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Morpho-Taxonomy and Phytopathology of Cercospora Species Invading Medicinal Plants in North-Eastern Uttar Pradesh, India

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Abstract: North-Eastern Uttar Pradesh, India has rich biodiversity of plants.Cercospora Fres. is a phytopathogenic fungus causing diseases in different plants of economic importance. In the present investigation, during survey of villages and forests of Gorakhpurdistrict, three phytopathogenic species of Cercospora have been collected and reported -Cercospora achyranthina, C. cocciniae and C. papaya, infecting three medicinally important plants -Achyranthes aspera, Coccinia grandis and Carica papaya. Morpho-taxonomy of these three species of Cercospora including camera lucida drawings have been done. Phyto-pathological investigations have also been performed including reductions in photosynthetic areas of leaves. It is concluded that these Cercospora species affect the productivity as well as medicinal properties of these medicinally important plants.

Keywords: Foliicolous Fungi, Morpho-taxonomy, Phytopathology, Medicinal Plants, Cercospora

Introduction

District Gorakhpur of North-Eastern Uttar Pradesh, India is located at the Rapti riverside, in the foot hills of Himalayas (Geographical location - 26.7637152° N; 83.4039116° E; average annual temperature of 26 - 27°C; elevation- 246ft). Its climatic conditions(high relative humidity and moderate temperature) from July to November are very suitable for plant pathogenic fungi (Srivastavaet al., 2011).

District Gorakhpur has a rich plant biodiversity including forest flora as well as plants of agricultural, horticultural and medicinal importance (Srivastava, 2007). Its humid and subtropical climate supports growth of various pathogens including fungal and bacterial pathogens etc. (Yadav etal., 2025).

The fungus genus Cercospora Frasenius ex Fuckel has been reported to be a phytopathogenic fungus (Systematic position: Kingdom- Fungi; Phylum- Ascomycota; Class- Deuteromycetes; Order- Moniliales; Family- Dematiaceae).It causes diseases in Angiosperms (Dicot and Monocot plants), Gymnosperms and Ferns etc. (Pollack, 1987). Its symptoms include leaf spots as well as necrosis of

flower, fruits, seeds and pedicels etc. (Agrios, 2005). Some species of Cercospora are used in biological control as these are hyperparasites on plant pathogenic fungi (Shin and Kim, 2001; Morris and Crous, 1994).

The monograph of Cercospora (Chupp, 1954) provided a rich information about various species of Cercospora. The genus Cercospora was further reclassified into numerous species (Deighton, 1967, 1971, 1973, 1974, 1976, 1979, 1983). Presence of conidial scar was taken as an important taxonomic criterion by Deighton as well as other mycologists too (Pons and Sutton, 1988; Braun, 1988 a, b, 1989, 1990, 1993).

Crous and Braun (2003) compiled over 3000 species of Cercospora. Thirumalachar and Chupp (1948) described and commented on Indian Cercosporae,and a number of plant pathogenic species of cercosporoid fungi including Cercospora have been reported from North-Eastern Uttar Pradesh, India by Kamal and his co-workers (Kamal, 2010; Sinha et al., 2022; Srivastava et al., 1994; Srivastava et al., 1994; Srivastava et al., 1995; Srivastava et al., 1995; Srivastava and Morgan Jones, 1996; Bhalla et al., 1996; Srivastava et al., 2007).

Medicinal Plants under Study

Three phytopathogenic species of Cercospora have been reported on medicinally important plants - Achyranthes aspera, Carica papaya and Coccinia grandis.

(1). Achyranthes aspera L.

It is a weed of Family - Amaranthaceae (Local name Chichira/ Chirchita/Apamarga/ Latjeera). It is distributed throughout India and abundantly found in district Gorakhpur and surrounding areas. Different plant parts are used as traditional medicine in Ayurveda, Unani and Kabiraji treatment systems to cure different diseases like Oedema/ Edema(Nadkarni, 1954), Arthritis, Leprosy, Heart and Kidney diseases and Asthma(Singh, 1995), Piles, Scorpion and Snakebites, Diabetes, Skin diseases (Jayaveera, 1982; Nadkarni, 1954), Malaria, Cough and fever; Fistula and nasal infections, dysentery, coldand tooth ache (Borthakur and Gowswami, 1995; Aziz et al. 2005);Gynaecological problems (Khan and Khan 2006; Shukla et al. 2008) andStomach pain (Ghani et al. 2003). The phytochemistry of this plant has proved presence of various medicinally important compounds like Alkaloids (Kapoor and Singh 1966), Flavonoids (Sinha and Dogara, 1985),Achyranthin (Basuet al. 1957; Basu et al. 1997; Bhom, 1992; Kapoor and Singh, 1966),Saponins (Batta and Rangaswami, 1973; Shesadriet al. 1981; Srivastava et al. 2002), Glycosides (Arunkumar et al. 2010), Sterols and Ecadysteron (Benerjiet al. 1971; Benerji and Chadha 1971; Ikan et al. 1971).These phytochemicals provide pharmacological importance to this plant.This plant has been studied in detail for its pharmacological and phytochemical importance (Krishnaveni and Thaakur, 2006; Mali et al. 1990).

