Phosphate Uptake by White Clover (*Trifolium repens* L.) Genotypes with Contrasting Nodal Root Morphology

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Introduction Phosphate (P) fertiliser is a major cost in New Zealand farm budgets. Movement of P to the root surface is the rate limiting step in P acquisition by plants. Plants with finely divided roots that colonise a large volume of soil are more efficient in obtaining P than plants with coarse, unbranched roots (Hill et al., 2006). In this study we analysed P uptake and the growth response of two white clover genotypes, previously selected for either relatively long fine roots (LFR), or relatively short thick roots (STR).

Materials and methods P response curves were determined for the two genotypes in a glasshouse experiment. $CaHPO_4$ was mixed with an allophane ash soil at 0, 50, 100, 200, 400, 600, 800, 1000, and 1200 mg P kg^{-1} dry soil. Basal potassium and magnesium fertilisers were also added. There were 5 replicates of each genotype x P level combination in a row-column design. After 40 days growth in pots, the plants were washed free of soil and shoot dry weight (DW) measured. Root length, surface area, and diameter were measured using WinRhizo5.0™ image analysis software. After the image analysis the roots were oven dried and weighed. Shoot and root systems were analysed for total P.

Results The clovers had identical root DW but the LFR genotype had thinner, longer roots with more root tips mg^{-1} DW (Table 1). The LFR genotype had higher P uptake per unit root DW in all P treatments. Shoot P content (mg P per plant) was higher in the LFR genotype and shoot DW of the LFR genotype was heavier than for the STR genotype in P treatments >600 mg P kg^{-1} (Table 1).

Table 1 *Average root DW, diameter, length, number of root tips mg^{-1} root DW, P uptake and shoot DW for white clover genotypes with contrasting root morphology, and grown over nine soil P levels.*

Genotype	Root DW	Diameter	Length	Tips	P uptake	Shoot DW
	mg	mm	m	tips mg^{-1} root DW	μgP mg^{-1} root DW	mg
LFR	133	0.376	24.33	12.6	20.9	618
STR	128	0.420	16.74	8.49	17.4	519
	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001

Discussion The thin, frequently branching roots of the LFR genotype acquired P more effectively than the relatively short, thick roots of the STR genotype, as was expected from the literature (e.g. Hill et al. 2006). The additional root length of the LFR genotypes was achieved at the same root DW as the STR genotype, so the LFR genotype made more effective use of carbon invested in the root system. Reducing fertiliser P inputs into New Zealand pastures while maintaining productivity would have major economic and environmental benefits. Clover breeders should select for high fine root length frequencies and increased branching to optimise P acquisition. Indirect selection through exploitation of linked root traits in white clover will be useful (Jahufer et al., 2007).

References

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