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Variation in Agronomic and Morphological Traits among Russian Wildrye Accessions

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ABSTRACT

Russian wildrye [*Psathyrostachys juncea* (Fischer) Nevski] accessions in the U.S. National Plant Germplasm System have not been adequately characterized for agronomic and morphological traits. Such characterization would be helpful in development of improved cultivars. Objectives of this study were to (i) measure consistency of dry-matter and seed yields as well as plant height and vigor of 65 Russian wildrye accessions and four cultivars at three diverse test sites, (ii) characterize phenotypic diversity among these accessions using cluster analysis, and (iii) define needs for future evaluation and collection of Russian wildrye germplasm. Field tests were conducted at Logan, UT; Mandan, ND; and Swift Current, Saskatchewan, Canada. Dry-matter and seed yields were not consistent among accessions and cultivars at the three locations, and testing at each location was necessary to identify accessions that were best suited to a specific location. Variance component estimates were small and of little consequence for accession × year interaction effects. The 69 entries were grouped into 10 clusters based on multivariate analysis of 17 classification variables. Accessions in Cluster 3 averaged well above the overall test mean for dry-matter yield, seed yield, and plant vigor and have high utility in plant breeding programs in North America. Only four accessions had high levels of resistance to *Septoria spraguei* Uecker & J.M. Krupinsky, an important foliar disease. Accessions from a defined geographic area tended to cluster, but some accessions from a particular area were spread among several clusters. This emphasizes the value of sampling diverse collection sites within a defined geographic area.

RUSSIAN WILDRYE is a drought-resistant, cool-season, perennial bunchgrass that was introduced through official channels to the USA from central Asia in 1927 (Rogler and Schaaf, 1963). Reports of Russian wildrye at the Dickinson, ND, Research and Extension Center date back to 1913, when a plant specimen sent from the Center to the National Herbarium of the Smithsonian Institution was identified as *Elymus junceus* Fischer (Syn: *Psathyrostachys juncea*). Russian wildrye is adapted to the Northern Great Plains and portions of the Intermountain West in the USA and to the Prairie Provinces of Canada. It is tolerant to grazing stress and is used to complement native grasslands in these regions of North America. The species produces an abundance of basal leaves that maintain relatively high levels of digestibility and protein with advancing maturity (Knipfel and Heinrichs, 1978). Thus, seeded pastures of Russian wildrye are often stockpiled for fall and early-winter grazing when nutritive value of most forages is relatively low (Smoliak and Johnston, 1980).

Current Russian wildrye cultivars such as Swift (Lawrence, 1979), Bozoisky-Select (Asay et al., 1985), and Mankota (Berdahl et al., 1992) have a narrow genetic base. No studies have been made of genotype × environment interaction involving a diverse array of accessions at widely separated geographic sites within the regions of adaptation for Russian wildrye in North America. Identification of germplasm with broad adaptation would be helpful in development of improved cultivars. Also, genetic diversity among Russian wildrye accessions in the U.S. National Plant Germplasm System for important agronomic and morphological traits is not known. Characterization of accessions for important traits will facilitate efficient synthesis of breeding populations that are designed to accomplish specific objectives. Knowledge of the extent of variability for plant traits and association of specific traits with geographic origin will help to define needs and locations for future collection of Russian wildrye germplasm.

Objectives of this study were to (i) measure consistency of dry-matter and seed yields as well as plant height and vigor of 65 Russian wildrye accessions at three diverse test sites, (ii) characterize diversity among these accessions for agronomic and morphological traits using cluster analysis, and (iii) define needs for future evaluation and collection of Russian wildrye germplasm.

MATERIALS AND METHODS

The Russian wildrye germplasm that was evaluated consisted of 62 diploid ($2n = 2x = 14$) and three tetraploid ($2n = 4x = 28$) plant introductions; a 21-clone synthetic (Syn-A) developed at Logan, UT; and the cultivars Bozoisky-Select (Asay et al., 1985), Mankota (Berdahl et al., 1992), and Vinall (Hein, 1960) (Table 1). Passport data were obtained from the Germplasm Resources Information Network (GRIN) System. Approximately 80 additional Russian wildrye introductions have been added to the U.S. National Plant Germplasm System after this study was initiated. Seed of introductions included in this study was provided by the USDA Western Regional Plant Introduction Station, Pullman, WA, and breeder's seed that was obtained from the location of origin was used for the cultivars and synthetic strain. Test locations were Logan, UT (41°46′ N latitude, 107°50′ W longitude), Mandan, ND (46°48′ N latitude, 100°46′ W longitude), and Swift Current, SK, Canada (50°17′ N latitude, 107°50′ W longitude), which provided three diverse environments within the regions of adaptation for Russian wildrye in North America. Field tests were established in 1990. Soil type was a fine, mixed,

