Rooting density of three grass species and eight *Lolium perenne* cultivars

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Abstract

Grassland with deeper and denser rooting can take up more nutrients and water, which increases productivity and reduces nutrient losses. The choice of specific grass species and/or cultivars could be an effective management tool to enhance rooting depth and density. This hypothesis was tested in two field experiments on sandy soil. In experiment I, the root mass, root length and root diameter of *Lolium perenne* (Lp), *Festuca arundinacea* (Fa) and *Dactylis glomerata* (Dg) were compared. In experiment II, the same was measured in eight selected cultivars of Lp, contrasting in terms of ploidy (diploid, tetraploid), production level (high, low) and earliness of production (early, late). In experiment I the results showed that the root biomass in the deeper soil layers (16–24 cm and 24–32 cm) of Fa was significantly higher compared to Lp or Dg. In experiment II, the root length density of the eight cultivars varied between 14.5 to 27.9 cm cm^{-3}. Diploid cultivars had a higher root mass, higher root length and lower mean root diameter than tetraploid cultivars. It can be concluded that using *Festuca arundinacea* and/or diploid *Lolium perenne* cultivars in grass mixtures can increase rooting depth and density.

Keywords: root mass, root length, grass species, *Lolium perenne* cultivars

Introduction

Increasing the nutrient uptake of grassland can reduce environmental pollution. Although grasses already have a dense rooting system, there are indications that increased rooting can still increase uptake of nutrients and production (Van Eekeren *et al.*, 2011; Van Loo *et al.*, 2003). Therefore, it is important to investigate which management practices promote deeper and denser rooting of grassland. One of those is the use of genetic variation among different grass species or cultivars (Bonos *et al.*, 2004; Crush *et al.*, 2007). In this paper, we describe the results of two experiments in which the distribution of root mass and density of three grass species and eight *Lolium perenne* cultivars were investigated.

Materials and methods

In experiment I, *Lolium perenne* (Lp) cv. Bargala, *Festuca arundinacea* (Fa) cv. Barolex and *Dactylis glomerata* (Dg) cv. Ambassador were sown in april 2007 on a sandy soil. In October 2010, root samples were taken in four soil layers: 0–8, 8–16, 16–24 and 24–32 cm. Per plot and per layer, three soil cores (8.5 cm diameter, 8 cm depth) were taken and pooled to one sample. The fresh samples were washed through a sieve (mesh size 2 mm) and non-root particles were removed. Root length per diameter class was measured by image analysis using WinRHIZO (Bouma *et al.*, 2000) (scan resolution 400 dpi; filter of particles smaller than 0.2 cm^2 and with a length / width ratio lower than 6) for calculating root length density (RLD). The root dry matter (DM) was determined after drying, first at 70 and then at 105°C.

In experiment II, eight *Lolium perenne* cultivars were selected (Table 1) from an experiment with more than 50 Lp cultivars sown in 2005 on a sandy soil. Sampling method and analysis procedure were the same as for experiment I, with the difference that only three soil layers were sampled: 0–8, 8–16 and 16–24 cm.

Table 1. Characteristics *Lolium perenne* cultivars in experiment II

Cultivar nr.	Cultivar characteristic		
	Ploidy	Production category (yield index)	Earliness category (yield index 1st cut)
1	Diploid	High (102%)	Early (111%)
2	Diploid	High (100%)	Late (84%)
3	Diploid	Low (97%)	Early (96%)
4	Diploid	Low (93%)	Late (89%)
5	Tetraploid	High (103%)	Early (123%)
6	Tetraploid	High (101%)	Late (91%)
7	Tetraploid	Low (99%)	Early (104%)
8	Tetraploid	Low (99%)	Late (82%)

Results and discussion

In experiment I, the total root DM and mean RLD in 0–32 cm were not significantly different between grass species. Significant differences appeared in the soil layers below the upper 8 cm (Figure 1). Overall, Fa developed more roots in the lower soil layers than Lp and Dg. This was confirmed by the significant lower percentage of total root DM in the upper 8 cm ($P = 0.010$) for Fa (65%) compared to Lp (83%) or Dg (76%). Analysis of the mean root diameter over the whole soil layer indicated a highly significant species effect ($P < 0.001$), with Dg having the thinnest roots (0.25 mm) and Fa the thickest (0.32 mm). In experiment II, significant differences in rooting parameters were found between cultivars (Figure 2).

