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Features Resistance of Sugar Sorgo (*Sorghum Saccharatum* (L) Pers.) Varieties to Environmental Stress Factors

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Abstract: One of the types of sorghum, the most drought-resistant crop in the world, sugar sorghum (*Sorghum sacchartum*) is characterized by the fact that, unlike grain and broom sorghum, its stem juice contains more than 10-20% sugars. Because it can be cultivated in the arid southern regions, where it is either unprofitable or impossible to grow sugar beets, the interest in sugar sorghum is undeniable. The aim of the study was to identify high-yielding varieties of sugar sorghum of domestic and foreign selection with a high content of soluble carbohydrates, characterized by resistance to adverse environmental conditions. Introduction of sugar sorghum in risky agriculture zones of the Republic of Kazakhstan for use as food, feed industries and alternative renewable energy. The article reveals high-yielding varieties of sugar sorghum of domestic and foreign selection with a high content of soluble carbohydrates, characterized by resistance to adverse environmental conditions and their introduction in the zones of risky farming of the Republic of Kazakhstan.

Keywords: *(Sorghum saccharatum (L) Pers.)*, Variety, Salinity, Drought, Heavy Metals, Resistance

Introduction

The flora of Kazakhstan has very rich genetic pool and unique stock of useful plants with medicinal properties. For deeper study of biological features of plants and their individual development, the study of morphological and anatomical structure helps identify systemic features, environmental character and improve the quality of pharmacological use of medical substances extracted from the plants (Kaliyeva *et al*., 2015).

Sweet sorghum (*Sorghum bicolor L. Moench*) is a widely used crop plant that provides grain and stem for feeding and industrial utilization and can be used to produce concentrated syrup, sugar or alcohol, forage as well as silage for animal feed. After the development of an efficient biomass gasifier the bagasse from sweet sorghum can be used for thermal energy production (Székely, 2011).

Sorghum sugar *Sorghum saccharatum* (L) Pers. the unique plant is a promising crop with a high potential for cultivation in southern arid, marginal and saline lands. Sugar sorghum includes a large number of varieties, characterized by the fact that they, in contrast to grain and broom, contain up to 20% or more soluble sugars in the stem juice. This is a rare plant that could synthesize carbohydrates so intensively, that is, with a high, C4-photosynthetic potential. In addition, the plant is distinguished by the efficient use of soil moisture. The use of sugar sorghum plants as a substitute for sugar in the food industry and a source of renewable energy in our republic has not previously been considered.

Sugar sorghum (*Sorghum saccharatum* (L) Pers.) Belongs to the genus *Sorghum* (L)., *Moench sorghum*. Family Bluegrass (*Rosacea*). The sugar sorghum plant is a tall shrub (200-350 cm) with juicy stems (up to 60% of the total mass). The yield of sorghum stalks is 50-60 t/ha. when grown without irrigation and 80-100 t/ha for irrigation. The biological features of this crop allow to obtain a good harvest of green mass even on very poor soils and saline soils in conditions of about 250 mM of precipitation per year. The most intense sugar accumulates in the stems after flowering. The plant contains the maximum amount of sugar in the phase of waxy and full ripeness of the grain. First of all, sorghum has the lowest transpiration coefficient, that is, water consumption per unit of dry matter. For example, sorghum consumes only 270-300 parts of water, while Sudanese grass - 340, corn - 388, wheat - 515, alfalfa, sunflower - 895 (Fig. 1).

Unexpected yield losses due to environmental stresses and disease outbreaks is another major concern on large-scale planting at marginal lands. A significant number of studies have been initiated to understand the mechanism of disease resistance and abiotic stress tolerance in sorghum (Mathur *et al*., 2017).

In Brazil, sorghum has been grown as a succession crop, i.e., second season after soybean. The sowing occurs after February when rain season is diminishing and post-flowering water stress is widespread (Baderna *et al*., 2017).

Even being one of the most drought-tolerant crops, under marked water stress the sorghum plant can suffer damages in all the development phases and the reproductive phase is the most affected by the stress, reducing weight and number of grains (de Menezes *et al*., 2015).

Drought may be the most important abiotic stress limiting crop productivity world-wide, including Brazil; in Brazil, sorghum is typically grown when rainfall is generally low or its distribution is erratic. The crop season often has a normal rain start but terminates prematurely, thereby exposing the crop to post-flowering stress (Menezes *et al*., 2014).

Sorghum is a thermophilic short-day culture. The minimum required temperature for seed germination is 8-9°C. However, more friendly shoots appear at a temperature of 13-15°C at the depth of seeding. The optimum temperature for seed germination is 20-25°C (Pigorev, 2010). Confirming its status as a thermophilic crop, sorghum is highly sensitive to low temperatures. Levels of min 2-3°C are harmful for sorghum.

Sorghum can be successfully grown on agricultural land, where soil pollution is observed as a result of economic activities of enterprises

for the extraction and processing of minerals. Growing agricultural products near such industrial enterprises becomes impossible. From a scientific point of view, it is most expedient in such a situation to create a bioenergy crop rotation in which the central place is given to sugar sorghum. Moreover, in such conditions, there are no disputes regarding the allocation of land for grain production and the cultivation of raw materials for bioenergy. With this approach, it is not necessary to tear off the areas occupied by grain, for the cultivation of bioenergy crops. Moreover, thanks to the cultivation of sorghum, the contaminated land will become suitable for the cultivation of cereals after a certain period of time. The advantage of sorghum as a source of bioethanol is reflected in the data in Table 1.

