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Studies of Taxonomic Biodiversity of powdery mildew disease on cucurbits in western region in Uttar Pradesh (India)

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Abstract: Western Uttar Pradesh has experienced rapid economic growth, in a fashion similar to Haryana and Punjab, due to the successes of the Green Revolution. A significant part of western Uttar Pradesh is a part of National Capital Region of India. The largest city of the region is Ghaziabad, while the second-largest city, Agra, is a major tourist destination. Western Uttar Pradesh's soil and relief has marked differences from that of the eastern part of the state. The soil tends to be lighter-textured loam, with some occurrences of sandy soil. Some loess soil is continuously deposited by winds blowing eastwards from Rajasthan's Thar Desert. Western Uttar Pradesh receives rain through the Indian Monsoon and the Western Disturbances. During the phytopathological survey from September to December, 2018, powdery mildew infection on five plant species (Populus sp., Ageratum conyzoides, Quercus sp., Aegle marmelos and Zinnia elegans) was recorded. The infected plant materials, mostly leaves and stem, were collected and brought to the laboratory for further analysis. The infected leaves were examined primarily with a hand-lens and then with a dissecting microscope for the presence of mildew symptoms.
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Introduction:

Cucurbit powdery mildew (CPM) is a serious disease of field and greenhouse cucurbit crops worldwide (Sitterly 1978; McGrath and Thomas 1996), causing reduction in plant growth, premature desiccation of the leaves and consequent reduction of the quality and marketability of the fruits. Observations from the last 20 years have revealed, that CPM 1) can start to develop on cucurbits early in crop production, often before or by the start of harvest period; 2) occurs in growing areas where it was not previously reported; and 3) host crops can be quickly colonized (Cohen et al. 2004; Lebeda et al. 2009).[1]

The world growing area of cucurbits both in the field and under cover of 8.6 million ha is almost two times higher than the growing area of tomatoes (4.6 million ha) (FAOSTAT 2014). The economic and ecologic impacts of disease considered from either the viewpoint of yield losses, or the viewpoint of chemical protection of plants by fungicides are enormous (Sedláková and Lebeda 2008; Lebeda et al. 2010b). [2,3]

Among three species (fam. Erysiphaceae) known to cause CPM (Braun 1995), Leveillula taurica (Lev.) Arnaud is considered to be of minor economic importance, while Golovinomyces orontii (Castagne) Heluta (Braun and Cook 2012) and Podosphaera xanthii (Castag.) U. Braun & N. Shish. (Shishkoff 2000) can heavily infect cucurbit crops with adverse ecologic and economic consequences (Braun 1995; Pitrat et al. 1998). Podosphaera xanthii (Px) (Castagne) U. Braun & Shishkoff (previously named Sphaerotheca (Podosphaera) fusca emend. (s. lat.) (Braun 1987), Sphaerotheca fuliginea f. cucurbitae Jacz.) is common in subtropical and tropical areas and greenhouse crops, while G. orontii (Go) (previously reported as Golovinomyces cichoracearum (DC.) V.P. Gelyuta (Vakalounakis and Klironomou 2001) occurs more frequently in temperate and colder areas under field conditions (Křístková et al. 2007). Podosphaera xanthii is the dominate pathogen in the USA where the climate is mostly temperate (McCreight et al. 2012). Go and Px occur singly or together on cucurbits in Central Europe (Lebeda 1983; Křístková et al. 2007; Lebeda et al. 2007b). Both species can be easily identified based on conidia morphology (Lebeda 1983). The broad host ranges of the two species are not completely identical, covering several different families and/or genera (Braun 1995; Braun and Cook 2012), and they differ also by variability in response to fungicides (McGrath 2001; Sedláková and Lebeda 2008; Lebeda et al. 2010b). [4,5]

Powdery mildew fungi are obligate parasites that tend to grow superficially or epiphytically on a variety of plant hosts. They cause various disease symptoms

including chlorosis, stunted growth, early leaf drop and flower bud deformation on different plant parts including leaves, young stems, buds, flowers and fruits. The disease causes heavy losses to field crops and other plants. [6]

Taxonomic Classification

Cucurbitaceous crops belong to the order Cucurbitales and family Cucurbitaceae (Juss.). All the cultivated species are found in the subfamily Cucurbitoide. This plant family consists of over 100 genera and more than 800 species distributed largely in tropical and subtropical regions of the world with few representatives in temperate to cooler climates. Recent phylogenetic research by Schaefer and Renner based on molecular and morphological data, described a new classification of 95 genera and 950 to 980 species comprising the Cucurbitaceae family. [7]

Study Area:

Western Uttar Pradesh: It is a region in India that comprises the western districts of Uttar Pradesh state, including the areas of Rohilkhand and those where Khariboli, Braj and Kannauji are spoken. The region has some demographic, economic and cultural patterns that are distinct from other parts of Uttar Pradesh, and more closely resemble those of Haryana and Rajasthan states. Western Uttar Pradesh has experienced rapid economic growth, in a fashion similar to Haryana and Punjab, due to the successes of the Green Revolution. A significant part of western Uttar Pradesh is a part of National Capital Region of India. The largest city of the region is Ghaziabad, while the second-largest city, Agra, is a major tourist destination.