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Abbreviations: GRIN, Germplasm Resources Information Network; PI, Plant Introduction.

mesic, semiactive Aquic Argiustolls (silty, clay loam) at Logan; a fine-silty, mixed Pachic Haploborolls (silty loam) at Mandan; and a fine, mixed, mesic, Aridic Haploborolls (sandy loam) at Swift Current. Plots of each entry consisted of a single row of eight plants that were space-transplanted on 1.0-m centers in a randomized complete block design with four replicates.

Data Collection

Dry matter yield (2 plants $plot^{-1}$), seed yield (3 plants $plot^{-1}$), plant height (3 plants $plot^{-1}$), and vigor score (8 plants $plot^{-1}$) were measured in 1991 and 1992 at Mandan and Swift Current and in 1992 and 1993 at Logan. Yields and heights were measured on the same plants each year. Dry-matter yields were measured by clipping plants at a 10-cm stubble height approximately 2 wk after anthesis. Seed (caryopsis and attached lemma and palea) was harvested at the stiff-dough stage of development. Seeds were threshed with a mechanical belt thresher using a minimum amount of air flow to clean chaff from the sample but retain nearly all developed seeds. Plant height was measured from ground level to the mid-point of the spike for a group of about 6 culms $plant^{-1}$ and averaged over 3 plants. Vigor was rated visually on a scale from 1 to 9, where 9 = most vigorous when plants were at the 5-leaf to early-boot stage of development. Data were collected at Mandan for 2 yr on five additional traits: (i) heading date recorded on 5 plants $plot^{-1}$ when approximately 50% of the spikes had emerged halfway from the boot, (ii) first anthesis date on 5 plants $plot^{-1}$, (iii) spike length (cm) averaged over 5 spikes from each of 5 plants $plot^{-1}$, (iv) seed mass (g 1000^{-1} seeds) measured on a random sample of 300 seeds from 3 plants $plot^{-1}$, and (v) reaction to leaf-spot disease caused by *Septoria spraguei* Uecker & J. M. Krupinsky (Uecker and Krupinsky, 1982) measured visually as an average score (1–9, where 9 = most resistant) recorded in 1994 and 1995 over 8 plants $plot^{-1}$ approximately 3 wk after anthesis. At Swift Current, seed yield per spike was averaged over 2 plants $plot^{-1}$. Other traits such as heads per plant (Swift Current), peduncle length (Mandan), leaf abundance (Mandan), and leaf color (Logan, Mandan, and Swift Current) were measured but did not have significant variation ($P > 0.05$) among entries at individual locations and were not used to characterize the accessions in this study.

Data Analysis

Individual plot means were used in analyses of variance. Entries were randomized at each location in a randomized complete block design. An analysis of variance, a split-plot in time (years), was first conducted separately for each location. Years were considered to have fixed effects. A split-plot in space (locations) and time (years) was used for a combined analysis, with locations and years considered fixed and accessions random in the model. A SAS PROC MIXED analysis (Littell et al., 1996) was used, where differences among locations and years plus the location × year interaction were tested by appropriate *F*-ratios (SAS v. 6.12, SAS Institute, Inc., Cary, NC). The relative magnitude of individual variance components was used to compare the contribution of those sources of variation that had random effects (accession, accession × location, accession × year, and accession × location × year). Pearson and Spearman-rank correlation coefficients were calculated on 2-yr accession means among locations for dry matter and seed yields as well as plant height and vigor score to further compare performance across locations (Steel and Torrie, 1980).

The 69 accessions and cultivars were subjected to principal

Table 1. Origin and major attributes of 69 Russian wildrye accessions and cultivars evaluated at Logan, UT; Mandan, ND; and Swift Current, SK.

