Diseases Caused by Fungi and Fungus-Like Organisms

First Report of *Fusarium oxysporum* f. sp. *lactucae* Race 1 Causing Fusarium Wilt of Lettuce in Norway

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Plant Dis. 105:2239, 2021; published online as <https://doi.org/10.1094/PDIS-01-21-0134-PDN>. Accepted for publication 9 April 2021.

Lettuce (*Lactuca sativa* L.) is produced in Norway both in field and greenhouses. In Norway, greenhouse lettuce is one of the most important vegetables grown year-round. In winter 2018, wilting symptoms were observed on soil-grown lettuce of the cultivar Frillice in a greenhouse in southeast Norway (Buskerud County). Affected plants showed stunted growth, wilting of outer leaves, and brownish discoloration of vascular tissues of taproots and crowns. According to the producer, the disease led to an estimated 10% yield loss. Fungal isolates were obtained from crowns and roots of diseased plants collected from the greenhouse in 2018 and 2019. Two single spore isolates, 231274 from 2018 and 231725 from 2019, were used in further studies. The isolates were incubated on synthetic nutrient-poor agar (SNA) at 18 to 20°C, and a 12-h dark, 12-h UV light cycle. Isolate 231274 produced abundant macro- and microconidia characteristics of *Fusarium oxysporum* while macroconidia were never observed in isolate 231725. On potato dextrose agar (PDA), colonies of isolate 231274 were purple and colonies of isolate 231725 were pinkish with abundant aerial mycelium. For the PCR assay, DNA from mycelia was extracted using an Easy-DNA kit (Invitrogen). A portion of the translation elongation factor 1- α (EF1- α) gene was amplified using primers F-728F (Carbone and Kohn 1999) and EF2 (O'Donnell et al. 1998) as described by Aas et al. (2018). BLAST analysis of both sequences (accession no. MW316853 for 231274 and MW316854 for 231725) obtained a 99% homology with the sequence of *F. oxysporum* f. sp. *lactucae* (FOL) race 1 strain S1 (accession no. DQ837657) (Mbofung et al. 2007). Both isolates were identified as race 1 by using specific primers Hani3' and Haniatt3rev (Pasquali et al. 2007) as described by Cabral et al. (2014). To complete Koch's postulate, lettuce plants of the cultivar Frillice were used. Race identity was confirmed using the

differential lettuce cultivars Costa Rica No. 4 (resistant to *F. oxysporum* f. sp. *lactucae* race 1), Banchu Red Fire (resistant to *F. oxysporum* f. sp. *lactucae* races 2 and 4), and Romana Romabella (resistant to *F. oxysporum* f. sp. *lactucae* races 1 and 2) (Gilardi et al. 2017) provided by the breeding company Rijk Zwaan (De Lier, The Netherlands). For inoculation, roots of six 2-week-old seedlings per cultivar were dipped in a spore suspension (1×10^6 CFU/ml) for 1 min, while controls were dipped in distilled water. Seedlings were planted in 250 ml pots containing fertilized potting substrate, and were placed in a greenhouse with temperature ranging from 15 to 35°C and an average of 23°C. After 10 days, reduced growth was observed in cultivars Frillice and Banchu Red Fire for both fungal isolates. After 25 days, wilting was observed in both cultivars. Affected plants presented discoloration of vascular tissue. No difference in growth was observed between cultivars Romana Romabella and Costa Rica No. 4 and their respective controls. *F. oxysporum* f. sp. *lactucae* was reisolated from all inoculated cultivars but not from controls. The colony patterns of the recovered isolates were the same as those of the isolates used for inoculation. These results confirm that the isolate belongs to race 1. Greenhouse lettuce in Norway is mainly produced in hydroponics. *F. oxysporum* f. sp. *lactucae* is here reported to cause damage in soil-grown lettuce. Nevertheless, *F. oxysporum* f. sp. *lactucae* in hydroponic systems has been reported in Japan (Fujinaga et al. 2003) and Thailand (Thongkamngam and Jaenaksorn 2017). Thus, the possibility of infections in hydroponics remains a major concern for lettuce production in Norway.

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The author(s) declare no conflict of interest.

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Keywords: fungi, vegetables, etiology

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