Evaluation of Bromegrass Introductions for Forage Yield and Quality

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SUMMARY

Smooth bromegrass (*Bromus inermis* Leyss.) is one of the most important cool-season forage grasses in the United States and Canada. Further improvement in this grass by breeding depends on identifying sources of genetic variability for forage yield and quality. Since smooth bromegrass is an introduced species, foreign introductions are an obvious source of genetic variability.

This study evaluated 49 smooth bromegrass introductions for forage yield and quality as measured by *in vitro* dry matter digestibility (IVDMD) and protein content and compared them with the cultivar 'Lincoln'. Evaluated in a separate study and reported here were eight meadow bromegrass (*Bromus biebersteinii* Roem. and Schult.) introductions.

There were large differences among the smooth bromegrass introductions for all traits evaluated including forage yield, panicle height, canopy height, seed production rating, IVDMD, and protein content. Forage yield was negatively correlated with IVDMD and crude protein content in the smooth bromegrasses. Several of the smooth bromegrass introductions, including PI 315374, 315378, 315398, and 325237, produced forage yields similar to those of Lincoln in 1977 and 1978 and had first cut forage IVDMD values three percentage units higher than Lincoln in 1978 and should be useful germplasm in breeding for both high yield and high IVDMD. Forage yields of the meadow bromegrass introductions were only about 50% of those of Lincoln and in general were not as promising for use in a breeding program as the smooth bromegrass introductions.

Evaluation of Bromegrass Introductions For Forage Yield and Quality

Kennth P. Vogel[1/]

INTRODUCTION

Smooth bromegrass, a productive cross-pollinated grass, is native to parts of Europe and Asia and was introduced into the U.S. in 1884 (Newell, 1973). Since its introduction, about 20 smooth bromegrass cultivars have been developed and released.

The first cultivars released, such as ‘Achenbach’ and ‘Lincoln’, were direct seed increases from highly productive bromegrass fields that developed via natural selection from early introductions. Subsequent cultivars were developed almost exclusively by selection within the older cultivars (Hanson, 1972). The use of recent plant introductions in smooth bromegrass breeding programs in North America has been minimal since only ‘Manchar’ has been developed from a specific introduction or has a specific introduction in its pedigree (Hanson, 1972). The potential gain that can be made in a plant breeding program depends upon the available genetic variability for economic traits including the variability in plant introductions. I believe the use of smooth bromegrass plant introductions has been neglected in breeding programs. One of my objectives has been to systematically screen introductions to identify accessions that can be used to improve the forage yield and quality of smooth bromegrass.

The limited quantity of seed collected by plant explorers is usually increased at plant introduction stations before being made available to plant breeders for evaluation. The number of introductions being increased at any one time precludes increasing the seed lots in isolation. Seed of cross-pollinated grasses is increased in the same nursery under open-pollination. Seed lots increased by plant introduction stations thus do not represent the original introductions but represent the combining ability of the original introductions with other accessions that were flowering at the same time. The limited amount of seed available to breeders from plant introduction stations necessitates evaluating the accessions in space-planted plots rather than in solid-seeded sward plots.

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Two of the most important agronomic traits of smooth bromegrass are forage yield and forage quality as measured by *in vitro* dry matter digestibility (IVDMD). Lebsock and Kalton (1954) demonstrated that space-planted plots of smooth bromegrass provide a good indication of their productivity in swards, and Ugherughe *et al.* (1980) showed that space-planted plots can be used to accurately access the differences among smooth bromegrass genotypes for IVDMD and are reflective of IVDMD values obtained in swards. Forage yield and IVDMD are both heritable traits in smooth bromegrass and research on their inheritance was recently summarized by Walton (1980).

This study evaluated 49 smooth bromegrass introductions for forage yield and quality as measured by IVDMD and percent protein. Also evaluated in a separate study and reported here were eight meadow bromegrass (*Bromus biebersteinii* Roem. and Schult.) introductions. Only one cultivar of meadow bromegrass, 'Regar', has been released and it is grown on a limited scale. Meadow bromegrass is similar to smooth bromegrass in adaptation and appearance except its leaves are dominately basal and mildly pubescent (Foster *et al.,* 1966).

