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Determination of *Alternaria* spp. habitats using 7-day volumetric spore trap, Hybrid Single Particle Lagrangian Integrated Trajectory model and geographic information system

Magdalena Sadyś [a,b,*], Carsten Ambelas Skjøth [b], Roy Kennedy [b]

[a] *Rothamsted Research, Bawden Building, West Common, Harpenden AL5 2JQ, England, United Kingdom*
[b] *National Pollen and Aerobiology Research Unit, University of Worcester, Henwick Grove, Worcester WR2 6AJ, England, United Kingdom*

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ABSTRACT

There are many species among the *Alternaria* genus, which hosts on economically important crops causing significant yield losses. Less attention has been paid to fungi hosting on plants constituting substantial components of pastures and meadows. *Alternaria* spp. spores are also recognised as important allergens.

A 7-day volumetric spore trap was used to monitor the concentration of airborne fungal spores. Air samples were collected in Worcester, England (2006–2010). Days with a high spore count were then selected. The longest episode that occurred within a five year study was chosen for modelling. Two source maps presenting distribution of crops under rotation and pastures in the UK were produced. Back trajectories were calculated using the HYSPLIT model. In ArcGIS clusters of trajectories were studied in connection with source maps by including the height above ground level and the speed of the air masses.

During the episode no evidence for a long distance transport from the continent of *Alternaria* spp. spores was detected. The overall direction of the air masses fell within the range from South-West to North. The back trajectories indicated that the most important sources of *Alternaria* spp. spores were located in the West Midlands of England.

* Corresponding author at: Rothamsted Research, Bawden Building, West Common, Harpenden AL5 2JQ, England, United Kingdom. Tel.: +44 (0)1582 763 133x2471; fax: +44 (0) 1582 469 036.

E-mail address: magdalena.sadys@rothamsted.ac.uk (M. Sadyś).

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1. Introduction

Air quality, especially in the urban areas, is an increasing concern of the European Union, local authorities, scientists and most of all inhabitants that become more aware of the quality of the surrounding environment (Harmful levels, 2013). The majority of the attention is, however, given to the concentration of in-organic particles of the air such as ozone, NO_x and SO_x, while the organic components are often being neglected (Morris et al., 2011; Elbert et al., 2007). Bioaerosols may consist of various elements, and the most important are pollen grains, fungal spores, bacteria, viruses (Georgakopoulos et al., 2009).

According to Hasnain et al. (2012) more than 100 genera of fungal spores have been identified as potential allergens that cause immunological response in susceptible individuals. The concentration of fungal spores may even reach up to tens of thousands per cubic metre of air within 24 h (Grinn-Gofroń, 2007). *Alternaria* spp. has been recognised as one of the leading fungal species responsible for respiratory tract diseases, such as asthma, eczema, rhinitis and chronic sinusitis (Hasnain et al., 2012; Breitenbach and Simon-Nobbe, 2002; St-Germain and Summerbell, 2011). Although the presence of *Alternaria* spp. conidia have been reported worldwide, it has been noticed that the fungus was more frequently observed in countries from the temperate zone rather than in tropics (Rodríguez-Rajo et al., 2005). This has a direct link with the distribution of potential host plants, which are being attacked by *Alternaria* spp.

There are many species among the *Alternaria* genus, which found susceptible hosts within a group of economically important crops (Thomma, 2003). In the temperate zone the highest yield losses are caused by an early blight of potato (Modesto Olanya et al., 2009), early blight of tomato (Chaerani and Voorrips, 2006; Vloutoglou and Kalogerakis, 2000), leaf blight of carrot (Boedo et al., 2010, 2012; Dugdale et al., 2000; Maude et al., 1992), purple blotch of onion (Meredith, 1966; Suheri and Price, 2000), purple blotch of leek (Gladders, 1981), leaf spot of bean (Russell and Brown, 1977), leaf spot of cabbage (Geeson and Browne, 1979; Valkonen and Koponen, 1990), leaf spot of linseed (Vloutoglou, 1994), which have been estimated to a minimum of 20% (Kasprzyk et al., 2013). The causal agents of these diseases are *Alternaria solani*, *Alternaria dauci*, *Alternaria porri*, *Alternaria alternata*, *Alternaria brassicicola*, *Alternaria raphani*, and *Alternaria linicola*, respectively.

Nonetheless, less attention has been paid to fungi, which cause pathogenesis of vascular plants constituting substantial components of pastures and meadows, which are in fact another potential source of *Alternaria* spp. (Scudamore and Livesey, 1998). Samples of maize and hay directly taken from the field showed that the greatest amounts of *Alternaria* spp. mycotoxins derived from *Alternaria tenuissima* and *A. alternata* (Müller, 1992). The latter species was identified as a major pathogen of white clover (Zahid et al., 2002). Other studies indicated also the negative impact of *Alternaria alternata* on spotted knapweed (Stierle et al., 1988), St. John's wort and lovage (Frużyńska-Jóźwiak and Andrzejak, 2007). Furthermore, *Alternaria dianthus* was frequently isolated from dianthus (Mikulík et al., 2002), and *Alternaria nobilis* from soapwort (Garibaldi et al., 2013).

Recent studies have suggested that long-distance transport can enhance concentrations of *Alternaria* spp. and that harvesting in areas with crops under rotation can be an important mechanism for high concentrations of *Alternaria* spp. (Skjøth et al., 2012). It is therefore relevant to explore, if other habitats (e.g. meadows) can be important source areas to *Alternaria* spp. and if long-distance transport of *Alternaria* spp. is a common or rare phenomenon.

Lagrangian models, such as Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) Draxler and Rolph, 2013; Rolph, 2013 and California Puff Model (CALPUFF, 1990) were constructed to examine forward and backward trajectories of the air masses. In the aerobiological studies the spatial analysis are the most frequently conducted with the aid of combination of the HYSPLIT model and geographic information system (GIS) techniques (Stach et al., 2007; Smith et al., 2008). Although a great number of interesting studies have been published with regard to the allergenic pollen, such as oak (Hernández-Ceballos et al., 2011), birch (Skjøth et al., 2009) or olive (Fernández-Rodríguez et al., 2014), there are only very few that would analyse an origin and transport of the allergenic fungal spores recorded in the air of urban areas (Skjøth et al., 2012; Isard et al., 2005; Sadyś et al., 2014).