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Pathogenic variability and vegetative compatibility among isolates of *Colletotrichum graminicola* and *C. gloeosporioids* causing foliar and grain anthracnose in sorghum

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ABSTRACT: *Colletotrichum graminicola* and C. *gloeosporioides* cause foliar and grain anthracnose of sorghum. Foliage infection is more widely prevalent, but at times, grain anthracnose occurs in severe form. To understand whether isolates infecting foliage (lamina and midrib) and that infecting grain are different, isolates from foliage and grain were compared for pathogenicity and vegetative compatibility. In greenhouse experiments, isolate x host differential interaction was highly significant indicating isolate specificity for infection to grain and foliage. Five popular sorghum hybrids also exhibited variable reactions to foliar and grain isolates. The results suggest that although isolates from grain, leaf lamina and midrib can infect both foliage and grains, the organ specificity for infection does exist, and that resistance to grain and foliar infection is likely to be governed by different genetic factors. The isdlates also varied in developing nitrate non-utilizing *(nit)* mutants on chlorate media and were identified in different vegetative compatibility groups. The isolates of *C. graminicola* were different from that of *C. gloeosporioides* both for pathogenicity and vegetative compatibility.

Key words: Sorghum, *Colletotrichum graminicola, C. gloeosporioides,* grain anthracnose, pathogenicity, vegetative compatibility

Anthracnose of sorghum *(Sorghum bicolor* (L.) Moench), incited by *Colletotrichum graminicola* (Ces.) Wils. (= *C. sublineolum* Henn. Kabat. & Bubak.) cuases substantial yield losses in many tropical and subtropical countries (Harris and Fisher 1974; Mishra and Siradhana, 1979). In India, it is quite widespread and severe on local landraces, though virulence to popular hybrids has also been detected (Mathur *et al.,* 1997a, 1997b). The pathogen is hypervariable and several races have been reported (AH and Warren, 1987; Pande *et al,* 1991; Thakur, 1995; Thomas, 1995; Rao *et al,* 1998). Anthracnose symptoms develop on all aerial plant parts, foliar infection is more widely prevatent, and at times grain anthracnose also occurs in severe form. Although *C. graminicola* is the most commonly occurring species. *C. gloeosporioides* (Penz.) Sacc. has also been found to cause foliar and grain anthracnose on local landraces of yellow sorghum in Karnataka and Tamil Nadu (Mathur *et al,* 1998). It is not known whether isolates infecting foliage and grain are different, or whether different genes govern resistance to grain and foliar infection. Though *C. gloeosporioides* isolates produce perfect state in culture (Freeman and Katan, 1997), there is no report of sexual reproduction in *C. graminicola* from sorghum. In the absence of sexual reproduction it is not known whether the populations of these two species are genetically related. In such mitosporic fungi, Possible genetic exchange via heterokaryosis and parasexual cycle is mostly studied using auxotrophic mutants that prevent the utilization of nutrition sources, such as nitrogen (Puhalla,1985; Correll *et al,* 1987, 1988). Vegetative compatibility grouping (VCG) using pitrate non-utilizing (*nit*) mutants, that subdivides the populations into groups that can exchange genetic information, has been found useful in the characterization of genetic relatedness of the isolates of *Colletotrichum* spp. (Brooker *et al,* 1991; Correll *et al,* 1993). The present investigations were aimed at comparing grain and foliar isolates of C. *graminicola* and *C. gloeosporioides* through differential virulence on foliage and grains, and to study their genetic relatedness through vegetative compatibility grouping using *nit* mutants.

