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Cercospora spp. from Goa and neighbouring areas

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ABSTRACT

In this paper, the diversity of cercosporoid foliicolous fungi from Goa and neighbouring areas has been dealt with. The genus *Cercospora* has been reviewed. Eighteen species of *Cercospora*, isolated from different host plants have been described and illustrated. All the species of *Cercospora* reported in this paper are new records to this region.

INTRODUCTION

Genus *Cercospora* was established by Fresenius (1863) based on *C. apii* Fres., a leaf parasite that cause brown spots of celery. The genus is one of the largest in the Hyphomycetes, with over 3000 species. Most of the species are plant pathogens and the specific epithets were host-based (Periera and Barreto, 2006; Den Breeÿen *et al.*, 2006; Hunter *et al.*, 2006). As plant pathogens, they occur on a wide range of hosts in almost all major families of dicots, most monocots, and even some gymnosperms and ferns (Goodwin *et al.*, 2001). According to Crous and Braun (2003), the number of species in the genus *Cercospora* exceeds 5500.

The cercosporoid fungi are characterized by coloured conidiophores. Since Fresenius (1863) did not give a clear-cut definition, Saccardo (1880) circumscribed the genus as having brown conidiophores and brown, olivaceous to sub-hyaline, vermiform conidia. Spegazzini (1910) split the genus and accommodated those species with hyaline conidia in a new genus *Cercosporina*. He also separated *Pseudocercospora* from *Cercospora* based on presence or absence of darkened and thickened conidial scars and hilum. Saccardo in 1913 agreed with the establishment of *Cercosporina* and transferred 89 species from *Cercospora*, including some with coloured as well as hyaline conidia, into the former. Miura (1928) transferred *C. apii* to *Cercosporina*. Considering the presence or absence of external mycelium and prominent stromata, branching of conidiophores, as well as the shape of conidia, Solheim (1930) proposed 21 sections in the genus *Cercospora*. Stevens (1930) accepted Solheim's treatment of *Cercospora*, added conidial scars as criteria and reorganized the genus into 38 sections.

Chupp (1954) monographed the genus *Cercospora* with 1758 species, many of which were new to science. Katsuki (1965) published a monograph on Japanese Cercosporae which included 226 species

based on Chupp's criteria. Deighton (1967, 1973, 1974, 1976) segregated the genus *Cercospora* and reclassified several species in other closely similar genera such as *Cercosporiella*, *Cercosporidium*, *Paracercospora*, *Pseudocercosporiella*, *Pseudocercospora* and *Pseudocercosporidium*. This broad assemblage is now referred to as '*Cercospora* complex'. Species of '*Cercospora* proper' are characterized by conspicuously thickened and darkened conidial scars and hyaline to sub-hyaline, acicular, filiform, multiseptate conidia. In recent years, the genus was divided into several genera based on new criteria, such as conidiomatal structure, mycelium, conidiophores, conidiogenous cells and conidial pigmentation (Crous and Braun, 2003). These criteria have been accepted by most investigators. However, various phylogenetic studies conducted in the recent times have shown that the morphology-based criteria are partly unreliable at the generic level, again leading to a reduction in the circumscription of the genus *Cercospora* (Crous *et al.*, 2000, 2001, 2004, 2006; Schubert and Braun, 2005; Ayala-Escobar *et al.*, 2006).

According to Assente (1977) many species of *Cercospora* are characterized by production of phytotoxic metabolite of polyketide nature, originally called as cercosporin. Fajola (1978) concluded that cercosporin production is associated with 'true' *Cercospora* species and those species that do not produce cercosporin might belong to other related genera. Pons and Sutton (1988) described *Distocercospora* for cercosporoid hyphomycetes having distoseptate scolecospores. Pons and Sutton (1988) and Braun (1993), split *Cercospora sensu lato* into numerous smaller genera based on morphological features exhibited as conidiogenous loci and conidial hila. Braun (1995), Braun and Melnik (1997) and Crous *et al.* (2000) published reviews on *Cercospora*-like generic assemblage. Crous *et al.* (2000) reduced the number of species of *Cercospora* based on molecular studies. Kobayashi *et al.* (1998, 2002), Nakashima *et al.* (2002) and Nakashima *et al.*