Accession/ Cultivar	Origin	Attribute(s)
PI 75737	Former USSR†	Early maturity
PI 206684	Turkey	
PI 222050	Afghanistan	*S. spraguei* resistance
PI 272136	Alma Ata, Kazakhstan	Dry-matter & seed yield
PI 314082	Rostov, Russia	Dry-matter & seed yield
PI 314521	Kuban, Russia	
PI 314668	Alma Ata, Kazakhstan	Late maturity
PI 314669	Alma Ata, Kazakhstan	*S. spraguei* resistance
PI 314670	Alma Ata, Kazakhstan	Low dry-matter & seed yield
PI 314671	Alma Ata, Kazakhstan	*S. spraguei* resistance
PI 314675	Alma Ata, Kazakhstan	Dry-matter & seed yield
PI 315080	Former USSR	Dry-matter & seed yield
PI 369234	Novosibirsk, Russia	Dry-matter & seed yield
PI 370672	Former USSR	Seed yield
PI 406468	Former USSR	'Bozoijskij', Dry-matter & seed yield
PI 406469	Former USSR	
PI 406470	Former USSR	
PI 406471	Former USSR	'Sortandinskij'
PI 429798	Alma Ata, Kazakhstan	
PI 429799	Alma Ata, Kazakhstan	Susceptible *S. spraguei*
PI 429800	Alma Ata, Kazakhstan	Susceptible *S. spraguei*
PI 429802	Alma Ata, Kazakhstan	Early maturity
PI 429803	Alma Ata, Kazakhstan	Early maturity
PI 429804	Alma Ata, Kazakhstan	Early maturity
PI 429805	Alma Ata, Kazakhstan	Early maturity
PI 429806	Alma Ata, Kazakhstan	Early maturity
PI 429807	Alma Ata, Kazakhstan	
PI 429808	Alma Ata, Kazakhstan	
PI 430863	Tselinograd, Kazakhstan	
PI 430864	Tselinograd, Kazakhstan	
PI 430865	Tselinograd, Kazakhstan	
PI 430866	Tselinograd, Kazakhstan	Early maturity
PI 430867	Tselinograd, Kazakhstan	
PI 430868	Tselinograd, Kazakhstan	Dry-matter yield
PI 430869	Tselinograd, Kazakhstan	
PI 430870	Tselinograd, Kazakhstan	
PI 430871	Tselinograd, Kazakhstan	Seed yield
PI 430872	Tselinograd, Kazakhstan	Seed yield
PI 430873	Tselinograd, Kazakhstan	
PI 430874	Tselinograd, Kazakhstan	Susceptible *S. spraguei*
PI 430875	Tselinograd, Kazakhstan	Seed mass
PI 430876	Tselinograd, Kazakhstan	Dry-matter & seed yield
PI 440624	Former USSR	Susceptible *S. spraguei*
PI 440625	Former USSR	Early maturity
PI 440626	Former USSR	Early maturity
PI 440627	Alma Ata, Kazakhstan	Dry-matter & seed yield
PI 476299	Bismarck, ND	Selected from 'Vinall'
PI 499558	Xinjiang, P.R. China	Late maturity
PI 499559	Xinjiang, P.R. China	Late maturity
PI 499672	Xinjiang, P.R. China	Late maturity
PI 499673	Xinjiang, P.R. China	Late maturity
PI 499674	Xinjiang, P.R. China	Late maturity
PI 499675	Xinjiang, P.R. China	Late maturity
PI 502571	Elista, Russia	Dry-matter & seed yield
PI 502572	Elista, Russia	Dry-matter yield
PI 502573	Elista, Russia	Seed yield
PI 502574	Kazakhstan	Dry-matter & seed yield *S. spraguei* resistance
PI 502575	Former USSR	Seed yield
PI 502576	Former USSR	'Nevski 1'
PI 502577	Former USSR	'Nevski 2'
PI 502578	Former USSR	'Nevski 3', Seed yield
PI 502579	Former USSR	
PI 549118	Logan, UT	'Bozoisky-Select'
PI 556988	Mandan, ND	Mankota
PI 565068	Kazakhstan	AJC 596 ($2n=4x=28$)
PI 565070	Kazakhstan	AJC 598 ($2n=4x=28$)
PI 565071	Kazakhstan	AJC 600 ($2n=4x=28$)
Vinall	Mandan, ND	
Syn-A	Logan, UT	

† Collection site within the former USSR is unknown when origin is designated "former USSR".

