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ОЦЕНКА ОБРАЗЦОВ ДВУКИСТОЧНИКА ТРОСТНИКОВОГО ДЛЯ РЕКУЛЬТИВАЦИИ УГОЛЬНЫХ ОТВАЛОВ

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Одним из надежных путей восстановления эродированных почв и техногенных земель является их рекультивация с посевом многолетних злаковых трав. Изучены и выделены образцы двукисточника тростникового, пригодные для рекультивации угольных отвалов Кемеровской области. Экспериментальная работа проведена в Томской области (58°11′с.ш., 83°00′в.д.) в 2017–2020 гг. Объекты исследований представлены отборами двукисточника тростникового, проведенными в 2016 г. Питомник изучения образцов, пригодных для рекультивации угольных отвалов, заложен в 2017 г. в количестве шести номеров – КМ-1, КМ-2, КМ-3, КМ-4, КМ-5 (Томская область), в качестве стандарта использовали сорт Витязь (Томская область). Почвы опытных участков дерново-подзолистые кислые супесчаные и суглинистые с содержанием гумуса в пахотном горизонте не более 2%. При оценке образцов основное внимание уделено изучению признаков и свойств, которые лимитируют их возделывание в условиях таежной зоны: густоте травостоя, высоте растений, облиственности, зимостойкости, устойчивости к полеганию, семенной продуктивности, урожайности зеленой массы, устойчивости к наиболее распространенным заболеваниям. За 3 года изучения отборов двукисточника тростникового по комплексу основных хозяйственно важных признаков выделен образец КМ-5. Данный образец обладает комплексом ценных признаков при создании адаптивного сорта, пригодного для рекультивации угольных отвалов (облиственность – 61,4%, урожайность зеленой массы – 38,5 т/га, сухого вещества – 11,9, семян – 0,21 т/га). Выделившийся номер имеет ежегодные достоверные прибавки к стандарту по урожайности зеленой массы 8,5 т/га, сухого вещества – 3,3, семян 0,04 т/га. Образцы КМ-1, КМ-5 проявили высокую устойчивость к данным заболеваниям: поражение гельминтоспориозом – 6,0–6,1%, септориозом – 2,6–4,2%.

Ключевые слова: рекультивация, двукисточник тростниковый, урожайность, адаптивность, селекция

EVALUATING REED CANARY GRASS SAMPLES FOR RECLAMATION OF COAL DUMPS

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One reliable way to restore eroded soils and technogenic land is to reclaim it by sowing perennial grasses. Samples of reed canary grass suitable for reclamation of coal dumps in the Kemerovo region have been studied and identified. Experimental work was carried out in the Tomsk region (5811 N, 8300 E) during the period of 2017-2020. The research subjects are represented by samples of reed canary grass taken in 2016. A nursery of study samples suitable for reclamation of coal dumps was laid in 2017 with six numbers - KM-1, KM-2, KM-3, KM-4, KM-5 (Tomsk region), the variety Vityaz (Tomsk region) was used as a standard. The soils of the experimental plots were sod-podzolic acidic loamy sandy loam and loamy with a humus content of no more than 2% in the arable horizon. When evaluating the samples, the main attention is paid to studying the traits and properties that limit their cultivation under taiga conditions: grass density, plant height, foliage,

winter hardiness, lodging resistance, seed productivity, green mass yield, resistance to the most common diseases. Over a 3-year study of selections of reed canary grass based on a set of the main economically important traits, the KM-5 sample has been identified. This specimen has a complex of valuable features in creating an adaptive variety suitable for reclamation of coal dumps (foliage - 61.4%, green matter yield - 38.5 t/ha, dry matter - 11.9, seeds - 0.21 t/ha). The selected number has annual reliable additions to the standard in terms of green matter yield of 8.5 t/ha, dry matter yield of 3.3, and seed yield of 0.04 t/ha. Samples KM-1, KM-5 showed high resistance to these diseases: helminthosporiosis - 6.0-6.1%, septoriosis - 2.6-4.2%.

Keywords: reclamation, reed canary grass, productivity, adaptability, selection.

