УДК 581.5
МРНТИ 68.01.94
DOI 10.37238/2960-1371.2960-138X.2025.98(2).91

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# ECOLOGICAL TESTING OF VARIETIES AND HYBRIDS OF SUGAR SORGHUM IN ADRID CONDITIONS OF AKMOLINA REGION

**Annotation**. The article discusses the prospects for expanding acreage for sugar sorghum in the northern regions of Kazakhstan. Its biological features are described, including drought resistance, the ability to restore vegetation after long periods without consequences, and high biomass productivity. The key agrotechnical problems are highlighted, such as the weak competitiveness of crops in the region with weeds and the requirements for sowing technologies. Special attention is paid to the consequences of the emergence of new varieties and hybrids of sugar sorghum, as well as the use of soil herbicides and early sowing dates to increase yields.
**Keywords:** Sugar Sorghum; agro-climatic conditions; drought resistance; productivity; variety testing.

## *Introduction*

In connection with the differentiation of agricultural production in the northern regions of Kazakhstan, commodity producers are showing increased interest in expanding the area under sugar sorghum, which in recent past was considered a rare crop in the region [1].

A valuable biological feature of sugar sorghum is the ability to withstand periods of drought and high temperatures without much damage to the crop, effectively use precipitation in the second half of summer, intensively renew the growing season after a long period without rain and form biomass yields of up to 80-100 c/ha of absolutely dry matter, with the amount of precipitation is 200-250 mm during the growing season [2-4].

Specific weather and soil features (constant wind activity, seasonality of precipitation, rapid increase in positive temperatures in spring, soil tendency to erosion) were a limiting factor for the expanded introduction of sugar sorghum in this region. Sorghum, like all small-seeded crops, requires shallow planting depth when sowing, and its seeds are not adapted to the rapid drying out of the top layer of soil [5, 6]. Previously recommended technologies do not provide reliable protection of sugar sorghum crops from weeds, for which it has poor competitiveness, since it grows slowly in the first half of summer.

Improving the means and methods of weed control and new technical solutions in the system of sowing machines are opening up new opportunities for realizing the potential productivity of sugar sorghum in the conditions of this agricultural zone. This creates the need to clarify their effectiveness in relation to zonal conditions. With the advent of reliable protection of seeds from the influence of external factors during their germination, as well as in connection with the introduction of soil herbicides into production, it became possible to clarify the effectiveness of early sowing dates. This opens up the prospect of using the active temperatures of the early spring period, which is of significant importance in conditions of a short summer [7-10].

Significant breeding successes have been achieved in the creation of new varieties of sugar sorghum and sorghum-sudan hybrids. As a result, a comparative assessment of them is required, highlighting the most promising ones for the conditions of the hilly-plain steppe. In this regard, the issues of improving agricultural techniques aimed at realizing the potential productivity of sugar sorghum in the conditions of this agricultural zone are relevant [11].

According to researchers, the cultivation area of sugar sorghum depends on the early maturity and agroclimatic resources of a particular agricultural zone. It has been established that in different zones of the region, not all varieties or hybrids have time to ripen to mowing ripeness. The most late-ripening of them stop the assimilation process under the influence of early autumn frosts, without reaching the maximum average daily increase in biomass, that is, their optimal mowing period. Therefore, the initial task of introducing sugar sorghum within a particular agricultural zone should be to determine the type of early maturity acceptable for it [12-15].

To establish the area of possible cultivation of different types of early ripening sugar sorghum, it was necessary to determine the maximum period of biomass accumulation, the required amount of heat for different varieties for ripening and the likelihood of favorable years for obtaining mowing ripeness in individual agricultural zones [16].

The creation of sugar sorghum hybrids approved for use in production in the northern regions of Kazakhstan has its own regional characteristics. They are created in the south of the republic, as a rule, on the basis of mid- and late-ripening lines that are part of the parent forms, the seeds of which cannot be obtained in short summer conditions. Therefore, in Northern Kazakhstan it is necessary to conduct environmental tests and select the most promising varieties and hybrids according to a scientifically based model [17, 18].

It seems to us that field germination should be included among the parameters that characterize a promising hybrid model. According to a number of researchers who studied the productivity of sugar sorghum in the northern regions of Kazakhstan and neighboring Western Siberia [19-24], field germination varied depending on the spring temperature within significant limits.

Sugar sorghum in the northern regions of Kazakhstan is cultivated mainly for silage. Therefore, the requirements for promising hybrids are similar to other crops. In the production conditions of this region, the most valuable indicators are: early maturity, drought resistance, high productivity, sugar content in cell sap of at least 15%, increased initial growth of biomass.

In Northern Kazakhstan, where in many agricultural zones the sum of active temperatures is in the range of 19000...2200 °C, hybrids and varieties approved for use manage to ripen to milky-waxy ripeness only in certain years [25]. In years with the onset of early frosts at the end of August, sugar sorghum stops its development at earlier stages and is therefore inferior in yield to other crops. In addition, when harvested in the early stages of development, the plant mass of sugar sorghum contains an increased content of cell sap, and the concentration of dry matter does not reach the standard level (at least 25%) required to obtain silage of the first quality class [26].

