Differentiation of cultivars within pasture grasses with regard to leaf tensile strength

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Abstract

The objective of this work was to analyse the differentiation of selected cultivars within five pasture grass species with regard to leaf tensile strength (LTS). The investigations were carried out in 2011-2012 on plant material obtained from two cultivar testing experiments, in which *Dactylis glomerata* (10 cultivars), *Festuca arundinacea* (10 cvs), *Festuca pratensis* (15 cvs), *Lolium perenne* (16 2× and 15 4× cvs) and *Phleum pratense* (10 cvs) were analysed. LTS was estimated on fully developed leaf blades using a prototype testing stand for measuring tensile strength of biological material, designed on the basis of a subassemblies of the Höttinger Baldwin Messtechnik (HBM) Company. The fresh matter and dry matter weight, width and specific leaf area of leaf blades were also determined. The LTS of investigated species ranged from 4.06 N (*L. perenne* 2×) to 12.46 N (*D. glomerata*). The differentiation of cultivars within species was also high and statistically significant. Performance of precise tensile strength measurements of leaf blades could be a helpful plant breeding tool for the development of improved pasture grass cultivars and selection of appropriate components in seed mixtures, particularly in high output dairy farming systems.

Keywords: cocksfoot, meadow fescue, perennial ryegrass, tall fescue, timothy

Introduction

Tensile strength of grass leaves is equated with resistance to the pulling motion that cattle apply to the sward when grazing. It influences bite mass, biting rate, sward preference and energy used by grazing animals (MacAdam and Mayland, 2003) and consequently affects dry matter (DM) intake. Grass leaves are dominant in pasture swards and, therefore, investigations associated with leaf tensile strength (LTS) are crucial for the determination of the total energy expenditure to ingest fodder. Grass genotype variability in this regard makes possible the appropriate selection of breeding materials with the aim of improving pasture cultivars (Rogalski and Kozłowski, 1981). The objective of this work was to evaluate the differentiation of selected cultivars within pasture grasses with regard to their LTS.

Materials and methods

LTS of selected cultivars of pasture grasses was evaluated during the 2010 and 2011 growing seasons at the Brody Experimental Station of PULS (52° 26' N, 16° 18' E). Plant material originated from two cultivar testing experiments established in 2009 and 2010 on an Albic Luvisols soil (pH_{KCl}=5.8, N_t = 0.72%, P = 0.083, K = 0.125, Mg = 0.063 mg g^{-1}) in randomized complete block designs (r=3) on 10 m^2 (1×10 m) plots, in which *Dactylis glomerata* – Dg (10 cvs), *Festuca arundinacea* – Fa (10 cvs), *Festuca pratensis* – Fp (15 cvs), *Lolium perenne* – Lp (16 2× and 15 4× cvs) and *Phleum pratense* – Php (10 cvs) were examined. In each year the following rates of fertiliser were applied: 120 kg ha^{-1} N, 26.2 kg ha^{-1} P and 83 kg ha^{-1} K, while 4 regrowth periods were harvested. The annual mean temperature and total precipitation for 2010 and 2011 was 8.0 and 9.4 °C, and 788, 537 mm, respectively. From each regrowth and each plot, 30 youngest fully developed grass leaf blades were randomly collected from plants in the vegetative growth stage (about 20 cm height – sward target for rotational grazing systems). LTS measured as force in Newtons (N) was estimated on 12 cm-long middle section leaf blades on the day of sampling using a prototype testing stand for measuring tensile strength of biological material designed on the basis of subassemblies (tensiometric sensors of appropriate nominal ranges, special measuring amplifiers with analogue/digital convertors) of the Höttinger Baldwin Messtechnik Company (Goliński, 2009). The fresh matter (FM) and dry matter (DM) weight, width and specific leaf area (SLA) of a leaf section of 12 cm in length taken for measuring tensile strength were also determined. The data were analysed by ANOVA. Tests of the main effects were performed by F-tests. Means were separated using the least significant difference and declared at $P<0.05$.

Results and discussion

Results on the tensile strength of grass leaves confirm that there were considerable differences between species (Table 1). When mean values for the entire period of investigations are compared, 2× cvs of Lp were characterised by the lowest LTS. The force required to break leaf blades of Fp was 20.4% higher than Lp2×. On the other hand, the force needed to break leaves of Php and 4× cvs of Lp was 69.2 and 44.8% higher, respectively, when compared with the Lp2×. The highest LTS, however, was observed in Fa and Dg, which, in comparison with that of Lp2× cvs, was found to be about 3 times higher. It is also worth emphasising the small coefficients of variation recorded for Fa (9.1%) in contrast to a much higher variation coefficient in the case of Dg (15.1%) and Lp2× (14.3%). It should also be added here that, following the performed statistical analysis, the existence of significant differences between cultivars was proved in all analysed grass species.