Thus, cultivating sugar sorghum can ensure food and energy security in the regions of risky farming, as well as the well-being of farms and the environment. The possible complex use of sugar sorghum can be represented as follows (Fig. 2).

At present, scientists from far and near abroad are fruitfully working on the use of sorghum in various sectors of the national economy. So, the All-Union Research Institute of Sorghum and Soybean "Slavyanskoe Pole" has developed a comprehensive State Program "Sorghum as a basic crop in fodder production for all types of agricultural animals, poultry, fish, as a new raw material for new directions of the processing industry, as a condition for the development of agriculture and rural areas. separately taken subjects of the Russian Federation ", which is being successfully implemented. Serious breeding and genetic research is being conducted in Ukraine (Crimea, Odessa). The scientist from Moldova Moraru, who created unique varieties of sugar sorghum "Porumben 4" and "Porumben 5". In Uzbekistan, under the auspices of ICARDA, an international group of researchers is successfully working, which selects the best sorghum varieties for the Central Asian region (Toderich and Massino, 2011). Currently, the United States annually cultivates sorghum on an area of up to 7 million hectares and produces more than 20 million tons of grain for use in feed production. The amount of grants ($ 47 million) allocated for research on sorghum is impressive. Intensive work on sugar sorghum is being carried out in the PRC. This is evidenced by the government's decision to reduce the import duty on bioethanol produced from sugar sorghum from 30 to 5% (Zhou *et al*., 2012). Drought is a major abiotic stress affecting crop growth and yield worldwide. Drought-induced oxidative stress results in the reduction of plant photosynthesis and reproductive success. Cerium oxide nanoparticles (nanoceria) possess potent antioxidant properties that can alleviate drought-induced oxidative stress by catalytic scavenging Reactive Oxygen Species (ROS), thereby protecting sorghum [*Sorghum bicolor* (L.) *Moench*] photosynthesis and grain yield. Drought was imposed at the booting stage by withholding water for 21 d. Foliar-sprayed nanoceria protect sorghum plants from oxidative damage under drought stress leading to higher grain yield (Djanaguiraman *et al*., 2018).

Sweet sorghum proved to be tolerant to saline waters if applied only during one crop season. However, the continuous use of saline waters for more than one crop season led to soil salinization and to root water uptake reductions due to the increasing salinity stress. The relation found between NNO^{3-} uptake and dry biomass yield (R2 = 0.71) showed that nitrogen needs were smaller than the uptakes estimated for the scenario with the highest levels of nitrogen application. The movement of N out of the root zone was dependent on the amount of water flowing through the root zone, the amount of N applied, the form of N in the fertilizer and the timing and number of fertigation events. The simulations with HYDRUS-2D were useful to understand the best strategies toward increasing nutrient

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uptake and reducing nutrient leaching. In this sense, NNO_3- uptakes were higher when fertigation events were more numerous and the amounts applied per event smaller (Ramos *et al*., 2012).

Table 1: Comparative characteristics of crops as sources of bioethanol

Comparative characteristics	Sorghum sugar	Sugar cane	Corn
1	2	3	4
Duration of vegetation, months	4	12	4,5
Irrigation water consumption per ha, m3	4000	36000	8000
Ethanol source	Juice, syrup, grain	Juice, bagasse	Grain, stems
Ethanol yield, l/ha	3160	8900	3220
Cultivation costs,			
USA $ per ha	258	995	287
Ethanol cost price, US $ per 1000 l	81,6	111,7	89,1
Note - The accuracy of the experiment P <5			

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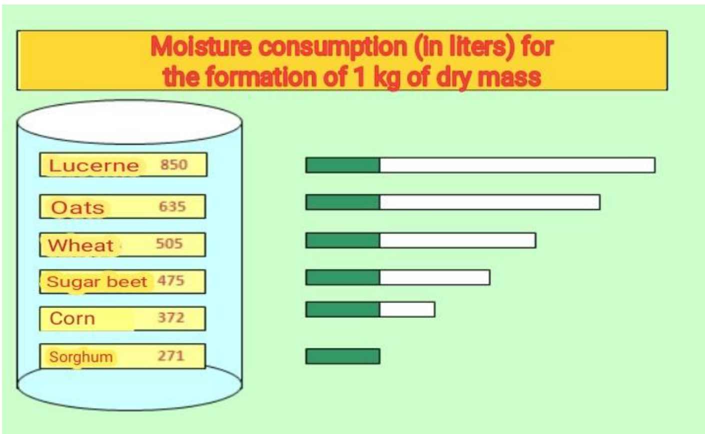