Table 1. List of *Cercospora* spp. reported from Goa and neighbouring areas

Sr. No.	Name of <i>Cercospora</i> sp.	Host	Locality
1.	<i>Cercospora amorphophalli</i>	<i>Amorphophallous campanulatus</i>	St. Estevam, Tiswadi Goa; Banastrai, Ponda Goa
2.	<i>Cercospora apii</i>	<i>Impatiens</i> sp.	Bondla, Ponda Goa; Banastari, Ponda Goa; Campal, Panjim Goa
3.	<i>Cercospora arisaemae</i>	<i>Arisaema</i> sp.	Amboli, Sawantwadi, Maharashtra India
4.	<i>Cercospora caladii</i>	<i>Colocasia antiquorum</i>	Valpoi, Sattari Goa; Banastari, Ponda Goa
5.	<i>Cercospora canscorina</i>	<i>Vigna catjang</i>	Caranzalem, Tiswadi Goa; Banastari, Ponda Goa
6.	<i>Cercospora canscorina</i>	<i>Canscora diffusa</i>	Amboli, Sawantwadi, Maharashtra India
7.	<i>Cercospora capsicigena</i>	<i>Capsicum annum</i>	Banastari, Ponda Goa
8.	<i>Cercospora citrullina</i>	<i>Coccinia grandis</i>	Corjuvem, Bardez Goa; Caranzalem, Tiswadi Goa,
9.	<i>Cercospora coicis</i>	<i>Coix</i> sp.	Carambolim, Tiswadi Goa
10.	<i>Cercospora colocasiae</i>	<i>Colocasia antiquorum</i> St.	Estevam, Tiswadi Goa; Paryem, Sattari Goa; Valpoi, Sattari Goa; Bondla, Ponda Goa
11.	<i>Cercospora erythrinicola</i>	<i>Erythrina indica</i>	Donapaula, Tiswadi Goa
12.	<i>Cercospora fukushiana</i>	<i>Impatiens pulcherrima</i>	Amboli, Sawantwadi, Maharashtra India
13.	<i>Cercospora gerberae</i>	<i>Gerbera</i> sp.	NIO Campus, Donapaula, Tiswadi Goa; Banastari, Ponda Goa
14.	<i>Cercospora hydrocotyles</i>	<i>Centella asiatica</i>	Mashem, Cancona Goa; Banastari, Ponda Goa
15.	<i>Cercospora kikuchii</i>	<i>Vigna unguiculata</i>	Banastari, Ponda Goa; Corjuvem, Bardez Goa; Caranzalem, Tiswadi Goa
16.	<i>Cercospora physalidis-minimae</i>	<i>Physalis minima</i>	Calem, Sanguem Goa
17.	<i>Cercospora timorensis</i>	<i>Ipomoeae biloba</i>	Campal, Panjim Goa
18.	<i>Cercospora vanderystii</i>	<i>Vigna unguiculata</i>	Banastari, Ponda Goa; Corjuvem, Bardez Goa; Mashem, Cancona Goa

(2004) added several species of *Cercospora* from the Japanese mycoflora.

MATERIALS AND METHODS

Leaves of different plant taxa bearing leaf spots were collected and brought to the laboratory in zip-seal polythene bags. Each specimen was carefully examined by hand-lens and under the stereomicroscope, for symptomology and colony characteristics. Fungal material from the leaf spot was scrapped with a fine-tipped needle, mounted on a slide containing a drop of lactophenol and examined under a light microscope. Detailed study of morpho-taxonomic characteristics of the fungus was further done under a compound microscope. The material was air-dried and placed in labeled paper bags along with a piece of naphthalene pellet, as herbarium specimen. If the symptom does not exhibit presence of

any associative fungus, the sample was subjected to moist chamber incubation (Hawksworth, 1974). The growing fungi were cultured by single spore isolation method or tissue-plating method (Pratibha, 2006), on a petri plate containing either 2% malt extract agar, 2% potato dextrose agar or leaf extract agar media.

RESULTS

TAXONOMIC PART

1. *Cercospora amorphophalli* Henn., 1902. *Hedwigia* 41: 147 (Fig.1, 1a-c)

Fungus Hyphomycete. Leaf spots amphigenous, circular, dark brown to black in the center with light brown margin, 3 – 5 mm in diam., later the center of the margin collapses, leading to the shot holes; infection observed on entire leaf surface and on most