MATERIALS AND METHODS

The pathogen isolates

Thirteen isolates, 11 *of Colletotrichum graminicola* and two of C. *gloeosporioides, were* collected from

infected leaves (lamina and midrib) and grains from different sorghum cultivars (Table 1). Single-lesion cultures were obtained from the infected leaves on oat meal agar (OMA) at 25°C under continuous fluorescent light. Infected grains showng visible acervuli were soaked in water for 20 min, then in $HgCl_2$ for 2 min, rainsed twice with distilled sterilized water (DSW), placed on moist blotting papers in petriplates and incubated at 25°C under continuous fluorescent light for 3 days. The spores developing on these grains were streaked on OMA. The plates were incubated at 25°C under continuous fluorescent light for seven days and colonies of *Colletotrichum* spp. were picked and transferred on fresh OMA plates. Of the 11 isolates of *C. graminicola* obtained this way, four were from lamina (L), two from midrib (M), and five from grains (G). Two isolatesone each from lamina and grain, belonged to *C. gloeosporioides.* Since significant intra-population variations have been reported in the sorghum anthracnose pathogen (Mathur *et at,* 1997c), single-hyphal tip cultures were used to truly reprsent each isolate.

Pathogenicity

Pathogenic variability among the isolates was studied in two greenhouse inoculation experiments. In the first experiment, six sorghum lines (A 2267-2, IRAT 204, IS 3758, IS 8354, IS 3089 and IS 18442) with differential susceptibility to *C. graminicola* (Mathur *et al,* 1997c; Rao *et al,* 1998) were used. In the second, five popular sorghum hybrids (CSH 5, CSH 6, CSH 9, CSH 14 and CSH 16) along with the susceptible check IS 18442 were evaluated. Surface sterilized seeds were sown in autoclaved black soil, sand and farmyard manure mix (3:2:2 by volume) in 18-cm square plastic pots (at 25 ± 2°C, rh >90%). Five plants were maintained in each pot and each plant was considered as a replication. Separate sets of plants were used for foliage and grain inoculations, and sowing of these sets was adjusted in a manner to obtain both the stages at one time. The experiments were repeated once.

The isolates were grown in *2%* oatmeal broth at 25°C in an incubator shaker at 125 rpm with 12-h photoperiod for 10 days. Conidia were separated by filtering through a double-layered muslin cloth. A spore suspension ($1x10^5$ conidia ml^{-1}) for each isolate was prepared, using a haemocytometer, and Tween-20 (2 mL^{-1}) was added to each suspension. Leaves were inoculated at the 5-6 leaf stage (21-day old), and grains were inoculated just after seed filling (75 days after sowing), with each of the 13 isolates by spraying the inoculum to run off with a hand-held sprayer. The inoculated plants were air-dried and transferred to a humidity chamber (>98 % RH) for 24 h. The plants were then transferred to greenhouse benches (25± 2°C) in a completely randomized design. To provide congenial conditions for disease development high humidity (RH >95%) was maintained in the greenhouse with the help of an electronically controlled mister.

Table 1. Origin of isolates of *Colletotrichum graminicola* (Cg) and *C. gloeosporioides* (Cgl) from sorghum leaves and grain

Location/state	Collection Year	Source cultivar	Plant part infected	Isolate designate[b]
Colletotrichum graminicola				
Patancheru, AP	1995	CSH 9	Grain	Cg 170-G
Patancheru, AP	1996	Bulk Y	Grain	Cg 171-G
Sangli, MS	1997	Local	Grain	Cg 172-G
Sangli, MS	1997	Local	Grain	Cg 225-G
Patancheru, AP	1997	94024B	Grain	Cg 226-G
Patancheru, AP	1994	IS 18760	Midrib	Cg 227-M
Patancheru, AP	1992	IS 18442	Lamina	Cg 042-L
Udaipur, Raj	1992	Local	Midrib	Cg 029-M
Udaipur, Raj	1992	Local	Lamina	Cg 029-L
Pankhan, Guj	1997	Yellow sorg.	Lamina	Cg 193-L
Pankahri, Guj	1997	Yellow sorg.	Lamina	Cg 194-L
C. gloeosporioides				
Pudur, TN	1996	Yellow sorg.	Lamina	Cgl 150-L
a, Kar	1997	Yellow sorg.	Grain	Cgl 173-G