Consequently, the main parameters when selecting promising hybrids should be determined by early maturity, which, along with productivity, is the main indicator.

A new direction in sugar sorghum breeding, based on the creation of hybrids instead of varieties and the use of the heterosis effect, involves the annual production of hybrid seeds to take advantage of first-generation heterosis. The creation of hybrids for the northern regions of Kazakhstan has its own specifics and consists in combining the characteristics of precocity and productivity in the resulting hybrids.

Signs of precocity can be formed in hybrids by acquiring the properties of Sudanese grass, the seeds of which can be obtained even in short summer conditions. In contrast, hybrids can inherit traits of high productivity only from the most productive parental forms of sugar sorghum. For them, varieties of sugar sorghum are selected, which belong to the early ripening types with a growing season of more than 120 days. Therefore, it is impossible to create hybrids for the northern regions in short summer conditions. They are working on their creation at the selection center of the Kazakh Research Institute of Agriculture and Plant Growing [27-30].

In turn, the results of studies on early ripening and productivity will be reliable if they are carried out under short summer conditions.

Based on the above, we believe that the full characteristics of a particular hybrid can be obtained only after 2...3 years of testing in the conditions of the northern regions for which they were created. A systematic comparative assessment of them, the so-called “ecological test” should be carried out in the conditions of Northern Kazakhstan at the zonal level and with the mandatory inclusion of standards from leading centers of the near and far abroad [31-34].

*Research methods*

The meteorological conditions that developed during 2015-2017 made it possible to study the patterns of formation of the sugar sorghum crop under the influence of various climatic factors, including those of an extreme nature. At the same time, hydrothermal conditions, in accordance with Figures 1 and 2, were generally typical for the climatic characteristics of the steppe and slightly deviated from the long-term average values.

The climate of the hilly-plain steppe is characterized by sharp continentality with a late return of spring frosts and an early onset of sub-zero temperatures in August. The duration of the frost-free period is 95-100 days with the sum of active temperatures up to 2200 °C. The average long-term sum of temperatures above +30 °C is 364 °C .

The soil of the experimental field is represented by southern carbonate chernozem of heavy loamy mechanical composition. The thickness of the humus horizon (A+B1) is in the range of 50-55 cm, the humus content is 4.41%, gross nitrogen - 0.23%, gross phosphorus - 0.12%.

During the research period, the earliest onset of frosts, after which sugar sorghum stopped its development, was observed in 2015 and 2016, respectively, on August 28 and 26. The lowest amount of active temperatures was in 2003, which was characterized by an average frost-free period, but insufficient solar activity. This year there were no occurrences of dry winds, as in 2016, when during July and August the air temperature did not rise above +240...+270 °C. Active solar radiation and the manifestation of dry winds were in 2017, where the sum of temperatures above +300 °C reached 420 °C with a long-term average level of 3640C.

In terms of water regime conditions, the years of research also differed from each other. During 2017, 2016, 2017, precipitation fell above the long-term average, which is 66% of years. The years 2015 and 2017 were acutely dry, or 27% of the years, when precipitation in July was 25-30% below the long-term average level, and the period without rain was 25 days (2015) and 38 days (2017).

There were relatively small fluctuations in the level of productive moisture reserves before sowing. Deviations from the long-term average level varied within +14%...+15%, which indicates timely implementation of snow reclamation. The smallest pre-sowing reserves of productive moisture were in 2004 and amounted to 92.9 mm. At the same time, this amount was sufficient to obtain vigorous shoots and to form a root system.

Consequently, the experiments were carried out on typical zonal soils of the hilly-plain agricultural zone. According to the state of the water regime, years favorable in terms of moisture accounted for 66.0% of years, dry years - 34%. In terms of the duration of the frost-free period, years with short summers accounted for 40% of the years and with an average long-term level of active temperatures – 20% of the years. Therefore, there is every reason to believe that the research period (2002-2206) included various weather conditions, including those of an extreme nature. This made it possible to more fully study the patterns of yield formation of sugar sorghum.