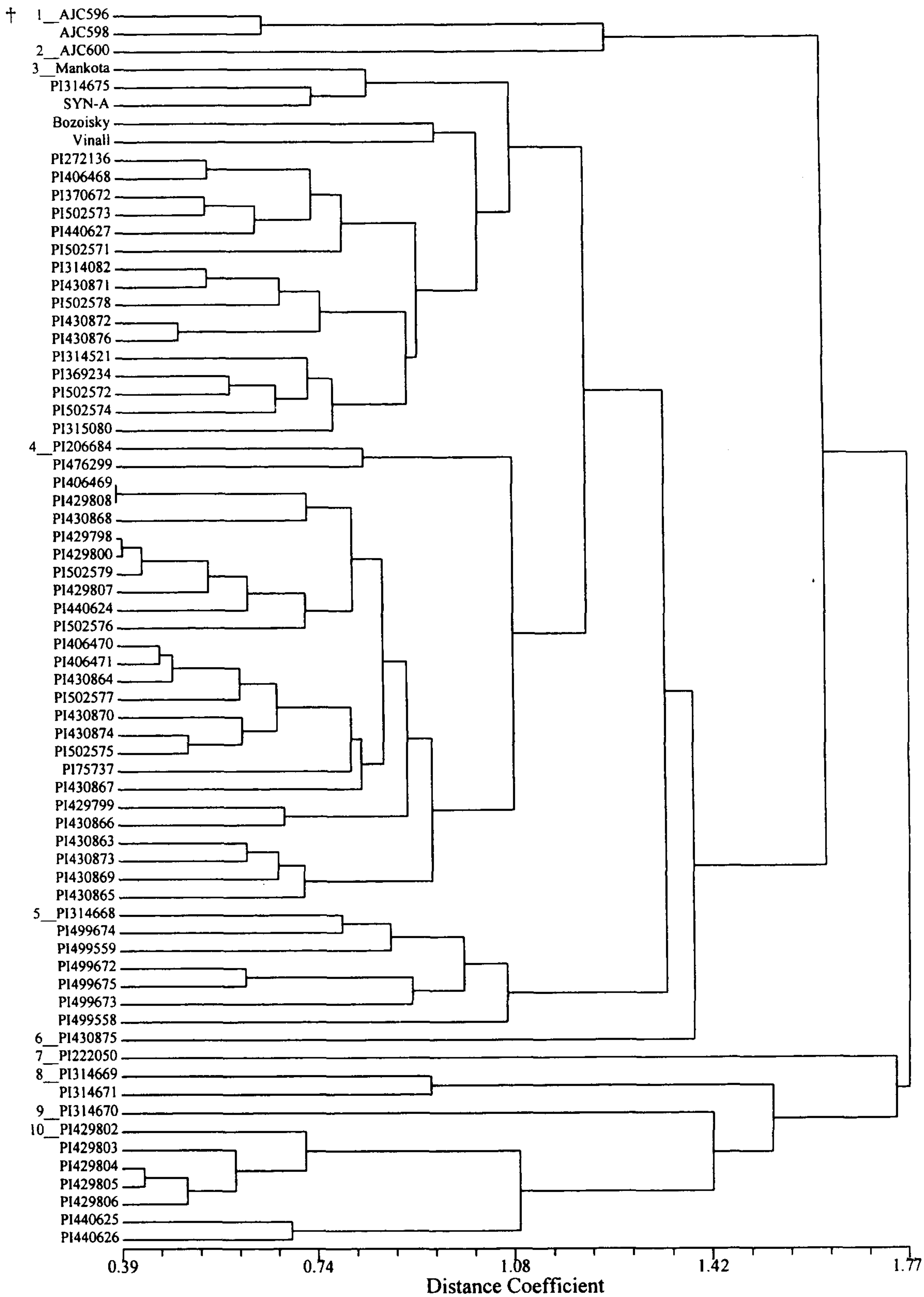

Fig. 1. Dendrogram of 69 Russian wildrye accessions and cultivars obtained by analysis of 17 agronomic and morphological characterization variables († Cluster number).

Table 2. Tests of significance for fixed effects (location, year, and location × year) and variance component estimates of random effects (accession, accession × location, accession × year, and accession × location × year) for dry-matter yield, seed yield, plant height, and vigor score of 69 Russian wildrye accessions and cultivars tested over three locations and two years.