MATERIALS AND METHODS

The seed lots of the introductions used in these studies were obtained from the USDA Regional Plant Introduction Station at Ames, Iowa (Skrdla *et al.,* 1976). Lincoln smooth bromegrass was used as a check in both the smooth bromegrass and the meadow bromegrass experiments. Seeds of the introductions and Lincoln were started in a greenhouse in February 1976 and transplanted into a nursery at the Mead Field Laboratory, Mead, Nebr., on 2, 3 June 1976. The smooth bromegrass and meadow bromegrass introductions were in separate areas of same nursery.

The experimental design for both experiments was a randomized complete block with two replicates. Plots were single rows of 20 plants with plants and rows spaced 1.1 m apart. In the smooth bromegrass experiment, the check cultivar Lincoln was located on the borders and in every eleventh row. Four of the smooth bromegrass introductions, PI 251681, 251682, 255870, and 255871, were unreplicated because of poor germination in the greenhouse. In the meadow bromegrass experiment, Lincoln was included once in every replicate and was used as border plants. The nursery site was a Sharpsburg silty clay loam (Typic Argiudoll).

Herbicides, hand weeding and cultivation were used for weed control and both experiments were essentially weed-free throughout the study period. The herbicides used were DCPA (dimethyl tetrachloroterephthalate) and 2,4-D[2,4-D-dichlorophenoxy) acetic acid]. Dates and rates for fertilizer applications were as follows: 1 September 1976, 112 kg/ha N; 28 September

1976, 17 kg/ha P; 1 April 1977, 123 kg/ha N and 13 kg/ha P; 24 August 1977, 56 kg/ha N; 26 April 1978, 70 kg/ha N. The nursery was mowed in the early spring of each year to remove aftermath from the previous year. The nursery was also roto-tilled with a heavy duty rototiller the spring of 1977 and 1978 to cut all plants back to a uniform size of 0.5 x 0.5 m or $0.25m^2$. Individual plants were essentially microplots.

Data were not collected during the year of establishment but it was observed that many of the accessions flowered in the establishment year. In 1977, heading date was scored on most individual plants in replicate 1 of the smooth bromegrass experiment and in 1978 on all plots in both experiments on a plot basis. Heading date was the day when two or more panicles per plant were emerging from the boot. The plants were scored for heading date on 12 and 24 May 1977 and on 26 May 1978. Introductions were scored as being earlier or later in maturity than Lincoln, which headed on 12 May 1977 and on 25 May 1978.

In 1977, panicle and canopy height were measured on each plant in both experiments just before harvest. Panicle and canopy height was the distance from the soil surface to an imaginary plane perpendicular to the top of the panicle or canopy, respectively. Plants were also scored for seed production based on panicle size and number, using a 1 to 5 scale with 1 = excellent and 5 = very poor. Lincoln was used as the standard for comparison and was rated 3 for seed production. In 1978, panicle and canopy height and the seed production rating were determined on a plot basis.

In 1977, forage yields of every plant in both studies were harvested on 6, 7, and 8 July with a flail type plot harvester. The cutting height for this and all other cuttings was 10 cm. Two plants per plot were sampled for dry matter percentage and the mean dry matter percentage of these two plants was used to calculate the dry weight yield for that plot.

In 1978, the first replicate on the smooth bromegrass experiment was harvested on 27 June and the second replicate on 5 July as was the meadow bromegrass experiment. The delay in harvesting was due to mechanical problems with the harvester. In 1978, forage was harvested on a plot basis. The total yield of a plot was divided by the number of surviving plants in a plot to obtain the mean yield per plant. Most plots had 100% survival. For the first cut in 1978, forage from each plot was subsampled using 4 to 6 grab samples per plot. The grab samples from a plot were bulked to form a plot sample that was used to determine dry matter percentage by oven drying, IVDMD, and crude protein content.

