



First report of '*Candidatus Phytoplasma asteris*' in commercial carrots in the United Kingdom

C. Nisbet*, S. Ross, W.A. Monger, F. Hight and C. Jeffries

Science and Advice for Scottish Agriculture, Roddinglaw Road, Edinburgh EH12 9FJ, UK

*E-mail: carolyn.nisbet@sasa.gsi.gov.uk

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As part of the PHYLIB EUPHRESKO project (Pearson *et al.*, 2014) on the epidemiology and diagnosis of phytoplasmas and '*Candidatus Liberibacter solanacearum*' (Lso), carrot growers in Scotland were asked to report symptoms of Lso in carrot (*Daucus carota*). These include leaf curling, leaf yellowing and reddening, and the presence of adventitious roots. During September, 2013, a grower from South East Scotland sent four carrot plants of the cultivar 'Nairobi' bearing Lso-like symptoms (Figs. 1, 2) to SASA (Science and Advice for Scottish Agriculture) for analysis. Tests for Lso using real-time PCR (Li *et al.*, 2009) were negative, and confirmed that Lso is not yet present in carrot plants grown in the UK.

Phytoplasma PCR amplicons were obtained from total DNA extracted (Reid *et al.*, 2009) from the four carrot samples using the generic primer pairs P1/tint, R16R2/R16F2 and fU5/rU3 that target the phytoplasma 16S rRNA gene. Direct sequencing of the PCR 16S rDNA products from both first and nested reactions identified the phytoplasma as an isolate of '*Candidatus Phytoplasma asteris*', (Aster Yellows group, 16SrI). The partial consensus sequence of 1408 nt was deposited in GenBank (Accession No. KJ819956). Comparison with the reference sequence of the '*Ca. Phytoplasma asteris*' genome (NC_007716) resulted in a 100% match with the 16S ribosomal RNA operon at location 271935-273342. Results were confirmed by phylogenetic analysis (MEGA version 5) based on the 16S rDNA sequences of the '*Ca. Phytoplasma asteris*' isolates identified in carrot in Scotland, the '*Ca. Phytoplasma asteris*' reference strain and other phytoplasma groups (Fig. 3). Two other cultivars of carrot (SASA 7400001 and SASA 13/91) grown in field trial plots at SASA were also found to have similar symptoms, and leaf samples were collected from five plants and tested by PCR as described above. All five plants were infected with '*Ca. Phytoplasma asteris*'. Other cultivars of carrot at SASA have shown Lso-like symptoms; however these have not been tested yet for phytoplasma.

During October 2013, leaf samples were collected from six non-symptomatic carrot and other non-carrot plants located at the field edges of the carrot field in South East Scotland. These included beech tree (*Fagus sylvatica*), *Chenopodium* sp., *Fumaria* sp., pansy (*Viola tricolor*), parsnip (*Pastinaca sativa*), and nettle (*Urtica dioica*), which tested PCR negative for '*Ca. Phytoplasma asteris*'. '*Ca. Phytoplasma asteris*' has been found at two locations in Scotland, which suggests that it may be more widespread than originally thought. '*Ca. Phytoplasma asteris*' infects a wide range of host

plants including crops, trees and weeds (Lee *et al.*, 2004), and is transmitted by insect vectors of the order Hemiptera in a persistent propagative manner as part of the vector life cycle. However, no hemipteran leafhoppers or planthoppers were observed within the carrot fields at the time of sampling, which may be related to the time of the year. '*Ca. Phytoplasma asteris*' (16SrI group) has been recorded in the UK, affecting Hebe (Jones & Arocha, 2006) and other plant species such as apple (*Malus domestica*), day-lily (*Heemerocallis* sp.), and wild carrot (Flint, 2009). However, as far as we know, this is the first report of '*Ca. Phytoplasma asteris*' in commercial carrots in the UK.

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Figure 1



Figure 2

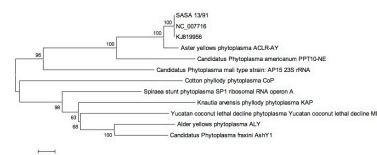


Figure 3

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