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RESEARCH ARTICLE

Biological features of the formation of *Festuca rubra* L. (Poaceae) seed productivity on the southeast of Kazakhstan

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Abstract

The article presents the results of seven sorts of *Festuca rubra* L. seed productivity of lawn significance, representing three subspecies and two local wild-growing forms. The onset of the main phenological phases in the first two years of plant life was analyzed, taking into account the weather conditions of the experience setting area, and a comparison between samples representing three subspecies was made. The correlation between the four signs of the reproductive sphere has been studied. The best indicators of seed productivity with high semination rate were noted in the varieties Phrida and Aida from the subspecies *commutata* and s. Echo from subspecies *rubra*. The significant relationship between the number and weight of seeds per panicle was revealed for all varieties. A strong variation of the relationship strength between potential and real seed productivity was noted. It has been established that mature fruiting plants of the first and second year are best able to realize their seed potential. Starting from the third year of seed production, the intensity of generative shoots formation in individual development and the yield of seeds from the registration area in row sowing sharply decreases.

Keywords

Festuca rubra, turf grasses, rate of semination, seed productivity, seed harvest, correlation relationship, southeast of Kazakhstan

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Introduction

Festuca rubra L. (seed Poaceae) is the most frequently used component in lawn mixtures. It makes up more than 50% of the composition of grass mixtures for parterre, ordinary and other lawns. A great number of sorts of this species, represented by three varieties of red fescue, are used all over the world. They are *F. rubra* ssp. *rubra*, ssp. *trichophylla* (= *F. rubra* ssp. *litoralis*) and ssp. *commutata*. This perennial boreal type grass is long-lived (lives up to 15–20 years), resistant to adverse climatic conditions typical for southeastern Kazakhstan, and to some environmental factors, such as salinization, dryness of air and soil, heavy soils and their compaction because of the exploitation of lawns. There are many published studies that examine the link between air temperature, snow cover and cold resistance. They provide the assessment of the impact of climatic factors on the growth and development of grass species and sorts (Tompkins et al. 2000; Gislum et al. 2010), and experiments with wild species of grasses (Mintenko et al. 2002).

In the United States, Canada, and Europe, they conduct active seed production to provide seeds of highly ornamental, productive and sustainable red fescue sorts for the growing lawn grass market. Many studies are devoted to the impact of agrotechnical measures, irrigation schedules and schedules of nitrogen fertilizers and bioregulators application on seed productivity and seed yields of lawn-forming species (Fairey 2006; Wiliam et al. 2007; Fairey 2008; Gislum and Boelt 2009; Johnston et al. 2010; Truhan 2014). A number of studies reflect the link between autumn floral induction, shooting and seed productivity of plants in the next growing season (Mal'tsev 1986; Havstad et al. 2004). In addition, interesting data on the relationship between the parameters of the components of seed productivity were previously obtained based on studying *Festuca arundinacea* Schreb. (Jafari et al. 2006; Afkar et al. 2007).

In Moscow Agricultural Academy named after K.L. Timiryazev and in the selection center of UralNIISkhoz, they carried out the analysis of variability of morphological features of vegetative and generative organs of different sorts of Poaceae family; sort- and species-specific correlations between morphological and anatomical features were established in order to determine a complex of approbation features for the identification of lawn grass sorts; an anatomical and morphological method (test) for the diagnosis of seed productivity during the selection of initial forms was developed (Khaseeva and Isachkin 2013; Khaseeva 2014; Stefanovich and Karpuhin 2014).

Fescue sorts are included almost in all grass mixtures used in Kazakhstan, but biological features of selected sorts and wild samples growing in our climate are not well studied, and there is almost no information on the impact of environmental and anthropogenic factors on these sorts. In addition, the use of promising sorts is restrained because there is no database of seeds. Research in this direction and organization of the reproduction of promising sorts in specialized farms of the Republic of Kazakhstan will help to solve these problems.

In this regard, the purpose of our research was to study the seed productivity of *F. rubra* grown with the use of different methods of growing as part of introduction tests of this valuable sod-forming grass in the southeast of Kazakhstan and to develop the scientific basis for the creation of seed stock which will contribute to the selection work.

Material and methods

Seven sorts of red fescue (*Festuca rubra* L.) were studied in field and laboratory experiments; they are: Boreal, Echo, Engina, belonging to the subspecies *rubra*; Aida, Phrida, Tatjana belonging to the subspecies *commutata*; Rufilla belonging to the subspecies *trichophylla* and two wild samples K-0026, K-0033 from the natural flora of our region – K-0026, K-0033.

