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CHARACTERIZATION OF SOIL ORGANISMS INVOLVED IN THE DEGENERATION OF *AMMOPHILA ARENARIA*

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Summary—The degeneration of *Ammophila arenaria* (marram grass) in stable stages of coastal foredunes may be due to pathogenic or parasitic soil organisms. To test this, and to characterize the organisms involved, biocides were applied to sand collected from the root zone of natural stands of *A. arenaria*. Seedlings of *A. arenaria* were grown and biomass production was measured and compared with growth of seedlings in γ-irradiated soil to determine effects of applied biocides. Sand from stable and mobile foredune sections (degenerated and vigorous *A. arenaria*, respectively) was examined.

Improved seedling growth followed fungicide and nematicide treatments in sand from stable, as well as from mobile foredunes. On the other hand, bactericides (streptomycin and penicillin) had no effect. The fungicide propamocarb only stimulated growth very weakly, whereas the fungicide benomyl increased growth significantly. However, the effect of benomyl may not be solely due to its fungicidal action, as it also prevented root infection by the nematodes *Heterodera* (*avenae* group) and *Meloidogyne maritima*.

The highest increase in yield was obtained with the nematicide oxamyl, which prevented root-infection by endo-parasitic nematodes (*Heterodera avenae* group, *M. maritima* and *Pratylenchus* sp.). Oxamyl also reduced numbers of ecto-parasitic nematodes.

It is concluded that plant parasitic nematodes could be important in the degeneration of *A. arenaria*, but that interactions with other groups of soil organisms, such as soil fungi, cannot be excluded.

INTRODUCTION

Amophila arenaria (L.) Link (marram grass) occurs dominantly in coastal foredunes of north-western Europe, the Mediterranean, Australia, and along the west coast of the U.S.A. (Knutson, 1978; Huiskes, 1979). It is vigorous when regular burial by windblown sand occurs but degenerates at sites where sand deposition has ceased (Willis, 1965; Marshall, 1965; Hope-Simpson and Jefferies, 1966; Huiskes, 1979, 1980). A similar response to sand burial is shown by the North American species *Ammophila breviligulata* (Laing, 1967; Eldred and Maun, 1982).

Several theories [listed by: Marshall (1965); Laing (1967); Eldred and Maun (1982)] have been presented to explain the relationship between burial by windblown sand and vigour of *Ammophila*. In summary, it has been suggested that windblown sand:

(1) provides *Ammophila* with nutrients;
(2) keeps away competing species; or
(3) enables *Ammophila* to avoid physiological ageing by developing new adventitious roots.

It was supposed that *A. arenaria* could benefit from vesicular–arbuscular mycorrhizas (Nicolson, 1960; Ernst *et al.*, 1984) or N_2-fixing bacteria (Hassouna and Wareing, 1964). However, it has recently been demonstrated that the root zone of *A. arenaria* contains soil organisms which may strongly reduce plant growth (Van der Putten *et al.*, 1988). Such organisms could be involved in the degeneration of *A. arenaria* (Van der Putten *et al.*, 1989).

The role of pathogens in natural vegetation has been studied mainly on above-ground organisms (Burdon, 1987; Jarosz and Burdon, 1988). Fewer studies concern the possible effect of soil-borne pathogens on the composition of vegetation. For instance, in coastal sand dunes the degeneration of *Hippophaë rhamnoides* (sea buckthorn) has been related to the occurrence of plant parasitic nematodes in the root zone (Oremus and Otten, 1981, Maas *et al.*, 1983).

The occurrence of soil micro-organisms in successional stages of coastal sand dunes has generally been related to physical and chemical soil factors (Brown, 1958) and to plant growth (Webley *et al.*, 1952). Soil organisms harmful to *H. rhamnoides* did not occur in the early colonization phases examined by Oremus and Otten (1981). Organisms harmful to *A. arenaria*, however, were found in the soil profiles of both vigorous and degenerated stands but not in beach sand (Van der Putten and Troelstra, 1990). It was supposed that the colonization of windblown sand enables *A. arenaria* to escape from soil pathogens (Van der Putten *et al.*, 1989). The rapid decline of *A. arenaria* after sand deposition has ceased (Hope-Simpson and Jefferies, 1966) could be related to the colonization of new roots of *A. arenaria* by harmful soil organisms within one growing season (Van der Putten *et al.*, 1989). Therefore, in this study soil pathogens were examined in both mobile and stable foredunes.

Characterization of harmful soil organisms can either be performed by selective elimination of groups of organisms from rhizosphere soil, or by isolating