Western Uttar Pradesh's soil and relief has marked differences from that of the eastern part of the state. The soil tends to be lighter-textured loam, with some occurrences of sandy soil. Some loess soil is continuously deposited by winds blowing eastwards from Rajasthan's Thar Desert. Western Uttar Pradesh receives rain through the Indian Monsoon and the Western Disturbances.

The Monsoon carries moisture northwards from the Indian Ocean, occurs in late summer and is important to the Kharif or autumn harvest. Western Disturbances, on the other hand, are an extratropical weather phenomenon that carry moisture eastwards from the Mediterranean Sea, the Caspian Sea and the Atlantic Ocean. They primarily occur during the winter season and are critically important for the main staple of the region, wheat, which is part of the Rabi or spring harvest.[23]

Methodology:

During the phytopathological survey from September to December, 2013, powdery mildew infection on five plant species (Populus sp., Ageratum conyzoides, Quercus sp., Aegle marmelos and Zinnia elegans) was recorded. The infected plant materials, mostly leaves and stem, were collected and brought to the laboratory for further analysis. The infected leaves were examined primarily with a hand-lens and then with a dissecting microscope for the presence of mildew symptoms. A piece of clear adhesive tape was placed on infected leaves, stripped o and then placed on a microscopic slide with one drop of clear distilled water. The microscopic observations were carried out for morphological characteristics of mycelia on the host, appressoria, size and shape of conidia an conidiophores and chasmothecia. Pathogenicity was confirmed for all isolates by dusting conidia on healthy plants and non-inoculated plants served as controls.

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Taxonomy

Five powdery mildew fungi identified in the present study are presented here.

1. *Phyllactinia guttata* (WaLlr.) Lev. var. *populi* Annales des Sciences Naturelles Botanique

On leaves, mycelium white to greyish, superficial, mostly hypophyllous, thin, effuse or in patches, persistent; hyphae straight to flexuous, branched, septate, 2–5 µm wide. Hyphal appressoria simple, nipple and hook-shaped, occasionally branched to moderately lobed. Conidiophores erect, straight, filiform, arising on upper surface of mother cells, up to about 195 µm long, bearing single conidia; foot-cells straight, cylindrical, up to about 100 × 5–8 µm, followed by 1–3 mostly shorter cells; conidia single-celled, club-shaped, rounded apex, non-apiculate, 55–85 × 15–20 µm, germ tube apical or basal, sometimes lateral, ovulariopsis type with alobate to moderately lobate. Chasmothecia globose, abundant dark brown, hypophyllous, scattered on abaxial leaf surfaces, 185–215 µm diam.; appendages hyaline, thick walled, tapering towards the apex, 125–190 µm, 10–19, 25–38 µm diam. at bulbous base; asci abundant, 70–85 × 35–45 µm, ellipsoid to obovoid, stalked, contained two ascospores; which were ellipsoid-ovoid, 29.5–42.5 × 17.525 µm yellowish-orange to colourless.

Material investigated: Lower side of leaves of *Populus* sp., western region in Uttar Pradesh (India), This powdery mildew was identified as *Phyllactinia guttata* (WaLlr.) Lev. var. *populi* based on the taxonomic characters of the present specimen with a previously described type specimen (Shin & Lee 2002; Braun & Cook 2012). The fungus is also reported from temperate regions of the world, such as Europe North America, Asia (India, China, India, Iran, Japan, Korea, Turkey). Records of *P. guttata* infecting plants include mulberry (Kurt & Soylu 2001) and Salicaceae, Betulaceae, Fagaceae, Juglandaceae (Kapoor 1967; Shin & Lee 2002). *P. guttata* was also isolated from the fungus *Cladosporium uredinicola* on European hazelnut (*Corylus avellana*) from Washington State (Dugan & Glawe, 2006).

2. *Podosphaera xanthii* (Castagne) U. Braun & N. Shishkoff, Schlechtendalia

On leaves, mycelium greyish white, amphigenous, epiphytic in irregular patches. Hyphae simple, smooth, thin, dense, up to 5–9.7 µm; hyphal appressoria wide, solitary, simple (sometimes nipple shaped). Conidiophores mostly erect, arising from the upper surface of hyphal mother cells, up to 95–126 × 12–23.8 µm, foot cells cylindrical, 39–75 × 7.5–15 µm, followed by 1–3 shorter cells; conidia catenescent, ellipsoid-ovoid to doliform, forming in long chains, 25–32 × 11–18 µm, containing fibrosin bodies, germ tubes simple (sometime forked), short and lateral. No perfect stage (chasmothecium) was found. Disease symptoms were observed to be more severe on plants present in shady places.