The field experiment was carried out on the arid lowlands of Talgar district of Almaty region (43°45.04'N, 77°06.44'E, altitude 300 m) The climate there is characterized by high continentality and aridity. The average July temperature is 22–24 °C, the average January temperature is 6–10 °C. In spring, the temperature starts to be steadily above 0 °C at the end of the second – beginning of the third decade of March, in autumn the temperature starts to be steadily below 0 °C at the end of the first – beginning of the second decade of November. The sum of positive temperatures is 3450–3750°. The average duration of the freeze-free period is 140–170 days. Annual precipitation is 350–600 mm. 120–300 mm of precipitation fall during the warm period. The vegetation of the area is feather-fescue and feather-grass. The soil is composed of ordinary gray soil. The experiment involved two methods of plant growing: 1 – sowing in rows with plots of 1 m2, with 30 cm space between rows, 4 times repeatedly; 2 – 20 plants sown for free development with 25 cm space between rows. During the growing season, the area was irrigated 10 times and the soil between rows was hoed 4 times.

Phenological observations were conducted using the method of Beydeman (1960). Plants were sown in large rows; it provides the possibility of care and creates the best light conditions for plants (Vas'ko and Chekel' 2007). Plants were grown with the use of different methods of growing; the number of generative shoots and the mass of seeds from an individual plant was calculated 10 times (n=10). Samples were collected by the following parameters: length of the panicle, the number of flowers and seeds in the panicle and the seed mass per panicle (n=30).

Seed productivity was studied according to the method of Levina (1981). During a three-year life of grasses, the seminification coefficient was determined from 30 shoots of each sample. To assess the normality of distribution, the graphical method of appendix Statistica 12 was used. Pearson correlation coefficient was calculated according to Zaitsev (1984); the differences between the average values were assessed using the LS (Ryazanova 2013). The correlation between the four characters of the reproductive sphere was studied. The correlation was assessed according to the scale given in the methodology of Kazan State Medical University (Correlation analysis 2011). The correlation is considered strong – at r = ±0.7 up to ±1; moderate – at r = ±0.3 up to ±0.699; weak – at r up to ±0.299.

Results

F. rubra used in lawn grass mixtures contributes to the creation of a decorative coating, as it has highly intensive tillering, delicate thin shoots, intensively green color. It forms a large number of orthotropic and plagiotropic shoots, fills the gaps on the lawn, which appear because of the fallout of other components of the mixture and adverse environmental conditions. Three subspecies of red fescue have not only different features of tillering, the formation of vegetative and generative shoots, seed productivity, habitus, but also different appearance (Kvalbein and Aamlid 2015).

Seed productivity is considered to be one of the main characteristics when assessing the viability of plants during their introduction to agriculture. It is characterized by such indicators as the number of generative shoots per plant in case of individual development of a plant or the number of flowers in the ear per unit of area in case of sowing in rows (Zueva 2001; Boller and Posset 2010). Real seed productivity is the number of mature and complete seeds in the ear (Vainagii 1974).

The seeds were sown on May 2, 2011; Tatjana seeds and wild samples were sown in autumn, on September 11. Mass seedlings were recorded on May 11. Plants of Aida, Phrida sorts from *commutata* subspecies started to tiller on the 20th day, that is 10 days earlier than plants of Boreal, Echo, Engina sorts from *rubra* subspecies; plants of Tatjana, K-0026, K-0028 sorts sown in autumn started to tiller on the 23rd day, see the additional file (Fig. 1).

F. rubra, as a slowly growing grass, has its feature, that is, *F. rubra* plants do not enter a reproductive period in the first year. It happens in the second year of life. Mal'tsev found that plants, having several vegetative shoots and 8–10 leaves, usually undergo flower induction in autumn in the first year of life in case of low positive temperatures and short daylight hours (Mal'tsev 1986). Flower buds are also formed in the following spring.

In our case, wild samples K-0026 and K-0033 sown in autumn did not have time to form a sufficient number of shoots and leaves, and, accordingly, most of the plants were in the 2nd phase of organogenesis. Therefore, in the second year of life, wild samples formed single generative shoots. Two wild samples sown in autumn, started spring regrowing 3–5 days later. All phenophases of the second year clearly differ within the subspecies and start 2–5 days earlier for the sorts of the subspecies *commutata* and *trichophylla* than for the sorts of the subspecies *rubra*. The wild sample K-0026 showed the fastest onset of ripeness – 76 days. The sample Tatjana showed the longest ripening period – 88 days.

