Differential Reactions on Mature Green and Ripe Chili Fruit Infected by Three *Colletotrichum* spp.

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ABSTRACT

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Differential reactions on mature green and ripe chili fruit of 10 genotypes from four cultivated *Capsicum* spp. (i.e., *Capsicum annuum*, *C. baccatum*, *C. chinense*, and *C. frutescens*) were investigated after being inoculated with 33 isolates of *Colletotrichum capsici*, *C. gloeosporioides*, and *C. acutatum* originating from Thailand. The inoculation was performed using an injection method. Differential reactions, based on qualitative host reactions (i.e., lesion development versus no infection) grouped the *Colletotrichum* isolates into different pathotypes. *C. capsici* was grouped into three pathotypes based on differential reactions on ripe fruit stage of two *Capsicum chinense* genotypes (PBC932 and C04714) and two pathotypes based on differential reactions on mature green fruit stage of C04714. *Colletotrichum gloeosporioides* was grouped into five and six pathotypes on their reactions in ripe and green fruit maturity stages, respectively. C04714 and two *Capsicum annuum* genotypes (Jinda and Bangchang) acted as differential hosts with ripe fruit, whereas C04714 with all *C. annuum* and *C. frutescens* genotypes acted as differential hosts with green fruit. No pathotype of *Colletotrichum acutatum* was identified on ripe fruit but three pathotypes were identified on green fruit based on differential reactions in two *Capsicum baccatum* genotypes (PBC80 and PBC81).

Anthrachnose is a major disease causing fruit rot in chili (*Capsicum* spp.). The disease causes significant yield losses in the tropics and subtropics worldwide. Estimated values of annual production losses of US\$100 million and 1.33 million were reported in Korea (7) and India (10), respectively. Anthrachnose of *Capsicum* spp. is caused by a complex of *Colletotrichum* spp., with three main species (*Colletotrichum capsici*, *C. gloeosporioides*, and *C. acutatum*) having been reported as key pathogens, particularly in Asia (5,8,10–12).

Pathotypes of *C. capsici* identified based on qualitative differential host reactions (i.e., the ability or inability to cause disease in specific host genotypes) were first reported by Montri et al. (5). Eleven *C. capsici* isolates were grouped into three

pathotypes based on differential reactions on ripe fruit of nine chili genotypes. Also, a disease severity scale, with scores from 0 to 9, was established based on percent lesion size relative to overall fruit size, with 0 representing no lesion development and 9 when the lesion covered >25% of the fruit surface. The disease scale developed by Montri et al. (5) provided an efficient and accurate measurement of disease severity, which has been well applied to breeding programs to assess anthrachnose resistance (3,4). Assessment of resistance to anthrachnose significantly corresponded with differential host reactions in the pathotype study. According to the inheritance studies conducted by Pakdeevaporn et al. (6) and Mahasuk et al. (3), the resistant phenotype had a disease score of 0 while the susceptible phenotype had disease scores ranging from 1 to 9. More interestingly, Mahasuk et al. (3,4) suggested that two different genes controlled resistance at different fruit maturity stages (i.e., “mature green” and “ripe”).

The indication of distinct genes responsible for resistance at different fruit maturity stages will have an impact on pathotype identification when inoculating chili genotypes at different fruit stages. Therefore, the aim of this study was to investigate

differential reactions in mature green and ripe fruit of 10 chili genotypes, inoculated with the three important *Colletotrichum* spp. causing anthrachnose of chili (i.e., *C. capsici*, *C. gloeosporioides*, and *C. acutatum*).

MATERIALS AND METHODS

***Colletotrichum* spp. collection and taxonomy verification.** Thirty-three isolates of *Colletotrichum* were recovered from chili fruit infected with anthrachnose in Thailand. All isolates were identified by morphological characteristics such as spore shape and size, and growth rate of cultures on potato dextrose agar (PDA; 9). Twelve isolates were identified as *C. capsici* (5) without further characterization. In all, 11 isolates were identified as *C. gloeosporioides* and 10 as *C. acutatum*, with their identities verified using species-specific primers for *C. gloeosporioides* and *C. acutatum* as described by Kim et al. (2). Isolate names and their origins are listed in Table 1. Isolations and establishment of single-spore cultures were carried out according to the procedures of Photita et al. (9) and Than et al. (11).

