

Fungal pathogens of aquatic weeds of Haryana

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During 1988-91 surveys for plant pathogenic fungi associated with aquatic weeds, *Eichhornia crassipes*, *Alternanthera philoxeroides*, *A. pungens*, *Astercantha longifolia*, *Convolvulus arvensis*, *Ranunculus scleratus* and *Typha angustata*, were conducted in different parts of Haryana (India). Eighteen fungal pathogens were isolated and identified from the infected plant materials. Pathogenicity of the various pathogens to their respective hosts was proved and Koch's postulates were confirmed. Disease symptoms and cultural characteristics of all the 18 fungal pathogens had been described. Literature search indicates that *Fusarium chlamydosporum*, *Bipolaris sorokiniana* on waterhyacinth, *Fusarium pallidoroseum* on *Convolvulus arvensis* are the first report of occurrence of these pathogens on these hosts from the world. Eight fungal pathogens, viz. *Cercospora piaropi*, *C. rodmanii*, *Curvularia lunata*, *Epicoccum nigrum*, *Phoma sorghina*, *Acremonium* sp., *Alternaria* sp., and *Stemphylium* sp., on waterhyacinth; *Alternaria* sp., on *Alternanthera philoxeroides*; *Fusarium* sp., on *Alternanthera pungens*. *Alternaria alternata* and *Acremonium* sp., on *Convolvulus arvensis*; *Fusarium* sp., on *Ranunculus scleratus*; and *Alternaria* sp., on *Typha angustata* are being reported for the first time from India. Status of these fungal pathogens along with their bio-control potential has been discussed. Further experiments on host-range studies and biocontrol potential of these fungal pathogens are in progress.

Key words : Aquatic weeds, Biological Control, Fungal Pathogens, Haryana

INTRODUCTION

Weeds-aquatic, terrestrial and parasitic-cause enormous direct (or) indirect losses to the ecosystem. Aquatic weeds choke irrigation canals, besides causing inconvenience in many other ways. In India many of the noxious weeds are of alien origin. They were either introduced negligently or accidentally into our country and have become serious problems, in the absence of host-specific

natural enemies (plant pathogens and insects) in the new environment. Most of these weeds have occupied such proportions where mechanical and chemical control methods are neither feasible nor economical (Anonymous, 1989). Since 1970, there has been increasing worldwide interest in exploiting the potential of plant fungal pathogens as biological control agents for aquatic weeds (Pieterse and Murphy, 1990), and this method is considered to be most efficient, longer lasting and less costly with minimum detrimental environmental impacts (Gopal, 1987).

So far 114 fungal taxa have been reported worldwide from water-hyacinth (Charudattan, 1990). Virulent pathogens reported on waterhyacinth around the world include *Acremonium zonatum* (= *Cephalosporium zonatum* = *C. eichhorniae*), *Alternaria alternata*, *A. eichhorniae*, *Bipolaris oryzae*, *Cercospora piaropi*, *C. rodmanii*, *Helminthosporium bicolor*, *Maramiellus inoderma*, *Myrothecium roridum*, *Rhizoctonia solani* and *Uredo eichhorniae* (Freeman, 1977 ; Gopal, 1987 ; Evans, 1987 ; Charudattan, 1984).

In order to control aquatic weeds by biocontrol agents, surveys were initiated to search natural enemies (fungal pathogens and insects) under a research project, "Biological control of weeds with mycoherbicides" sanctioned by the Ministry of Environment and Forests, Govt. of India, New Delhi (1988-1991).

MATERIALS AND METHODS

Collection of samples

During 1988-91 series of surveys for natural enemies (fungal pathogens), of waterhyacinth (*Eichhornia crassipes* (Mart.) Solms, *Alternanthera philoxeroides* (Mart.) Griseb., *A. pungens* L., *Astercantha longifolia* L., *Convolvulus arvensis* L., *Ranunculus scleratus* L. and *Typha angustata* Chaub & Bory. were conducted in Haryana. Plants showing various types of disease symptoms were collected in sterilized polyethylene bags and brought to laboratory for study of symptoms, isolation, identification and pathogenicity test of the pathogens involved. Some specimens were pressed, dried and kept as herbarium records. Infected leaves were washed thoroughly in running tap water to remove the dust particles adherent to the leaves. The infected portions of the leaves were cut and incubated in moist chambers at 25 °C for 3-5 days to allow the fungus to grow and sporulate on infected spots.

