Breeding for root system shape in perennial ryegrass (*Lolium perenne* L.)

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ABSTRACT

Root dry weight (DW) distribution was measured in the progeny of four contrasting root shape pools. Shoot DW, root DW, and root/shoot DW ratios did not differ among the progeny. Type 2 (high surface root mass, roots to 1m) progeny had a significantly higher percentage of total root DW between 0-10 cm than type 1 (low surface root mass, roots to 1m). The root type 2 progeny had a lower percentage of total root DW between 10 -20 cm than the other root types, and also, type 2 had a significantly lower % of root DW 20-30 cm than types 1 and 4 (high 0-10 cm root mass, shallow).The probability of the root type 4 plants having roots at 1m depth was 0.67 – a significantly lower probability than for the other progenies.

KEYWORDS: breeding, root depth, root shape, ryegrass, *Lolium*

INTRODUCTION

Increased rooting depth in ryegrass has the potential to improve both access to subsoil moisture, and uptake of leaching nutrients. Heritability estimates for root mass in ryegrass suggest breeding is feasible for this trait (Crush et al. 2006), and there is substantial variation in root mass among different populations (Crush et al. 2009). Bonos et al. (2004) reported selection for increased root mass at depth in ryegrass, and Faville et al. (2006) reported a successful QTL analysis of root distribution in ryegrass, with significant synteny between ryegrass and rice root trait QTL.

METHODS

Four contrasting rooting pattern pools were selected using earlier results (Crush et al. 2006; 2007; 2009). They were: (1) low surface root mass, roots to 1m, (2) high surface root mass, roots to 1m, (3) high root mass 10-20cm, roots to 1m, (4) high surface (0-10 cm) root mass, shallow rooting. Polycrosses were done for each group and progenies raised. Three single-tiller ramets were taken off 50 plants of each progeny group, and planted into individual tubes (1m deep by 0.09m diameter) of sand culture irrigated with a low ionic strength culture solution based on nutrient composition of New Zealand pasture soil solutions. The experiment ran for 115 days in a glasshouse with average day/night temperatures of 19.3 and 14.1 °C, and 12h day length. At harvest, shoots were cut off and the sand/root column cut into 10 cm increments (Crush et al. 2005). The roots were washed free of sand and the shoots and root samples were dried overnight at 70 °C and weighed.

RESULTS

The four root shape progeny groups did not differ significantly for shoot DW, root DW, total plant DW, or root/shoot DW ratio. There were significant differences between progeny groups for % root in each of the first three 10 cm increments (Table 1). In particular, Group 1 had a lower % of root at 0-10cm than Group 2 and a higher % at 20-30cm. The probability of root type 4 (high surface root mass, shallow rooting) plants having roots at 1m depth was 0.67 and this was a significantly ($P<0.05$) lower probability than for the other selections (0.87- 0.93).

Table 1. Percentage of root total DW between 0-30 cm depth for the root type progeny groups

	Root type				
Depth (cm)	1	2	3	4	$LSD_{0.05}$
0-10	51.8	58.5	55.3	55.7	4.4
10-20	22.8	19.5	22.1	22.6	1.8
20-30	9.7	7.7	8.5	9.4	1.2

DISCUSSION

These results, from a single cycle of mass selection, and those of Bonos et al (2004), show that it will be possible to breed for change in root DW distribution in perennial ryegrass. This is despite substantial variation in root DW distribution at the genotype level which is suggested to be a mechanism to reduce intraspecific root competition (Crush et al. 2009). Further cycles of selection will be necessary to identify and develop an optimum root system in ryegrass, and the optimum shape could vary regionally. In many situations, advantages of increased root mass at depth would include better access to subsoil moisture, better interception of nitrate, and carbon sequestration in the subsoil. In other situations e.g. irrigated dairying on shallow soils, high surface root mass may lead to more effective use of nutrients and moisture for plant growth Shoot DW was not affected by selection for root shape, and other work has shown that increased root mass in ryegrass can be achieved with no penalty in shoot mass (Crush et al. 2007).

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