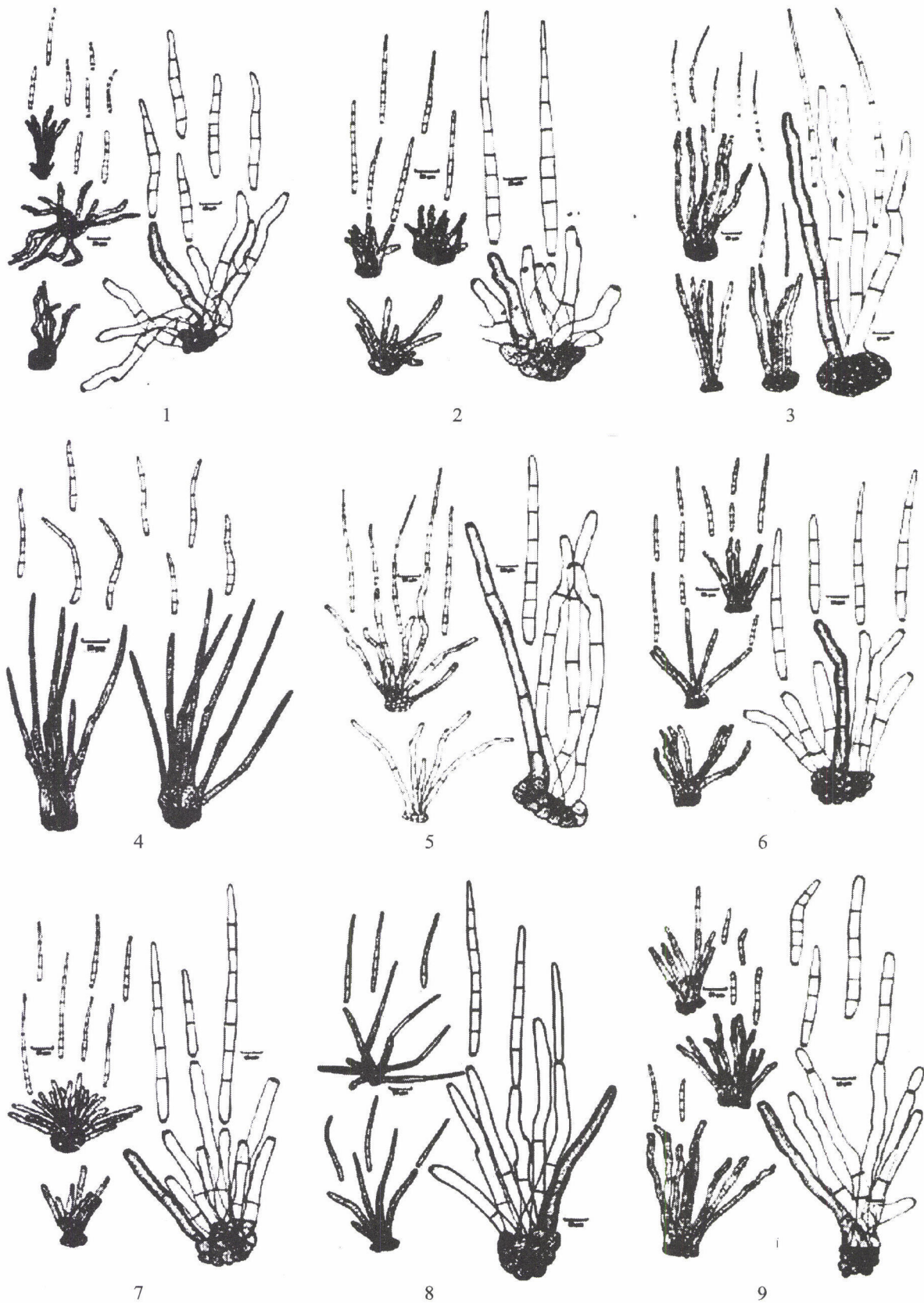


Fig. 1. *Cercospora amorphophalli*, 2. *C. apii*, 3. *C. arisaemae*, 4. *C. caladii*, 5. *C. canescence* 6. *C. cansorina*, 7. *C. capsicigena*, 8. *C. citrullina*, 9. *C. coicis*

