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Importance of soil characteristics for plant-parasitic nematode communities in European coastal foredunes

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ABSTRACT

Plant-parasitic nematodes are involved in soil fatigue processes in coastal foredunes and, therefore, have an impact on the growth of plants such as marram grass (*Ammophila arenaria*) that enhance sand accretion and the stabilisation of dunes. Transects were sampled in European Atlantic and Mediterranean foredunes at different locations. Plant-parasitic nematode communities and physico-chemical soil properties were analysed, and multivariate techniques were used to link them. Although all the dunes are of sandy texture, the Atlantic and Mediterranean dunes mainly differ by their ratio of coarse and fine sands. Mediterranean dunes, although more disturbed by storms than the Atlantic dunes, have fine-textured soils that can accumulate organic matter. They trap a large amount of minerals and have a high carbonate concentration due to the salinity of the Mediterranean Sea. As a result of the higher content of coarse sand in the top horizons, probably due to a higher accretion of sand, Atlantic foredune soils are low in organic matter and minerals. Soils from North and Irish Sea dunes have intermediate characteristics. These soil contrasts lead to specific plant-parasitic nematode communities. Thus, nematodes such as *Hemicycliophora* spp., *Neodolichorhynchus* spp., *Longidorus* spp. and *Merlinius* spp. generally colonise the carbonated and mineralised soils of the Mediterranean dunes, and do not seem to be affected by high salinity. Conversely, populations of *Meloidogyne* spp. and *Pratylenchus* spp. nematodes are more commonly found in coarse textured soils and the oligotrophic conditions that occur in Atlantic dunes. Specific local conditions such as the presence of paleosols do not seem to disturb them. Considering that both nematode species are major pests in cropping systems, higher population levels due to their fit to such soil characteristics can explain their contribution to soil fatigue encountered in Atlantic dunes.

1. Introduction

Ammophila arenaria L. (Poaceae), commonly referred to as Marram grass, is frequently used on coastal foredunes to stabilise sand accretion from beaches [1]. However, soil fatigue was observed in the Northern European foredunes and was partly attributed to plant-parasitic nematodes [2–7]. Several surveys have shown that plant-parasitic nematodes are very diverse and more or less frequent, depending on the dunes, but always occur in low abundance (less than 500 specimens/dm^3 of soil) [8–11].

Since plant-parasitic nematodes are obligate parasites, the host-plant is essential to complete their life cycle. This dependency is widely used to control them in agriculture, either by using resistant or non-host plants. In addition to the host plant, soil type is also known to be a major factor that affects nematode distribution. Some surveys have even demonstrated that the distribution of certain species strongly corresponds to that of soil type [12]. One factor likely to interfere with the uniform spread of the nematodes is soil texture because porosity, size and arrangement of aggregates, and the movement of water, air and chemicals influence the abundance and distribution of numerous species of nematodes [13–15]. For example, species of *Meloidogyne* [16], *Globodera* [17], *Heterodera* [18] and *Trichodorus* [19] are frequently more numerous and more pathogenic in light-textured soils, giving rise to greater symptom expression in the sandier areas within the field. In contrast, *Rotylenchulus reniformis* reproduction was highest in soils with moderate levels of clay and silt [20], and the plant-damaging

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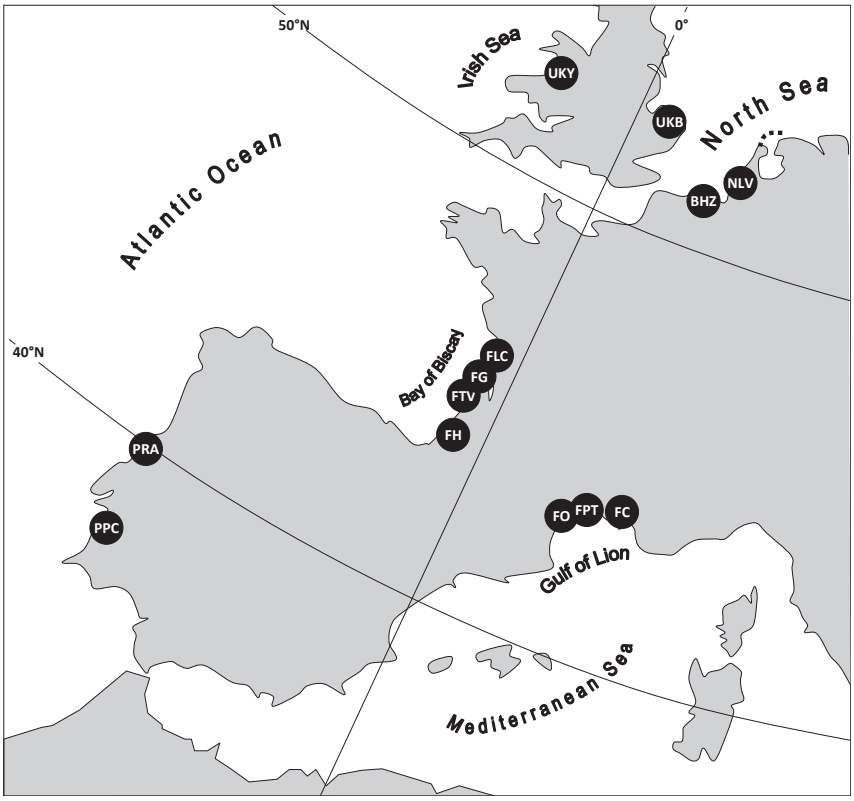