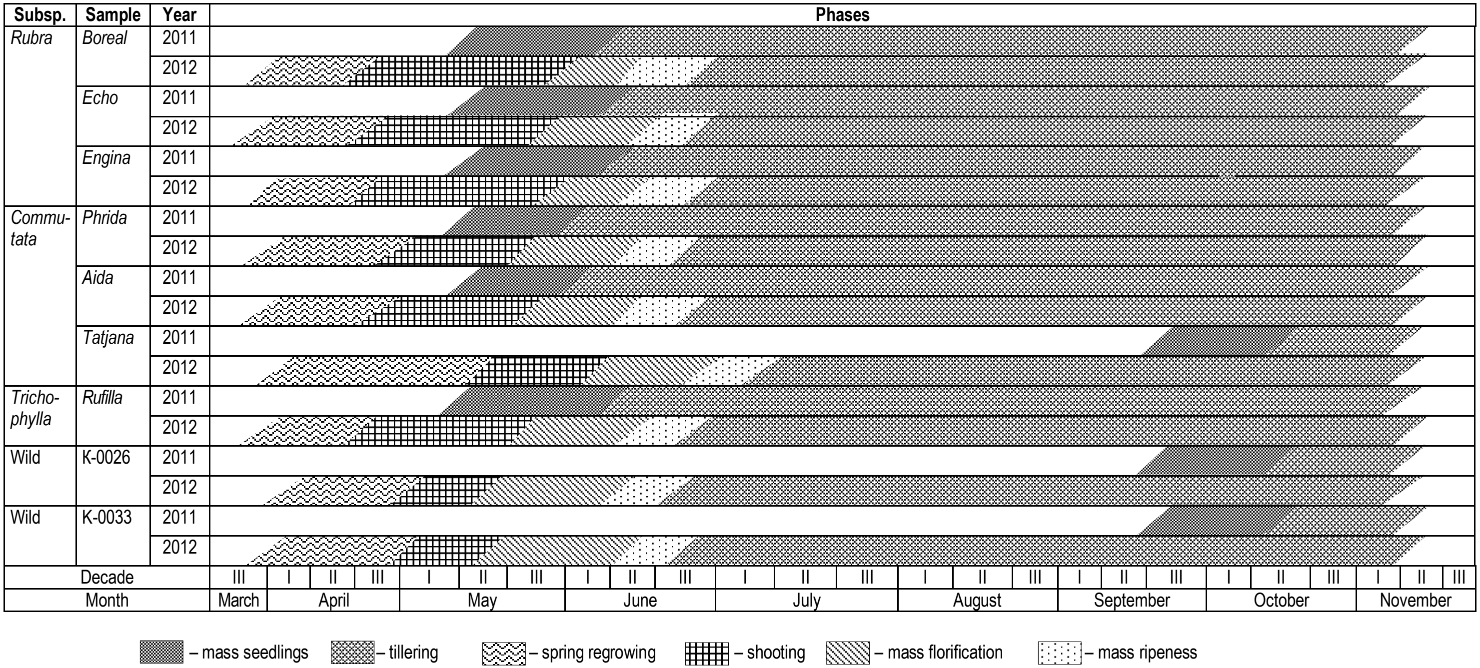

Figure 1. Phenological spectrum of *Festuca rubra* sorts and samples during the first two years.

Weather conditions have an impact on potential and actual seed productivity, especially at the time of florification and ripening of seeds. In this research, a ten-day schedule of changes in the average daily temperature and precipitation during the first year of fruiting plants is provided (Fig. 2). In the second and third decade of May, the amount of precipitation was quite large (18–26 mm), which coincides with the phenophase of florification. The sorts Phrida and Engina had a large number of flowers (240 and 236) and many seeds, especially the plants of sorts Phrida and Engina (152 and 129 respectively); it ensured a high coefficient of seminification in the first year (Aida – 69%, Phrida – 63%, Echo – 58%).

The peak of florification of the sort Tatjana is in the first decade of June. In total, 111 flowers and a substantially smaller number of seeds – 26, were formed.

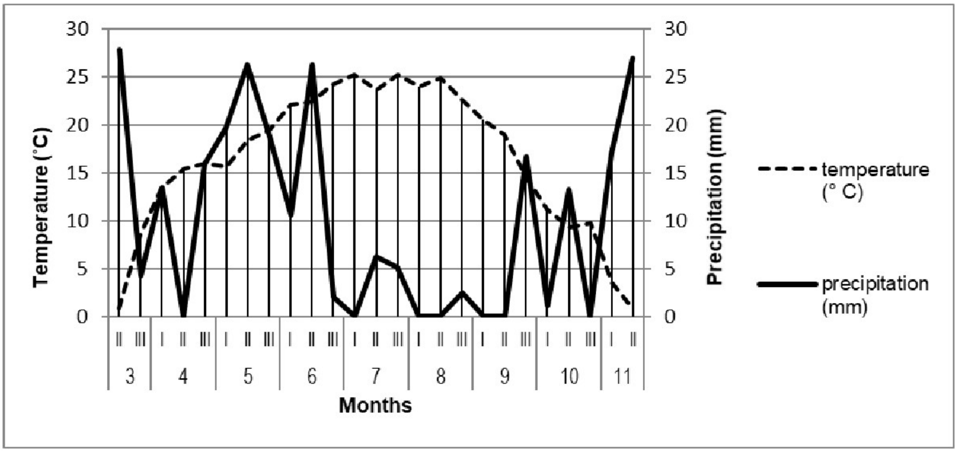

Figure 2. Weather conditions in the 1st year of fruiting of *Festuca rubra* sample: On the Y-axis – Temperature (°C) and precipitation (mm), on the X-axis – Decades and months.

