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Downy Mildew in Lilac

Margaret Mmbaga

Abstract. *Syringa* spp. 'Old Glory' is a disease-resistant selection of lilac that was developed from a controlled hybridization between *Syringa* 'Sweet Charity' and *Syringa* × *hyacinthflora* 'Pocahontas'. 'Old Glory' is credited for high-level disease resistance to powdery mildew, bacterial blight, and other foliage diseases common in the southern region of the United States, but in 2005 and 2006,'Old Glory' plants developed symptoms of downy mildew in McMinnville, Tennessee, U.S. Symptoms started in late April as chlorotic lesions and later became necrotic. Upper leaf surface symptoms appeared similar to common leaf spots with necrotic lesions, but underside leaf lesions were covered with masses of sporangiophores and sporangia. Morphologic features of the sporangiophores and sporangia matched that of *Plasmopara* spp. The leaf lesions were circular or irregular and developed between veins. Coalesced lesions formed large necrotic patches; severely infected leaves defoliated prematurely. Surface-sterilized healthy leaves were spray-inoculated with sporangiospores and placed in Petri dishes over triple-layered wet paper towels at 23°C to 25°C (73.4°F to 77°F). Disease symptoms were reproduced in approximately 12 days. Noninoculated control leaves did not develop disease symptoms. Oospores were not observed. Downy mildew has not previously been reported in lilac and this is the first report of the disease in Tennessee.

Key Words. Plant health care; *Plasmopara* spp. leaf spot diseases; *Syringa* species.

Lilac (*Syringa* spp.) is one of the most common flowering shrubs, known for its beautiful and fragrant bloom in spring. Several foliage diseases affect lilac in Tennessee, U.S., the most common of which are bacterial blight (*Pseudomonas syringae* pv *syringae*), powdery mildew *Erysiphe* (Sect. *Microsphaera*) *syringae, Cercospora* spp., and *Alternaria altinatum* (Westcott 1898; Hibben et al. 1977; Sinclair et al. 1993; Clement et al. 1994; Pscheidt and Moorman 2001; Mmbaga et al. 2005). Disease resistance is the best management approach for lilac diseases, and cultivars that are resistant to individual or multiple diseases have been identified in field evaluations (Hibben et al. 1977; Mmbaga et al. 2005). *Syringa* 'Old Glory' is a product of the lilac hybridization program at the U.S. National Arboretum, representing a selection from a controlled hybridization between *Syringa* 'Sweet Charity' and *Syringa* × *hyacinthflora* 'Pocahontas' made by Don Egolf in 1978 and released in March 2006 (U.S. National Arboretum 2006). 'Old Glory' was selected for its abundant fragrant bluish purple flowers, rounded growth habit, and foliar disease tolerance (Figure 1). Syringa 'Old Glory' is credited for high-level disease resistance to powdery mildew, bacterial blight, and other foliage diseases common in the southern U.S. region (US National Arboretum 2006). Common leaf spot symptomatology was observed on 'Old Glory' in Summer 2005 and 2006. The objective of this study was to identify the causal agent of this disease.

MATERIALS AND METHODS

New hybridized selections, Syringa 'Old Glory' and 'Declaration', were field-grown for observation at the USDA National Arboretum germplasm evaluation plots in McMinnville, Tennessee State University (TSU) Otis L. Floyd Nursery Research Center. In May 2005, disease symptoms exhibiting necrotic lesions on the foliage were observed in 'Old Glory', but not in 'Declaration'. Disease symptoms intensified in 2006 making the 'Old Glory' hybrid unsightly (Figure 2). The upper side of affected leaves yielded distinct symptoms consistent with common leaf spots, but the underside of the leaves showed the lesions were covered with white mass of sporangiophores and sporangia that later turned grayish in color. The symptomatology was suggestive of downy mildew disease, but the disease has not previously been observed on more than 50 lilac accessions grown in the local area (Mmbaga et al. 2005). Temperatures were ideal for downy mildew with April temperatures ranging between 15°C and 23°C (59°F and 73.4°F) and May temperatures ranging between 18°C and 28°C (64.4°F and 82.4°F) (Cotner 1930; Spencer 1981). The sporangiophores and sporangia were isolated from underside leaf lesions and were characterized under a compound microscope.