Isolation of the pathogen

The sporulated, infected portions were cut into small pieces, surface sterilized with 0.1% HgCl₂ or 10% clorax for different durations (e. g. 30-120 seconds)

rinsed thoroughly in sterile distilled water and blot with dry with sterile filter paper. Two to three such surface sterilized and washed leaf fragments were later transferred onto potato dextrose agar plates supplemented with streptomycin sulphate with the help of a sterilized forceps under aseptic conditions. The plates were inverted and incubated at 25 ± 1 C for 3-7 days. After 3-4 days of incubation, the fungus growing from leaf segments was purified from the surface contaminants by hyphal tip and/or streaking methods. Pure cultures of the pathogens so obtained were maintained on PDA slants for further investigation.

Pathogenicity Test

Pathogenicity of the various isolates was determined on detached leaves (*in vitro*). Artificial inoculations were made on young, medium and large healthy leaves (leaves without signs of infection) of waterhyacinth, *Alternanthera philoxeroides*, *A. pungens*, *Astercantha longifolia*, *Convolvulus arvensis*, *Ranunculus scleratus* and *Typha angustata*. Leaves were first washed in running tap water followed by 70% ethanol and finally in sterile distilled water. Inoculations were made by placing mycelial discs from 7-day old fungal cultures on wounded (pricked with a sterilized needle) and non-wounded portions of the leaves. Inoculated leaves were kept in moist chambers and incubated at 25 ± 1 °C. Regular observations for the appearance of symptoms were made after 3 days of incubation.

RESULTS

During 1988-91 surveys conducted in various aquatic bodies of Hayana it was observed that numerous plants of waterhyacinth and other aquatic weeds were infected and some were in decline state. Leaf spots and blotches were the common symptoms observed, petiole infection was also observed in some cases. Isolations from diseased waterhyacinth leaves on PDA, PSA, PDA+Y, WHDA yielded 10 fungal isolates, which were identified as *Acremonium* sp., *Alternaria* sp., *Bipolaris sorokiniana*; *Cercospora piaropi*; *Cercospora rodmanii*; *Curvularia lunata*; *Epicoccum nigrum*; *Fusarium chlamydosporum*; *Phoma sorghina* and *Stemphylium* sp. Isolations from diseased leaves of other aquatic weeds, yielded eight fungal pathogens, they are as follows: unidentified species of *Alternaria* on *Alternanthera philoxeroides*; *Fusarium* species on *Alternanthera pungens*; *Alternaria alternata* and *Cercospora* species on *Astercantha longifolia*; *Fusarium pallidoroseum* and unidentified species of *Acremonium* on *Convolvulus arvensis*; unidentified species of *Fusarium* on *Ranunculus scleratus* and *Alternaria alternata* on *Typha angustata* (Table 1). Koch's postulates were proved for all the pathogens on their respective hosts.

Bipolaris sorokiniana (Sacc.) Shoem.

Infection of waterhyacinth leaves characterized by severe leafspotting, small in size, punctate to elliptical, dark-coloured, light yellowish on the borders of the spot, tip of the leaf often necrotic. Petioles are most often affected.

