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BV Tembhurne
Department of Genetics and Plant Breeding, University of Agricultural Sciences, Raichur, Karnataka, India

Umesh Babu BS
Department of Genetics and Plant Breeding, University of Agricultural Sciences, Raichur, Karnataka, India

DS Aswathanarayana
Department of Plant Pathology, University of Agricultural Sciences, Raichur, Karnataka, India

Corresponding Author
BV Tembhurne
Department of Genetics and Plant Breeding, University of Agricultural Sciences, Raichur, Karnataka, India

Evaluation of inbred lines for Anthracnose resistance in chilli

BV Tembhurne, Umesh Babu BS and DS Aswathanarayana

Abstract
Chilli (*Capsicum annuum* L.) is one of the most economically important vegetable crops in the world. Among different biotic constraints, anthracnose disease is the major limiting factor affecting yield and production of chilli crop not only in India but also worldwide. Therefore, thirty inbred lines with different genetic background were selected and evaluated for anthracnose (*Colletrotrichum capsici*) (Family *Glomerellaceae*) resistance in chilli. The experiments were conducted in field as well as laboratory conditions and repeated two years to confirm the resistant genotypes during 2016-2017 and 2017-2018. The genotypes, PBC-80 and G-4-L, registered resistance and ACB1-L and HDC-75-1 moderately resistance to anthracnose disease in chilli. Therefore, these genotypes can be used as donors for anthracnose disease resistance breeding programme in future. This study proposed identification of anthracnose resistance sources for providing more opportunity to the breeder to improve the fruit quality and enhance the yield.

Keywords: Chilli, capsicum annuum, anthracnose disease.

Introduction
Species of the genus Capsicum, family Solanaceae, are among the most cultivated annual herbaceous vegetables [1], and it comprised of many cultivated species, one being *Capsicum annuum* L. other domesticated species include *C. Baccatum*, *C. Chinensis*, *C. Frutescens*, and *C. Pubescens* [2]. Chilli (*Capsicum annuum* L.) is one of the world's most important commercial crops, grown in almost all of nation, which include India. This country is the world's largest consumer and exporter of chilli, generating 2149 thousand MT of dry chilli from an area of 752 thousand ha in 2017-2018 [3]. *C. annuum* includes both sweet (bell pepper) as well as sour flavours. It's high in Vitamin A and C, and also potassium and folic acid [4]. Red chilli has much more vitamin A than carrots, and fresh green chilli has more vitamin C then citrus fruit [5, 6]. Color and pungency levels being two important industrial qualities that make Indian chilli well-known around the world.

Chilli crops are attacked by a variety of pests and pathogens in the field, and contamination with mycotoxins during post-harvest is a major constraint in chilli production. Capsicum is susceptible to a wide range of pests, weeds, fungal, bacterial, and viral pathogens worldwide; among the fungal diseases, anthracnose/die-back/fruit-rot of chillies is a serious problem that results in massive losses in field, transit, transport, and storage [7, 8].

The word anthracnose is derived from the Ancient Greek language and indicates "coal." It is the common name for a plant disease characterized by very dark, sunken lesions and the existence of fungal spores [9]. Dark spots, sunken necrotic tissue, as well as concentric rings of acervuli are indeed typical symptoms of anthracnose on chilli fruit. In particular with respect to fruit rot, it causes leaf spots, stem dieback, seedling blight, as well as damping off. This disease not only reduces the dry weight of fruit and the quantity of capsaicin as well as oleoresin, but it also minimizes the dry weight of fruit and the quantity of capsaicin and oleoresin [10, 11].

This disease causes losses all across the world; it has been reported that it causes 20–80 percent yield loss in Vietnam [12], 10 percent yield loss in Korea [13], 50 percent yield loss in Malaysia [14], and as much as 80 percent yield loss (during severe epidemics) in Thailand [15]. In India, a calculated yield loss of 10–54 percent has been reported due to this disease [16, 17], and while this disease has been reported throughout the country, it has been found to be more common and aggressive in Assam, Bihar, Andhra Pradesh, as well as Uttar Pradesh [18].

