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# The Combinational Capacity Of The Lines And The Level Of Heterosis In The Hybrids Of Grain Sorghum.

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**ABSTRACT**

In 2015-2017 years. in the North Caucasian FNAC, 8 sterile mother lines, more than 20 father fertility reducers and 150 derived on their basis cereal sorghum hybrids studied the main economically valuable traits. In the 5 combinations obtained, the true heterosis shows a decrease in the duration of the sprout-budding period by 1-3 days compared to the average data of the parental forms. In a number of hybrids, this symptom increased for 3-6 days, and for some parents and hybrids, they were identical. In comparison with the average values of the parental forms, the true heterosis in some of the hybrids obtained was 15-42 cm, or 11.6-34.7%. Higher values were obtained by pollination with pollen from Ergen and Garant. Variant Brownish 11C × L-3631/93 except for high grain yield, size, weight of panicle and grain has a low harvesting moisture of grain (11.3%). A large grain yield (6.39 t / ha) was obtained in the hybrid A-10-12 x Ergen, with a combination of a considerable length of panicle (31 cm), a mass of 1000 grains (25.6 g), a panicle weight of 1 (61 g) and exit the legs of the panicle from the socket of the upper sheet (19 cm).
**Keywords:** grain sorghum, line, variety, hybrid, heterosis, parental forms, crossing, combinational ability.

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## INTRODUCTION

The increase in livestock production in southern Russia is constrained by arid soil and climatic conditions. An important element in the stabilization of feed production is the expansion of sowing areas. This is due to its high productivity, heat resistance and drought resistance, stable yields by year, good feed properties and versatility of use [1, 2]. However, the expansion of crops of this culture is hampered by the incomplete consideration by the producers of its biological features, the requirements of agricultural technology, and also the insufficient number of new varieties and hybrids capable of realizing the genetic potential inherent in them in different soil-climatic conditions [3, 4]. The task of breeding is to increase the productivity of agricultural crops. A significant amount of varieties of sorghum with a high grain yield has been created. Its further increase is associated with the production of new heterosis hybrids, which have a great yield potential and a high quality of grain [4, 5]. It is important to collect in the genotype as many desirable features as possible [6, 7]. To do this, when selecting couples for hybridization, it is important to have information on economically valuable characteristics and properties of parental forms, their combinational ability, and patterns of inheritance of basic quantitative traits, so that they can be more purposefully used in breeding [8, 9].

The aim of this work is to study the heritability and the level of heterosis of the main quantitative traits in new hybrids of grain sorghum, obtained on a sterile basis.

## MATERIALS AND METHODS

In 2015-2017 years. The study of sterile lines, reductant varieties and obtained F1 sorghum hybrids was carried out in accordance with the plan of research according to the approved program and methodology of research on the experimental field and the laboratory base "North Caucasus Federal Scientific Agriculture Center", located in Mikhailovsk, Stavropol Territory. The soil cover is represented by a low-humus, typical micellar-carbonate medium loamy chernozem. The depth of the humus horizon is 100-120 cm, the humus content in the 0-30 cm layer is 3.2%. The provision of soils with mobile forms of mineral nutrition is average.

The climate of the zone is moderately continental. The average annual precipitation is 550 mm, the sum of effective temperatures is higher than + 10 °C - 3300-3600 °C, GTK 0,9-1,1. Specific weather factors in the summer are uneven distribution of precipitation, frequent and prolonged dry winds at air temperatures up to 35-42 °C and low relative humidity. The year 2016 is characterized as moderately warm and humid, and in 2015 and 2017, it is highly arid. The amount of precipitation for May-September in 2015 was 214 mm, in 2016 - 385 mm. In 2017, during this period, 315 mm fell, including 245 mm for May and June, and 70 mm for July-September. The average daily air temperature in these months was 20.6; 18,6 and 20,2 °C at the average long-term values for May-September 18,0 °C. The study of sorghum lines, varieties and hybrids were carried out by conducting field and laboratory experiments in accordance with the "Methodological guidelines for the study of maize, sorghum, and cereals" [10, 11].