The results of morphological studies are provided in the form of arithmetic averages with a confidence interval on four characters of seed productivity (Table 1). The analysis of three-year data showed high seed productivity of the sorts Aida, Echo, and Engina, with a high coefficient of seminification (61, 59, 58 %, respectively). The real seed productivity of the sort Tatjana was 37 pieces/per ear. The other samples had a higher coefficient of seminification than Tatjana, but lower than Aida, Engina, and Echo. High coefficients of seed productivity are recorded in the first and second years of the fruiting plants. Thus, the weather conditions in the first year of fruiting contributed to the realization of the potential of seeds of the studied samples *F. rubra*.

We performed an assessment of the significance of the differences in the length of the ear and the seed mass per ear between the samples by the method of finding the smallest significant difference in the first year of fruiting (Table 2).

Table 1. Seed productivity of sorts and samples of *Festuca rubra*

Sample, year of fruiting		Inflorescence length (cm)	Number per panicle (pcs)		Rate of seminification (%)	Seed mass per panicle (g)
			Flowers	Seeds		
Boreal	1st	15.9 ± 0.5	183.9 ± 8.1	76.2 ± 8.0	41.43	0.10 ± 0.01
	2nd	13.1 ± 0.5	117.2 ± 9.8	73.3 ± 6.3	62.54	0.08 ± 0.01
	3rd	10.8 ± 0.5	129.0 ± 13.8	56.0 ± 5.6	43.41	0.06 ± 0.01
	Average	13.3	143.4	68.5	47.8	0.08
Echo	1st	15.30 ± 0.4	159.70 ± 8.0	70.9 ± 5.9	44.4	0.11 ± 0.01
	2nd	15.40 ± 0.6	166.60 ± 10.4	123.2 ± 11.1	73.9	0.16 ± 0.02
	3rd	11.50 ± 0.4	100.40 ± 6.0	57.3 ± 4.7	57.1	0.07 ± 0.02
	Average	14.1	142.2	83.8	58.9	0.11
Engina	1st	15.70 ± 0.6	236.80 ± 18.0	129.8 ± 14.1	54.8	0.18 ± 0.02
	2nd	12.30 ± 0.6	123.30 ± 7.1	77.5 ± 7.2	62.8	0.09 ± 0.01
	3rd	12.70 ± 0.4	121.50 ± 7.0	73.3 ± 5.1	30.7	0.05 ± 0.01
	Average	13.6	160.5	93.5	58.2	0.11
Phrida	1st	15.20 ± 0.4	240.2 ± 16.0	152.8 ± 6.4	63.6	0.18 ± 0.01
	2nd	14.20 ± 0.4	177.1 ± 12.5	112.7 ± 10.6	63.6	0.13 ± 0.01
	3rd	9.70 ± 0.4	151.1 ± 11.0	32.9 ± 2.4	21.8	0.04 ± 0.01
	Average	13.0	189.5	99.5	52.5	0.12
Aida	1st	13.0 ± 0.3	180.0 ± 8.1	124.3 ± 6.0	69.1	0.12 ± 0.01
	2nd	15.8 ± 0.8	143.8 ± 10.2	87.0 ± 6.3	60.5	0.08 ± 0.1
	3rd	11.3 ± 0.3	189.4 ± 15.6	71.5 ± 7.5	37.8	0.05 ± 0.01
	Average	13.4	171.1	104.3	61.0	0.08
Rufilla	1st	12.5 ± 0.4	157.1 ± 11.3	58.3 ± 8.8	37.1	0.07 ± 0.01
	2nd	14.3 ± 0.5	181.4 ± 12.2	74.8 ± 11.9	41.2	0.09 ± 0.01
	3rd	11.7 ± 0.4	164.6 ± 13.9	55.9 ± 7.5	34.0	0.07 ± 0.01
	Average	12.8	167.7	63.0	37.6	0.08
Tatjana	1st	8.4 ± 0.3	111.9 ± 8.4	26.0 ± 2.0	23.2	0.05 ± 0.01
	2nd	9.3 ± 0.3	102.6 ± 7.2	58.4 ± 4.2	56.9	0.02 ± 0.01
	3rd	8.1 ± 0.3	86.2 ± 4.8	27.5 ± 2.7	31.9	0.02 ± 0.01
	Average	8.5	100.2	37.3	37.2	0.03
K-0026	1st	10.6 ± 0.4	107.9 ± 8.5	60.7 ± 6.2	56.2	0.04 ± 0.01
	2nd	8.8 ± 0.3	155.1 ± 9.8	55.3 ± 8.1	36.6	0.04 ± 0.01
	3rd	10.6 ± 0.4	162.6 ± 8.7	68.7 ± 5.9	42.2	0.06 ± 0.01
	Average	10.0	141.9	61.6	43.4	0.05
K-0033	1st	11.6 ± 0.5	176.9 ± 10.6	79.5 ± 7.7	44.9	0.07 ± 0.01
	2nd	10.7 ± 0.3	139.6 ± 9.2	68.3 ± 7.7	48.9	0.05 ± 0.01

