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FEATURES OF THE 1000 GRAIN MASS INHERITANCE IN HYBRID COMBINATIONS OF WINTER WHEAT

1000 дандын массасынын куздук буудайдын гибриддик комбинацияларында тукум куучулугунун езгечелуктеру

Особенности наследования массы 1000 зерен в гибридных комбинациях озимой пшеницы

Abstract: *the article is devoted to the problem of drought tolerance of grain crops that is an actual for the agriculture of Kyrgyzstan. In the conditions of Kyrgyzstan, crops are grown in different soil and climatic zones both on irrigated and on rainfed lands, located at an altitude of 500 to 2000 meters, where the total precipitation is 200-800 mm per year. In this regard, for the rainfed areas, it is a need for early ripening, hot and drought tolerant varieties with intensive growth in spring and rapid grain filling, resulting from air and soil drought. Weight of 1000 grains is dominant trait, due to this the study of inheritance of 1000 grain mass in hybrids is carried out by crossing of geographically remote varieties of winter wheat from the International CIMMYT-ICARDA Centers and Kyrgyz Breeding.*

Аннотация: *статья посвящена актуальной для сельского хозяйства Кыргызстана проблеме засухоустойчивости зерновых колосовых культур. В условиях Кыргызстана зерновые культуры выращивают в разных почвенно-климатических зонах, как на орошаемых, так и на богарных землях, расположенных на высоте от 500 до 2000 метров, где общая сумма осадков составляет 200 - 800 мм в год. В этой связи для полуобеспеченной и необеспеченной осадками богары нужны скороспелые, жаро- и засухоустойчивые сорта с интенсивным ростом весной и быстрым наливом зерна, уходящие от воздушной и почвенной засух. Масса 1000 зерен - доминантный признак, поэтому для изучения особенностей наследования массы 1000 зерен проведено скрещивание географически отдаленных сортообразцов озимой пшеницы из Международных Центров СИММИТ-ИКАРДА, ближнего зарубежья и кыргызской селекции.*

Аннотация: *макала Кыргызстандын айыл чарбасы үчүн актуалдуу болгон дан өсүмдүктөрүнүн кургакчылыкка туруктуулук проблемасына арналган. Кыргызстандын шартында өсүмдүктөр 500 - 2000 метрде жайгашкан сугат жана кайрак жерлерде өстүрүлөт. Бул жердеги жаан-чачындын көлөмү 200-800 мм түзөт. Ошондуктан мындай шарттарда эрте бышуучу, кургакчылыктын баардык түрлөрүнө туруктуу сортторду чыгаруу зарыл. 1000 дандын массасы доминанттык белги болгондуктан, ушул белгинин гибриддик тукумдарга берилүү өзгөчөлүктөрүн аныктоо максатында эл аралык борбор СИММИТ-ИКАРДАдан алынган жана кыргыз селекиясынын күздүк буудайларынын сортторун кыйыштыруу жүргүзүлдү.*

Keywords: *drought tolerance; hybrid combinations; domination; heritability; transgression; phenotypic domination; segregation of hybrid generation; perspective lines.*

Ключевые слова: *устойчивость к засухе; гибридные комбинации; доминирование; наследование; трансгрессия; фенотипическое доминирование; расщепление гибридных комбинаций; перспективные линии.*

Негизги свздвр: *кургакчылыкка туруктуулук; гибриддик комбинация; доминанттуулук; трансгрессия; фенотиптик доминаттулук; гибрид тукумдарынын ажыроосу; перспективдүү линиялар.*

Introduction.

Wheat is major crop in dryland agriculture [1]. A total volume of wheat production in the world makes currently more than 600 million tons [2]. By 2020, the world would need 840 million metric tons of wheat and 2/3 of this need to be produced in developing countries [3]. More than half of wheat yield in the world (237 million hectares) are periodically subjected to drought. In the developing countries of North Africa, Central and West Asia there are accounted for 45% or 120 million hectares of all wheat crops [4]. The annual harvest of wheat in arid zones is only half of the potential harvest under optimal cultivation conditions [5].

During the period of grain filling, the influence of high temperatures, when accompanied by dry winds, even if there is a sufficient amount of moisture in the soil, can cause a decrease in winter wheat yield by 30-50% or more [6]. Wheat varieties adapted to this area require good seedling vigor, early maturity combined with competitive grain yield [7].

The modern crop breeds are developed not only to producte high yield but also achieve sustainable yields through the years. Yield increase as well as stabilization of grain production are priority challenges for the scientists and farmers for achievement of food security [8].

It is known that hybridization of ecologically and geographically remote genotypes is very effective. Top crosses, back-crosses and repeated selections are the basic methods of breeding [9]. The hybrids F1 and F2 usually have better productivity and better resistance to biotic and abiotic conditions. Plant height and number of grains per spike are intermediate characters of inheritance. Weight of 1000 grains is dominant trait [10].

