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Root depth and biomass of tall fescue vs. perennial ryegrass

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Abstract

Tall fescue (*Festuca arundinacea* Schreb.; Fa) is gaining interest due to its good drought resistance compared to other grass species. Although this attribute is commonly explained by the deeper roots of tall fescue, quantitative data on rooting depth are scarce and the effects of soil type and season are hardly known. We measured the root biomass of diploid perennial ryegrass (*Lolium perenne* L.; Lp) and Fa in a series of yield trials differing in soil type, location and management. Soil core samples were taken up to 70 or 90 cm depth in spring and in autumn. Higher root biomass was found for Fa compared to Lp in the deeper soil layers. Both species had higher root biomass in autumn than in spring.

Keywords: root biomass, tall fescue, perennial ryegrass

Introduction

Tall fescue (*Festuca arundinacea* Schreb.; Fa) is gaining interest due to its good drought resistance compared to other grass species (Wilman *et al*., 1998; Reheul *et al*., 2012). The drought resistance of Fa compared to ryegrasses is explained by the deeper rooting of the former especially in deeper soil layers (Wilman *et al*., 1998; Eekeren *et al.,* 2010; Deru *et al.,* 2012). Durand and Ghesquière (2002) found that tall fescue extracted water down to 180 cm whereas Italian ryegrass (*Lolium multiflorum* Lam.; Lm) was limited to 80 cm, based on data from neutron probe measurements. Quantitative data on rooting depth in the field for Fa in comparison with other species are scarce; hence it is not clear whether the deeper rooting of Fa compared to other species occurs in all soil types and under different management conditions. We compared the rooting depth of Fa and diploid perennial ryegrass (*Lolium perenne* L.; Lp) in different field trials that included both species. We hypothesised that below 30 cm, root biomass would be consistently higher for Fa than for Lp and that the root biomass would differ between soil types and seasons.

Materials and methods

Four herbage yield trials, comprising both Fa and diploid Lp, were sampled for root biomass. Trials were located on different soil types and conducted under different management regimes (Table 1). All trials were complete randomized block designs with three replicates. In the Belgian trials, located at Melle, Merelbeke and Poperinge, the Fa and Lp varieties were 'Castagne' and 'Plenty' respectively. In the Dutch trial located in Helvoirt, the Fa and Lp varieties were 'Barolex' and 'Bargala'. Using a root auger (Eijkelkamp, Giesbeek, the Netherlands), soil cores with a diameter of 8 cm were extracted at six depths (0-15, 15-30, 30-45, 45-60,60-75, 75-90 cm) in the Belgian trials and at seven depths (0-10, 10-20, 20-30, 30-40,40-50, 50-60, 60-70 cm) in the Dutch trial. Two samples for each depth were taken per plot. Soil samples were stored at -18°C prior to washing. Soil was washed from unfrozen samples with tap water on a sieve (0.4mm) and the roots were dried for 24 h at 75°C. The effect of the grass species on the root biomass at the different depths was tested using one-way Anova. In Melle and Helvoirt, we tested the effect of the season (spring vs. autumn) on the root biomass at different depths. Statistics were performed in R, using the aov() function (R Development Core Team, 2011).

Table 4 Trial identification, soil type and management regime.

Trial	*Location*	*Sowing date*	*Soil type*	*Sampling date*	*Management regime*
1 A	Melle (B)	April 2009	Sandy loam	27/4/2011	Mowing (1st cut) followed by grazing
B				16/10/2011	350 kg N yr^{-1}
C				1/10/2012	
2 A	Helvoirt (NL)	September 2007	Sand	13/5/2011	Cutting (4 cuts yr^{-1})
B				5/8/2011	300 kg N yr^{-1}
3	Merelbeke (B)	April 2009	Sandy loam	15/10/2012	Cutting (5 cuts yr^{-1}) 300 kg N yr^{-1}
4	Poperinge (B)	April 2009	Loam	7/11/2012	Cutting (5 cuts yr^{-1}) 300 kg N yr^{-1}

Results

In the upper soil level, no significant differences in root biomass were found between Fa and Lp (Table 2). Below 15 cm, significant differences between Fa and Lp occurred at different locations for different depths (Table 2). At Helvoirt, on the sandy soil, no significant differences were found in root biomass between Fa and Lp (Table 3).

In Melle and in Helvoirt, a significant seasonal effect on the root biomasses was found at some depths. In Melle, Fa had a higher root biomass at 75-90 cm depth in autumn than in spring (P=0.02), but for Lp there was no significant seasonal effect. In Helvoirt, higher root biomasses were found in mid summer than in spring for Fa in the layers 10-20 cm (P=0.008), 20-30 cm (P=0.009) and 40-50 cm (P=0.01) but for Lp only in the 40-50 cm layer (P=0.09).

