PLANT BREEDING AND SEED SCIENCE
Volume 57 2008

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THE RELATIONSHIP BETWEEN SOD STRENGTH AND TURF QUALITY OF COMMON GRASS CULTIVARS

ABSTRACT

The sod strength, rooting depth and turf quality (expressed by shoot density and visual merit) of ten turf grass cultivars were studied during three years under medium intensive turf maintenance. Cultivars of smooth stalked meadow grass (SMG), prostrate meadow grass, tall fescue (TF), red fescue., tufted hairgrass (TH) and perennial ryegrass (PR) were examined. Simple and fast evaluation 'hand tool' to determine overall sod strength was used. Seasonal variation of traits for tested cultivars was described. The highest values of sod strength were noted for SMG cultivars and the lowest – for PR, TF and TH cultivars. Sod strength was not affected by rooting depth. Visual merit and shoot density were positively correlated with sod strength only for few SMG cultivars. The method of testing can be recommended for small turf plots or existing sport areas.

Key words: *Poa pratensis, Poa supina, Deschampsia cespitosa, Lolium perenne, Festuca rubra,* rooting depth, shoot density, visual merit

INTRODUCTION

The general term 'turf quality' involves many characters. In addition to traits affecting the aesthetic value of turf, also '*functional'* traits should be included, especially for sport or sod production purposes. One of 'functional' traits of grasses is *sod strength* which is very important for sod production, due to its importance for handling with sod pieces during cutting, transportation and installation (Heckman *et al.* 2001). Sod strength is also important for football or other sports areas where direct and strong impact of players could significantly affect turf integrity. Here, it is claimed that if greater is the force required to tear the turf apart, the more able turf is to resist physical damage.

Many methods have been developed so far to determine turf strength or hardness and all of them measure the physical force needed to tear the turf (Beard, 1976; Sorochan *et al.* 1999 after Stier *et al.* 2000; Hurley and Skogley 1975; Burns and Futral, 1980; Haake, 1991; McNitt *et al.* 1997;

Communicated by Andrzej Anioł

Erusha *et al.* 1999). A device for sod strength testing has been described. This operated with a hydraulic lever powered by battery and require rather large sod pieces of ca. 1.5 × 0.5 m (Sorochan *et al.* 1999 after Stier *et. al* 2000). It is suitable while testing for sod production purposes, but if someone wants to measure turf sod strenght on existing football or athletic field or on experimental plots of 1 or 2 m^2 such testing unit is not suitable. Therefore, we developed a simple, fast and easy evaluation method, powered only by human hand force for tearing of small sod pieces (Prończuk, 1993).

For many cool season turf grass species recommended for sport areas, smooth stalked meadow grass (*Poa pratensis* L.) is one of the most popular species, due to its ability to form sod, even under unfavourable conditions. It is a highly variable species, with cultivars which differ in color, texture, density, vigor, disease resistance and tolerance to close mowing. Bluegrass is best adapted to well-drained, moist, fertile soils with a pH between 6.0 and 7.0 (Wedin and Huff, 1996; Duble, 2004).

Other species, widely used in turf production are: perennial ryegrass (*Lolium perenne* L.), red fescue (*Festuca rubra* L.) and tall fescue (*Festuca arundinacea* Schreb.). Examples of species that are not normally included in sod strength investigation are: prostrate meadow grass (*Poa supina* Schrad.) and tufted hairgrass (*Deschampsia cespitosa* L. P. Beauv.). The ability to produce rhizomes or stolons in the above species could be ranked from tufted hairgrass (no rhizomes or stolons) through perennial ryegrass and tall fescue (rhizomes absent or only short) to red fescue and smooth stalked meadow grass (creeping by stolons or rhizomes) and prostrate meadow grass (vegetative spreading only by aboveground stolons) (Davy, 1980; Edmondson,1980; Markgraff-Dannenberg, 1980; Gibson and Newman 2001).

The aim of the work was to evaluate sod strength, rooting depth, sward density and visual merit for a selection of common smooth stalked meadow grass cultivars in comparison to cultivars of other turf grass species and to describe relationships between the traits.