Byerlee and Traxler [11] in their studies have shown that the increase in yields is influenced by selection based on more clearly inherited gualities.

As a result of Kovtun's studies, the leading elements in the structure of the crop are the mass of grain from the spike, the number of spikelets and grains in the spike and the mass of 1000 grains [12]. A number of scientists have proved that wheat varieties having a high mass of 1000 grains can have a high degree of drought resistance [13]. Many studies [14; 15] show that in a number of cases when a general decrease in yield the mass of 1000 grains may remain high.

Grain yield or grain weight per unit area is the main indicator of the economic value of the variety and is closely related to all elements of productivity [16]. The most stable elements of the crop structure are the mass of 1000 grains, the length and number of spikelets in the ear. The most variable value among the elements of productivity is the mass of grain from the plant, productive bushiness, the number of productive spikelets per square meter, the mass of grain from the main spike. Slightly variable are due to more varietal features, and highly variable ones largely depend on external conditions [17].

Selection should be conducted in the direction of increasing the productivity of the ear (the number of spikelets and grains in the ear), the mass of grain from the ear and the mass of 1000 grains.

In the conditions of Kyrgyzstan, crops are grown in different soil and climatic zones both on irrigated and on rainfed lands, located at an altitude of 500 to 2000 meters, where the total precipitation is 200-800 mm per year.

In our republic, wheat occupies the third part of the whole arable land. On average, 300 thousand hectares of wheat are spread on irrigated land; about 200 thousand hectares are in the zone of rainfed farming.

Most of the rainfed lands are located in insufficient and semi-arid area, where their amount rarely exceeds 300-400 mm per year. The accumulation of moisture usually begins in October. Maximum reserves accumulated in the spring, but in May the rainfall stops and there is a period of intensive water consumption due to evaporation and transpiration [18].

In this regard, for the rainfed areas, there is a need for early ripening, hot and drought-resistant varieties with intensive growth in spring and rapid grain filling, resulting from air and soil drought.

When creating varieties for the conditions of the rainfed areas, it is necessary to have a diverse gene pool with a wide range of variability, which would ensure a directed selection of varieties of the required type. To create such a source material, hybridization of specially selected parental pairs is carried out, which are preliminarily studied in local conditions to identify positive and negative characteristics and properties.

Currently, released varieties in years with insufficient moisture form a small, unfulfilled grain, resulting in a significant decline in yield. Despite significant success in breeding, it is necessary to create new varieties combining resistance to drought with high and stable productivity.

Methods and materials.

Field experiments are conducted in experimental farms of the Kyrgyz Agricultural Research Institute on rainfed zones, located in the foothills of the Chui Valley, on the south-western outskirts of Bishkek city. Altitude - 829 m, average summer temperature - 22-25 ° C, the average relative air humidity during the grain filling period is 40%; and in conditions of semi-provided rainfed, located 110 km from the city of Bishkek in the seed farm "Jany-Pakhta", altitude - 650 m, average summer temperature is 23.5-24.5 °

C, the average relative air humidity during the grain filling period is 32-35%, where the samples and the hybrid material are selected. These zones are also differentiated by the soil cover.

Basic soil cultivation is carried out in late October after the previous crop harvest plow with coulters at a depth of 23-25 cm.

Annually before the sowing on the experimental site, the soil is treated with discs harroned with rollers or paw cultivators with simultaneous harrowing. In spring, after atmospheric precipitation ammonium nitrate is applied 60-70 kg/ha. Harrowing is carried out during the tillering phase in spring.

556 samples of winter wheat, represented by 10 species and populations: grekum, erythrospermum, lutescence, nigroaristatum, albidum, alborubrum, eritrolekum, kesium, milturum и ferrugineum are studied to search for and identify sources of resistance to drought by international centers CIMMYT-ICARDA, neighboring countries and Breeding institute of Kyrgyzstan. The international nurseries from Turkey-CIMMYT-ICARDA program in Turkey, CIMMYT-ICARDA program in Syria and CIMMYT headquarters in Mexico are annually shipped to almost all the wheat breeding programs in Central Asia and Caucasus [19]. Since 1995-1996 Kyrgyzstan started to get the genetic samples from CIMMYT-ICARDA [20].

The studies of winter wheat are conducted by the classifier of breeding characteristics of Triticum species. Repetition: fourfold; row length: 1,6m; row spacing: 22-25cm; seed sowing was carried out manually. The standard is released variety - Adyr, for rainfed areas, which was located every 10 rows. High-yielding samples and perspective lines are sown in the breeding nursery of the second year (SN-2), repetition: threefold, area of plots: 7.5 m^2.