Source of variation	Dry-matter yield	Seed yield	Plant height	Vigor score
	Fixed effects			
	g plant⁻¹	g plant⁻¹	cm	1 to 9
Location (Loc)	**	**	NS	**
Year	**	**	**	**
Loc × year	**	**	**	**
	Random effects			
Variance component				
Accession (Acc)	1827	45.9	36.6	0.28
Acc × Loc	683	34.0	0	0.18
Acc × Year	0†	6.5	0	0.04
Acc × Loc × Year	0	2.5	0	0

** Significant at $P \leq 0.01$; NS, Non significant.
† Variance component is negative or zero.

component and cluster analyses with NTSYS v. 2.01d software (Exeter Software, Setanket, NY) (Romesburg, 1990). First a standard one-way analysis of variance was conducted on all classification variables from each location. Seventeen classification variables had significant ($P \leq 0.05$) variation among accessions and were subsequently used in principal component and cluster analyses. Eigenvectors and eigenvalues from the first four principal component axes were calculated from a similarity correlation matrix. The 69 entries were clustered by a dissimilarity distance matrix and the UPGMA (unweighted pair group method using arithmetic averages) clustering procedure. Phenotypic means of each classification variable were standardized to an overall mean of zero and standard deviation of one in the original data matrix prior to cluster analysis. A distance coefficient of 1.15 was arbitrarily chosen to separate the accessions into 10 cluster groups in a dendrogram (Fig. 1).

RESULTS AND DISCUSSION

Analyses of Variance

Location, year, and location × year interaction effects were significant ($P \leq 0.01$) for dry-matter yield, seed yield, and vigor score (Table 2). Location effects were not significant ($P > 0.01$) for plant height, but year and location × year effects were significant ($P \leq 0.01$). These data indicate that a considerable amount of variation existed among locations and years. Variance component estimates for accessions were greater than estimates for any of the interactions that involved accessions with locations and years (Table 2). For dry-matter yield, the variance component for accession was approximately three times larger than the estimate for accession × location. This suggests that accessions would be ranked similarly for dry-matter yield at the three locations, but only five of the 69 entries were ranked in the top quartile at all three locations and only seven were ranked in the bottom quartile. Pearson and Spearman-rank correlation coefficients for dry-matter yield among the three locations, while significant ($P \leq 0.01$), were of only moderate magnitude, ranging from 0.48 to 0.63 (Table 3).

Accession × location interactions for seed yield and vigor score were sizable, as indicated by the relative magnitude of variance components for this interaction

Table 3. Pearson (above diagonal) and Spearman rank (below diagonal) correlation coefficients between locations for dry-matter yield, seed yield, plant height, and vigor score using 2-yr means from 69 Russian wildrye accessions and cultivars.

	Logan	Mandan	Swift Current
	Dry-matter yield		
Logan	–	0.63**	0.53**
Mandan	0.63**	–	0.49**
Swift Current	0.48**	0.52**	–
	Seed yield		
Logan	–	0.61**	0.51**
Mandan	0.64**	–	0.57**
Swift Current	0.52**	0.57**	–
	Plant height		
Logan	–	0.77**	0.68**
Mandan	0.71**	–	0.64**
Swift Current	0.67**	0.67**	–
	Vigor score		
Logan	–	0.52**	0.20
Mandan	0.54**	–	0.42**
Swift Current	0.19	0.32**	–

** Significant at $P \leq 0.01$.

compared with that for accessions (Table 2). For seed yield, only two of the 69 entries were ranked in the top quartile at all three locations and eight consistently were ranked in the bottom quartile. Accessions had similar ranking for plant height, regardless of location or year. Correlation coefficients among locations were highest for plant height and lowest for vigor score (Table 3). Thus, while accessions had some consistency in performance across locations, the data indicate that testing would be necessary at each location to adequately characterize accessions for dry-matter yield, seed yield, and vigor score and to identify accessions that express desirable traits across environments. Resources were not available to sample a larger number of plants within plots. A larger sample size may have reduced experimental error and accession × location interaction effects.

