Preliminary Screening of Indigenous *Curcuma* Germplasm against Taphrina Leaf Blotch and Colletotrichum Leaf Spot

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A total of 237 accessions of various species of the genus *Curcuma* such as *Curcuma brog* Val. (2), *C. amarissima* Rosc. (5), *C. aromatica* Salisb. (34), C. *caesia* Roxb. (5), *C. comosa* Roxb. (2), C. *ferruginea* Roxb. (2), *C. haritha* Mangaly & Sabu (15), *C. latifolia* Rosc. (2), *C. leucorrhiza* Roxb. (6), *C. aeruginosa* Roxb. (38), *C. montana* Roxb. (1), *C. amada* Roxb. (49), C. *soloensis* Val. (1), *C. zanthorrhiza* Roxb. (45), *C. longa* var. *vanaharidra* Vela *et al*. (1), C. *amada* var. *glabra* Vela *et al*. (7) and *C. raktakanta* Mangaly & Sabu (8) and two unidentified entities (14 accessions) collected from different ecogeographical regions of India and maintained at Vellanikkara were subjected to observation on incidence of Taphrina leaf blotch and Colletotrichum leaf spot diseases under natural epiphytotic conditions at Vellanikkara which is a hot spot for these diseases. The results indicated a complete absence of Taphrina leaf blotch symptom in ten entities containing 97 accessions. Four entities with 14 accessions showed complete absence of symptoms of both the diseases over the years. With respect to Colletotrichum leaf spot disease variation among the species and within the species over the years was noticed.

Key Words: Colletotrichum leaf spot, *Curcuma,* Germplasm, Taphrina leaf blotch

Introduction

The genus *Curcuma* consists of an important condiment such as turmeric and several medicinally useful as well as edible wild and cultivated species. The genus includes around 120 species (Skornickova and Sabu, 2002) distributed mainly in tropical and sub-tropical Asia extending to Australia. India has largest area under turmeric cultivation. Sporadic cultivation of mango ginger (*C. amada*) and yellow zedoar (*C. zanthorrhiza)* is also noticed. Apart from this, a large number of wild species numbering 29 also occur (Karthikeyan *et al.*, 1989). However, according to Velayudhan *et al.* (1999) the number of Indian species may be around 40. Several distinct entities of the genus have been collected and maintained at NBPGR Regional station, Thrissur without proper identity in some accessions due to lack of flowering, large number of species numbering 19 happens to be from southern region along the Western Ghats (Sabu, 2006). As a part of the exploration and collection of genetic resources of turmeric and its wild relatives in India, NBPGR had amassed a huge wealth leading to their characterization, classification and conservation. A total of 248 accessions belonging to 16 species of *Curcuma* such as *C. aeruginosa, C. amada, C. amada* var. *glabra, C. amarissima, C. aromatica, C. brog, C. caesia, C. comosa, C. ferruginea, C. haritha, C. latifolia, C. leucorrhiza,* (Velayudhan *et al.,* 2009a), *C. longa* var. *vanaharidra* (Velayudhan *et al.,* 2009b), *C. Montana, C. raktakanta, C. soloensis,* and *C. zanthorrhiza* along with some unidentified entities have been conserved at NBPGR, Vellanikkara, Thrissur. Turmeric (*C. longa* L.) being an important crop of both ethnic and commercial importance in India (Velayudhan *et al.*, 1999), two diseases such as leaf blotch disease caused by *Taphrina maculans* Butl. and leaf spot caused by *Colletotrichum capscici* (Syd.) Butl. commonly occur in all turmeric-growing areas in India. *T. maculans* was first described by Butler (1911) from Gujarat and Uttar Pradesh in India and also from Pakistan. Reddy *et al.* (1963) and Upadhyay and Tyagi (1974) reported varietal reaction to leaf blotch in turmeric. Recently, Prasadji *et al.* (2005) reported variation in turmeric with respect to incidence of these diseases. However, information on this aspect in case of various tuber bearing species of the genus *Curcuma* could not be traced in literature. Hence as a part of the preliminary characterization and evaluation, the surviving accessions of various species of *Curcuma* have been subjected to observation on the incidence of the above two diseases under natural field conditions. The results of the study are dealt in the paper.

