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THE EFFECT OF DIFFERENT ENVIRONMENTAL CONDITIONS ON VISUAL MERIT OF TURF GRASSES

ABSTRACT

Three different types of environmental conditions were used in five years of turf grass evaluation: no.1 – in sun, moderately intensive management with irrigation; no.2 – in park shade, extensively managed but irrigated when necessary; no.3 – in park shade, extensively managed and not irrigated. Visual merit (VM) of following cultivars was scored in 1 – 9 scale: perennial ryegrass Stadion, red fescue Nimba, smooth-stalked meadow grass Conni, tall fescue Asterix, prostrate meadow grass Supranova and tufted hairgrass Brok. Significant differences between cultivars as a response to different environmental conditions were observed. Variation of VM across seasons and years was different for particular cultivars. Irrigation strongly influenced turf quality especially in shade conditions. For each type of environment 'reference' cultivars were proposed.

Key words: *Deschamspia cespitosa, Festuca arundinacea, Poa pratensis, Poa supina, Lolium perenne, Festuca rubra*, turf maintenance, shade

INTRODUCTION

Specific reaction of grasses to different conditions of site and management is a well known fact (Watschke and Schmidt, 1992). Most field experiments on turf grasses refer to sun conditions. In the case of combinations of different stress conditions (i.e. deficit of light and water) studies are scarce. Natural shade conditions in combination with other stress factors can weaken plant growth (Dudeck and Peacock, 1992; Fresenburg, 2005). Tree roots compete with grasses for water and nutrients. Allelopathic (i.e. inhibitory) effects of some trees are also important for several species. Excessive organic matter from leaf litter may also inhibit turf growth. Therefore it is hard to make good interpretation of variable shade effects in field conditions. However any new results are valuable as a 'new example' of relationships between species and specific conditions.

The aim of our study was to evaluate how different environmental conditions affects the performance of turf grass cultivars.

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MATERIALS AND METHODS

Evaluation was carried out on the following turf cultivars: perennial ryegrass (*Lolium perenne* L.) cv. Stadion, red fescue (*Festuca rubra* L. ssp. *trichophylla*) cv. Nimba, smooth-stalked meadow grass (*Poa pratensis* L.) cv. Conni, tall fescue (*Festuca arundinacea* Schreb.) cv. Asterix, prostrate meadow grass (*Poa supina* L.) cv. Supranova and tufted hairgrass (*Deschampsia cespitosa* L.P.Beauv.) breeding strain Brok. Seed of above cultivars was sown on plots of 1 m^2 in April of 2001. Sowing rates ranged from 10 g × m^{-1} for tufted hairgrass, prostrate meadow grass and smooth stalked meadow grass cultivars, 15 g × m^{-1} for red fescue, 20 g × m^{-1} for perennial ryegrass up to 30 g × m^{-1} for tall fescue. 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) in three following environmental conditions:

— environmental condition no.1 - full sun, medium intensive management, fertilization ca. 190 kg N × ha^{-1}, 20 – 25 cuts per year at ca. 4 cm, irrigation during drought periods;
— environmental condition no.2 - heavy park shade (*Sorbus* sp. and *Acer* sp. trees), extensive management, fertilization ca. 40 kg N × ha^{-1}, from 9 to 11 cuts per year at 7 cm, irrigation during drought periods;
— environmental condition no.3 – heavy park shade (*Tilia* sp. and *Pinus* sp.), extensive management with fertilization 40 kg N × ha^{-1}, from 9 to 11 cuts per year at 7 cm, without irrigation.

Chemical control against insects from *Cecidomyiidae* family (*Diptera*), seriously damaging tillers of tufted hairgrass was applied in May 2002 (lambda-cyhalothrin, 7.5 g per 1 ha).

Visual merit (VM), which is a combination of sward density, leaf width, disease resistance and healthy color, was evaluated during early spring (es), spring (sp), summer (su), autumn (au) and winter (wi) using 1 – 9 scale, where 9 is perfect turf, 5 – least acceptable turf and 1 is no turf cover (Prończuk, 1993). In spring of 2003 and 2004 snow mould (SM) infection was evaluated on a 1 – 9 rating scale, where 9 is no disease symptoms observed and 1 – no resistance, all plants diseased (Prończuk, 2000).

Light intensity in shade was different in hours and seasons. Intensity of PAR (Photosyntetically Active Radiation) was measured before, during and after noon on a sunny day with LICOR spectroradiometer. Values measured in summer exactly at 12:00 ranged from 120 to 200 mol × m^{-2} × s^{-1} as compared to full sun light 1225 mol × m^{-2} × s^{-1}. PAR intensity in shade was reduced before noon (10%) to afternoon (30%) as compared to full sun light at 12:00. During autumn, after leaf fall and during spring (before tree leafing) light intensity in shade strongly increased up to level of full sun light afternoon (Prończuk *et al.* 2003, Prończuk and Prończuk 2006).