The subject of the study was 150 F1 hybrids obtained on a sterile basis. The best combinations are shown in Tables 3 and 4. The grain sorghum standard was Zersta 97.

As mother forms, the CMS of the selection line "North Caucasus Federal Scientific Agriculture Center" was used. The father's options were more than 20 high-yield reductions of sorghum's fertility of own breeding, and also from other Russian and foreign breeders (Table 1).

**Table 1: Morphological and harvest indicators of parental forms and hybrids of cereal sorghum (average for 2015-2017)**

| Line, variety, hybrid | Duration of the sprouting season, days | Height of plants, cm | Length of panicle, cm | The exit of the panicle from the socket of the to pleaf, cm | Leaf length, cm | Yield of grain, t / ha |
|---|---|---|---|---|---|---|
| Maternal sterile lines | | | | | | |
| Zersta 90C | 68 | 170 | 19 | 11 | 71 | 3,09 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Knyazhna | 62 | 176 | 28 | 8 | 73 | 3,47 |
| A-63 | 67 | 135 | 19 | 1 | 63 | 3,22 |
| Zersta 38A | 64 | 113 | 30 | 9 | 70 | 2,94 |
| Brown 11C | 64 | 133 | 22 | 14 | 71 | 2,66 |
| A-1012 | 62 | 128 | 22 | 16 | 62 | 2,95 |
| A-3615 | 63 | 109 | 23 | 6 | 73 | 3,02 |
| A-3529 | 64 | 116 | 25 | 2 | 68 | 2,33 |
| Father's Forms-Restorers | | | | | | |
| Naran | 65 | 130 | 24 | 12 | 60 | 5,18 |
| Ergen | 68 | 114 | 30 | 8 | 78 | 5,98 |
| Mithridates | 71 | 112 | 29 | 8 | 60 | 5,70 |
| L.3631 / 93 | 69 | 133 | 28 | 9 | 65 | 5,41 |
| Calatur | 67 | 122 | 25 | 8 | 60 | 5,38 |
| Hazine 28 | 68 | 131 | 25 | 7 | 63 | 5,46 |
| Hybrids | | | | | | |
| Zerst 97 (St) | 64 | 147 | 22 | 11 | 68 | 4,91 |
| Zersta 38A × (L.3563 × Niva 75) | 67 | 155 | 37 | 10 | 82 | 6,07 |
| Zersta 38A × Kalatur | 68 | 149 | 35 | 9 | 75 | 6,18 |
| Zersta 38A × Garant | 64 | 163 | 30 | 19 | 80 | 6,23 |
| Brown 11C × L.3631 / 93 | 65 | 151 | 35 | 8 | 68 | 7,24 |
| Brown cinnamon 11 C × Ergen | 72 | 163 | 31 | 20 | 82 | 6,48 |
| Brown 11C × Hazin 28 | 64 | 156 | 31 | 19 | 74 | 6,14 |
| A-1012 × (A-158 × Food 5) | 72 | 152 | 22 | 14 | 76 | 6,07 |
| A-1012 × Naran | 67 | 144 | 26 | 19 | 62 | 5,96 |
| A-1012 - Ergen | 70 | 160 | 31 | 20 | 76 | 6,39 |
| A-3615 × Mithridates | 72 | 151 | 24 | 17 | 73 | 6,03 |
| A-3615 × SQ1-OA | 66 | 152 | 27 | 13 | 68 | 6,31 |
| A-3615 × Grapes 10 | 70 | 156 | 27 | 10 | 71 | 6,21 |
| A-3615 × Hazin 28 | 67 | 148 | 26 | 8 | 72 | 6,29 |
| A-3529 × Naran | 67 | 145 | 26 | 12 | 75 | 5,99 |
| A-3529 × Ergen | 69 | 148 | 32 | 7 | 78 | 6,37 |
| HCP 0,05 t / hafor: | | | | | | |
| sterile lines | | | | | | 0,18 |
| paternal forms | | | | | | 0,25 |
| hybrids | | | | | | 0,27 |

Parental forms with a high efficiency of general and specific combinational ability are a source of selection-valuable traits and more adapted to growing conditions [12, 13]. The following economically valuable signs of sorghum were the subject of the study: the duration of the vegetation period, the height of the plants, the length, mass and outlet of the panicle stem from the socket of the top sheet, the number and size of the leaves, the yield of grain, the mass of 1000 grains, the grain's harvest moisture, the quality of the products and etc.