Materials and Methods

A total of 236 accessions of various *Curcuma* species (Table 1) such as *C. brog* Val.(2), *C. amarissima* Rosc. (5), *C. aromatica* Salisb. (34), C. *caesia* Roxb. (5), *C. comosa* Roxb. (2), C. *ferruginea* Roxb. (2), *C. haritha* Mangaly & Sabu (15), *C. latifolia* Rosc. (2), *C. leucorrhiza* Roxb.

(6), *C. aeruginosa* Roxb. (38), *C. montana* Roxb. (1), *C. amada* Roxb. (49), *C. soloensis* Val. (1), *C. zanthorrhiza* Roxb. (45), C. *raktakanta* Mangaly & Sabu (8), *C. longa* var. *vanaharidra* (1) and *C. amada* var. *glabra* (7), and two unidentified entities *Curcuma* sp. 1 (6), and *Curcuma* sp. 2 (8) were planted in 1994 on permanent raised beds in partially shaded and rain fed conditions at Vellanikkara (10º 50' N latitude and 76º 20' E longitude and 20 m altitude) with 3,631 mm average annual rainfall and laterite soil. Three plants per collection were planted in lines at line-to-line and plant-to-plant distance of 1x 0.3 m. The plants were allowed to regenerate and perpetuate themselves there itself for facilitating observation on flowering. The beds were weeded out once during June and FYM along with dry decayed mulch were applied with one earthing up. These plants exhibited symptoms of Taphrina leaf blotch and Colletotrichum leaf spot disease every year at the late vegetative crop growth period during October-November. Since these diseases have been recurring at the site every year since 1978, the year of start of *Curcuma* conservation and the place is undoubtedly a hot spot for the diseases. Plants kept on permanent beds favoured the natural inoculum build up and spread during the main rainy season every year. During 2004 and 2006 plants grew vigorously and got infection at later stage and were observed for incidence of both the diseases. Observation was made on three plants subjectively and was scored on 0-9 scale based on magnitude of disease expression on all the leaves of all the suckers of each plant as done in the case of turmeric by Velayudhan and Liji (2003) and infestation severity was calculated as per the formula given by Misra and Chowdhury (1997). In case of *C. aeruginosa*, 36 accessions were observed during 2004 and 38 during 2006. In *C. amada* 47 accessions were observed in 2004 and 49 during 2006. In *Curcuma* sp. 27 accessions could be observed during 2004 and six during 2006. Out of nine classes observed from 0-8, class 0 indicated the absence of any symptom, classes 1-3 low, classes 4-5 medium and classes 6-8 high incidence of each disease separately. The data were analyzed as per standard statistical procedures. Plant pathologists from Department of Pathology, KAU, Vellanikkara, have helped in identification of diseases.

Formula for calculation of dicease severity:

$$\text{Infection severity (\%)} = \frac{\text{Sum of all infection ratings}}{\text{Total number of ratings} \times \text{Maximum score}} \times 100$$

Table 1. Materials used for the study

Species	Origin	Years	
		2004	2006
Curcuma sp. 1	Kerala	6	6
Curcuma sp. 2	Odisha	8	8
C. aerugenosa Roxb.	Kerala, Karnataka	36	38
C. amada Roxb.	Kerala, Tamil Nadu, NE	47	49
C. amada var. *glabra* Vela *et al.*	Kerala	7	6
C. amarissima Roxb.	North-east (NE)	5	5
C. aromatica Salisb.	South	34	34
C. brog Val.	North-east (NE)	2	2
C. caesia Roxb.	North-east (NE)	5	5
C. comosa Roxb.	North-east (NE)	2	2
C. ferrugenia Roxb.	North-east (NE)	2	2
C. haritha Mangaly & Sabu	Kerala	15	15
C. latifolia Rosc.	North-east (NE)	2	2
C. leucorrhiza Roxb.	Odisha	6	6
C. longa var. *vanaharidra* Vela *et al.*	Andhra Pradesh	1	1
C. montana Roxb.	Odisha	1	1
C. raktakanta Mangaly & Sabu	Kerala, Karnataka	8	8
C. soloensis Val.	North-east (NE)	1	1
C. *zanthorrhiiza* Roxb.	Kerala, Taminadu	45	45
		236	**236**

Results and Discussion

Frequency distribution of the diseases for each year is given in Table 2 along with disease severity percentage of diseases for each species. Range, mean, SD for both diseases in each species after pooling the data for two years is furnished in Table 3. Accessions, which were completely free of symptoms in both the years, are listed separately for each disease in Table 4.