Table 1. Fungal pathogens isolated from various aquatic weeds of Haryana

Name of the host	Pathogen isolated
<i>Eichhornia crassipes</i>	<i>Bipolaris sorokiniana</i>
	<i>Cercospora piaropi</i>
	<i>Cercospora rodmanii</i>
	<i>Curvularia lunata</i>
	<i>Epicoccum nigrum</i>
	<i>Fusarium chlamyosporum</i>
	<i>Phoma sorghina</i>
	Unidentified species of <i>Acremonium</i>
	Unidentified species of <i>Alternaria</i>
	Unidentified species of <i>Stemphylium</i>
<i>Alternanthera philoxeroides</i>	Unidentified species of <i>Alternaria</i>
<i>Alternanthera pungens</i>	Unidentified species of <i>Fusarium</i>
<i>Astercantha longifolia</i>	<i>Alternaria alternata</i>
<i>Convolvulus arvensis</i>	Unidentified species of <i>Cercospora</i>
	Unidentified species of <i>Acremonium</i> , <i>Fusarium pallidoroseum</i>
<i>Ranunculus scleratus</i>	Unidentified species of <i>Fusarium</i>
<i>Typha angustata</i>	<i>Alternaria alternata</i>

Conidiophores solitary, brown, with five to six transverse septa, $30-34 \times 3.7-7.8 \mu\text{m}$. Conidia straight, fusiform to broadly ellipsoidal, dark brown, smooth, three to five pseudoseptate, $49-71.5 \times 18-23 \mu\text{m}$. On living leaves of *Eichhornia crassipes* (Mart.) Solms. Narkatari and Kurukshetra. The living culture of this isolate has been deposited at the International Mycological Institute, England (IMI : 341167). Koch's postulates were confirmed.

Cercospora piaropi Tharp.

Leaf spots and blotches are the common symptoms observed on all the stages of leaves (small, medium and large) and sometimes on petioles too, particularly of mature leaves. Lesions or zonations are variable in sizes, ranging from minute, punctate, dark or light pale brown coloured spots, to large brown coloured spots, elliptical or pear-shaped, measuring $0.3-5 \times 0.2-2 \text{ mm}$. The centre

of the spot is stiff and shiny, with greyish tan or purplish black margins. The margins raised and brighter than the inner border or circle. Coalescing of leaf spots results in the formation of chain in a row. Conidiophores, fasciculate, but very few in each fascicle, sparse, bright brownish in colour with bluish apices, multiseptate (50—100 x 3.5—4 μm). Conidia hyaline, obconic at base, upward attenuate, slightly curved, septate, 112-165 x 3.75 μm .

On living leaves of *Eichhornia crassipes* (Mart.) Solms, Shahabad, Ambala. The herbarium specimen has been deposited at the International Mycological Institute, England (IMI : 334827). Koch's postulates were confirmed.

Cercospora rodmanii Conway

Leaf spots small punctate to circular, dark coloured, chlorosis of lamina and petioles are the common symptoms (0.5-5 x 0.3-2 mm). Some spots coalesce to form large irregular zonations covering the entire leaf surface, severely on tip of the leaf. Chlorosis of lamina and petioles is also seen. In moist chambers, conidiophores are in fascicles of 3-8 in number, dark or olive brown coloured, epiphyllous, growth sympodial, simple, erect, septate, arising or emerging through the well developed stroma, 150-250 x 2-4 μm . Conidia hyaline, acicular, multi-septate, truncate at base, simple, straight or slightly bent, 180-250 x 2-4 μm . Associated *Asteromella*, pycnidial state, is present in culture. Pycnidia are dark-brown, ostiolate, globose, 30-100 x 20-90 μm . Conidia hyaline, bacilliform, 2-3 x 1-1.5 μm .

On living leaves of *Eichhornia crassipes* (Mart.) Solms, Pehowa, Narkatari, Jyotisar, Bhorsaindan and Kurukshetra. The herbarium specimen and living culture have been deposited at the International Mycological Institute, England (IMI : 329783 and 348707). Koch's postulates were confirmed.

Curvularia lunata (Wakker) Boedijn

Leaf spots leading to compact zonations, starting from tip of the leaf and spreading backwards, large leaves comparatively showing more infection. Petioles are also affected. Leaf spots light brown or yellowish-cream coloured rounded or elliptical in shape (1-2 x 0.5-1 mm). Conidiophores straight (or) flexuous, often geniculate, brown, usually smooth (130-145 x 3.75-5.6 μm). Conidia solitary, acropleurogenous, simple, curved or ellipsoidal, with 2-4 transverse septa, pale olive or brown in colour, end cells paler than the central cells (18-24 x 7-13 μm). On living leaves of *Eichhornia crassipes* (Mart.)