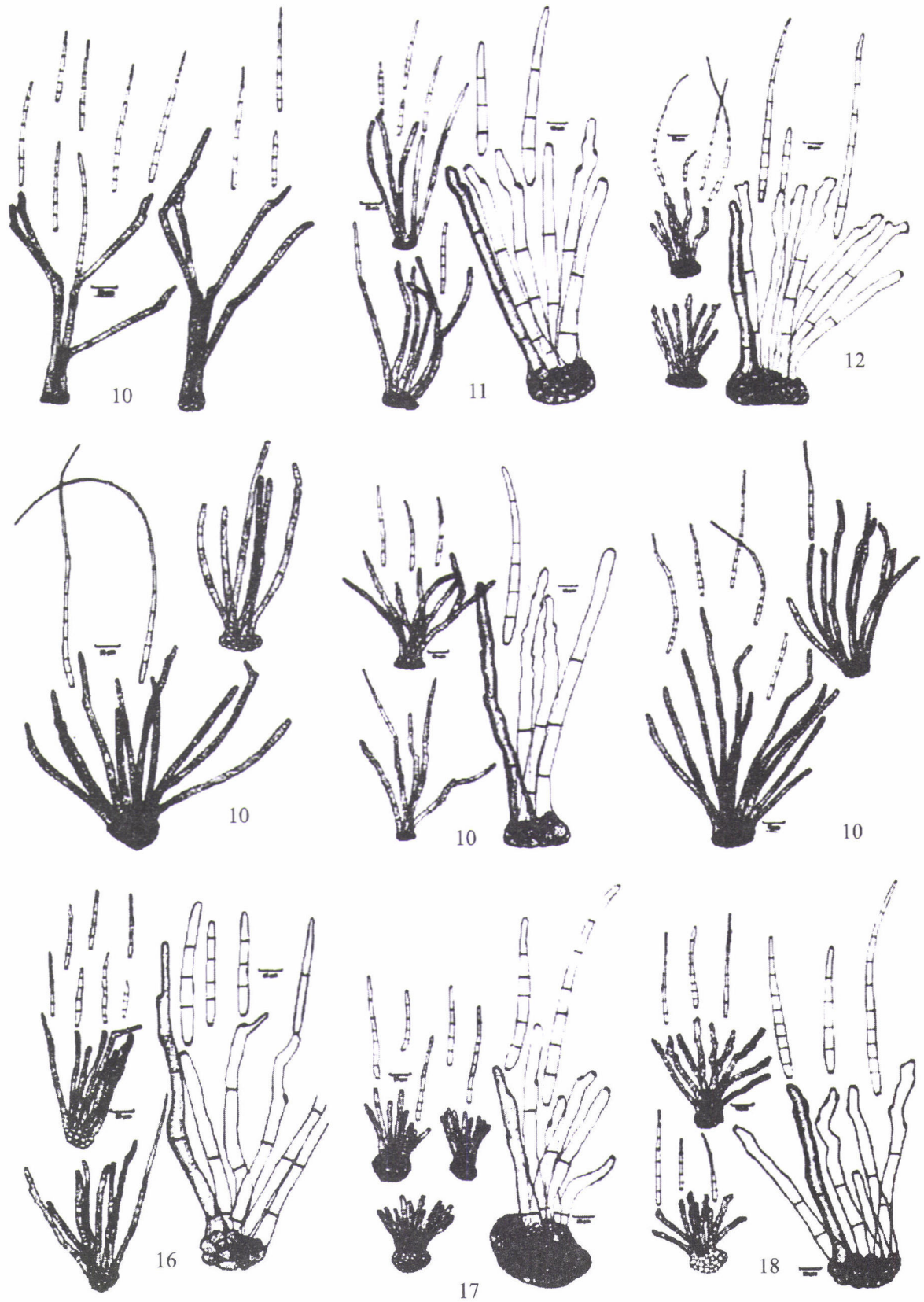


Fig. 10. *Cercospora colocasiae*, 11. *C. erthrinicola*, 12. *C. fukushiana*, 13. *C. gerberae*, 14. *C. hydrocotyles*,
 15. *C. kikuchii*, 16. *C. physalidis-minimae*, 17. *C. timorensis*, 18. *C. vanderystii*

of the leaves. *Colonies* on leaf spots effuse, dark brown, hairy. *Mycelium* immersed. *Stroma* poorly developed, light brown. *Conidiophores* macronematous, mononematous, in loose fascicles, erect, straight to slightly flexuous, unbranched, septate, smooth, pale olivaceous, $40.5 - 215 \times 4 - 7 \mu\text{m}$. *Conidiogenous cells* polyblastic, terminal later becoming intercalary, integrated, determinate, sympodial, cicatrized, conidial scars unthickened, somewhat darkened. *Conidia* solitary, simple, dry, acropleurogenous, hyaline, pluriseptate, scolecosporous, acicular, smooth, straight to slightly flexuous, $20 - 70 \times 3 - 5 \mu\text{m}$, with unthickened, somewhat darkened hilum.

Specimen examined: On living leaves of *Amorphophallous campanulatus* Decne. (Araceae), St. Estevam, Tiswadi, Goa, 19-07-03, Herb. No. GUBH P55; Banastari, Ponda Goa, 02/11/04, Pratibha, J., Herb. No. GUBH P55.

2. *Cercospora apii* Fresen., 1863. *Beitr. Mykol.* 3: 91 (Fig.2, 2a-c)

Leaf spots amphigenous, circular, pale brown with white spot in the centre, margin dark brown, 2-4 mm in diam., observed on the entire leaf surface. *Conidiophores* arising from stomata, $17.5 - 60 \times 3 - 5.5 \mu\text{m}$. *Conidia* 5-8 septate, $57 - 92 \times 2.5 - 5.5 \mu\text{m}$.

Specimen examined: On living leaves of *Impatiens* sp., (Balsaminaceae), Bondla, Ponda Goa, 24/05/03, Herb. No. GUBH P32; Banastari, Ponda Goa, 17/04/04, Herb. No. GUBH P32; Campal, Panjim Goa, 27/08/04, Pratibha, J., Herb. No. GUBH P32.

3. *Cercospora arisaemae* Tai, 1936. *Bull. Chin. Bot. Soc.* 2: 47 (Fig. 3, 3a-c)

Leaf spots amphigenous, circular, brown in the centre with grayish margin, 2-3 mm in diameter, central portion later collapses leaving the shot hole, only one to three spots were seen on each leaf. *Stroma* poorly developed. *Conidiophores* arising in dense fascicles, $50 - 130 \times 4.5 - 7.5 \mu\text{m}$. *Conidia* $65 - 130 \times 2.5 - 4.5 \mu\text{m}$.

Specimen examined: On living leaves of *Arisaema* sp. (Araceae), Amboli, Sawantwadi, Maharashtra India, 17/07/04, Pratibha, J., Herb. No. GUBH P156; Culture No. GUFCC No. 4906.

4. *Cercospora caladii* Cooke, 1880. *Grevillea*, 8(47): 95 (Fig.4, 4a-c)

Leaf spots amphigenous, numerous, circular, light brown with dark brown margin, 1-2 mm in diam., observed on entire leaf surface. *Conidiophores*

arising in loose fascicles, $70 - 150 \times 3 - 4.5 \mu\text{m}$. *Conidia* $70 - 80 \times 2 - 3.5 \mu\text{m}$.