The results indicated that more variation is existing in the case of Colletorichum leaf spot disease as compared to that for Taphrina leaf blotch. Among various species observed, *C. caesia* (5) *C. ferruginea* (2), *C. comosa* (2), *C. montana* (1) and *Curcuma* sp. 3 (5) as depicted in Table 4 did not express any disease symptoms. Seed setting is absent in all the entities except in the case of *C. montana* probably pointing to triploid nature of most of these species. *C . montana* with seed set probably appears to be an entity that may be exploited in conventional breeding programme for disease resistance in turmeric if proved resistant after screening under controlled conditions. Taphrina leaf blotch disease incidence was observed in different accessions of *C. brog* (2), *C. amarissima* (5), *C. aromatica* (34), *C. latifolia* (2), *C. leucorrhiza* (6), *C. aeruginosa* (36), *C. amada* (47 during 2004 and 48 during 2006), *C. harita* (15 during 2004 and 14 during 2006), *C. raktakanta* (8 during 2004), *C. zanthorrhiza* (45 during 2004 and 43 during 2006), *C. amada* var. *glabra* (seven during 2004 and six during 2006) and *Curcuma* sp. 2 (eight during

Table 2. Frequency class distribution of Taphrina leaf blotch and Coletotrichum leaf spot disease for 2004 and 2006

Species	Year	Disease	Score									Disease severity (%)
			0	1	2	3	4	5	6	7	8	
Curcuma sp. 1	04	*Taphrina*	6									0
	06	*Taphrina*	6									
	04	*Colletotrichum*	6									0
	06	*Colletotrichum*	6									
Curcuma spp. 2	04	*Taphrina*	8									12.5
	06	*Taphrina*	7	1								
	04	*Colletotrichum*	5	3								16.67
	06	*Colletotrichum*	3	2	1	1			1			
C. aeruginosa	04	*Taphrina*	36									0
	06	*Taphrina*	38									
	04	*Colletotrichum*	1		1	4	5	16	6	3		63.13
	06	*Colletotrichum*	1		2	4	16	14	1			
C. amada	04	*Taphrina*	47									0.52
	06	*Taphrina*	48	1								
	04	*Colletotrichum*	2	17	20	5	2	1				35.94
	06	*Colletotrichum*	48		1							
C. amada var. *glabra*	04	*Taphrina*	7									0
	06	*Taphrina*	6									
	04	*Colletotrichum*	5		1		1					21.43
	06	*Colletotrichum*	2	2	1	1						
C. amarissima	04	*Taphrina*	5									0
	06	*Taphrina*	5									
	04	*Colletotrichum*	4		1							15
	06	*Colletotrichum*	4	1								
C. aromatica	04	*Taphrina*	34									0
	06	*Taphrina*	34									
	04	*Colletotrichum*		15	8	6	1	4				39.64
	06	*Colletotrichum*			3	4	14	6	5	1	1	
C. brog	04	*Taphrina*	2									0
	06	*Taphrina*	2									
	04	*Colletotrichum*		1	1							62.5
	06	*Colletotrichum*		2								
C. caesia	04	*Taphrina*	5									0
	06	*Taphrina*	5									
	04	*Colletotrichum*	5									0
	06	*Colletotrichum*	5									
C. comosa	04	*Taphrina*	2									0
	06	*Taphrina*	2									
	04	*Colletotrichum*	2									0
	06	*Colletotrichum*	2									
C. ferruginea	04	*Taphrina*	2									0
	06	*Taphrina*	2									
	04	*Coletotrichum*			2							50
	06	*Coletotrichum*				2						
C. harita	04	*Taphrina*	15									23.3
	06	*Taphrina*	1	6	2	3	1	1	1			
	04	*Colletotrichum*	11	3	1							6.1
	06	*Colletotrichum*	14						1			
C. latifolia	04	*Taphrina*	2									0
	06	*Taphrina*	2									
	04	*Colletotrichum*			2							50
	06	*Colletotrichum*	2									
C. leucorrhiza	04	*Taphrina*	6									0
	06	*Taphrina*	6									
	04	*Colletotrichum*	4	2								25
	06	*Colletotrichum*	5	1								