MATERIALS AND METHODS

Materials used in experiment were six common European turf cultivars (smooth stalked meadow grass: Conni, Limousine, Balin, Baronie, prostrate meadow grass Supranova, tall fescue Asterix), three Polish cultivars (smooth stalked meadow grass Bila, perennial ryegrass Stadion and slender creeping red fescue Nimba) and one breeding strain (tufted hairgrass Brok) recognized for turf potential by Prończuk (1994). Seed was sown on plots of $1m^2$ in April of 2001. Sowing rates ranged from 10 g × m^2 for tufted hairgrass, smooth stalked and prostrate meadow grass cultivars, 15 g × m^2 for Nimba, 20 g × m^2 for Stadion up to 30 g × m^2 for Asterix. Experiment was arranged in randomized block design with three replications, on silt sandy soil (pH 6.7) in central Poland (Radzików, 52°12’N, 20°37’E). After sowing (in April 2001) plots were covered with ca. 0.5 cm of peat and white propylene no-woven cover and watered daily until seedlings emerged. Plots were further watered during drought periods, and few cuts were done using a rotary mower with clippings collected. Herbicide treatment (fluroxypyr) against broad-leaf weeds was applied once before the second cut. During three years (2002 – 2004) plots were cut 22 – 25 times per year at 3 cm height and fertilized with: 180 kg of N per ha (5 doses per year), 67.2 kg of K per ha (2 doses) and 26.2 kg of P per ha (1 dose). No special management practices (i.e. aeration, rolling, top dressing etc.) were applied during the evaluation period.

Observations and measurements started in spring of 2002 and lasted for three consecutive years. Each year in the middle of spring, summer and autumn sod strength (SS), rooting depth (RD), shoot density (SD) and visual merit (VM) were determined. VM and SD were evaluated on a 1-9 scale rating: 9 - ideal turf or of maximum density and 1 - the poorest or dead. A rating of 5 was generally considered as the least acceptable turf (Prończuk, 1993).

Table 1

Climatic conditions during experiment (according to readings from automatic meteo station situated at Radzików)

Year/Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
	Precipitation [mm]												
2002	34.1	42.4	25.9	21.2	33.4	57.6	19.1	39.5	0.0	34.0	0.0	8.0	315.2
2003	8.2	0.0	6.2	7.5	21.0	25.4	61.9	35.3	4.3	14.8	15.4	27.1	227.1
2004	0.0	10.8	0.0	66.6	67.0	56.4	102.5	54.1	7.8	2.2	39.5	9.7	416.6
Normal (1955-2005)	23.9	21.7	24.5	34.8	52.7	66.6	77.3	56.6	41.8	31.4	35.5	32.4	499.1
	Temperature [°C]												Mean
2002	-0.1	4.5	5.3	10.2	19.4	19.4	23.0	22.8	13.7	7.2	4.1	-6.6	10.2
2003	-2.9	-4.9	1.9	7.3	15.7	18.0	20.2	18.7	13.8	15.4	4.9	0.9	9.1
2004	-5.1	0.0	3.5	8.7	12.0	15.8	17.9	19.0	13.5	10.0	3.7	1.8	8.4
Normal (1955-2005)	-2.3	-1.4	2.3	8.1	14.0	17.1	18.7	18.1	13.4	8.8	3.2	-0.6	8.3

SS and RD were determined according to the following methodology. Turf cores (3 per plot) of 5.3 cm in diameter and 15 cm in depth were obtained by inserting a soil corer (metal tube), vertically into soil. Rooting depth was measured as a length of the whole root system with soil. No special treatments were applied to separate roots from soil. Further to this, the upper part of turf core of 3 cm thickness was cut off by knife and sod strength (SS) was evaluated as the resistance of sod rings to tearing in hands. The highest SS value was given 9 when it was not possible to tear the sod, 7 – relatively high power necessary to tear sod ring, 5 – easy tearing (light power), 3 – tearing without power (loose sod) and the lowest SS value was 1 – no sod, no green cover.

Results were analyzed with SAS® statistical package: three-way ANOVA was performed and LSD values were calculated using Fisher test with probability of 95% (SAS Institute, 2004 a, b).