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INTRODUCTION

At present, the processes of anthropogenic disturbance of the vegetation cover, including in Western Siberia, are becoming global. The mining industry has a negative impact on all components of the natural environment, causing undesirable changes. Disturbed lands become focal points of atmospheric, water and soil pollution, adjacent lands, worsen sanitary and hygienic living conditions of the population. In order to restore the ecological integrity of disturbed areas, it is necessary to carry out reclamation works[1] [1–3].

Overgrowth of waste dumps is an example of primary succession occurring under specific edaphic conditions. The rate of self-vegetation on waste dumps varies from site to site. Phytomelioration significantly accelerates the process of self-restoration [4].

One of the reliable ways to restore eroded soils and technogenic lands is their reclamation with sowing of perennial grasses [5, 6]. The reed canary grass[2] is important for the restoration of disturbed areas [7].

The reed canary grass (*Phalaroides arundinacea* (L.) Rausch.) is a cosmopolitan perennial forage plant on intrazonal excessively wet soils in all continents except Antarctica. It is a perennial loose rootstock cereal for forage and erosion control use. Biological features of reed canary grass include wide adaptability to excessively humid areas, longevity, resistance to long-term flooding (up to 90 days), and high photosynthetic capacity. Longevity of economic use is 9-12 years, there is evidence of herbage more than 30 years old. The bicarbonate plays an important role as a fixer on landslide sites and a phytoremediator on sites of soils polluted with heavy metals [8]. The aim of the research

[1]Technologies of reclamation and arrangement of disturbed lands in Western and Eastern Siberia: monograph / Zenkov I.V., Nefedov B.N., Baradulin I.M., Yuronen Y.P., Voken V.N., Kiryushina E.V. Krasnoyarsk, 2015. 308 p. [Electronic resource]: URL: http://www.knigafund.ru Accessed 20.04.2021.

[2]Lamanova T.G., Sheremet N.V., Doronkin V.M. Collections of the Central Siberian Botanical Garden as a source of biodiversity restoration at overburden dumps of Kuzbass [Electronic resource]: URL: https://elar.urfu.ru/ bitstream/10995/32729/1/ brimnz_2012_27.pdf. Accessed 20.04.2021.

is to study and isolate samples of reed canary grass suitable for reclamation of coal dumps in the Kemerovo region.

MATERIAL AND METHODS

Experimental work was carried out in the Narym Department of Breeding and Seed Production at the Siberian Research Institute of Agriculture and Peat - Branch of the Siberian Federal Scientific Center of AgroBioTechnologies RAS, located in Kolpashevo, Tomsk Region (58°11′N, 83°00′E) in 2017-2020. The objects of the research are represented by the sampling of reed canary grass conducted by Kemerovo State University in 2016. The nursery garden for the study of samples suitable for reclamation of coal dumps was laid in 2017 in the amount of six numbers - KM-1, KM-2, KM-3, KM-4, KM-5 (Tomsk region), the standard - variety Vityaz (Tomsk region). Experimental work was carried out in natural field conditions.

The technology of laying a field experiment is generally accepted for perennial grasses in Western Siberia. Evaluation, observations and recordings were carried out in accordance with the methodological guidelines for perennial grasses breeding[3] and the methodology of the State Variety Testing Commission[4].

Samples were sown manually using dibbling along marker traces with a row spacing of 70 cm in the first days of June. The method of sowing was wide-row to a depth of 1-2 cm, seeding rate 0.6 g/m^2 (at 100% economic validity of seeds), plot area - 2 m^2. Sowing care consisted of 3-4 times weeding with simultaneous loosening of the row spacing.

The climate in the study area is sharply continental with long, harsh winters and short but hot, often arid summers. Snow cover lasts for about 7 months (usually from October to April). The frost-free period is short. Annual precipitation is about 500 mm, including more than 300 mm during the growing season. The sum of air temperatures above 10°C is 1300-1600°C.

Soils of the experimental plots are sod-podzolic acidic (pH_{salt} 4.3-4.9) sandy loam and loamy by granulometric composition with humus content in the arable horizon not exceeding 2% (by Tyurin). The nutrient supply of mobile nitrogen is low - 0,20-0,22 mg/100 g of air-dry soil (according to disulfo-phenolic acid), exchangeable potassium is medium - 8,3-13,9 mg/100 g of air-dry soil (by Peiva), mobile phosphorus is high - 12,1-18,1 mg/100 g of air-dry soil (by Kirsanov), aluminum content is high - 4,4-9,6 mg/100 g of soil (by Sokolov).