***Colletotrichum* cultures and inoculum preparation.** *Colletotrichum* cultures derived from single conidia were grown on PDA (Difco, Becton, Dickinson and Company, Sparks, MD). Conidial suspensions of each *Colletotrichum* isolate were prepared to a concentration of approximately 10^6 conidia/ml following the protocol of Montri et al. (5).

Chili genotypes. Ten chili genotypes of *Capsicum annuum* L., *C. baccatum* L., *C. chinense* Jacq., and *C. frutescens* L. (Table 2) were inoculated with the 33 *Colletotrichum* isolates.

Pathogenicity study. Fruit were harvested at the mature green stage (35 to 45 days after flowering, depending on genotype) and ripe stage (40 to 50 days). Five detached mature green fruit and five ripe fruit of each chili genotype were inoculated with each *Colletotrichum* isolate using an injection method (1,5). Each fruit was injected once in the center of the fruit. Each injection contained approximately 1,000 spores.

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Anthrachnose symptoms at the inoculation site were evaluated at 9 days after inoculation (DAI) based on percent lesion size (lesion size as a proportion to fruit size; 5). Mean percent lesion size was then converted to 0-to-9 disease severity scores, where 0 = no lesion, 1 = lesion size covering 1 to 2% of fruit surface, 3 = >2 to 5% lesion size, 5 = >5 to 15% lesion size, 7 = >15 to 25% lesion size, and 9 = lesions >25% (5). All experiments were repeated and gave similar results.

Pathotypes were identified where qualitative differences in lesion development (0 versus 1-to-9 scores) occurred for isolates on a specific chili genotype at the same fruit maturity stage. Pathotype designations for each *Colletotrichum* spp. are as follows: PCc for *Colletotrichum capsici*, PCg for *C. gloeosporioides*, and PCa for *C. acutatum*. Suffixes -R and -G designate pathotypes identified based on reactions of ripe and mature green fruit, respectively.

RESULTS

Differential reactions of chili genotypes to *C. capsici* infection. Ripe fruit stage. Fruit of 10 *Capsicum* genotypes at ripe stage exhibited a range of host reactions following inoculation with the 12 *C. capsici* isolates. None of the three *Capsi-*

cum baccatum genotypes developed measurable lesions, whereas all *C. frutescens* and *C. annuum* genotypes were susceptible to all *Colletotrichum capsici* isolates, receiving disease scores ranging from 5 to 9 (Table 3). *Capsicum frutescens* cvs. Kheenoo Suan and Karen and *C. annuum* line 83-168 were the most susceptible genotypes, with average scores of 9. *C. chinense* genotypes C04714 and PBC932 developed lesions following inoculation with some isolates but not others. Three pathotypes were identified (Table 3) based on the three differential reactions expressed by C04714 and PBC932 as follows: PCc1-R, six *C. capsici* isolates that incited lesions in both C04714 and PBC932; PCc2-R, four isolates that incited lesions only on C04714; and PCc3-R, two isolates that did not incite lesions on either C04714 or PBC932.

Mature green fruit stage. Host reactions of mature green fruit were different from those of the ripe fruit with the same *Colletotrichum capsici* isolates. Green fruit of four chili genotypes, including the three *Capsicum baccatum* lines and *C. chinense* line PBC932, were resistant to all 12 *Colletotrichum capsici* isolates (Table 4). All *Capsicum annuum* and *C. frutescens* genotypes at the green fruit stage were susceptible to all the *Colletotrichum capsici* isolates with disease scores from 3 to 9. Similar to the ripe fruit stage, mature green fruit of *Capsicum annuum* line 83-168 and *C. frutescens* cvs. Kheenoo Suan and Karen were very susceptible to *Colletotrichum capsici*, with average scores of 9. Reactions of Bangchang, Jinda, and C04714 were more variable, with average scores of 8, 6, and 5, respectively. Only C04714 gave differential reactions because isolates F7-3A and SKP16 did not incite lesions in this genotype and were classified as PCc2-G (Table 4). The remainder of the *C. capsici* isolates were classified as PCc1-G.