Material investigated: Leaves of *Ageratum conyzoides* in different localities of western region in Uttar Pradesh (India). This appears to be the first record of *P. xanthii* on *Ageratum conyzoides*. Previously, *P. xanthii* has been reported from Pakistan (Mukhtar *et al.* 2013) and from Meghalaya, from India. In India it was reported on *A. houstonianum* at only genus level. This fungus has been reported in America, Africa, Europe, Australia and Asia (Perez-García *et al.* 2009). It is now well established that cucurbits are the group most severely affected by powdery mildew and *P. xanthii* is one of the main causal agents (Kousik *et al.* 2011; Lee 2012; Zhao *et al.* 2013; Mercier *et al.* 2014).

3. *Erysiphe quercicola* S. Takam. & U. Braun, Mycological Research

On leaves, mycelium, amphigenous, effuse or forming patches, persistent, specific violet-to-wine red discoloration of leaves. Hyphae simple, septate, thin walled, branched, 5–9.7 µm wide; hyphal appressoria simple to lobed, solitary or in opposite pairs. Conidiophores erect, 50–80 µm long, foot cells

cylindrical, 25–40 × 10–18 µm, followed by 1–2 cells, bearing single conidia commonly. The primary conidia were obovoid to ellipsoid, rounded apex and subtruncate base. Secondary conidia 30.1–43.2 × 14.1–21.1 µm, obovoid to ellipsoid or sometimes cylindrical but doliform when mature; germ tubes long, with multilobed appressoria. No perfect stage (chasmothecium) was found.

Material investigated: Leaves of *Quercus* sp., on road side and agricultural fields in western region in Uttar Pradesh (India). The fungus is also reported from tropical and subtropical regions of the world on *Citrus* sp. from Mexico (Yánez-Morales *et al.* 2009), on various *Quercus* spp. including Ubame Oak (*Quercus* phillyraeoides) in Korea (Lee *et al.* 2011), and on Flamboyant tree (*Delonix regia*) in Brazil (Dallagnol *et al.* 2012). To the best of our knowledge, this is the first report in India.

4. *Oidium* Link, in Willdenow, Willd., Sp. pl.

On leaves and stem, white mycelium amphigenous, persistent, effuse or patches. Hyphae, septate, thick, branched, 3–5 µm wide; hyphal appressoria lobed or hooked. Conidiophores simple, mostly erect, 16–60 µm; foot cells cylindrical increasing in width from base to top, followed by 1–3 shorter cells, ends with single conidia commonly; conidia were obovoid-ellipsoid to doliform-subcylindrical, 20–25 x 9–15 µm; germ tubes long, arising from an end, occasionally from a side, terminating in a slightly swollen appresorium. No perfect stage (chasmothecium) was found.

Material investigated: Leaves and stem of *Aegle marmelos* in natural environment, non-agricultural fields in western region in Uttar Pradesh (India). There are a few reports of powdery mildew on *Aegle marmelos* caused by *Oidium* sp. from India. Giri *et al.* (1989) and Preetha *et al.* (2007) reported the disease previously from Kolkata and Kerela respectively. Hence, but to the best of our knowledge, this is the first report from North India. Disease symptoms were commonly abundant during winter. Chlorosis of infected leaf tissues accompanied the fungal infection. Infected leaves turned yellow followed by tissue necrosis. The pathogen is broadly distributed in Asia and Africa and has been reported to infect a number of plant families including Malvaceae, Fabaceae, Asteraceae, Apicyanaceae, Euphorbiaceae, on various plants like oak, peanut, papaya, flax, tomato, etc. Most reports in Asia were from India Cambodia, Indonesia, Malaysia, Sri Lanka, Thailand and Vietnam.

5. *Sphaerotheca fuliginea* (Schltdl.) Pollacci, Atti dell'Istituto Botanico della Università e Laboratorio Crittogamico di Pavia

White mycelium amphigenous, forming thin white persistent patches on leaves, stem or even on flower petals. Hyphae persistant, branched, septate, thin-walled, smooth, hyaline initially later turning brown, 4–8 µm wide; hyphal appressoria indistinct to somewhat simple to nipple-shaped. Conidiophores, straight, erect, arising centrally or usually laterally on hyphal mother cells; foot-cells cylindrical, 25–70 × 9–14 µm, followed by 1–3 shorter cells, forming catenescent conidia; conidia mostly ovoid or cylindrical, 30.8 × 15.0 µm. No fruiting bodies observed.

Material investigated: Zinnia elegans Jacq., on leaves, stem, flower petals in western region in Uttar Pradesh (India), anamorph. *S. fuliginea* is considered one of the most common recorded fungi causing cucurbit powdery mildew across the globe. The most common plant host from cucurbitaceae include *Cucumis sativus, C. melo, Cucurbita maxima, C. pepo, Citrullus lanatus*. The fungus was also recorded from non-cucurbits families like Crassulaceae, Myrtaceae and Asteraceae.

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