The anthracnose pathogen has been spotted in seed, and it has been reported that there is pathogen incidence in seed samples, with up to 5% infection index denoting its widespread occurrence in India.
Chemical management of anthracnose disease is not sustainable and is associated with health threats and pollution [20]. Although fungicide sprays may be advantageous, their use has been ineffective and costly to maintain for small-holding farmers despite the risks to environmental safety. Recently, [21] confirmed that the use of *S. violaceoruber* fermentation broth decreased the prevalence of chilli anthracnose by promoting seedling growth in chilli, but it is not a long-term solution for disease control. Thus, cultivating resistant varieties, or hybrids, is among the most cost-effective and significant strategies to minimize crop losses. The most effective method to control anthracnose in chilli is host resistance breeding, but the absence of resistance sources is a major setback [22]. The development of disease-resistant chilli cultivars is a critical environmental requisite for removing the use of chemicals. The use of resistant varieties not only eradicates anthracnose, but also eliminates the disease's chemical and mechanical responses. To increase the yield of high-quality chilli, genotype resistance to anthracnose must also be confirmed. The identified genotypes carrying resistant genes to anthracnose will be utilised for further improvement of the varieties or hybrids. The inheritance of *Colletotrichum acutatum* resistance is dominant [23]. and the molecular markers associated with anthracnose-resistant traits in *Capsicum* have been identified [24]. The use of synthetic chemicals is one of the most common practises for the control of anthracnose in peppers. However, it may be harmful to human health if used in post-harvest management, in addition to accumulating potential resistance in pathogens to fungicides [25]. The development of high yielding F1 hybrids resistance to anthracnose disease is difficult but possible. Most of the existing varieties of chilli have export quality but susceptible to anthracnose disease, which is affecting the yield and quality of chilli. Hence, there is a need to develop F1 hybrids resistant to anthracnose disease. To develop the hybrid resistant to anthracnose there is necessity to identify the parents resistant to this disease. Keeping this in mind, the experiments were conducted to identify the chilli inbred lines resistant to anthracnose as preliminary study.

Material and Methods

Thirty inbred lines of chilli with different genetic background were selected and used for screening of anthracnose (*Colletrotrichum capsici*) resistance in chilli. These genotypes were sown during 2016-2017 at the College of Agriculture, Raichur, using Randomized Complete Block Design (RCBD) under unprotected field conditions by following the recommended agronomic practices. The genotypes were categorized into resistance and susceptible to anthracnose in chilli. Further, to confirm the resistant reaction of selected genotypes against anthracnose was screened at the laboratory and evaluated by using the pin prick method.
Seven genotypes were chosen from among the thirty promising genotypes, and each was screened for further confirmation of anthracnose resistance reaction and evaluated in 2017-2018.

Resistance to anthracnose (*Colletotrichum capsici)*

Chilli fruits infected with anthracnose were collected from the field and taken to the laboratory. *Colletotrichum capsici* isolates were identified using colony colour, growth pattern, and acervuli formation pattern on PDA and confirmed using a microscope [26]. Pathogenicity of purified fungus was tested in both field and laboratory conditions using artificial spore inoculation in the field and artificial inoculations using the pin prick method in the lab [27].
Colletotrichum capsici inoculation sprayed evenly onto chilli plants bearing semi-green fruits in the field. The data was collected for the percentage of infected fruit after seven days of artificial inoculation on a scale of 0-9, and the disease reaction of each genotype was categorised as shown in Table 1 [28].
Per cent disease index (PDI) was calculated by using following formula.

$$\text{PDI} = \frac{\text{Sum of individual disease rating}}{\text{No.of Fruits assessed x Maximum disease grade}} \times 100$$

Per cent disease incidence is calculated by using the formula:

$$\text{Per cent disease incidence} = \frac{\text{Number of infected fruits}}{\text{Total number of Fruits}} \times 100$$

