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***Golovinomyces spadiceus* causing powdery mildew on *Coreopsis* hybrid ‘Full Moon’ (Heliantheae, Asteraceae) in Washington State**

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Key words: *Coreopsis*, *Coreopsis* ‘Full Moon,’ *C. lanceolata*, *C. rosea*, *Erysiphe arcuata*, *Golovinomyces ambrosiae*, *G. cichoracearum*, *G. franseriae*, *G. spadiceus*, *Leveillula taurica*, *Podosphaera xanthii*.

A powdery mildew was found on a *Coreopsis* cultivar in the Horticulture and Landscape Architecture Garden at Washington State University campus. Although many leaves bore a whitish “bloom” typical of powdery mildew symptoms, neither chlorosis nor necrosis were evident (Fig. 1). The host was documented as

Coreopsis ‘Full Moon’—a cross between *C. rosea* Nutt. and an interspecific hybrid of unspecified parentage (U.S. Plant Patent 19,364 P2). White to off-white areas of sporulating mycelium 5mm in diam to confluent were confined to the adaxial surfaces of the leaves (Fig. 1). Hyaline, short-cylindrical to ovoid conidia, 24-40 x 13-19 µm

and lacking fibrosin bodies (Fig. 2) were formed in chains (Fig. 3). Conidiophores were 65-100(-125) long with foot cells 30-70 x 10-13 µm and usually with 2-3 cells between the foot cell and the basal conidium (Fig. 3). Appressoria were papillate, 4-5 µm in diam (Fig. 4). Conidial germination was of the *Euoidium* type *sensu* Braun and Cook (2012), apical to sub-apical, with germ tubes ending in club-shaped or swollen appressoria (Fig. 5). Chasmothecia were not seen. A voucher collected by the author is deposited as WSP 72215.

The specimen keyed to *Golovinomyces* sect. *Golovinomyces* in Braun and Cook (2012), and the conidial state matched the description of *Golovinomyces spadiceus* (Berk. & M.A. Curtis) U. Braun except that foot cells in the Pullman specimen commonly reached only 70 µm in length, not 80 µm as described in Braun and Cook (2012). Braun and Cook (2012) list two species of powdery mildew on *Coreopsis*: *Golovinomyces spadiceus* and *Podosphaera xanthii* (Castagne) U. Braun & Shishkoff. The latter has conidia with fibrosin bodies and germination tubes arising laterally and often apically branched, (*Fibroidium* type). *Leveillula taurica* (Lév.) G. Arnaud also has been listed on *Coreopsis* sp. (Amano 1986). *Leveillula* species have dimorphic conidia (navicular and cylindrical), which the Pullman specimen did not; nor did the Pullman specimen have fibrosin bodies or display germination of the *Fibroidium* type such as characterize *P. xanthii*.

Golovinomyces has been reported on other *Coreopsis* species in North America, as *Erysiphe cichoracearum* DC (current name, *G. cichoracearum* (DC) V.P. Gelyuta), in 1944 and subsequently (Farr and Rossman n.d.), and later under *G. cichoracearum*, including reports by Glawe et al. (2006) and Seijo et al. (2006). Recently, Braun and Cook (2012) confined *Golovinomyces cichoracearum* s. str. to hosts of the Asteraceae subfamily Cichorioideae, citing Matsuda and Takamatsu (2003), wherein DNA sequences from internal transcribed spacer (ITS) and 28S regions apportioned *Golovinomyces* isolates into clades derived from hosts in the Cichorioideae, Heliantheae (of which *Coreopsis* is a member) and other subfamilies. The closest phylogenetic affinities of an isolate from *Coreopsis* in Japan were not consistent between ITS and 28S cladograms in Matsuda and Takamatsu (2003), and within-clade boot-strap levels were sometimes < 50%, but all isolates in the clade were from plants in the Heliantheae.

Matsuda and Takamatsu (2003) still applied the name *G. cichoracearum* to all isolates from the Heliantheae and the Astereae, and this name was applied also to some isolates in each of the clades from subfamilies Cardueae, Anthemideae and Lactuceae (Cichorieae). Other isolates in each of the latter three clades were assigned additional species names in *Golovinomyces*. Although ITS and 28S sequences may not fully resolve species assignment for species on the Heliantheae, *G. ambrosiae* (Schwein.) U. Braun & R.T.A. Cook is clearly separated from *G. spadiceus* since conidia of the former are up to 7 µm wider than those of the latter; likewise *G. franseriae* U. Braun has conidia up to 5 µm wider than those of *G. spadiceus* (Braun and Cook 2012). Conidia of *G. ambrosiae* and *G. franseriae* also differ from those of *G. spadiceus* in the type of germination, with germ tubes often very long and narrow in the former two species (Braun and Cooke 2012). Lee (2012) reported *Erysiphe arcuata* U. Braun, Takamatsu & Heluta on *Coreopsis lanceolata* L. in Korea, but *E. arcuata* is readily distinguished from *G. spadiceus* because the former consistently produces multi-lobed appressoria and conidia are not in chains (Braun and Cook 2012).

Multiple gardening sites (e.g., www.finegardening.com, www.ballhort.com, and www.waltersgardens.com) refer to “powdery mildew” on *C. rosea* or *Coreopsis* ‘Full Moon’ but without providing further identification or host range of the fungi. This note is issued to report occurrence of *G. spadiceus* on *Coreopsis* ‘Full Moon,’ to advise diagnosticians and others of the desirability of applying the name *G. spadiceus* to isolates from *Coreopsis* which previously were considered *G. cichoracearum*, and to provide clear photomicrographs of diagnostic characters that distinguish *G. spadiceus* from *Erysiphe*, *Leveillula*, *Podosphaera* and other species of *Golovinomyces* with hosts in the Heliantheae.

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Figs. 1-5. *Golovinomyces spadiceus* on *Coreopsis* 'Full Moon.' Fig. 1. Symptoms on host. Fig. 2. Conidium, showing absence of fibrosin bodies. DIC. Bar = 10 µm. Fig. 3. Two conidiophores: Left, mature conidiophore with (basally to apically) foot cell, two additional cells, and two conidia; right, immature conidiophore. DIC. Bar = 25 µm. Fig. 4. A typical, papillate appressorium. DIC. Bar = 5 µm. Fig. 5. Two conidia, each displaying germination of the *Euoidium* type. DIC. Bar = 20 µm. All photomicrographs from mounts in 3% KOH.

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