In addition, cultivars within individual species were also characterised by considerable variations in LTS. The greatest variability amounting to 106.5 and 88.1%, was recorded in the case of Dg and Fa cvs, respectively, whereas Php (74.5%), Fp (66.3%) and Lp4× (53.4%) cvs varied much less between one another in this regard. The lowest LTS variability (49.8%) was registered in the Lp2× cvs.

Pasture grasses differ with regard to their morphological structure and for this reason it is of interest to investigate LTS with reference to selected biological features (Zhang *et al.*, 2004). Rogalski and Kozłowski (1981) reported a correlation between LTS and length and width of leaves. In our study the leaf blade weight was also considered, because, for the same length of leaf blade section, this feature is positively correlated with leaf thickness and higher percentage of structural tissue. The negative correlation of ruminant preference with leaf strength may actually indicate a preference for grasses with a higher proportion of mesophyll tissue (MacAdam and Mayland, 2003). Data shown in Table 2 confirm that Fa and Dg cvs were characterised by the highest LTS when calculated per unit of leaf weight. With regard to 1 g of dry matter, the LTS of Fa was from 110.0 to 141.2% higher in comparison with Fp, Php and Lp cvs. Similar differences were observed in the case of Dg cvs. These results differ significantly from those reported by Rogalski and Kozłowski (1981) who found that LTS of Dg cvs was only 19.6% higher in comparison with Php cvs. The results in the present experiment used a different set of cultivars, and the considerable differences obtained here are attributed to these cultivar differences, as well as to measurement accuracy resulting from technical advances in measuring equipment. In the past, LTS

Table 1. Leaf tensile strength of cultivars within pasture grasses over the investigation period.

Species	Mean (N)	Coefficient of variation (%)	Cultivar means (N)		$LSD_{0.05}$ for cultivars based on plot error
			Minimum	Maximum	
Dactylis glomerata	12.46	15.1	8.64	17.84	2.333
Festuca arundinacea	11.25	9.1	8.07	15.18	1.618
Festuca pratensis	4.89	12.8	3.80	6.32	0.997
Lolium perenne 2×	4.06	14.3	3.27	4.90	0.750
Lolium perenne 4×	5.88	12.5	4.57	7.01	0.761
Phleum pratense	6.87	12.9	5.56	9.70	1.799

Table 2. Leaf tensile strength of cultivars within pasture grasses with regard to leaf parameters.[1]

Species	Weight[2]		Width[2]	SLA	Leaf tensile strength			
	FM (g)	DM (g)	(mm)	(cm^2)	N g^{-1} FM	N g^{-1} DM	N mm^{-1} of width	N cm^{-2} SLA
Dactylis glomerata	0.111	0.027	6.53	7.84	112.3	461.5	1.908	1.590
Festuca arundinacea	0.105	0.023	5.07	6.08	107.1	489.1	2.219	1.849
Festuca pratensis	0.064	0.021	5.01	6.01	76.4	232.9	0.976	0.813
Lolium perenne 2x	0.068	0.018	3.32	3.98	59.7	225.6	1.223	1.019
Lolium perenne 4x	0.076	0.029	4.15	4.98	77.4	202.8	1.417	1.181
Phleum pratense	0.117	0.030	6.69	8.03	58.7	229.0	1.027	0.856

[1] FM = fresh matter; DM = dry matter; SLA = specific leaf area = leaf area (width × 12 cm)/dry mass.

[2] Refers to the weight and width of a leaf blade section of 12 cm in length

investigations were conducted with the aid of simple devices operating on the principle of dynamometers (Evans, 1967; Martens and de Booysen, 1968; Rogalski and Kozłowski, 1981). With regard to the 1 mm leaf blade width, the lowest LTS was registered in the Fp and Php cultivars and the highest in Fa. For the rank order of LTS per SLA the following results were obtained: Fp, Php, Lp2×, Lp4×, Dg and Fa.

Conclusions

Leaf tensile strength of the investigated species ranged from 4.06 N (Lp2×) to 12.46 N (Dg). The greatest variability of this feature was recorded in the case of Dg and Fa cvs and the lowest in the Lp2× cvs. Intraspecific differences in leaf tensile strength in each of the analysed pasture grass species were statistically significant. Performance of precise tensile strength measurements of leaf blades could be a helpful tool in plant breeding for the development of improved pasture grass cultivars and selection of appropriate components in seed mixtures, particularly in high output dairy farming systems. The results obtained here help to provide a better understanding of the impact of plant functional traits on forage intake.

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