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Reproductive ability of *Poa pratensis* L. and P. *angustifolia* L. in conditions of Kazakhstan and Western Siberia

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Abstract. The article presents the seed productivity of five cultivars of *Poa pratensis L*. for lawn purposes and three wild-growing specimens of *Poa pratensis L*. and *Poa angustifolia L*. from natural populations in the south-east of Kazakhstan and in the south-west of Siberia, summarized over three years. The onset of the main phenological phases was determined, taking into account the weather conditions of the region where the experiment was held, and a comparative analysis between the samples was carried out. The correlation connection between three signs of the reproductive sphere and their consistency with weather conditions was researched. For all varieties, a significant conjunction was revealed between the number and weight of seeds per spike, a considerable variation in the coefficient of seed production over the years. The best indicators of seed productivity were noted in the plant variety 'Novosibirskiy' and wild forms 'C-2' and 'D1-78' in Western Siberia, in the plant variety 'Balin' and wild specimen 'K-0027' in Kazakhstan. The influence of environmental conditions on the organogenic process of *P. pratensis* was revealed. Additional moisture contributes to the manifestation of the potential capability for seed reproduction of the researched samples of *P. pratensis*.

1 Introduction

The type *Poa pratensis L*. (species *Poaceae*) is the most frequently used component in grass mixtures for lawn purposes and includes a share of 30 percent or more in the composition of grass mixtures for parterre, ordinary and other lawn coverings. A huge number of varieties of this species are used all over the world [1]. This perennial boreal grain, long-term (dwells up to 15–20 years or more), is resistant to unfavorable climatic conditions inherent in the region of both South-East Kazakhstan and Western Siberia, and to some environmental factors, such as salinity, drought of air and soil, heavy soils and their compaction due to the operation of lawn coverings. The question of the correlative variability of characters has not been sufficiently investigated. Considering the significant

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genetic heterogeneity of introduced species and the prospects for expanding the area of introduction, this issue remains largely relevant.

In this regard, the purpose of our research was to investigate the seed productivity of *P. pratensis* and *P. angustifolia* in the framework of introduction tests of sod-forming grasses in the South-East of Kazakhstan and *Poa pratensis* in Western Siberia; development of scientific foundations for creating a seed fund for breeding work.

2 Materials and Methods

2.1 Object of study and experimental conditions

The objects of research included three varieties *Poa pratensis* ‘Balin’, ‘Sobra’, 'Fortuna', used as lawn, and a wild sample of *Poa angustifolia L.* from the natural flora of Kazakhstan (Almaty region, Dzhambul district, Kastek gorge, cereal forbs, bank of the river Kastek). The field experiment was held in the foothill-plain Talgar district of Almaty region (43º45'04"N, 77º06'44"E). The climate is characterized by high continental and drought conditions. The sum of positive temperatures is 3450–3750 ºC. The average duration of the frost-free period is 140–170 days. Annual precipitation is 350–600 mm. During the warm period, 120–300 mm of it falls. The soil cover is represented by ordinary gray soils. The method of growing plants is row sowing with a plot size of 1 m^2, row spacing of 30 cm in 4 repetitions.

In the conditions of Western Siberia, the research objects were three varieties of *P pratensis*: ‘Sobra’ (Sweden), ‘Novosibirskiy’ (CSBG), ‘Congar’ (USA), and two wild forms S-2 (Igarka) and D1-78 (Novosibirsk). The investigation was carried out in the Central Siberian Botanical Garden of the Siberian Branch of the Russian Academy of Sciences, which is located in the south of Western Siberia in the forest-steppe zone in a sharply continental climate with a moderate supply of heat and moisture. The amount of heat is 2183°, the average annual precipitation is 420 mm. The frost-free period lasts 116 days. Soils are marginal soils with low fertility, represented by podzolized sandy loam and light loam. Plants in the experimental plots were investigated in two versions: natural conditions and artificial moisture.

2.2 Methods of study

Phenological observations were carried out according to the method of I.N. Beideman [2]. Crops are wide-row. The number of generative shoot counting and the seed mass from an individual plant was carried out with different methods of cultivation in 10-fold repetition (n=10). The volume of samples by the parameters spike length, number of flowers and seeds per spike, weight of seeds per spike (n=30). The study of seed productivity was carried out according to the method of R.E. Levina [3]. Assessment of real and potential seed productivity – according to I.V. Vainagiy [4] The differentiation degree of the apical meristem was carried out according to the method of F.M. Kuperman [5].