Specimen examined: On living leaves of *Colocasia antiquorum* (Linn.) Schott (Areceae), Valpoi, Sattari Goa, 05/07/03, Herb. No. GUBH P40; Banastari, Ponda Goa, 21/09/04, Pratibha, J., Herb. No. GUBH P40.

5. *Cercospora canescence* Ellis & Martin, 1882. *Nat.* 16: 1003 (Fig. 5, 5a-c)

Leaf spots amphigenous, circular, light brown with grey spot in the centre, tiny about 2-3 mm in diameter, spreading on entire leaf surface, most of the leaves in the field showed infection. *Conidiophores* arising in small to moderately large fascicles, $55 - 220 \times 3 - 5.5 \mu\text{m}$. *Conidia* $30 - 355 \times 3 - 4.5 \mu\text{m}$.

Specimen examined: On living leaves of *Vigna catjang* (Burm.) Walp. (Fabaceae) Caranzalem, Tiswadi Goa, 08/06/03, Herb. No. GUBH P37; Banastari, Ponda Goa, 08/11/04, Pratibha, J., Herb. No. GUBH P37.

6. *Cercospora canscorina* Chidd., 1959. *Sydowia* 13: 155 (Fig. 6, 6a-c)

Leaf spots amphigenous, circular to irregular, light brown, 3-5 mm in diam. *Stroma* brown, 20-25 μm . *Conidiophores* $35 - 90 \times 3 - 7 \mu\text{m}$. *Conidia* $50 - 70 \times 2.5 - 5.5 \mu\text{m}$.

Specimen examined: On living leaves of *Canscora diffusa* (Vahl.) Roem. and Schult. (Gentianaceae), Amboli, Sawantwadi, Maharashtra India. 29/11/03, Pratibha, J., Herb. No. GUBH P117.

7. *Cercospora capsicigena* Bhartiya, Dubey & Singh, 2000. *Indian Phytopath.* 53(2): 149-152 (Fig. 7, 7a-c)

Leaf spots amphigenous, circular, to irregular, initially tiny, later coalescing to form large patches, grayish white in the centre with dark brown to black margin, upto 10 mm wide, spreading on entire leaf surface, many leaves in the field showed the infection. *Stroma* well developed, spherical, compact, brown, 25-35 μm in diam. *Conidiophores* 15-85 \times 3.5-7 μm . *Conidia* 30-120 \times 2-4 μm .

Specimen examined: On living leaves of *Capsicum annum* Linn. (Solanaceae), Banastari, Ponda Goa, 07/04/04, Pratibha, J., Herb. No. GUBH P125.

8. *Cercospora citrullina* Cooke, 1883. *Grevillea* 12(61): 31 (Fig.8, 8a-c)

Leaf spots amphigenous, circular, grey in the centre with light brown margin, tiny about, 1-2 mm