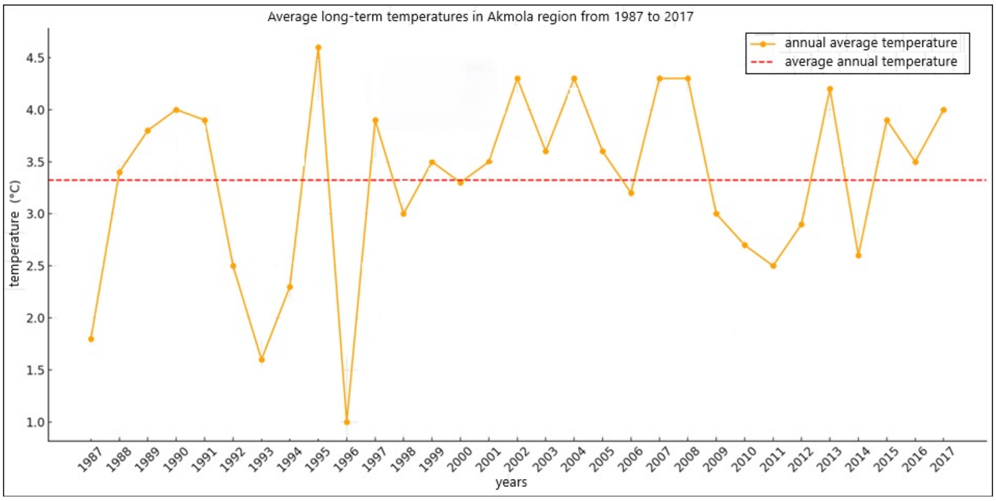


Figure 1 - Temperature regime during the growing season of sugar sorghum

The relatively average multi-year temperature of the climate (1987-2017) is 3.3 °C. In 2015, the average annual temperature was 3.9 °C, in 2016 it was -3.5 °C, and in 2017 it was 4.0 °C.

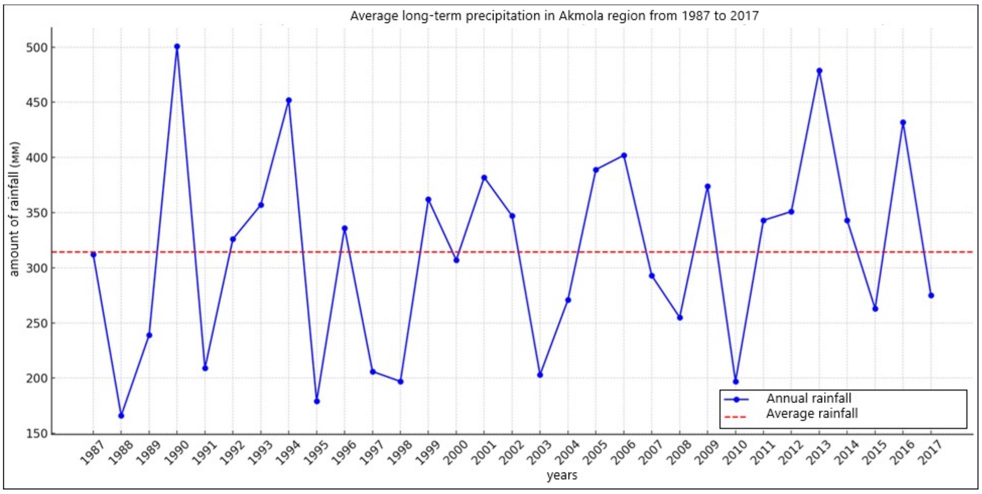


Figure 2 - Main characteristics of the water regime during the research period

Table 1 - Temperature conditions during the study period, $^0$C

| Months | Average long-term value (1987-2017 y.) | The year under study | | |
|---|---|---|---|---|
| | | 2015 | 2016 | 2017 |
| January | -14.42 | -12.5 | -17.8 | -12.3 |
| February | -13,4 | -10.2 | -7.4 | -13.0 |
| March | -6,1 | -5.9 | -2.2 | -5.4 |
| April | 4,7 | 4.5 | 8.6 | 5.6 |

| | | | | |
|---|---|---|---|---|
| May | 13.4 | 14.6 | 13.1 | 13.8 |
| June | 19.2 | 20.8 | 17.5 | 19.5 |
| July | 20.1 | 19.2 | 19.1 | 18.8 |
| August | 18.5 | 16.5 | 20.0 | 19.4 |
| September | 12.3 | 11.5 | 13.5 | 11.6 |
| October | 4,3 | 2.9 | 0.4 | 2.8 |
| November | -6.2 | -8.3 | -10.0 | -1.8 |
| December | -11.0 | -6.1 | -12.9 | -10.7 |

Table 2 - Humidification conditions during the study period, mm

| Months | Average long-term value (1987-2017 y.) | The year under study | | |
|---|---|---|---|---|
| | | 2015 | 2016 | 2017 |
| January | 13,7 | 10 | 20 | 13 |
| February | 10,9 | 10 | 13 | 13 |
| March | 13,2 | 8 | 19 | 19 |
| April | 18,3 | 9 | 17 | 17 |
| May | 27,3 | 43 | 34 | 34 |
| June | 40,2 | 17 | 51 | 51 |
| July | 73,4 | 40 | 49 | 49 |
| August | 61,7 | 24 | 9 | 9 |
| September | 28,5 | 15 | 9 | 9 |
| October | 33,7 | 43 | 35 | 35 |
| November | 19,6 | 28 | 18 | 18 |
| December | 15,1 | 16 | 8 | 8 |

Research on the development of basic methods for cultivating sugar sorghum in the steppe zone of the Akmola region was conducted in 2015–2017.