Species	Year	Disease	Score									Disease severity (%)
			0	1	2	3	4	5	6	7	8	
C. longa var. *vanaharidra*	04	*Taphrina*	1									0
	06	*Taphrina*	1									
	04	*Colletotrichum*	1									0
	06	*Colletotrichum*	1									
C. montana	04	*Taphrina*	1									0
	06	*Taphrina*	1									
	04	*Colletotrichum*	1									0
	06	*Colletotrichum*	1									
C. raktakanta	04	*Taphrina*	8									34.36
	06	*Taphrina*		5	3							
	04	*Colletotrichum*	3	4	1							25
	06	*Colletotrichum*	6	2								
C. soloensis	04	*Taphrina*	1									50
	06	*Taphrina*		1								
	04	*Colletotrichum*		1								100
	06	*Colletotrichum*		1								
C. zanthorhiza	04	*Taphrina*	45									4.4
	06	*Taphrina*	43	2								
	04	*Colletotrichum*	44	1								1.11
	06	*Colletotrichum*	45									

Table 3. Species-wise minimum and maximum, mean, Standard deviation for *Taphrina* leaf spot disease and *Colletotrichum* leaf blotch disease

Species	Parameters	Taphrina leaf spot	Colletotrichum leaf blotch	Number of collections
Curcuma sp. 1	Range	0	0	5
	Mean	0	0	
	SD	0	0	
Curcuma sp. 2	Range	0-1	0-6	8
	Mean	0.063	1	
	SD	0.25	1.59	
C. aerugenosa	Range	0	0-7	38
	Mean	0	4.49	
	SD	0	1.20	
C. amada	Range	0-2	0-5	48
	Mean	0.01	0.91	
	SD	0.10	1.14	
C. amada var. *glabra*	Range	0-2	0-5	7
	Mean	0.01	0.91	
	SD	0.10	1.14	
C. amarissima	Range	0	0-1	5
	Mean	0	0.25	
	SD	0	0.5	
C. aromatica	Range	0	1-8	35
	Mean	0	3.26	
	SD	0	1.76	
C. brog	Range	0	1-2	2
	Mean	0	1.25	
	SD	0	0.5	
C. caesia	Range	0	0	5
	Mean	0	0	
	SD	0	0	
C. comosa	Range	0	0	2
	Mean	0	0	
	SD	0	0	
C. ferruginea	Range	0	0	2
	Mean	0	0	
	SD	0	0	
C. harita	Range	0-6	0-6	15
	Mean	1.67	0.36	
	SD	1.67	1.18	
C. latifolia	Range	0	0-2	2
	Mean	0	1	
	SD	0	1.155	
C. leucorrhoea	Range	0	0-1	6
	Mean	0	0.29	
	SD	0	0.47	
C. longa var. *vanaharidra*	Range	0-1	0	1
	Mean	0.5	0	
	SD	0.5	0	
C. montana	Range	0	0	1
	Mean	0	0	
	SD	0	0	
C. raktakanta	Range	0-2	0-2	8
	Mean	0.69	0.5	
	SD	0.79	0.79	
C. soloensis	Range	0-1	1-1	1
	Mean	0.5	1	
	SD	696.36	0	
C. zanthorrhiza	Range	0-1	0-3	45
	Mean	0.02	0.23	
	SD	0.15	0.23	