AP = Andhra Pradesh, MS = Maharashtra, Raj = Rajasthan, Guj = Gujarat. TN = Tamil Nadu, Kar = Karnataka

a. not-known

b. G = grain; M = midrid; L - lamina

Data were recorded for latent period (time in days from inoculation to the appearance of the first chlorotic/necrotic lesion with spores) on foliage, everyday beginning second day after inoculation. Plants were scored for foliar anthracnose 14 days after inoculation for disease reaction as R = resistant (no symptoms or restricted chlorotic flecking); MR = moderately resistant (red spots or necrotic spots without acervuli); and S = susceptible (lesions with acervuli), and for disease severity on a 1-9 scale, where, 1 = no lesions, 2=1-5%. 3=6-10%, 4=11-20%, 5=21-30%, 6=31-40%, 7=41-50%, 8=51-75%, and 9>75% leaf area covered with lesions (Thakur, 1995). Disease severity on grain anthracnose was recorded on earheads 30 days after inoculations following a 1-9 scale, similar to that used for foliar anthracnose, but it was based on per cent earhead area infected (Frederiksen *et at,* 1982).

Vegetative compatibility grouping (VCG)

Puhalla's minimal nitrate agar medium (NM), a sucrose-salt medium containing nitrate as the nitrogen source (Puhalla, 1985) was used to develop *nit* mutants. The cultures were first grown on MM for 5 days at 25°C under continuous fluorescent light. Growth segments (2-mm dia) from the periphery of each culture was removed and placed in the center of each of the 20 petridishes (9-cm dia) containing chlorate (medium based on MM) or potato dextrose agar (PDA) amended with 15 g L^{-1} potassium chlorate (MMC or PDC, respectively). The plates were incubated at 25°C under continuous fluorescent light for 4 weeks. Fast growing chlorate resistant sectors emerging from the restricted colonies were transferred to NM plates (6.2-mm dia), and examined after 5 days. Colonies with a thin expanding mycelium were considered *nit* mutants. Frequency and time of appearance of each sector was recorded and *nil* mutants from each medium were recovered up to 4 weeks.

Partial phenotyping of *nit* mutants was attempted by growing these on Puhalla's basal medium supplemented with different nitrogen sources: sodium nitrate 3g L^{-1}, sodium nitrite 0.5 g L^{-1}, hypoxanthine 0.2 g L^{-1}, and ammonium tartrate 1 g L^{-1}. The plates were incubated at 25°C for one week, and phenotyping of the mutants determined on the basis of their ability to utilize the particular nitrogen sources (Correll *et al.,* 1987).

Formation of heterokaryon through complementation was determined by opposing different *nit* mutants from different isolates in all the possible combinations. Mycelial bits (2-mm dia) from different *nit* mutants were placed 1 cm apart on MM plates and incubated for 3 weeks. All of the *nit* mutants recovered from the same parent were also paired with at least *nit1, nit2, nit3* and *nitm* mutants from that parent, to determine if these heterokaryons were self-compatible. If two strains are vegetatively compatible and carry complementary nit mutants, they can form a prototrophic heterokaryon when cultured on MM. Mutants from different isolates showing heterokaryon formation are considered to be of the same compatibility group.

RESULTS

Pathogenicity on six differential lines

Foliar anthracnose

The mean latent period of the 11 C. *graminicola* isolates across the six sorghum lines ranged from 3.85 to 4.8 days, and of the two *C. gloeosporioides* isolates 4.97 to 5.42 days (Table 2). The shortest mean latent period (3.85 days) was of isolates Cg 226-G and Cg 042-L, and the longest (5.42 days) of Cgl 150-L. Among the sorghum lines, IS 18442, a highly susceptible fine, had the shortest mean latent period (4.28 days), while IRAT 204 had the longest latent period (4.7 days) with isolate Cg 171-G. Highly significant ($P<0.001$) effects, of isolates, sorghum lines and isolate x sorghum line interaction were obtained for latent period (Table 3).