2.3 Statistical methods

The statistical analysis of the observation results, taking into account the mean values and the coefficient of variation, was carried out using Microsoft Excel 2010. The least significant difference was estimated in Statistica 12 software based on Excel 2010 using the Mann-Whitney formula with a preliminary estimate of normal distribution by constructing histograms. Degree evaluation of the correlation force between the characteristics of the reproductive sphere and weather conditions is provided according to N.A. Plochinskiy [6] Variability assessment of morphological characters using the coefficient of variation, proposed by S.A. Mamaev [7].

3. Results

Meadow bluegrass (*P. pratensis*), when it is used in lawn grass mixtures, contributes to the creation of a decorative coating, as it comprises a high tillering intensity, delicate thin shoots, and an intense green color. It forms a large number of orthotropic and plagiotropic shoots, fills bald spots on the lawn, appearing as a result of the fallout of other mixture components and harsh environmental conditions. *Poa pratensis L.* is distributed in all regions of the European part, including the Arctic, the Caucasus, Siberia, the Far East, Central Asia and throughout the temperate zone of the world. In Russia, about 30 varieties of *P. pratensis* are zoned for different areas.

Mass seedlings were observed in bluegrass on the tenth day after sowing in Kazakhstan and on the 12th day in Western Siberia. The biological feature of *P. pratensis*, as a slowly developing cereal, is that the plants do not enter the generative phase in the first year. It was revealed that the plants on the main shoot (stage II of organogenesis) by the end of the growing season comprise up to 10 assimilating leaves. The differentiation of the growing cone into the rudimentary inflorescence is completed in Western Siberia at the end of August, and in the south-east of Kazakhstan at the beginning of November. Young shoots, which appeared as a result of summer-autumn tillering, proceed to the winter in a vegetative state and continue the processes of blooming induction in the spring of the second year of life.

Spring regrowth throughout the observation years commenced on March 16–31, depending on the accumulation of active temperatures from 61 to 77 ˚C, which are considered to be effective for cereals after passing through 5 ˚C. The average period of phase passages from spring regrowth to maturity is 84–86 days for varietal specimens and 83 days for a species specimen. It takes 26-29 days on average to ripen seeds. A decrease is observed in the coefficient of variation during the transition from vegetative to generative phases for all investigated samples (in the regrowth phase V=20–25%, in the ripeness phase V=1–3%).

Weather conditions affect the indicators of potential and real seed productivity, especially if unfavorable factors coincide with the moment of blooming and seed ripening. In the second and third ten days of May, a fairly large amount of precipitation occurs (20–26 mm), which coincides with the blooming phenophase, therefore this year is taken as a model year. A strong direct dependability was recorded between the number of flowers and the average minimum and average maximum temperature. Between the number of seeds and the relative air humidity, as well as between the seed weight and the average minimum temperature and relative air humidity.

A strong feedback was found out between the amount and weight of seeds per spike and the amount of precipitation throughout the period of blooming and seed setting. In addition, between the number of seeds, the weight of the seeds and the accumulation of active temperatures at the time of blooming. It was revealed that the formation of flower buds is more influenced by the minimum temperature throughout this period, whilst the accumulation of active temperatures and the amount of atmospheric moisture throughout the period of seed setting influence strongly on the formation of seeds and their weight. Seed productivity is considered to be one of the main features in assessing the viability of plants when when they are introduced into culture. Real seed productivity is the number of ripe and full-value seeds per spike [3]. From the IV stage of organogenesis, generative shoots are formed. The formation of the future inflorescence depends on natural and artificial conditions at the time of plant development. Favorable conditions favor the formation of more spikelets in a panicle. Conditions with a sufficient amount of nutrients in the soil, as well as moisture, affect the development of morphological parameters such as the length of the inflorescence, which will ultimately increase seed productivity (Table 1).

Table 1. Reproductive ability of the studied samples of *Poa pratensis* under different growing conditions in Western Siberia and artificial moisturisation in the conditions of South-East Kazakhstan.