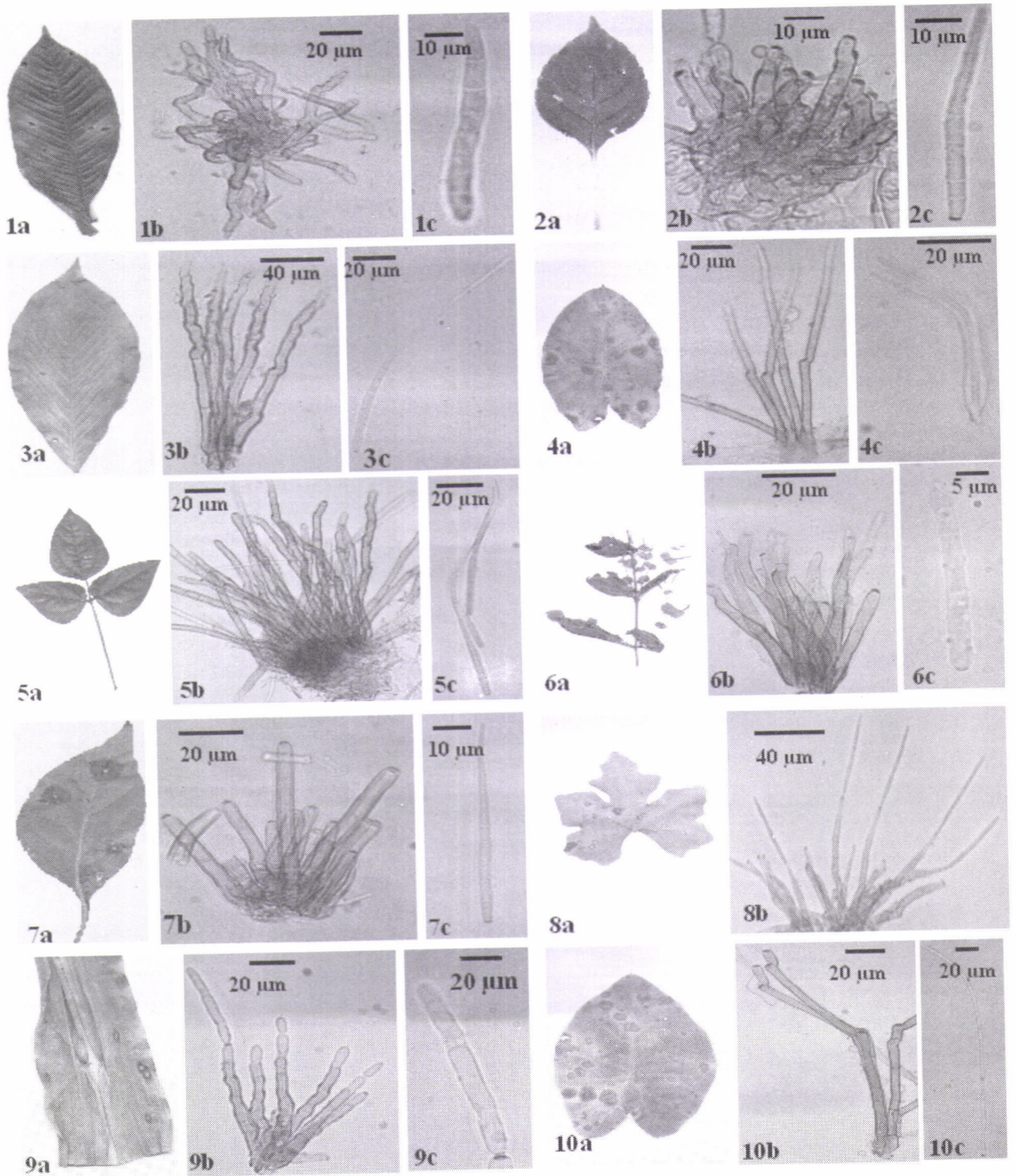


Fig 1a-c *Cercospora amorphophalli*, 2a-c *C. apii*, 3a-c: *C. arisaemae*, 4a-c: *C. caladii*, 5a-c: *C. canescence*, 6a-c: *C. canscorina*, 7a-c. *C. capsicigena*, 8a-c: *C. citrullina*, 9a-c: *C. coicis*, 10a-c: *C. colocasiae*

