Root Growth Dynamics and Nutrient-Use Efficiency of *Grevillea robusta* Grown under Nitrogen and Phosphorus Co-limitation

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Plants have several adaptations to survive in nutrient-deficient habitats. *Grevillea robusta* which belongs to family Proteacea forms specialized root structures known as "cluster roots" as an adaptive response to P-deficiency. This study was aimed to investigate root growth changes, nutrient uptake and nutrient use efficiency of *G. robusta* grown in N and P-limited conditions during a three-month period. A hydroponic pot experiment was conducted with four different nutrient media conditions; nitrogen (N) and phosphorus (P) sufficient, P-deficient, N-deficient, and (N+P)-deficient in a glasshouse. In nutrient-sufficient medium, all nutrients were supplied in required amounts. In nutrient-deficient medium, N and P concentrations were maintained at 0.25 ppm. The impact of N- or P-deficiency and their co-limitation on cluster root formation, dry weight of different plant organs, N, P, and potassium (K) uptake and use efficiencies were measured. *Grevillea robusta* did not develop cluster roots when it was grown with sufficient nutrient levels. Highest number of cluster roots were formed in P-deficient condition. Although, cluster roots were formed under N- and (N+P)-deficient conditions, it was comparatively lower than that of P-deficient conditions suggesting that P-deficiency is the principle parameter determining cluster root formation of *G. robusta*. There was a tendency to increase the total plant dry weight when cluster roots are present and growth of *G. robusta* was not reduced in the P-deficient treatment. The greatest reduction of plant dry weight was observed under (N+P)-deficient condition. Although the uptake of particular nutrient reduced when the growing solution is nutrient-deficient, use efficiency of the relevant nutrient in biomass formation was significantly ($P<0.05$) enhanced. P-remobilization efficiency was greatly increased both under N- and (N+P)-deficiency indicating the efficient use of acquired P under these nutrient-deficient conditions.

Keywords: Cluster roots, *Grevillea robusta*, Nutrient remobilization, Nutrient uptake, Proteaceae

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