Results and Discussion

The anthracnose resistance of the 30 genotypes was evaluated, and disease incidence was graded on the 0-9 scale [28]. PBC-80, G-4-L, and M-421 genotypes had disease grade 1 and showed resistant response, whereas SUM-17, RAB-1, P-3, Selection-1, BCH-42 -F2-2, HDC-75-1, and ACB1-L genotypes had disease grade 3 and were found to be moderately resistant. 9608-U, Sitara, KBCH-1, BVC-42, Byadagi dabbi-1, BCH-42 -F2-1, Tiwari, Sankeshwar, KA2-L, and JNB-1 are ten genotypes with a disease grade of 5 and showed moderately susceptible reaction. Disease grade 7 was observed in eight genotypes: BCH-42-1, Pant C-1-B, G-4-S, Rajput, M-262, JCH-42, Arka Meghana, and LCA-206.
The susceptible check Byadagi dabbi and Byadagi kaddi had a disease grade of 7 and were susceptible. Table 2 and Figure 1 display the results. Among the 30 genotypes tested, none were found to be immune or highly susceptible [29, 30].
It showed that the genotypes were distinctly different from each other in suspect of anthracnose prevalence under field as well as laboratory condition. The findings revealed that the varieties differed significantly in terms of anthracnose prevalence under natural field conditions.
Byadagi dabbi (59.80%) had the highest disease index, followed by Byadagi kaddi (58.46%), G-4-S (57.86%), Pant C-1-B (57.35%), and M-262 (57.35%). PBC-80 (05.91%) has the lowest disease index, followed by G-4-L (06.36%), M-421 (07.86%), BCH-42-F2-2 (11.25%), and SUM-17 (11.25%). The percent disease incidence is also calculated, and genotype B.dabbi (61.30%) has the highest percentage of disease incidence, followed by B.kaddi (59.52%), G-4-S (58.71%), Pant C-1-B (57.20%), and M-262 (56.16%). PBC-80 (03.52%) had the least disease incidence, followed by G-4-L (08.75%), M-421 (09.36%), BCH-42-F2-2 (11.84%) and SUM-17 (13.55%). Table 3 showed that the wild relative PBC-80 species *C. baccatum* possesses a resistant source; similar findings were observed by [31].
During 2017-2018, the experiment was repeated to confirm the anthracnose (*Colatotrichum capsici*) resistance source in chilli by selecting promising seven genotypes for anthracnose resistance based on resistance/susceptible reaction. For anthracnose resistance, the results are presented in Table 4.
PBC-80 as well as G-4-L genotypes showed resistance to

anthracnose disease in chilli, whereas ACB1-L and HDC-75-1 genotypes showed moderate resistance. This may be due to pre-formed structures and chemicals, as well as infection-induced immune responses in these genotypes.

Table 1: Scale for grouping of genotypes into resistance and susceptible to anthracnose

Sl. No.	Grade	Percent fruit area infected	Reaction
1	0	0% fruit area infected	Immune
2	1	1-10% fruit area infected	Resistant
3	3	11-25% fruit area infected	Moderately resistant
4	5	26-50% fruit area infected	Moderately susceptible
5	7	51-75% fruit area infected	Susceptible
6	9	>75% fruit area infected	Highly susceptible

Table 2: Grouping of chilli genotypes to anthracnose disease reaction

Disease reaction	Number of genotypes	Name of genotypes
Resistance	03	PBC-80 (1)*
		G-4-L (1)
		M-421 (1)
Moderately resistance	07	BCH-42-F$_2$-2 (3)
		SUM-17 (3)
		RAB-1 (3)
		P-3 (3)
		HDC-75-1 (3)
		ACB1-L (3)
		Selection-1 (3)
Moderately susceptible	10	Sitara (5)
		Sankeshwar (5)
		BCH-42-F$_2$-1 (5)
		JNB-1 (5)
		Tiwari (5)
		Byadagi dabbi-1 (5)
		BVC-42 (5)
		9608-U (5)
		KA2-L (5)
		KBCH-1 (5)
Susceptible	08	JCH-42 (7)
		Arka Meghana (7)
		Rajput (7)
		BCH-42-1 (7)
		LCA-206 (7)
		M-262 (7)
		Pant C-1-B (7)
		G-4-S (7)
Checks		
Susceptible	02	Byadagi dabbi (7)
		Byadagi kaddi (7)