In both 1977 and 1978, the foliage of all plants for the first cut was still green at harvest and the seed was approaching maturity. In 1978, regrowth (cut 2) was harvested on 24 and 26 October using the same procedures as for the first cut. However, for the second cut only 12 plots were sampled for dry matter content in the smooth bromegrass experiment and the mean dry matter content of these plots was used to calculate dry weight yields. In the meadow bromegrass experiment, five of the higher yielding introductions and the Lincoln check were sampled for dry matter content and the samples were also used to determine IVDMD and crude protein content. The Tilley and Terry procedure (1963) was used to determine IVDMD and the Kjeldahl procedure (A.O.A.C., 1960) was used to determine crude protein content.

Data for both the smooth and meadow bromegrass experiments were analyzed on plot mean basis, i.e., mean value/plant for a plot. This was done to eliminate the effects of missing plants within a plot. The mean of all Lincoln plots within a replicate was used as the value of Lincoln for that replicate in the statistical analyses. The unreplicated introductions were included in the analyses for a single year and the data were analyzed as an unbalanced design. The traits for which two years' data were available; namely, cut 1 forage yield, dry matter %, panicle height, canopy height, and seed production rating, were analyzed over years as a split-plot in time. Unreplicated introductions were excluded from the analyses over years. All statistical analyses were conducted using Statistical Analyses System software (Helwig and Council, 1979).

RESULTS AND DISCUSSION

Smooth Bromegrass

In the analyses over years, there were significant differences among the smooth bromegrass introductions for all traits for which two years data were available (Table 1). There were also significant differences among the introductions for all the traits evaluated in each individual year of the study (Table 2). Year x strain (introduction) interaction effects were not significant for cut 1 forage yield, dry matter %, and canopy height, indicating that the introductions performed consistently for these traits in the two years of the study. Year x strain interaction effects were significant for panicle height and seed production rating. The 1978 data for panicle and canopy height and seed production rating are not as accurate as the 1977 data for these traits since they were determined on a plot basis instead of on an individual plant basis. The difference in accuracy between the 1977 and 1978 data may have contributed to the magnitude of the year x strain interaction effect for these traits. Only the 1977 panicle and canopy height and seed production ratings are presented (Table 2).

The check cultivar Lincoln is one of the most widely grown bromegrass cultivars in the United States, yet several of the accessions yielded as high or higher than Lincoln in both 1977 and 1978 (Table 2). None of the introductions were significantly higher in forage yield than Lincoln, however. In-

Table 1. Analyses of variance over years for cut 1 forage yield, dry matter %, panicle and canopy height, and seed production rating for the *B. inermis* introductions evaluated at Mead, Nebr., in 1977 and 1978.

Source	Degrees of freedom	Mean squares				
		Yield	Dry matter	Height: Panicle	Height: Canopy	Seed production[a/]
		g/plant	%	cm	cm	
Replicates (R)	1	5,603	0.9	39	152	0.09
Strains (S)	44	6,696**	24.8**	392**	171**	0.37**
S X R	44	1,966	7.7	36	36	0.14
Year (Y)	1	119,844	1,101.0	8,940	13,909	1.15
Y X S	44	3,134	10.6	78**	23	0.26**
Y X R	1	37,684	63.4	12	196	0.55
Error	44	2,173	11.2	35	30	0.10

** indicates significant at the 0.01 level of probability for strains and strain x year interaction effects.

a/ Rating scale: 1 = excellent, 5 = very poor.

dividual plants were harvested for the first cut in 1977 to get an estimate of the within accession variability for forage yield. There was considerable variation for forage yield within accessions as indicated by the 1977 cut 1 range values. Standard deviation also provide an estimate of variation. The overall individual plant standard deviation for first cut forage yield per plant for the smooth bromegrass experiment was s = 117 g. The standard deviation for the Lincoln bromegrass check plants was s = 102 g, while the standard deviation range for the introductions was s = 72 to 139 g. These results indicate that there is considerable variation both between and within accessions for forage yield. Narrow-sense heritability estimates for total annual yield for smooth bromegrass of H = 0.25 to 0.37 have been reported (Walton, 1980). With these heritabilities and with the variation that exists among and within these bromegrass accessions it should be possible to improve the yield potential of smooth bromegrass by using the better plants of the higher-yielding accessions in a breeding program.