Sample, year of fruiting		Inflorescence length (cm)	Number per panicle (pcs)		Rate of seminification (%)	Seed mass per panicle (g)
			Flowers	Seeds		
	3rd	12.0 ± 0.4	199.3 ± 11.1	48.2 ± 5.7	24.2	0.04 ± 0.01
	Average	11.4	171.9	65.3	38.0	0.05

Table 2. Analysis of the statistical significance of the differences in the studied samples in the first year of fruiting according to the length of the panicle and seed mass per panicle

Sample	Echo	Engina	Phrida	Aida	Rufilla	Tatjana	K-0026	K-0033
Boreal	NS** NS	NS 0.07a*	NS 0.04c	2.08c NS	2.22c 0.03a	1.95c 0.04c	2.16c 0.03b	2.36c 0.03a
Echo		NS 0.06c	NS 0.05c	1.95c 0.04c	2.08c 0.03a	1.74c 0.03c	2.08c 0.03c	2.22c 0.04c
Engina			NS NS	2.43c 0.05b	2.54c 0.07c	2.29c 0.06c	2.47c 0.06c	2.64c 0.06c
Phrida				1.69c 0.04c	1.91c 0.06c	1.57c 0.03c	1.81c 0.04c	2.05c 0.01c
Aida					NS 0.03c	1.42c 0.02c	2.36c 0.03c	NS 0.03c
Rufilla						1.63c 0.03b	1.88c 0.01a	NS NS
Tatjana							1.60c 0.01b	1.84c 0.02c
K-0026								NS 0.02b

Notes: *Numerator – the value of the least significant difference (LS) by the length of panicle, the denominator is the LS by the seed mass per panicle, a – confidence level 95%, b – confidence level 99%, c – confidence level 99.9%. **NS – not significant differences.

To identify the differences, the data on the average values of the studied characters were used, as well as the difference between sample averages, the error of the difference between sample averages, as well as the Student's tabular coefficient. Significant differences were found between the wild sample K-0026, Tatjana and other samples, with confidence levels 99.9 and 99%. There were significant differences with a confidence level of 99.9% not only between Tatjana samples and samples of other subspecies but also between Tatjana samples and the sorts of *commutata* subspecies.

The same assessment was performed between the samples based on the number of flowers and seeds in the ear in the first year of fruiting (Table 3). There was a significant difference between the samples Tatjana and Phrida and other samples and between the samples Tatjana and Phrida themselves with a confidence level of 99.9 and 99%.

The samples Boreal and Echo, Rufilla and K-0033 are similar to each other by four characters, which is determined by the calculation of combinations of characters.

By a combination of data on potential and real seed productivity in one diagram (Fig. 3), a distribution of curves was obtained; it showed a low and very low average level of variation in the number of flowers (9 and 8%) and seeds (5 and 11%) of wild samples during three years. When studying reproductive biology, the potential significance of the samples, which is necessary for selection, was determined. The size of the reproductive effort is crucial for cultivated plants, because for the vast majority of species and sorts, the increase in yield is primarily provided by an increase in the outflow of organic substances into the reproductive organs (fruits and seeds) and therefore, it is the main goal of selection (Zlobin 2000; Grekova 2012).

Among the studied samples, the sort Phrida had a small variation in the number of flowers (11%) and the largest number of seeds formed during three years; it makes this sort quite promising for grass seed production (Fig. 3). The sort Tatjana showed a minimum number of flowers and seeds, as well as a minimum semenification coefficient for three years. It was noticed that K-0026 had a minimum variation in the number of seeds for three years (5%).