Differential reactions of chili genotypes to *C. gloeosporioides* infection. Ripe fruit stage. All 11 *C. gloeosporioides* isolates failed to incite lesions in ripe fruit of the three *Capsicum baccatum* lines and the *C. chinense* line PBC932. Among the

C. annuum genotypes, 83-168 was the most severely affected by *Colletotrichum gloeosporioides* isolates, with an average score of 9 (Table 5). Both *Capsicum frutescens* cvs. Kheenoo Suan and Karen were also severely affected, with average scores of 9. *C. chinense* line C04714 and *C. annuum* cvs. Bangchang and Jinda reacted differentially to the *Colletotrichum gloeosporioides* isolates. Considering only the differential reactions of C04714, Bangchang, and Jinda, five pathotypes were identified (Table 5). PCg1-R group contained five isolates that incited lesions in C04714, Bangchang, and Jinda. PCg2-R contained two isolates, F7-4A and F7-1B, that caused lesions in C04714 and Bangchang. PCg3-R, PCg4-R, and PCg5-R differentiated by reactions of chili genotypes C04714, Jinda, and Bangchang.

Mature green fruit stage. Reactions of mature green fruit were more varied than those on ripe fruit of the same genotypes when inoculated with the same 11 *C. gloeosporioides* isolates. Specific chili genotypes that were not infected at mature green fruit stage by *C. gloeosporioides* were the same as those not infected at the ripe fruit stage (Table 6). However, the infected chili genotypes at the mature green stage showed higher variations in infection, and six pathotypes were identified (Table 6). The three most susceptible chili genotypes, Kheenoo Suan, Karen, and 83-168, were also severely infected by most *C. gloeosporioides* isolates; however, with slightly lower mean score of 7. The other three chili genotypes, C04714, Bangchang, and Jinda, were only slightly infected by *C. gloeosporioides*, with average scores of 1.

Differential reactions of chili genotypes to *C. acutatum* infection. Ripe fruit stage. *C. acutatum* isolates were the most aggressive among the three *Colletotrichum* spp., inciting lesion development in all genotypes of *Capsicum annuum*, *C. frutescens*, and *C. chinense* as well as line PBC1422 of *C. baccatum* (Table 7). *C. baccatum* lines PBC80 and PBC81 were highly resistant to all *Colletotrichum acutatum* isolates tested. PBC1422 expressed intermediate levels of resistance to all *C.*

Table 1. Single-spore isolates ($n = 33$) of *Colletotrichum capsici*, *C. gloeosporioides*, and *C. acutatum* and their origins in Thailand

<i>Colletotrichum</i> spp.	Origin
<i>C. capsici</i>	
F4-2C	Kanchana Buri
F4-5A	Kanchana Buri
F7-3A	Nakhon Pathom
F8-1A	Suphan Buri
F8-2A	Suphan Buri
F8-3A	Suphan Buri
F8-3B	Suphan Buri
F8-4C	Suphan Buri
F8-5A	Suphan Buri
F8-5B	Suphan Buri
SKP16	Chiang Mai
158ci	Unknown
<i>C. gloeosporioides</i>	
F1-3A	Ratchaburi
F1-3C	Ratchaburi
F4-1B	Kanchana Buri
F4-1C	Kanchana Buri
F5-1A	Kanchana Buri
F5-2D	Kanchana Buri
F5-4A	Kanchana Buri
F7-1B	Nakhon Pathom
F7-3B	Nakhon Pathom
F7-4A	Nakhon Pathom
DOA	Nakhon Si Thammarat
<i>C. acutatum</i>	
211	Chiang Mai
311	Chiang Mai
313	Chiang Mai
314	Chiang Mai
316	Chiang Mai
322	Chiang Mai
MJ3	Chiang Mai
MJ5	Chiang Mai
MJ7	Chiang Mai
MJ8	Chiang Mai

Table 2. Ten chili genotypes of four *Capsicum* spp. assessed for differential reactions to *Colletotrichum* spp.

