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EFFECT OF SUMMER DROUGHT IN 1999 ON TURF GRASS SPECIES

ABSTRACT

Basing on the response to drought in 1999 of 27 turfgrass cultivars and ecotypes of 9 species made possible ranking of turf grasses in the decreasing order of drought resistance.

Key words: drought, turf grasses, *Deschamspia caespitosa, Festuca arundinacea, Festuca rubra, Festuca nigrescens, Festuca ovina, Koeleria piramidata. Koeleria macrantha, Lolium perenne, Poa pratensis.*

INTODUCTION

Drought is a complex event that can be defined from several points of view. The main criterion is water deficit but definition of drought is difficult since it is necessary to specify hydrologic cycle resulting from water deficit and its duration (Eagels et al. 1999, McNab and Karl 1991). Undoubtedly drought is a major environmental factor hampering world agriculture production. An accumulated precipitation deficiency accompanied by above normal atmospheric evaporative demand is caused by a period of abnormally dry weather, which when sufficiently prolonged cause severe water shortage and plant damage (Beard 1989, Humphreys and Thomas 1993).

Adaptation to seasonal droughts for temperate perennial grasses involves plant survival and enhancement of growth (Kemp and Cluvenor 1994). Recovery from drought is of major importance for perennial grasses, more for existing plants than for establishment of new plants. During drought periods some species pass into dormancy (turn brown) and recover when water is supplied. Efficient recovery from drought may prove to be more important than plant growth during dry season for it enables species to persist in swards or pastures etc. and improve their

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competition with less drought resistant species (Kemp and Cluvenor 1994, Thomas et al. 1996, Volaire et al. 1998).

The objective of our studies was to determine the effect of summer drought in 1999 on several turf grass cultivars and ecotypes with particular regard on recovery and general turf performance after natural summer drought period.

MATERIAL AND METHODS

Seeds for this study were kindly provided by breeding stations, scientists and gene banks as listed in Table 1. Three replicate experimental design with randomied plots was used. The soil was lessive brown - gray, developed from sandy clay (Dysarz, Wiśniewski 1996). Seeds were sown directly by hand in April of 1998 on 1 m^2 plots with the densities: 10 g/m^2 - *Poa pratensis* (kentucky bluegrass), *Deschampsia caespitosa* (tufted hairgrass), *Koeleria* sp. (crested grass); 15 g/m^2 - *Festuca nigrescens* (chewings fescue), *F. rubra rubra* (creeping red fescue), *F. ovina* (sheep fescue); 20 g/m^2 - *Lolium perenne* (perennial ryegrass) and 25 g/m^2 - *Festuca arundinacea* (tall fescue). Thereafter the plots were watered daily until germination of seeds. Then, plots were kept without any irrigation. Fertilisation was accomplished in autumn 1998 with application of 64 kg/ha NO_2 and 192 kg/ha of K_2O and P_2O_5 and at spring 1999 with 71.4 kg/ha NO_2, 214 kg/ha of K_2O and P_2O_5 (1999). The grass was mowed weekly (excluding drought test period) from early spring to autumn at 30mm using rotary grass mower with clippings collected. No additional treatment was applied.

Sward density (Sd) was estimated monthly from May 1998 to September 1999 by visual rating using a scale from 1 (complete absence of sward) to 9 (uniform and complete sward cover) (Prończuk 1993, Prończuk et al. 1997). Summer meteorological values were averaged from June and July, autumn values – from September to October.

Condition of plants (CP) during drought and recovery period was recorded visually using following scale (Humphreys and Thomas 1993, Minner and Butler 1985):

1 – completely dead plants, no green tissue visible, even when tillers dissected,

3 – trace of green tissue, usually at the base of the youngest leaves,

5 – approximately half of plants with appreciable amounts of green leaves,

7 – most or all of leaves alive, but with most leaves scorched,

9 – all leaves alive without symptoms of scorching.

Results of above estimation was expressed as a percentage of initial value recorded at 16 of July 1999.