Table 3. Analysis of the statistical significance of the differences of the studied samples in the first year of fruiting by the number of flowers and the number of seeds

Sample	Echo	Engina	Phrida	Aida	Rufilla	Tatjana	K-0026	K-0033
Boreal	30.35b* NS**	39.40a 42.72b	35.74a 34.79c	NS 33.92c	27.76a NS	40.56c 27.67c	40.67c NS	NS NS
Echo		68.13c 53.11c	61.90c 30.26c	NS 29.25c	NS NS	40.24c 21.65c	40.56c NS	NS NS
Engina			NS NS	52.35b NS	73.66c 57.77c	68.86c 49.50c	68.99c 54.36c	55.43b 42.73b
Phrida				47.51b 23.33b	67.82c 37.89c	62.57c 23.29c	62.74c 30.97c	50.89b 34.76c
Aida					NS NS	40.5c 22.0c	40.7c 30.0c	NS 33.9c
Rufilla						37.4b 31.3c	49.0c NS	NS NS
Tatjana							NS 22.6c	47.1c 27.8c
K-0026								47.2c NS

Notes: *Numerator – the value of the least significant difference (LS) by the number of flowers, the denominator is the LS by the number of seeds per panicle, a – confidence level 95%, b – confidence level 99%, c – confidence level 99.9%. **NS – not significant differences.

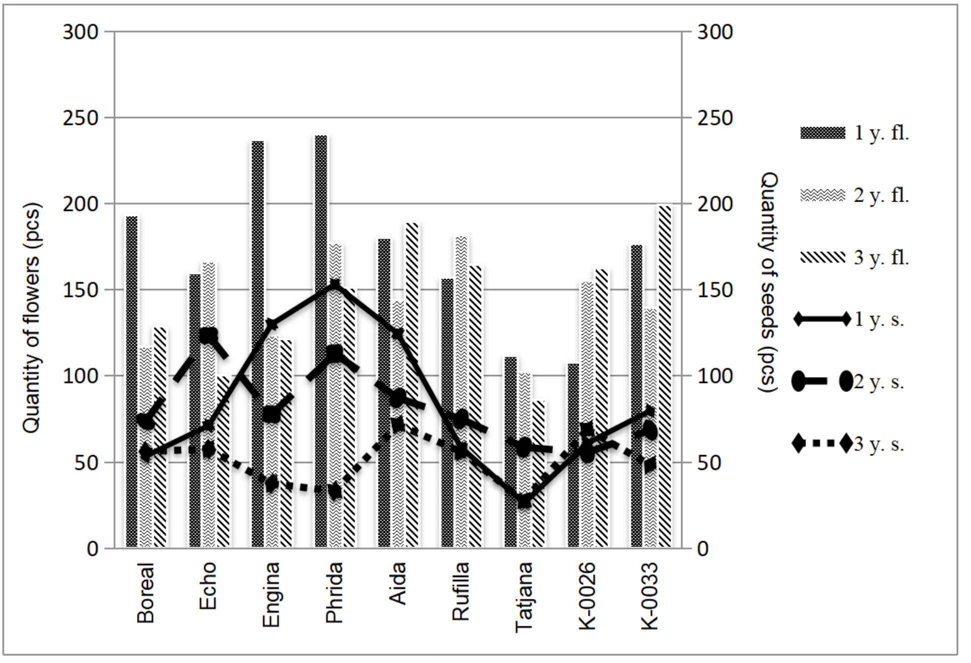

Figure 3. Realization of the reproductive effort of samples *Festuca rubra* for three years: On the Y-axis – Quantity of flowers and seeds per panicle (pcs), on the X-axis – Sorts. (1–3) y. fl. – the year of florification, (1–3) y. s. – the year of seed production.

Based on the results of the three-year test, a correlation analysis of the average seed productivity of the samples showed that there was a strong and moderate correlation between the inflorescence length and the number of flowers r1 for all sort samples (Table 4).

Wild samples K-0026 and K-0033 showed a moderate correlation r1 only in the third year, and a weak correlation in the other years. Rufilla showed a strong correlation r2 between the length of the inflorescence and the number of seeds in the first and third years; Echo, Aida – in the second year; Tatjana, K-0026, and K-0033 showed a weak correlation in three years. Boreal, Echo, Aida, Rufilla showed a strong and moderate correlation r3 between the length of the inflorescence and the seed mass from one panicle during three years of observation; Engina – in the first and third years, Tatjana, K-0026, K-0033 showed a weak correlation.

All sorts showed a strong and moderate correlation r4 between the number of flowers and the number of seeds. Among wild samples, K-0026 showed a moderate correlation, K-0028 showed a weak correlation. It is possible that the natural growing conditions are very different from the soil and climatic conditions of the experiment (growing in mountainous areas in conditions of high humidity, on rich chernozem soils). Almost all sorts showed a strong correlation r5 between the number of seeds and the seed mass from one panicle for three years.

