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БИОЛОГИЧЕСКАЯ ОЦЕНКА КОСТРЕЦА БЕЗОСТОГО В РАЗЛИЧНЫХ АГРОКЛИМАТИЧЕСКИХ ЗОНАХ ЯКУТИИ

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Представлены результаты биологической оценки сортообразцов костреца безостого в разных агроклиматических зонах Якутии. В исследованиях использованы 143 коллекционных сортообразца костреца безостого из генетической коллекции ВИР, других научно-исследовательских учреждений, а также местные дикорастущие образцы. Изучаемые сортообразцы обладают высокой зимостойкостью, селекционные номера в большей степени. Дана оценка засухоустойчивости сортообразцов, выращиваемых в трех зонах Якутии. Установлена тесная взаимосвязь признаков зимостойкости и засухоустойчивости (водоудерживающей способности) у костреца безостого. Коэффициент корреляции в среднем составил 0,74. Дана оценка интенсивности транспирации у сортообразцов костреца безостого. Анализ дневной динамики транспирации выявил, что в начальной фазе развития генеративных побегов (выход в трубку) минимальная интенсивность транспирации происходила в вечернее время, максимальная – в утренние и дневные часы. В фазе колошения и цветения интенсивность транспирации зависит от погодных условий. Установлено, что высокая зимостойкость костреца безостого обусловливает высокую урожайность сена; низкий процент водоудерживающей способности – зимостойкость и получение максимального урожая сена в условиях криолитозоны Якутии. Коэффициенты корреляции между параметрами зимостойкости, засухоустойчивости с урожайностью сена при разном травостое в среднем составили –0,85…–0,24. Стандартный сорт костреца безостого Камалинский 14 устойчив и высоко адаптирован к условиям Якутии, рекомендуется как родительская форма в селекционном процессе по кострецу безостому. При отборе сортообразцов костреца безостого следует обратить внимание на сортообразцы из местной селекции, а также на популяции экспедиционных сборов по Якутии, которые обладают высокой урожайностью семян.

Ключевые слова: кострец безостый, зимостойкость, засухоустойчивость, семена

BIOLOGICAL EVALUATION OF AWNLESS BROMEGRASS IN DIFFERENT AGRO-CLIMATIC ZONES OF YAKUTIA

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The results of biological evaluation of awnless bromegrass varieties in different agroclimatic zones of Yakutia are presented. A total of 143 collection varieties of awnless bromegrass from the genetic collection of VIR, other research institutions and local wild specimen were used in the research. The varieties studied are highly winter-hardy, the breeding specimen numbers to a greater extent. The drought tolerance of the varieties grown in the three zones of Yakutia is evaluated. A close relationship between winter hardiness and drought tolerance (water retention capacity) in awnless bromegrass was established. The correlation coefficient averaged 0.74. The intensity of transpi-

ration in awnless bromegrass cultivars is evaluated. Analysis of the daily dynamics of transpiration revealed that during the initial development phase of generative shoots (emergence into a tube), the minimum intensity of transpiration occurred in the evening and the maximum in the morning and afternoon hours. During the earing and flowering phase, the intensity of transpiration depends on weather conditions. It has been established that high winter hardiness of awnless bromegrass accounts for high hay yield; low water-holding capacity accounts for winter hardiness and maximum hay yield in the conditions of Yakutia's cryolithozone. The correlation coefficients between winter hardiness, drought tolerance parameters and hay yield at different herbage levels averaged –0,85… –0,24. The standard variety of awnless bromegrass Kamalinsky 14 is stable and highly adapted to the conditions of Yakutia, and is recommended as a seed parent in the selection process for awnless bromegrass. When selecting varieties of awnless bromegrass, attention should be paid to varieties from local breeding, as well as populations of expeditionary collections across Yakutia, which have high seed yields.

Keywords: awnless bromegrass, winter hardiness, drought resistance, seeds.

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INTRODUCTION

Awnless bromegrass (Bromopsis inermis Leyss) is one of the most common perennial grasses. Due to its biological features, it grows in various soil and climatic conditions, including the Far North [1, 2].

Awnless bromegrass is characterized by high yield, drought tolerance and winter hardiness. It is willingly eaten in pastures and as hay by all kinds of livestock. It grows well after mowing or straining. Grows early in spring and yields large quantities of green fodder; thus, it may be used as an early green supplementation instead of winter crops. In Yakutia it survives in grass on fenced plots for 8-9 years. It is widely used in grass mixtures when creating cultivated hayfields and pastures, as well as for sowing in drained bogs and lands subject to water and wind erosion[1] [1-9].

