean separation within columns on harvest dates by Duncan's new multiple range test ($P = 0.05$).

Table 4. Effect of fungicides applied at various intervals on the control of anthracnose in bell pepper, Bell Boy, during 1984.

Interval/fungicide	Percent diseased pods ^z					
	8/9	8/23	9/7	9/11	9/19	9/26
1 week						
Chlorothalonil	14 a ^y	35 a	28 a	41 ab	19 a	0 a
Maneb	9 a	25 a	72 b	41 ab	13 a	3 a
2 week						
Chlorothalonil	20 a	21 a	68 b	31 a	26 ab	0 a
Maneb	20 a	50 ab	86 b	74 bc	32 abc	29 a
3 week						
Chlorothalonil	27 a	93 c	97 b	67 bc	52 bcd	21 a
Maneb	15 a	75 bc	76 b	65 bc	66 d	26 a
4 week						
Chlorothalonil	41 a	89 c	98 b	83 c	64 cd	19 a
Maneb	32 a	86 c	96 b	70 bc	73 d	44 a
No spray						
Chlorothalonil – Control	30 a	87 c	100 b	82 c	71 d	0 a
Maneb – Control	23 a	81 c	99 b	85 c	77 d	34 a

^zMean percentage of diseased pods determined from a 50-pod subsample from the four replications at each harvest. ^yMean separation within columns on harvest dates by Duncan's new multiple range test ($P = 0.05$).

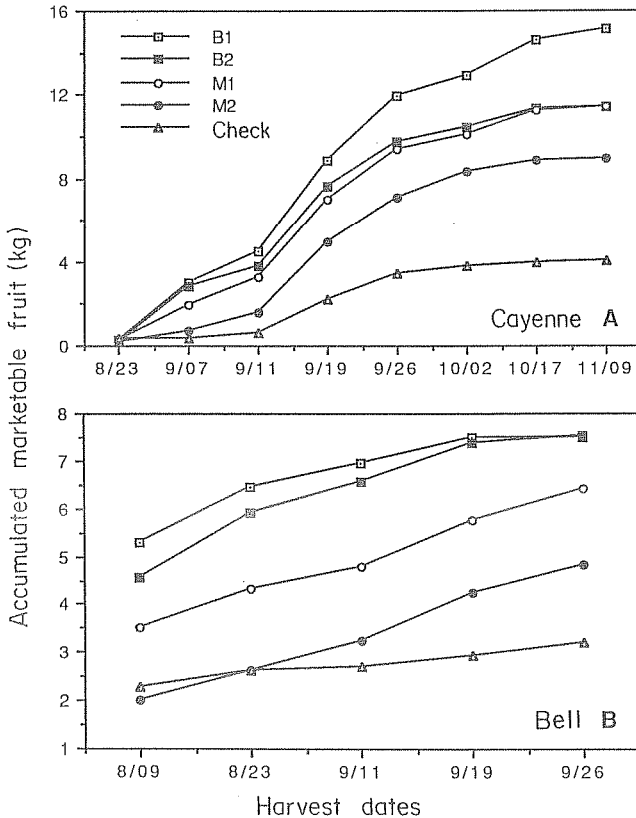


Figure 2.

Accumulated marketable fruit weight of (A) cayenne and (B) bell peppers as influenced by weekly and biweekly applications of chlorothalonil (Bravo 500 at 3.8 ml/liter; B1 = chlorothalonil weekly, B2 = chlorothalonil biweekly) and maneb (Manex 4F at 1.9 ml/liter; M1 = maneb weekly, M2 = maneb biweekly; Check = no application).

between treatments were not observed at the latter harvest dates, bell peppers treated with chlorothalonil at one and two-week intervals continued to produce the highest yields of marketable fruit.

Cross Inoculation Studies

Isolates of the four *Colletotrichum* spp., regardless of host origin, produced lesions on both pepper and tomato fruit (Table 5). Mean lesion diameters ranged from 9.4 to 19.3 mm on bell pepper fruit and from 17.8 to 43.4 mm on tomato fruit. Lesions incited by any given isolate were larger on tomato than those by the same isolate on pepper.

Mean lesion diameters incited by the four *C. gloeosporioides* isolates ranged from 9.4 to 15.0 mm on pepper and 22.5 to 36.7 mm on tomato. There was no statistical difference in virulence, based on lesion size, among the isolates tested on either host.