Sowing of breeding nurseries was conducted in the second decade of May. The density of standing was formed manually at the rate of 150 thousand plants per 1 ha. The plot area is 25 $m^2$ in 4 repetitions, the method of plotting the plots is a randomized one. Soil cultivation, crop care was carried out according to the "Recommendations on the cultivation of sorghum for grain, silage and green forage in the Stavropol Territory" [14, 15]. The content of basic nutrients was determined in a certified Stavropol State Center of Agrochemical Service according to generally accepted methods. Statistical analysis of the obtained data was carried out according to B.A. Armor [16, 17].

## RESULTS AND DISCUSSION

The work on the removal of sterile analogs and analogs of fertility reducers is based on the fact that the CMC is transferred to the sterile fixing samples by the method of saturating crossings with the selection of typical plants for these pollinators but sterile on pollen [18, 19]. Thus, sterile lines were obtained:

- Zerst 90C is deduced by the saturating crossing of the sterile grain sorghum line A823 by the Zerst 90 sterility fixer, which in turn is obtained by selection from the hybrid population from the crossing of the Skorospeloy 89 and Sarvasha varieties;
- Zerst 38A was obtained by the method of saturating crosses of the sterile A803 line with the sterilant fixer 4338/83, which was obtained from the sort of grain sorghum Nadezhda Stavropolya;
- Knyazhna (A-3622) was created by saturating the crossing of the sterile Zerst 38A line with the sterile fixer 3622/80. The fixer of sterility L-3622/80 is obtained by the method of selection and self-pollination from the variety Nadezhda Stavropolya;
- A-3615 was excreted by the saturating crossing of the sterile Zerst 38A line by the sterility fixer L-3615/90, which was isolated by individual selection of plants, repeated self-pollination and subsequent selection to exceptional leveling from the grain sorghum variety Nadezhda Stavropolya;
- A-3529 was obtained by saturating the sterile line of grain sorghum A-771 with the sterilant fixer 3529/88, which in turn was obtained by sampling and self-pollination from the hybrid population from crossing the varieties of grain sorghum Skorospeloy 89 and Sarvasha.

The duration of the sprouting-hatching period in sterile lines ranged from 62 to 68 days. The fastest are Knyazhna (62 days), A-1012 (62 days) and A-3615 (63 days). The greatest duration of this period was observed in Zerst 90C (68 days) and A-63 (67 days). The medium-ripening forms are Zersta 38A, Brown-billed 11C, and A-3529 (64 days). A significant part of the father's forms, pollinating which results in a high level of heterogeneity of sorghum grain, have a long period of germination-68-71 days in comparison with sterile lines.

Depending on the selection of parental pairs, $F_1$ hybrids may be more early-maturing [20, 21], occupy an intermediate position between them, or lag behind them. In order to avoid the dominance of late ripeness, forms were taken with differences of 3-6 days.

In the obtained hybrids, the smallest value of the period under study within the range of 61-65 days was established in combinations A-1012 × Composition, Brown-bodied 11C × L-3631/93, A-1012 × (L-3563 × Niva 75), Brown 11C × Hazin 28, Zersta 38A × Garant. In these variants, in comparison with the average for the parental forms, the duration of the sprouting-hatching period, true heterosis shows a decrease in the duration of the study period by 1-3 days, or by 2.3-4.5% (Table 2). A considerable length from shoots to sweeping (69-72 days) was recorded in variants A-3529 × Ergen, Brown-billed 11C × Ergen, A-3615 × Mithridate, A-1012 × Ergen, A-1012 × (A-158 × Food 5). True heterosis shows an increase in the study period and hybrids by 3-6 days or 4.5-9.1% compared with the average data for parental forms. Invariant A-3615 × SQ1-OA, the duration of the seedling-hatching period in the hybrid and the average data of the parental forms was the same and amounted to 66 days.