There was considerable variation among accessions for panicle and canopy height (Table 2). Lincoln was one of the tallest cultivars in the nursery for both traits. In addition to differences among introductions for panicle and canopy height there were also large differences for the height of the panicle above the canopy, i.e., panicle height minus canopy height. For Lincoln the height of the panicle above the canopy was 45 cm while for some of

Table 2. Means and other statistics for the traits measured or scored for the *B. inermis* introductions evaluated at Mead, Nebr., in 1977 and 1978.

		1977-1978	1977						1978						
		Yield (dry matter)				Height		Seed				Dry			
					Dry	Pan-	Can-	pro-	Yield (dry weight)			matter[d]	IVDMD[d]	Protein[d]	Matu-
Accession	Origin	Mean	Mean	Range	matter	icle	opy	duction[c/]	Total	Cut 1	Cut 2	Cut 1	Cut 1	Cut 1	rity[e/]
---PI---		g/plant	g/plant	g/plant	%	cm	cm		g/plant	g/plant	g/plant	%	%	%	
172393	Turkey	334	302	54-538	43	82	45	3.4	683	366	317	36	51.6	13.4	L
173645	” ”	372	435	101-900	45	93	52	3.2	627	315	312	36	51.8	14.2	L
173647	” ”	351	340	124-529	45	89	49	3.6	620	361	260	33	48.2	12.9	L
173648	” ”	342	327	84-569	42	89	49	3.4	633	357	276	36	50.8	13.7	L
178843	” ”	319	324	66-726	44	84	48	3.3	605	313	292	36	43.4	13.7	S-L
204432[a/]	” ”	355	381	104-644	46	84	46	3.2	506	329	177	36	45.1	12.8	L
205264[b/]	” ”	---	---	---	--	---	--	---	--	---	---	--	----	----	-
251681[b/]	USSR	344	362	215-564	41	67	44	3.7	579	327	252	32	44.0	14.6	S
251682[b/]	” ”	276	283	124-437	38	65	41	3.6	519	270	249	29	48.0	15.9	S
255870[b/]	Poland	261	209	111-361	37	62	43	3.6	509	314	195	33	47.7	14.0	S-L
255871[b/]	” ”	301	293	70-470	40	64	41	3.8	545	310	235	33	46.5	13.6	S
267054	” ”	331	341	132-528	44	65	43	3.6	590	321	269	34	46.8	15.0	S-L
311020	Romania	341	328	130-580	40	86	48	3.1	657	353	304	36	44.6	14.2	S-L
311022	” ”	366	388	96-540	48	94	49	3.3	690	344	346	36	45.0	12.5	S-L
314071	USSR	317	296	113-512	41	92	53	3.1	660	338	322	39	49.9	13.8	S-L
315374	” ”	425	447	161-713	46	95	58	3.1	763	403	360	39	48.0	12.6	S-L
315375	” ”	387	361	64-677	43	90	51	3.1	701	399	302	36	47.3	13.4	S
315376	” ”	401	397	94-623	47	94	56	3.3	723	406	317	38	45.6	12.8	S-L
315377	” ”	448	433	64-688	43	94	52	3.1	864	462	402	39	45.8	11.4	S-L
315378	” ”	398	332	29-585	39	102	61	3.2	906	464	442	35	48.0	13.6	L

Table 2. Means and other statistics for the traits measured or scored for the *B. inermis* introductions evaluated at Mead, Nebr., in 1977 and 1978 (continued).