Table 3: Reaction of genotypes to anthracnose disease in chilli during 2016-2017

Sl. No.	Genotypes	Disease Incidence (%)	Disease Index (%)
01	PBC-80	03.52	05.91
02	9608-U	44.02	45.09
03	Sitara	27.34	26.45
04	BCH-42-1	54.48	53.92
05	KBCH-1	48.62	49.45
06	SUM-17	13.55	12.94
07	RAB-1	14.63	14.17
08	M-421	09.36	07.86
09	Pant C-1-B	57.20	57.35
10	G-4-L	08.75	06.36
11	P-3	17.50	16.82
12	BVC-42	43.40	42.86
13	G-4-S	58.71	57.86
14	Byadagi dabbi-1	41.63	41.71
15	BCH-42-F$_2$-1	31.73	31.72
16	Selection-1	24.70	23.61
17	BCH-42-F$_2$-2	11.84	11.25

18	Sankeshwar	28.82	28.18
19	Tiwari	39.41	40.32
20	HDC-75-1	20.10	19.32
21	Rajput	52.25	53.40
22	ACB1-L	23.25	22.15
23	M-262	56.16	56.12
24	JCH-42	51.35	51.63
25	KA2-L	47.54	47.52
26	Arka Meghana	51.81	52.84
27	JNB-1	35.50	36.60
28	LCA-206	55.61	54.92
Susceptible checks			
29	Byadagi dabbi	61.30	59.80
30	Byadagi kaddi	59.52	58.46

Table 4: Reaction of genotypes to anthracnose disease in chilli during 2017-2018

Genotypes	Reaction to Anthracnose disease			Disease Grade
	Disease index (%)	Disease incidence		
		Field	Protected	
PBC80	05.50	04.07	5.18	1
G-4-L	08.33	09.72	9.47	1
G-4-S	61.11	55.37	57.37	7
M-262	55.56	52.15	52.60	7
ACBL-L	22.22	18.42	19.23	3
HDC-75-1	22.22	18.78	18.12	3
Sankeshwar (c)	27.27	21.68	22.44	5

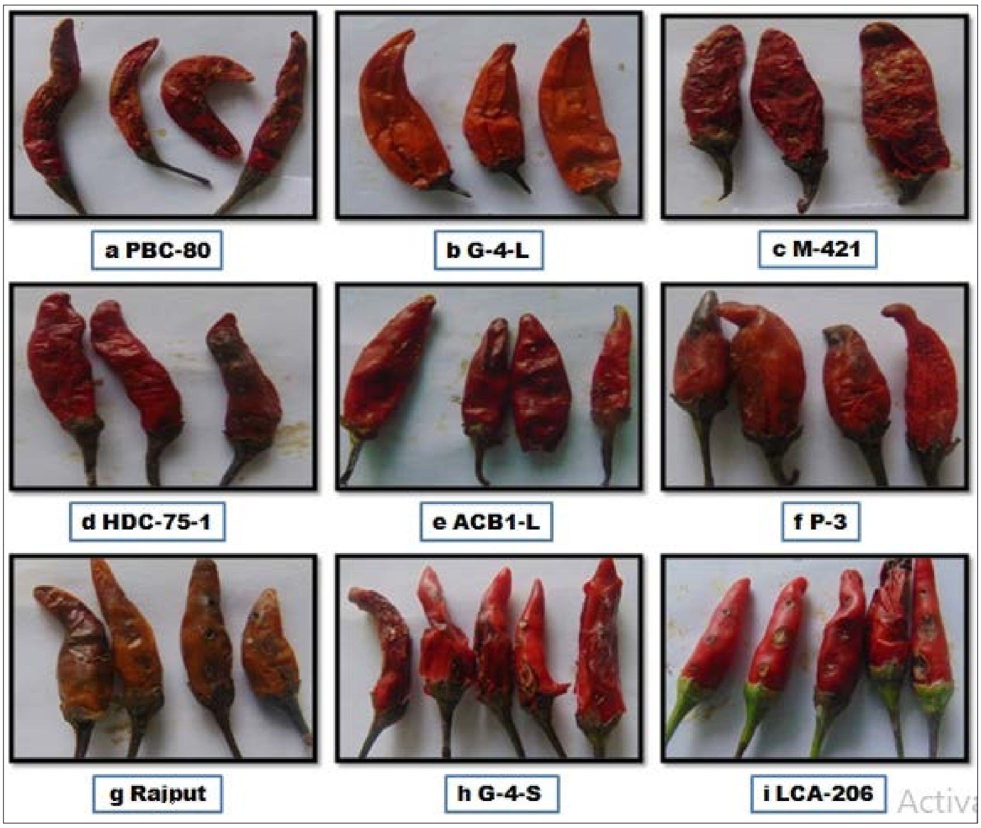

Fig 1: Genotypes showing highly resistant (a, b & c), moderately resistant (d, e & f) and susceptible (g, h & i) to anthracnose disease in chilli