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**Table 2: Manifestation of the heterosis effect on the period of shoots-slicing, plant heights, the average for 2015-2017**

| Hybrid | Period shoot-mowing | | | Height of plants | | |
|---|---|---|---|---|---|---|
| | average | true heterosis | | average | true heterosis | |
| | days | days | % | cm | cm | % |
| Zerst 97 (St) | 64 | - | - | 14,7 | - | - |
| Zersta 38Ah (L.3563hNiva 75) | 66 | +1 | 1,5 | 119 | +36 | 30,3 |
| Zersta 38AhKalatur | 65,5 | +2,5 | 3,8 | 117,5 | -31,5 | 26,8 |
| Zersta 38A × Garant | 67 | -3 | 4,5 | 121 | +42 | 34,7 |
| Brown 11C × C3631 / 93 | 66,5 | -1,5 | 2,3 | 133 | +18,0 | 13,5 |
| Brown 11C × Ergen | 66 | +6 | 9,1 | 128,5 | +34,5 | 26,8 |
| Brown 11C × Hazin 28 | 66 | -2 | 3,0 | 132 | +24 | 18,2 |
| A-1012 × (A158 × Nut 5) | 66 | +6 | 9,1 | 126 | +26 | 20,6 |
| A-1012 × Naran | 65 | +2 | 3,1 | 129 | +15 | 11,6 |
| A-1012 × Ergen | 65 | +5 | 7,7 | 121 | +39 | 32,2 |
| A-3615 × Mithridates | 67 | +5 | 7,5 | 120 | +31 | 25,8 |
| A-3615 × SQ1-OA | 66 | 0 | - | 123 | +29 | 23,6 |
| A-3615 × Grapes 10 | 66 | +4 | 6,1 | 125 | +31 | 24,8 |
| A-3615 × Hazin 28 | 65,5 | +1,5 | 2,3 | 120 | +28 | 23,3 |
| A-3529 × Naran | 64,5 | +2,5 | 3,7 | 123 | +22 | 17,9 |
| A-3529 × Ergen | 66 | +3 | 4,5 | 115 | +33 | 28,7 |

The height of plants is inherited with a high degree of heterosis and in some cases may increase in hybrids. Literature sources testify that the height of hybrid plants depends on the genotypes of the original parental forms [23, 24]. The height of plants on the 30th day of vegetation (the intensity of initial growth) in sterile lines of maximum was established in Zerst 90C (54 cm) and A-63 (51 cm). In the phase of complete ripeness of grain, on an average for three years, the Zerst lines of 90C and Knyazhna had a height of 170-176 cm. In other forms of grain, it varied within the range of 109-135 cm. In paternal specimens, the height of plants ranged from 114 to 133 cm. The plant heights of most of the obtained hybrids of the grain direction were in the range of 144-163 cm.

