Preliminary study on micro area based spatial distribution of powdery mildew in an organic apple orchard

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Summary: In this study, the objective was to report a preliminary study on micro area based spatial distribution of powdery mildew in an organic apple orchard. Results showed that number of symptomatic plant part ranged between 11 and 20 on shoot and between 9 and 24 on fruit. Number of asymptomatic plant part ranged between 85 and 109 on shoot and between 133 and 206 on fruit. Disease incidence ranged between 13.8 and 17.6% on shoot and between 9.1 and 11.3% on fruit. Disease aggregation index ranged between 0.098 and 0.228 on shoot and between 0.043 and 0.108 on fruit. One of the four trees showed significant within canopy aggregation of disease for shoot powdery mildew symptoms in both years. For leaf powdery mildew, all tree exhibited random patterns in both years.

Keywords: *Podoshphaera leucotricha*, spatial pattern, organic apple

Introduction

Apple powdery mildew (*Podoshphaera leucotricha*) is a wordwide known fungal pathogen of apple. It is a key important fungal disease of apple which causing severe econimic loss on susceptible cultivars in every years where apple are grown (Hickey & Yoder, 1990; Holb, 2009, 2013; Szentivanyi & Kiss, 2003).

Spatial analysis can characterize more accurately and deeply the inner structure of epidemics in a plant stand/orchard, which was widely studied from 1990s after the introduction of novel statistical-mathematical methods (e.g. Gibson and Austin, 1996; Gottwald, 1995; Kocks *et al.,* 1999). Epidemics can be investigated in micro-areas for instance inside a plant/tree in any small areas (e.g. Sposito *et al.,* 2008; Vereijssen *et al.,* 2007). Data collected in micro-areas require accurate localization (such as within tree investigation) as well as show foci of epidemics and their behaviour in time, i.e. investigation can be linked in time and space.

Previous studies examining spatial disease patterns within tree canopies either divided the canopy into layers (Holb & Scherm, 2007) or quadrats (Batzer *et al.*, 2008; Spósito *et al.,* 2008). However, an important limitation of using such stratification is that the associated grouping of data may fail to capture fine-scale patterns within each block. In a recent pilot study, Everhart *et al.* (2011) used a digitizer to map different brown rot symptom types (blossom blight, shoot blight, and twig cankers) caused by the fungal plant pathogen *Monilinia laxa* in individual sour cherry canopies. Micro-area based spatial aspects of powdery mildew have received very little attention.

In this study, the objective was to report a preliminary study on micro area based spatial distribution of *P. leucotricha* in an organic apple orchard.

Materials and methods

Orchard site

The experiment was carried out in an organic orchard located at Eperjeske, Hungary. The orchard was planted with cultivars Mutsu, Jonathan, Prima on M26 rootstocks in 1997. The distance between rows was 5 m, and the distance between trees within a row was 2. The orchard was treated according to the Hungarian Organic Growing Guidelines derived from the IFOAM guidelines. The micro-area based spatial experiment was set in 2013 and 2014.

Assessment of spatial pattern of symptoms

At harvest, fruit and shoot symptom caused by *P. leucotricha* was present and readily distinguishable. Four trees (Table 1) of different sizes and with varying levels of disease incidence were selected for digitizing. The x, y and z co-ordinates of all symptomatic elements were digitized, as were all asymptomatic (healthy) shoot and fruit (Table 1). Each digitized canopy element was tagged with coloured tape to ensure that points were not measured twice and that no relevant point was omitted. Disease incidence of shoot and fruit was also measured also for each tree.

Spatial pattern analysis

Spatial patterns of aggregation for a given symptom type within the canopy were characterized based on nearest neighbour distances, i.e. the shortest Euclidian distance between symptoms derived from the x, y and z co-ordinates of points. The frequency distribution of nearest-neighbour distances within each tree could then be used to determine deviation from randomness.

Disease aggregation index (dw) was also determined. The test statistic dw, the maximum departure of the observed cumulative frequency distribution. Values of dw represents the index of disease aggregation and is calculated based on the cumulative frequency distribution of nearest-neighbour distances among powdery-mildew affected shoot and fruit. Significant positive values indicate aggregation, whereas significant negative values correspond to a more regular distribution compared with the random simulation.

Results

Disease pattern

Number of symptomatic plant part ranged between 11 and 20 on shoot and between 9 and 24 on fruit (Table 1). Number of asymptomatic plant part ranged between 85 and 109 on shoot and between 133 and 206 on fruit. Disease incidence ranged between 13.8 and 17.6% on shoot and between 9.1 and 11.3% on fruit.

Table 1. Summary of symptomatic patterns on fruit and shoot disease incidence of powdery mildew on 4 apple trees within the tree canopy (Eperjeske 2013 and 2014)

No of tree	No of symptomatic plant part	No asymptomatic plant part	Disease incidence (%)
2013–2014, shoot			
I	15	85	17.6
II	11	97	15.5
III	20	109	13.8
III	16	97	15.5
2013–2014, fruit			
I	24	165	9.1
II	9	149	10.1
III	11	206	7.3
III	20	133	11.3

Disease aggregation

Disease aggregation index ranged between 0.098 and 0.228 on shoot and between 0.043 and 0.108 on fruit (Table 2). One of the four trees showed significant within canopy aggregation of disease for shoot powdery mildew symptoms in both years (Table 2). For leaf powdery mildew, all tree exhibited random patterns in both years.

Conclusions

Spatial disease incidence of apple powdery mildew on leaf and fruit did not reached 20 % in the two years. Most diseased shoots caused by *P. leucotricha* were not aggregated within the tree and none of the diseased leaves were aggregated.

Table 2. Summary of disease agrregation index and spatial patterns for powdery mildew symptoms on 4 apple trees within the tree canopy (Eperjeske 2013 and 2014)

No of tree	Disease aggregation index (dw)	P value	Spatial pattern
2013-2014, shoot			
I	0.124	0.119	random
II	0.098	0.432	random
III	0.228	0.046	aggregated
IV	0.101	0.234	random
2013-2014, fruit			
I	0.087	0.543	random
II	0.054	0.654	random
III	0.043	0.765	random
IV	0.108	0.201	random

dw represents the index of disease aggregation and is calculated based on the cumulative frequency distribution of nearest-neighbour distances among powdery mildew-affected shoot and fruit. Significant positive values indicate aggregation, whereas significant negative values correspond to a more regular distribution compared with the random simulation. Significant dw values (P≤0.05) are in bold.

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