Virulence among isolates within each of the other three species – *C. acutatum*, *C. capsici*, and *C. coccodes* – varied significantly when compared on pepper fruit and also when compared on tomato fruit (Table 5). However, the level of virulence of each isolate was not always the

Table 5. Mean lesion diameters caused by isolates of *Colletotrichum* spp. on ripe bell pepper and tomato fruit.

Species/Isolates	Isolate origin	Original host	Mean lesion diameter ^z (mm)	
			Pepper ^y	Tomato ^x
<i>C. gloeosporioides</i>				
C-15	Avery Island, LA	Pepper	15.0 a ^w	22.5 a
C-5	Baton Rouge, LA	Pepper	12.4 a	29.0 a
C-3	Baton Rouge, LA	Pepper	11.7 a	36.7 a
CFTS	Avery Island, LA	Pepper	9.4 a	31.0 a
Check Distilled water	–	–	0.0 b	0.0 b
<i>C. acutatum</i>				
C-4	Pointe Coupee, LA	Pepper	17.3 a	39.1 a
TB-101	Bridgeton, NJ	Tomato	13.7 ab	34.8 a
C-8	Grundy County, TN	Pepper	12.1 ab	30.2 b
TB-128	Montrose, VA	Tomato	11.3 b	35.4 a
Check Distilled water	–	–	0.0 c	0.0 c
<i>C. capsici</i>				
FCLS	Baton Rouge, LA	Pepper	19.3 a	33.5 ab
C-19	Baton Rouge, LA	Pepper	17.7 ab	33.2 ab
C-11	Baton Rouge, LA	Pepper	16.2 ab	40.3 a
C-2	Baton Rouge, LA	Pepper	16.0 ab	34.0 ab
C-1	Baton Rouge, LA	Pepper	14.1 abc	24.8 bc
TB-132	Montrose, VA	Tomato	14.0 bc	40.3 a
TB-59	Charleston, SC	Tomato	10.9 c	37.7 ab
C-6	Baton Rouge, LA	Pepper	10.0 c	17.8 c
Check Distilled water	–	–	0.0 d	0.0 d
<i>C. coccodes</i>				
TB-4	Beltsville, MD	Tomato	17.3 a	43.4 a
TB-145	Rock Springs, PA	Tomato	11.3 b	37.7 ab
TB-126	Bridgeton, NJ	Tomato	10.0 b	25.8 c
TB-9	Beltsville, MD	Tomato	9.9 b	30.9 bc
Check Distilled water	–	–	0.0 c	0.0 d

^zFruit inoculated by injection with a 10⁶ conidia/ml suspension; lesion diameter measured after 9 days. ^yYolo Wonder. ^xHeinz 1350. ^wMean separation within columns for isolates of each *Colletotrichum* sp. and host combination by Duncan's new multiple range test ($P = 0.05$).

same on pepper and tomato fruit. Mean lesion diameter of *C. acutatum* – incited lesions ranged from 11.3 to 17.3 mm on pepper and 30.2 to 39.1 mm on tomato fruit. Mean lesion diameter of *C. capsici* – incited lesions ranged from 10.0 to 19.3 mm on pepper and 17.8 to 40.3 mm on tomato fruit. Mean lesion diameter of *C. coccodes* – incited lesions ranged from 9.9 to 17.3 mm on pepper, and 25.8 to 43.4 mm on tomato fruit.

Discussion

One of the objectives of the current study was to examine various sources of inoculum for their impact on anthracnose development in pepper fields. During both years of the study, low levels of anthracnose occurred in fields with no known source of inoculum i.e., the CS-CF treatment. Pod infections in these fields ranged from 3 to 6% during the earlier harvests and rose to a high of 27% in one late season harvest during 1985. The incidence of pods with anthracnose symptoms that were grown in the fields with infested crop debris (CS-IF) and those grown from infected seed (IS-CF) ranged from 36 to 96% at various harvests throughout the season. The occurrence of anthracnose in the fields in which an effort was made to eliminate the inoculum sources (CS-CF) suggests that there is a local source of the pathogen. However, the possibility of a low level of undetected seed infection and/or movement from other pepper fields, although they were separated by 150 m or more, cannot be ruled out. *Colletotrichum gloeosporioides* was the primary pathogen associated with pod lesions in this treatment. Based on the wide host range and the ubiquitous nature of *C. gloeosporioides* (Mordue, 1971; Sutton, 1980), it seems likely that this pathogen is endemic to the area and that the inoculum came from some local weed host.