The isolates showed significant variations in virulence (reaction types) on sorghum lines. All the isolates were avirulent (R reaction) on A 2267-2, and except Cg 171-G, also on IRAT 204 (Table 2). Isolates of *C. graminicola* both from grain and foliage (midrib and lamina) readily infected foliage of the four differential lines and mostly produced S reaction. Isolates Cg 171-G was the most virulent, inducing S reaction in five of the six sorghum lines, while Cg 170-G caused S reaction only on two lines. Of the four foliar isolates, Cg 42-L and Cg 29-L caused S reaction on four lines, while Cg 193-L and Cg 194-L caused S reaction on three. Midrib isolate Cg 227-M was also virulent on four lines, while Cg 29-M was virulent on three. Isolates of C. *gloeosporioides* Cgl 150-L and Cgl 173-G were avirulent and caused only R or MR reaction on all six lines.

Considerable variations were also recorded for aggressiveness among the isolates both on foliage and grain. All isolates were least aggressive on A 2267-2, Cg 042-L was more aggressive on IRAT 204 for grain infection than others (Table 4). The most aggressive isolate was Cg 171-G for foliar infection (mean score 4.23) and Cg 227-M for grain infection (mean score 4.27), The two *C. gloeosporioides*..isolates (Cgl 150-L and Cgl 173-G) were least aggressive across the six

Table 2. Latent period (days) and disease reaction of grain and foliar isolates of *Colletotrichum graminicola* (Cg) and *C. gloeosporioides* (Cgl) on foliage of six sorghum lines

	Sorghum lines												
	A 2267-2		IRAT-204		IS 3758		IS 8354		IS 3089		IS 18442		Mean
Isolate	LP	DR	LP	DR	LP	DR	LP	DR	LP	DR	LP	DR	LP
Cg 170-G	-[a]	R	-	R	4.7	MR	4.7	MR	4.1	S	4.8	S	4.57
Cg 17I-G	-	R	4.7	S	4.1	S	4.4	S	4.3	S	4.1	S	4.32
Cg 172-G	-	R	-	R	4.1	MR	3.5	S	4.0	S	4.2	S	3.95
Cg 225-G	-	R	-	R	5.0	S	5.1	S	4.7	S	4.2	S	4.75
Cg 226-G	-	R	-	R	3.8	MR	4.6	S	3.7	S	3.3	S	3.85
Cg 227-M	-	R	-	R	4.4	S	4.1	S	4.0	S	4.0	S	4.12
Cg 193-L	-	R	-	R	5.4	S	4.2	MR	4.1	S	3.4	S	4.27
Cg 194-L	-	R	-	R	5.9	S	3.9	MR	5.0	S	4.4	S	4.80
Cg 042-L	-	R	-	R	3.8	S	4.1	S	4.2	S	3.3	S	3.85
Cg 029-M	-	R	-	R	3.9	S	4.4	S	4.4	MR	4.4	S	4.27
Cg 029-M	-	R	-	R	4.2	S	4.0	S	4.0	S	4.4	S	4.15
Cgl 150-L	-	R	-	R	5.2	MR	5.5	MR	5.3	MR	5,7	MR	5.42
Cgl 173-G	-	R	-	R	4.5	MR	4.6	MR	5.3	MR	5.5	MR	4.97
Mean	-	-	4.70	-	4.54		4.39	-	4.39	-	4-28	-	-

SE±: isolate 0.83; sorghum line 0.06; isolate x sorghuin line = 0.20.

LP - latent period; DR = disease reaction, where R = resistant, MR = moderately resistant, and S = susceptible

[a]Resistant reaction

Table 3. Analysis of variance (ANOVA) for foliar [latent period (LP) virulence (V) and aggressiveness (AG)] and grain (AG) infection by isolates of *Colletotrichum graminicola and C. gloeosporioides*

		Ms			
		Foliar infection			Grain infection
Source	d.f	LP	V	AG	AG
Experiment (E)	1	0.36[NS]	0.003[NS]	44.1***	30.00**
Isolate (1)	12	12.5*	37***	28.8***	34.24***
Sorghum lines (L)	5	7.6***	81.9***	290.1***	105.5***
1 x L	38	2.1***	1.1***	12.2***	8.65***
E x 1 x L	60		0.5		2.14***

*** Significant P<0.001, NS =Not significant.

sorghum lines. Among the sorghum lines, IS 18442 developed highest mean disease severity both for foliar (4.9) and grain (4.38) infection. Highly significant (P< 0.001) effects were obtained for aggressiveness of isolates, sorghum lines and isolates x sorghum lines both for foliar and grain infection (Table 3).