Fig. 1. Map of the foredune sites surveyed. Site codes are given in Table 1.

effect of *Ditylenchus dipsaci* was greater in heavier soils than in those with a lighter texture [21]. Organic matter is also of great importance because toxic decomposition products can affect nematodes [22] or, conversely, improve soil structure. Such specific effects of soil on nematodes can be observed at short spatial scales. At the local scale, *Helicotylenchus retusus* was only found in vertisols on Martinique Island, whereas *R. reniformis* was more frequently encountered in heavier soils, rich in organic matter [23]. At the field scale, spatial variability of nematode distribution was recorded with the same soil type and the same plant [24].

In coastal dunes, observation of the vegetation succession from areas of bare moist sand up to stages with mature heath vegetation revealed that community diversity and evenness of the global nematofauna (plant-feeding, bacterivorous, fungivorous, omnivorous nematodes) were lower in dune heath, whereas the maturity index was lower at the beach site and, to a lesser extent, separated the foredune samples from the grey and yellow dunes [10]. In addition to the effects of plant diversity and environmental factors, soil moisture, organic matter and pH seem to be key factors influencing the structure of the entire nematode community [25,26]. Experiments showed that the introduction of organic matter in young white dune soil was conducive to the colonisation of nematofauna [27].

However, until now, no study of plant-parasitic nematode communities has been carried out that would help us to understand their distribution in foredunes and their structuration at a large geographical scale, perhaps explaining unbalanced damage patterns on *A. arenaria*, especially along the North and South Atlantic seashores. In order to more deeply explore the influence of environmental factors on the distribution of plant-parasitic nematode communities in white foredunes with *A. arenaria*, the present study focused on interactions between soil factors and nematode community patterns.

2. Materials and methods

2.1. Site description

Samples were collected in foredunes (Fig. 1 and Table 1) along the French Mediterranean coastline (three sites), along the Atlantic shore in Portugal (two sites), in France (four sites), and in Wales (one site along the Irish Sea), and along the North Sea shore in Belgium, in the Netherlands and in England (one site in each).

Mediterranean dunes in France are sandwiched between the sea and the lagoons and do not exceed seven metres in height. Despite protective measures, they are easily disturbed by storms because of their narrowness. From east to west, the “Capelude” site (FC) is located west of the Rhone delta (Camargue), in the Espiguette area (European Coastal Union (EUCC) French site n°32 [28]). The “Petit Travers” site (FPT) is south of the Or Lagoon, and the “Orpellières” site (FO) is just east of the mouth of the Orb River.

The Atlantic dunes surveyed in this study are very diversified. From south to north, the sites in Portugal (PPC and PRA) are located south of the mouth of the Sado River (“Praia de Comporta”, EUCC Portugal site n°19) and south of the Sao Jacinto (“Ria de Aveiro”, EUCC Portugal site n°8a, and CORINNE site C011/C019), respectively. They are sandwiched between the sea and estuaries parallel to the coast and are characterised by flat dunes with large amounts of material of fluvial origin. The PPC site is controlled with protective measures, while the PRA site suffers from a lack of management. They are both subject to trampling and have crops growing close to them. All French Atlantic sites border the Landes Forest. At site FH, the Southern Landes shoreline (referred to as the “Huchet”, ONF site L25 [29]), 30-m high permanent dunes are to the result of balanced deposition/erosion of sediments, leading to accretion in some cases. Dunes surveyed at the FTV site located on the west side of Cap Ferret (“Le Truc Vert”, ONF site G40) are shaped by