The high incidence of anthracnose-infected pods from the infested field (CS-IF) and infected seed (IS-CF) treatments implicates crop debris and seed as important sources of anthracnose inoculum. Both *C. gloeosporioides* and *C. capsici* were present in crop debris plowed under to establish the CS-IF treatment and in the infected seed used to plant the IS-CF treatment. Although the percentages of lesions caused by each of the species were not the same each year, both *C. gloeosporioides* and *C. capsici* were incitants of pod infections in the experimental fields. These results suggest that both *C. gloeosporioides* and *C. capsici* can be carried from season to season by crop debris and seed and that any disease management scheme must take these factors into account.

The residence of the pepper anthracnose fungi from the seedling stage until pods are produced remains a question. Vegetative infections of cotyledons, leaves, and stems have been reported (Dastur, 1921; Higgins, 1930) and logically could serve as a link between primary inoculum on infected seed or crop debris to provide secondary inoculum for fruit infection. In the current study, vegetative symptoms of the disease were observed only once, occurring on leaves late in the 1984 season (J.F. Hadden, 1984, unpublished). A few scattered leaf lesions incited by *C. capsici* and *C. gloeosporioides* occurred long after pod symptoms had appeared. The lesions were small (1-3 mm) circular spots with dark borders and light centers. Damage to the leaves was insignificant, and due to their sporadic and late season occurrence it is difficult to visualize a role for these lesions in perpetuating the disease cycle.

Both chlorothalonil and maneb were effective against anthracnose, but the time interval between applications greatly affected their efficacy. Application intervals of 21 days or more with chlorothalonil or maneb were ineffective in controlling the disease. Requirements for fruit to be accepted as marketable in the current study were fairly stringent (one lesion = unmarketable) which might have resulted in lower marketable yields than might be expected in normal production conditions. Applications of chlorothalonil or maneb at 7- or 14-day intervals reduced anthracnose severity and increased the yield of marketable fruit in bell and cayenne pepper (Tables 3 and 4 and Figure 2). The most effective treatment was weekly applications of chlorothalonil, and biweekly applications of this material provided protection equal to or better than weekly applications of maneb. The results with maneb agree with previous studies in which seven- or

14-day application intervals were effective in controlling anthracnose (Narain and Panigrahi. 1971; Smith. 1958; Smith and Crossan. 1958). Chlorothalonil is relatively persistent under a variety of environmental conditions (Fry. 1982). This characteristic may explain its increased effectiveness over maneb and allow a reduced number of sprays while maintaining an acceptable level of disease control. Even though chlorothalonil is labelled on many other vegetable crops, it is not labeled for use on peppers in the United States at this time. Presently, efforts are being made to obtain a registration for use of chlorothalonil on pepper. Registration of chlorothalonil on pepper crops would give the pepper grower a valuable alternative in the choice of fungicides to control anthracnose.

One purpose of the present study was to determine if host specificity occurred among isolates of these four *Colletotrichum* species obtained from pepper and tomato. Virulence among isolates within each fungal species to pepper and tomato was determined by comparing mean lesion diameters on each host, independently (Table 5). All isolates tested caused larger lesions on tomato than on pepper fruit, but this was interpreted to be due to the different fruit types rather than a difference in host preference by the fungal isolates. Some isolates within species varied significantly in their virulence to pepper or tomato, and the level of virulence for any given isolate was not necessarily parallel on both hosts. Nevertheless, all isolates, regardless of their original host, were pathogenic to both pepper and tomato fruit in cross-inoculation tests, thus showing no evidence for host specific isolates.

The appearance of *C. gloeosporioides* – infected peppers in the CS-CF treatment suggested that other hosts in the area, such as weeds or other crop plants, may serve as an inoculum source. It is not likely, therefore, that pepper anthracnose can be eliminated from Louisiana pepper fields by crop rotation and the use of disease-free seed, but the initial disease incidence can be greatly reduced by implementing these practices. Through crop rotation and use of disease-free seed perhaps the inoculum level can be kept sufficiently low to allow for more successful chemical control.

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Symposium Discussion

- I.D. Erinle:** As a way of further reducing the number of sprays, have you used benomyl?
- J.F. Hadden:** No. We only evaluated maneb and chlorothalonil. In other *Colletotrichum*-incited diseases such as anthracnose crownrot of strawberry benomyl-resistant strains have occurred. For this reason, we chose not to include benomyl in this test.