SHORT COMMUNICATION

Rushes and sedges are non-mycotrophic

Summary

Few rushes and sedges were infected by endomycorhizal fungi in the field, and many of the infections which were formed were mainly of mycelium in the rhizosphere with only occasional lodgements in epidermal cells. In a pot experiment using a soil of very low P availability, rushes and sedges remained non-mycorrhizal and yet produced more shoot dry matter than mycorrhizal *Poa colensoi* (Graminae). Rushes and sedges had much longer root systems than non-mycorrhizal *Poa colensoi*, but comparable shoot P concentrations. I suggest that they have evolved extensive and finely branched root systems rather than the mycorrhizal habit for extracting P from infertile soils. In pot experiments, they differ from mycotrophic angiosperms in rejecting mycorrhizal infection, even if suffering P deficiency.

Introduction

Gerdemann[4] concluded that the Juncaceae (rushes) and Cyperaceae (sedges), along with a few other angiosperm families, were not infected by endomycorrhizal fungi. It has been commonly found for many mycotrophic species, that as soil P fertility rises, fewer roots are converted to endomycorrhizas[1][3][7]. There appears to be a feed back mechanism at work, ensuring that as plant P concentration approaches its optimum, and ceases to limit growth, mycorrhizal infection decreases.

I wanted to verify the mycorrhizal status of rushes and sedges in New Zealand, and to see whether infection was related to plant P levels.

Field sampling

I stained and examined the roots of rushes and sedges collected from sea coast, forest, alpine grassland, fell field, and herbfield habitats. Only 36 of the 97 species and 88 out of the 481 samples collected, were endomycorrhizal. Often the mycelium was mostly in the rhizosphere with only occasional lodgements in epidermal cells. I recognized three phycomycetous endophyte types. *Rhizophagus tenuis* – the most important endophyte of alpine and montane grasses in New Zealand[2] – only infected four samples. Coarse endophytes, morphologically similar to the endophytes previously found in a wide variety of native New Zealand species[2][6] infected 67 samples.

17 samples were infected by an endophyte having fine (<1 μm) intracellu-

TABLE 1

Mycorrhizal roots used to inoculate rushes, sedges and *Poa colensoi*

Inoculum	Host species	Endophyte
A	*Uncinia uncinata* *Uncinia rupestris*	} Coarse
B	*Schoenus pauciflorus*	Coarse superficial
C	*Coprosma robusta*	{ *Rhizophagus tenuis* Greenhall [5] Honey coloured sessile*
D	Autoclaved mixture of equal parts of A, B, C.	

* Described by Mosse [8].

lar hyphae as in *Rhizophagus tenuis* and large intracellular vesicles, similar to those produced by coarse endophytes.

Pot experiments

In several preliminary experiments, in soil deficient in P, rushes and sedges grew steadily, maintained low to moderate shoot P concentrations (0.06 to 0.1 per cent P) and showed massive growth responses to small additions of P fertilizer. In these experiments rushes and sedges failed to become mycorrhizal despite the mycorrhizal inocula in the unsterilised field soils, infective to and causing growth responses in *Leptospermum scoparium*. Careful inoculation with many endomycorrhizal fungi from Coprosma pot culture also failed to infect rushes and sedges in these soils.

This led to an experiment where rush and sedge seedlings were grown under extreme soil P starvation, with a number of endophytes from rushes and sedges found infected in the field. Seedlings of *Juncus articulatus*, *J. planifolius*, *J. novae-zelandiae*, *Carex coriacea*, *Uncinia divaricata* and the grass *Poa colensoi*, were inoculated by planting with 150 mg of chopped mycorrhizal roots (Table 1). The two endophytes of inoculum C were from standard glasshouse culture in Coprosma. There were eight replicates per treatment. The plants were grown in 500 ml pots of steam sterilized silt loam, affording only 3.6 µg/ml Olsen available P. Pots were maintained outdoors at sites 30, 870 and 1300 m above sea level. The low soil temperatures (7.1°C and 5.5°C, mean weekly minima) and low soil moisture content at the 870 and 1300 m sites throughout the 120 days of the experiment were expected to reduce the soil's available P even further [10].