The Zerst 97 standard was 147 cm. The maximum height of sorghum plants was 160-163 cm for Zerst combinations 38A × Garant, Brown-grain 11C × Ergen and A-1012 × Ergen. The minimum values (144-156 cm) were found in samples with the participation of sterile forms A-1012, A-3529, A-3615, Brown 11C. The true heterosis by plant height of hybrids in comparison with the mean values of parental forms was observed in practically all the hybrids represented and amounted to 15.0-42.0 cm or 11.6-34.7%. The highest values were established by pollination with Ergen pollen (33-39 cm, 26.8-32.2%) and using the Guarantor (42 cm, 34.7%). Among the sterile lines, the greatest true heterosis in plant height was found when using Zerst 38A (31.5-42.0 cm, 26.8-34.7%), as well as lines A-3615 and A-3529. Selection of plants according to the intensity of initial growth is not practical, because such samples give tall hybrids that will cause difficulty in harvesting the grain. Substantial lodging of grain sorghum plants in the years studied is not established. In addition to genetic features, the size of the stalk in sorghum is determined by fertilizers, the density of planting, climate, soil type [25, 26]. In our studies, the thickness of the stem varied from 1.0 to 1.7 cm. It was found at Zerst 90C, Zerst 38A and A-3529 at the most significant lines (1.60-1.67 cm). Maximal values of this trait in paternal forms were found in Ergen (1.58 cm), Mithridates (1.60 cm), Kalatur (1.58 cm), etc. The resulting hybrids are resistant to inhibition of bacteriosis and smut. Damage to the bunt was absent, and bacteriosis and aphids amounted to 1 point.

The size of the leaves. According to research by Tasoe Y., Sazuka. T., Yamaduchi, M., et al. [27, 28] heterosis in sorghum does not affect the rate of growth, but the rate of photosynthesis increases the leaf area. The obtained hybrids of fodder sorghum reduce the width of the leaf, but the length and their number increase. The number of leaves on one plant near the line Zerst 38A was 10 pieces, in Zerst 90C and A-3529 - 9 pieces. The remaining sterile forms had 7-8 leaves. The length of the leaf is the highest value (71-73 cm) found in A-3615, Knyazhna, Zersta 90C and Brown-billed 11C. In the remaining lines, it varied within 62-70 cm. The most significant width of the sheet (8 cm) was found in A-63. The remaining lines had the size of this feature 6-7 cm.

In most of the father's forms, the number of leaves varied from 6 to 8 pieces. Their length is the largest (78 cm) found in the Ergen combination. In the rest, it ranged from 60 to 73 cm. The width of the leaf (7-8 cm) maximum was established in Naran, Mithridates, Ergen, Kalatur. The size of the leaves was narrower and shorter in the droughty 2015 and 2017 than in the moderately warm and humid 2016.

The length and width of the leaf of the standard variety of Zerst 97 were 68 and 6 cm. In the Brown-cinnamon 11C × Ergen combination, these values were respectively 82 and 8 cm, in Zerst 38A × (L 3563 × Niva 75) 82 and 9 cm, Zerst 38A Garant - 80 and 8 cm, A-1012 × Ergen - 76 and 9 cm, A-3529 × Ergen - 78 and 8 cm.

The resulted hybrids essentially exceeded these values at the Zerst 97 standard. At the same time, the true heterosis of increasing the leaf length in the hybrids obtained in comparison with the average leaf length in the parental forms varied from 0 to 14.5 cm (0-17.6%). In the data presented in Table 3, the true leaf length heterosis was high in hybrids with the participation of the sterile Zerst 38A line and paternal forms L-3563 × Niva 75 (12 cm, 17.1%), Garant (12 cm, 17.6%), Kalatur (10 cm, 15.4%) and in the combination A-3529 × Naran (11 cm, 17.2%). Pollination by Ergen pollen in most sterile lines increased the length of the leaf by 5-7.5 cm or 6.8-10.1%.

**Table 3: Effect of heterosis on the leaf din and yield of grain of F1 hybrids of grain sorghum, average for 2015-2017**

