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4.1.2 Селекция, семеноводство и биотехнология растений (биологические науки, сельскохозяйственные науки)

ВЛИЯНИЕ МЕТЕОРОЛОГИЧЕСКИХ УСЛОВИЙ НА ПАРАМЕТРЫ ВОДНОГО РЕЖИМА ЛИСТЬЕВ ЦМС-ЛИНИЙ СОРГО

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Сорго – одна из засухоустойчивых культур, способная произрастать и давать стабильные урожаи зерна и биомассы даже при недостаточном увлажнении. На повышение устойчивости к абиотическим стрессорам в селекционный процесс важно включать исходный материал (сорта, селекционные линии, линии с ЦМС), отвечающий предъявляемым требованиям. Для диагностики засухоустойчивости стерильных линий использовали один из показателей водного баланса листьев. Лабораторно-полевые исследования проведены в течение 2019-2022 гг., различающихся по метеорологическим условиям. В результате проведенного опыта выявлено, что большая часть коллекции стерильных линий являются высокозасухоустойчивыми: общая оводненность тканей листьев составила 71,02-74,55%. При этом наибольший вклад в общую изменчивость признака вносит генотипический фактор: его доля составляет 40,8 %, средовой фактор – 22,1 %. В среднем самая высокая оводненность ткани листа в коллекции линий с ЦМС наблюдалась в условиях 2021-2022 гг. – 73,00-73,80%. Выявлено, что при увеличении гидротермического коэффициента на 0,1 показатель водного режима листьев увеличивается на 3,73%. Кроме того, выявлен цитоплазматический эффект на насыщение клеток тканей водой изоядерных ЦМС-линий. Таким образом, полученные результаты рекомендуется использовать в последующей селекции для повышения засухоустойчивости гибридов сорго F1

Ключевые слова: СОРГО, ЦМС-ЛИНИИ, ЛИСТ, ОВОДНЕННОСТЬ, УСТОЙЧИВОСТЬ К ЗАСУХЕ, МЕТЕОРОЛОГИЧЕСКИЕ УСЛОВИЯ

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4.1.2 Plant breeding, seed production and biotechnology (biological sciences, agricultural sciences)

THE INFLUENCE OF METEOROLOGICAL CONDITIONS ON THE PARAMETERS OF THE WATER REGIME OF CMS-LINES SORGHUM LEAVES

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Sorghum is one of the drought resistant crops capable of growing and yielding stable yields of grain and biomass even with insufficient moisture. In breeding to increase resistance to abiotic stressors, it is important to include the source material (varieties, breeding lines, lines with CMS) that meets the requirements. To diagnose the drought resistance of sterile lines, one of the indicators of the water balance of the leaves was used. Laboratory and field studies were conducted during 2019-2022, differing in meteorological conditions. As a result of the conducted experiment, it was revealed that most of the collection of sterile lines are highly drought-resistant: the total hydration of leaf tissues was 71.02-74.55%. At the same time, the genotypic factor makes the greatest contribution to the overall variability of the trait: its share is 40.8%, the environmental factor is 22.1%. On average, the highest hydration of leaf tissue in the collection of lines with CMS was observed in the conditions of 2021-2022 – 73.00-73.80%. It was revealed that with an increase in the hydrothermal coefficient by 0.1, the indicator of the water regime of the leaves increases by 3.73%. In addition, the cytoplasmic effect on the saturation of tissue cells with water of iso-nuclear CMS lines was revealed. Thus, the results obtained are recommended to be used in subsequent breeding to increase the drought resistance of sorghum F1 hybrids

Keywords: SORGHUM, CMS-LINES, LEAVES, WATER CONTENT, DROUGHT RESISTANCE, METEOROLOGICAL CONDITIONS

Introduction. In breeding to increase the resistance of field crops to environmental factors (drought, elevated air temperatures, reduced precipitation, salinization, and others), it is important to select the source material with a complex of adaptive properties. Drought is one of the most harmful abiotic stressors affecting the reduction of crop yields. In this regard, the acreage of drought- and heat-resistant crops, including grain sorghum, should increase. This crop can adapt to various agroclimatic conditions, especially those characterized by a small amount of precipitation [6]. At the same time, sorghum is universal in its field of use: food, feed and technical.