Accession	Origin	1977-1978 Yield (dry matter) Mean	1977 Yield (dry matter) Mean	1977 Yield (dry matter) Range	1977 Dry matter	1977 Height Pan-icle	1977 Height Can-opy	1977 Seed pro-duction[c/]	1978 Yield (dry weight) Total	1978 Yield (dry weight) Cut 1	1978 Yield (dry weight) Cut 2	1978 Dry matter[d] Cut 1	1978 IVDMD[d] Cut 1	1978 Protein[d] Cut 1	1978 Matu-rity[e/]
---PI---		g/plant	g/plant	g/plant	%	cm	cm		g/plant	g/plant	g/plant	%	%	%	
315379	” ”	396	378	194-591	43	88	51	3.2	778	414	364	36	46.2	14.0	S
315381	” ”	379	347	104-618	38	99	55	3.1	798	412	386	36	46.0	13.8	S-L
315382	” ”	370	326	121-484	44	94	56	3.3	761	413	348	38	46.7	13.0	S-L
315383	” ”	364	295	82-461	41	98	58	3.2	766	398	368	36	45.8	12.7	S
315384	” ”	364	307	118-538	43	100	59	3.2	824	421	403	38	47.6	13.5	S-L
315385	” ”	301	282	56-439	45	71	35	3.4	496	320	176	37	45.4	13.6	L
315398	” ”	383	296	99-462	33	98	55	3.4	845	470	375	38	48.6	12.2	S-L
316172	Australia	339	310	144-459	36	70	44	3.6	644	368	276	35	45.1	13.2	S-L
324305	USSR	344	291	92-492	41	86	50	3.4	702	397	305	36	44.5	12.7	S-L
325227	” ”	408	396	209-671	44	99	52	3.1	768	419	349	40	45.6	12.8	S-L
325230	” ”	417	380	132-792	48	102	65	3.1	816	454	363	48	46.6	13.0	S-L
325237	” ”	402	352	104-678	46	102	61	3.1	813	454	359	38	48.6	12.8	S-L
326258	” ”	351	310	68-536	39	73	48	3.3	693	391	302	34	42.4	12.6	S-L
326259	” ”	382	347	50-520	40	66	42	3.5	667	417	250	35	42.0	13.1	S
326260	” ”	307	225	51-425	34	64	43	3.8	641	348	293	33	43.3	15.4	S
326262	” ”	291	222	57-475	38	48	35	4.1	543	361	182	33	44.8	16.9	S-L
326263	” ”	306	257	46-500	37	62	43	3.9	572	354	218	33	43.7	14.6	S
326264	” ”	388	322	117-614	39	74	45	3.5	668	420	248	34	40.8	13.6	E-S
326265	” ”	364	324	56-546	37	69	45	3.3	694	404	290	32	42.6	13.4	S
340068	Turkey	399	308	45-641	45	93	53	3.2	786	440	346	38	44.3	13.8	S

Table 2. Means and other statistics for the traits measured or scored for the *B. inermis* introductions evaluated at Mead, Nebr., in 1977 and 1978.

Accession	Origin	1977-1978 Yield (dry matter) Mean	1977 Yield (dry matter) Mean	1977 Yield (dry matter) Range	1977 Dry matter	1977 Height Panicle	1977 Height Canopy	1977 Seed production[c/]	1978 Yield (dry weight) Total	1978 Yield (dry weight) Cut 1	1978 Yield (dry weight) Cut 2	1978 Dry matter[d] Cut 1	1978 IVDMD[d] Cut 1	1978 Protein[d] Cut 1	Maturity[e/]
---PI---		g/plant	g/plant	g/plant	%	cm	cm		g/plant	g/plant	g/plant	%	%	%	
340069	” ”	407	368	118-570	43	92	53	3.0	776	447	328	39	45.3	13.7	S
340070	” ”	448	416	196-667	46	93	50	3.7	869	480	389	36	45.6	13.6	S-L
345594	USSR	361	320	104-570	38	80	46	3.2	695	402	293	38	44.6	13.8	E-L
345595	” ”	393	340	117-643	39	68	42	3.4	760	446	314	36	42.7	13.4	E-S
345596	” ”	408	361	78-624	39	92	58	3.2	876	455	421	36	46.0	12.8	S-L
345597	” ”	402	386	184-542	35	76	48	3.2	717	418	299	34	41.8	13.2	S
345598	” ”	413	397	185-663	39	74	50	3.4	715	428	288	33	42.2	14.8	S
369211	” ”	287	260	27-540	36	70	42	4.0	570	314	256	33	44.2	14.8	S-L
369212	” ”	377	342	178-588	42	73	48	3.6	746	411	335	35	45.4	13.0	S
Lincoln		438	438	88-726	44	104	59	3.0	862	438	424	38	44.7	12.5	S
Statistics:															
Nursery mean		371	341	75-2000	42	84	50	3.4	705	393	312	36	45.7	13.5	
F ratio for strains		3.4**	2.4**		1.7*	29.3**	7.5**	8.4**	4.1**	2.6**	3.3**	2.3**	2.3**	4.1**	
L.S.D. .05		62	93		8	7	7	0.3	145	90	99	4	4.6	1.3	
C.V. %		13.0	13.4		9.5	4.2	6.7	3.9	10.1	11.4	15.7	5.4	5.0	4.8	