Fig. 1: Sorghum uses water efficiently to form biomass

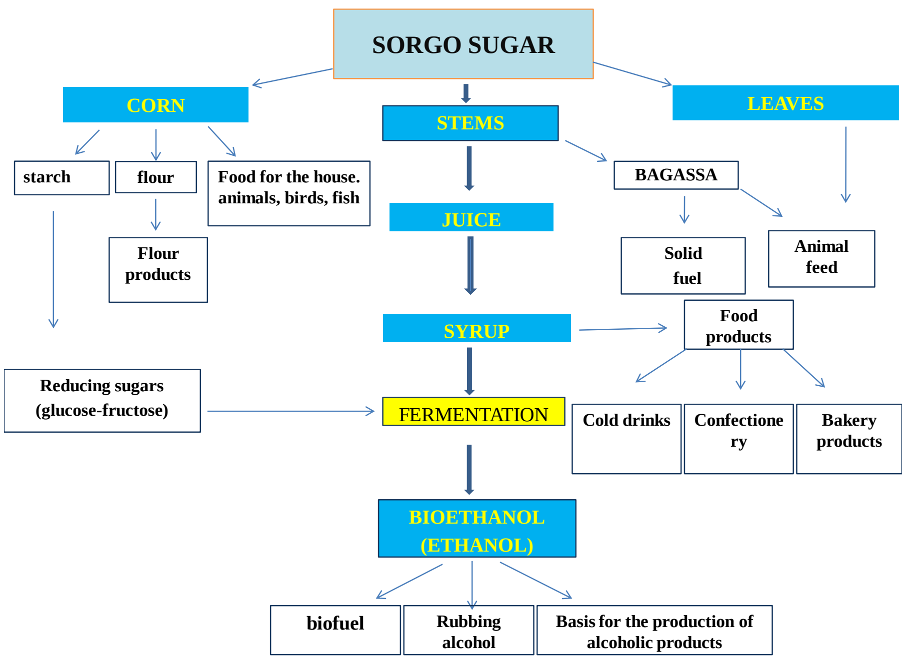

Fig. 2: Integrated use of sugar sorghum

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Materials and Methods

The objects of research were varieties of domestic and foreign selection of Sugar sorghum (Sorghum saccharatum (L) Pers.) - "Kazakhstanskoe -16" and "Kazakhstanskiy-20" "Sudan grass Collective 10" (Kazakhstan), "Orange-160", "Larets", "Alga", "Stavropol-36", "Rostovsky", "Nizkosloe-81", (Russia), "Uzbekistan-18", "Karaboshch" (Uzbekistan), Sugar drip (USA) and others Fig. 3.

In the conditions of field experiments, the features of growth and development, biological productivity of varieties of sugar sorghum were investigated Edited, 1990. Growth biological parameters such as plant height, panicle length, number of nodes, number of lateral shoots, dry biomass of individual organs were studied by measuring and weighing. The definition of the sowing qualities of seeds as the germination energy, the rate of consumption of endosperm reserves and germination were carried out according to the method of.

Vegetation experiments with sorghum were laid in the foothill zone on light chestnut soils, the thickness of the humus horizon is 50 cm with a humus content of 2.7 to 3% on the territory of the Main Botanical Garden of the Institute of Botany and Phytointroduction of the Ministry of Education and Science of the Republic of Kazakhstan.

Brief Description of the Experiment Scheme

The cultivation of domestic and foreign varieties of sugar sorghum in the south-east of Kazakhstan showed that the seeds of the selected varieties germinate in 7-9 days and form normal shoots. This is 2-4 days later than 2017. Later, despite the rather cool and rainy season of 2018 and also the cool and dry season of 2019, the plants went through all stages of growth and development and matured before the onset of the first frosts. The spring-summer period of 2019 turned out to be dry and cool. Obviously, this explains the relatively late emergence of seedlings on the 7th day after sowing.

Crop care and harvesting. Agrotechnical measures for caring for sorghum crops are very similar to caring for corn. Sorghum seedlings are initially weakened due to a lack of endosperm reserves. Therefore, throughout the entire growing season of plants, the sowing must be kept clean from weeds, this is especially important in the first period after the emergence of seedlings (Fig. 4).

For this, light harrowing of the soil must be carried out 4-5 days after sowing. If necessary, this operation can be done again 3-4 days after the first. When a plant height of 15-20 cm is reached, it is important to loosen the soil with hilling plants in a row to strengthen and stimulate root formation. However, it is impossible to keep the field clean from weeds only by mechanical means. Therefore, herbicides "Dual" or "Avangard" are used at the rate of 1.5-2.0 l/ha. This operation is combined with sowing seeds. To ensure the root system of sorghum sprouts, the soil is loosened, especially after watering or rain.

Fig. 3: Collection of varieties of sugar sorghum

Fig. 4: Sowing of sugar sorghum 2019

Results and Discussion

Obtaining Biomass of Sorghum Stalks

Sorghum is a very responsive crop for irrigation, although it is considered drought-resistant. As can be seen from the data in the table, the varieties differed among themselves in terms of the duration of the growing season and growth rates. Phenological observations made it possible to conditionally divide the studied varieties into early ripening (105-112 days), mid-ripening (119-125 days) and late-ripening (132-135 days) ... In terms of plant height, panicle length and the number of internodes and leaves, as well as lateral shoots, the Rostovsky variety was significantly ahead of other varieties in 2018. The biometric parameters of the studied varieties of sugar sorghum are presented in Table 2.

It is known that shoot-forming activity determines the bio productivity of plants. The studied varieties of sorghum bush quite actively, indicating the favorable conditions for plant growth. However, according to the accumulation of biomass in the aboveground organs, the varieties of local selection (Kazakhstanskiy-20 and Kazakhstanskaya -16) were more productive. The varieties Alga and Orange-160 differed in grain productivity. However, the growing conditions in 2014 were more favorable for varieties of domestic (Kazakhstanskaya-20, Kazakhstanskoe-16) and Moldavian (Porumben-4) selection, which were distinguished by the highest biological productivity.

Thus, the sorghum varieties involved in the study of sorghum varieties in the south-east of Kazakhstan (foothill zone of the Zailiyskiy Alatau) for 3 years passed all stages of growth and development and matured before the onset of the first frosts, indicating the possibility of cultivating them in the region. The studied varieties significantly differed among themselves in a number of biological parameters such as the duration of the growing season, growth and development rates, shoot formation, biomass accumulation and their distribution among organs, as well as in the sugar content of the stems, biological and grain productivity (Table 3).

