P L A N T B R E E D I N G A N D S E E D S C I E N C E
Volume 58 2008

Grzegorz Żurek[1], Sławomir Prończuk[2]

Plant Breeding and Acclimatization Institute, Department of Grasses, Legumes and Energy Plants, [1]Laboratory of Nonfooder Grasses and Energy Plants, [2]Laboratory of Grasses and Legumes, Radzików, 05-870 Błonie, Poland

RELATIONSHIP BETWEEN SEED YIELD AND TURF QUALITY IN *POA PRATENSIS* L.

ABSTRACT

Twenty seven entries (10 cultivars and 17 breeding strains) of smooth-stalked meadowgrass (*Poa pratensis* L.) were tested during 2002 – 2004 for seed yield and turf quality. Seed yield potential was estimated on the basis of: seed yield per plot, seed yield per panicle, seed heads per 1 m^2, panicle length, 1000 seed weight, plant height, leaf width and heading time. Turf quality was estimated on the basis of: visual merit, shoot density, leaf fineness and colour. Tested entries were significantly different for all traits measured. No significant correlations were calculated for seed yield and any from turf quality traits. None of top quality turf varieties (BARCELONA, LIMUSINE and CONNI) yielded as high as the highest yielding entries (BALIN, BARON etc.). The best marker trait for seed yield was seed yield per panicle and for turf quality – late heading time, short panicle and low seed yield per panicle. Efforts should be made to improve seed yield components but only minor chances are to combine excellent turf quality with very high seed yield in one variety.

Key words: seed productivity, smooth-stalked meadowgrass, turf quality

INTRODUCTION

From many cool season turf grasses, smooth-stalked meadowgrass (*Poa pratensis* L.) is one of most popular species, due to combination of softness, medium to fine-leaf texture, high shoot density, dark green colour and persistency (Wedin and Huff, 1996). It is a variable species, with cultivars that differ in colour, texture, density, vigour, disease and drought resistance and tolerance to close mowing (Johnston *et al.* 1997; Prończuk and Prończuk, 2003; Martyniak 2003 a).

Experience has shown that however outstanding a variety may be in terms of excellence of turf, it is little hope of making an impact on the agricultural market without a satisfactory seed production (Griffiths *et al.* 1980). In many breeding programs turf quality receives much attention, which has to do with strong VCU testing system in most EU countries. Only cultivars with excellent turf performance, prominently appearing in cultivar lists, are interesting

Communicated by Andrzej Anioł

enough to commercialize, without enough attention paid to seed productivity (Wijk, 1996). Many cultivars still continue to be sold in large quantities even though they have lower turf quality of any presently existing commercial cultivar (Watkins and Meyer, 2004).

The aim of our study was to select best quality turf strains of smooth-stalked meadowgrass having also high seed yield.

MATERIALS AND METHODS

Ten common European turf cultivars (BALIN, BARON, BARONIE, BARCELONA, CONNI and LIMUSINE), four Polish turf cultivars (ALICJA, ANI, BILA and NANDU) and seventeen Polish breeding strains of smooth-stalked meadowgrass (*Poa pratensis* L.) were used as a material in the experiment. Seed was sown in April of 2001 in two experiments: (1) for seed yield determination - on plots of 2 m^2 in 4 rows 0.25m apart, 5 g of seeds per $1m^2$, (2) for turf quality determination - on plots of $1m^2$, 10 g per plot.

Both experiments were arranged in three replicate design on silt sandy soil (pH 6.7) in central Poland (Radzików, 52°12’N, 20°37’E). Seed yield experiment was fertilized two times with mineral fertilizer starting from sowing year (June and August) and during further vegetation (March and August). During each fertilizer application mineral compounds were applied with following doses (in kg × ha^{-1}): N — 60, P — 26 and K — 50. Herbicide treatment (fluroxypyr) against broad-leaf weeds was applied twice in sowing year and once in 2002. Post-harvest residues were cut with tractor mower and hand raked. For turf quality assessment, plots after sowing were covered with propylene non-woven cover and watered until seedlings emerged. During full maintenance (2002–2004) turf plots were cut with rotary mower (clippings collected) 22 – 25 times per year at 3 cm height and fertilized with mineral fertilizer at amount: N — 180 kg × ha^{-1}, 5 doses per year, K — 75 kg × ha^{-1}, 2 doses per year and P — 26 kg × ha^{-1}, 1 dose per year. No special management practices (i.e. aeration, rolling, top dressing etc.) were applied during evaluation period. During prolonged periods of drought turf plots were watered with sprinklers.