According to published data, the yield of the species *Festuca rubra* was studied in central Russia and in Belarus (Rod'kin 2005; Kabanova et al. 2015). According to Rod'kin, the average yield for three years of the sort GBS-202 of Soviet selection was 45.9 g/m^2, in the case of sowing in wide rows this value corresponds to 18.4 g/l.m.; the average yield for three years of Phrida was 27.8 g/m^2, which corresponds to 11.1 g/l.m. In Siberia (Novosibirsk), the data on the seed mass obtained in an experiment with additional moistening is 50.5 g/m^2, which corresponds to 12.6 g/l.m. (Zuyeva 2009).

When studying the yield of samples in the experiment (Fig. 4), the authors of the research took into account the mass of seeds in sowing in rows from 1 l.m. In the first year of fruiting, the yield of seeds was high for all sorts. Boreal, Phrida (105.2 and 101.3 g/l.m. respectively) were particularly distinguished. For three years of testing, in sowing in rows, Phrida and Aida were distinguished (51.4 and 53.8 g/l.m.); their yield far exceeds the yield indicated by A.A. Rod'kin (Moscow) in his work.

Table 4. Correlation between four characters of seed productivity of sorts and samples of *Festuca rubra* during three years

Sample	**r1**			**r2**			**r3**			**r4**			**r5**		
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Boreal	0.30	**0.77**	0.41	0.59	0.57	0.42	0.62	0.48	0.45	0.23	**0.83**	**0.86**	**0.94**	**0.9**	**0.98**
Echo	0.59	0.45	0.55	0.32	**0.89**	0.5	0.44	**0.9**	0.47	0.09	**0.72**	0.44	**0.92**	**0.95**	**0.96**
Engina	0.46	0.46	**0.8**	0.58	0.09	0.47	**0.71**	0.07	0.55	**0.84**	**0.72**	0.54	**0.91**	**0.88**	**0.91**
Phrida	0.59	**0.8**	0.68	0.43	-0.2	0.19	0.34	-0.2	0.11	**0.76**	0.25	**0.7**	**0.81**	**0.85**	**0.99**
Aida	0.57	0.59	**0.84**	0.51	**0.77**	0.66	0.44	**0.74**	0.61	**0.84**	**0.81**	**0.77**	**0.92**	**0.93**	**0.96**
Rufilla	**0.79**	0.5	0.68	**0.72**	0.29	**0.77**	**0.75**	0.3	**0.8**	**0.72**	0.22	0.6	**0.98**	**0.96**	**0.97**
Tatjana	**0.8**	0.53	0.34	0.12	0.15	-0.01	0.01	0.11	0.18	0.2	0.69	0.36	**0.73**	**0.9**	**0.9**
K-0026	0.22	0.27	0.54	0.09	-0.39	0.14	0.11	-0.39	0.26	0.61	0.57	0.15	0.47	**0.81**	**0.9**
K-0033	0.2	0.18	0.51	0.35	0.12	0.2	0.28	0.25	0.21	0.03	0.29	0.04	**0.96**	**0.96**	**0.96**

Note: Strong correlation between characters is highlighted in bold.

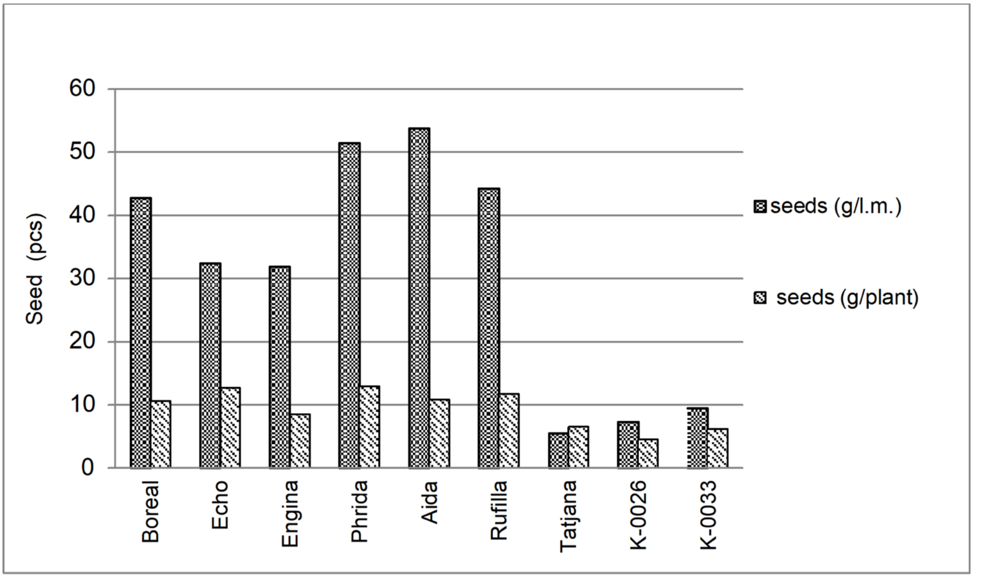

Figure 4. Average yield of sorts and samples of *Festuca rubra* in sowing in rows and in the individual development of plants.