Mean air temperature and precipitation during the testing period (2002 – 2004) are shown in Table 1.

Table 2

Analysis of variance with mean squares and significance of variation components

Variable	Years (Y)	Seasons (S)	Cultivars (C)	Y × S	Y × C	S × C	Y×S×C	Error mean square
Turf strenght [1-9]	4.16 **	4.29 **	101.56 ***	0.18 ns	2.99 ***	2.10 ***	1.32 **	0.73
Rooting depth [cm]	64.19 ***	79.06 ***	17.88 ***					

RESULTS

Significant differences between tested cultivars were noted for all traits (Table 2). The highest variation between tested cultivars was noted for SS, SD and the lowest for VM and RD. Significant interactions between all treatments (years, seasons and cultivars) were noted for SD and VM. Variation of RD was mostly affected by different climatic conditions during testing period (Y × S).

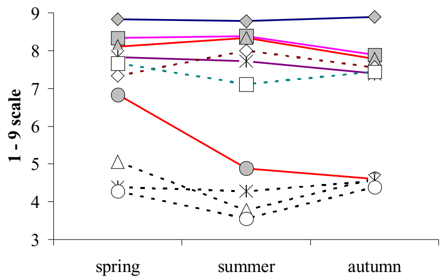
Sod strength (SS) of smooth stalked meadow grass cultivars, excluding Balin, was generally higher than for other cultivars (Table 3). It ranged from ‘untearable’ (unbreakable) sod (Conni, Bila) to very loose, quite easy to tear (non-rhizomatous cultivars)– Brok, Asterix and Stadion). Minor differences between tested cultivars were observed for RD, with very shallow root system observed for Supranova. The highest values of SD were noted for smooth stalked meadow grass Conni and Limousine and for cultivars of other species: Supranova, Nimba, Asterix, Brok. Generally, SD of sm ooth stalked meadow grass cultivars was of medium value (mean 6.7) and close

Table 3

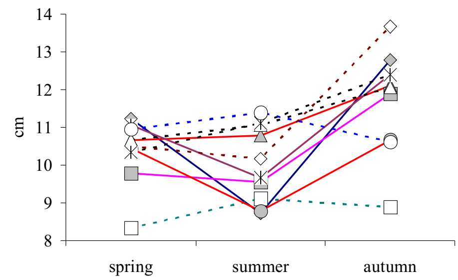
Mean values of traits of tested cultivars (average from 3-years of maintenance)

Genus, specis	Name of variety	SS [1-9]				RD [cm]				SD [1-9]				VM [1-9]			
		SP	SU	AU	Mean	SP	SU	AU	Mean	SP	SU	AU	Mean	SP	SU	AU	Mean
Poa pratensis	CONNI *	8.8	8.8	8.9	8.8a	11.2	8.7	12.8	10.9ab	8.0	7.9	7.9	7.9a	7.8	7.6	7.3	7.6a
Poa pratensis	BILA	8.3	8.4	7.9	8.2b	9.8	9.6	11.9	10.4ab	6.7	6.6	5.4	6.2c	6.7	6.6	5.3	6.2c
Poa pratensis	LIMOUSINE	8.1	8.3	7.8	8.1bc	10.7	10.8	12.1	11.2ab	8.1	7.2	8.0	7.8a	8.0	6.2	6.7	7.0ab
Poa pratensis	BARONIE	7.8	7.7	7.4	7.6cd	11.1	9.7	12.4	11.0ab	7.0	5.9	6.2	6.4b	6.6	5.0	5.6	5.7c
Festuca rubra	NIMBA	7.3	8.0	7.6	7.6cd	10.5	10.2	13.7	11.4a	7.9	7.8	7.9	7.9a	7.2	7.3	7.6	7.4ab
Poa supina	SUPRANOVA	7.7	7.1	7.4	7.4d	8.3	9.1	8.9	8.8c	7.9	8.0	8.0	8.0a	8.0	6.3	6.4	6.9ab
Poa pratensis	BALIN	6.8	4.9	4.6	5.4e	10.4	8.8	10.7	10.0bc	4.9	3.1	3.6	3.9c	4.1	3.1	3.9	3.7d
Lolium perenne	STADION	5.1	3.8	4.6	4.5f	10.7	11.1	12.1	11.3ab	7.0	6.3	6.0	6.4b	7.1	6.6	6.9	6.9ab
Festuca arundinacea	ASTERIX	4.4	4.3	4.6	4.4f	10.3	11.1	12.4	11.3ab	6.8	8.1	8.6	7.8a	6.3	5.7	6.2	6.1c
Deschampsia cespitosa	BROK N	4.3	3.6	4.4	4.1f	10.9	11.4	10.6	11.0ab	7.6	7.4	7.4	7.5a	7.2	5.7	5.7	6.2c
Total mean		6.9	6.5	6.5	6.6	10.4	10.0	11.7	10.7	7.2	6.8	6.9	7.0	6.9	6.0	6.2	6.4
LSD (P < 95%)		0.9	1.0	0.9	0.55	n.s	1.6	1.7	1.44	0.9	0.8	0.8	0.51	1.0	0.9	0.9	0.59