Climatic conditions during evaluation period are summarized in Table 1. Results of observations were analyzed with SAS® statistical package, LSD values were calculated according to Fisher test with probability of 95% (SAS Institute, 2004 a, b).

Table 1

Summary of climatic data during the experiment

Years	Months												Yearly	IV–X
	1	2	3	4	5	6	7	8	9	10	11	12		
	Precipitation [mm]												Total	
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	204.8
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	170.2
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	356.6
2005	30.8	38.5	33.5	22.4	46.2	18.2	44.6	41.8	23.8	3.6	31.0	63.3	397.7	200.6
2006	31.0	44.2	12.4	38.8	52.0	29.0	4.6	190.0	27.8	23.2	55	31	539.2	365.2
1955–2006	24.0	22.1	24.3	34.9	52.6	65.8	75.9	59.2	41.5	31.2	35.9	32.3	499.9	361.2
	Temperature [°C]												Average	
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	16.5
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	15.6
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	13.8
2005	1.3	-1.4	0.7	9.3	14.1	16.5	20.7	18.0	16.0	9.5	3.4	-0.1	9.0	14.9
2006	-8.4	-2.9	-0.7	9.2	14.3	18.3	23.4	18.1	16.2	11.0	6.0	4.3	9.1	15.8
1955–2006	-2.4	-1.5	2.2	8.1	14.0	17.1	18.8	18.1	13.5	8.8	3.3	-0.5	8.3	14.1

RESULTS AND DISCUSSION

All sources of variation (cultivars, seasons, years and managements) as well as all interactions significantly affected VM (Table 2). Managements accounted for more than a half of total variation. Cultivars used in experiment gave different results under different: conditions, years and seasons (Table 3 and 4).

The best performing cultivars in environmental conditions no. 1 were red fescue Nimba and smooth - stalked meadow grass Conni (VM = 6.6 and 6.4, respectively), however only fair in early spring (VM_{es} = 5.0 and 5.9). Cultivars of the highest early spring VM were tufted hairgrass Brok and prostrate meadow grass Supranova (VM_{es} = 6.8 and 6.7, respectively). Gradual decrease of VM resulted in the lowest winter values of both cultivars (VM_{wi} = 4.9 and 4.3, for Brok and Supranova, respectively). Both cultivars were brown instead of green during late autumn. Supranova exhib-

Table 2

Analysis of components of variation

Variation components	df	Mean square effect	F
Seasons (1)	4	24.1	31.5 ***
Managements (2)	2	199.5	260.4 ***
Years (3)	4	67.8	88.5 ***
Cultivars (4)	5	33.1	43.2 ***
Interactions:			
1 × 2	8	8.5	11.1 ***
1 × 3	16	13.4	17.5 ***
2 × 3	8	15.7	20.5 ***
1 × 4	20	17.2	22.5 ***
2 × 4	10	48.1	62.7 ***
3 × 4	20	20.2	26.3 ***
1 × 2 × 3	32	6.0	7.8 ***
1 × 2 × 4	40	2.6	3.4 ***
1 × 3 × 4	80	2.6	3.4 ***
2 × 3 × 4	40	2.3	3.0 ***
1 × 2 × 3 × 4	160	1.5	1.9 ***
Mean square error 0.77			

ited the highest seasonal variation of VM (18.4%). Cultivar of the lowest overall performance was tall fescue Asterix, of especially low VM values during early spring. It was mostly due to severe snow mould infection as well as wide leaf negatively affecting visual merit. No strong snow mould infection was noted for perennial ryegrass Stadion (tab. 5), as usually reported by other authors (Prończuk, Zagdańska, 1993; Prończuk, 2000). VM of Stadion was much more stable (CV = 5.6%) across seasons than for other cultivars.

In environmental conditions no. 2 the highest overall performance was noted for Supranova (VM = 6.0), which lost much of its quality during autumn and winter, mostly due to change in color of leaves from green to yellowish brown. Nimba, Brok and Conni gave good results from early spring to summer but lost its aesthetic values in autumn and winter. The highest winter VM (5.6) was noted for Asterix, which gradually regenerated after heavy snow mould infection at spring (SM = 2.7, VM_{es} = 3.0). The most stable cultivar was Stadion (CV = 10.1%) and the least – Brok (CV = 22.9%).