For each experiment following observations were taken during three years:

(1) traits related to seed yield: heading time (HT), plant height (PH) and panicle length (PL) were measured according to OECD rules (1971); number of seed heads per 1 m^2 - (SH): total number of fertile seed heads counted inside frame 20 × 20 cm and results calculated for $1m^2$; for seed yield per panicle (SPP): ten panicles per one entry on replication were collected, panicles were threshed, cleaned and seed was weighed; for seed yield per unit area (SY) all panicles from plot were collected, seed was treated as mentioned above and results were calculated per 1 m^2. Leaf width (LW) was evaluated on 1–9 scale basis (Prończuk, 1993);

Table 1.

Results of evaluation of smooth-stalked meadowgrass (entries ordered according to descending VM values)

Name of variety or breeding line	Turf quality traits			Seed yield traits							
	VM	SD	C	LF	HT	PH	PL	LW	SH	SPP	TSW	SY
		[scale]			[days]	[cm]	[cm]	[scale]	No × m^{-2}]		[g]	
Conni	7.5 a	8.0	7.8	6.7	47.8	35.8	6.0	6.3	2806	0.69	0.338	75.55 def
Barcelona	7.1 ab	7.8	8.3	6.9	47.5	48.3	7.8	6.0	2999	0.79	0.302	72.75 defg
BA-1036	7.0 abc	8.1	7.9	7.6	48.3	46.7	5.7	6.0	4864	0.54	0.218	80.00 de
Limousine	7.0 abc	8.0	7.6	7.4	47.5	40.0	6.0	7.0	4166	0.57	0.247	74.45 def
Chałupy	6.9 bcd	7.4	7.7	7.4	47.2	50.0	6.5	7.0	2777	0.67	0.331	82.90 cde
Dresa	6.8 bcde	7.0	7.8	6.3	47.2	51.7	7.1	5.0	3061	0.93	0.318	105.80 a
BA-2090	6.8 bcde	7.9	7.5	7.4	47.3	45.0	5.9	5.7	5454	0.54	0.258	97.95 abc
BA-2028	6.5 cdef	6.9	8.6	6.5	44.8	60.0	8.2	5.7	2187	0.82	0.334	57.30 ghij
BA-915	6.3 efgh	7.0	7.8	5.9	47.8	60.0	7.2	4.7	2086	0.83	0.273	63.70 fghi
Bila	6.3 defg	6.5	8.8	5.8	46.0	53.5	7.8	5.0	2319	0.99	0.362	71.15 defg
BA-2196	6.2 fghi	6.6	8.2	6.0	48.2	47.5	7.5	4.7	1908	0.74	0.240	42.90 k
6/85	6.2 fghi	6.4	8.0	6.2	47.8	48.3	7.2	5.0	1879	1.36	0.278	99.80 ab
BA-2169	6.2 fghi	5.8	7.6	5.4	46.2	50.0	7.5	4.3	1712	0.95	0.324	52.40 ijk
Nandu	6.2 efgh	6.8	8.6	5.5	48.2	47.0	9.6	5.7	1552	1.07	0.331	63.85 fghi
Contra	6.1 fghij	6.4	8.0	5.9	47.7	47.5	6.7	5.0	1886	1.18	0.284	83.65 cd
BA-2012	6.1 fghij	6.9	7.5	6.4	45.7	65.0	6.7	5.7	4048	0.62	0.238	60.05 fghi
Baron	6.0 fghij	6.8	8.4	5.9	48.3	42.5	6.5	4.7	3026	0.98	0.349	105.55 a
RA-1571	5.9 fghijk	6.7	7.6	5.9	41.5	71.5	8.0	5.0	1725	1.40	0.322	81.80 de