Conclusions

Since anthracnose disease has represents a threat to the cultivation of the chilli crop, preliminary research to find resistance sources for these diseases has initiated. Three genotypes, PBC-80, G-4-L, and M421, indicated anthracnose resistance. The identified resistant genotypes may not have desirable agronomic traits and thus may not be directly introduced for large-scale cultivation, but they can be used as donors in the future anthracnose disease resistance breeding programme.

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References

1. Mishra RE, Rout RK, Joshi. Identification of resistant

sources against anthracnose disease caused by *Colletotrichum truncatum* and *Colletotrichum gloeosporioides* in *Capsicum annuum* L. Proc. Natl. Acad. Sci. India Sect. B Biol. Sci. 2019;89:517
2. Tong N, Bosland PW. *Capsicum tovarii*, a new member of the *Capsicum baccatum* complex. Euphytica. 1999;109(2):71-77.
3. Anonymous. Horticultural Statistics at a Glance, Horticulture Statistics Division Department of Agriculture, Cooperation & Farmer's Welfare Ministry of Agriculture & Farmer's Welfare Government of India, 2018, 11. http://nhb.gov.in/statistics/Publication/Horticulture%20Statistics%20at%20a%20Glance-2018.pdf
4. Pathirana R. Peppers: Vegetable and spice capsicums. In: Bosland PW, Votava EJ, editors. Crop Production Science in Horticulture Series 22. 2nd ed. Wallingford, UK: CAB International, 2012, 248.
5. Osuna-Garcia JA, Wall MM, Waddell CA. Endogenous levels of tocopherols and ascorbic acid during fruit ripening of new Mexican-type Chile (*Capsicum annuum* L.) cultivars. Journal of Agricultural and Food Chemistry. 1998;46(12):5093-5096
6. Marin A, Ferreres F, Tomas-Barberan FA, Gil MI. Characterization and quantitation of antioxidant constituents of sweet pepper (*Capsicum annuum* L.). Journal of Agricultural and Food Chemistry. 2004;52(12):3861-3869.
7. Singh RS. Disease of Vegetable Crops. 2nd ed. New Delhi: Publishing Company Pvt. Ltd, 1987, 362.
8. Dev U, Akhtar J, Chaudhury R, Kandan A, Chand D, Kumar J. Survival of *Colletotrichum capsici* (Syd.) Butler & Bisby in decade-long cryopreserved chilli seeds. Seed Research. 2012;40(1):92-94.
9. Isaac S. Fungal-Plant Interactions. London: Chapman and Hall Press, 1992, 115.
10. Azad P. Fate and role of chemical constituents of chilli fruits during infection with *Colletotrichum capsici*. Indian Phytopathology. 1991;44:129-131.
11. Mistry DS, Sharma IP, Patel ST. Bio-chemical parameters of chilli fruits as influenced by *Colletotrichum capsici* (sydow) butler and bisby infection. Karnataka Journal of Agricultural Sciences. 2010;21(4):586-587.
12. Don LD, Van TT, Phuong V, Kieu PT. *Colletotrichum* spp. Attacking on chilli pepper growing in Vietnam. Country report. In: Abstracts of the First International Symposium on Chilli Anthracnose. Republic of Korea: National Horticultural Research Institute, Rural Development of Administration, 2007, 24.
13. Byung SK. Country report of anthracnose research in Korea. In: First International Symposium on Chili Anthracnose. Seoul: Hoam Faculty House, Seoul National University, 2007, 24.
14. Sariah M. Incidence of *Colletotrichum* spp. on chili in Malaysia and pathogenicity of *C. gloeosporioides*. BIOTROP Special Publication. 1994;54:103-120.