To confirm that the observed fungal organism was a pathogen associated with the observed symptoms, a pathogenicity test was done using a detached leaf technique (Dhingra and Sinclair 1995). Sporangiospores were harvested from the leaf underside and suspended in sterilized double-distilled water containing a surfactant (Tween 20, Cayman Chemical Company, Ann Arbor, MI, U.S.) at a rate of 0.04 μL/L. The spore suspension was adjusted to a concentration of 1×10^5 spores/mL. Twelve disease-free leaves of *Syringa* 'Old Glory' were detached and surface-sterilized using 10% Clorox® bleach (Clorox Company, Oakland, CA) for 2 min and rinsed in sterilized water. Six sterilized leaves were aseptically inoculated with the sporangiospore suspension by using an atomizer to deliver the inoculum uniformly; leaves were sprayed to runoff. The noninoculated controls were sprayed with sterile water. Inoculated and noninoculated leaves were placed in Petri dishes over triple-layered sterilized paper towels soaked in sterilized water and incubated at 23°C to 25°C (73.4°F to 77°F) with 14/10 hr (light/dark) periods. A randomized complete block design with a replication of six individual leaves per treatment was used. The inoculated and noninoculated leaves were monitored for symptoms and signs of disease development. Twelve days after inoculation, the underside of the leaves was observed under a dissecting microscope

Figure 1. *Syringa* 'Old Glory' hybrid introduction (NA 62974; P1641803) US National Arboretum Plant Introductions, Floral and Nursery Plants Research Unit (www.usna.usda.gov/Research/Lilacs_Release.html).

and sporangiosphores and sporangiospores were harvested and characterized under a compound microscope.

RESULTS

The field-grown Syringa 'Old Glory' hybrids did not develop symptoms of powdery mildew nor *Pseudomonas syringae*, both of which are problematic in the local area. However, inoculated 'Old Glory' leaves developed symptoms consistent with common leaf spots, originally observed (Figure 2). The inoculated leaf lesions developed between the veins appearing angular in shape. Lesions often coalesced to form large patches of necrotic tissue covering a large part of the leaf. The symptoms were at first evident on the upper side of the leaves, appearing as chlorotic lesions that later turned brown and necrotic with indefinite edges (Figure 2). The lesions on the underside of the leaves were covered with white mass of sporangiophores and sporangia that later turned grayish in color (Figure 3A). Although the disease was first observed in spring, the necrotic lesions persisted throughout summer with the mycelia becoming grayish in color. Severely infected leaves defoliated prematurely. Symptoms were not observed on Syringa 'Declaration' that was growing in close proximity.

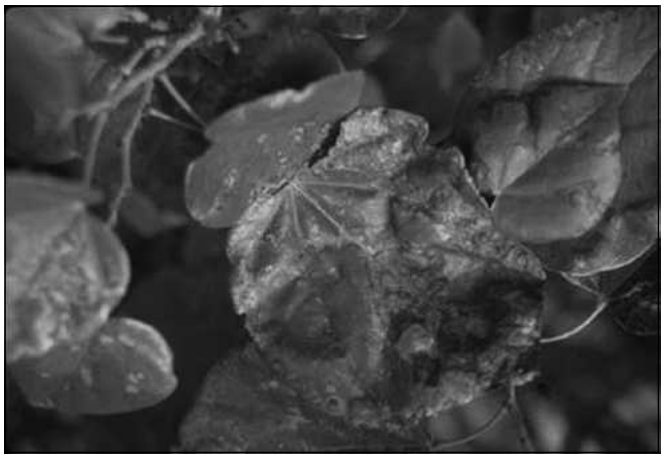

Figure 2. Necrotic lesions caused by downy mildew in *Syringa* 'Old Glory'.