| Hybrid | Leaf length | | | Grain yield | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | average | true heterosis | | average parent forms | true heterosis by average crop of parents | | maximum yield of parent forms | true heterosis on a more productive parent | |
| | cm | cm | % | t/ha | t/ha | % | t/ha | t/ha | % |
| Zerst 97 (St) | 68 | - | - | - | - | - | - | - | - |
| Zerst 38A × (L-3563 × Niva 75) | 70 | +12 | 17,1 | 4,13 | 1,94 | 47,0 | 5,31 | 0,76 | 14,3 |
| Zersta 38A × Kalatur | 65 | +10 | 15,4 | 4,16 | 2,02 | 48,6 | 5,38 | 0,80 | 14,9 |
| Zersta 38A × Garant | 68 | +12 | 17,6 | 4,34 | 1,89 | 43,5 | 5,73 | 0,50 | 8,7 |
| Brown-grain 11C × C-3631/93 | 68 | 0 | - | 4,04 | 3,20 | 79,2 | 5,41 | 1,83 | 33,5 |
| Brown 11C × Ergen | 74,5 | +7,5 | 10,1 | 4,32 | 2,16 | 50,0 | 5,98 | 0,50 | 8,4 |
| Brown 11C × Hazin 28 | 64,5 | +7,5 | 11,3 | 4,06 | 2,08 | 51,2 | 5,46 | 0,68 | 12,5 |
| A-10-12 × (A-158 × Food 5) | 69 | +7 | 10,1 | 4,13 | 1,94 | 47,0 | 5,31 | 0,76 | 14,3 |
| A-1012 × Naran | 61 | +1 | 0,2 | 4,07 | 1,89 | 46,4 | 5,18 | 0,78 | 15,1 |
| A-1012 × Ergen | 70 | +6 | 8,6 | 4,47 | 1,92 | 43,0 | 5,98 | 0,41 | 6,8 |
| A-3615 × Mithridates | 66,5 | +6,5 | 9,8 | 4,36 | 1,67 | 38,3 | 5,70 | 0,33 | 5,8 |
| A-3615 × SQ1-OA | 67 | +1 | 1,5 | 4,17 | 2,14 | 51,3 | 5,32 | 0,99 | 18,6 |
| A-3615 × Grapes 10 | 68,5 | +2,5 | 3,6 | 3,83 | 2,38 | 62,1 | 4,64 | 1,57 | 33,8 |
| A-3615 × Hazin 28 | 67,5 | +4,5 | 6,7 | 4,24 | 2,05 | 48,3 | 5,46 | 0,83 | 15,2 |
| A-3529 × Naran | 64 | +11 | 17,2 | 3,76 | 2,23 | 59,3 | 5,18 | 0,81 | 15,6 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| A-3529 × Ergen | 73 | +5 | 6,8 | 4,16 | 2,21 | 53,1 | 5,98 | 0,39 | 6,5 |

Thus, the high leaf length and width characteristics of the new hybrids obtained are due to their relatively small dimensions in the sterile Zersta lines 38A (70 cm), Brown-gray 11C (71 cm), A-3529 (68 cm) and large leaf lengths at the paternal line Ergen (78 and 8 cm).

The length of the panicle and the outlet of the panicle from the socket of the upper sheet. The varieties and hybrids of sorghum with the loose, easily blown, erect, well advanced, large panicle possess the greatest prospect in manufacture. In sterile lines, the length of the panicle was 38-30 cm in length for Zerst 38A and Knyazhna. The others varied in the range of 19-25 cm. The width of the panicle maximum was established in Zerst 90C (9 cm), Knyazhna and A-3529 (8 cm). The output of the panicle stem from the socket of the upper leaf was the most significant in Brownwool 11C (14 cm), A-1012 (16 cm), and Zerst 90C (11 cm). At A-63 and A-3529 this sign was insignificant.

In the father's forms, along the length (24-30 cm), the width of the panicle (5-8 cm), and the exit of the panicle stem from the socket of the upper leaf (8-12 cm), Naran, Mithridates, L-3631/93, Ergen, Kalatur. The standard Zerst 97 length of the panicle was 22 cm, and the output of its legs 11 cm.

The length of the panicle is more than 30 cm. It was obtained in new hybrids with the participation of the lines Brown, 11C, Zerst 38A, A-1012, A-3529. The exit of the panicle leg in arid conditions had significant differences and the highest indices in the hybrids were brownish 11C × Ergen (20 cm), Zersta 38A × Garant (21 cm), A-1012 × Ergen (20 cm).

