



Dossier: Pansy Downy Mildew

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Introduction and Importance

Pansies are popular garden plants due to the beauty of their flowers and their variety of colors. Annual pansies—also referred to as violas—are usually sold as flats, pots, hanging baskets alone or mixed with other types of flowers. In shady, cool landscape beds it can be used as an annual ground cover. Due to their tolerance to cold temperatures, pansies offer many bloom cycles in early spring and late fall and winter. The annual bedding garden plants industry, which includes pansies/viola plants, ranks first in the United States alone in the wholesale values of floriculture crops, with annual sales of ~ \$1.2 billion (USDA-NASS 2016 Report). Pansies and violas just sold as flats, hanging baskets and as pots have a wholesale value of ~ \$98 million (USDA-NASS 2016 Report). Relatively few diseases affect pansies and violas. However, downy mildew could have a significant impact on the industry sales due to the material lost during production because of the disease. During the fall/winter of 2002 there was a severe outbreak of pansy downy mildew across the U.S. [1] and the disease continues to be problematic for growers.

Plant Description

Genus Viola

The genus *Viola* contains approximately 500 species of pansies and violas distributed worldwide but found most abundantly in temperate climates. There is also a great variety of species occurring in the Andes Mountains of South America, Hawaii and Australia [2]. Wild species of *Viola* can be annuals or perennials, and a few are considered shrubs. Due to extensive hybridization, taxonomy at the species level is often difficult [2]. Pansy flowers are single with five petals, rounded in shape, and have one of three basic color patterns: (1) yellow, red, purple, among others; (2) a single color having black lines radiating from its center (similar to species *Viola* markings); and (3) a dark center pattern called a “face” which has two or three different colors [3]. The pansy plant



itself is compact, not more than 9 inches in both height and spread, and bears many stems, and the medium green, coarsely notched leaves are oval or heart-shaped [3]. Pansies are some of the most popular cultivated *Viola* (violets). Pansies have been derived via hybridization of several *Viola* species in the taxonomic section *Melanium*, but more particularly *Viola tricolor*, a wildflower from Europe and Asia [4]. Pansies are grown from seeds, and are used in containers, garden borders and as ground covers. They grow well in sunny or partially sunny locations and well-drained soil, and can survive light freezes and short periods of snow cover [4].

Figure 1. Pansy cultivar with species *Viola* markings (left) and dark central faces (right)



Photos taken from: http://www.almanac.com/sites/default/files/image_nodes/pansies-purple.jpg and http://www.thegardenhelper.com/psd/viola_x_wittrockiana.jpg

Pathogen Description

Downy mildew disease of pansy is caused by the oomycete *Peronospora megasperma* Berl. (synonyms: *Plasmopara megasperma* (Berl.) Berl.; *Bremiella megasperma* (Berl.) G.W. Wilson; *Peronospora violae* sensu Ellis & Everhart). This *Peronospora* species was formally described in 1898 [5]. It was previously believed that *P. megasperma* was found only distributed on *Viola* spp. in North America, and *P. violae* was only distributed on *Viola* spp. in Europe [6]. Currently, all downy mildew pathogens affecting *Viola* spp. are regarded as *P. megasperma*, independent of the geographic location. Microscopic features of *P. megasperma* include white-yellowish or white-greyish mat of mycelial growth, sometimes covering most of the underside surface of the leaf, with intracellular haustoria. Sporangiohores arising through stomata can appear singly or in groups of 2-6, hyaline or colorless and gradually tapered towards the tip. Sporangiohores branch dichotomously branched in their upper part, with the ultimate branchlets curved or flexuous (Figure 2). Sporangia are hyaline, ellipsoidal with an apical pore covered by a papilla. Round oospores can be produced on all attacked host parts but especially on stipules and have a thick and smooth yellowish cell wall [6].

Pathogen Biology and Disease Cycle

Peronospora megasperma produces zoospores and oospores [6]. Zoospores are motile spores that are the result of asexual reproduction and are produced in the abaxial surface of infected leaves. Sporangia are the sac-like structures that contain spores and where the zoospores are formed. As with other downy mildew diseases, pansy downy mildew disease spreads mainly through the propagation of infected plants, by wind or water currents that move the pathogen's infective propagules or by transplanting healthy plants into soil infected with the pathogen. In an infected pansy, sporangiohores and sporangia will form during cool and very humid conditions and emerge from the internal tissue of the underside of the leaf. If water is present in the surface of the leaves, sporangia can germinate and produce massive quantities of zoospores that can cause secondary infections within the same plant, or being spread by wind or water splash. Sporangia can also be dislodged from the leaf tissue and fall in the ground where the zoospores can be released and spread short distances by water splash, or longer distances by wind currents to nearby plants. Once in a new plant, zoospores encyst, then form germ tubes that enter stomata and from there invade inner tissues of the plant by growing between the cells. The sporangia and zoospores can serve as the source of inoculum for new infections in nearby plants in landscape settings. Oospores formed in diseased tissues can potentially become inoculum source for recurrent infections season after season.