Principal Component and Cluster Analysis

Multivariate analysis has been used in several cross-fertilized forage species to group accessions and cultivars into clusters (Casler, 1995; Smith et al., 1995; Steiner et al., 1998). Principal component analysis is often used prior to cluster analysis to determine the relative importance of classification variables (Jackson, 1991). Eigenvalues from the first, second, third, and fourth principal component axes, respectively, accounted for 41, 16, 10, and 7% of the total variance present. The relative magnitude of eigenvectors from the first principal component axis (Table 4) indicates that dry-matter yield and plant vigor score at Logan and Mandan, seed yield and plant height at all locations, and spike yield at Swift Current were important traits for classifying accessions into clusters. From the second principal component axis, plant vigor score at Swift Current, seed yield at Swift Current, seed mass at Mandan, heading and anthesis date at Mandan, and *S. spraguei* score at Mandan were all important classification variables. Seed yield at Swift

Table 4. Eigenvectors from the first four principal component axes for traits used to classify 69 Russian wildrye accessions and cultivars into 10 clusters.

	Principal component axis			
Trait	1	2	3	4
Plant vigor score, Logan	2.20	0.32	0.14	0.27
Plant vigor score, Mandan	2.11	−0.50	0.42	−0.28
Plant vigor score, Swift Current	0.98	−1.01	−0.12	0.30
Plant height, Logan	2.10	0.54	0.10	0.41
Plant height, Mandan	2.12	0.42	0.50	−0.05
Plant height, Swift Current	1.96	0.11	0.18	0.16
Dry-matter yield, Logan	2.28	0.11	0.14	0.18
Dry-matter yield, Mandan	2.14	−0.23	0.39	−0.25
Seed yield, Logan	2.15	−0.18	−0.37	0.04
Seed yield, Mandan	2.02	−0.51	−0.27	−0.24
Seed yield, Swift Current	1.43	−0.93	−0.60	−0.14
Seed mass, Mandan	0.64	0.70	0.53	−0.71
Heading date, Mandan	1.10	1.09	−0.62	−0.22
Anthesis date, Mandan	0.44	1.04	−0.84	−0.28
Spike length, Mandan	0.94	0.48	0.13	0.15
S. spraguei score, Mandan	−0.69	−1.02	0.23	−0.39
Spike yield, Swift Current	1.63	−0.72	−0.58	−0.14

Current as well as heading and anthesis date at Mandan also had relatively high eigenvectors in the third principal component axis.

The entries in this study were grouped into 10 clusters (Fig. 1). Clusters 1 and 2 include the three tetraploid accessions in this study. The tetraploids all had high dry-matter yield, low seed yield, tall stature, high vigor score, and high seed mass compared with diploid accessions (Table 5). The two accessions in Cluster 1 have greater spike length and seed yield per spike than the tetraploid accession in Cluster 2. Cluster 3 includes the improved cultivars and the accessions from which they were derived, as well as other unimproved accessions. Cluster 3 averages 15% above the overall mean of all entries for dry-matter yield and 42% higher for seed yield. Cluster 3 also averages higher than the overall mean for plant height, vigor score, seed mass, heading and anthesis date, spike length, spike yield, and resistance to leaf spot caused by *S. spraguei*. The 17 unimproved accessions in Cluster 3 were collected over a wide geographic area, and all would provide valuable germplasm to North American breeding programs for development of improved cultivars. Cluster 4, the largest group, contains 26 accessions: 10 collected near Tselinograd, Kazakhstan; five near Alma Ata, Kazakhstan; one from Turkey; and 10 from unidentified collection sites within the former USSR. Means for traits in Cluster 4 are similar to the overall mean of all entries. Six of the seven accessions in Cluster 5 were collected in Xinjiang Province, P.R. China. The remaining accession, PI 314668, was collected about 180 km east of Alma Ata, Kazakhstan, which is in close proximity to the Chinese accessions. Accessions in Cluster 5 average 3.1 d later in heading date and 2 d later in anthesis date than the overall mean. The single accession in Cluster 6 was collected near Tselinograd, Kazakhstan. It has high seed mass and low seed yield per spike relative to the other diploid accessions. The accession in Cluster 7, PI 222050, was collected in Afghanistan. This accession has relatively low dry-matter yield, seed yield, and vigor score but relatively high resistance to leaf spot disease caused by *S. spraguei*. Cluster 8, consisting of two accessions collected approximately 180 km east of Alma Ata, Kazakhstan, has very low dry-matter yield and seed yield, but these two accessions have the highest level of resistance to *S. spraguei*. Cluster 9, a single accession from the same geographic area as Cluster 8,

Table 5. Means of traits used in classification of each of the 15 clusters.