Reaction on hybrids

The grain and foliar isolates showed variations in latent period, virulence and aggressiveness on the five commercial sorghum hybrids (Table 5). Generally, grain isolates had shorter latent period and more virulent than on foliage than foliar isolates. The latent periods of isolates were significantly longer on hybrids (3.0 to 5.3 days) than on the susceptible check IS 18442 (3.0 to 4.2 days). Hybrid CSH 16 foliage was resistant to all the six isolates, while the remaining hybrids developed MR or R reaction. All the six isolates from foliage or grain were nonaggressive on CSH 16 for foliar infection and on CSH 6 for grain infection (Table 6). Hybrids CSH 5 and CSH 14 recorded more grain infection than CSH 9 and CSH 14. On other hybrids and IS 18442, grain isolates appeared to be more aggressive both for foliar and grain infection than foliar isolates. There 'was a weak negative correlation (r = -0.1Q) between aggressiveness of foliar and grain anthracnose

Table 4. Aggressiveness (disease severity) of foliar and grain isolates of *Colletotrichum graminicola* (Cg) and *C. gloeosporioides* (Cgl) on foliage and grains of six sorghum lines

	Sorghum lines													
	A 2267-2		iRAT-204		IS 3758		IS 8354		IS 3089		IS 18442		Mean	
Isolate	F	G	F	G	F	G	F	G	F	G	F	G	F	G
Cg 170-G	1.0	1.0	1.0	1.0	2.1	2.2	2.5	2.0	5.9	1.2	2.6	2.6	2.52	1.67
Cg 171-G	1.0	1.0	2.6	1.0	3.7	4.8	4.1	3.2	6.3	1.0	17.7	8.4	4.23	3.23
Cg 172-G	1.0	1.0	1.0	1.0	1.9	4.4	2.2	2.4	2.2	1.0	6.0	5.4	2.38	2.53
Cg 225-G	1.0	1.0	1.0	1.0	3.1	1.4	2.3	2.0	5.8	1.0	5.3	2.4	3.08	1.47
Cg 226-G	1.0	1.0	1.0	1.0	2.4	7.0	3.9	5.2	4.2	1.0	3.6	8.4	2.68	3.93
Cg 193-L	1.0	1.0	1.0	2.0	2.0	2.0	2.8	2.0	2.7	1.0	5.2	4.0	2.45	2.00
Cg 194-L	1.0	1.0	1.5	1.4	1.8	2.0	2.0	2.0	2.1	1.0	1.8	2.0	1.9	1.57
Cg 029-M	1.0	1.0	1-0	1.0	2.3	5.8	2.6	3.4	3.6	1.0	5.5	2.6	2.7	2.47
Cg 029-L	1.0	1.0	1.0	1.0	2.4	2.0	3.6	2.0	5.8	1.0	6.2	2.6	3.33	1.60
Cgl 227-M	1.0	1.4	1.0	1.6	2.9	5.8	3.2	7.2	2.6	1.0	8.6	8.6	3.22	4.27
Cgl 042-L	1.0	1.6	1.0	5.2	5.2	2.8	7. 1	5.6	2.2	1.0	6.3	6.0	2.97	3.70
Cg 150-L	1.0	1.0	1.0	1.0	2.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.68	1.17
Cg 173-0	1.0	1.0	1.0	1.0	2.0	1.0	2.0	1.0	2.0	1.0	2.0	2.0	1.9	1.17
Mean	1.00	1.10	1.16	1.48	2.61	3.25	2.1	3.00	3.65	1.00	4.90	4.38	-	-