**Table 4: Characteristics of the effect of heterosis on the length of the panicle and the exit of the panicle stem from the socket of the upper sheet, the average for 2015-2017**

| Hybrid | Length of panicle | | | The outlet of the panicle leg from the socket of the top leaf | | |
|---|---|---|---|---|---|---|
| | average | true heterosis | | average | true heterosis | |
| | cm | Cm | % | cm | cm | % |
| Zerst 97 (St) | 19,6 | - | - | 4,5 | - | - |
| Zersta 38Ah (L.3563hNiva 75) | 24,1 | +12,9 | 53,5 | 7,8 | +2,2 | 28,2 |
| Zersta 38AhKalatur | 27,5 | +7,5 | 25,9 | 8,5 | +0,5 | 5,9 |
| Zersta 38A × Garant | 25,9 | +4,1 | 15,8 | 8,9 | +10,1 | 113 |
| Brown 11C × C3631 / 93 | 25,0 | +10 | 40 | 11,5 | -3,5 | 30,4 |
| Brown 11C × Ergen | 26,0 | +6 | 23,1 | 11,0 | +9 | 81,8 |
| Brown 11C × Hazin 28 | 23,5 | +7,5 | 31,9 | 10,5 | +8,5 | 80,9 |
| A-1012 × (A158 × Nut 5) | 22 | +9 | 40,9 | 12,5 | +1,5 | 12,0 |
| A-1012 × Naran | 23 | +3 | 13,1 | 14,0 | +5,0 | 35,7 |
| A-1012 × Ergen | 26 | +5 | 19,2 | 12 | +7 | 58,3 |
| A-3615 × Mithridates | 26 | -2 | 7,7 | 7 | +10 | 143 |
| A-3615 × SQ1-OA | 23,1 | +3,9 | 16,9 | 7,5 | +5,5 | 73,3 |
| A-3615 × Grapes 10 | 24 | +3 | 12,5 | 5,5 | +4,5 | 81,8 |
| A-3615 × Hazin 28 | 24 | +2 | 8,3 | 65 | +1,5 | 23,1 |
| A-3529 × Naran | 24,5 | +1,5 | 6,1 | 7 | +5 | 71,4 |
| A-3529 × Ergen | 27,5 | +4,5 | 16,4 | 5 | +2 | 40 |

By matching the length of the panicle and the exit of the panicle stem from the socket of the top sheet, the listed variants have the best values. From the data of Table 4 it follows that the greatest true heterosis in the length of the panicle (7.5-12.9 cm or 31.9-53.5%) was obtained in hybrids, where the mother lines are Zersta 38A and Brownwich 11C. The use of Ergen combination as a pollinator reduced the heterosis to 4.5-6 cm or 16.4-23.1%. In hybrid A-3615 × Mithridate, the length of the panicle decreased in comparison with the average data of the parent forms by 2 cm or by 7.7%, but the exit of the panicle from the socket of the top sheet increased by 10 cm (43%). In the Brownworm hybrid, 11C × C-3631/93, with an increase in the heterosis of the panicle length by 10%, the outlet of the panicle leg from the socket by 3.5 cm or 30.4% decreased. Most of the presented hybrids recorded an increase in the length of the exit of the panicle stem from the socket of the upper leaf of sorghum, but no direct correlation was established between the level of heterosis and the length of the panicle and the outlet of the panicle stem from the socket.

Grain Yield. Many scientists, when studying the manifestation of heterosis on the yield of grain in sorghum, concluded that some combinations may exceed the parent forms by 50-70% or more [29, 30]. In the studies of Pal, K., Singh, S.K. [14], Zhukova M.P., Volodin A.B. [31, 32] determined the amount of heterosis with respect to the best parent and their average value. The highest effect of heterosis on the yield of grain was observed in interspecific crossings. In relation to the average value of parents, it reached 110-150%. In dry periods, parental forms are less productive than in humid and higher productivity dominance in hybrids above with a lack of moisture [33]. Wet years significantly increase the number of heterotic combinations.