Achyranthes asperaplant is medicinally so important that its phyto-pathological investigations have been done by different plant pathologists.Various fungal,

bacterial, phytoplasma, viral and nematode diseases have been reported, (Jairaman, 1988; Raj et al. 2009; Raman et al. 2007).

(2). Carica papaya L.

Carica papaya (English- Papaya; Local name - Papeeta) is a tropical fruit tree of Family -Caricaceae. It is well distributed in tropical and subtropical countries of the world including India. According to a report of the year 2020, India is the largest producer of papaya in the world. It is considered as a magic plant because of its nutritional benefits and traditional and modern medicinal uses in disease management etc. Papaya leaves and fruits (unripe and ripe) are rich in phytonutrients (Alara et al. 2020; Karunamoorthiet al. 2014; Saeed et al. 2014). It is used in traditional (folk) medicines (De Oliveira and Vitória, 2011; Starley et al. 1999). The nutraceutical significance of papaya fruits includes presence of antioxidant and immunostimulant compounds, Vitamin - C, Organic acids, Glucoseetc. (Begum, 2014). The milky latex of Papaya is used to treat dyspepsia, burns,whooping cough and diarrhea (Reed, 1976). The unripe fruits of papaya have been reported to cure ulcers, menstrual problems and impotency (Elizabeth, 1994).

In modern medicine and pharmacology, the leaf extract of papaya is used to treat various human diseases and lethal viruses (Sharma et al., 2022),It contains various types of alkaloids, tannins,glycosides,steroids,saponins and flavonoids etc. (Hu et al. 2012; Patil et al. 2014).

Papaya plant is infected by various plant pathogens including fungi, bacteria,nematodes andviruses etc. (Fatima et al. 2006; Rahman et al. 2008; Srivastava and Singh, 2022; Umer et al. 2022).

(3). Coccinia grandis L.

Coccinia grandis(English name - Ivy Gourd;HindiName -Kundaroo) is a medicinally important plant of Family-Cucurbitaceae.It is well distributed in tropical and sub-tropical countries of the world including India (Munir and Qureshi,2018) and a popular vegetable of district Gorakhpur and surrounding areas.

This plant has been used as traditional herbal medicine to cure various diseases like diabetes (Akhtar et al.2021;Neamsuvanet al. 2018; Packirisamiet al.2018; Rahman et al.2023); as antimicrobial and insecticidal medicine(Mahendrarajahet al. 2020); in hypertension and fever (Uddin et al. 2019); treatment of piles (Kunwar et al. 2012);hyperglycemia(Munir and Qureshi, 2018); in spleen problem and abdominal pain (Bussman et al. 2021); jaundice(Morvin Yabesh et al. 2014)etc.Different parts of this plant like roots,shoots,leaves, flowers and fruits etc.have medicinal properties(Neamsuvanet al. 2018; Waisundaraet al. 2015).

Various types of bioactive compounds of Coccinia grandis are responsible for its pharmacological activities,such as Alkaloids(Kondhare and Lade,2017),Senecionin andCathinoneetc. (Chandaet al. 2020),Alkanes like Tritetracontane etc.(Jayalakshmi et al. 2019).

Materials and Methods

Villages and forest areas of district Gorakhpurwere visited for collection of diseased plant samples.The infected leaves of Achyranthes aspera,Carica papayaandCoccinia grandisshowing disease symptoms were collected, pressed and dried to make permanent Herbarium for depositing in Applied Mycology Lab. as Isotype. Herbarium Cryptogamae Indiae Orientalis (HCIO), IARI, New Delhi was visited to study diseased specimens deposited. The Phytopathology of fungi was studied with special reference to reduction in photosynthetic areas of leaves, which was compared with the leaf areas of healthy leaves.