Table 3

Visual merit (VM) of tested varieties in different seasons

Species abbreviation/ Cultivar name	VM [scale 1 - 9]						CV [%]
	Early spring	Spring	Summer	Autumn	Winter	Mean	
Environmental condition no. 1 - sun with irrigation							
L.p. STADION	5.8 AB	6.6 A	6.1 AB	6.3 BC	6.7 A	6.3 AB	5.6
F.a. ASTERIX	4.2 C	5.1 B	4.9 B	5.5 BCD	5.5 CD	5.1 C	10.6
D.c. BROK	6.8 A	6.5 A	5.2 B	4.9 CD	4.9 DE	5.7 BC	16.3
P.s. SUPRANOVA	6.7 A	6.1 AB	5.4 B	4.6 D	4.3 E	5.4 C	18.4
F.r. NIMBA	5.0 BC	7.0 A	7.1 A	7.3 A	6.6 AB	6.6 A	14.1
P.p. Conni	5.9 AB	6.9 A	6.5 A	6.9 AB	5.9 BC	6.4 A	7.6
LSD	1.13	1.16	0.98	0.93	0.76	0.74	X
Environmental condition no. 2 - shade with irrigation							
L.p. STADION	3.1 C	4.2 C	3.6 D	3.5 C	3.5 C	3.6 C	10.8
F.a. ASTERIX	3.0 C	4.2 C	4.7 C	5.4 A	5.6 A	4.6 B	22.8
D.c. BROK	5.2 AB	5.7 B	5.8 B	4.1 B	3.4 C	4.8 B	21.4
P.s. SUPRANOVA	5.9 A	6.6 A	7.5 A	5.2 A	4.8 AB	6.0 A	17.9
F.r. NIMBA	4.7 B	5.5 B	5.9 B	5.7 A	4.9 AB	5.4 B	9.9
P.p. CONNI	5.2 AB	5.8 AB	5.5 BC	4.2 BC	4.1 BC	5.0 B	15.2
LSD	0.94	0.82	0.60	0.79	0.98	0.58	X
Environmental condition no. 3 - shade without irrigation							
L.p. STADION	3.9 AB	5.7 A	3.5 B	4.2 C	4.9 B	4.5 BC	19.6
F.a. ASTERIX	3.7 AB	5.1 AB	5.7 A	6.6 A	6.0 A	5.6 A	20.6
D.c. BROK	4.1 AB	4.6 CD	3.7 B	3.7 C	3.1 CD	3.9 CD	14.6
P.s. SUPRANOVA	4.5 A	5.5 AB	4.9 A	4.9 B	3.9 C	4.9 AB	12.5
F.r. NIMBA	4.1 AB	5.7 A	5.3 A	6.3 AB	5.0 B	5.3 AB	15.4
P.p. CONNI	3.2 B	3.8 C	3.1 B	3.5 C	2.8 D	3.3 D	11.8
LSD	1.13	1.10	1.09	1.10	0.95	0.82	X

Explanations: A, B, C, ….E – means followed by the same letters are not significantly different
Species abbreviations: L.p. – *Lolium perenne*, F.a. – *Festuca arundinacea*, D.c. – *Deschampsia cespitosa*, P.s. – *Poa supina*, F.r. – *Festuca rubra*, P.p. – *Poa pratensis*

In environmental conditions no. 3 Asterix as well as Nimba exhibited the highest values of VM (VM = 5.6 and 5.3, respectively). Mentioned cultivars gave quite stable ‘offer of green’ from spring to winter. Moderate results of VM were noted for Stadion and Supranova. Performance of Stadion decreased during summer (VM_{su} = 3.5) and of Supranova during winter (VM_{wi} = 3.9). Stadion was only slightly infected by snow mould. Unsatisfactory turf was observed for Conni and Brok (VM = 3.3 and 3.9, respectively). The most stable cultivar was Stadion (CV = 12.1%) and the poorest stability of VM was found for Supranova (CV = 40.1%).