Table 5. Root biomass (g dry matter m^{-2}) for *Festuca arundinacea* (Fa) and diploid *Lolium perenne* (Lp) measured in sandy loam and loam soils. Soil profile 0-90 cm. Significance of differences between species indicated as *** P<0.001; ** P<0.01; * P<0.05; ns = not significant.

Trial		*0-15 cm*	*15-30 cm*	*30-45 cm*	*45-60 cm*	*60-75 cm*	*75-90 cm*	*0-90 cm*
1 A	Fa	1082.3	167.0	47.0	26.9	17.6	10.1	1350.9
	Lp	847.5	183.3	32.2	14.6	11.0	6.2	1094.8
		ns	ns	ns	ns	ns	ns	ns
1 B	Fa	763.3	108.8	48.6	36.5	37.0	37.4	1031.6
	Lp	811.7	162.6	39.9	31.6	23.7	13.1	1082.6
		ns	ns	ns	ns	ns	*	ns
1 C	Fa	730.9	142.8	59.5	39.3	37.4	26.1	1036.1
	Lp	894.1	118.2	35.1	28.3	13.8	13.8	1103.3
		ns	ns	ns	ns	*	ns	ns
3	Fa	841.0	181.0	113.1	55.0	42.4	38.3	1270.8
	Lp	509.3	106.5	53.6	13.1	1.5	1.0	685.0
		ns	*	*	*	*	ns	*
4	Fa	742.3	71.7	53.1	58.8	45.8	28.5	1000.1
	Lp	692.0	62.4	24.4	12.5	5.2	2.1	798.7
		ns	ns	ns	*	**	***	ns

Table 6. Root biomass (g dry matter m^{-2}) for *Festuca arundinacea* (Fa) and diploid *Lolium perenne* (Lp) measured on a sandy soil in Helvoirt at six different depths. Significance of differences between species indicated as *** P<0.001; ** P<0.01; * P<0.05; ns = not significant.

Trial		*0-10 cm*	*10-20 cm*	*20-30 cm*	*30-40 cm*	*40-50 cm*	*50-60 cm*	*60-70 cm*	*0-70 cm*
2 A	Fa	669.1	83.6	42.6	44.7	15.8	11.8	10.0	877.6
	Lp	1039.2	91.1	76.4	63.4	14.6	8.9	5.1	1298.7
		ns	ns	ns	ns	ns	ns	ns	ns
2 B	Fa	821.2	195.6	120.5	101.8	42.2	55.1	45.6	1382.0
	Lp	1263.5	165.6	135.6	55.6	40.2	18.7	7.9	1687.1
		ns	ns	ns	ns	ns	ns	ns	ns

Discussion

The results found for root biomass were in line with the results of Hejduk and Hrabe (2003) who found a root biomass of 976 g m^{-2} in a sandy loam soil in the Czech Republic in a soil layer of 0-200 mm averaged over a period of five years on grassland with different grazing managements and fertilizations. Eekeren *et al.* (2010) found root biomasses of 1034 g m^{-2}, 217 g m^{-2} and 135 g m^{-2} for the 0-10 cm, 10-20 cm and 20-30 cm layers averaged over five grass treatments under a cutting regime on a sandy loam soil in the Netherlands. Significant differences in root biomass between Fa and Lp occurred mostly in the soil layers below 30 cm and the difference between the Fa and Lp increased with depth. In contrast to Eekeren *et al.* (2010) and Deru *et al.* (2012) we found no significantly higher root biomass for Fa on the sandy soil in Helvoirt, neither in spring nor in mid summer of 2011. The methodology might explain these differences: the samples from Helvoirt contained a lot of organic material (peat) that was hard to separate from the roots, especially from the fine roots of Lp.

In the sandy loam and loam soils, root biomass of Fa below 45 cm tended to be substantially higher than that of Lp, indicating better access to water in the deeper soil layers. The differences were most accentuated (and nearly always significant) in the samples taken in the autumn in the plots under an intensive cutting regime. Root biomass in these plots below 45 cm was approximately 10% and 2% of total root biomass for Lp and Fa respectively.

While total root biomass in the autumn was comparable for Fa and Lp in the predominantly grazed trial, Fa had at least 20% to 50% more root biomass than Lp in the trials with an intensive cutting regime, indicating that the potential benefit of Fa may be more important under a cutting regime.

As the leaves of Fa have a longer lifespan than leaves of Lp, it is recommended to analyse the difference in lifespan of roots in order to get a better view on root dynamics of Fa.

Conclusions

A consistently higher root biomass for Fa compared to Lp was found below 40-45 cm, but over the whole soil profile the root biomass of Fa was not necessarily higher than that of Lp.

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