Many literature sources indicate the importance of winter hardiness in the preparation of plants depending on their belonging to the type groups (in relation to negative air temperatures). The following types of crops are distinguished: those resistant to low temperatures of atmospheric air, soil layer and under-snow temperature [10-16]. Awnless bromegrass has many forms, which are united into two types according to biological, ecological, and economic characteristics: northern and southern (see footnote 1) [6, 16].

[1]Efimova A.Z. Agroecological justification of awnless bromegrass (Bromopsis inermis (Leyss.) Holub) cultivation for seeds in Yakutia: Ph.D. in Agricultural sciences. Yakutsk, 2004. 24 p.

In Yakutia, the main limiting factors are severe overwintering conditions and drought conditions during the growing season. The selection of source material adapted to the harsh conditions of Yakutia should be the basis for the creation of varieties with a stable yield of aboveground mass.

The purpose of the study is to evaluate the biological characteristics of awnless bromegrass varieties in different agroclimatic zones of Yakutia.

MATERIAL AND METHODS

Experimental studies were conducted in three scientific field stations of the M.G. Safronov Yakut Scientific Research Institute of Agriculture, which are located in different agroclimatic zones of crop cultivation: Prigorodnaya (Khangalassky ulus), Zarechnaya (Ust-Aldansky ulus) and Northern (Oymyakonsky ulus).

In Khangalassky ulus, the research was conducted in 1989-1993 on a floodplain site located in the middle course of the Lena River. The soil is frozen-floodplain, soddy, light gray sandy loam with neutral and slightly alkaline reaction of soil medium. Salinity type is sulfate-chloride. Humus content in arable layer is 2.14-2.95%, exchangeable potassium is 3.5-19.7 mg/100 g, pH is 7.2-7.4.

In the Ust-Aldan ulus, the research was conducted on the thermokarst alas Bedi in 2006-2008. The alas is flat and belongs to the basin-valley type. The site is located on alas xeromorphic solonets, which are widespread in alas meadows of the studied region. This soil type occupies 47.4% of the area of the main bottom of Badi alas, which is 672.7 ha [17].

The microrelief of the experimental plot is flat, with a slight slope from north to south, from the periphery of the alas to the center. The humus content at the depth of 0-20 cm is very high (8.9%) with decreasing down the profile to 1.9%. Provision of nitrate nitrogen is very high - 46-48 mg/kg of soil, phosphorus content is very low - 58 mg/kg, potassium at 0-20 cm depth is very high - 305 mg/kg, 20-40 cm is high - 159 mg/kg. Salinity is weak, sulfate-chloride at 0-20 cm horizon and hydrocarbonate at 20-40 cm horizon. According to the observations of R. Desyatkin [17], permafrost during the growing season drops to 2.0-2.5 m.

In the Oymyakonsky ulus the research was conducted in 1998-2001. The site is located on the floodplain of the Yuchyugei River. The soil is permafrost north taiga podzolized. The soil profile is subjected to permafrost cryoturbations, gleyed, and has thixotropy on soils of heavy texture. By mechanical composition, the soils are light, medium and heavy loamy on ancient alluvial deposits, underlain by sand and pebbles from below. The humus content is 2.11-2.47%, the reaction of the aqueous solution of the soil medium is neutral, pH 6.4-7.7. The content of phosphorus and potassium is high. In the upper layers (0-20 cm), the phosphorus content is 29.9-31.78 mg/100 g of soil, exchangeable potassium is 25.6-26.4 mg/100 g.

Meteorological conditions during the years of research were characterized by very harsh winters (temperature dropped to -57 °C in Khangalassky and Ust-Aldansky uluses and lower to -62 °C in Oymyakonye) and more favorable conditions during the growing season.

Hydrothermal coefficient (HTC) in the first site for 1989-1993 was from 1.2 to 2.7. The dry period was 1989 (HTC 1.20), 1993 (HTC 1.53), humid - 1990, 1991 (HTC 2.07 and 1.62, respectively). The year 1992 was humid (GTC 2.7).

At the second site in 2006-2008 the meteorological conditions of the growing season can be divided into dry (2007) and wet (2006, 2008) according to the hydrothermal coefficient. Weather conditions of vegetation period 2007 were characterized by relatively low air temperature and deficit of atmospheric precipitation. During the first and second ten-day periods of July, the weather was dry and hot, while rains started only from the third ten-day period. The HTC was 0.55. The sum of active temperatures above 10°C was 1,295°C, and precipitation totaled 71.4 mm during the period.