15. Poonpolgul S, Kumphai S. Chilli pepper anthracnose in Thailand. In: Oh DG, Kim KT, editors. Abstracts of the First International Symposium on Chilli Anthracnose. Rural: National Horticultural Research Institute, 2007, 23.
16. Lakshmesha KK, Lakshmidevi N, Mallikarjuna SA. Changes in pectinase and cellulase activity of *Colletotrichum capsici* mutants and their effect on anthracnose disease on *capsicum* fruit. Archives of Phytopathology and Plant Protection. 2005;38(4):267-279.
17. Ramachandran N, Rathnamma K. *Colletotrichum acutatum*-A new addition to the species of chilli anthracnose pathogen in India. In: Annual Meeting and Symposium of Indian Phyto-pathological Society. Kasarago: Central Plantation Crops Research Institute, 2006, 27-28.
18. Singh RS. Disease of Vegetable Crops. 2nd ed. New Delhi: Publishing Company Pvt. Ltd, 1987, 362.
19. Akhtar J, Singh B, Kandan A, Kumar P, Dubey SC. Status of *Colletotrichum* species infecting chilli germplasm processed for pathogen-free conservation in national gene bank, India. Bangladesh Journal of Botany. 2017;46(2):631-637.
20. Neetha J, Mohanrao A, Ramesh S, Manjunath B, Mangalagowri N, Ashwini M. "Tagging SSR markers to genomic regions associated with anthracnose disease resistance and productivity per se traits in hot Pepper (*Capsicum annuum* L.)." Env. Eco. 2016;34(4A):1440-1446.
21. Thilagam R, Hemalatha N. Plant growth promotion and chilli anthracnose disease suppression ability of rhizosphere soil actinobacteria. J. Appl. Micro. 2019;126(6):1835-1849.
22. Mishra R, Rout E, Joshi RK. Identification of resistant sources against anthracnose disease caused by *Colletotrichum truncatum and Colletotrichum gloeosporioides* in *Capsicum annuum* L. Proceedings of the national academy of sciences, india section b: biological sciences, 2018, 1-8.
23. Suwor P, Jirawat S, Petcharat T, Sanjeet K, Suchila T. Inheritance analysis of anthracnose resistance and marker-assisted selection in introgression populations of Chili (*Capsicum annuum* L.). Scientia Horticulturae. 2017;220(16):20-26.
24. Suwor P, Thummabenjapone P, Sanitchon J, Kumar S, Techawongstien S. Phenotypic and genotypic responses of Chili (*Capsicum annuum* l.) progressive lines with different resistant genes against anthracnose pathogen (*Colletotrichum* spp.). Eur. J Plant Path. 2015;143:725-736.
25. Ali APK, Bordoh A, Singh Y, Siddiqui, Droby S. Postharvest development of anthracnose in pepper (Capsicum spp.): Etiology and management strategies. Crop. Prot. 2016;90:132-141.
26. Gupta V, Kaur A. Comparative studies on isolation, identification and purification of *Colletotrichum capsici* causing anthracnose disease of Chilli. Int. J Chemical Studies. 2017;5(6):744-747.
27. Naik MK, Angadi HD, Devikarani GS, Patil MG. Evaluation of Chilli (*Capsicum annuum* L.) genotypes, fungicides and plant products for management of anthracnose disease. J Mycopath. Res. 2008;46(2):213-219.
28. Mayee CD, Datar VV. *Phytopathometry.* Technical Bulletin-1 (Special bulletin-3), Marathwada Agric. Univ. Parbhani, Maharashtra, 1986, 29
29. Ajith PM, Manju P. Genetic analysis of yield and resistance to anthraconse in Chilli (*Capsicum annuum* L). Int. J. Agric. Innov. Res. 2015;4(1):2319-2321.
30. Machenahalli SR, Nargund VB, Sridevi O. Reaction of Chilli genotypes against fruit rot complex. Int. J Life Sci. 2016;11(2):715-719.
31. Susheela K. Evaluation of screening methods for anthracnose disease in Chilli. Pest Manage. Horti. Ecos. 2012;18(2):188-19.