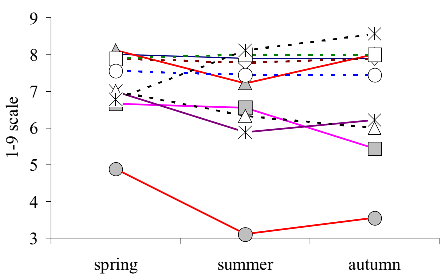
Explanations:
* - cultivars ranked due to decreasing sod strength value
SS – sod strength, RD – rooting depth, VM – visual merit, SD – shoot density,
SP – spring, SU – summer, AU – autumn
a…f – means with same letters are not statistically different



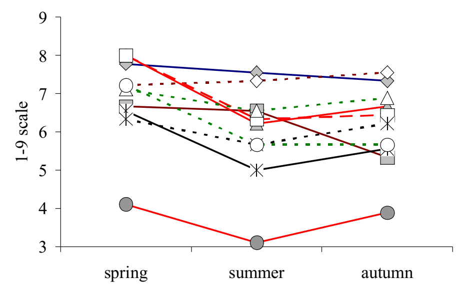
a) sod strength (SS)



b) rooting depth (RD)



c) shoot density (SD)



d) visual merit (VM)

Solid lines and shaded symbols – smooth stalked meadowgrass cultivars. Dashed lines and empty symbols – cultivars from other species. Symbols used for cultivars:

● - BALIN, ∗ - BARONIE , ■ - BILA, ◆ - CONNI, ▲ - LIMOUSINE,
○ - BROK, ∗ - ASTERIX, □ - SUPRANOVA, ◇ - NIMBA, △ - STADION

Fig. 1. Seasonal variation of examined traits (means from 3 years)

to perennial ryegrass (6.4). VM was high for Conni and Limousine, as well as for a few other cultivars: Nimba, Supranova and Stadion. Mean value of

VM for smooth stalked meadow grass cultivars (6.2) was comparable to tufted hairgrass and tall fescue (6.2 and 6.1, respectively).

For some cultivars seasonal variation of SS was observed (Fig. 1a). SS decline from spring to summer and increase from summer to autumn was observed for Brok, Stadion and Supranova. Summer increase of SS was noted only for red fescue Nimba. Rhizomatous cultivars had high SS values, excluding Balin where a rapid decrease of SS was observed from spring to autumn. In contrast to the above, all non-rhizomatous cultivars showed low SS values during all seasons.

Rooting depth (RD) of majority of tested cultivars decreased during summer and increased in autumn (Fig. 1b). For tall fescue Asterix a constant increase was observed from spring to autumn. Only for Supranova and Brok slightly higher values were observed during summer.

Seasonal variation of shoot density (SD) was observed for Limousine, Baronie and Balin (Fig. 1c). Decrease in SD values across seasons was observed for Bila and Stadion while increases where noted for Asterix. For the other cultivars tested no significant variation among seasons was observed.

Visual merit (VM) increased from spring to autumn for Nimba and decreased for Conni, Bila, Supranova and Brok (Fig. 1d). Summer decrease in VM was observed for Limousine, Baronie, Balin, Stadion and Asterix.