No.	<i>Capsicum</i> sp.	Genotype	Code for this study	Origin and description ^a
1	<i>Capsicum annuum</i>	Bangchang	BC	Thai elite cultivar
2		Jinda	JD	Thai elite cultivar
3		83-168	83	AVRDC line
4	<i>C. baccatum</i>	PBC80	80	AVRDC anthracnose-resistant line
5		PBC81	81	AVRDC anthracnose-resistant line
6		PBC1422	1422	AVRDC line
7	<i>C. chinense</i>	PBC932	932	AVRDC anthracnose-resistant line
8		C04714	4714	AVRDC line
9	<i>C. frutescens</i>	Kheenoo Suan	KN	Thai elite cultivar
10		Karen	KR	Thai local variety

^a AVRDC = The World Vegetable Center, Shanhua, Tainan, Taiwan.

acutatum isolates, with an average score of 5. Kheenoo Suan, Karen, 83-168, and PBC932 were very susceptible to *C. acutatum*, with all genotypes receiving scores of 9 for all isolates. Ripe fruit of the 10 chili genotypes tested did not exhibit differential reactions to any of the *C. acutatum* isolates; therefore, no pathotype was identified (Table 7).

Mature green fruit stage. *Capsicum baccatum* genotypes PBC80 and PBC81, found to be resistant to all *Colletotrichum acutatum* isolates at the ripe fruit stage,

were moderately susceptible at the mature green fruit stage to six of the *C. acutatum* isolates (Table 8). The other eight chili genotypes were susceptible to all *C. acutatum* isolates, with severity levels similar to those at the ripe fruit stage. Three pathotypes were identified based on differential reactions in PBC80 and PBC81 in mature green fruit and designated PCa1-G, PCa2-G, and PCa3-G (Table 8). PCa1-G contained five isolates that incited lesions in both PBC80 and PBC81. PCa2-G included only isolate 313, which incited lesions in

PBC81 but not PBC80. PCa3-G contained four isolates that failed to incite lesions in either PBC80 or PBC81.

In summary (Table 9), three pathotypes of *C. capsici* were identified at the ripe fruit stage based on differential reactions in *Capsicum chinense* lines PBC932 and C04714 and two pathotypes at the mature green fruit stage based on differential reactions in C04714. *Colletotrichum gloeosporioides* could be grouped into five pathotypes at the ripe fruit stage based on differential reactions in *Capsicum chinense*

Table 3. Anthracnose severity scores on a 0-to-9 scale^a and pathotypes of 12 *Colletotrichum capsici* isolates at the ripe fruit stage of 10 chili genotypes

Isolate	<i>Capsicum baccatum</i>			<i>C. chinense</i>		<i>C. annuum</i>			<i>C. frutescens</i>		Mean	Pathotype
	80	81	1422	932	4714	JD	BC	83	KN	KR		
F4-2C	0	0	0	0	5	9	5	9	9	9	5	PCc2-R
F4-5A	0	0	0	0	9	9	9	9	9	9	5	PCc2-R
F7-3A	0	0	0	0	0	7	9	9	9	7	4	PCc3-R
F8-1A	0	0	0	9	9	9	9	9	9	9	6	PCc1-R
F8-2A	0	0	0	7	7	9	9	9	9	9	6	PCc1-R
F8-3A	0	0	0	9	7	7	9	9	9	9	6	PCc1-R
F8-3B	0	0	0	7	9	9	9	9	9	9	6	PCc1-R
F8-4C	0	0	0	9	9	9	7	9	9	9	6	PCc1-R
F8-5A	0	0	0	0	9	9	9	9	9	9	5	PCc2-R
F8-5B	0	0	0	9	9	9	9	9	9	9	6	PCc1-R
SKP16	0	0	0	0	0	5	5	9	9	7	4	PCc3-R
158ci	0	0	0	0	7	9	9	9	9	9	5	PCc2-R
Mean	0	0	0	4	7	8	8	9	9	9	5	...

^a Anthracnose severity scores (0 to 9) based on percent lesion size as a proportion to fruit size as described in Materials and Methods (pathogenicity study).