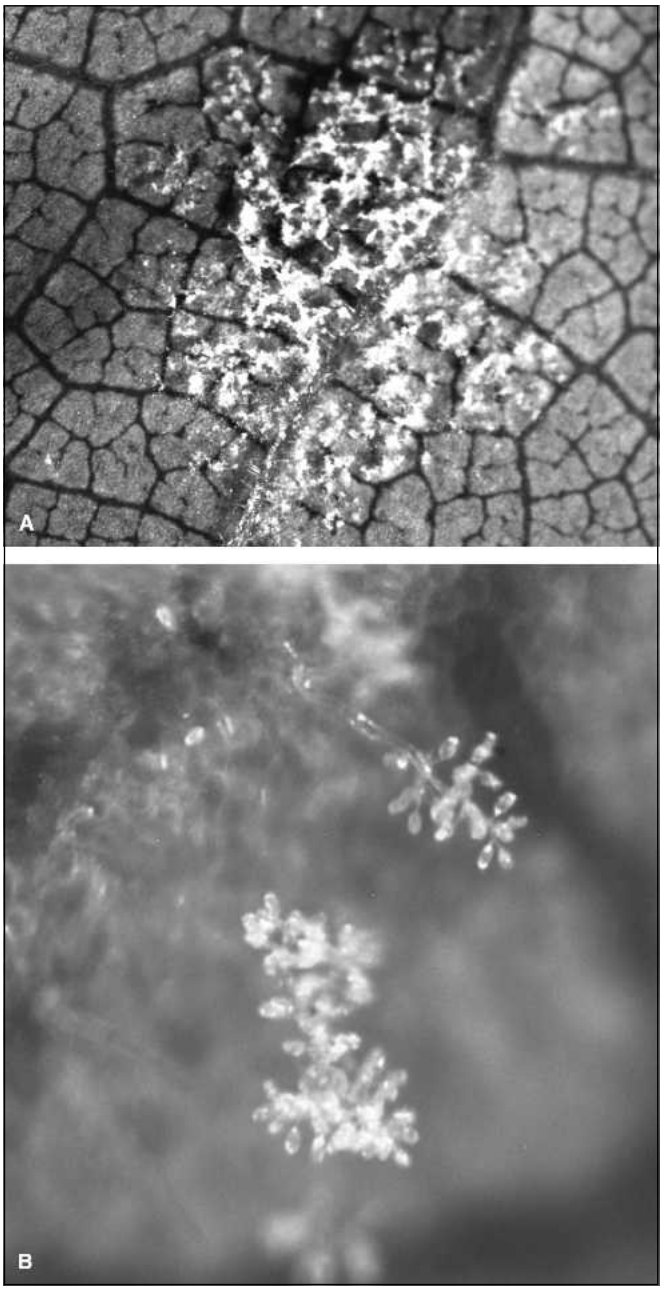

Figure 3. Mycelial tuft characteristic of the downy mildew fungus on foliage underside. (A) Mycelial tufted mycelia visible with the naked eye. (B) Microscopic view of sporangiophores and spororangiospores produced from the mycelial tuft (100×).

Observation of the fungal mycelia under a dissecting and compound microscope revealed an abundance of sporangiospores borne on branched sporangiophores (Figures 3B and 4). Sporangiophore branching was distinctly monopodial with smaller branches arranged at right angles to the supporting branches; tips of sporangiophore branches measured 8 to 14 μm long (Figure 4). The sporangia were hyaline and ovoid in shape measuring