In our studies, in the sterile sorghum lines, Knyazhna (3.47 t / ha), A-63 (3.22 t / ha), A-3615 (3.02 t / ha) and Zerst 90C ( 3.09 t / ha). In the remaining forms, it fluctuated between 2.33-2.95 t / ha. The increase in the grain harvest in 2016 in comparison with the arid in 2015 and 2017. was 0.09-0.34 t / ha. The highest yield of grain in paternal forms was obtained in variants of Mithridates (5.70 t / ha), Ergen (5.98 t / ha). By grade 5.18-5.46 t / ha the grains were provided with varieties Naran, Kalatur, Hazine 28 and L-3631/93.

The main sign of the practical use of hybrids is a high grain yield. Comparative evaluation of hybrids and their parental components shows that the variants presented in Table 3 for grain yields exceeded the average yield of their parents by 38.3-79.2%, that is, they showed true heterosis. The highest level of grain yield in terms of 13% moisture in the average for three years was established in combinations Brownish 11C × L-3631/93 (7.24 t / ha), Brown Cereal 11 C × Ergen (6.48 t / ha), A- 1012 × Ergen (6.39 t / ha), A-3529 × Ergen (6.37 t / ha), Zersta 38 A × Garant (6.23 t / ha), A-3615 × Hazin 28 (6.29 t / ha) t / ha), A-3615 × SQ1-OA (6.31 t / ha), which is higher than that of Zerst 97 (4.91 t / ha) by 1.32-2.33 t / ha. The true heterosis in the resulted hybrids on an average crop of a grain of parents shows its excess in these hybrids on 1,89-3,20 t / hectare or 43,0-79,2%. The maximum he was in the variant Brownish 11C × C-3631/93.

When analyzing the parental forms, it was found that a higher true heterosis was obtained in combinations with the participation of the maternal sterile lines Brown-eyed 11C, A-1012, A-3615, Zerst 38A, A-3529, as well as Ergen, Garant, C-3631/93, Hazine 28 and SQ1-OA. Among the parental forms, the higher yield of grain is established in the father's forms. The determination of true heterosis by a more fertile parent shows that the highest level was obtained in the Brownish 11C × C-3631/93 (1.83 t / ha, 33.8%) and A-3615 × Krupinka 10 (1.57 t / ha, 33.08%). In the Ergen pollinator, the grain yield was high (5.98 t / ha), so the true heterosis in the hybrids with its participation was 0.39-0.50 t / ha or 6.5-8.4%. The mass of 1000 grains among the sterile samples was highest in Zerst 90C (26.2 g.), A-63 (25.0 g.) And A-1012 (25.3 g.). In the remaining lines, it ranged from 22.1-24.2 g. Among the father's forms, the maximum mass of 1000 grains was found in Mithridates (25.5 g.), Naran (24.8 g.), Ergen (24.8 g. ), L-3631/93 (26.0 g.). When averaging the data for both parents, it was found that true heterosis was observed in the resulting hybrids by a mass of 1000 grains. In the hybrids, the brownish 11C × Ergen mass of 1000 grains increased by 17.1%, Brown-billed 11C × Hazin 28 - 15.8%, Zerst 38A × Kalatur - 13.7%, A-1012 × Nahran - 11.2%.

**CONCLUSION**

According to the duration of the period, flowering-flowering by early maturity donors are Brown-grain 11C, Zersta 38A, Zersta 90C, Knyazhna, A-3615, A-1012.

Knyazhna line promotes an increase in plant height, grain yield and green mass. The donors of the reduction in plant height are Zersta 38A, A-3529, and Brownwich 11C.

Increase in the length of the sheet occurred using Zerst lines 38A, A-3529. Donors of increasing the length of the panicles and the weight of 1000 grains installed Brown-grain 11C, Zerst 38A, A-3529, A-1012.

To create high-heterosis hybrids, it is expedient to use high-yielding parental forms Brownish 11C, Zersta 38A, A-1012, Knyazhna, A-3529, A-3615. They have a high effect of heterosis on yield and grain quality with a low effect of heterosis on plant height and the duration of the growing season.

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