On the basis of the data obtained, it was concluded that the varieties of domestic selection Kazakhstanskaya - 20 and Kazakhstan Score - 16, as well as Porumben - 4, Moldavian selection favorably differ in productivity and sugar content of the stems from other samples (Table 2). The named varieties, as promising, can be recommended for cultivation and inclusion in the breeding process of creating local varieties of this most important crop in the south-east of the republic.

Study of the influence of abiotic factors on physiological and biochemical parameters of varieties of sugar sorghum.

The value of the sorghum crop lies in its ability to endure periods of drought, salinity and high temperatures without much damage to the crop. Plants effectively using the precipitation of the second half of summer, they can start growing after a long dry period and form fairly high yields. These qualities make it possible to grow it in the arid zones of the south of Ukraine, Moldova, Rostov region, Stavropol and Krasnodar regions, Central Asia, in the regions of the Middle and Lower Volga regions, on the saline lands of the Caspian lowland, Kazakhstan and the Republic of the North Caucasus. In order to successfully cultivate and effectively use the sorghum crop, to obtain stable yields, it is necessary to know the biological characteristics of the growth and development of common varieties of sorghum in various ecological environmental conditions.

Influence of environment salinity on some biological parameters of sugar sorghum varieties.

A great advantage of sorghum is its ability to grow on saline and saline soils. This crop is a plant that can withstand an increased concentration of soil solution. Sorghum is able to grow and develop normally when the salt concentration in the soil is twice as high as required by corn. In a model experiment, the effect of various NaCl concentrations on seed germination, seedling formation and biomass accumulation by individual organs under stressful environmental conditions was studied. The results of accounting for germinated seeds of sugar sorghum varieties under salinity (NaCl) conditions after 72 h are presented in Table 4.

Thus, the plants, already during the germination period, reacted negatively to the conditions of salinization of the environment. It can be seen from the data in the table that the salinity of the medium already at a concentration of 0.3% significantly suppresses the process of seed germination. An increase in the salinity of the environment further suppressed the process of seed germination of the studied sorghum varieties. The studied varieties reacted differently to the salinity of the environment. Plants of varieties Rostovskiy and Kazakhstanskaya 20 showed the highest resistance, while Orange160 and Larets showed greater sensitivity to salinity. High salt concentrations, reducing the flow of water into the seeds, suppressed their swelling and metabolism in general. This is evidenced by the data on the consumption of endosperm stocks (Table 5).

As you can see, there is a steady tendency to decrease the consumption of endosperm reserves for the process of seed germination as the salt concentration in the medium increases.

Further, the effect of salinity on the formation of seedlings of varieties of sugar sorghum was studied. The results show that salinization of the environment, first of all, strongly suppresses the growth of roots than of aerial organs. This is evidenced by the data in Fig. 6 and 7, about the accumulation of biomass by 14 day old seedlings under conditions of salinization of the environment. A particularly sharp suppression of root growth was recorded in the Orange 160 variety, which was distinguished by a high sensitivity to salinity, judging by the germination of seeds (Table 6). According to the accumulation of biomass in the aboveground organs, the studied varieties of sugar sorghum reacted weakly to the salinity of the environment. Nevertheless, it can be seen from Fig. 5 and 6 that the accumulation of biomass in them has a dependence on the concentration of salt in the environment.

Data similar to the accumulation of biomass by individual organs of sugar sorghum varieties under conditions of salinization of the environment were obtained from the biometrics of linear indicators of sorghum organs when grown under salinization conditions (Table 6).

From the data in the table it can be seen that even a small concentration of NaCl (0.3%) strongly suppresses the growth of roots in length. However, some of the more resistant varieties (Rostovsky) retained lateral root growth. The greatest suppression of root growth was observed in the Orange 160 variety. The linear growth of aboveground organs is less susceptible to the action of salts.

Under stress conditions, many plants and not only plants, are able to accumulate large amounts of free proline in individual organs.

According to the researchers, proline accumulates due to a disturbance in the metabolism of nitrogen-containing compounds under the influence of a stress factor. This may be the result of hydrolysis of proteins or, conversely, suppression of their synthesis. The formation of free proline is the body's response to adverse environmental conditions. It takes part in the regulation of the osmotic potential of the cell, ensures the structural integrity of functionally active proteins and enzymes, plays an antioxidant role and is a post-stress reserve source of nitrogen and carbon (Panda, 2001).

The study of the effect of salinity on the content of free proline in the aboveground organs of 14-day-old sorghum seedlings showed that NaCl significantly stimulates the accumulation of proline. Moreover, the content of free proline depended on the salt concentration in the medium. The studied varieties of sugar sorghum differed in the accumulation of free proline. The greatest amplitude of fluctuations was observed in the less resistant variety Larets. In the more salt-tolerant cultivar Rostovskiy, the change in proline content was less noticeable (Fig. 7).