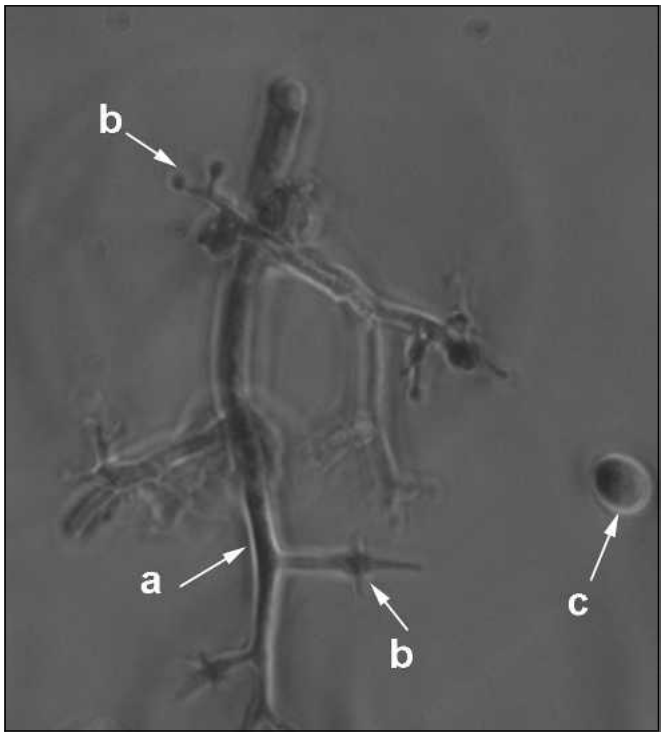

Figure 4. Morphologic characteristics of lilac downy mildew pathogen at 400× magnification showing (a) primary monopodial branching of sporangiophores with (b) smaller sporangiophore branching arranged at right angles to the supporting branches and (c) obovoid sporangia.

approximately 19.5 to 22 μm × 14 to 17 μm. Overwintering structures, oospores, were not observed.

Pathogenicity tests on detached leaves confirmed that the originally observed organism was pathogenically associated with the observed symptoms. All leaves inoculated with the downy mildew sporangiospores developed fungal induced symptoms in 12 days; noninoculated leaves did not develop symptoms. The lesions started as chlorotic lesions and in 10 to 12 days; the symptoms turned brown to ashy brown and necrotic similar to symptom development in the field. Symptoms and signs were characteristic of downy mildew; morphologic features of the fungus observed under a compound microscope were characteristic of *Plasmopara* species.

DISCUSSION

Downy mildew fungi can survive for many years as overwintering oospores in the soil or in colonized roots and host debris (Scribner 1886; Cotner 1930; Barrett 1939; Spencer 1981). New infection may occur soon after transplanting a susceptible host in an infested area or transplanting a previously infested plant to a location where environmental conditions are favorable for disease development. The source of inoculum for this disease is not clear. The location where *Syringa* 'Old Glory' and 'Declaration' were grown did not have lilac plants in the previous 12 years. It is probable that the infection started from infested plant material or overwintering oospores, which may have remained dormant in soils for decades (Scribner 1886; Cotner 1930; Barrett 1939). More than 50 accessions of lilac have been growing at TSU Otis Floyd Research farm in McMinnville, Tennessee, U.S., since 1995, but downy mildew has not previously been detected (Mmbaga et al. 2005).

Ideal conditions for pathogenic development of downy mildew are cool night temperatures of 6°C to 15°C (42.8°F to 59°F) and day temperatures no greater than 25°C (77°F). Free surface moisture such as rain, condensation, or fog persisting until midmorning for at least 4 days in a row is required for sporangiospore germ tube development and subsequent epidermis penetration (Cotner 1930; Spencer 1981). In McMinnville, Tennessee, environmental conditions favorable to downy mildew may occur during April to May when monthly mean temperature range from 15°C to 26°C (59°F to 78.8°F). Once downy mildew infection has occurred from previously infested plants, or from infested soil, a new crop of conidia can be produced in 4 to 5 days. The sporangiospores are disseminated by rain and wind and they can germinate within 4 hrs (Cotner 1930; Spencer 1981). As seasonal temperatures rise, plants tend to outgrow the disease. New infections may also occur in the fall when seasonal temperatures once again become favorable. Infections that develop in fall may pass unnoticed because of natural change in leaf colors associated with defoliation. Thus, it is not clear when the first symptoms of downy mildew infection developed on 'Old Glory'.