At the third test site, the HTC was 1.65 in 2000 and 1.23 in 2001.

Field experiments, biometric measurements and observations were carried out according to the methodological guidelines of VIR (1985)

and VNIIK (1985, 1993). Daily transpiration rate was determined according to N. Gusev's method "Some methods of plant water regime research" (1966). Mathematical processing of the research results was carried out according to B.A. Dospekhov (1985) using the software package Sandor (2009) and Microsoft Office Excel 2007.

143 collection variety samples of awnless bromegrass from the genetic collection of VIR and other research institutions, as well as local wild specimens were used in the studies: 40 variety samples in Khangalass Ulus, 90 variety samples in Oymyakonsky Ulus, and 13 samples in Ust-Alansky Ulus. The standard is a zoned variety Kamalinskiy 14.

RESULTS AND DISCUSSION

When determining the selection features of awnless bromegrass, important biological traits: winter hardiness, drought tolerance and water retention capacity were taken into account. According to the developed farming technique of this crop in the conditions of Yakutia, sowing was carried out by wide-row method in the summer period [2, 12]. Good adaptability of awnless bromegrass under Yakutian conditions is observed with such sowing.

In Khangalassky and Oymyakonsky uluses, experimental plots were used for winter grazing of horses during the winter period. As a result, winter-hardy and drought-resistant varieties were identified.

In Khangalassky ulus, in the standard variety Kamalinsky 14 winter hardiness in the first 2 years of plant life is generally good, which becomes excellent with age.

When evaluating awnless bromegrass cultivars for drought tolerance, it was determined that the water-holding capacity is well manifested in vegetative shoots. Generative shoots in dry year are less stable than vegetative ones in water-holding capacity. In this connection, the specimens were studied during the tillering phase.

Water loss from the total weight of plants was recorded in the first year of vegetation of plants in the variety Kamalinsky 14 at 4.5%, in local samples - from 2 to 3%. In subsequent years of herbage use, it was noted that water retention capacity reached 5% in variety Kamalinsky 14 and up to 4% in local populations, except for hybrid number G-18. It showed homeostasis effect and did not change its water-holding capacity from the third to the fourth year of plant life (at the level of 2%).

Hay yields were 14.4 to 33.3 c/ha for Kamalinsky 14 on the bogara depending on HTC of the year and the first point of research. The first life year of awnless bromegrass coincided with a moderately humid year (HTC 0.81). Hay yield reached 33.3 c/ha. In the second year of awnless bromegrass life (HTC 1.03) hay yield was 21.1 c/ha. In the third year of life this indicator was 14.4 c/ha, which is associated with the age of the herbage and a very dry summer (HTC 0.59). In the fourth year of life in a more favorable year (HTC 1.09) the hay yield was 21.98 c/ha.

Thanks to agrotechnological methods, the variety Kamalinskiy 14 adapted well in the cryolithozone. Negative correlation was noted both between yield and winter hardiness (up to -0.6), and between hay yield and water retention capacity (-0.8) (see Table 1).

A similar agronomic technique with wide-row sowing method was used in the second point of research when studying the VIR collection of awnless bromegrass in the harsh conditions of the cold Pole of Oimyakon.

It was noted that Kamalinskiy 14 adapted well in the cryolithozone. In this variety, the negative relationship between yield with winter hardiness (to -0.5), and between hay yield and water-holding capacity (-0.5) was confirmed.

Local varieties showed themselves differently: a positive correlation between winter hardiness and hay yield and water-holding capacity and hay yield was noted. Correlation coefficients were 0.6-1.0 and 0.6, respectively. In hybrid samples the negative relationship with winter hardiness and hay yield is clearly expressed, indicating homeostasis and inheritance of the parental form of the Kamalinskiy 14 variety (see Table 2).

Peculiarities of winter hardiness of awnless bromegrass and drought tolerance expressed themselves in a certain correlation with forage

Табл. 1. Хозяйственно ценные признаки и определение взаимосвязи с урожайностью сена у сортообразцов костреца безостого в условиях Хангаласского улуса (посев 1989 г., учет 1990–1993 гг.)