	Cluster										
Trait	1	2	3	4	5	6	7	8	9	10	Overall mean
Plant vigor score (1–9)†											
Logan	6.9	7.1	6.3	5.5	5.7	4.5	5.0	4.6	4.5	4.6	5.8
Mandan	6.0	6.1	6.0	5.5	4.8	6.2	2.8	2.7	3.6	4.6	5.5
Swift Current	5.9	5.8	7.1	7.1	6.4	6.5	5.5	6.7	5.8	6.4	6.9
Plant height (cm)											
Logan	107	109	102	91	94	87	95	89	81	82	94.7
Mandan	111	110	104	97	95	98	96	85	90	91	98.8
Swift Current	99	96	99	92	92	97	102	82	75	89	93.4
Dry-matter yield (g plant^{-1})											
Logan	384	431	341	260	235	306	197	141	119	170	284.1
Mandan	211	204	196	165	123	222	58	69	119	103	165.2
Seed yield (g plant^{-1})											
Logan	20.0	24.3	41.3	24.2	26.1	21.8	22.8	9.4	6.2	9.3	28.3
Mandan	13.3	12.2	25.4	18.9	15.5	25.6	8.2	3.9	5.3	8.1	19.2
Swift Current	2.9	2.4	18.2	14.5	13.1	3.2	5.5	1.6	0.7	8.1	13.2
Seed mass (mg seed^{-1})											
Mandan	3.54	3.38	3.16	3.08	3.14	3.54	3.21	2.70	3.80	3.12	3.14
Heading date (DOY)‡											
Mandan	145.7	146.2	145.0	143.7	147.8	145.0	147.4	142.9	144.4	142.6	144.6
Anthesis date (DOY)‡											
Mandan	158.8	159.7	159.3	158.4	161.0	159.4	161.7	158.8	160.6	158.0	159.0
Spike length (cm)											
Mandan	11.9	10.4	11.5	11.3	11.1	11.8	12.2	11.4	11.3	10.8	11.4
***S. spraguei* score (1–9)§**											
Mandan	4.3	3.9	4.0	3.6	3.9	3.3	4.5	5.0	3.9	3.5	3.8
Spike yield (g spike^{-1})											
Swift Current	0.04	0.02	0.11	0.09	0.09	0.03	0.06	0.03	0.02	0.05	0.089

† Scored using 1 to 9 scale with 9 = most vigorous.
‡ DOY, Day of year.
§ Scored using 1 to 9 scale with 9 = most resistant.

also has low dry-matter yield and seed yield and only average resistance to *S. spraguei*. Five of the seven accessions in Cluster 10 were collected near Alma Ata, Kazakhstan. Accessions in Cluster 10 have low dry-matter yield and seed yield and early heading and anthesis date.

Results from this study have implications for future plant collection and breeding efforts with Russian wildrye. The 17 unimproved accessions in Cluster 3 averaged well above the overall mean in dry-matter yield, seed yield, and plant vigor (Table 5) and have high utility in breeding programs in North America. Collection sites for 12 of these 17 accessions are fairly well defined, and future collection efforts should target these geographic areas. Even though accessions from a defined geographic area tended to cluster, some accessions from a localized area (i.e., Alma Ata, Kazakhstan) were spread across several cluster groups. This suggests that distinct microenvironments may have existed within a localized collection area and that Russian wildrye populations with distinct traits colonized these microenvironments. This emphasizes the value of sampling diverse collection sites within a defined geographic area whenever possible and of describing the collection sites adequately. The 65 Russian wildrye accessions available from the National Plant Germplasm System when this study was initiated do not provide adequate genetic diversity to develop a core collection. A core collection of Russian wildrye that represents genetic diversity present in the species should be considered after additional germplasm is collected and characterized.

Only four accessions (PI 22050, PI 314669, PI 314671, and PI 502574) had disease resistance scores for *S. spraguei* that were at least two standard errors above the overall test mean. *Septoria spraguei* is the most prevalent foliar disease of Russian wildrye in the Northern Great Plains region of North America (Berdahl and Krupinsky, 1995), and symptoms become severe on susceptible plants in most years. Resistance to *S. spraguei* in current cultivars is not adequate, and new sources are needed. Levels of resistance to *S. septoria* need to be determined for recent Russian wildrye introductions from the general geographic area of Cluster 8. Additional collection should be targeted approximately 180 km east of Alma Ata, Kazakhstan, if disease resistance is not found in other accessions from this general area.

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