Downy mildew is a destructive disease on many field and vegetable crops, but it has little economic impact on woody plants except in roses and grapes (Sinclair et al. 1993). Although some defoliation may be associated with this disease, the impact of downy mildew disease on lilac is mostly aesthetic. Because cool temperatures are critical for continued downy mildew disease development, higher temperatures characteristic of the Tennessee summers will probably not allow the perpetuation of this disease as a production problem. If other lilac accessions are susceptible, and the disease has opportunity to spread to other hosts, downy mildew infection would likely be limited to early spring.

Studies on the management of this disease in lilac were not undertaken. However, recommendations for the management of downy mildew in other crops include avoiding planting susceptible plants in infested areas, use of resistant plants, chemical fungicides, and cultural methods that improve air circulation and avoid wetting plant foliage (www.ces.ncsu.edu/depts/pp/cucurbit/). Broad-spectrum contact protectant fungicides such as dithiocarbamate (Mancozeb), copper (copper sulfate, copper hydroxide), and Benzonitrile (chlorothalonil) provide some downy mildew control (Paulus et al. 1983; Horst 1990). Fungicides that specifically target oomycete fungi allow better control of downy mildew fungi. Most effective fungicides are systemic or partially systemic and have combined systemic and protectant efficacy (Horst 1990). Several systemic fungicides are now available for downy mildew, including fosetyl–aluminium (Aliette®; Bayer Crop Science, Research Triangle Park, NC), azostrobin (Heritage®; Zeneca Professional Products, Wilmington, DE), strobilurin (Compass®; Norvatis Crop Protection, Greensboro, NC), mefenoxam (Ridomil Gold®; Syngenta Crop Protection, Wilmington, DE), cymoxanil (Curzate® or Tanos®; DuPont Company, Wilmington, DE), propamocarb (AgrEvo USA Co., Wilmington, DE) (Previcur Flex®; Bayer Crop Science, Research Triangle Park, NC), cyazofamid (Ranman®; FMC Corporation, Philadelphia, PA), dimethomorph (Forum®; BASF Chemical Corporation, Florham Park, NJ), phosphorus acid fungicides (Phostrol®; Nufarm Americas Inc., Burr Ridge, IL; ProPhyt®;

Luxembourg-Pamol, Inc., Memphis, TN), and cyazofamid (Fosphite®; JH Biotech Inc., Raleigh, NC). Of these, propamocarb, cyazofamid, and dimethomorph have systemic and protective actions (www.bayercropscienceus.com/products; Westcott 1898). Literature search in plant disease, phytopathology, and mycological journals and secondary sources for lilac downy mildew (Westcott 1898; Sinclair et al. 1993; Pscheidt and Moorman 2001) showed that downy mildew has not previously been reported in lilac and this is the first report of the disease in Tennessee. Evaluation of lilac accessions for susceptibility or resistance to downy mildew is needed to provide more information on the economic potential of this disease.

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Margaret Mmbaga
Otis L. Floyd Nursery Research Centre
Tennessee State University
472 Cadillac Lane
McMinnville, TN 37110, U.S.
mmmbaga@tnstate.edu

Résumé. Le *Syringa* spp. 'Old Glory' est une sélection de lilas résistante aux maladies qui a été développée à partir d'une hybridation contrôlée entre *Syringa* 'Sweet Charity' et *Syringa* × *hyacinthflora* 'Pocahontas'. 'Old Glory' a été crédité par le passé quant à sa résistance élevée au mildiou, à la brûlure bactérienne et aux autres maladies de feuilles communes dans la Sud des États-Unis, mais en 2005 et 2006, 'Old Glory' a développé des symptômes de mildiou à McMinnville au Tennessee. Les symptômes de lésions chlorotiques ont débuté en avril et sont devenus nécrotiques par la suite nécrosées. Les symptômes sur le dessus de la feuille étaient similaires à ceux plus communs de lésions nécrotiques avec des taches, mais sous la surface foliaire il y avait des lésions qui étaient recouvertes de masses de sporangiophores et de sporanges. La description morphologique des sporangiophores et des sporanges étaient celles correspondantes au *Plasmopara* spp. Les lésions foliaires étaient circulaires ou irrégulières et se développaient entre les veines. Les lésions coalescentes formaient de larges zones nécrotiques; les feuilles sévèrement affectées tombaient prématurément. La surface de feuilles saines et stérilisées a été inoculée par vaporisation de sporangiospores et ces dernières placées dans des Pétri sur une triple couche de papier absorbant humide entre 23 et 25°C. Les symptômes de maladie se sont reproduits environ 12 jours plus tard. Les feuilles non inoculées du groupe témoin n'ont pas développées de symptômes de maladie. Aucun oospore n'a été observé. La présence de mildiou n'avait pas été rapportée auparavant et ceci constitue le premier cas observé de cette maladie au Tennessee.