Drought Tolerance of Some Varieties of Sugar Sorghum

By the degree of drought resistance and heat resistance, sorghum is one of the outstanding plants due to its special anatomical and physiological structure. These properties are not comparable to any other agricultural crops. Sorghum has a low transpiration coefficient compared to other crops. So, for the formation of a unit of dry matter, sorghum spends 300 parts of water, corn - 388, wheat - 515, sunflower - 895. It is no coincidence that sorghum is popularly called the “camel of the flora” for its high drought resistance. The first signs of economic use of water appear already during the germination period. So, the amount of water for swelling of sorghum seeds is only 35%, corn - 40%, wheat - 60% of its own weight. A characteristic feature of sorghum is the ability to suspend its growth for a while, remaining in anabiotic state until favorable conditions arise. The drought resistance of sorghum is also increased by the fact that during high temperatures, when it sweeps out panicles, a white waxy bloom is released on the leaves and stems, which protects the plants from strong overheating and evaporation. The ratio of some varieties of sugar sorghum to the moisture deficit in the soil was studied in laboratory conditions. Different levels of soil drought from 30 to 60% (PVP) were artificially created by the gravimetric method of daily introduction of water into the growing vessels. On the 30th day, the experiment was stopped and the linear parameters of individual organs, the accumulation of biomass during this period were taken. The statistically processed data are presented in Table 7.

As can be seen, all the studied varieties of sugar sorghum suffered from moisture deficit. This is evidenced by a decrease in the growth of roots and aboveground organs. At the same time, the root system was more susceptible to moisture deficit than the aboveground organs. The biomass of individual organs is an integrative indicator of the effect of drought on plants. Judging by the biomass of the whole organism, the studied varieties reacted differently to moisture deficit. So, for example, the Orange 160 variety reduced its productivity by 50% with a slight deficiency of soil moisture. Among the studied varieties of sugar sorghum, the variety Yantar Early was distinguished by a higher resistance to drought, which maintained a high level of biological productivity in an acute moisture deficit (30%).

In another series of experiments, the drought tolerance of the more drought-tolerant sorghum and the supposedly moisture-sensitive Sudanese grass was studied in a comparative aspect. As expected, the Kazakhstanskaya 20 sugar sorghum showed a unique ability to withstand acute soil moisture deficit compared to Sudan. This is evidenced by the data in Table 8, which presents the results of biological productivity. The loss of sorghum productivity against the background of an acute moisture deficit (20%) was 59%, while that of the Sudanese grass was 83.6%.

In connection with the different reactions of the varieties of sugar sorghum to the deficiency of soil moisture, it was interesting to follow the dynamics of the content of proline in the aboveground organs of plants. Determination of the content of free proline showed that the increasing soil drought promotes the accumulation of amino acids - the protector of the organism's resistance to unfavorable environmental conditions (Table 9).

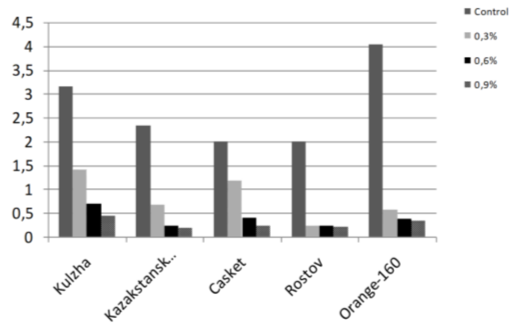

Fig. 5: Influence of NaCl on biomass accumulation by roots of sorghum seedlings, mg/plant

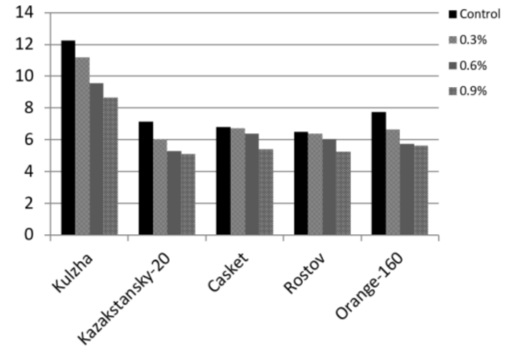

Fig. 6: Influence of NaCl on biomass accumulation by aboveground organs of sorghum seedlings, mg/plant

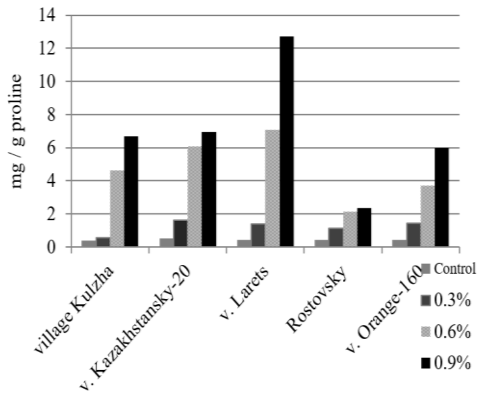

Fig. 7: Influence of different NaCl concentrations on the content of proline in the aboveground organs of sugar sorghum varieties (mg/g fr wt)

Table 2: Biometric indicators of sorghum varieties in the conditions of Almaty region

Variety	Plant height, cm	Broom length ki, cm	Number of internodes, pcs	The number of side shoots, PCS	Panicle weight, g/rast	Mass over terrestrial vegetative organs g/rast
Orange -160	230,0	24.0	11,0	2.0	120,0	812,5
Rostov	235,0	28,0	10,0	2,0	107,5	392,5
Casket	184,0	19,0	10,0	1,0	60,8	327,5
Kazakh-20	246,0	24,7	14,0	2,0	122,5	965,0
Kazakhstan-16	231,7	22,0	12,0	2,0	138,5	940,0
Porumben-4	290,0	24,7	16,0	2,0	67,5	1160,0
Stavropol -36	174,5	29,3	10,0	1,0	112,0	278,3
North	118,0	19,0	11,0	0,0	22,5	127,5
Honey	202,0	33,7	10,0	1,0	127,5	327,5
Fathom	185,7	30,3	13,0	2,0	247,5	652,5
Sugar-32	206,0	18,3	12,0	2,0	102,5	705,0

