PROTEOID ROOT MORPHOLOGY AND FUNCTION IN LUPINUS ALBUS

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Key words

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Summary

Current theories of phosphorus uptake by plants imply that they can augment diffusion to their root axes by the development of abundant root hairs or mycorrhizas. Some phosphorus efficient plants have root morphology with multi-branched roots and localised regions of densely packed root hairs, which we suggest is better suited to the retention of substances exuded by the roots than uptake of substances moving to the root by diffusion. Evidence of substantial exudation by the proteoid roots of Lupinus albus is presented.

Models of phosphorus uptake by plants are based on the fact that plant roots act as sinks, and cause phosphate ions to move to the root surface by diffusion, by inducing a low concentration in the soil very near their surface. From these theories, it follows that fine roots with moderate root hair development, or alternatively an extensive mycorrhizal mycelium in the soil, are the most efficient anatomical forms for the uptake to phosphorus. Proteoid roots are dense bottle-brush-like clusters of rootlets of limited growth covered in a dense mat of root hairs and have been observed in most genera of the Proteaceae, and also on some legumes (Viminaria juncea, Kennedia sp., Acacia mucronata, Lupinus cosentennii). The present investigation has shown that L. albus develops proteoid roots. Analagous structures termed ‘dauciform roots’ have been observed on some rushes and sedges. Members of the Proteaceae, the rushes and sedges, and lupins are notable firstly, for their ability to grow on soils low in available phosphorus, and secondly, for their apparent lack of mycorrhizal association. These observations suggest that the structures may promote the uptake of phosphorus, but the mechanism is not understood. It has been suggested that proteoid roots provide an increased surface area for the absorption of phosphate, but their compact nature makes this questionable.

Firstly, an unbranched root would absorb more phosphorus than the same weight of...
aggregated roots (of similar morphology) because of overlapping phosphorus depletion zones in the latter case. Secondly, high densities of root hairs would increase uptake in the short term but competition effects in the longer term would make uptake similar to that obtainable with more moderate root hair densities. An alternative idea is to postulate that these roots enable the plant to modify the soil. The effect of any substances produced by roots and diffusing away from them would be far greater in dense aggregations such as

Fig. 1. Proteoid roots growing in a film of agar containing either CaHPO₄ or MnO₂, approximately two times actual size.
A – white precipitate of CaHPO₄ in agar.
B – proteoid root and associated dissolution of the precipitate.
C – black suspension of MnO₂ in agar.
D – proteoid root and associated dissolution of the suspension.