Table 4. Species showing absence of disease symptoms

Species	Number of collections	Collection identity
Species and collections showing absence of symptoms of both diseases		
Curcuma sp. 3	5	IC266596, 349879B, 210466, 349850A and 349879
C. caesia	5	IC313064, 313085, 266511, 266608 and 331735
C. comosa	2	IC313097 and 313092
C. ferrugenia	2	IC 266513 and 313098
C. latifolia	2	IC266595 and 313093
C. montana	1	IC406441
Species and collections showing absence of *Colletotrichum* only		
C. longa var. *vanaharidra*	1	IC360212
Species and collections showing absence of *Taphrina* only		
C. aeruginosa	33	IC 88593, 266532, 88842, 88843, 88844, 88845, 88846, 70009, 70013, 70015, 70061, 70072, 88848, 70110b, 88849, 88888, 88917, 88914, 88912, 313083, 266538, 88941, 266546, 266550, 266551, 266553, 266561, 266564, 266566, 266585, 266588, 266591, 266524, 406438, 406439 and 349989
C. amarissima	5	266531, 29968, 266511-B, 210290 and 137087
C. aromatica	32	IC 88850, 88852, 88929, 88853, 88856, 88857, 88858, 88859, 88860, 88861, 313087, 266537, 88938, 88957, 266543, 266544, 313090, 406440, 266569, 266572, 266577, 266579, 266580, 266581, 266582, 266583, 266590, 360204, 360205, 210361 A, 266605, 262716, 34974, 33215 and 349878
C. brog	2	IC 29881 and 313086
C. latifolia	2	IC 266595 and 313093
C. leucorrhiza	5	IC 210263, 210267, 210284, 210325 and 210328

2004 and seven during 2006) showed complete absence of symptoms. On the contrary, Colletotrichum leaf spot disease in the observed species showed good amount of variation between the species, accessions and years as presented in Tables 2 and 3. *C. brog* (2), *C. comosa* (2) and *C. ferrugenia* (2) had mild infection of *Colletotrichum* during both the years. *C. aromatica* showed maximum variation (0-5 scales during 2004 and 0-8 scales during 2006) followed by *C. aeruginosa* with 0-7 during 2004 and 0-6 during 2006 with one free during each year). However, *C. amada* exhibited a wide range of variation (0-6 scale during 2004) and 45 accessions were found to be free from disease. In *C. raktakanta* three got infected in 0-2 scale during 2004 and all were free from infection during 2006. Accessions belonging to *C. harita, C. leucorrhiza, C. zanthorrhiza, C. soloensis* and *C. amada* var. *glabra* and species 2 had mild infection during both the years. Thus**,** more number of species and accessions showing almost a vertical resistance to *Taphrina* and a horizontal resistance to *Colletotrichum* may be probably indicative of the inherent heterogeneity in the genus right from its origin through dibasic amphidiploidy from two unknown progenitors into entities with 2n=42 (Ramachandran, 1961) and later on diversification by triplodization into triploid entities with 2n = 63 chromosomes and palmately branched rhizomes (sessile tubers). Further, among other species, only *C. longa* var. *vanaharidra* with a single collection was free of *Colletotrichum* on one side and susceptible to *Taphrina* on the other side. This entity, though wild is very much related to cultivated turmeric (*C. longa* L.) in almost all characters including those of rhizome quality such as colour and aroma except for its thin fragile leaves with purple brown tint along the midrib. Among the species observed, C*urcuma* sp., *C. amada, C. haritha, C. raktakanta, C. soloensis* and *C. zanthorrhiza* were susceptible to both the diseases at varying intensities. In the case of *C. amada* (Table 2) 47 accessions were free of Taphrina leaf blotch during 2004 where as, the newly added one accession from Orissa with central spike was susceptible during 2006 indicating some heterogeneity in the species with respect to its flowering behaviour. With respect to *Colletotrichum* spot incidence, it was present in all the collections in 2004 and absent in 2006 except in one newly added accession. This probably indicates the influence of climatic and other uncontrollable factors influencing the disease infection on the species. The most susceptible species to Colletotrichum leaf spot appeared to be *C. aromatica*. Under the wild situation, also the disease is rampant in all the localities in Western Ghats from where collections of this have been amassed. Overall results indicated that majority of the species and collections were free from Taphrina leaf blotch and a fair amount of

expression of Colletotrichum leaf spot disease symptom in the genus. With respect to Taphrina leaf blotch disease, severity percentage was 0 in 12 identified entities and in one unidentified species as given in Table 2. Severity percentage for Colletotrichum leaf spot disease varied from 0% in *C. montana*, *C. caesia* and *C. amada* to 100% in *C. soloensis*. Further screening of the accessions without disease symptoms in the present studies is needed under controlled conditions. This can prove to be a very important criteria in the utilization of these germplasm in turmeric improvement. The results may also be useful in tracing the origin and evolution of various species in relation to these diseases. Both vertical and horizontal resistance is suspected in the genus for the diseases.

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