

Diseases Caused by Oomycetes

First Report of Downy Mildew Caused by *Pseudoperonospora cannabina* on *Cannabis sativa* in New York

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Funding: Funding was provided by New York State Department of Agriculture and Markets through Empire State Development Corporation (grant/award no. 132997). Plant Dis. 107:1638, 2023; published online as <https://doi.org/10.1094/PDIS-08-22-1930-PDN>. Accepted for publication 18 October 2022.

Hemp (*Cannabis sativa* <0.3% tetrahydrocannabinol) is an emerging crop used for grain, fiber, and cannabinoid production (Fike et al. 2020). In New York, hemp is grown both in controlled environment facilities, including greenhouses, and as a field crop. In August 2020, downy mildew-like symptoms were observed on leaves and inflorescences of hemp plants in a field research trial in Ithaca, NY. Several cultivars, including 'Auto CBD', were affected. Disease was severe with some plants reaching 75% disease severity at the individual plant level. In the most severely affected plots, there was no marketable yield. The disease was characterized by chlorotic and necrotic lesions producing sporangioophores under high humidity. Pigmented sporangia were produced on branched sporangiophores. On artificially inoculated leaves incubated at 18°C, 80% humidity, and 12 h light for 5 days, sporangiophores produced 8 to 19 pigmented, lemon-shaped sporangia with mean ± SD dimensions of 25.2 ± 3.0 (18.9 to 30.4) × 18.2 ± 2.1 (14.6 to 23.2) μm ($n = 50$). Each sporangium produced two to five zoospores after less than 45 min in water at room temperature (22°C). Sporangia were collected from sporulating lesions and DNA was extracted as outlined in Crowell et al. (2020). Fragments of the ribosomal internal transcribed spacer (ITS) region (White et al. 1990), the beta-tubulin ras-associated *ypt1* gene (Moorman et al. 2002), and the mitochondrial cytochrome B oxidase subunit 2 (*cox2*) gene (Hudspeth et al. 2000) were amplified

by PCR and sequenced bidirectionally. Sequences were deposited in GenBank under accession numbers OK086084, OM867581, and OM867580, respectively. BLAST searches using the amplified ITS and *cox2* sequences resulted in 100% identity to *Pseudoperonospora cannabina* (HM636051.1, HM636003.1) with *ypt1* aligning at 97.95% identity (382/390 bp) with *P. cannabina* (KJ651402.1). The molecular characterization identified the causal agent as *P. cannabina*. A representative isolate was deposited in the Cornell Plant Pathology Herbarium as CUP-070922. Sporangia were rinsed from detached leaves and used to confirm pathogenicity on whole plants. Ten 4-week-old 'Anka' plants were spray-inoculated until runoff with a suspension of 1×10^4 sporangia ml⁻¹. Ten control plants were sprayed with water. After inoculation, plants were placed in a 19°C growth chamber with a 12-h photoperiod and misted for 30 min twice daily to maintain humidity above 80%. Sporangia and previously described symptoms were observed 7 days postinoculation, while control plants were asymptomatic. The pathogen was reisolated onto detached leaves of 'Anka' from inoculated leaves where both sporangia and oospores were observed. The reisolated pathogen was confirmed morphologically and molecularly, through PCR amplification and bidirectional sequencing of the ITS, *cox2*, and *ypt1* genes, as *P. cannabina*. To our knowledge, this is the first report of *P. cannabina* causing hemp downy mildew in New York. Depending on the severity and timing of infections, this disease could pose a significant threat to hemp production in the state. Two other members of the genus, *P. cubensis* and *P. humuli*, cause downy mildew on cucurbits and hops, respectively. As these can cause devastating diseases on their hosts, *P. cannabina* must be monitored with vigilance as an emerging pathogen (Purayannur et al. 2021; Savory et al. 2011).

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The author(s) declare no conflict of interest.

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Keywords: *Cannabis sativa*, downy mildew, hemp, *Pseudoperonospora cannabina*

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