In their work, breeders use laboratory and vegetative methods to reflect the drought resistance of the source material at different stages of plant development. Some researchers cite more drought-resistant genotypes that tolerate short-term dehydration with the least decrease in yield [1], others argue that drought resistance is due to the relatively high water content in the leaves and its low losses [2]. It is known that physiological processes in a plant normally proceed only with sufficient water supply [4].

Despite the tolerance of sorghum to many abiotic stressors, drought can reduce the yield and quality of the products obtained [5]. Therefore, one of the stages of the breeding process is to study the influence of weather conditions on the physiological, morphometric and economic characteristics of sorghum samples included as the starting material. In particular, when creating drought-resistant F1 hybrids, special attention should be paid to the physiological features of the water regime of the leaves of the crossing components (CMS lines and pollinator varieties).

The purpose of the research: to study the effect of genotype and meteorological conditions on the overall hydration of the tissues of the leaves of CMS sorghum lines with different types of sterile cytoplasm.

To achieve this goal, the following tasks were solved:

– determination of the indicator of the water regime of sorghum leaves;

– contribution of factors (CMS-line genotype and meteorological conditions, their interaction) to the formation of the studied trait;

– comparative analysis of iso-nuclear CMS lines with different types of sterile cytoplasm by the hydration of leaf tissues.

Materials and methods. The research involved 15 female forms of grain sorghum with CMS-inducing cytoplasmas (A1 – O-Yang 1, Efremovskoe 2; A2 – Tamara, KVV 181, KVV 114, Karlik 4v, Sudzern, Delight; A3 – Feterita 14, Karlik 4v, Zheltozernoe 10; A4 – Zheltozernoe 10; A5 – Karlik 4v; 9E – Pischevoe 614, Zheltozernoe 10), grown annually in the breeding field of the Institute during 2016-2022, differing in the level of moisture availability. Thus, the hydrothermal coefficient (HTC) for the period “shoots-flowering” varied in the range of 0.50-0.87. Sorghum was characterized by very arid vegetation conditions in 2019, and by arid conditions in 2020-2022.

The accounting area of the plot is 7.7 m^2 in three-fold repetition. The number of plants on the plot is 75-77. The total hydration of the tissues of the largest leaves was determined in 4-5 plants according to the generally accepted method [3].

Statistical processing of experimental data was carried out by two–factor analysis of variance (factor A is the genotype of the CMS-line, factor B is meteorological conditions) using the Agros 2.09 program.

Results. Plants of sterile lines based on different types of CMS differed in the leaf water content during the study period. The average value of the trait was 69.32-73.80%. A lower water content of the largest leaf was observed in the conditions of 2019-2020: the minimum indicators were found in the range of 63.16-65.08%, and the maximum – 74.01-74.56%, depending on the genotype of the CMS-line. The coefficient of variation was low and amounted to 3.9-5.4% (Table 1).

Table 1 – Leaf water content CMS-lines in different weather conditions in years (2019-2022)

Year	The value of the attribute, %				Coefficient of variation, %
	minimum	maximum	average	average error	
2019	65,08	74,01	70,98	0,73	3,9
2020	63,16	74,56	69,32	0,85	4,7
2021	67,07	80,78	73,80	1,03	5,4
2022	68,40	77,69	73,01	0,70	3,7

As a result of the two-factor analysis of variance, all the factors under consideration have a significant impact on the trait (Table 2). It was found that the share of the CMS-line genotype in the formation of the trait was 40.8%, meteorological conditions – 22.1%. Moreover, the contribution of the interaction of factors of the "CMS-line genotype × meteorological conditions" turned out to be almost equivalent to the environmental factor indicator – 29.9%.