The experiments were laid out in accordance with the requirements of the field experiment methodology [223], and the guidelines of the All-Russian Research Institute of Fodder [224]. The plot area was 200-350 m2, the repetition was three- and four-fold, the placement of the plots was standard in the experiments of the ecological test and randomized in other field experiments.

The plot area is 350 m2, the plots are standardly placed, the sowing method is wide-row with 70 cm row spacing, the seeding rate is 100 thousand seeds per 1 ha, the experiment is repeated three times. The experiment was carried out in the period 2015-2016.

The experiment was laid out in a grain-fallow crop rotation, the predecessor in the experiment was the first wheat after fallow. Sowing of sugar sorghum was carried out in the studied periods in the second ten-day period of May on plots with a row spacing of 70 cm and a seeding rate of 100 thousand viable seeds per 1 ha. The plot area is 42 m2.

Object of the study. In the experiments, hybrids of sugar sorghum were sown - Tsunami 85, Stavropolskoe 36, Kamyshinskoe 8, Kaskelenskiy 1, Kazakhstanskiy 1, Alma-Atinskiy 81, Kolektivny 10. The Tsunami 85 variety was taken as the control variant.

In our studies (Table 3), the Tsunami 85 hybrid provided the highest average daily growth during 2015-2017, starting from the heading phase, and reached its maximum in the milk ripeness phase.

Table 3 – Dynamics of green biomass yield increase of sugar sorghum under drought cinditions in the steppe of the Akmola region.

| Accounting date | Development phase | Average mass per plant, g | Biological yield | |
|---|---|---|---|---|
| | | | t/ha | % of maximum |
| 2015 | | | | |
| June 11 | 5th leaf | 38,6 ± 7,8 | 37,6 | 15,5 |
| June 30 | 7th leaf | 90,7 ± 19,0 | 86,1 | 35,6 |
| July 15 | 10th leaf | 182,6± 24,3 | 173,6 | 71,8 |
| July 31 | Heading | 200,4 ± 24,3 | 190,3 | 78,8 |
| August 20 | Grain formation | 221,3 ± 36,2 | 210,2 | 87,1 |
| August 31 | Milk ripeness | 254,0 ± 19,6 | 241,3 | 100,0 |
| 2016 | | | | |
| June 15 | 5th leaf | 58,5 ± 10,0 | 55,5 | 18,9 |
| July 5 | 7th leaf | 108,4 ± 21,0 | 102,9 | 35,0 |
| July 24 | 10th leaf | 214,6 ± 36,6 | 203,8 | 69,4 |
| August 3 | Heading | 238,1 ± 46,7 | 226,6 | 77,1 |
| August 23 | Grain formation | 276,4 ± 36,1 | 252,5 | 86,4 |
| September 5 | Milk ripeness | 308,1 52,4 | 293,6 | 100,0 |
| 2017 | | | | |
| June 10 | 5th leaf | 60,8 | 57,7 | 15,9 |
| June 27 | 7th leaf | 121,6 ± 17,0 | 193,8 | 53,6 |
| July 13 | 10th leaf | 204,0 ± 32,5 | 243,8 | 67,9 |
| July 28 | Heading | 255,6 ± 40,0 | 243,8 | 67,9 |
| August 13 | Grain formation | 291,0 ± 56,4 | 276,4 | 76,5 |
| August 26 | Milk ripeness | 337,6 ± 52,6 | 325,7 | 90,0 |
| September 9 | Milk-wax ripeness | 380,2 ± 70,5 | 361,2 | 100,0 |

Calculations indicate that during the grain formation phase in 2015, the average daily yield increase was 101 kg/ha per day, rising to 103 kg/ha in 2016, and 200 kg/ha in 2017. During the milk maturity phase, the biomass accumulation continued and reached, respectively, amounting to 280 kg/ha, 290 kg/ha and 370 kg/ha per day in 2015, 2016, 2017. The Tsunami 85 hybrid reached the milk-wax maturity phase under 2017 conditions, when the first autumn frost occured on September 9, 15 days later than the long- term average date. However, biomass accumulation in the phase of milk-wax maturity phase was lower compared to the previous period. Therefore, it can be assumed that the milk-wax maturity phase contributes the highest yield of sugar sorghum under the conditions of the steppe zone.

Nevertheless, under these conditions, the Tsunami 85 hybrid does not accumulate sufficient active temperatures to reach annually the milk-wax maturity phase. The agrometeorological resources of this agricultural zone are more suited for cultivating the earliest maturing types of sugar sorghum.

Consequently, the duration of the maximum yield accumulation period in any given year depends on the number of frost-free days in the second half of summer, i.e., the date of the first autumn frost. Hence, the earlier the plants reach the heading phase, the longer their period of maximum daily yield growth and the higher their yield in local conditions. Under short-summer conditions mid-early sugar sorghum varieties and hybrids, despite their high potential field, are concede to early-maturing varieties in actual yield.