Table 4

Visual merit (VM) of tested varieties during 5 years of experiment

Species abbreviation/ Cultivar name	VM [scale 1 - 9]						CV [%]
	2002	2003	2004	2005	2006	Mean	
Environmental condition no. 1 - sun with irrigation							
L.p. Stadion	6.5 AB	6.5 C	7.1 A	6.5 A	4.9 B	6.3 AB	12.8
F.a. Asterix	6.0 C	5.4 D	6.5 A	4.2 C	3.2 D	5.1 C	26.5
D.c. Brok	6.9 A	6.3 C	5.5 B	4.8 BC	4.8 BC	5.7 BC	16.5
P.s. Supranova	6.3 BC	6.7 BC	6.5 A	4.2 C	3.5 CD	5.4 C	26.7
F.r. Nimba	6.3 BC	7.2 AB	6.9 A	6.3 A	6.3 A	6.6 A	6.6
P.p. Conni	6.2 BC	7.3 A	6.5 A	5.5 AB	6.5 A	6.4 A	10.5
LSD	0.49	0.65	0.66	1.05	1.33	0.74	X
Environmental condition no. 2 - shade with irrigation							
L.p. Stadion	3.5 C	3.3 C	3.6 C	3.4 C	4.2 CD	3.6 C	10.1
F.a. Asterix	4.8 B	5.1 B	5.1 B	4.2 BC	3.7 D	4.6 B	13.1
D.c. Brok	6.3 A	5.2 B	3.3 C	4.3 B	5.0 BC	4.8 B	22.9
P.s. Supranova	6.5 A	6.6 A	6.2 A	5.8 A	4.9 BC	6.0 A	11.6
F.r. Nimba	4.3 BC	5.5 B	5.1 B	5.9 A	6.1 A	5.4 B	12.9
P.p. Conni	4.4 BC	5.3 B	4.3 BC	5.1 AB	5.7 AB	5.0 B	11.7
LSD	1.04	0.59	1.01	0.88	0.81	0.58	X
Environmental condition no. 3 - shade without irrigation							
L.p. Stadion	5.1 BC	4.6 CD	4.9 AB	3.9 C	3.9 B	4.5 BC	12.1
F.a. Asterix	6.4 A	6.9 A	5.5 A	4.8 B	4.1 B	5.6 A	20.4
D.c. Brok	5.1 BC	4.9 C	3.9 BC	3.0 D	2.4 C	3.9 CD	30.6
P.s. Supranova	6.1 AB	6.6 AB	6.0 A	3.3 CD	2.3 C	4.9 AB	40.1
F.r. Nimba	4.1 CD	5.6 BC	5.8 A	5.9 A	5.2 A	5.3 AB	13.4
P.p. Conni	3.7 D	3.7 D	3.3 C	3.1 D	2.6 C	3.3 D	13.5
LSD	1.08	1.19	1.37	0.79	0.57	0.82	X

Explanations: A, B, C, ….E – means followed by the same letters are not significantly different
Species abbreviations: see Table 3

Seasonal changes of visual merit were observed for all tested cultivars. However, in case of tall fescue and tufted hairgrass it is possible to use effect of ‘seasonal compensation’ of visual merit in hypothetical turf mixture (Fig. 1). It also showed how changes of VM could be seriously affected by different environmental conditions.

Apart from seasonal variation also changes in visual merit between years of maintenance were analyzed (Table 4). It is especially important in case of persistency of turf (Diesburg *et al.* 1997; Żurek 2007).

In environmental conditions no. 1 two groups of cultivars were selected: one of relatively high stability of VM (Nimba, Stadion and Conni) and second of decreasing VM (Asterix, Brok and Supranova). High stability of Stadion and low stability of Asterix were surprising. For Asterix low VM was the effect of severe infestation of snow mould (Table 5).

Table 5

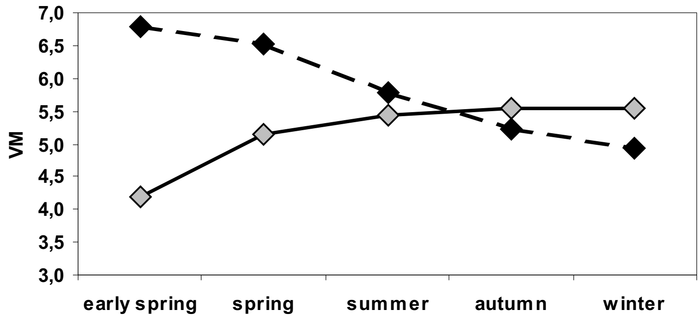
The occurrence of snow mould symptoms on tested varieties after winter 2003/2004

Species abbreviation/ Cultivar name	Environmental condition no. 1	Environmental condition no. 2	Environmental condition no. 3
L.p. STADION	6.3 B	3.8 B	7.7 A
F.a. ASTERIX	3.0 D	2.7 B	4.7 C
D.c. BROK	7.8 A	5.7 A	8.0 A
P.s. SUPRANOVA	7.0 AB	6.7 A	5.7 BC
F.r. NIMBA	4.8 C	5.7 A	6.3 B
P.p. CONNI	7.3 AB	6.3 A	5.3 BC
LSD	1.33	1.45	1.19

