Diseases Caused by Fungi and Fungus-Like Organisms

First Report of Root Rot Caused by *Fusarium armeniacum* on American Ginseng in China

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American ginseng (*Panax quinquefolius*) is an important medicinal plant cultivated in China since the 1980s. Its dried roots are used for food, health care products, and medicine in China (Yuan et al. 2010). Root rot caused by *Fusarium* spp. was a major disease, with 33 to 41% incidence surveyed in main production areas of Wendeng County (121.80 °E, 37.09 °N) in Shandong Province, China, in 2016 to 2019. Symptoms included soft, water-soaked, dark brown to black lesions on the roots. Lesions progressed and the inner parts gradually disintegrated. One-year-old diseased roots were collected in September 2016. Symptomatic tissues were surface sterilized in 75% ethanol for 30 s and 0.8% NaOCl for 3 min, rinsed in sterile water, plated on potato dextrose agar (PDA), and incubated at 25°C in darkness. Single colonies were then obtained and transferred to carnation leaf agar (CLA) (Burgess et al. 1993) for growth at 25°C with a 12-h photoperiod. Colonies cultured on PDA for 7 days were white to light pink, turning to apricot pigmentation in color. After 30 days on CLA, the colonies produced elongate, falcate macroconidia having three to five septa, with a long, tapering and curved apical cell, and having the size ranging from 31.1 to 45.6 µm long × 4 to 4.6 µm wide. Microconidia were zero to one septate, ellipsoid to ovoid, and varied in size from 9.5 to 16.8 µm long × 3 to 3.2 µm wide. Chlamydospores formed abundantly, in chains or clusters. This fungus was identified as *Fusarium armeniacum* (Burgess et al. 1993). Identification was confirmed by sequencing three DNA regions including the internal transcribed spacer ribosomal DNA (ITS), elongation factor 1α, and β-tubulin genes (Lu et al. 2020). The three DNA regions

(MN417271, MG457199, and MN427653) had 100% homology to the sequences of *F. armeniacum* (KJ737378, HM744664, and HQ141640) (Wang et al. 2015; Yli-Mattila et al. 2011). Pathogenicity tests were conducted on 1- to 2-year-old bare roots and 2-year-old whole plants. For root inoculation, 14 healthy roots were inoculated with two mycelial PDA plugs/root. After 3 to 10 days at 25°C, all the inoculated roots showed water-soaked and root rot symptoms, whereas no lesions were observed in the control roots. For plant inoculation, eight seedlings planted in pots filled with sterilized soil were inoculated by pouring a conidial suspension of 1×10^5 conidia/ml at 30 ml/pot. Eight seedlings inoculated with sterilized water served as the controls. After 90 days, only 37.5% of the roots survived with typical root rot symptoms, whereas the control plants remained symptomless. *F. armeniacum* was reisolated from symptomatic roots but not from the control roots. Besides *F. armeniacum*, *F. solani* and *F. oxysporum*, which have been reported to be associated with American ginseng root rot in China and Canada (Punja et al. 2008; Reeleder et al. 2002), were also obtained from the diseased root samples in this study. However, the development of root rot caused by *F. armeniacum* was much more rapid, and its symptoms were more severe. Moreover, *F. armeniacum* could directly infect American ginseng with no wound requirement. *F. armeniacum* was previously reported on *Glycine max* (Leguminosae) (Ellis et al. 2012), *Platycodon grandiflorus* (Campanulaceae) (Wang et al. 2015), and natural grasses (Poaceae) (Nichea et al. 2015). This is the first report of *F. armeniacum* causing root rot on American ginseng in China. As this species is more virulent to American ginseng, more research is needed to work on this disease.

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