Currently, the cultivation of sugar sorghum necessitates a differentiated approach to selecting varieties and hybrids of varying maturity types, based on the agro-climatic resources of each agricultural zone. However, the application of different maturity types is complicated by varying approaches to defining these concepts. In the literature, in various recommendations and agricultural practices, there is a range of opinions on the classification of maturity types; which are based either on the number of days or on the sum of effective temperatures for individual periods.

We propose that the maturity type is determined by the sum of active temperatures. For sugar sorghum, they are above +10$^{o}$C. This should exclude the "sowing to emergence" period, which depends not only on temperature but also on other factors and can vary for the same variety under different weather conditions.

In relation to the conditions of agricultural zones in Northern Kazakhstan, the following classification can be considered acceptable (Table 4).

Table 4 – Classification of sugar sorghum by maturity types

| Maturity types | Number of Leaves on the Main Stem, pcs | Sum of Temperatures During the "emergence to milk maturity" Period, °C | | Permitted Hybrid (Variety) |
|---|---|---|---|---|
| | | Active (above +10°C) | Effective | |
| Early maturing | Up to 9 | 1900…2000 | Up to 500 | - |
| Mid-early | 9…10 | 2000…2300 | 510…550 | Kinelyskoe 3 |
| Mid-maturing | 11…14 | 2300…2500 | 560…600 | Alma-Atinsky 81 |
| Mid-late | 15…18 | 2500…2800 | 610…650 | Ranniy Yantar 161 |

Table 4 shows 4 types of precocity. For late-maturing types, the required sum of active temperatures exceeds the agro-climatic resources of Northern Kazakhstan.

It should be noted that the classification presented in the table is relative. Firstly, with advances in sugar sorghum breeding and the possibility of replacing approved varieties, hybrids or hybrid populations with more advanced ones. Secondly, it has been developed specifically for the conditions of all agricultural zones, including the dry and semi-arid steppe of Northern Kazakhstan. According to our data, during the 2015-2017, an average of 130-156$^{o}$ C of active temperatures were required for the formation of each successive leaf, provided the soil moisture in the root zone remained at 60–70% of field capacity.

*Research results*

Consequently, in the northern regions of Kazakhstan, the cultivation sugar sorghum varieties is promising, requiring from 1900 to 2500$^{o}$ C of active temperatures to reach silage ripeness. These varieties are classified by maturity types as early-maturing, mid-early, mid-maturing and mid-late. Other varieties with longer vegetation periods exceed the agro-climatic resources of this region. However, such a classification by maturity types does not provide a complete understanding of the potential cultivation range of a particular variety. By calculating the sums of active temperatures (above +10°C) for each specific agricultural zone and analyzing the number of years with deviations in either direction, it is possible to estimate the probability (% of years) of different maturity types reaching silage ripeness in a given agricultural zone.

To characterize agricultural zones in terms of active temperatures above +10°C, including within the frost-free period, the thermal conditions were analyzed during the 1987–2017 period (Figure 3). Considering that sums of active temperatures can vary in individual years, it can be stated that the probability of sugar sorghum reaching optimal silage ripeness may accordingly differ. Based on ecological trials conducted at variety testing sites in Northern Kazakhstan (Appendix A) during 1991–1993, the active temperatures were calculated for varieties and hybrids of different maturity. As a result of agro-climatic zoning of agricultural areas in Northern Kazakhstan, it was established that in the forest-steppe zone of North Kazakhstan and Kostanay regions, sugar sorghum reaches silage ripeness in 50–75% of years. However, as seen in Table 2, its yield at earlier maturity phases amounts to 67.1–78% of the yield at the silage ripeness phase.

In the moderately arid zone, the probability of achieving silage ripeness increases to 80–85% of years, but primarily for mid-early varieties. These varieties have higher potential yields compared to early-maturing ones. In the dry steppe zone, the probability of sugar sorghum reaching the milk maturity phase reaches 95–100% for mid-early varieties. Under these conditions, with annual precipitation during the warm season not exceeding 200 mm, sugar sorghum can occupy a dominant position in yield among other silage crops.

Therefore, the main condition for choosing a cultivation area for different maturity types of sugar sorghum is the correspondence of the sum of biologically active temperatures necessary for ripening to sloping ripeness and agro-climatic resources, taking into account the probability of favorable years.