Table 1. Economically valuable traits and determination of correlation with hay yield in awnless bromegrass cultivars in Khangalass ulus conditions (seeding 1989, records 1990–1993)

Year of Life	Winter hardiness, score	HTC	Drought tolerance (water retention capacity), %	Hay yield, c/ha
First (1990)	4,5	0,81	4	33,3
Second (1991)	4,5	1,03	4,5	21,1
Third (1992)	5	0,59	5	14,4
Fourth (1993)	5	1,09	5	21,98
Property correlation coefficient with the yield of awnless bromegrass hay	–0,66	0,24	–0,87	1,00

harvesting in the second field point. The correlation coefficient between winter hardiness and waterholding capacity for Kamalinsky 14 variety was 1,00, for Karavaev's bromegrass Э№07-1/37 – 0,82, variety G-18 - 0,58, for bromegrass Э№07-1/51 – 0,58. The average correlation coefficient for the samples was 0.74.

In Ust-Aldansky ulus the sowing was made in the autumn term. Observations of transpiration intensity in awnless bromegrass cultivars were carried out during the second, third and fourth years of life according to plant development phases (emergence of a tube, earing and flowering).

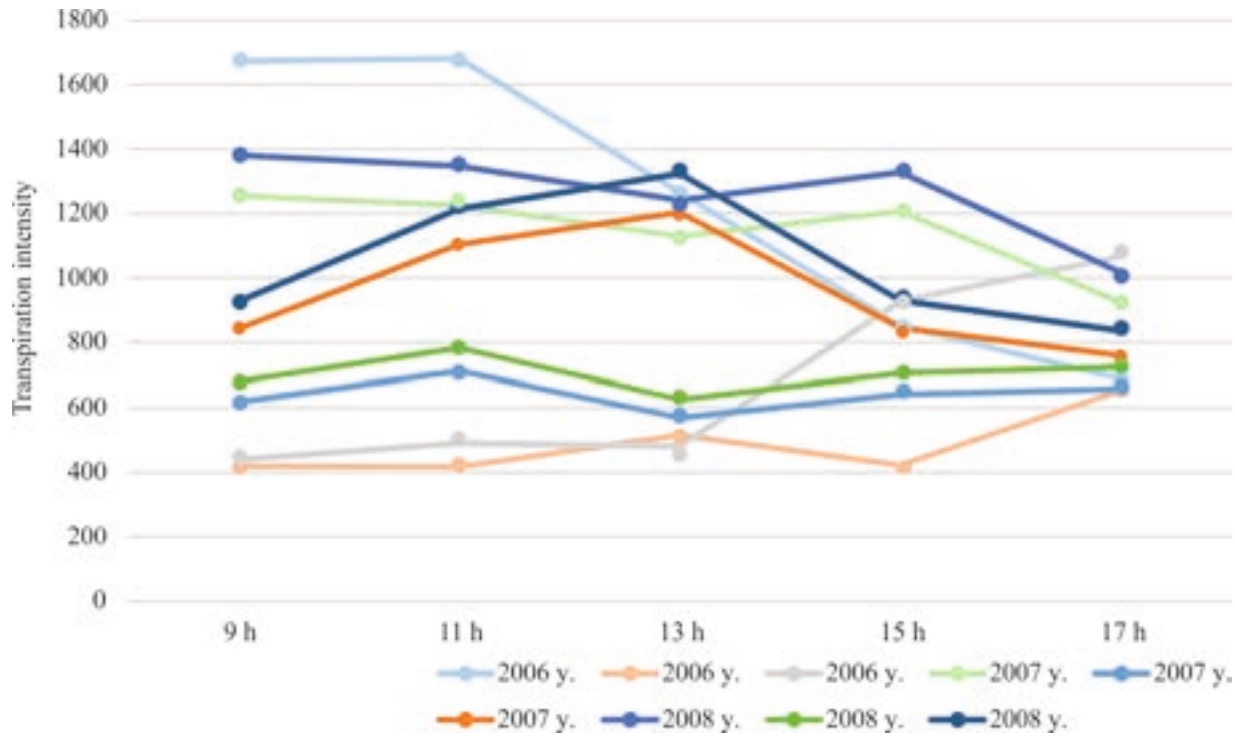
Over the years of research, the daily transpiration rate of awnless bromegrass cultivars is expressed by single- and double-peaked curves shown in the figure.

The analysis of daily dynamics of transpiration revealed that in the initial phase of development of generative shoots (emerging into the tube) the minimum intensity of transpiration occurred in the evening, the maximum - in the morning and afternoon hours. In the earing and flowering phase, the intensity of transpiration depends on weather conditions. In favorable conditions of moisture supply in 2007 and 2008, maximum (11 h) and minimum (13 h) evaporation was recorded during daytime during earing and flowering phases. During flowering, the peak of transpiration intensity fell on daytime (13 h), the minimum value - in the evening (17 h). During unfavorable moisture availability in 2006, the minimum intensity of transpiration was observed at 9 and 11 h, the maximum - in the evening time (17 h). The analysis of transpiration intensity by development phases in awnless bromegrass showed that the maximum evaporation of moisture from leaves occurs in the phase of emerging into a tube. By years this indicator varied from 1149 to 1263 mg/h, considerably less in the earing phase - from 486 to

Табл. 2. Коэффициент корреляции у местных образцов костреца безостого и адаптированного сорта Камалинский 14 (Оймяконский улус, посев 1998 г., учет 1999–2001 гг.)