Table 1

continued

Name of variety or breeding line	Turf quality traits				Seed yield traits							
	VM	SD	C	LF	HT	PH	PL	LW	SH	SPP	TSW	SY
		[scale]			[day]s	[cm]	[cm]	[scale]	Number × m-2]		[g]	
Alicja	5.8 ghijk	6.8	7.6	5.7	47.5	42.5	7.0	5.0	2423	0.86	0.324	71.80 defg
Ani	5.8 ghijk	6.5	7.6	5.6	47.7	47.0	7.5	4.3	1941	0.95	0.322	74.40 def
Baronie	5.7 ijklm	6.7	7.7	5.9	45.0	69.2	7.5	6.0	2107	0.72	0.323	61.90 fghi
43/83	5.7 hijklm	6.4	7.8	6.2	48.0	45.0	7.2	4.7	2022	1.43	0.269	102.80 a
Przełęcz S	5.4 klm	6.0	7.8	5.8	41.3	73.8	9.5	4.3	1664	1.36	0.262	85.70 bcd
NIB-176	5.3 lm	5.9	7.6	6.3	45.3	46.7	7.5	6.0	1123	1.06	0.384	67.30 efgh
NIB-398	5.2 m	6.0	7.9	6.0	44.7	47.5	7.4	5.7	1689	1.09	0.300	71.70 defg
BA-2260	4.4 n	5.0	7.7	5.4	46.8	44.2	7.8	5.3	2171	0.83	0.315	36.75 k
Balin	3.6 o	4.1	7.4	6.8	34.0	88.3	11.2	5.0	1525	1.65	0.322	109.05 a
LSD (P<95%)	0.56	0.71	0.31	0.46	1.5	5.4	0.9	0.7	25.8	0.38	2.2E-09	17.55
CV (%)	12.4	13.4	4.7	10.3	6.6	22.8	15.9	13.9	42.5	31.1	13.6	24.8

Explanations: a,b,… n, o – numbers followed by the same letters are not significantly different

(2) traits related to turf quality: at the middle of June, August and October shoot density (SD), visual merit (VM), turf colour (C) and leaf fineness (LF) were determined according to Prończuk (1993). SD and VM were evaluated on 1-9 scale basis: 9 being outstanding, ideal turf or of maximum density and 1 being poorest or dead. For C: 1 means no turf and 9 – dark green. For LF 9 is very narrow leaf and 1 – very wide. A rating of 6 is generally considered acceptable (Prończuk, 1993).

All statistical analyses were performed with SAS statistical package (SAS, 2000). Means were separated with Fisher's protected LSD (P=0.05). Multiple regression analysis was performed on standardized data basis due to different units used in particular traits.

RESULTS

Significant differences were found among all tested entries for all examined traits (Table 1). Traits related to seed yield were generally more variable than turf quality traits and the most variable traits were: SH, SPP, SY and PH.

The group of the highest seed yielding entries (SY from 98 to 109 $g \times m^{-1}$) consists of four breeding strains and two varieties: BALIN and BARON. Multiple regression analysis indicated that from all traits related to seed yield: SPP, SH and TSW accounted for 79% of total variation of SY (Table 2). VM of tested entries ranged from values close to 7.0 (CONNI, BARCELONA, LIMUSINE and BA-1036) to quite unacceptable turf (less than 6.0 – for varieties ALICJA, ANI, BARONIE, BALIN and five breeding strains). SD and C accounted for 94% of total VM variation (Table 2).

Table 2.

Results of multiple regression analysis for seed yield and turf quality traits

Seed yield (SY):				
R2= 0.79, F(7.19) =10.59, p<0.000				
Trait	Regression coefficient	Standard error	t - statistic values	Significance
SPP	1.42	0.19	7.30	0.00
SH	1.10	0.19	5.80	0.00
TSW	0.33	0.13	2.50	0.02
HT	0.30	0.26	1.13	0.27
PH	0.22	0.23	0.97	0.34
LW	0.11	0.14	0.83	0.42
PL	-0.23	0.20	-1.14	0.27
Visual merit (VM):				
R2= 0.94 F(3.23) =121.56, p<0.000				
Trait	Regression coefficient	Standard error	t - statistic values	Significance
SD	0.95	0.06	14.71	0.00
C	0.12	0.05	2.24	0.03

Table 3.