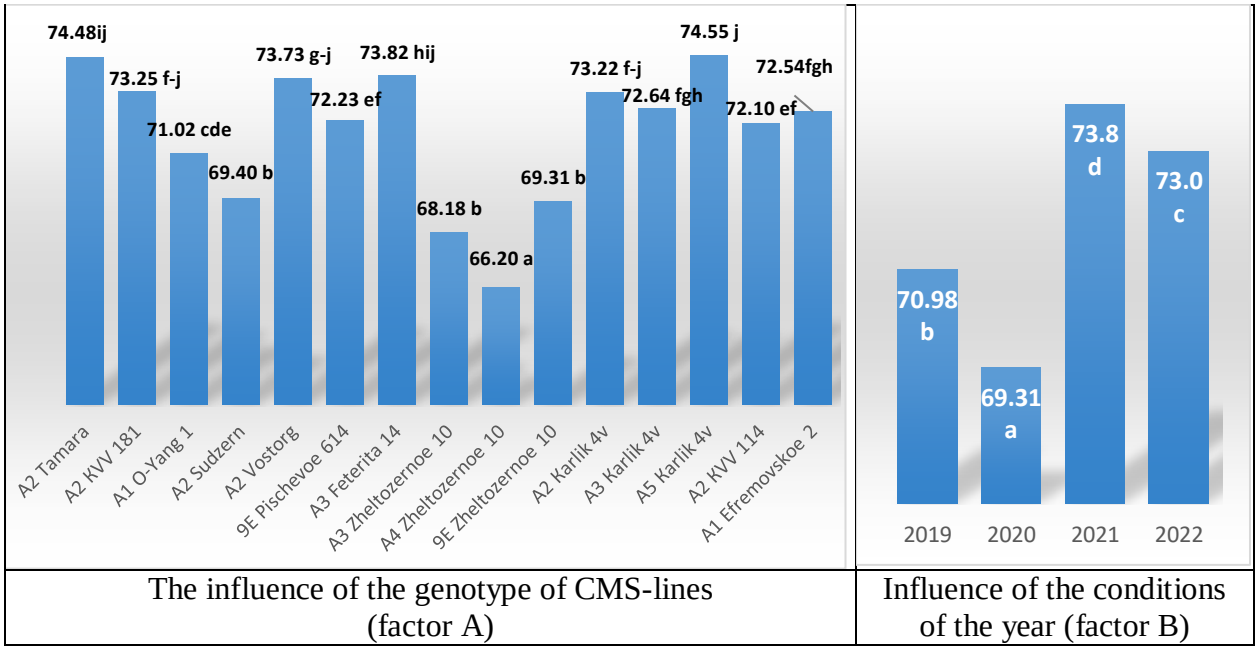
Table 2 – Results of the dispersion analysis on the leaf water content of CMS-lines sorghum

Indicator	SS	df	ms	F_{05}	LDS_{05}	Share of factors
General	1667,673	119				
Variants	1547,762	59	26,233	15,206*	2,627	
Factor A	681,125	14	48,652	28,202*	1,313	40,8
Factor B	368,604	3	122,868	71,222*	0,678	22,1
Interaction AB	498,033	42	11,858	6,874*	2,627	29,9
Other factors	101,783	59	1,725			7,2

On average, in 2019-2022, the CMS-lines of grain sorghum varied in the total leaf water content in the range of 66.20-74.55%. The highest values of the trait were characterized by the following sterile lines – A2 Tamara and A5 Karlik 4v. Sterile lines based on Zheltozernoe 10 with A3, A4 and 9E types of CMS, Sudzern with CMS A2 type should be considered medium drought resistant, since the value of the studied trait was in the range of 66.20-69.40%.

In addition, significant differences were noted between the average (for all CMS lines) water content in different growing seasons: a higher relative water content in leaf tissues was noted in 2021-2022 compared to 2019-2020, which corresponds to 73.00-73.80% and 69.31-70.98%.