Note - The accuracy of the experiment P <5

Table 3: Distribution of dry biomass by plant organs of sugar sorghum varieties in % of the total mass

	Varieties							
Plant organs	Amber early	Orange -160	Victoria	Casket	Kulzha	Rostov	Grainy	Boratola
Main escape	22.2	20,3	47,2	60,8	14,4	15,2	48,5	41,2
Side escape	30,3	27,7	4,0	1,2	38,6	48,9	--	--
Common stems	52,5	48,0	51,2	62,0	53,0	64,1	48,5	41,2
Leaves of the main stems	3.8	3,8	9,3	10,4	2.6	2,2	13,0	12,5
Lateral stems	6.2	4,9	1,8	1,1	6,1	9,1	--	---
Common leaves	10,0	8,7	11,1	11,5	8,7	11,3	13,0	12,5
Main panicles	12.0	13,2	24,2	15,8	9,1	6,9	28,4	35,3
Side panicles	10.1	13,8	2,3	--	14,5	5,7	--	---
Common panicles	22,1	27,0	26,5	15,8	23,6	12,6	28,4	35,3
Common aboveground part	84.7	85,2	89,4	89,4	85.4	88,2	89,9	88,9
Roots	15.2	14,7	10,6	10,6	14,6	11,8	10,1	11,1

Note - The accuracy of the experiment P<5

Table 4: Effect of salinity on seed germination of sugar sorghum varieties, in %

Concentration, NaCl, %	Kulzha	Kazakhstanskaya 20	Casket	Rostov	Orange 160
Control	100,0	100,0	100,0	100,0	100,0
0,3	95,1	95,2	91,6	97,3	85,1
0,6	92,4	92,6	75,0	94,6	81,4
0,9	86,4	89,0	72,0	92,3	70,3

Note - The accuracy of the experiment P<5

Table 5: Consumption of endosperm stocks for germination of seeds of sugar sorghum varieties, %

Concentration, NaCl, %	Kulzha	Kazakhstanskaya 20	Casket	Rostov	Orange 160
Control,	100,0	100,0	100,0	100,0	100,0
0,3	93,6	81,3	94,5	88,2	83,2
0,6	89,3	73,9	95,1	88,2	89,6
0,9	89,7	78,1	90,3	88,6	84,7

Note - The accuracy of the experiment P <5

Table 6: Influence of NaCl on the growth of individual organs of sugar sorghum varieties

Concentration, NaCl,%	Root length, cm	% of concentration	Height of the aboveground part, cm	% of control
Kulzha variety				
control	9,65±0,09	100	17,40±0,23	100
0,3 % NaCl	3,35±0,03	34,7	14,85±0,40	85,3
0,6 % NaCl	3,29±0,03	34,1	7,70±0,09	44,2
0,9 % NaCl	3,14±0,14	32,5	6,58±0,00	37,8
grade Kazakhstanskaya-20				
control	6,43±0,69	100	11,53±0,29	100
0,3 % NaCl	3,17±0,02	49,3	7,65±0,19	66,3
0,6 % NaCl	2,81±0,09	43,7	5,56±0,01	47,8
0,9 % NaCl	2,23±0,02	34,7	4,94±0,00	42,8
grade Casket				
control	19,65±0,07	100	12,99±0,34	100
0,3 % NaCl	7,81±0,22	39,7	10,82±0,024	83,3
0,6 % NaCl	6,98±0,06	35,5	6,57±0,18	50,6
0,9 % NaCl	6,98±0,15	35,5	5,23±0,07	40,3
grade Rostovsky				
control	13,63±0,43	100	13,21±0,00	100
0,3 % NaCl	4,94±0,21	36,2	7,33±0,03	55,5
0,6 % NaCl	3,71±0,08	27,2	6,50±0,01	49,2
0,9 % NaCl	3,09±0,04	22,7	5,33±0,02	40,3
grade Orange-160				
control	14,83±0,04	100	17,03±0,17	100
0,3 % NaCl	4,30±0,49	29,0	9,63±0,26	56,5
0,6 % NaCl	4,06±0,07	27,4	8,08±0,11	47,4
0,9 % NaCl	3,11±0,01	21,0	7,12±0,41	41,8

Table 7: Impact of drought on biometric parameters of sugar sorghum varieties

Variety	Humidity,% of PVP	Root length, cm	Shoot height, cm	Dry weight of roots, mg/plant	Dry weight of the aerial part, mg/plant.	Whole plant weight, mg
Early amber	60%	31,1±0,6	58,5±1,7	60,5±2,5	826,5±34,9	887,0
	50%	22,7±0,5	54,5±0,4	56,3±2,0	571,3±7,2	627,6
	40%	17,7±0,1	48,2±0,3	51,8±0,9	433,7±10,6	485,6
	30%	16,9±0,4	45,6±0,3	38,9±0,3	357,1±9,1	396,0
Rostov	60%	24,4±0,3	65,0±2,5	52,2±1,1	1247,9±26,4	1300,2
	50%	20,8±0,1	58,1±0,9	73,8±0,2	691,3±20,2	765,2
	40%	17,1±0,5	55,5±0,5	44,5±0,8	613,1±4,6	657,6
	30%	15,6± 0,1	47,6±1,2	40,7±0,3	292,9±5,9	333,6
Casket	60%	23,7±0,7	47,2±0,1	62,4±1,0	470,5±0,2	532,9
	50%	22,0±0,6	52,3±1,2	52,9±2,3	423,8±6,3	476,7
	40%	18,3±0,2	50,5±0,4	49,5±0,7	403,8±2,2	453,3
	30%	16,2±0,4	39,8±0,2	34,5±0,1	164,6±5,5	199,2
Orange-160	60%	29,9±0,3	57,8±0,8	45,2±0,1	1436,9±11,0	1482,2
	50%	23,3±0,8	54,2±1,2	39,5±0,7	703,5±0,9	743,0
	40%	21,5±0,5	49,6±0,8	37,3±0,3	341,9±3,9	379,2
	30%	17,8±0,3	42,9±0,4	33,5±0,1	301,0±13,2	334,5