Turf aesthetic value (TAV) was estimated visually before and after drought test using scale from 1 (no plants) to 9 (ideal turf) (Prończuk 1993, Prończuk *et al.* 1997).

Pearson correlation coefficients were calculated for CP and turf quality parameters (SD andTAV) estimated before and after the drought and recovery test. Data were analysed using STATISTICA 5.0 for Windows ®.

Table 1.

Trade name of varieties, names of breeding lines and number of ecotypes with seed provider names

Genus, species, authority - latin name, common name	Name of variety or ecotype number	Seed donor name (institution, location)
Deschampsia caespitosa (L.) P.B., tufted hairgrass	Ec. 408/94	Bot. Garden PB&AI, Bydgoszcz
	Ec. BEŁCHATÓW	S. Prończuk, PB&AI, Radzików
	BROK	S. Prończuk, PB&AI, Radzików
Festuca arundinacea Schreb., tall fescue	BAROCCO	Barenbrug Polska, Poznań
	RAHELA	ESPB&AI, Radzików
	TERROS	PBS, Szelejewo
Festuca nigrescens Lam., chewings fescue	BARGREEN	Barenbrug Polska, Poznań
	KRH - 4	R. Lutyńska, PB&AI, Kraków
	NIMBA	PBS, Nieznanice
Festuca ovina L., sheep fescue	BY - 63	S. Prończuk, PB&AI, Radzików
	ESPRO	ESPB&AI, Bartążek
	GABI	ESPB&AI, Grodkowice
Festuca rubra ssp. rubra L., creeping red fescue	ARETA	PBS, Antoniny
	BARGENA	Barenbrug Polska, Poznań
	LEO	PBS, Nieznanice
Koeleria macrantha (Ledeb.) Schult., crested hair-grass	Ec. 1050/94	Bot. Garden PB&AI, Bydgoszcz
Koeleria pyramidata (Lam.) Beauv., crested meadow-grass	Ec. 1032/94	Bot. Garden PB&AI, Bydgoszcz
Lolium perenne L., perennial ryegrass	KRH - 22	R. Lutyńska, PB&AI, Kraków
	NIRA	PBS, Nieznanice
	STADION	S. Prończuk, PB&AI, Radzików
Poa pratensis L., kentucky bluegrass	DRESA	S. Prończuk, PB&AI, Radzików
	ALICJA	PBS, Nieznanice
	BA - 2/94	ESPB&AI, Bartążek
	BA - 3/94	ESPB&AI, Bartążek
	BA - 4/94	ESPB&AI, Bartążek
	BARZAN	Barenbrug Polska, Poznań
	Ec. CHAŁUPY	S. Prończuk, PB&AI, Radzików

Explanation: PBS - Plant Breeding Station, PB&AI - Plant Breeding and Acclimatization Institute, ESPB&AI - Experimental Station of Plant Breeding and Acclimatization Institute. Ec. - ecotype

Climatic data (temperature and rainfall) for the area of Botanical Garden of Plant Breeding and Acclimatization Institute, in Bydgoszcz were kindly provided by Institute of Meteorology and Water Management, Department in Słupsk. To induce recovery, plots were watered using commercial rotary sprinkler and total amount of water applied was: 20.3 mm (August 9, 1999) and 35.4 mm (August 10, 1999).

RESULTS

Climatic conditions of vegetative season.

General description of climatic conditions (mean monthly temperatures with total monthly rainfall) during 1998 – 1999 in Bydgoszcz were compared with respective long-term (1950 – 1980) values (Table 2).

Vegetative season in 1999 was warmer by 1.5°C than normal (mean value for years 1951 – 1980). At the same time total amount of rainfall was 1.2 mm higher than normal recorded from July to October. Distribution of precipitation over vegetative season along with high temperatures were also different from normal. From March to the end of July 1999 total rainfall was 264.3 mm (i. e. 146.8% of normal) but from the July 1 to the end of October – only 153.9 mm (i. e. 64.9% of normal). Air temperature and rainfall data during test period are given in Table 3.