*, ** indicates significance at the 0.05 and 0.01 levels of probability, respectively.

a/ PI206264 did not survive winter of 1976.

b/ Unreplicated accessions.

c/ Rating scale: 1 = excellent, 5 = very poor.

d/ For the 12 plots sampled for cut 2 in 1978, mean dry matter % = 39.5%, mean IVDMD = 51.8%, and mean protein % = 15.6%.

e/ E = earlier than, S = same as, and L = later than Lincoln, respectively.

the shorter introductions such as PI 326260 it was less than 25 cm. Accessions such as PI 326260 consequently had a "bushy" appearance in comparison to Lincoln. There was not apparent relationship between the bushy characteristic and forage quality as measured by IVDMD.

Many of the accessions were similar to Lincoln in seed production scores but several had significantly poorer scores. Most of the high yielding introductions had seed production scores that were not significantly different from the Lincoln score.

There were significant differences among accessions for first cut IVDMD in 1978 (Table 2). IVDMD values were obtained only for the first cut. Ugherughe *et al.* (1980) suggested that selection for improved IVDMD in smooth bromegrass should be restricted to the first cut since this harvest produces the highest yields and there are the largest differences among genotypes for IVDMD at this cut. As a bromegrass plant matures, the IVDMD- and protein percentage of the forage decreases.

Most introductions in the nursery headed within a two-week period in both years. Due to differences in maturity, the later maturing introductions would be expected to have higher IVDMD and protein percentages than the earlier maturing accessions. This in general occurred, particularly for IVDMD. However, there was considerable variation within maturity classes

Table 3. Analyses of variance over years for cut 1 forage yield, dry matter %, panicle and canopy height, and seed production rating for the *B. biebersteinii* introductions evaluated at Mead, Nebr., in 1977 and 1978.

Source	Degrees of freedom	Mean squares				
		Yield	Dry matter	Height: Panicle	Height: Canopy	Seed production[a/]
		g/plant	%	cm	cm	
Replicates (R)	1	344	10.2	30	35	0.04
Strains (S)	7	25,400**	9.8	255**	389**	0.74**
S X R	7	806	5.4	18	14	0.04
Year (Y)	1	21,673	0.9	1,783	797	0.02
Y X S[b/]	7	1,384	10.9	42	34	0.03
Y X R	1	337	1.5	2	8	0.04
Error	7	656	5.1	28	11	0.17

** indicates significant at the 0.01 level of probability for strains and strain x year interaction effects.

a/ Rating scale: 1 = excellent, 5 = very poor.

b/ Degrees of freedom for yield and dry matter % was 6.

for these traits indicating that much of the differences in IVDMD and protein could not be attributed solely to maturity. Some of the introductions such as PI 315374, 315378, 315398 and 325237 had yields similar to that of Lincoln but have IVDMD values that are three percentage points higher in IVDMD than Lincoln. These differences are not significant at the 0.05 level of probability but are significant at the 0.10 level (L.S.D. 0.1 = 3.0). In 1978, cut 1 yield was positively correlated with yield for cut 2 ($r = 0.25$) but was negatively correlated with IVDMD ($r = -0.43$) and protein percentage ($r = -0.27$). This negative correlation between yield and IVDMD should make the high yield and high IVDMD accessions identified here extremely valuable to grass breeders.

Although I evaluated only a portion of the available bromegrass introductions, several superior accessions were identified that could be used in breeding programs for improved forage yield and quality. The continued exclusive reliance on old cultivars and old fields as germplasm sources for breeding work in smooth bromegrass appears to be unwarranted. Some of the shorter introductions may be useful in developing cultivars for conservation uses such as roadsides where excessive forage production is not a desirable attribute since it necessitates additional mowings.