Table 4. Anthracnose severity scores on a 0-to-9 scale^a and pathotypes of 12 *Colletotrichum capsici* isolates at the mature green fruit stage of 10 chili genotypes

Isolate	<i>Capsicum baccatum</i>			<i>C. chinense</i>		<i>C. annuum</i>			<i>C. frutescens</i>		Mean	Pathotype
	80	81	1422	932	4714	JD	BC	83	KN	KR		
F4-2C	0	0	0	0	3	5	5	9	9	9	4	PCc1-G
F4-5A	0	0	0	0	3	9	7	9	9	9	5	PCc1-G
F7-3A	0	0	0	0	0	5	9	9	9	9	4	PCc2-G
F8-1A	0	0	0	0	7	9	9	9	9	9	5	PCc1-G
F8-2A	0	0	0	0	5	7	9	9	9	9	5	PCc1-G
F8-3A	0	0	0	0	9	7	9	9	9	9	5	PCc1-G
F8-3B	0	0	0	0	9	7	9	9	9	9	5	PCc1-G
F8-4C	0	0	0	0	9	7	9	9	9	9	5	PCc1-G
F8-5A	0	0	0	0	5	5	9	9	9	9	5	PCc1-G
F8-5B	0	0	0	0	7	3	9	9	5	9	4	PCc1-G
SKP16	0	0	0	0	0	3	3	9	9	9	3	PCc2-G
158ci	0	0	0	0	5	7	9	9	9	9	5	PCc1-G
Mean	0	0	0	0	5	6	8	9	9	9	5	...

^a Anthracnose severity scores (0 to 9) based on percent lesion size as a proportion to fruit size as described in Materials and Methods (pathogenicity study).

Table 5. Anthracnose severity scores on a 0-to-9 scale^a and pathotypes of 11 *Colletotrichum gloeosporioides* isolates at the ripe fruit stage of 10 chili genotypes

Isolate	<i>Capsicum baccatum</i>			<i>C. chinense</i>		<i>C. annuum</i>			<i>C. frutescens</i>		Mean	Pathotype
	80	81	1422	932	4714	JD	BC	83	KN	KR		
F1-3A	0	0	0	0	0	0	9	9	9	9	4	PCg5-R
F1-3C	0	0	0	0	5	5	9	9	9	7	4	PCg1-R
F4-1B	0	0	0	0	0	9	0	9	9	9	4	PCg4-R
F4-1C	0	0	0	0	7	0	0	9	7	9	3	PCg3-R
F5-1A	0	0	0	0	9	9	5	9	9	9	5	PCg1-R
F5-2D	0	0	0	0	5	3	9	9	9	9	4	PCg1-R
F5-4A	0	0	0	0	9	9	9	9	9	9	5	PCg1-R
F7-1B	0	0	0	0	5	0	5	9	9	5	3	PCg2-R
F7-3B	0	0	0	0	0	0	5	9	9	9	3	PCg5-R
F7-4A	0	0	0	0	3	0	9	9	9	9	4	PCg2-R
DOA	0	0	0	0	9	7	7	9	9	9	5	PCg1-R
Mean	0	0	0	0	5	4	6	9	9	9	4	...

^a Anthracnose severity scores (0 to 9) based on percent lesion size as a proportion to fruit size as described in Materials and Methods (pathogenicity study).

line C04714 and *C. annuum* cvs. Bangchang and Jinda. Six *Colletotrichum gloeosporioides* pathotypes were identified at the mature green fruit stage based on differential reactions in C04714 and all genotypes of *Capsicum annuum* and *C. frutescens*. *Colletotrichum acutatum* was grouped into three pathotypes at the mature green fruit stage based on differential reactions in *Capsicum baccatum* lines PBC80 and PBC81, while no pathotype was identified at the ripe fruit stage.

DISCUSSION

Differential host reactions that occurred in the 10 chili genotypes inoculated with

three *Colletotrichum* spp. were a result of specific host and pathogen interactions at two fruit maturity stages.

The three pathotypes of *Colletotrichum capsici* at the ripe fruit stage are the same as those identified by Montri et al. (5), who used the same isolates and chili genotypes. The addition of isolate 158ci and screening of isolates on the additional *Capsicum frutescens* genotype Karen did not distinguish any new pathotypes. Isolate 158ci was identified as PCc2-R.