Solms Narkatari and Kurukshetra. The living culture has been deposited at the International Mycological Institute, England (IMI : 335392). Koch's postulates were confirmed.

Epicoccum nigrum Link

Leaf spots or lesions leading to compact zonation starting from tip of the leaf and spreading backwards (0.5-1.1 × 0.5-7 mm). Several lesions coalesce resulting in large irregular shaped zonations, covering the leaf tip area. Petioles are also affected. Sporodochia 2 mm in diameter. Conidiogenous cells are 7-18 × 3.7 μm. The conidia are solitary, subspherical or pyriform often with a pale protuberant basal stalk cell. Conidia are 18-22 μm diameter. Muriform but with septa obscured in mature conidia by the rough opaque wall.

On living leaves of *Eichhornia crassipes* (Mart.) Solms, Karnal and Kurukshetra. The living culture has been deposited at the International Mycological Institute, England (IMI : 333324). Koch's postulates were confirmed.

Fusarium chlamydosporum Wollenw and Reinking.

Small, punctate leaf spots with an ash coloured center, becoming elliptical to irregular shaped structures (0.5-3 × 0.5-1.5 mm) on small and medium sized plants. Macroconidia are curved, sickle shaped, hyaline, fusoid with narrowly rounded to pointed apex, each with a marked foot cell, with two to five transverse septa (i. e. 3 to 6 cells) 10-18 × 1-3 μm.

On living leaves of *Eichhornia crassipes* (Mart.) Solms, Ambala and Kurukshetra. The living culture has been deposited at the International Mycological Institute, (IMI : 333323). Koch's postulates were confirmed.

Phoma sorghina (Sacc.)

Lesions on leaves and petioles. Brown coloured and irregular in outline (1-8 × 0.5-3 mm). Coalescence of several lesions results in the formation of large irregular blotches (8-27 × 2-5 mm). Pycnidia globose to irregular in shape, dark brown, 22.5-30 μm in diameter. Conidia ellipsoid, unicellular, eguttulate, 7-13 × 7-11 μm; sometimes one or more celled chlamydospores are present.

On living leaves of *Eichhornia crassipes* (Mart.) Solms, Kurukshetra. The living culture has been deposited at the International Mycological Institute, England (IMI : 333325). Koch's postulates were confirmed.

Acremonium species

Leaf spots are zonate, oval to irregular, up to 3-4 cm long, marked with light and brown rings 0.5-2 mm wide, on the older leaves of localised patches of tall plants, but not on smaller floating plants. Conidiophores with one celled conidia, exceptionally two celled, hyaline or pigmented, globose or cylindrical, $3.75-7.5 \times 3-3.75 \mu\text{m}$.

On living leaves of *Eichhornia crassipes* (Mart.) Solms (Family Pontederiaceae), Narkalari and Kurukshetra. The living culture has been deposited at the International Mycological Institute, England (IMI : 341105). Koch's postulates were confirmed.

Alternaria species

The disease symptoms are characterized by oval, elliptical, or sometimes irregular spots on different morphotypic stages of waterhyacinth leaves, mature leaves comparatively with severe infections, $0.5-1.3 \times 1-9 \text{ mm}$. Coalescence of spots results in the formation of large spots ($18-50 \times 8-35 \text{ mm}$). Petioles are also infected. Conidiophores simple, erect, septate; conidia commonly in chains of 2-3, obclavate or ellipsoidal, with 2-3 transverse and 1 or 2 longitudinal septa, $60-161 \times 7.5-22.5 \mu\text{m}$, beak length is equal or slightly more than the body of a conidium. On living leaves of *Eichhornia crassipes* (Mart.) Solms Narkatari, Kurukshetra, Ambala, Rajpura, Delhi, Shamli and Chandigarh. The living culture of this isolate has been deposited at the International Mycological Institute, England (IMI : 341106). Koch's postulates were confirmed.