Rhizophagus tenuis infected *Poa colensoi* heavily at all sites and caused three to six fold shoot dry weight increases over controls (Fig. 1). The experiment was thus conducted under soil conditions in which even a grass with a much branched fibrous root system was strongly mycotrophic. None of the other endophytes infected the grass and no rush or sedge became infected by any endophyte. Yet all rushes and sedges made much greater growth
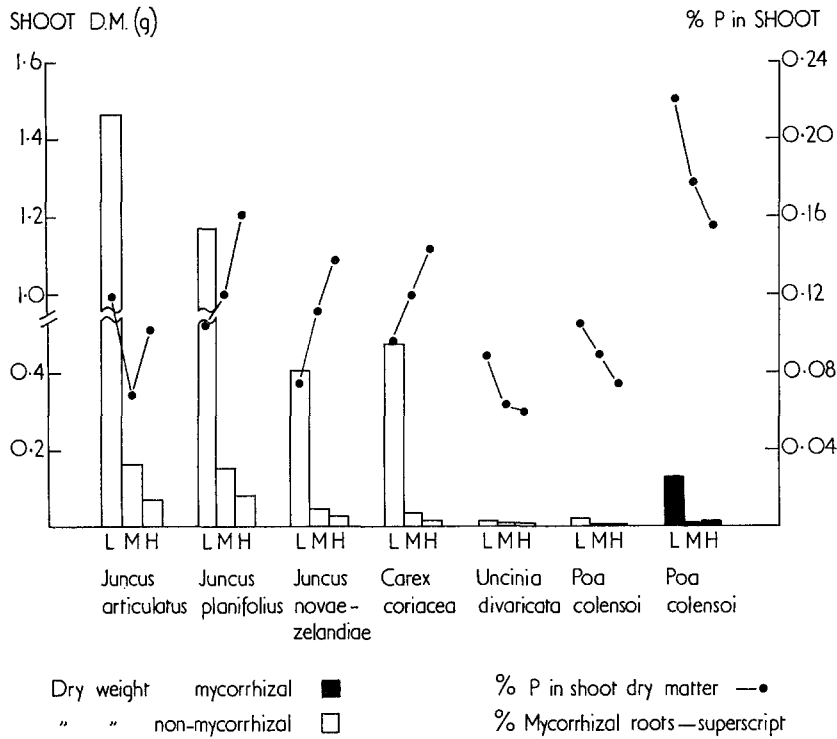
Fig. 1. Shoot dry weight and percentage P at the 30-m (L), 870-m (M) and 1300-m (H) growing sites. Percentages mycorrhizal root for mycorrhizal *Poa colensoi* are resp. 23, 23 and 39 for Sites L, M and H.

TABLE 2

Total root length and mean root hair length, at the 1300-m site

	Root length	Mean root hair length
	(cm)	(mm)
Juncus articulatus	1170	1.15
Juncus planifolius	1063	1.12
Juncus novae-zelandiae	714	1.61
Carex coriacea	524	0.97
Poa colensoi	391	0.70
Uncinia divaricata	141	1.00

throughout, than *Poa colensoi*, except the inherently slow-growing *Uncinia divaricata* (Fig. 1).

The shoot P concentrations in non-mycorrhizal rushes, sedges and *Poa colensoi* were similar at 0.06 to 0.16 per cent P. Mycorrhizas in *Poa colensoi* raised this value to 0.15 to 0.22 per cent.

Root production

I measured the total root length of two replicates of each of the five rushes and sedges and non-mycorrhizal *Poa colensoi* from the 1300-m site (Table 2), using the line intercept method of Newmann [9]. Also presented in Table 2 are the mean root hair lengths for each species.

It is apparent from Figure 1 and Table 2 that species with the largest shoot production (*e.g. Juncus planifolius* and *J. articulatus*) have the largest root systems and longest root hairs. *Poa colensoi* and *Uncinia divaricata* with small root systems can only manage much lower shoot weight production, in this very infertile soil.

Conclusions

The rushes and sedges are fundamentally non-mycotrophic. Mosse [7] found that mycorrhizal formation in onions is completely prevented only at optimal or supra-optimal plant P concentrations. But rushes and sedges have remained completely nonmycorrhizal, even when severely P deficient and stunted in growth in infertile soils.

The prime function of mycorrhizal fungi is to enhance P uptake from low fertility soils. Rushes and sedges have evolved fine root systems highly suited for P uptake from infertile soils. Consequently, they have achieved almost complete rejection of a fungal symbiont for which they appear to have no need.

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