Table 2

Monthly mean temperature [°C] and total rainfall [mm] in Bydgoszcz for 30 year period and during 1998 and 1999 seasons as compared with normal values.

Month	1951 - 1980		1998		1999	
	Temperature [°C]	Rainfall [mm]	Temperature [°C]	Rainfall [mm]	Temperature [°C]	Rainfall [mm]
March	1.4	24	1.9	44.6	4.2	51.9
April	6.9	37	9.5	32.3	9.0	86.7
May	12.4	53	14.1	59.6	12.7	47.4
June	16.7	66	17.0	65.6	16.9	78.3
July	17.8	91	17.0	101.8	20.2	56.8
August	17.0	58	15.7	74.5	17.6	43.5
September	12.9	48	13.0	71.6	16.3	30.1
October	7.9	40	7.5	52.5	8.2	23.5
Mean temp.	11.6		12.0		13.1	
Total rainfall	417		502.5		418.2	

Drought and recovery test results

Drought and recovery test results are presented in Table 4. The decrease of initial plant conditions (CP) was noted on the 13^{th} day of drought and amounted 13 to 16%.

Table 3.

Mean air temperatures and total rainfall during test period (July and August 1999) in Bydgoszcz.

Period and its duration [days]	Temperature [°C]	Rainfall [mm]
drought - 22 days (from Jun 18 to Aug 8)	20.3	3.2
watering - 2 days (from Aug 9 to Aug 10)	21.0	55.7
recovery - 18 days (from Aug 11 to Aug 28)	16.0	40.4

None of these cultivars maintain initial CP till 18th day of drought, but no further reduction of CP was observed during the next two and a half up to three weeks of drought. Reduction of initial CP recorded at the end of drought varied from 73.3% (kentucky bluegrass 'Barzan' and BA-3/94) to 18.7% (chewings fescue 'Bargreen').

Plant recovery was connected with a final reduction of initial value of CP. Tall fescue 'Terros', 'Rahela', 'Barocco' and chewings fescue 'Bargreen' recovered to initial CP 2 - 4 days after watering. After 7 days of watering all cultivars of chewings and creeping red fescue, perennial ryegrass, crested hair and meadow grass and two cultivars of sheep fescue ('Espro' and 'Gabi') recovered to the initial value of CP, while four kentucky bluegrass cultivars ('Barzan', 'Alicja', 'Dresa' and BA-3/94) and sheep fescue BY-63 restored initial CP after 17 days of watering. At the same time tufted hair-grass ecotypes and three kentucky bluegrass (BA-4/94, BA-2/94 and 'Chałupy') still did not recover to initial CP.

Turf aesthetic value (TAV) before drought was positively correlated with CP up to 18 days of drought and CP during recovery after 4 days of water supply (Table 5). TAV estimated after drought test was positively correlated with CP after 7 days of regrowth.

Sward density (Sd) before drought test was positively correlated with CP up to 13 days of drought. Sd after drought test was also correlated with CP after 7 days of water application. In some cases (tufted hairgrass, perennial ryegrass) damages after drought were irreversible.

DISCUSSION

Effect of drought conditions in 1999 summer on turf grass was different in grass species. Tested cultivars and ecotypes could be divided into 3 groups according to their performance during drought and recovery:

Tall fescue 'Terros', 'Rahela', 'Barocco' and chewings fescue 'Bargreen' were the varieties recovering fast after drought (in two days after watering), able to remain green and maintaining acceptable turf quality during drought.

Table 4.

Turf quality and performance during drought and recovery period.