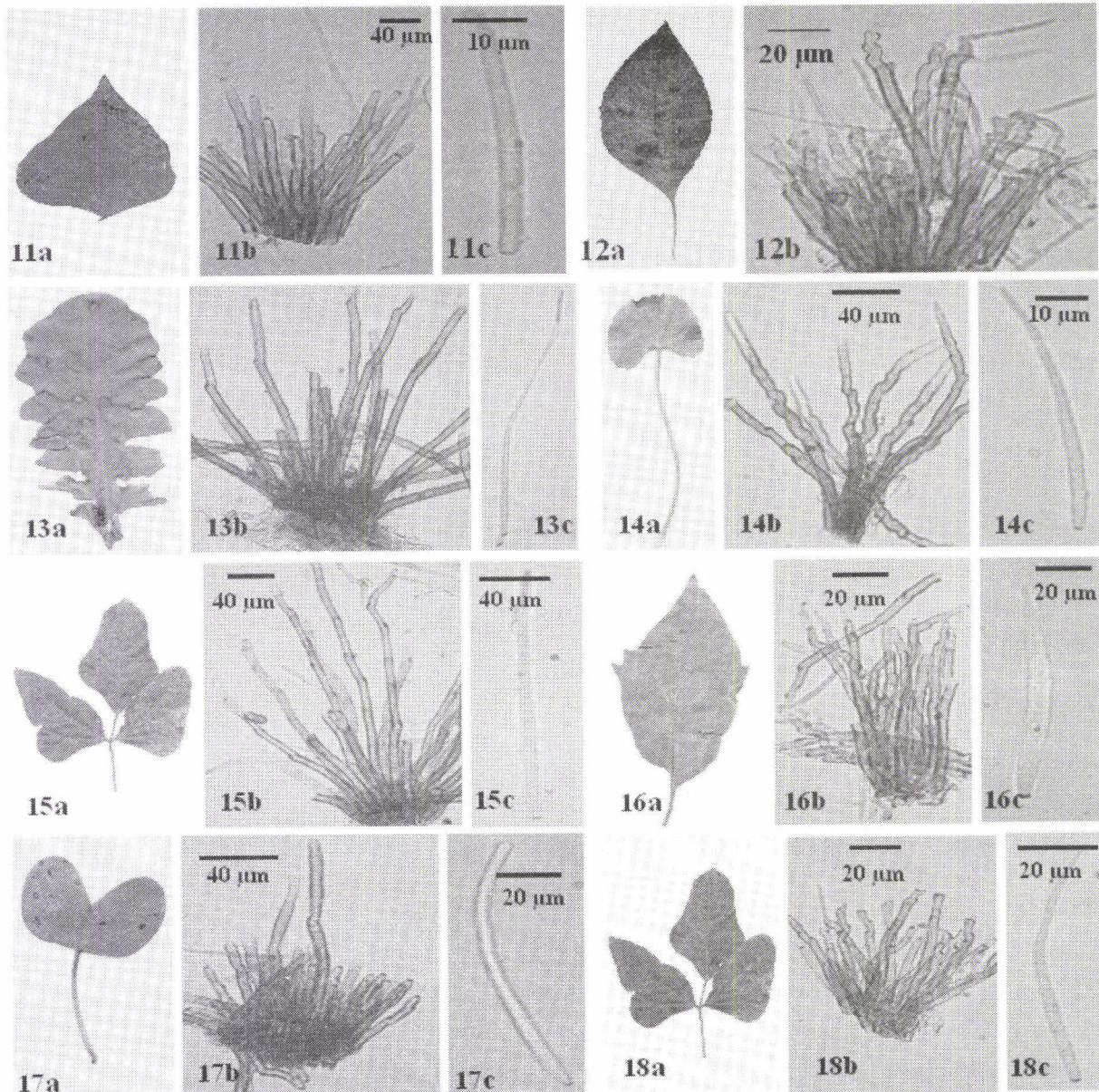


Fig 11a-c : *Cercospora erythrinicola*, 12a-c: *C. fukushiana*, 13a-c: *C. gerberae*, 14a-c: *C. hydrocotyles*, 15a-c: *C. kikuchii*, 16a-c: *C. physalidis-minimae*, 17a-c: *C. timorensis*, 18a-c: *C. vanderystii*

in diameter, observed on almost entire leaf and most of the leaves in the field. *Conidiophores* $35.5 - 80 \times 3 - 7 \mu\text{m}$. *Conidia* $22.5 - 55.5 \times 3.5 - 4.5 \mu\text{m}$.

Specimen examined: On living leaves of *Coccinia grandis* (Linn.) Voigt. (Cucurbitaceae), Corjuvem, Bardez Goa, 31/05/03, Herb. No. GUBH P36; Caranzalem, Tiswadi Goa, 08/06/03, Pratibha, J., Herb. No. GUBH P36.

9. *Cercospora coicis* M.S.Patil & Sawant, 1991.
Indian Phytopath. 44 (1): 17 (Fig. 9, 9a-c)

Leaf spots amphigenous, spindle shaped, gray in the centre with dark brown to black margin, 2-3 mm wide. *Colonies* on leaf spots effuse, light brown, hairy. *Conidiophores* $80 - 130 \times 3.5 - 7.5 \mu\text{m}$. *Conidia* $50 - 80 \times 3 - 6.5 \mu\text{m}$.

Specimen examined: On living leaves of *Coix* sp. (Poaceae), Carambolim, Tiswadi Goa, 01/10/03, Harshala, G., Herb. No. GUBH P102.

10. *Cercospora colocasiae* (Höhn.) Chupp, 1954.
Monograph of Cercospora, 58p (Fig.10, 10a-c)

Leaf spots amphigenous, numerous, circular, light brown with dark brown margin, 1–2 mm in diam., observed on entire leaf surface. *Colonies* on leaf spots effuse, dark brown, hairy. *Conidiophores* in dense fascicles, $130 - 195 \times 3 - 6.5 \mu\text{m}$. *Conidia* $70 - 87.5 \times 3 - 5 \mu\text{m}$.

Specimen examined: On living leaves of *Colocasia antiquorum* (Linn.) Schott (Areceae), St. Estevam, Tiswadi, Goa, 19-07-03, Herb. No. GUBH P54; Paryem, Sattari Goa, 02/07/04, Herb. No. GUBH P54; Valpoi, Sattari Goa, 10/08/04, Herb. No. GUBH P54; Bondla, Ponda Goa, 07/07/05, Pratibha, J., Herb. No. GUBH P54.

11. *Cercospora erythrinicola* Tharp, 1917.
Mycologia, 9: 109 (Fig.11, 11a-c)

Leaf spots amphigenous, circular to irregular, dark brown to black, 6–8 mm wide, only one spot on each leaf was observed on few leaves of the tree. *Colonies* on leaf spots effuse, light brown, hairy. Mycelium immersed. *Conidiophores* $60 - 180 \times 3 - 6 \mu\text{m}$. *Conidia* $55 - 190 \times 3 - 6 \mu\text{m}$.

Specimen examined: On living leaves of *Erythrina indica* Lam. (Fabaceae), Donapaula, Tiswadi Goa, 13/11/03, Pratibha, J., Herb. No. GUBH P112.

12. *Cercospora fukushiana* (Matsuura) Yamamoto, 1943. *J. Soc. Trop. Agr.* 6: 601 (Fig.12, 12a-c)

Leaf spots amphigenous, circular, gray with dark brown margin, 2–5 mm in diameter, later the central portion collapses leaving the shot hole, spreading on entire leaf surface. *Conidiophores* $40 - 130 \times 3 - 6 \mu\text{m}$. *Conidia* $30 - 165 \times 2 - 3.5 \mu\text{m}$.

Specimen examined: On living leaves of *Impatiens pulcherrima* Dalz. (Balsaminaceae), Amboli, Sawantwadi, Maharashtra India, 13/09/03, Pratibha, J., Herb. No. GUBH P82.