Morpho-taxonomy, photomicrography and Camera Lucida drawings ofCercospora species associated with these three medicinally important plants were done from fresh and dried leaves by using compound microscope.

Observations and Results

Three species of Cercospora invading leaves of these three medicinally important plants were described and illustrated as follows:

(1). CercosporaachyranthinaThirum and Chupp

on leaves of Achyranthes aspera L.(Family-Amaranthaceae).

(i).Leaf Symptoms: Spots are amphigenous(present on adaxial and abaxial, both surfaces),circular to angular or irregular in shape,2.0mm to 6.0mm in diameter (in advanced stage of infection, spots coalesce to form larger spots of 10-12mm in diameter),light to dark brown in colour with creamishcenter and reddish-brown margin.Older leaves show dark brown spots with a halo.

(ii). Morpho-taxonomyof Pathogen:

Vegetative Mycelium: Internal, intercellular, branched, septate and each cell is uninucleate.

Stromata: Sub-stomatal formed by aggregation of vegetative hyphae; small in size (10-20µm in diameter).

Conidiophore: These are produced in fascicles of 4-6,arising from stromata and emerging out through stomata of leaf; erect to curved and geniculate and sinuous; unbranched, septate (septa2-10), olivaceous brown in colour, conidiogenous cells are integrated, length is 10 to 40µm., clear scars are present on bendings corresponding to hilum of conidia.

Conidia: Solitary, acicular (needle shaped), slightly obclavato-cylindrical, hyaline, thin and smooth walled, apex acute, base truncate, 30 -150µm long and 2-5 µm wide, septate. Each conidium has thick and dark hilum at the base, corresponding to scar on conidiophore.

Holotype: HCIO No. 50223; Isotype: SAC/AML/NS10001

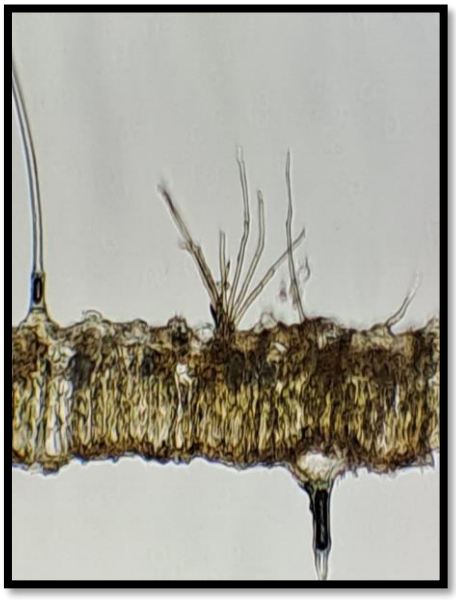
(iii). Phytopathology of Cercospora achyranthina: The leaf spots on diseased leaves were measured and compared with the leaf areas of healthy leaves. In general, this fungus causes approximately 45-50% reduction in the photosynthetic areas of leaves.

Plate – 1

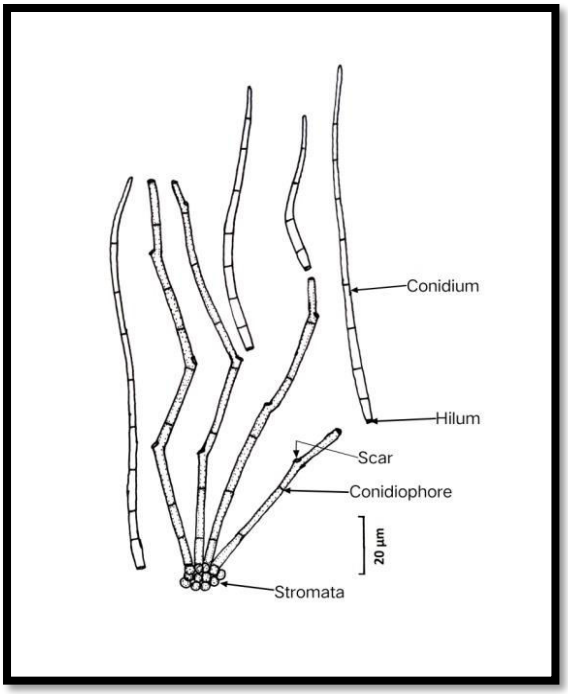
Cercospora achyranthina Thirum and Chupp on Achyranthes aspera L.