The influence of CMS type on the water content in the leaf tissues of iso-nuclear lines with CMS types A3, A4, 9E based on Zheltozernoe 10 and Karlik 4v (with CMS types A2, A3, A5) was also considered. On average, for 2019-2022, the cytoplasmic effect of types A3 and 9E on the indicators of the water regime of leaves was established. The water content in A3 and 9E Zheltozernoe 10 was higher – 68.18-69.31% compared to the analog on the cytoplasm A4 – 66.20%. In CMS-lines with the Karlik 4v genome, the sterile A5 cytoplasm contributed to an increase of up to 74.55% compared to the analog on the A3 cytoplasm – 72.64%. At the same time, the CMS-lines A2 Karlik 4v and A3 Karlik 4v did not significantly differ from each other (Figure 1).



The influence of the genotype of CMS-lines (factor A)	Influence of the conditions of the year (factor B)

Figure 1 – Leaf water content of CMS-lines sorghum (average for 2019-2022)

Note. The data of the drawing, marked with different letters, differ significantly from each other according to the criterion of Duncan's multiple comparisons.

Regression analysis revealed the following patterns of dependence of the hydrothermal coefficient on the water content of leaf tissues 10 days before the experiment (Figure 2).

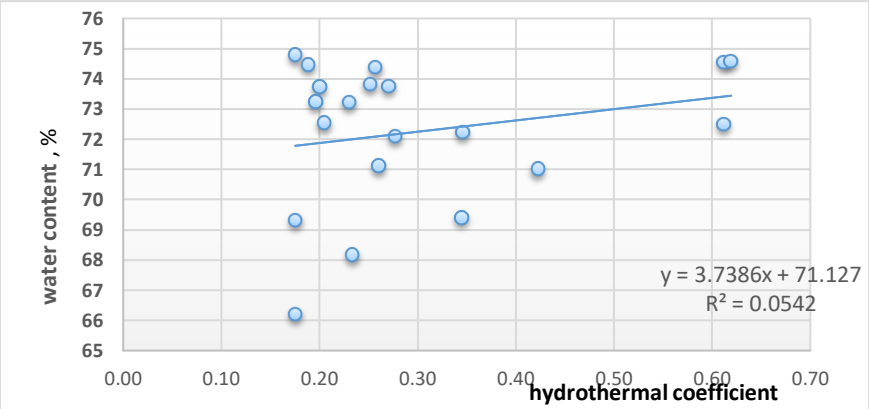


Figure 2 – Dependence of water content leaf on the hydrothermal coefficient 10 days before the experiment (average for 2019-2022)

This is evidenced by the calculated linear regression equation *y=3.7386x+71.127*. Thus, with an increase in HTC by 0.10, it leads to a greater saturation of leaf tissue cells with water up to 3.73%.

Conclusions. As a result of the analysis, differences were established between 15 studied CMS-lines in terms of the water content leaf tissues, of which 11 sterile lines should be attributed to highly drought-resistant (71.02-74.55%). The genotypic reaction of sterile lines with cytoplasmic male sterility to changes in meteorological conditions during growing seasons was noted. Thus, leaf tissues were the most waterlogged in arid conditions in 2021-2022 (average HTC = 0.82-0.87 for the period “shoots-flowering”) – 73.00-73.80%, which is confirmed by the linear regression equation. The greatest contribution to the overall variability of the indicator of the water regime of the leaves is made by the genotypic factor – 40.8%. At the same time, a comparative analysis of iso-nuclear CMS-lines allowed us to establish the effect of sterile cytoplasmas A3 and 9E on increasing the hydration of the largest leaf in relation to the analogue with cytoplasm A4, as well as cytoplasm A5 in relation to the analogue with cytoplasm A3 by 1.9-3.1%. The obtained results should be used in a new breeding process to increase the drought resistance of first-generation sorghum hybrids.

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