Table 8: Comparative assessment of the resistance of sorghum and Sudan grass to drought

Variety	Humidity, % of PVP	Dry biomass of roots, mg/plant	Dry biomass of the aboveground part, mg/plant.	Whole plant dry weight, mg	% of control
Kazakhstanskaya 20	50	24,00±1,10	203,75±0,57	227,80	100
	40	18,65±0,53	170,10±0,40	188,75	82,8
	30	16,20±0,47	83,85±2,08	100,05	43,9
	20	13,90±0,25	79,50±2,30	93,40	41,0
Sudanese grass Kazakhstan-3	50	34,50±1,25	313,50±1,17	348,00	100
	40	18,77±0,48	152,40±7,47	171,17	49,0
	30	16,45±0,23	118,60±3,15	135,05	38,8
	20	8,30±0,35	48,80±0,40	57,10	16,4

Note - The accuracy of the experiment P<5

Table 9: Influence of soil moisture deficit on proline content in aboveground organs of sugar sorghum varieties, mg/g fr wt

	Early amber		Rostov		Casket		Orange 160	
Soil moisture, % of PVP	мг/г	%	мг/г	%	мг/г	%	мг/г	%
60	0,6 ±0,0	100	2,1±0,1	100	0,2±0,0	100	2,2±0,1	100
50	2,3 ±0,1	383	5,3±0,3	249	0,2±0,0	100	2,9±0,0	135
40	5,8±0,2	967	6,4±0,2	303	1,4±0,1	778	3,0±0,3	137
30	6,0±0,3	1000	6,8±0,1	319	1,9±0,1	1056	3,6±0,1	165

From the data in Table 8, it can be seen that varieties of sugar sorghum initially differ in proline content. Sorghum varieties Rostovsky and Orange 160 were significantly richer in proline than Larets. The Yantar early variety occupied an intermediate position. High-proline varieties of sorghum underwent less changes under the influence of increasing drought, while varieties with low proline content showed a sharp increase in its content. However, at this time, there are few statistically reliable experimental data explaining this phenomenological result and its connections with the resistance and/or adaptability of plants to unfavorable environmental conditions.

Influence of heavy metal ions on some physiological and biochemical processes of sugar sorghum varieties.

More than 500 thousand chemical substances enter the Earth's biosphere - products of techno genesis, most of which are accumulated in the soil. A special place among them is occupied by Heavy Metals (HM), which are second only to pesticides in terms of hazard and are significantly ahead of such widely known pollutants as carbon dioxide and sulfur. Due to the existing resource-raw material orientation of the nature management industry, more than 20 billion tons of industrial waste has been accumulated in the Republic of Kazakhstan to date, with an annual intake of about 1 billion tons. Therefore, Kazakhstan, which is one of the ten largest countries in the world community in terms of territory, is currently classified as environmentally vulnerable in all respects. Passing from soil to plants and passing along food chains,

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HMs have a toxic effect on plants, animals and humans. Considering the above, the study of the influence of HMs on sorghum plants, which is a promising food, fodder and industrial crop due to its high productivity and resistance to unfavorable factors, should be attributed to an urgent problem. The work studied the effect of the most common HMs - Cu, Zn, Cd on seed germination, seedling formation, biomass accumulation and free proline content in seedlings of sugar sorghum varieties of domestic and foreign selection in order to identify the samples most resistant to the stress factor. Cadmium, already at a concentration of 2 mg/L, strongly suppressed the growth of sorghum seedlings. It was particularly effective in inhibiting root formation. At a HM concentration of 8 mg/L, root formation was completely absent in all studied sorghum varieties. Variety Larets showed high sensitivity to cadmium. At the lowest concentration (2 mg/L), the variety lost its ability to form roots. The absence of roots obviously made it difficult for HM to enter the aboveground part. This can explain the relatively vigorous growth of aboveground organs in comparison with other varieties (Table 10).

Similar data were obtained on the accumulation of biomass by sugar sorghum seedlings (Table 11).

Thus, the most abundant heavy metal, cadmium, had a strong toxic effect on plants from the very beginning of the growth of varieties of sugar sorghum. Sugar sorghum varieties reacted differently to the action of HM. The absence of a root allowed s. The casket successfully resists the toxic effects of cadmium. The suppression of growth processes under the influence of cadmium was the result of ineffective use of endosperm reserves for the formation of seedlings.

Zinc, as well as cadmium, strongly suppressed the process of root formation of seedlings. Root formation is observed only in the Rostovsky variety at low and medium doses of metal (Table 12).