13. *Cercospora gerberae* Chupp & Viégas, 1945. In: Viegas, *Boln da Soc. Brasil de Agron.* 8: 27 (Fig.13, 13a-c)

Leaf spots amphigenous circular, sometimes irregular, light brown in the centre with dark brown to black margin, 5–6 mm wide, spreading on entire leaf surface. *Conidiophores* $120 - 305 \times 3.5 - 6 \mu\text{m}$. *Conidia* $150 - 360 \times 3 - 5 \mu\text{m}$.

Specimen examined: On living leaves of *Gerbera* sp. (Asteraceae), NIO Campus, Donapaula, Tiswadi Goa, 12/08/04, Ashish, P., Herb. No. GUBH P165;

Banastari, Ponda Goa, 21/10/04, Pratibha, J., Herb. No. GUBH P165(a).

14. *Cercospora hydrocotyles* Ellis & Everh., 1887. *J. Mycol.* 3: 16 (Fig.14, 14a-c)

Leaf spots amphigenous, circular, light brown, 2–3 mm in diam. *Colonies* on leaf spots effuse, light brown, hairy. *Conidiophores* $70 - 170 \times 4 - 7.5 \mu\text{m}$. *Conidia* $55 - 80 \times 3 - 5 \mu\text{m}$.

Specimen examined: On living leaves of *Centella asiatica* Linn. (Apiaceae), Mashem, Cancona Goa, 06/04/04, Ashish, P., Herb. No. GUBH P172; Banastari, Ponda Goa, 17/06/04, Pratibha, J., Herb. No. GUBH P172(a); Culture No. GUFCC No. 4907.

15. *Cercospora kikuchii* (Tak. Matsumoto & Tomoy.) M. W. Gardner, 1927. *Proc. natn. Acad. Sci. India, Sect. B, Biol. Sci.* 36: 12 (Fig.15, 15a-c)

Leaf spots amphigenous, pale brown, circular, margin dark brown with white spot in the centre, 1–3 mm in diam., present entirely on the surface of the leaf. *Stroma* $30 - 40 \mu\text{m}$ in diam. *Conidiophores* $100 - 150 \times 3.5 - 5.5 \mu\text{m}$. *Conidia* $43 - 132.5 \times 2 - 3.5 \mu\text{m}$.

Specimen examined: On living leaves of *Vigna unguiculata* (Linn.) Walp. (Papilionaceae), Banastari, Ponda Goa, 15/03/03, Herb. No. GUBH P25; Corjuvem, Bardez Goa, 31/05/03, Herb. No. GUBH P25; Caranzalem, Tiswadi Goa, 08/06/03, Herb. No. GUBH P25; Colem, Sanguem Goa, 22/06/04, Pratibha, J., Herb. No. GUBH P25.

16. *Cercospora physalidis-minimae* Pavgi & U.P. Singh, 1965. *Mycopath. Mycol. appl.* 27: 92 (Fig.16, 16a-c)

Leaf spots amphigenous, circular, light brown, 3–5 mm in diameter, central portion later collapses. *Colonies* on leaf spots effuse, light brown, hairy. *Conidiophores* $47 - 120 \times 3.5 - 6.5 \mu\text{m}$. *Conidia* $28 - 85 \times 2.5 - 5 \mu\text{m}$.

Specimen examined: On living leaves of *Physalis minima* Linn. (Solanaceae), Calem, Sanguem Goa, 22/06/04, Pratibha, J., Herb. No. GUBH P137.

17. *Cercospora timorensis* Cooke, 1883. *Grevillea*, 12: 38 (Fig.17, 17a-c)

Leaf spots amphigenous, initially light brown later becoming dark brown with white spot in the center, circular, 2–3 mm in diam. *Colonies* on leaf spots effuse, dark brown, hairy. *Conidiophores* $40 - 150 \times 4 - 6 \mu\text{m}$. *Conidia* $40 - 100 \times 2 - 4.5 \mu\text{m}$.

Specimen examined: On living leaves of *Ipomoeae biloba* Forsk. (Convolvulaceae) Campal, Panjim Goa, 15 - 08 - 03, Pratibha, J., Herb. No. GUBH P64.

18. *Cercospora vanderystii* Henn., 1907. [as 'vanderysti'], *Annals de Musée du Congo, Botanique Série 5 2(2): 104 (Fig.18, 18a-c)*

Leaf spots amphigenous, pale brown, circular, margin dark brown with white spot in the centre, 1 - 3 mm in diam., present on the entire leaf surface, most of the leaves in the field showed the infection. *Conidiophores* 27 - 127 × 3.5 - 6.5 µm. *Conidia* 40 - 150 × 3 - 6 µm.

Specimen examined: On living leaves of *Vigna unguiculata* (Linn.) Walp. (Papilionaceae), Banastari, Ponda Goa, 15/03/03, Herb. No. GUBH P27; Corjuvem, Bardez Goa, 31/05/03, Herb. No. GUBH P27; Mashem, Cancona Goa, 10/10/04, Pratibha, J., Herb. No. GUBH P27.

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