Zusammenfassung. Syringa spp Old Glory ist eine krankheitsresistente Fliederselektion, die aus einer kontrollierten Hybridisation zwischen Syringa Sweet Charity und Syringa x hyacinthflora Pocahontas entwickelt wurde. Old Glory ist bekannt für eine hohe Resistenz gegen echten und falschen Mehltau und andere typische Blattkrankheiten in den südlichen USA, aber in der Jahren 2005 und 2006 zeigten Old Glory-Pflanzen in der Region von McMinnvill, Tennessee, Symptome von Echtem Mehltau. Die Symptome traten zuerst im späten April als chlorotische Flecken auf, die später nekrotisch wurden. Die Oberblattsymptome sahen zunächst ähnlich wie gewöhnliche Blattflecken aus, aber die Unterseiten waren bedeckt mit Sporangiophoren und Sporangien. Die morphologischen Erscheinungen der Sporangiophoren und Sporangien stimmten mit denen von Plasmopara spp. überein. Die Blatttflecken waren kreisrund oder irregulär und entwickelten sich zwischen den Blattvenen. Vereinigte Flecken ergaben große, nekrotische Flecken, heftig infizierte Blätter fielen rasch ab. Oberflächen-sterilisierte, gesunde Blätterwurden mit Sporangiosporen besprüht und in Petrischalen über dreifachem Zellstoff bei 23–25°C. Nach ca. 12 tagen zeigten sich die ersten Krankheitssymptome. Die nicht okulierten Kontrollblätter haben diese Symptome nicht entwickelt. Oosporen wurden nicht beobachtet. Mehltau wurde vorher nicht bei Flieder beobachtet und dies ist der erste Report dieser Krankheit in Tennessee.

Resumen. *Syringa* spp. 'Old Glory' es un cultivar resistente que fue desarrollado de un híbrido controlado entre *Syringa* 'Sweet Charity' y *Syringa* × *hyacinthflora* 'Pocahontas'. 'Old Glory' es acreditado por su alto nivel de resistencia a la cenicilla polvorienta, quemadura bacterial y otras enfermedades del follaje comunes en el la región sur de los Estados Unidos. Pero en el 2005 y 2006, plantas de 'Old Glory' desarrollaron síntomas de hongos en McMinnville, Tennessee, U.S. Los síntomas empezaron a fines de Abril como lesiones cloróticas y más tarde se convirtieron en necróticas. Los síntomas en la parte superior de la hoja parecieron similares a las manchas foliares con lesiones necróticas, pero debajo las lesiones estaban cubiertas con masas de esporangios. Las características morfológicas de los esporangios fueron de *Plasmopara* spp. Las lesiones de las hojas fueron circulares o irregulares y se desarrollaron entre las venas. Las lesiones formaron grandes parches necróticos; las hojas severamente infectadas defoliaron prematuramente. Hojas sanas fueron inoculadas con esporas y colocadas en platos de Petri sobre triples toallas húmedas de 23°C a 25°C (73.4°F a 77°F). Los síntomas de la enfermedad se produjeron en aproximadamente 12 días. Hojas no inoculadas de control no desarrollaron síntomas de la enfermedad: no se observaron esporas. Esta cenicilla no había sido reportada previamente en lila, este es el primer reporte de la enfermedad en Tennessee.