No	Species, varieties and ecotypes	Turf quality parameters				Condition of turf plots (initial value = 100)							
		Before drought (summer 1999)		After drought (autumn 1999)		Drying [Number of days from last rain]				Recovery [Number of days from the beginning of watering]			
		Sd	TAV	SD	TAV	13	15	18	22	2	4	7	18
1.	D.c. - Ec. 408/94	8.5	8.0	7.8	6.0	93.8	93.8	37.5	43.8	43.8	43.8	75.0	93.8
2.	D.c. - Ec. BEŁCHATÓW	8.8	8.0	7.8	5.8	100.0	93.8	62.5	50.0	62.5	56.3	81.3	93.8
3.	D.c. - BROK	8.7	8.0	7.5	6.0	93.8	106.3	43.8	43.8	43.8	43.8	75.0	75.0
4.	F.a. - BAROCCO	7.3	8.0	8.2	7.3	112.5	112.5	62.5	62.5	100.0	100.0	100.0	112.5
5.	F.a. - RAHELA	7.0	6.5	7.0	6.0	100.0	123.1	69.2	69.2	107.7	115.4	115.4	130.8
6.	F.a. - TERROS	7.0	6.5	7.5	6.3	107.7	130.8	69.2	76.9	115.4	123.1	123.1	130.8
7.	F.n. - BARGREEN	9.0	8.0	9.0	8.8	112.5	112.5	93.8	81.3	93.8	100.0	112.5	112.5
8.	F.n. - KRH - 4	7.8	7.5	8.0	6.8	86.7	93.3	46.7	40.0	66.7	66.7	113.3	106.7
9.	F.n. - NIMBA	7.7	7.5	7.5	6.8	93.3	93.3	66.7	66.7	80.0	80.0	100.0	93.3
10.	F.o. - BY - 63	8.5	6.0	7.7	5.5	100.0	83.3	41.7	41.7	58.3	58.3	66.7	108.3
11.	F.o. - ESPRO	7.7	7.0	7.8	7.3	85.7	85.7	42.9	28.6	78.6	92.9	107.1	114.3
12.	F.o. - GABI	7.8	7.0	8.2	7.0	85.7	78.6	28.6	35.7	64.3	85.7	107.1	107.1
13.	F.r. - ARETA	5.8	5.0	5.8	5.8	80.0	110.0	50.0	70.0	80.0	60.0	130.0	130.0
14.	F.r. - BARGENA	6.3	5.5	7.0	6.5	90.9	100.0	45.5	54.5	72.7	81.8	118.2	118.2

Table 4

Continued

No	Species, varieties and ecotypes	Turf quality parameters				Condition of turf plots (initial value = 100)							
		Before drought (summer 1999)		After drought (autumn 1999)		Drying [Number of days from last rain]				Recovery [Number of days from the beginning of watering]			
		SD	TAV	Sd	TAV	13	15	18	22	2	4	7	18
15.	F.r. - LEO	5.8	5.5	6.7	6.5	90.9	100.0	54.5	63.6	81.8	72.7	127.3	127.3
16.	K.m. - Ec. 1050/94	8.2	6.5	7.5	7.0	107.7	76.9	46.2	53.8	61.5	76.9	115.4	115.4
17.	K.p. - Ec. 1032/94	7.5	6.5	7.3	6.5	100.0	69.2	30.8	30.8	46.2	69.2	100.0	123.1
18.	L.p. - KRH - 22	6.5	7.0	6.8	6.8	85.7	85.7	64.3	50.0	78.6	85.7	100.0	107.1
19.	L.p. - NIRA	7.0	7.0	6.3	6.5	85.7	107.1	35.7	42.9	71.4	78.6	100.0	100.0
20.	L.p. - STADION	7.5	7.5	6.8	7.8	93.3	106.7	66.7	60.0	86.7	93.3	106.7	106.7
21.	P.p. - DRESA	7.0	6.5	7.3	6.8	107.7	100.0	30.8	30.8	46.2	69.2	92.3	100.0
22.	P.p. - ALICJA	7.3	7.0	7.0	6.8	100.0	100.0	28.6	35.7	50.0	85.7	92.9	107.1
23.	P.p. - BA - 2/94	7.0	6.5	6.2	5.5	92.3	84.6	30.8	30.8	46.2	84.6	92.3	92.3
24.	P.p. - BA - 3/94	7.3	7.5	7.0	6.5	86.7	93.3	33.3	26.7	46.7	66.7	93.3	106.7
25.	P.p. - BA - 4/94	7.5	8.0	7.2	7.3	93.8	100.0	37.5	31.3	50.0	62.5	87.5	93.8
26.	P.p. - BARZAN	7.3	7.5	7.7	7.8	100.0	93.3	40.0	26.7	53.3	73.3	93.3	106.7
27.	P.p. - Ec. CHAŁUPY	7.5	9.0	8.0	8.3	83.3	83.3	22.2	33.3	50.0	77.8	83.3	94.4
	mean	7.5	7.1	7.4	6.7	95.2	96.9	47.5	47.4	68.0	77.9	100.3	107.7
	standard deviation	11.1	13.1	9.4	11.9	9.5	14.5	35.7	34.7	30.3	24.3	16.2	12.7
	LSD (P = 95%)	0.5	0.6	0.6	0.7	19.5	35.0	26.7	19.1	27.1	37.2	35.0	32.0