Table 2. Correlation coefficient in local samples and adapted cultivar Kamalinsky 14 (Oymyakonsky ulus, seeding 1998, records 1999–2001).

Factor relationship	Kamalinsky 14	Karavaev bromegrass E№07-1/37	G-18	Bromegrass E№07-1/51	Average value
Hay winter hardiness and yield	–0,5	1,0	–0,4	0,6	0,2
Water-holding capacity and yield of hay	–0,5	0,6	0,7	0,6	0,4



Среднесуточная интенсивность транспирации сортообразцов костреца безостого (учет 2006–2008 гг.), мг/ч

Average daily transpiration rate of awnless bromegrass cultivars (records 2006–2008), mg/h

704 mg/h, flowering - from 681 to 951 mg/h. Low transpiration coefficient (486-1231 mg/h) was registered in plants during unfavorable heat and moisture deficit vegetation period of 2006.

Among awnless bromegrass cultivars the lowest intensity of transpiration is characterized by varieties Antey and Amethyst. In the booting phase in the third and fourth years of life they had the highest value of transpiration coefficient - 1599 and 1614 mg/h, respectively.

In the third year of life of awnless bromegrass varieties in the booting phase, high rates of transpiration were revealed. In standard Kamalinsky 14 it was 3718 mg/h. With optimal signs of winter hardiness and drought tolerance, bromegrass plants formed a good seed yield during this period (see Table 3).

Due to biological features of awnless bromegrass, it reaches the maximum seed yield in the third and fourth years of plant life. Reliably high seed yield is provided by six varieties: Haptagaisky, Mestny Yakutsky, Ammachaan, K-02-8, E-118, K-02-6, in which the excess over the standard varieties varies from 22 to 49% (see Table 3).

CONCLUSIONS

1. The standard variety of awnless bromegrass Kamalinsky 14 is stable and highly adapted to the conditions of Yakutia, and is recommended as a parent form in the breeding process for awnless bromegrass.

2. Water retention capacity of awnless bromegrass plants in the tillering phase decreases to 5% with age.

3. Correlation coefficients between the parameters of winter hardiness, drought tolerance and hay yield with different herbage on average are at -0,85 ... -0,24.

4. High winter hardiness of awnless bromegrass determines the high yield of hay; low percentage of water-holding capacity - winter hardiness and getting the maximum yield of hay in conditions of Yakutia cryolithozone.

5. Close correlations of winter hardiness and drought tolerance (water retention capacity) in awnless bromegrass were established. The correlation coefficient averaged 0.74.

6. Analysis of daily dynamics of transpiration revealed that in the initial phase of gen-

Табл. 3. Урожайность семян костреца безостого на третьем участке (условия аласа Бэди), посев 2005 г., г/м^2

Table 3. Seed yields of awnless bromegrass in plot 3 (Bedi Alas conditions), seeding 2005, g / m^2

Variety	Year of Life			Average value	% to the standard
	second	third	fourth		
Kamalinsky 14 (standard)	5,3	7,8	15,9	9,7	100
Langepas	4,7	7,5	17,5	9,9	102
Ametist	4,5	8,5	16,6	9,9	102
Antei	6,4	8,9	17,6	11	113
Local Yakut	7,3	8,5	20,1	12	124
Ammachaan	6,8	10,1	21,2	12,7	131
Khaptagai	4,8	8,9	21,6	11,8	122
E-118	6,1	11,8	23,7	13,9	143
K-02-5	4,9	8,7	17,2	10,3	106
K-02-6	7,7	12,2	23,4	14,4	149
K-02-8	6	8,4	23,3	12,6	130
$LSD_{0,5}$	1,7	2,9	3,1	2,1	

erative shoots development (booting stage) the minimum intensity of transpiration occurred in the evening, the maximum - in the morning and daytime hours. In the phase of earing and flowering the intensity of transpiration depends on weather conditions.

7. When selecting varieties of awnless bromegrass, one should pay attention to varieties from local breeding, as well as to populations of expeditionary collections in Yakutia.

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