Stemphylium species

Leaf spots are small, punctate, round, elliptical or irregular in shape ($0.5-3.5 \times 0.5-2 \text{ mm}$), generally observed on medium to larged sized plants. Several spots coalesce and forms large irregular blotches covering the entire leaf surface, especially margins and leaf tip areas ($3.5-7 \times 1-3 \text{ mm}$). Conidiogenons cells straight to variously curved, simple, occasionally branched, cylindrical but enlarging apically to the site of conidium production, brown to olive brown, darkening at the swollen apex, $30-40 \times 3.75-4.5 \mu\text{m}$. Conidia solitary, broadly ellipsoidal, obpyriform or obclavate, with 2-5 transverse septa and 1-4 longitudinal or oblique septa, $22-26 \times 11-18 \mu\text{m}$.

On living leaves of *Eichhornia crassipes* (Mart.) Solms and various other aquatic weeds, Narkatari, Kurukshetra, Ambala and Kaithal. Koch's postulates were confirmed.

Alternaria species

The spots are initially very small, pin head-like, becoming oval to elliptical bearing a cream coloured eye or centre spot (1-4 mm in diameter). Coalescence of lesions results in the formation of large irregular spots (3-5 x 1-3 mm). Conidiophores are branched, brown and smooth, Conidia solitary (or) in chains, dry, typically ovoid to obclavate, pale to mid olivaceous brown, smooth with six transverse and frequently 1-4 longitudinal or oblique septa are also present, 35-42 x 8-10 μm , having small beak measuring 15-19 x 3.75-7.0 μm .

On living leaves of *Alternanthera philoxeroides* (Mart.) Griseb. (Family Amaranthaceae). Kurukhetra. Koch's postulates were confirmed.

Fusarium species

Leaf spots small, oval to irregular in shape, brown, 0.5-3 x 0.5-1.5 mm. Conidia produced in sporodochia are slender, slightly sickle-shaped or moderately curved, mostly 4-septate, with the pointed apical cells, 15-30 x 1.8-5.6 μm .

On living leaves of *Alternanthera pungens* H. B. & K., Kurukshetra. The living culture has been deposited at the International Mycological Institute, England (IMI : 343554). Koch's postulates were confirmed.

Alternaria alternata (Fr.) Keissler.

Spots on the leaves are oval, cream centre and surrounded with black margin (0.5-5 x 0.5-3 mm). Coalescence of spots results in the formation of large, irregular shaped blotches (4-6 x 2-3 mm). Conidiophores brown, simple, typically with a simple and branched conidial chain. Conidia, dark, obclavate to elliptical or ovoid, with 1-4 transverse and 1-3 longitudinal or oblique septa, 10-30 x 3.75-7.5 μm .

On living leaves of *Astercantha longifolia* Nees. (Family Acanthaceae), Jyotisar, Narkatari and Kurukshetra. Koch's postulates were confirmed.

Cercospora species

Leaf spots obovate to elliptical, brownish to black, pale to light brownish, central portion of the spot surrounded by brownish to black coloured margins, 3-10 mm in diameter. Conidiophores straight, or slightly flexuous, unbranched, olivaceous brown or brown, smooth. Conidiogenous cells integrated, terminal, polyblastic, sympodial, cylindrical, 70-75 x 5.6-7.5 μm . Conidia solitary, acropleurogenous, simple, colourless, smooth, 2-3 septate, 130-185 x 3.5-6.0 μm .

On living leaves of *Astercantha longifolia* Nees, Jyotisar and Narkatari (Kurukshetra). Koch's postulates were confirmed.

Acremonium species

Leaf spots prominent, small or big in size, black to light brown in colour, oval, round (or) sometimes irregular in shape, cream coloured eye spots surrounded by black and cream colour concentric rings, often surrounded by a light green halo (1-7 mm in diameter). Mycelium hyaline producing simple, awl-shaped, erect phialides, from the substratum or from fasciculate aerial hyphae. Conidiogenous cells slender, simple or compound, branching is confined to the lower part. Conidia, hyaline, smooth, oval to ellipsoidal in shape, one celled, occasionally two-celled, 6-8X1.8-3.7 μm .