In individual development, when competitive relationships are reduced, most of the seeds are formed in the second year. In that year, plants of the sorts Boreal and Phrida formed the largest number of seeds (24.2 and 20.2 g/plant). The other sorts formed a maximum number of seeds in the first year of fruiting, followed by a decrease in seed yield in the second and third years. Boreal showed a high seed yield – up to 23.6 g of seeds in the first year. On average for three years, Phrida showed the highest yield. A statistical analysis of average data on seed mass between the sorts for three years was carried out by the method of comparing sample average values (Ryazanova et al. 2013) and it showed insignificant differences between the sorts. In small samples, a failure to reject the null hypothesis should not be considered as proof of equality between the general parameters; and the final conclusion is not reached. In sowing in rows, the calculation of the number of shoots revealed that the sort Aida had a maximum number of generative shoots from 1 l.m. in the first and second year (up to 1872 and 680 shoots respectively). In the second year, the number of generative shoots was significantly reduced (in sort's samples the reduction reaches 76%). Wild samples had a minimum number of shoots for three years (182 and 105 shoots/ l.m.).

When testing plants under conditions of individual development, Rufilla showed the largest number of generative shoots from one plant in the first and in the second year of fruiting (173.5, 184 g/plant, respectively), and also the largest number of shoots on average for three years of fruiting (133.4 g/plant). In the second year of fruiting, the sorts Phrida, Aida, Rufilla, and Tatjana also had a large number of shoots. From the third year, plants of all sorts started to form a significantly smaller number of generative shoots from a plant. On average for three years in sowing in rows, the sort Aida formed the largest number of shoots (923 shoots/l.m.). The number of generative shoots of wild samples was already decreased in the second year of fruiting (the number was decreased by 47% for the sample K-0033, by 67% for the sample K-0028).

These data correspond to the results obtained by Williams Fodder Research Institute for the Central region of Russia, which show a decrease in the fruiting of red fescue in the second year. The number of generative shoots is decreased by 1.8–2.1 times, seed yield – by 2 times (Truhan 2013).

The rhythm of the seed production of *F. rubra* is different depending on the method of sowing. In case of sowing in rows, plants show the full potential of seeds and give maximum shoots and seeds in the first year of fruiting. In the second year, tillering intensity increases, the root system is actively formed, and, accordingly, competitive relationships are growing. In the third year, depletion of reproductive forces is noticeable and the shoot system deteriorates. In case of individual development, competitive relationships are reduced, there is a sufficient nutrition area, and it contributes to the active growth and development of plants; therefore, in the first two years of fruiting, the yield is maximum.

Upon the use of two methods of sowing which were studied in this research, the seed yield and productivity of generative shoots were minimum in the third year. Therefore, it is not economically viable to continue to use the seed plants.

Conclusion

All studied samples of *F. rubra* sown in spring reached the tillering phase in the first year; in autumn, the shoots of the samples were at the third phase of organogenesis. The plants continued to grow in the following spring, they grew flowers and bore fruit. The plants sown in autumn were at the second phase of organogenesis at the end of the growing season; thus, the plants formed single generative shoots in the following year.

The subspecies *commutata*, *trichophylla*, and the subspecies *rubra* have a significant difference only in the onset of phenological phases of florification and ripeness of seeds, and the difference is 3–5 days. The slowest growing sample is Tatjana. The difference between the periods of entering into the florification phase of wild samples is from 5 to 9 days.

During three years of testing, the sorts Phrida, Aida from the subspecies *commutata* showed high seed productivity, and the sort Echo from the subspecies *rubra* also showed good results.

A strong correlation was found between the following characters: the number of seeds and seed mass per panicle r5, the number of flowers and the number of seeds r4, the panicle length and the number of seeds r2 (in the sorts Rufilla, Echo, and Aida), the panicle length and the number of flowers for one year in all sorts except Echo. A moderate correlation was found between the following characters: the panicle length and the number of flowers for all samples, the ear length and seed mass per ear, except for Tatjana and K-0028. The wild samples K-0026 and K-0028 are characterized by weaker correlation, compared to the varietal samples.

On average for three years, the sorts Phrida and Aida from the subspecies *commutata*, Boreal and Rufilla from the subspecies trichophylla had the highest yield from 1 l.m. The sort Aida from the subspecies *commutata* and the sort Rufilla from the subspecies *trichophylla* had the most intensive formation of generative shoots. These sorts can be recommended to seed farms for seed production. They can be used as the main component in lawn grass mixtures and for creating turf-forming decorative grass stands in southeastern Kazakhstan.

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