Cultivated varieties and species	Inflorescence length, cm	Number per spike, pcs.		Seminification coefficient, %	Weight of seeds per spike, g
		flowers	seeds		
Natural moisturisation in the conditions of South-West Siberia					
Novosibirskiy	7,7	367,3±13,9	353,0±16,2	96,1	0,08±0,003
Sobra	9,6	332,4±15,9	243,3±10,7	73,1	0,04±0,001
Congar	10,0	326,0±12,1	286,0±17,2	87,7	0,05±0,002
C-2	7,0	374,4±29,5	269,0±17,6	72,0	0,06±0,003
D1-78	7,4	400±21,6	378,0±19,7	94,5	0,08±0,003
Artificial moisturisation in the conditions of South-West Siberia					
Novosibirsk	11,2	**440,0**±13,2	**380,0**±19,0	86,3	0,08±0,002
Sobra	8,4	370,0±14.0	250,4±11,0	67,6	0,06±0,002
Congar	7,0	368,0±22,1	302,0±10,3	82,0	0,03±0,001
C-2	7,0	**436,0**±17,4	**396,0**±15,8	90,8	0,07±0,003
D1-78-	9,2	**450,0**±18,0	**350,0**±20,0	78,0	0,07±0,003
Artificial moisturisation in the conditions of South-East Siberia					
Balin	7,1	418,9±71,5	**272,8**±36,5	**68,8**	0,08±0,005
Sobra	7,1	442,2±53,3	257,2±40,5	57,4	0,07±0,005
Fortuna	6,2	271,9±36,0	113,5±20,9	41,7	0,05±0,004
K-0027	8,8	**546,3**±20,7	**315,4**±25,4	57,7	0,09±0,006

A high variation is pointed out in the seminification coefficient over the years. The processes of blooming and fertilization occur at the IX stage of organogenesis. Fertilization is susceptible to exposure to light and temperature conditions combined with humidity. A deficiency of soil moisture or an excessive amount of atmospheric humidification affects the number of fertilized flowers, and their decrease affects the seed productivity of plants. The results of the experiment confirm that additional irrigation increases the indicators of seed productivity in all studied samples. The maturation of *P. pratensis* seeds depends not only on the origin of the plants (varietal or wild), but also on the temperature factor and humidity.

Table 2. Influence of moisture conditions on plant development and seed productivity of *Poa pratensis* and *P. angustifolia* accessions in Western Siberia and in the conditions of South-East Kazakhstan.

Cultivated varieties and species	Number of generative shoots, pcs/m^2	Seed yield, g/m^2	Weight of 1000 seeds, g
Natural moisturisation in the conditions of Western Siberia			
Novosibirskiy	268,0±8,0	40,0	0,24
Sobra	234,0±14,0	32,0	0,20
Congar	198,0±5,9	30,0	0,20
C-2	300,6±5,6	37,5	0,23
D1-78	303,0±12,0	41,0	0,22
Artificial moisturisation in the conditions of Western Siberia			
Novosibirsk	292,0±14,6	46,2	0,23
Sobra	324,0±6,5	42,6	0,24

Congar	204,0 ±8,2	33,6	0,11
C-2	340,4±17,0	40,0	0,20
D1-78	320,0±12,2	44,5	0,20
Artificial moisturisation in the conditions of South-East Kazakhstan			
Balin	987,2±123,4	50,8	0,30
Sobra	1055,2±131,9	59,6	0,29
Fortuna	1015,2±126,8	31,2	0,40
K-0027	1104,0±138,0	63,2	0,27

As a result of the experiment, it was revealed that the yield increases from 14 to 50% in the variant with artificial moisture. Wild-growing samples ‘C-2’, ‘D1-78’ and ‘K-0027’ are distinguished, which comprise high rates of both potential and real seed productivity. Sample comparisons of Siberian and Kazakhstan reproduction in terms of the number of seeds formed per spike establish that samples of Kazakhstan reproduction include a low real seed productivity against the background of a low coefficient of seed production. The Mann-Whitney U-test demonstrates significant differences between the samples in one of the main morphological traits of seed productivity – the number of seeds per spike. Under moisture conditions, 3-28% more generative shoots are formed and 6-25% more seed yield per m^2 (Table 2). Indicators reflecting the yield of samples are noticeably higher in a more heat-supplied region, such as the southeast of Kazakhstan.

4 Discussion

Differences between the investigated samples were established for three characteristics of seed productivity. Biomorphological investigations of *P. pratensis* samples made it possible to determine the IV stage of organogenesis, when the formation of reproductive organs takes place – the laying of the elements of the future inflorescence, at this moment additional moisture is effective. The lack of moisture can be replenished with artificial moisture. The maturation of the seeds of P. pratensis and P. angustifolia depends not only on the biological characteristics of the species, but also on temperature conditions. Low average monthly temperatures in March and April can lead to a delay in plant development and late seed maturation. It was revealed that the limiting factor in the formation of the elements of seed productivity is the lack of soil moisture during the period of setting-maturation of seeds and insufficient accumulation of active temperatures. The obtained results of the seed productivity of the studied samples of *P. pratensis* and *P. angustifolia* indicate a wide ecological amplitude and plasticity, as well as the profitability of seed production of these crops under the condition of additional moisture. This, in turn, will create real prerequisites for the successful usage of the studied samples in the conditions of creating sod coverings in Western Siberia and in the South-East of Kazakhstan.

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