On living leaves of *Convolvulus arvensis* L. (Family Convolvulaceae), Jyotisar, Narkatari and Kurukshetra. The living culture has been deposited at the International Mycological Institute, England (IMI : 343553). Koch's postulates were confirmed on both wounded and non-wounded detached *C. arvensis* leaves.

Fusarium pallidoroseum (Cooke) Sacc.

Spots on leaves are elliptical to irregular in outline (2-8X1-6 mm). Several spots coalesce to form large irregular spots, covering the entire leaf surface area (11-19X 5-9 mm). Macroconidia formed in aerial mycelium from loosely branched conidiogenous cells. Conidia slender slightly curved or straight, mostly 3-5 transversely septate and pointed apex, 11.25-22.75X3.75-5.6 μm .

On living leaves of *Convolvulus arvensis* L. Narkatari, Jyotisar and Kurukshetra. The living culture has been deposited at the International Mycological Institute, England (IMI : 333326). Koch's postulates were confirmed.

Fusarium species

Leaf spots and zonations are oval or round, and sometimes irregular in shape. Although all the morphotypic stages of leaves showed infection, but more disease was observed on mature and large sized leaves. Petioles and stems are also oftenly infected. Lesions variable in size, ranging from minute, dark brown spots to large irregular spots. The leaf spots are initially small, pin-head like, later on they changed to oval, round and sometimes irregular in outline (1-5 x 0.5-1 mm). Coalescence of spots results in formation of large irregular spots (5-7.5 x 3-4 mm). Conidiophores loosely branched, macroconidia formed in aerial mycelium. Microconidia slender, slightly curved, straight, mostly 3-5 septate with the apical cells having pointed apex, 11.25-22.75 x 3.75-5.6 μm .

On living leaves of *Ranunculus scleratus* Linn., Kurukshetra, Narkatari and

Jyotisar. The living culture has been deposited at the International Mycological Institute, England (IMI : 333327). Koch's postulates were confirmed.

Alternaria alternata (Fr.) Keissler

The leaf spots are variable in sizes, ranging from minute to large symptoms. All the stages of leaves showed infection, dark brown in colour, 1-10 x 0.5-2.5 mm. Conidiophores and conidia are light to dark brown and simple, conidia are formed in acropetal chains, uniform, with a broadly round base, 7.5-11.25 x 3.75-11.25 μm and with an apical beak.

On living leaves of *Typha angustata* Chaub and Bory. (Family Typhaceae), Kurukshetra, Ambala, Kaithal and Karnal. Koch's postulates were confirmed.

DISCUSSION

During 1988-91 surveys for plant pathogenic fungi associated with various aquatic weeds of Haryana and its adjoining States, a total of 18 fungal pathogens have been isolated and identified on the basis of their cultural characteristics.

Typical disease symptoms were caused by all the isolated pathogens on their respective hosts on both wounded and non-wounded detached leaves *in vitro*. The inoculated pathogens were reisolated and were found similar to the original isolates in cultural characteristics, thus confirming the pathogenicity to their respective hosts and competing the Koch's postulates.

Literature search (Bilgrami *et al.*, 1979, 1981 ; Mukherji and Bhasin, 1986 ; Sarbhoy *et al.*, 1986 ; Gopal, 1987 ; Charudattan, 1990) indicates that *Fusarium chlamyosporum*, *Bipolaris sorokiniana* on waterhyacinth ; *Fusarium pallidroseum* on *Convolvulus arvensis* are the first report of occurrence of these pathogens on these hosts for the world. Another eight fungal pathogens, viz *Cercospora piaropi*, *C. rodmanii*, *Curvularia lunata*, *Epicoccum nigrum*, unidentified species one each of *Acremonium*, *Alternaria* and *Stemphylium* on waterhyacinth ; *Alternaria* species on *Alternanthera philoxeroides* ; *Fusarium* species on *Alternanthera pungens* ; *Alternaria alternata* and *Acremonium* species on *Convolvulus arvensis* ; *Fusarium* species on *Ranunculus scleratus* ; *Alternaria* species on *Typha angustata* are being reported for the first time from India.