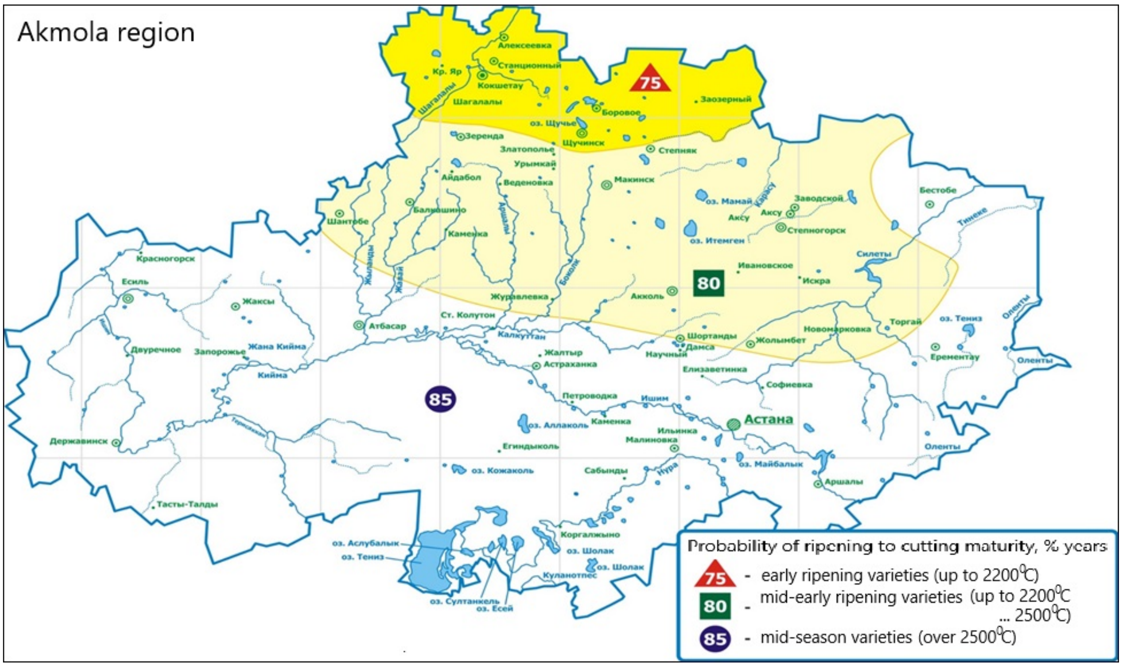


Figure 3 – Agro-climatic zoning of sugar sorghum varieties by maturity types
(Kostikov I.F., Tynykylov M.K:)

In our studies, it was found that the correlation coefficients between soil temperature at the seed planting depth and field germination indicate a strong relationship between these traits, especially during the "sowing to emergence" period (r=0,92±0,8). Rapid increases in air and soil temperature during the spring are typically interspersed with equally abrupt, albeit short-term, cold spells. Therefore, in the hilly-plain steppe, where the rugged terrain contributes to significant daily temperature fluctuations, particularly in the spring, it is crucial to select promising hybrids not only based on maturity type but also for their resilience to variable temperatures. Overall, all agricultural zones in the region can be differentiated for sugar sorghum cultivation based on the sum of active temperatures (Table 5).

Table 5 – Biological parameters of promising silage-purpose sugar sorghum hybrids

| Technological Parameters | Measurement unit | Agricultural Zones with Sum of Active Temperatures | |
|---|---|---|---|
| | | up to 2300°C | above 2300 $^0$C |
| Field germination | % | > 80 | > 60 |
| Number of leaves on the main stem | pcs | Up to 10 | Above 10 |
| Productive tillering | | 1,5…2,0 | 1,5…2,0 |
| Duration of the "emergence to milk maturity" period | Days | 100…105 | 106…115 |
| Sugar content in cell sap | % | 13…15 | 14…15 |
| Yield of absolutely dry matter | g/ha | > 50 | > 70 |

For agricultural areas where the sum of active temperatures does not exceed 2300 $^0$C during the growing season, it is possible to cultivate only early-maturing hybrids. Practice shows that hybrids of the precocious type yield up to 45-50 kg /ha in terms of absolutely dry matter. In selecting late-maturing samples, the lower productivity limit is 70 c/ha of absolutely dry matter. Other parameters depend on the maturity type, including the number of leaves on the main stem.

In our studies, it was found that the formation period of each successive leaf corresponds to temperatures sum of 170-156 0C with soil moisture levels of 70... 60% of the total field moisture capacity. Therefore, the duration of maturation to silage ripeness is directly related to the number of leaves.

Table 6 presents the results of accounting for yields for those hybrids that were at or above the standard.