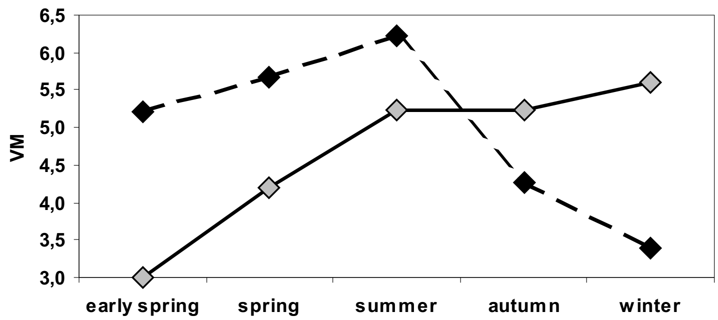
Explanations: A, B, C, ….E – means followed by the same letters are not significantly different, 1-9 scale, where 1 – no turf, 9 – no visible disease symptoms; Species abbreviations – see Table 3.

In environmental conditions no. 2, Stadion, Supranova and Conni were relatively stable (CV from 10.1 to 11.7%, respectively), as compared to other tested cultivars. Each of tested species exhibited different type of changes with time: tufted hairgrass decreased from 2002 to 2004 and further increased up to 2006. In case of this species, observed VM increase could be probably due to chemical control against insects applied since 2004. VM of Asterix was stable from 2002 to 2004 and further decreased to 2006. VM of Nimba increased during all test period with slight decrease in 2004 and VM of Supranova decreased from 2002 to 2006.

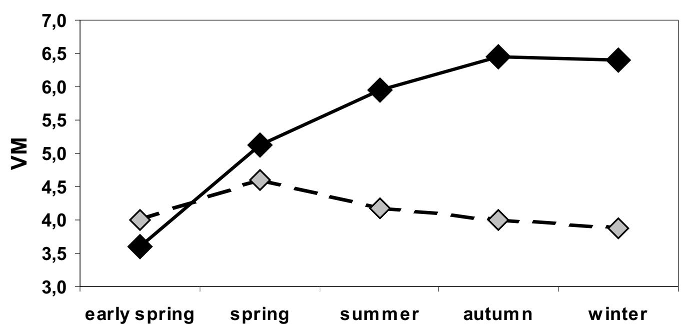
In environmental conditions no. 3 high VM of Asterix was observed during 2002 – 2004 and slight decrease up to 2005. Other cultivars, exposing rather high and stable VM values in such unfavourable conditions, were Nimba and surprisingly, Stadion. The lowest VM values were noted for Conni, Supranova and Brok, where gradual decrease in VM values led practically to



a — Environmental condition no. 1 (sun with irrigation)



b — Environmental condition no. 2 (shade with irrigation)



c — Environmental condition no. 3 (shade without irrigation)

Fig. 1. Seasonal 'compensation' of turf quality of *Festuca arundinacea* Asterix (solid line, shaded boxes) and *Deschampsia cespitosa* Brok (dashed line, black boxes) in different managements

turf disappearance. It could be partly due to the water deficit, which is very damaging for smooth stalked meadow grass and tufted hairgrass in turf culture, especially in extensive management in the sun (Żurek 2006; 2007).

The overall quality of tested cultivars was summarized in Table 6. Cultivar of the highest aesthetic values in the sun conditions were red fescue Nimba, in moderate wet shade conditions – prostrate meadow grass Supranova and in dry shade conditions – tall fescue Asterix. Nimba and Supranova were the mostly 'universal' cultivars. Visual merit of both cultivars was at least 5.0 in all environments.

Table 6

Mean values of VM across seasons and years

Species abbreviation/ Name of cultivar	VM (visual merit) in following environmental conditions:			Mean	LSD for managements
	No. 1 (Sun with irrigation)	No. 2 (Shade with irrigation)	No. 3 (Shade without irrigation)		
L.p. Stadion	6.3	3.6	4.6	4.8	0.50
F.a. Asterix	5.1	4.6	5.6	5.1	0.78
D.c. Brok	5.7	4.8	4.0	4.8	0.78
P.s. Supranova	5.4	6.0	5.0	5.5	0.99
F.r. Nimba	6.6	5.4	5.3	5.8	0.52
P.p. Conni	6.4	5.0	3.4	4.9	0.50
LSD for cultivars	0.74	0.57	0.75	0.5	X

Species abbreviations: see Table 3

CONCLUSIONS

1. Visual merit (quality) of turfgrass cultivars was highly dependent on environmental conditions.
2. Some cultivars, the best in sun conditions were the worst in shade conditions.
3. The highest variation of turfgrass quality across seasons and years of maintenance were observed under non irrigated shade conditions.
4. The results of evaluation were strongly influenced by prevalence of snow mould.

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