Table 4

Correlation coefficients calculated between sod strength (SS) and other traits evaluated

Genus. species. variety	RD	SD	VM
Festuca arundinacea - ASTERIX	-0.10	0.30	0.35
Lolium perenne - STADION	-0.25	0.25	0.17
Deschampsia cespitosa - BROK	-0.32	0.02	0.31
Non-rhizomatous species (n=3)	-0.20	0.12	0.28 **
Festuca rubra - NIMBA	0.09	0.35	-0.17
Poa supina - SUPRANOVA	0.20	-0.09	0.06
Poa pratensis - CONNI	-0.06	0.51 **	0.50 **
Poa pratensis - BALIN	0.19	0.39 **	0.23
Poa pratensis - BARONIE	0.06	0.39 **	0.39 **
*Poa pratensi*s - BILA	0.08	0.47 **	0.47 **
Poa pratensis - LIMOUSINE	-0.36	0.064	0.062
Rhizomatous species (n=7)	0.11	0.58 ***	0.54 ***

Explanation: *** - significance at level 0.001, ** - significance at level 0.05
RD – rooting depth, VM – visual merit, SD – shoot density

SS was significantly related to SD for smooth stalked meadow grass cultivars, excluding Limousine (Table 4). When calculated for groups of cultivars (rhizomatous and non rhizomatous) significant and positive relationships were noted between SS and VM. However, only for Conni, Baronie and Bila significant correlations were found when calculated separately for each cultivar.

DISCUSSION

Good sod strength for most of the smooth stalked meadow grass cultivars tested in our experiment was no surprise. It was undoubtedly due to the rhizomes, appearing from the axils of leaves, the base of which may be above or just below the surface of the soil (Hurley and Skogley, 1975). Moreover, some shoots of smooth stalked meadow grass turn downward and develop into rhizomes beneath the soil. Most rhizomes, however, develop beneath the soil surface as branch shoots of other rhizomes (Duble, 2004). Roots of smooth stalked meadow grass develop from the underground nodes of rhizomes and from the basal nodes of above ground shoots. Roots also develop at the terminal nodes of rhizomes that emerge above the soil as shoots. In established stands, the mixture of roots and rhizomes concentrated in the upper 6-8 cm of soil and form an extremely dense, resistant sod (DaCosta *et al.* 2004; Stewart *et al.* 2004). An exception to the high ranked smooth stalked meadow grass cultivars was Balin, which in fact is a forage variety, however commonly used in turf mixtures due to its early spring greenness and good seed production (Prończuk, personal communication). All 'turf quality' related traits of Balin (SD and VM) were of the lowest values.

Low sod strength values noted for non-rhizomatous cultivars were mostly due to different sod structure. Plants from Stadion, Asterix and Brok cultivars produce tussocks. Generally, perennial ryegrass and tall fescue rarely produce rhizomes and prostrate meadow grass is known to produce only above-ground stolons (Falkowski, 1982). Therefore, sod made from above species consists rather of separate plants more or less loosely connected by roots rather than by rhizomes.

Sod strength is one of many traits extensively tested during National Turf Evaluation Program (NTEP) in USA. Results from above program were similar to ours. Conni, Limousine and Baronie exhibited high sod strength values but differences between them were not always significant (NTEP, 1995, 2000, 2005). No differences between sod strength of smooth stalked meadow grass cultivars were reported by Hurley and Skogley (1975). Information is limited concerning sod strength of tufted hairgrass, prostrate meadow grass or tall fescue. As it has been reported by Hurley and Skogley (1975) concerning red fescues this species it has not been widely used in sod production because of poor sod quality. Such statement was not confirmed by our results concerning red fescue Nimba (SS = 7.6).

CONCLUSIONS

It is possible to rank tested cultivars due to sod strength values from strong sod of rhizomatous species to loose sod of non-rhizomatous species. Cultivars can differ significantly.

The common use of perennial ryegrass and tall fescue on football pitches was not supported by our results considering sod strength values.

Simple and fast method of testing the overall sod strength can be recommended.

The lack of significant relation beetween sod strengt and rooting deepth was found and for some cultivars relation between sod strength and turf quality (sod density and visual merit) was noted.

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