Table 6 – Yield of Sugar Sorghum Varieties and Hybrids in the Steppe Zone of Northern Kazakhstan, q/ha.

| Variety, Hybrid | Research Period, Year | | | | | |
|---|---|---|---|---|---|---|
| | 2002 | 2003 | 2004 | 2005 | 2006 | 2002-2006 |
| Tsunami 85 (St) | 305,8 | 324,1 | 354,2 | 324,5 | 330,5 | 330,1 |
| Stavropolskoye 36 | 279,0 | 304,5 | 322,7 | 333,0 | 314,0 | 310,6 |
| Kamyshinskoye 8 | 294,2 | 330,3 | 340,5 | 355,6 | 370,8 | 338,2 |
| Kaskelensky 1 | 327,5 | 387,0 | 379,0 | 409,0 | 370,8 | 374,6 |
| Kazakhstansky 1 | 430,7 | 485,3 | 449,2 | 465,9 | 466,4 | 459,6 |
| Alma-Atynsky 81 | 300.0 | 312,2 | 244,7 | 367,7 | 369,4 | 338,8 |
| Kollectivnyi 10 | 419,3 | 461,3 | 383,0 | 424,3 | 410,5 | 419,7 |

| | | | | | | |
|---|---|---|---|---|---|---|
| $HCP_{05}$ | 31,3 | 24,0 | 41,9 | 45,0 | 51,9 | |
| $S_{\bar{x}}$, % | 3,9 | 3,9 | 3,6 | 4,1 | 5,0 | |
| In terms of absolute dry matter | | | | | | |
| Tsunami 85 (St) | 52,0 | 56,8 | 60,2 | 64,9 | 66,1 | 60,0 |
| Stavropolskoye 36 | 61,4 | 67,0 | 71,0 | 76,6 | 78,5 | 70,9 |
| Kamyshinskoye 8 | 62,9 | 68,7 | 73,5 | 77,9 | 81,0 | 72,8 |
| Kaskelensky 1 | 65,5 | 71,6 | 75,8 | 81,8 | 85,3 | 76,0 |
| Kazakhstansky 1 | 50,4 | 55,0 | 58,4 | 62,9 | 65,3 | 58,4 |
| Alma-Atynsky 81 | 51,0 | 56,2 | 58,6 | 66,2 | 66,5 | 59,7 |
| Kollectivnyi 10 | 62,9 | 69,2 | 72,8 | 78,5 | 82,1 | 73,1 |
| $HCP_{05}$ | 3,8 | 10,8 | 9,6 | 6,7 | 7,6 | |
| $S_{\bar{x}}$, % | 3,2 | 4,1 | 4,6 | 3,9 | 4,8 | |

The Kaskelensky hybrid 1 stands out in terms of yield, which was the most precocious among the hybrids of Kazakh breeding. In the conditions of the hill-plain steppe, the period of maximum biomass growth began earlier than in other hybrids and was longer. However, a more complete picture is provided by comparing hybrids in different weather periods (Table 7).

Table 7 – Variation in the sugar sorghum hybrids yield in different weather periods

| Hybrid | Deviation in Yield of Absolute Dry Matter, q/ha | | | |
|---|---|---|---|---|
| | from the standard | | from the average yield for 2002-2006 years. | |
| 2015 year | | | | |
| Tsunami 85 (St) | - | - | -8,0 | -13,3 |
| Kamyshinskoye 8 | 10,9 | 20,9 | -9,0 | -12,5 |
| Kaskelensky 1 | 16,5 | 31,7 | -8,1 | -10,5 |
| Kollectivnyi 10 | 10,9 | 21,0 | -10,4 | -14,2 |
| 2016 year | | | | |
| Tsunami 85 (St) | - | - | -3,2 | -5,3 |
| Kamyshinskoye 8 | 11,9 | 21,3 | -3,2 | -4,4 |
| Kaskelensky 1 | 14,8 | 26,0 | -5,0 | -6,3 |
| Kollectivnyi 10 | 12,4 | 21,8 | -3,9 | -4,9 |
| 2017 year | | | | |
| Tsunami 85 (St) | - | - | +0,2 | +0,3 |
| Kamyshinskoye 8 | 13,3 | 22,0 | +1,6 | +2,2 |
| Kaskelensky 1 | 15,6 | 25,4 | 0,8 | 1,3 |
| Kollectivnyi 10 | 12,6 | 21,0 | 0,3 | 0,4 |
| 2005 year | | | | |
| Tsunami 85 (St) | - | - | 4,9 | 8,1 |
| Kamyshinskoye 8 | 9,0 | 12,5 | 2,0 | 2,7 |
| Kaskelensky 1 | 16,9 | 22,3 | 5,2 | 6,7 |
| Kollectivnyi 10 | 13,6 | 18,5 | 5,4 | 7,3 |
| 2006 year | | | | |
| Tsunami 85 (St) | - | - | 6,1 | 10,1 |
| Kamyshinskoye 8 | 14,9 | 22,5 | 9,1 | 12,5 |
| Kaskelensky 1 | 13,2 | 29,0 | 8,7 | 10,3 |
| Kollectivnyi 10 | 16,0 | 24,2 | 9,0 | 12,3 |

The entire period of ecological testing of hybrids can be divided into years with short and cool summers (2015-2017), when the sum of active temperatures above +10°C ranged from

1910…2050 $^{0}$C, and years with a longer growing season (2016-2017), with a sum of active temperatures exceeding 2300°C.