Figure 2. *Peronospora megasperma* microscopic characteristics

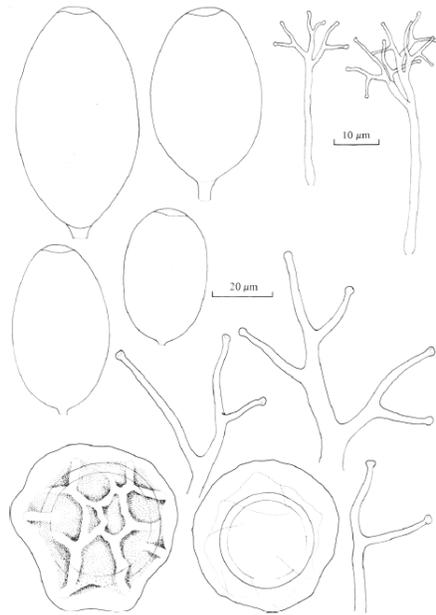


Photo taken from: <http://www.sciencedirect.com/science/article/pii/S0007153679801709>

Epidemiology

High environmental moisture, overcrowding and cool temperatures characteristic of spring and fall weather have been correlated with the development of the pansy downy mildew disease [7, **Error! Reference source not found.**]. Although oospore formation has been observed, indicating the possibility of a sexual life cycle for *P. megasperma* [6], little is known about the effect of oospores in disease epidemics. No information is available about the overwintering structures for *P. megasperma*.

Disease Symptoms

The symptoms of pansy downy mildew include brown-purple spots on the upper leaf surfaces, sometimes with a surrounding yellow halo of chlorotic discoloration. Sporulation of *P. megasperma* can be seen in the underside of leaves. The margins of severely affected leaves may curl under, become necrotic and eventually die. Severe infections lead to stunting and reduction in the number of flowers [8,9].

Figure 3. Pansy downy mildew disease symptoms



Photos taken from: http://apps.rhs.org.uk/Advice/ACEImages/SCN0000351_620510.jpg and http://apps.rhs.org.uk/Advice/ACEImages/SCN0000350_101272.jpg



Host Range

Peronospora megasperma solely infects plants in the genus *Viola* (pansy, violet) [10].

Geographic Distribution

Although there are few published reports of downy mildew disease caused by *P. megasperma*, this pathogen is considered widespread in the U.S. and Western and Central Europe [10].

Cultural Practices

- Inspect plant material upon arrival for any sign of disease problems.
- When growing in greenhouses, minimize humidity and leaf wetness for extended periods of time, if feasible.
- Ensure good air circulation and water drainage with well-spaced plants.
- Scouting frequently for detection of early symptoms and remove infected plants to prevent disease spreading.
- Remove suspect plants and send samples to a diagnostic lab for prompt identification
- Practice good sanitation, removing fallen leaves and debris.
- Do not compost infected material onsite.

Cultivar Disease Resistance

Several pansy and viola cultivars have been tested for downy mildew resistance. The majority of cultivars are susceptible to the disease, however some cultivars like Crown Rose and Dancer Baconsfield showed very low incidence of the disease, while some others such as Crown Yellow and Bingo Light Rose w/Blotch are highly susceptible and show the strongest response to the pathogen [1].

Fungicide Management

Current recommendations for pansy downy mildew management rely on protective fungicide treatments with applications as soon as environmental conditions are favorable for disease development and before noticeable symptoms and inoculum are present. Contact fungicide treatments, such as Protect (mancozeb) and Daconil (chlorothalonil), combined with systemic active ingredients, such as Heritage (azoxystrobin) and Subdue Maxx (mefenoxam) provide options from multiple mode of action groups. In fungicide trials to control pansy downy mildew conducted in 2002, the best eradicants proved to be products with dimethomorph alone or in combination with mancozeb. Cooper formulations such as Camelot-O showed very good to excellent control. Strobirulin fungicides, such as Heritage and Compass and organic phosphates such as Aliette perform very well although do not give 100 % control [1]. For additional options from other downy mildew systems, consult the IR-4 Downy Mildew Efficacy Summary and Literature Review (<https://www.ir4project.org/ehc/environmental-horticulture-research-summaries/>) [20]. Disease management is more effective when full coverage of the underside of the leaves is achieved during contact fungicide treatments or when systemic products such as those in FRAC groups 4 (mefenoxam), 33 (phosphorus acid generators) and 49 (oxathiapiprolin) are employed in rotation.

To slow the development of resistance, it is highly recommended that label directions are followed closely and that rotations occur among different modes of action as established by the Fungicide Resistance Action Committee (FRAC).

Genetics and Genomics

Not much information is available about *P. megasperma* – *Viola* spp.

Knowledge Gaps

- **Biology.** Almost nothing is known about the disease cycle of pansy downy mildew, with no data generated through peer-reviewed scientific research. It is unknown whether *P. megasperma* is homothallic or



heterothallic. Since oospores of *P. megasperma* have been observed in plant tissues, it might be homothallic; however, this needs confirmation.

- **Epidemiology.** It is unknown whether this disease is seed transmitted. It is unknown how *P. megasperma* overwinters.
- **Disease Management.** Only general recommendations for cultural practices are available applicable to DMs, generally. Newer fungicides are now available but have not been screened for performance with pansy downy mildew.
- **Genetics.** To the best of our knowledge, the pathogen and host plant genomes have not been sequenced.
- **Genomics.** *Peronospora megasperma* and *P. violae* are considered species synonyms, however, these species were originally described as having restricted geographic distribution (*P. megasperma* in North America and *P. violae* in Europe). Some other species of downy mildew pathogens have been found to be complexes of species. Is it possible this is the case for *P. megasperma* – *P. violae*?
- **Diagnostics.** Currently, there is no diagnostic assay for this downy mildew pathogen.

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