Waterhyacinth thread height due to *Cercospora piaropi* was first of all described by Tharp (1917) from Texas, the U. S. A. Later on it was reported by Thirumalachar and Govindu (1954) from Gulzaribagh, Patna (India) and Nag Raj (1965)

from Calicut (Kerala). The pathogenicity of *C. piaropi* to waterhyacinth is well documented, but most reports indicate that it causes only minor to moderate damage to the plant (Nag Raj, 1965 ; Freeman and Charudattan, 1974). In a recent study Martyn (1985) reported that *C. piaropi* can be highly aggressive towards waterhyacinth causing large-scale severe damage leading to significant reduction in plant density, under certain conditions. Thus it should not be ruled out as a possible biological control agent of waterhyacinth.

Cercospora rodmanii was first of all reported on waterhyacinth from the Rodman reservoir, Florida, USA (Conway, 1967a, b) and this is the second report of its occurrence for the world and first for India. The biocontrol potential of *C. rodmanii* has been evaluated in the field in several locations in the south-eastern United States. Conway *et al.* (1978, 1979) reported that *C. rodmanii* can severely affect waterhyacinth growth, especially under conditions that favour a reduced growth rate of the plant. The Abbott Laboratories, Chicago, United States, has obtained a U. S. Environmental Protection Agency (EPA) Experimental Use Permit (EUP), as required to evaluate *C. rodmanii* as a mycoherbicide. Several studies have confirmed *C. rodmanii* as a successful biocontrol agent (Charudattan, 1982, 1984). *C. rodmanii*, when used in combination with waterhyacinth insects, resulted in 99 per cent control (surface clearance) in the test plots (Charudattan, 1986, 1990).

Bipolaris sorokiniana on waterhyacinth is being reported for the first time from India and the world (Gopal, 1987 ; Charudattan, 1990). Though it has been reported earlier on several graminaceous (wheat, barley, rice, rye), non-graminaceous (bean, pea, lucerne) hosts and a pteridophyte (*Neprolepis biserrata*) and should not be evaluated for biocontrol of waterhyacinth.

Epicoccum nigrum Link on waterhyacinth is a new record for India. The pathogen has been reported earlier, by Galbraith and Hayward (1984) from Australia and Conway *et al.* (1974) from Florida, U. S. A. *Phoma sorghina* on waterhyacinth is a new record for our country. Earlier report of its occurrence on this host is from Sudan (Abdel-Rahim, 1984 ; Abdel-Rahim and Twafiq, 1985). This pathogen is considered to be a ubiquitous, weakly pathogenic fungus (Evans, 1987), hence should not be pursued further for biocontrol. *Fusarium chlamydosporum* on waterhyacinth is being reported for the first time from the world.

Literature search reveals *Stemphylium* sp., *Alternaria* sp. and *Acremonium* sp. on waterhyacinth are new records for India (Bilgrami *et al.* 1979 ; 1981 ; Gopal, 1987 ; Mukerji and Bhasin, 1986 ; Sarbhoy *et al.*, 1986). An unidentified species of *Stemphylium* has been earlier reported on this host from Australia (Galbraith and Hayward, 1984). *Alternaria* sp. has been

reported earlier from the U. S. A. (Charudattan, 1973b ; Conway *et al.*, 1974 ; Charudattan *et al.*, 1978), Sri Lanka (Hettiarachchi *et al.*, 1983) and Australia (Galbraith and Hayward, 1984). *Acremonium* sp. has been reported earlier from Australia (Galbraith and Hayward, 1984) and the U.S.A. (Charudattan *et al.*, 1978).

On the basis of the surveys made and experimental observations made in the laboratory and fields, it is suggested that of the 10 fungal pathogens reported on waterhyacinth only two namely *Alternaria eichhorniae* and *Cercospora rodmanii* seem to be probable candidates for their evaluation as biocontrol agents of waterhyacinth, one of the most notorious aquatic weed of the world, including India.

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