Diseased Leaf
(Adaxial Surface with Leaf Spots)

Healthy Leaf



Photomicrographs of V.S. Leaf showing Conidiophores & Conidia



Camera Lucida Drawings
(Stromata, Conidiophore, Conidia)

(2). Cercospora papaya Hansf

on leaves of Carica papaya(Family – Caricaceae).

(i). Leaf Symptoms: Leaf spots amphigenous (present on adaxial and abaxial, both surfaces), 3-6mm in diameter and scattered, circular to sub-circular in shape, creamish to light brown to dark brown in colour, margins dark brown. In advance infection, leaf spots coalesce to form larger spots of 8 to 10 mm in size.

(ii).Morpho-taxonomy of Pathogen:

Vegetative Mycelium: Internal, intercellular branched, septate and uninucleate.

Stromata: These are formed by aggregation of mycelia beneath the epidermis. 15-30µm in diameter, made of sub-globular to irregular brown cells.

Conidiophores: Producedin divergent fascicles of 5-15 (45-200 µm long and 3-5 µm wide),emerging out through stomata, olivaceous brown in colour, straight to slightly curved and geniculate, scar is present in each bent corresponding to hilum of conidium.

Conidia: Solitary, acicular, obconically truncate at the base, straight to curved, hyaline, septate (15-40 septa), thick and dark hilum (1 to 2 µm in diameter) is present at the base of conidium.

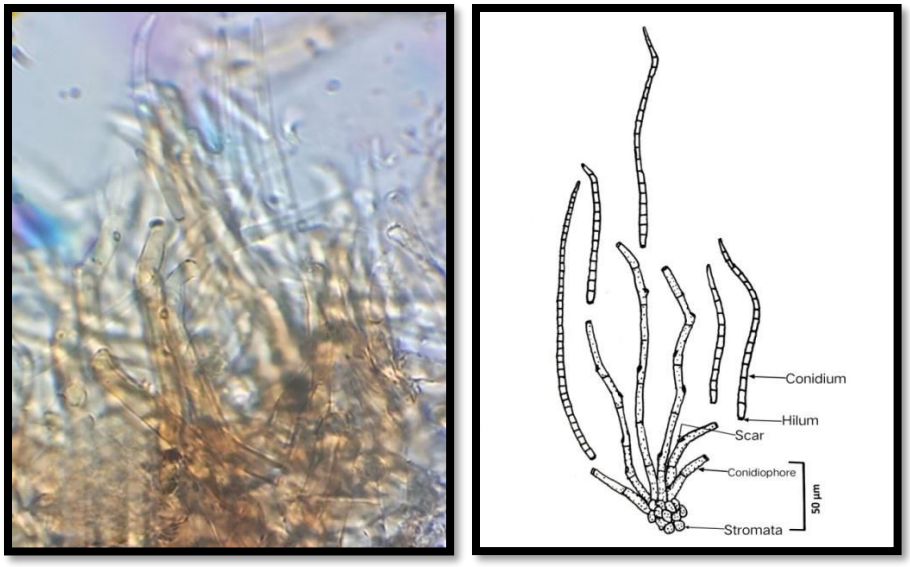
Holotype: HCIO No. 23908; Isotype: SAC/AML/NS 10002

(iii). Phytopathology of Cercosporapapayae: The areas of leaf spots are measured and compared with total leaf areas of disease-free healthy leaves. It is estimated that this fungus causes approximately 25 to 30% reduction in the photosynthetic areas.

Plate 2:

Cercospora papayae Hansf on Carica papaya

Diseased Leaves (Adaxial Surface with Leaf Spots) **Healthy Leaf**



Photomicrograph of Conidiophores and Conidia **Camera Lucida Drawings (Stromata, Conidiophore, Conidia)**

(3). Cercospora cocciniae Munjal,Lall and Chona

On leaves ofCoccinia grandis(Family – Cucurbitaceae)

(i). Leaf Symptoms: Leaf spots are2-6 mm in diameter and amphigenous(present on adaxial and abaxial, both surfaces), circular to sub-circular in shape, light yellow to creamish in colour and whitish in the centre, the margin is light brown to dark brown.

(ii).Morpho-taxonomy of Pathogen:

Vegetative Mycelium: Internal, intercellular, branched, septate and uninucleate.

Stromata: 20-24 µm in diameter, sub-globular in shape and light brown to dark brown in colour.

