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Short communication

First report of *Aspergillus awamori* as a fungal pathogen of garlic (*Allium sativum* L.)

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ABSTRACT

Garlic (*Allium sativum* L.) is one of the oldest horticultural crops and an important element for cuisines worldwide, especially in Korea. After isolating several black aspergilli from brownish lesions with black spores on garlic bulbs, we identified a representative isolate GL-125 through molecular analysis of its internal transcribed spacer (ITS)1-5.8S rRNA-ITS2 region, β-tubulin gene, and calmodulin gene. Morphological features of GL-125 were also compared with those of the *Aspergillus awamori* type strain NRRL 4948^T. As a result, GL-125 was identified as *A. awamori* by neighbor-joining and maximum-likelihood methods with the examined gene sequences. The macro-morphological (colony growth and color) and micro-morphological (stripes, vesicles, metulae, phialides, and conidia) features of GL-125 were also similar, compared with those of NRRL 4849^T. Furthermore, we conducted pathogenicity tests for GL-125 and NRRL 4948^T against garlic cloves, using pin-prick inoculation with spore suspensions. Both GL-125 and NRRL 4948^T were pathogenic on garlic cloves producing brown to pinkish sunken, water-soaking lesions with white mycelia and black spores in the center. These isolates were successfully re-isolated from the lesions, thereby fulfilling Koch's postulates, whereas no fungal mycelia were isolated from water-inoculated cloves (control). The identities of the re-isolated mycelia were re-confirmed by sequence analyses of the previously examined genes. To the best of our knowledge, this is the first report of *A. awamori* as a fungal pathogen of garlic.

Garlic (*Allium sativum* L.), a bulbous vegetable, is considered to be one of the oldest horticultural crops in the world (Moyers, 1996). This garlic species is grown worldwide, particularly in mild climate regions, with the total world annual production being 24 million tons on average. The top producers are China, Egypt, India, Korea, and USA, according to the Food and Agriculture Organization of the United Nations in 2013 (http://faostat.fao.org/faostat/collections?subset=agriculture). Garlic is an important ingredient for cuisines worldwide and used in a wide variety of foods. It also has potential medicinal benefits; for example, it helps in reducing high blood pressure, preventing heart diseases, and improving immunity, and is a good source of antioxidants (Bozin et al., 2008; Rivlin, 2001).

Garlic is normally propagated from cloves and, after harvest, the garlic bulbs are usually placed in storage houses. During the postharvest stage, the bulbs like other storage products (Oh et al., 2010; Sang et al., 2014) are prone to fungal contamination that could lead to spoilage, discoloration, and disintegration of the bulb tissues (De La Cruz Medina and Garcia, 2007), as well as mycotoxin contamination (Seefelder et al., 2002). Fungal pathogens such as *Aspergillus niger*, *Aspergillus ochraceus*, *Botrytis porri*, *Diplodia natalensis*, *Fusarium oxysporum*, *Fusarium proliferatum*, and *Penicillium hirsutum* can cause significant economic losses at the postharvest stage of garlic (Kim et al., 2003; Llamas et al., 2013; Schwartz and Mohan, 2008; Seefelder et al., 2002).

Garlic belongs to the family *Alliaceae* along with onion (*Allium cepa* L.), and these two crops seem to share many kinds of plant pathogens (Schwartz and Mohan, 2008). In our previous studies (Oh et al., 2015; Sang et al., 2014), we identified the predominant fungal pathogens including *Aspergillus awamori* from stored onion in Korea. *A. awamori* was also reported to be the causal agent of the black mold on onions in Hungary, which was responsible for fumonisin contamination (Varga et al., 2012). However, this fungus has not been previously reported as a plant pathogen of garlic.

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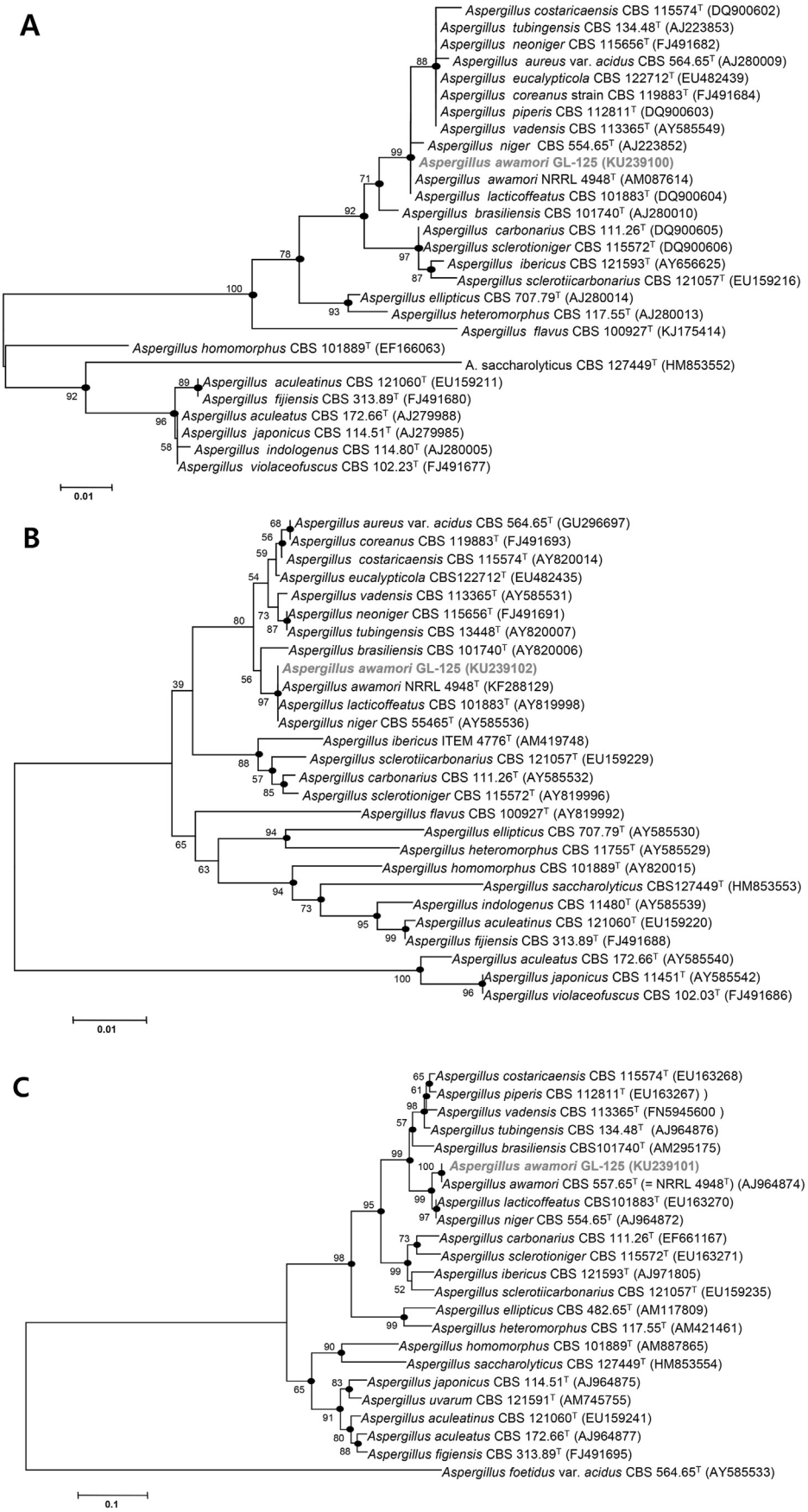
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