To the action of zinc, p. Orange 160, while c. Rostovsky was the most resistant in comparison with other varieties. Thus, data were obtained indicating the variety-specific effect of heavy metals on the example of varieties of sugar sorghum. If c. Orange 160, then the action of zinc was more resistant to. Rostov.

Copper, at a concentration of 5 mg/L and higher, completely suppressed root formation in all studied sorghum varieties (Table 13).

Judging by the growth of the aboveground organs, the villages of Orange 160 and Casket are more resistant to the action of copper. However, according to the accumulation of biomass in them, p. Rostovsky and Kulzha are less susceptible to the toxic effects of copper (Table 14).

For the same indicator, p. Kazakhstan 20 is the most sensitive to the toxic effects of copper. Summing up the results of studying the influence of heavy metals on the growth of seedlings of varieties of sugar sorghum, we can conclude that heavy metals such as Cd, Zn, Cu have a toxic effect on plants from the beginning of their germination. Moreover, the toxicity of their action differs from each other. HMs suppress the process of root formation, reduce the efficiency of using endosperm reserves, inhibit the growth and accumulation of biomass by individual organs. The cultivars react differently to certain heavy metals, showing the cultivar specificity to the action of HM.

Table 10: Influence of cadmium on the growth of seedlings of varieties of sugar sorghum in% to control

	Kulzha		Kazakh 20		Casket		Rostov		Orange 160	
Concen tradition, Cd, mg/l	roots	stems	roots	stems	roots	stems	roots	stems	roots	stems
2,0	11	64	16	63	0	99	50	75	37	96
4,0	0	57	7	32	0	80	0	55	6	40
8,0	0	40	0	26	0	46	0	18	0	38

Note - The accuracy of the experiment P<5

Table 11: Influence of cadmium on the accumulation of dry biomass by individual organs of sugar sorghum seedlings in % to control

Концен трация, Cd, мг/л	Kulzha		Kazakh 20		Casket		Rostov		Orange 160	
	roots	stems	roots	stems	roots	stems	roots	stems	roots	stems
2,0	28	87	41	89	0	84	67	79	48	95
4,0	0	75	0	62	0	80	0	65	0	78
8,0	0	65	0	51	0	60	0	44	0	64

Note - The accuracy of the experiment P<5

Table 12: The effect of zinc on the accumulation of dry biomass by individual organs of sugar sorghum seedlings in % to control

Concen tradition, Zn, mg/l	Kulzha		Kazakh 20		Casket		Rostov		Orange 160	
	Roots	Stems	Roots	Stems	Roots	Stems	Roots	Stems	Roots	Stems
50	0	88	0	86	0	76	39	94	0	43
100	0	61	0	51	0	65	21	87	0	33
200	0	40	0	45	0	35	0	66	0	25

Note - The accuracy of the experiment P <5

Table 13: Influence of copper on the growth of sugar sorghum seedlings in% to control

Concentration, Cu, mg/l	Kulzha		Kazakh 20		Casket		Rostov		Orange 160	
	Roots	Stems	Roots	Stems	Roots	Stems	Roots	Stems	Roots	Stems
5,0	0	52	0	49	0	78	0	51	0	76
10,0	0	27	0	35	0	62	0	44	0	50
20,0	0	21	0	19	0	33	0	24	0	49

Note - The accuracy of the experiment P<5

Table 14: Influence of copper on the accumulation of dry biomass by individual organs of sugar sorghum seedlings in % to control

Concen tradition,	Kulzha		Kazakh 20		Casket		Rostov		Orange 160	
Cu, mg/l	Roots	Stems	Roots	Stems	Roots	Stems	Roots	Over Land	Roots	Over land
5,0	0	99	0	83	0	79	0	99	0	76
10,0	0	80	0	65	0	68	0	95	0	61
20,0	0	73	0	49	0	68	0	72	0	59

Note - The accuracy of the experiment P<5

Conclusion

The studied varieties of sugar sorghum reacted differently to the action of the stress factor. The cultivars for resistance to environmental salinity showed that NaCl inhibits seed germination, growth and accumulation of biomass by individual organs. The studied cultivars reacted differently to salt stress, showing high sensitivity or resistance to the stress factor. Resistance to environmental salinization, cultivar Rostovsky of Russian selection and Kazakhstanskaya 20 of domestic selection.

Based on the results of studying the effect of heavy metals on the growth of seedlings of varieties of sugar sorghum, it can be concluded that heavy metals such as Cd, Zn, Cu have a toxic effect on plants from the beginning of their germination. Moreover, the toxicity of their action differs from each other. HMs suppress the process of root formation, reduce the efficiency of using endosperm reserves, inhibit the growth and accumulation of biomass by individual organs. The cultivars react differently to certain heavy metals, showing the cultivar specificity to the action of HM.

All this is a serious basis for the diversification of crop production in the Republic of Kazakhstan, the search and identification of the most drought-resistant, heat-resistant, salt-tolerant and at the same time highly productive crops to meet the needs of the food, feed industries and alternative renewable energy in the new emerging environmental conditions in the south and south east of the republic.

Author's Contributions

Mukasheva Danagul: Participated in all experiments, coordinated the data - analysis and contributed to the writing of the manuscript.

Kirshibayev Yerlan Ahmetkalievich, Baiseitova Gulnaz, Orazbayev Adilkhan and Admanova Gulnur: Designed the research plan and organized the study.

Ethics

This article is original and contains unpublished material. The corresponding author confirms that all of the other authors have read and approved the manuscript and no ethical issues involved.

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