Grass density was measured in the first year of the study at full sprouts and before going into winter, in the second and subsequent years - at spring growth, by cutting and before going into winter on a 5-point scale. Plant height was measured in the phase of mass earing for green mass and at the beginning of seed ripening for seed. Plants were measured from the soil surface to the apex of the inflorescences at five locations.

Winter hardiness (percentage of plants surviving the overwintering period) was determined by counting the number of live and dead plants in the plot in autumn and spring at the beginning of the growing season.

In the study of resistance to leaf infections, counts were conducted during the period of maximum disease development according to the methodological guidelines of the VIR, VIC[5,6]. To determine the degree of infestation, 25 leaves from each plot were collected in the field and then compared with the Peterson scale tables [9].

The green mass productivity of reed canary grass was recorded under a two-crop system: the first cut was made in the phase of full lodging, and the second cut was made when the grass reached its maturity (height of the herbage). Before taking into account, the herbage was assessed by eyeballing in terms of density and alignment, disease infestation, and height. The herbage was then mowed and a sample sheaf was taken along the length of the swath in

[3]Methodological guidelines for breeding perennial grasses. MOSCOW: VIC. 2012. pp. 35-46.

[4]Methodology of state variety testing of agricultural crops. M., 1985. pp. 49-57, 120-125.

[5]Methodological guidelines for the study of cereal grass resistance to fungal pathogens for the conditions of the Non-Chernozem zone of the RSFSR. M.: VNIIR, 1976. 65 p.

[6]Guidelines for breeding perennial grasses. Moscow: Publishing House Of RSAU-MAA, 2012. 51 p.

various places by handfuls of 1 kg to determine the dry matter yield.

The leaf coverage was determined by analyzing the sample sheaves as the ratio of leaf weight to the total dry weight of the sample, expressed as a percentage. Seed productivity of the breeding material was determined by sowing the samples in pure form according to the optimal agricultural technique. Grass vegetation was mowed from the whole recording area with a sickle. The threshed seeds were brought to the condition of purity and germination.

Experimental material was processed according to B.A. Dospekhov[7] using an application software package[8].

RESULTS AND DISCUSSION

The evaluation of the samples focused on the traits and properties that limit their cultivation under taiga conditions: winter hardiness, yield of fodder mass and seeds, resistance to the most common diseases.

The growing season is an important biological trait that reflects the adaptation of plants to growing conditions. The natural and climatic conditions of the taiga zone in Western Siberia allow cultivated plants, in particular reed canary grass, to form a good herbage and conditioned seeds during a short summer.

Under our conditions, spring sprouting in 2018 was recorded on 10 May, the beginning of earing on 25 June, full earing on 27 June, mass flowering on 2 July, and mass seed ripening on 19 July. In 2019, regrowth occurred on 7 May, beginning of earing on 23 June, full earing on 27 June, mass flowering on 2 July, and mass seed ripening on 20 July. Thanks to an early and warm spring in 2020, germination started on 20 April, heading emergence on 8 June, complete heading on 12 June, mass flowering on 18 June, and mass seed ripening on 14 July. The duration of the growing season in 2018 was 70 days (74 days in 2019, 85 days in 2020). The end of the growing season in 2018 was on 29 October, in 2019 on 20 October and in 2020 on 10 November.

The density and thickness of the herbage of the studied numbers was 4-5. These estimates correspond to the state of the grass stand of the samples before the winter. All studied samples had high winter hardiness (100%), foliage (5 points), resistant to lodging (5 points). Plant height varied from 136 to 145 cm during the mass earing phase and from 151 to 162 cm during flowering (average data for 2018-2020).

Thanks to the high snow cover in the winter of 2017/18, 2018/19 and 2019/20, the reed canary grass specimens overwintered well, with a winter hardiness of 100%. The plants went into the winter in a well-developed condition. Mowing and harvesting of crop residues was carried out one month before the onset of permanent frost, so no fallout was observed on the crops.