Previous studies (3,4,6) of resistance to anthracnose in chili have shown distinct genes to be responsible for resistance at mature green and ripe fruit stages. There-

fore, the different genes expressed at different fruit maturity stages reacted differentially to a *Colletotrichum* isolate. *C. baccatum* genotypes PBC80 and PBC81 were more susceptible to *Colletotrichum acutatum* isolates at the mature green fruit stage than the red fruit stage. In contrast, *Capsicum chinense* line PBC932 was more resistant to *Colletotrichum capsici* at the mature green fruit stage than the ripe fruit stage.

Among the three *Colletotrichum* species, *Colletotrichum acutatum* appeared to be the most aggressive pathogen, with the overall mean scores over 6 for both fruit maturity stages (Tables 7 and 8). *C. acu-*

Table 6. Anthracnose severity scores on a 0-to-9 scale^a and pathotypes of 11 *Colletotrichum gloeosporioides* isolates at the mature green fruit stage of 10 chili genotypes

Isolate	<i>Capsicum baccatum</i>			<i>C. chinense</i>		<i>C. annuum</i>			<i>C. frutescens</i>		Mean	Pathotype
	80	81	1422	932	4714	JD	BC	83	KN	KR		
F1-3A	0	0	0	0	0	0	0	0	9	0	1	PCg5-G
F1-3C	0	0	0	0	0	0	0	9	0	9	2	PCg4-G
F4-1B	0	0	0	0	0	0	0	9	9	9	3	PCg3-G
F4-1C	0	0	0	0	0	0	0	9	9	9	3	PCg3-G
F5-1A	0	0	0	0	0	0	0	9	9	7	3	PCg3-G
F5-2D	0	0	0	0	5	0	0	9	9	9	3	PCg1-G
F5-4A	0	0	0	0	0	0	0	7	7	9	2	PCg3-G
F7-1B	0	0	0	0	0	0	0	9	9	9	3	PCg3-G
F7-3B	0	0	0	0	0	0	0	0	0	7	1	PCg6-G
F7-4A	0	0	0	0	5	0	0	9	5	7	3	PCg1-G
DOA	0	0	0	0	0	7	5	9	9	0	3	PCg2-G
Mean	0	0	0	0	1	1	1	7	7	7	3	...

^a Anthracnose severity scores (0 to 9) based on percent lesion size as a proportion to fruit size as described in Materials and Methods (pathogenicity study).

Table 7. Anthracnose severity scores on a 0-to-9 scale^a and pathotypes of 10 *Colletotrichum acutatum* isolates at the ripe fruit stage of 10 chili genotypes

Isolate	<i>Capsicum baccatum</i>			<i>C. chinense</i>		<i>C. annuum</i>			<i>C. frutescens</i>		Mean	Pathotype
	80	81	1422	932	4714	JD	BC	83	KN	KR		
211	0	0	3	9	5	9	7	9	9	9	6	...
311	0	0	3	9	9	5	7	9	9	9	6	...
313	0	0	5	9	7	7	5	9	9	9	6	...
314	0	0	5	9	7	9	7	9	9	9	6	...
316	0	0	5	9	9	9	7	9	9	9	7	...
322	0	0	5	9	7	9	9	9	9	9	7	...
MJ3	0	0	3	9	7	9	5	9	9	9	6	...
MJ5	0	0	7	9	9	7	5	9	9	9	6	...
MJ7	0	0	5	5	7	9	7	9	9	9	6	...
MJ8	0	0	5	9	9	9	5	9	9	9	6	...
Mean	0	0	5	9	8	8	6	9	9	9	6	...

^a Anthracnose severity scores (0 to 9) based on percent lesion size as a proportion to fruit size as described in Materials and Methods (pathogenicity study).