Abbreviations of the species names: D.c. - *Deschampsia caespitosa,*, F.a. - *Festuca arundinacea,* F.r. - *Festuca rubra,*ssp. *rubra,* F.n. - *Festuca nigrescens,* F.o. - *Festuca ovina,* K.m. - *Koeleria macrantha,* K.p. - *Koeleria pyramidata* , L.p. - *Lolium perenne,* P.p. - *Poa pratensis*
Other abbreviations: Ec. - ecotype

Table 5.
Pearson correlation coefficients for turf quality parameters (Sd – sward density, TAV – turf aesthetic value) and condition of turf plots during drought and recovery test.

Turf quality parameters	Condition of plots during drought and recovery :							
	Drying [number of days from last rain]				Recovery [number of days from watering]			
	13	15	18	21	2	4	7	17
Sd, summer '99	0.6744***	0.3289	0.3475	0.1981	0.0755	0.0610	-0.0206	0.2367
TAV, summer '99	0.8274***	0.6905***	0.3982**	0.2587	0.2970	0.4013**	0.3520	0.5035**
Sd, autumn '99	0.7096***	0.3768**	0.4368**	0.3317	0.3651	0.3796**	0.3493	0.5783**
TAV, autumn '99	0.2517	0.1139	0.1679	0.0088	0.1633	0.3575	0.4483**	0.4179**

Significance of correlation estimated with probability of 99% (***) or 95% (**).

Tall fescue is classified as a very drought resistant species mainly due to its deep root system (Beard 1989, Diesburg et al. 1997, Eagels at al. 1999, Hull 1997, Thomas 1994). Also, 'Bargreen' is known as an extremely drought resistant cultivar (Anonymous 1993). Wood and Buckland (1966) found that although drought destroyed some chewings fescue plants, the regrowing and emerging sprouts were sufficient to produce increased total number of plants.

Above cultivars are also referred to as dehydration avoiding for they are able to remain green and maintain acceptable turf quality during drought or low precipitation period. Some grass species belong to this category due to their root structure, density and relative low water demand (Beard 1989, Dean et al. 1996).

Plants partly remaining green during drought and able to medium fast recovering after water supply made another group including the following species: creeping red fescue and sheep fescue, perennial ryegrass and crested hair and meadow grass.

The last two species (*Koeleria macrantha* and *K. pyramidata*) represent a drought escape strategy. The rapid early regrowth followed by rapid leaf senescence as water and stress increases suggests the idea of above strategy rather than drought tolerance mechanism (Kemp and Cluvenor 1994, Frank 1994). Plants can reduce leaf area and rely on dormant buds or underground organs to enable rapid regeneration when rain falls (Eagels et al. 1999). This is a desired trait for areas where the primary concern is soil stabilisation but not an aesthetic value (Diesburg et al. 1997). Cattani and Smith (1997) suggest that wet conditions may even be detrimental for turf from crested hairgrass which is a dryland species.