Conidiophore: Simple, straight, light yellow to brown,48-82×4-7 µm in diameter, 6 to 12 in number, branched and geniculate. Conidiophores form loose feascicles and come out on the leaf surface through stomata.Thick and dark scars are presenton each bending, corresponding to the hilum of conidia.Scars are also present, one on each apex of conidiophore. Conidiogenuous cells are holoblastic.

Conidia: 70-240µm long and 1-4µm wide, produced solitary on each bending of conidiophores, sub acicular to obclavate in shape, straight, colourless, septate (septa 5 to 16).Thick and dark hilum is present at the base of each conidium corresponding to scar on conidiophore; rim of hilum is 1 to 3 µm in diameter.

Holotype: HCIO-50121; Isotype: SAC/AML/NS- 10003.

(iii). Phytopathology of Cercospora cocciniae

The spots of diseased leaves were measured and compared with the total leaf areas of healthy leaves. In general, this fungus causes 35-45% reduction in photosynthetic areas of leaves.

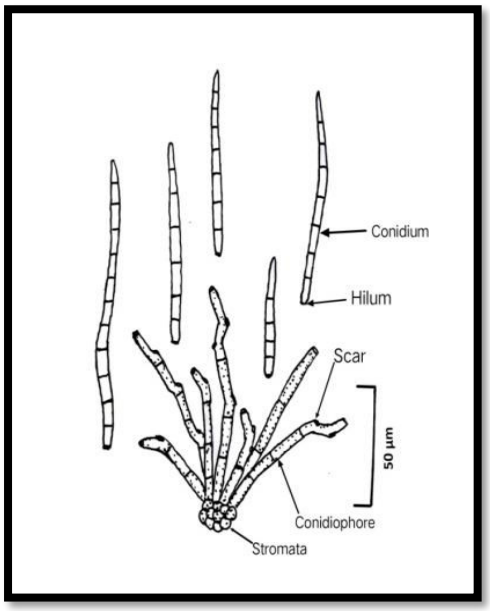
Plate 3

Cercospora cocciniae Munjal, Lall and Chona on Coccinia grandis L.

Diseased Leaves
(Adaxial Surface with Leaf Spots)

Healthy Leaf

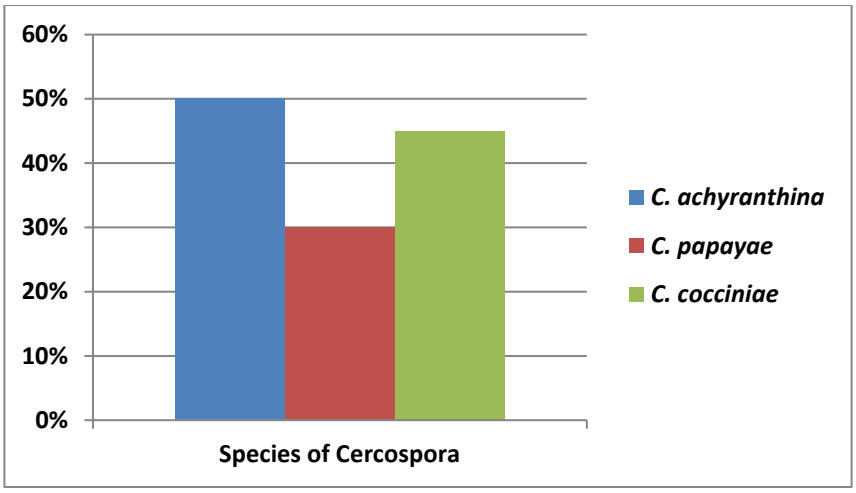
Photomicrographs of Conidiophoresand Conidia Single Conidium with Hilum Rim



Camera Lucida Drawings
(Stromata, Conidiophore, Conidia)

Discussion

As it is evident from present investigations, species of Cercospora produce smaller to larger leaf spots, thereby causing reduction in the photosynthetic areas of leaves and consequent reduction in the productivity of host plants. This results into less production of medicinally/pharmacologically important compounds and secondary metabolites of plants. Therefore, the infected and diseased plants have less medicinal importance as compared to healthy plants.



Per cent Reduction in Photosynthetic Areas of Leaves

Cercospora achyranthina is showing maximum reduction in photosynthetic areas of leaves of Achyranthes aspera (45-50%), followed by C. cocciniae(35-45%). Cercospora papayae shows minimum reduction in photosynthetic area of Carica papaya(25-30%).

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