Meadow Bromegrass

In the analyses over years, there were significant differences among the meadow bromegrass introductions for all traits for which two years' data were available except for dry matter % (Table 3). Year x strain interaction effects were not significant for any of the traits (Table 3). In the individual year analyses, there were significant differences among introductions for all traits except for dry matter % in 1977, dry matter % and IVDMD for both cuts in 1978, and for protein content for cut 1 in 1978 (Table 4).

The smooth bromegrass check cultivar Lincoln produced almost twice as much forage as the meadow bromegrass introductions and had a higher seed production rating than any of the meadow bromegrasses (Table 4). The meadow bromegrasses had cut 1 IVDMD values equal to or greater than Lincoln even though they were earlier in maturity. These differences in IVDMD, however, were not stastistically significant. The meadow bromegrass introductions do not appear to be well adapted to eastern Nebraska and areas with similar climates since the poorest smooth bromegrass introductions were equal to or better than the meadow bromegrass accessions in yield. Improving the present superior productivity of smooth bromegrass in this area by breeding would be more profitable than trying to improve meadow bromegrass.

Table 4. Means and other statistics for the traits measured or scored for the *B. biebersteinii* introductions evaluated at Mead, Nebr., in 1977 and 1978.

Accession	Origin	1977-1978 Yield (dry weight) Mean	1977 Yield (dry weight) Mean	1977 Yield (dry weight) Range	1977 Dry Matter	1977 Height Panicle	1977 Height Canopy	1977 Seed production[c/]	1978 Yield (dry weight) Total	1978 Yield (dry weight) Cut 1	1978 Yield (dry weight) Cut 2[d/]	1978 Dry matter Cut 1	1978 Dry matter Cut 2	1978 IVDMD Cut 1	1978 IVDMD Cut 2	1978 Protein Cut 1	1978 Protein Cut 2	Maturity[e/]
---PI---		-----------g/plant-----------			%	-------cm-------			--------g/plant--------			----------------------- % -----------------------						
172389	Turkey	157	133	29-322	39	74	44	4.0	397	182	215	42	42	53.1	57.8	12.5	15.5	E
172390[a/]	" "	227	230	63-357	42	84	46	4.0	473	224	248	42	43	50.0	55.2	11.8	14.0	E
172392	" "	215	178	32-400	42	78	38	4.0	488	252	236	44	--	48.1	----	11.2	----	E
172394	" "	187	144	21-273	42	76	33	4.0	458	229	229	44	42	48.8	49.3	11.1	16.3	E-S
325226	USSR	163	---	---	--	75	23	4.5	333	163	170	44	--	47.3	----	11.0	----	E
341222	Canada	300	216	72-430	41	76	32	4.0	664	341	322	43	38	48.9	51.5	11.8	15.4	E-S
341223	" "	281	240	117-380	39	79	38	4.0	671	322	349	38	38	51.5	56.6	13.0	15.3	S
314419[b/]	USSR	---	---	---	--	--	--	---	---	---	---	--	--	----	----	----	----	
Lincoln		404	392	207-713	46	103	58	3.0	881	414	466	39	37	47.7	54.9	13.0	15.3	S
Statistics:																		
Nursery mean		245	220		42	81	40	4.0	546	266	280	42	40	49.4	54.4	12.0	15.3	
F ratio for strains		32**	26**		1	15**	29**	6**	61**	17**	29**	3	2	1	1	4*	7*	
L.S.D.$_{.50}$		47	56		--	8	6	0.6	77	69	59	4	--	--	--	1.4	1.0	
Coefficient of variation		12.9	10.9		6.9	4.4	6.9	6.2	6.0	11.0	8.9	4.1	9.5	5.1	11.1	5.0	2.6	

*, ** indicates significance at the 0.05 and 0.01 levels of probability, respectively.

a/ Regar was selected from PI 172390.

b/ PI 314419 did not survive the establishment year.

c/ Rating scale: 1 = excellent, 5 = very poor.

d/ Dry matter % of 39.5% used to calculate dry weight yield for cut 2 in 1978.

[redacted]

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