Table 8. Anthracnose severity scores on a 0-to-9 scale^a and pathotypes of 10 *Colletotrichum acutatum* isolates at the mature green fruit stage of 10 chili genotypes

Isolate	<i>Capsicum baccatum</i>			<i>C. chinense</i>		<i>C. annuum</i>			<i>C. frutescens</i>		Mean	Pathotype
	80	81	1422	932	4714	JD	BC	83	KN	KR		
211	0	0	5	9	7	7	7	9	9	9	6	PCa3-G
311	0	0	5	9	9	5	7	9	9	9	6	PCa3-G
313	0	3	5	9	5	9	7	9	9	9	7	PCa2-G
314	5	5	7	9	5	9	5	9	9	9	7	PCa1-G
316	5	5	7	7	7	9	5	9	9	9	7	PCa1-G
322	5	5	5	9	7	9	7	9	9	9	7	PCa1-G
MJ3	0	0	5	9	7	5	5	9	9	9	6	PCa3-G
MJ5	0	0	5	7	9	5	7	9	9	9	6	PCa3-G
MJ7	3	5	5	9	5	7	9	9	9	9	7	PCa1-G
MJ8	5	5	5	9	9	9	9	9	9	9	8	PCa1-G
Mean	2	3	5	9	7	7	7	9	9	9	7	...

^a Anthracnose severity scores (0 to 9) based on percent lesion size as a proportion to fruit size as described in Materials and Methods (pathogenicity study).

Table 9. Summary of numbers of pathotypes (P) identified for the three *Colletotrichum* spp. at ripe (R) and mature green (G) fruit stages and their differential *Capsicum* genotypes^a

<i>Colletotrichum</i> spp.	Stage	P	<i>Capsicum baccatum</i>			<i>C. chinense</i>		<i>C. annuum</i>			<i>C. frutescens</i>	
			80	81	1422	932	4714	JD	BC	83	KN	KR
<i>Colletotrichum capsici</i>	R	3	•	•	•	±	±	+	+	+	+	+
	G	2	•	•	•	•	±	+	+	+	+	+
<i>C. gloeosporioides</i>	R	5	•	•	•	•	±	±	±	+	+	+
	G	6	•	•	•	•	±	±	±	±	±	±
<i>C. acutatum</i>	R	...	•	•	+	+	+	+	+	+	+	+
	G	3	±	±	+	+	+	+	+	+	+	+

^a Symbols: – = no lesions incited by any isolate within a *Colletotrichum* spp., + = lesions incited by all isolates within a *Colletotrichum* spp., and ± = differential host reactions within a *Colletotrichum* spp.

tatum isolates were generally able to incite lesions on all tested chili genotypes, including mature green fruit of *Capsicum baccatum* lines PBC80 and PBC81, which were resistant to *Colletotrichum capsici* and *C. gloeosporioides*. In other words, PBC80 and PBC81 contained the broadest spectrum of anthracnose resistance. *C. capsici* was the second most virulent pathogen after *C. acutatum* and more virulent than *C. gloeosporioides*. *Capsicum chinense* line PBC932, which was used as the source of anthracnose resistance to introgress into *C. annuum* elite chili (3,6), was relatively resistant to *Colletotrichum capsici* and *C. gloeosporioides* but highly susceptible to *C. acutatum*. Of the four *Capsicum* spp., *Capsicum frutescens* cultivars and *C. annuum* line 83-168 showed the highest susceptibility to all three *Colletotrichum* spp.

Park et al. (8) have recently studied differential reactions of 41 *Capsicum* germplasm lines with 10 Korean isolates of *Colletotrichum acutatum* and found that only *Capsicum baccatum* lines were resistant. PBC80 and PBC81 were not the most resistant among the 22 *C. baccatum* lines tested across the *Colletotrichum acutatum* isolates. The study by Park et al. (8) suggested that the *Capsicum baccatum* germplasm pool contained higher levels of resistance to anthracnose than other *Capsicum* spp., which will be useful genetic resources for anthracnose resistance, and that the Korean *Colletotrichum acutatum* isolates

may be more aggressive than the Thai isolates used in our study.

The identification of pathotypes of *C. capsici*, *C. gloeosporioides*, and *C. acutatum* is a significant finding that will impact on chili breeding for resistance to anthracnose, and will provide a better understanding of the specific interactions between chili genotype, *Colletotrichum* isolate, and chili fruit maturity.

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