SE±-: for foliar infection: isolate = 0.07; sorghum line = 0.05-1 isolate x sorghum line = 0.03; for grain infection: isolate = 0.08; sorghum line = 0.06; isolate x sorghum line = 0.20; F = foliage, G = grain

Table 5. Latent period (LP) and virulence (V) of *Colletotrichum graminicola* (Cg) isolates on foliage of five popular sorghum hybrids

	Sorghum hybrids											
	CSH 5		CSH 6		CSH 9		CSH 14		CSH 16		IS 18442"	
Isolate	LP	V	LP	V	LP	V	LP	V	LP	V	LP	V
Cg 170-G	5.2	MR	4.8	MR	4.8	S	4.6	MR	[b]	R	3.0	s
Cg 171-G	4.8	S	4.4	MR	4.0	S	-	R	-	R	3.2	s
Cg 172-G	-	R	4.7	MR		R	5.3	MR	-	R	3.0	s
Cg 193-L	-	R	-	R	5.0	MR	-	R	-	R	4.2	s
Cg 194-L	5.4	MR	-	R	5.4	MR	-	R	-	R	3.6	s
Cg 042-L	3.0	MR	5.2	MR	4.8	MR	-	MR	-	R	1.0	s

SE± for LP 0. 23

R = resistant; MR = moderately resistant and S = susceptible

[a]IS 19442 is a susceptible check line

b= no infection

indicating the lack of relatedness between grain and foliar isolates.

Vegetative Compatibility Grouping

The isolates showed variation for growth on the two chlorate media, and formation of *nit* mutants (Table 7). Isolate Cg 172-G formed the highest number of *nit* mutants (56), while Cg 170-G formed the lowest (2). Isolates Cgl 150-L and Cgl 173-G formed only 10 and three *nit* mutants, respectively. Isolates Cg 226-G, Cg 193-L and Cg 194-L developed more mutants on MMC than on PDC. All the isolates generated *nit2* mutants on MMC and PDC, Cg 042-L also formed *nit* mutants. Although the mutants from the same phenotype appeared to have approximately the same chances of being selected, it was not unusual to obtain only one phenotype from a particular isolate, and *nit* mutants were not recovered from some isolates, like Cg 226-G. Only one mutant was recovered from Cg 170-G on each chlorate medium. Efforts to develop heterokaryon formation among isolates were not successful despite repeated tests.

Table 6. Aggressiveness (disease severity) of *Colletotrichum graminicola* (Cg) isolates on foliage and grains of five popular sorghum hybrids

Isolate	Sorghum hybrids						
	CSH 5	CSH 6	CSH 9	CSH 14	CSH 16	IS 18442	Mean
			Foliar anthracnose				
Cg 170-G	2.0	2.2	2.6	2.4	1.0	3.2	2.2
Cg 171-G	2.4	2.4	6.2	1.0	1.0	8.8	3.6
Cg 172-G	1.0	1.6	1.0	1.6	1.0	6.0	2.0
Cg 193-L	2.0	1.0	1.6	1.0	1.0	4.2	1.8
Cg 194-L	2.0	1.0	2.0	1.0	1.0	3.6	1.8
Cg 042-L	1.4	2.0	2.0	1.8	1.0	7.0	2.5
Mean	1.8	1.7	*6*	1.5	1.0		
			Grain anthracnose				
Cg 170-G	5.0	1.0	2.4	6.6	1.0	1.0	2.8
Cg 171-G	7.8	1.0	3.2	7.4	5.8	7.6	5.5
Cg 172-G	2.2	1.0	8.0	8.0	6.4	7.6	4.7
Cg 193-L .	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Cg 194-L	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Cg 042-L	1.0	1.0	4.6	8.2	7.2	1.0	3.8
Mean	3.0	1.0	2.5	5.4	3.7	3.2	