Perennial ryegrass is generally more sensitive to drought than tall fescue or chewings fescue (Amin, Thomas 1996, Beard 1989, Kemp, Kluvenor 1994, Kenna, Horst 1993, Minner, Butler 1985) but less sensitive than kentucky bluegrass (Minner and Butler 1985). In case of species such as tall fescue and perennial ryegrass, fast or medium fast regrowth after drought is due to a better regeneration in autumn from the growing points of vegetative and sterile tillers which stop growing over summer (Kemp, Cluvenor 1994).

Creeping red fescue and sheep fescue are commonly used for low maintenance turf (Dernoeden et al. 1994, 1998, Diesburg et al. 1997, Harkot, Czarnecki 1999, Lutyńska 1993). However, along with increasing drought, turf from the above species usually display a brown patchy appearance, rather than uniform dormancy in contrast to perennial ryegrass and kentucky bluegrass. Mulch of dead leaves or dormant turf is difficult to mow. Finally, the dead areas of turf of creeping red fescue or sheep fescue never fill in with new growth and therefore the above species were recorded to be less drought resistant than perennial ryegrass and kentucky bluegrass (Minner and Butler, 1985).

Kentucky bluegrass, tufted hairgrass, sheep fescue BY-63 plants slowly recovering after drought are characterized by fast decrease of initial quality and slow recovery. It was recorded by Wood and Buckland (1966) that kentucky bluegrass regrowth after drought was insufficient and slow as compared to chewings fescue. Minner and Butler (1985) found kentucky bluegrass to be less drought tolerant than chewings fescue and perennial ryegrass. One possible explanation is poor rooting depth of kentucky bluegrass comparing to fine fescues and tall fescue (Beard 1989, Minner and Butler 1985). In case of tufted hairgrass which is typically associated with mesic meadows, the U. S. Forest Service has had success resowing of dry sites using ecotypes from similar habitats (Walsh 1995). Generally, there is lack of information concerning quality of tufted hairgrass turf grown in dry conditions. Moreover, slow regrowth of above species could be associated with early dormancy or insect injury (Prończuk 2000, personal communication).

Basing on the data above we can list turf grass species from fast to slow recovering from drought in the following order: tall fescue → chewings fescue → sheep fescue → creeping red fescue → crested hair and wheat grass → perennial ryegrass → kentucky bluegrass → tufted hairgrass.

This ranking is partly consistent with the relative ranking of drought resistance reported by Beard (1989). According to him wheatgrass was the best drought resistant cool season fairway while tall fescue was the second one in ranking and perennial ryegrass, kentucky bluegrass, creeping red and chewings fescue were described as fair drought resistant.

Turf aesthetic value (TAV) was a good predictor for plot condition up to 18 days of drought and following 4 days recovery. TAV is a qualitative, subjective and complex parameter that combines a lot of single traits such as: colour of leaves, sward density, leaf width, leaf angle, diseases etc. (Prończuk 1993). In view of plant performance which is a function of green area (i. e. total area covered by green leaves) it is evident that both parameters are closely connected. However, because of seasonal changes in TAV it is hard to appraise the exact effect of drought on aesthetic value of turf. It has been well documented that turf species differ in major turf quality parameters of species and varieties observed in successive seasons (Dernoeden 1998, Prończuk, Żurek 1994, Prończuk *et al.* 1997).

Observations made on regrowth of several turf grass species after summer drought are preliminary concerning the effect of natural drought on grasses grown as a turf. As it was mentioned above, good recovery after drought may be the major factor, more important than plant growth from the farmer's or turf manager's point of view (Kemp and Cluvenor 1994, Thomas et al. 1996). Also further work on performance of different cultivars or ecotypes of turf grasses under drought is necessary for improvement of turf area quality and persistence during prolonged seasons of water deficit.

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