Reed canary grass grows early in spring and is characterized by fairly intensive growth. Spring regrowth begins at a temperature of about 2-3°C. At the end of May, the grass can reach a height of 7-10 cm. In the phase of seed ripening in the conditions of Western Siberia, the reed canary grass grows to 200 cm in height. Plant height during the mass earing phase ranged from 136 to 145 cm, during flowering from 151 to 162 cm (average data for 2018-2020). All reed canary grass specimens were highly resistant to lodging (4-5 points).

Cereal grasses are affected by a large number of fungal diseases. The importance of one or another disease varies depending on the species of cereal, the environmental conditions and the way it is used. The most widespread are leaf diseases: helminthosporiosis, septoriosis and rust. Severely weakened plants poorly tolerate extreme conditions of heat, drought or low temperature. In the conditions of the Tomsk region, reed canary grass is most often affected by Helminthosporiosis (*Helminththosporium bromi* Died.) and septoriosis (*Septoria* sp.).

At the stage of maturity of seeds helminthosporiosis affection of samples was 6,0-7,6%, septoriosis - 2,6-7,0% (for standard - 3,0 and 2,9% respectively). Samples KM-1, KM-5 showed high resistance to these diseases: dam-

[7]Dospekhov B.A. Methodology of field experience. Moscow: Kolos, 1985. 351 p.

[8]Sorokin O.D. Applied statistics on computer. Novosibirsk, 2007. 206 p.

Характеристика образцов двукисточника тростникового в питомнике отбора (двухукосное использование) (средние данные за 2018–2020 гг.)
Characteristics of reed canary grass samples in the selection nursery (two-cuts use) (average data for 2018–2020)

Variety (Tomsk region)	Yield									Leaf coverage, %
	herbage			dry matter			seeds			
	t/ha	% to the standard	± to the standard	t/ha	% to the standard	± to the standard	t/ha	% to the standard	± to the standard	
Vityaz (standard)	30,0	100,0	0	8,6	100,0	0	0,17	100,0	0	52,8
KM-5	38,5	128,3	+8,5	11,9	138,4	+3,3	0,21	123,5	+0,04	61,4
KM-3	35,3	117,7	+5,3	10,3	119,8	+1,7	0,12	70,6	–0,05	51,7
KM-4	32,7	109,0	+2,7	9,0	104,7	+0,4	0,11	64,7	–0,06	52,0
KM-1	30,7	102,3	+0,7	9,8	114,0	+1,2	0,17	100,0	0	53,9
KM-2	29,2	97,3	–0,8	8,7	101,2	+0,1	0,11	64,7	–0,06	52,3
LSD_{05}			0,7			1,2			0,02	1,3

age by helminthosporiosis was 6.0-6.1%, septoriosis 2.6-4.2%.

Yield of green matter (dry matter) is the main indicator of the value of varieties. In haying, productivity was recorded in two-crop use: the first cutting was done in the full-thickness phase on July 5 (2018), June 27 (2019), June 8 (2020), the second on July 18 (2018), July 30 (2019), July 20 (2020).

The average green matter yield of the studied samples in two cuttings in 2020 was 23.5-42.0 t/ha, air-dry - 5.6-14.1 t/ha. The average green matter yield for 2018-2020 was 29.2-38.5 t/ha, air-dry 8.6-11.9 t/ha. All selections except KM-2 stood out on these traits. The excess over the standard variety was 2,3-28,3% for green mass yield and 1,2-38,4% for dry matter. Leaf coverage of the studied samples on the average over the 3 years changed in the first cut from 51,7% (KM-3) to 61,4% (KM-5).

In terms of seed yield in both 2020 and the 3-year average, the KM-5 selection stood out. The excess over the standard was 50.0 and 23.5%, respectively.

The results of the study of reed canary grass samples in the selection nursery are shown in the table below.

The criterion for the adaptability of selected genotypes in breeding is the level of their yield. Preference is given to samples that have maximum environmental adaptability. The selected number has annual reliable additions to the standard in terms of green matter yield of 8.5 t/ha, dry matter yield of 3.3, and seed yield of 0.04 t/ha.

CONCLUSION

As a result of studying the selection of reed canary grass in the taiga zone of the Tomsk region, a sample of KM-5 has been isolated, which possesses a set of valuable features (leaf coverage - 61.4%, green matter yield - 38.5 t/ha, dry matter - 11.9, seeds - 0.21 t/ha) that is used in breeding work to create an adaptive variety suitable for reclamation of coal mines.

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