SE ± for isolates 0.12; sorghum hybrid = 0.13; isolate x sorghum hybrid = 0.28
IS 18442 is a susceptible check line

Table 7. Number of sectors of *Colletotrichum graminicola* (Cg) and *C. gloeosporioides* (Cgl) originating on media amended with potassium chlorate at weekly intervals at 25°C

Isolate	Medium[a]	1 wk	2wk	3wk	4wk	Total[b]
Cg 029-L	PDC	5	9	3	3	20
	MMC	-[c]	12	-	1	13
Cg 029-M	PDC	-	10	-	2	12
	MMC	-	-	-	-	0
Cg 042-L	PDC	-	9	1	-	10
	MMC	2	9	-	2	11
Cg 170-G	PDC	-	1	-	-	1
	MMC	-	1	-	-	1
Cg 171 -G	PDC	2	15	1	-	18
	MMC	5	10	2	-	17
Cg 172-G	PDC	5	18	5	2	30
	MMC	3	20	2	1	26
Cg 193-L	PDC	-	4	-	1	5
	MMC	5	5	2	-	12
Cg 194-L	PDC	-	4	-	1	5
	MMC	5	*5*	2	-	5
Cg 225-G	PDC	1	10	-	-	11
	MMC	-	2	-	-	2
Cg 226-G	PDC	-	-	-	-	0
	MMC	-	3	1	1	5
Cg 227-M	PDC	-	2	-	-	
	MMC	-	1	1	-	2
Cg 150-L	PDC	-	4	1	1	6
	MMC	-	3	1	1	4
Cgl 173-G	PDC	-	2	-	-	2
	MMC	-	1	-	-	1

[a]PDC = potato dextrose-agar amended with potassium chlorate, MMC = minimal medium amended with potassium chlorate
[b]Data obtained from 20 chlorate media plates for each Isolate.
[c]No sectors recorded.

DISCUSSION

There has been conflicting reports in literature on the nature and resistance to foliar and grain anthracnose (Harris *et al,* 1964). In this study, we used C. *graminicola* isolates from different areas (states, and locations within states), that seem to represent distinct populations. The isolates from foliage (lamina and midrib) could infect grains and vice versa, although they varied in aggressiveness. Most of the hybrids showing resistance to foliar infection readily developed grain anthracnose. These results suggest that resistance to foliar and grain infection is possibly governed by different mechanisms and by dffferent genes. Resistance to anthracnose in sorghum is reported to be governed by dominant genes at multiple loci, and in many varieties, resistance is partial (Tenkouano, 1993).

The foliage and grain isolates were also vegetatively incompatible when tested in all combinations using *nit* mutants, and they formed separate VCGs. Each VCG is thought as a series of clones of a single parental strain, which posses a particular set of VCG alleles. Isolates that are vegetatively incompatible are assumed not to be clones, but to have developed their pathogenic capabilities independently (Leslie, 1993). The results also indicated that *C. gloeosporioides* isolates from local yellow sorghum were different from those of *C. graminicola* isolates, although these have the potential of infecting both grain and foliage of sorghum cultivars.

Grain anthracnose is reported to reduce viability and germination of seeds, and act as a source of primary inoculum in the field (Saifula and Rangnathiah, 1989; Cardwell *et al,* 1989). Grain anthracnose, therefore, needs to be closely monitored, and while evaluating for anthracnose resistance, it would be useful to evaluate the breeding materials for grain anthracnose as well. In most parts of India sorghum being a marginal crop, there has not been much selection pressure on the pathogen population because of limited use of resistant varieties or fungicides that could cause guided evolution in *C. graminicola* population. These variable pathotypes seem to have developed on different strains of local landraces of sorghum being traditionally cultivated in dffferent parts of India. Further studies using multiple sampling from the same location or field at different time-intervals may elucidate possible genetic relatedness among the prevalent populations. Nevertheless, their virulence to popular hybrids as observed *in* controlled conditions should be viewed critically for closer monitoring of their resistance stability.

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