Under the conditions of a short summer, the greatest yield increase was observed in faster-maturing hybrids. In our trials, during this period, the hybrid *Kaskelensky 1* provided the highest yield increase compared to the standard. The deviation from the standard ranged from 25.4% to 31.7%, while the other hybrids listed in Table 5 showed results 5-8% lower.

In the years with better heat availability (2016-2017), all the studied hybrids outperformed the standard in terms of accumulation rates and significantly surpassed it in productivity. Based on this, all the hybrids listed in the table can be considered the most intensive in terms of biomass growth compared to the standard. The hybrid *Kaskelensky 1* exceeded the standard by an average of 25.6% during this period, which was higher than that of the other hybrids. For example, during the same period, the yield of *Kollektivny 10* exceeded the standard by only 25.6%, and the performance of other hybrids was even lower.

Compared to the average yield, the amplitude of annual variations reflects the hybrids' resilience to extreme conditions. The most resilient hybrids should show the smallest amplitude. Based on this criterion, *Kaskelensky 1* emerged as one of the best, with yield deviations ranging from -8.1% to +8.7% under extreme conditions.

However, the hybrid *Kaskelensky 1* does not fully meet all the requirements of the industry standard for silage raw material [169]. According to our data, the biomass moisture at harvest for this hybrid ranged from 77% in favorable weather years to 81.5% in short summer conditions. This indicates that it did not always reach the cutting maturity phase by the time of harvest. Therefore, it is necessary to include the faster-maturing hybrids in the ecological testing list, with biomass moisture not exceeding 75%, as required by the industry standard for the production of first-class silage.

Thus, during 2015-2017, as a result of ecological testing, the hybrid *Kaskelensky 1* stood out for its early maturity and productivity, which exceeded *Tsunami 85* (the standard) by 14.6 centners/ha of absolute dry matter and was the most resilient in terms of productivity under extreme weather conditions.

*Conclusion*

In the steppe-plains agricultural zone its promising to cultivate sugar sorghum hybrids of early maturing type, which have time to ripen to harvest ripeness at the sum of active temperatures during vegetation not more than 2300 $^{0}$C.

Between 2015 and 2017, as a result of ecological testing, the hybrid *Kaskelensky 1* stood out for its early maturity and productivity, which yielded 76.0 centners/ha of absolute dry matter, which was 14.6 centners/ha higher than the standard *Tsunami 85*..

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**Тыныкулов М.К., Тургумбаев А.А., Уалиахметова Ж.Н., Хайруллина А.К.**

**АҚМОЛА ОБЛЫСЫНДАҒЫ АДРИД ЖАҒДАЙЫНДА ҚАНТ СОРГУМЫНЫҢ СОРТЫ МЕН ГИБРИДТЕРІН ЭКОЛОГИЯЛЫҚ СЫНАУ.**

**Аңдатпа.** Мақалада Қазақстанның солтүстік аймақтарында қант құмайының егіс алқаптарын кеңейту перспективалары қарастырылған. Оның биологиялық ерекшеліктері сипатталған, соның ішінде құрғақшылыққа төзімділік, өсімдік жамылғысын ұзақ уақыт өткеннен кейін зардапсыз қалпына келтіру мүмкіндігі және биомассаның жоғары өнімділігі. Өңірдегі ауылшаруашылық дақылдарының арамшөптермен бәсекеге қабілеттілігінің әлсіздігі және себу технологиясына қойылатын талаптар сияқты негізгі агротехникалық мәселелер атап өтілді. Қант құмайының жаңа сорттары мен будандарының пайда болуының зардаптарына, сондай-ақ өнімділікті арттыру үшін топырақ гербицидтері мен ерте себу мерзіміне ерекше назар аударылады.

**Кілт сөз:** Қант құмай; агроклиматтық жағдайлар; құрғақшылыққа төзімділік; өнімділік; сорт сынау.

**Тыныкулов М.К., Тургумбаев А.А., Уалиахметова Ж.Н., Хайруллина А.К.**

**ЭКОЛОГИЧЕСКОЕ ИСПЫТАНИЕ СОРТОВ И ГИБРИДОВ САХАРНОГО СОРГО В ЗАСУШЛИВЫХ УСЛОВИЯХ АКМОЛИНСКОЙ ОБЛАСТИ**

**Аннотация.** В статье рассматриваются перспективы расширения посевных площадей сахарного сорго в северных регионах Казахстана. Описаны его биологические особенности, в том числе засухоустойчивость, способность восстанавливать вегетацию после длительных периодов без последствий, высокая продуктивность биомассы. Выделены основные агротехнические проблемы, такие как слабая конкурентоспособность сельскохозяйственных культур региона с сорняками и требования к технологиям посева. Особое внимание уделено последствиям появления новых сортов и гибридов сахарного сорго, а также использованию почвенных гербицидов и ранних сроков посева для повышения урожайности.

**Ключевые слова:** Сахарное сорго; агроклиматические условия; засухоустойчивость; урожайность; сортоиспытание.