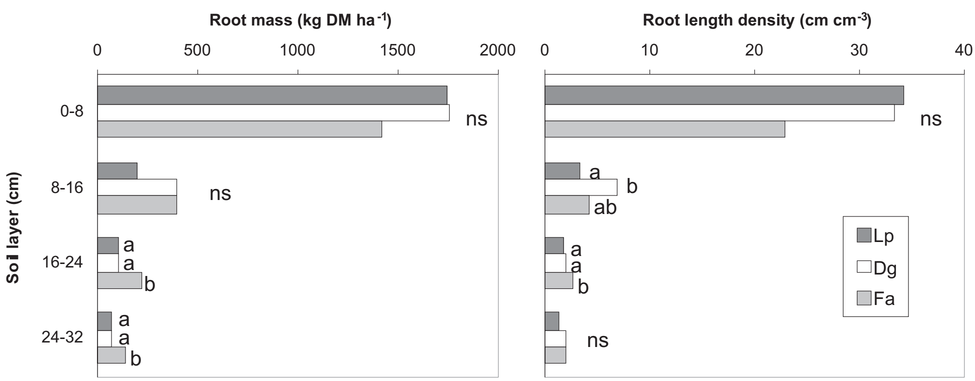

Figure 1. Root mass (kg DM ha^{-1}) and root length density (cm cm^{-3}) of the grass species *Lolium perenne* (Lp), *Festuca arundinacea* (Fa) and *Dactylis glomerata* (Dg) over four soil-depth layers (Experiment I). Different letters indicate a significant difference between means of grass species in a given soil layer ($P < 0.005$)

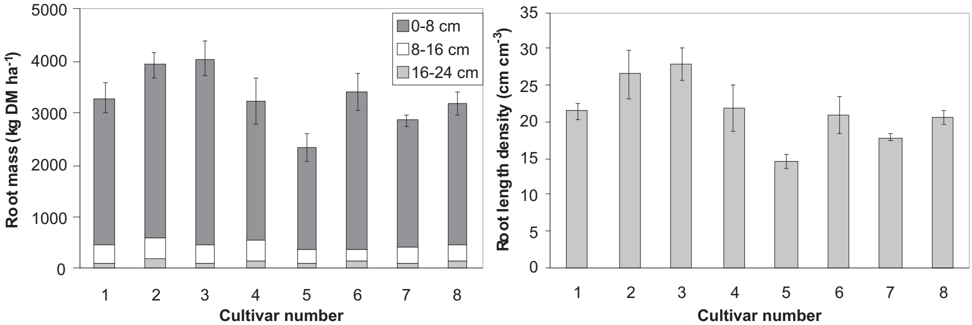

Figure 2. Cumulated root mass (kg DM ha^{-1}) and mean root length density (cm cm^{-3}) of eight *Lolium perenne* cultivars over three soil-depth layers (Experiment II). Error bars represent standard errors in the soil layer 0–24 cm

Rooting parameters were influenced by ploidy: in soil layer 0–24 cm, diploid cultivars had more root DM, higher RLD and lower mean root diameter (P = 0.005) than tetraploid cultivars (Table 2).

Table 2. Means of root DM and RLD (0–24 cm) per category (Experiment II)

		Root mass (kg DM ha^{-1})	*P*-value	Root length density (cm cm^{-3})	*P*-value
Ploidy	Diploid	3624	0.004	24.4	<0.001
	Tetraploid	2949		18.5	
Production	High	3243	0.686	20.8	0.432
	Low	3331		22.1	
Earliness	Early	3137	0.168	20.4	0.211
	Late	3436		22.4	

Conclusions

Based on the results of these two experiments, it can be concluded that the root mass and density in grassland can be influenced by the choice of grass species and cultivars. *Festuca arundinacea* had more roots in deeper soil layers than *Lolium perenne* and *Dactylis glomerata*. Diploid cultivars of *Lolium perenne* had a higher root mass and a higher root length density than tetraploid cultivars.

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