Correlation coefficients for all traits examined

Traits	SD	C	LF	HT	PH	PL	LW	SH	SPP	TSW	SY
VM	0.96***	0.27	0.49**	0.66***	- 0.50**	- 0.67***	0.42*	0.60**	- 0.64***	- 0.24	0.03
SD		0.16	0.56**	0.63***	- 0.49**	- 0.72***	0.51**	0.70***	- 0.69***	- 0.31	0.06
C			- 0.18	0.29	- 0.19	0.12	- 0.07	- 0.15	- 0.01	0.23	- 0.13
LF				0.01	- 0.08	- 0.39 *	0.70***	0.71***	- 0.41*	- 0.36	0.35
HT					- 0.86***	- 0.74***	0.14	0.34	- 0.59**	- 0.16	- 0.22
PH						0.68***	- 0.24	- 0.28	0.47*	- 0.01	0.13
PL							- 0.36	- 0.64***	0.67***	0.28	0.00
LW								0.43*	- 0.54**	0.01	- 0.10
SH									- 0.69***	- 0.51**	0.19
SPP										0.23	0.45**
TSW											- 0.02

Explanation: *. **. *** indicate significance of correlation coefficient at 0.05. 0.01 and 0.001 levels of probability, respectively

Entries of high visual merit values (CONNI, BARCELONA, LIMUSINE and BA-1036) yielded only slightly above mean value (76 g × m^{-1}). No correlation was found between seed yield and visual merit, shoot density or colour (Table 3). Visual merit and shoot density were positively correlated with late heading, narrow leaf and high number of seed heads per unit area. Negative correlations were calculated between mentioned turf traits and plant height, panicle length and seed yield per panicle.

DISCUSSION

The basic factors contributing to seed yield in grasses are the number of inflorescences produced per plant, the number of florets produced per inflorescence (or head size), the proportion of florets which set seed (or seed setting) and individual seed weight (Griffiths *et al.* 1980; Martyniak 2003b). As it was shown in our experiment in case of BALIN variety, early plant heading and many long panicles are among the best components to select for high seed yield (Ensign *et al.* 1989).

We have found that seed yield of smooth-stalked meadowgrass had the most positive correlation with seed yield per panicle but not with number of seed heads per unit area as contrary to Canode and Law (1975). Insignificant effect of number of seed heads on seed yield was also described by Ensign *et al.* (1989) however other authors suggested positive and significant relation between mentioned traits (Canode and Law 1975; Ensign *et al.* 1989; Johnson *et al.* 2003).

Results similar to ours, concerning correlation of seed yield per unit area with seed yield per panicle were also noted for timothy, tall and meadow fescue (Griffiths *et al.* 1980). Our results confirmed previous findings about significant and negative correlation between seed yield per panicle and number of panicles per unit area (Canode and Law, 1975). According to Canode and Law (1975) the major components of seed yield variation in cool season grasses were: seed yield per panicle, number of panicles per unit area and 1000 seed weight. Similar conclusions appeared from multiple regression analysis in our experiment.

Numerous experiments have shown that there was no positive correlation between seed yield and turf quality (Johnston *et al.* 1997; Żyłka, 2001; Johnson *et al.* 2003). The first turf-type smooth-stalked meadowgrass varieties released, including MERION, had low to moderate seed-yielding capability. Later introductions of other varieties, including BARON, with high seed yield and good turf quality has made seed yield an important criterion in turfgrass breeding (Meyer and Funk, 1989).

Traits, which are usually the components of seed yield are related to generative phase of plant development, as contrary to turf quality traits, representing the vegetative phase. For example low growth - trait desirable for turfgrass, will result in seed heads close to or even below leaf canopy, and finally difficult seed harvest and cleaning (Johnston *et al.* 1997).

CONCLUSIONS

The combination of excellent turf quality with high seed productivity was not found among tested entries.

Combinations at little lower quality of turf and little lower quantity of seed were present in 4 from 17 breeding lines.

It is possible to select promising turf quality on the basis of some plant characters as: late heading, short panicles, high number of panicles per unit area.

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