The initial assessment of drought tolerance and heat tolerance are carried out under laboratory conditions. Physiological analyzes for drought tolerance of winter wheat samples are determined by germination of seeds on sucrose solutions with high osmotic pressure, according to the methods of Oleynikova TV., Osipova UF. [21]. Determination of the relative heat tolerance of the samples is carried out according to the methods of Volkova AM., Perepadya UG. [22], heating samples in temperature of 54 and 56°C.

Field method for determining drought tolerance is used according to the scale of assessment of Udolskaya NL. [23].

Sample selection is based on the results of a study of the effect of environmental conditions on economically valuable characteristics and field resistance to drought. Analyzes on the quality of grain (protein, gluten) are made in the technological laboratory of the Kyrgyz Agricultural Research Institute by using "Informatik"- tool.

The data obtained are subjected to statistical processing [24]. The most interesting and productive samples are involved in crossing.

Phenologic observations, description of vegetative features, eye estimation of the vegetation state, disease resistance (powdery mildew, yellow rust) and pests are carried out in accordance with the Classifier of Selection Characteristics of the Triticum species.

To determine the nature of the variability and inheritance of productivity elements are identified: the degree of phenotypic dominance (hp), degree of dominance (D^I), heritability (H^2) and transgression (TL - level of transgression; TF - frequency of transgression).

Phenotypic dominance was identified according to Abramova ZB. [25]:

hp=F1 - MP/HP - MP

HP - the maximum value of the characteristic for the parent form;

MP - the average arithmetic characteristics of both parental forms;

F1 - an average arithmetic characteristics of F1 plants;

hp - degree of phenotypic dominance.

The degree of dominance was calculated by Gustafson A. and Dormling B. [26].

D^I = F1 - Pmin x 100% /Pmax - Pm_{in}

Pmax - the maximum value of the characteristic for the parent form; Pm_{in} - the minimum value of the characteristic for the parent form; F1 - an average arithmetic characteristics of F1 plants. The heritability (H^2) and transgression (TL) were calculated according to Abramova ZB. [25]:

H^2=OF2 - **Vo**$_{P1}$ XOP2X100/^{2}F2

o^2F2 - F_2 variance;

o_{P1} and o_P2 - variances of parent forms.

TL = MF2 - MP x 100/MP

TL - degree of transgression in %;

MF2 - the maximum value of the characteristic for F2 hybrids;

MP - the maximum value of the characteristic for the parent forms.

To study the inheritance of *productivity elements in hybrids (1000 grains, the mass of grain from the spike, the mass of grain from the plant, and the number of grains in the main spike), is carried by crossing of geographically distant varieties of winter wheat from the International CIMMYT-ICARDA Centers and Kyrgyz Breeding.* Parental components are selected according to the timing of flowering. As a maternal form, in most cases, the varieties from CIMMYT-ICARDA are selected, since their flowering occurred 2-4 days earlier compared to the varieties of Kyrgyz breeding.

During the research, a different degree of binding of hybrid seeds (from 0 to 100%), depending on the selection of parental forms was observed. The seeds are sown in a thin manner to obtain a higher multiplication factor according to the scheme: **$**-hybrid-^, the number of rows is determined by the presence of hybrid seeds, the parent forms are

sown in one row; seed sowing is carried out manually. Hybrid material are studied in comparison with the parent forms and the standard Adyr variety, sown every 10 numbers.

The results and discussions

Inheritance of 1000 grain mass. The variability of the 1000 grain mass in parental (V = 1.0-6.5%) and hybrid combinations (V = 2.1-9.1%) is insignificant. According to the nature of the inheritance (D^I) of the sign of 1000 grains mass, heterosis (20%), dominance of the signs of the best parent (12%), intermediate inheritance (28%), predominance of signs of the worst parent (28%) and depression (12%) were observed.

Table 1

The nature of 1000 grain's weights dominance

Hybrids	1000 grain mass, g			D^I
	P1	P2	F1	
Intensivnaya/Grekum634/1	44.4±0.2	48.0±0.3	39.1±0.3	-90
Mironovskaya61// Khersonskaya ostistaya/ Skifyanka	42.6±0.9	40.9±0.9	49.1±0.8	430
4777/2/Fkn/Gb/3/Vee'S'/Pvn'S'/5/Ald'S'/3/Cc//Inia/Bb/6/Gerek 79	42.7±0.7	40.1±0.1	45.1±0.5	150
4777/2/Fkn/Gb/3/Vee'S'/Pvn'S'/5/Ald'S'/3/Cc//Inia/Bb/6/GRK	42.3±0.5	47.5±0.1	44.4±0.9	-10
71St2956/Grow'S'/3/Agaf//MCX/Tob/4/Gerek79	40.6±0.2	44.4±0.2	48.2±0.5	90
Ducula/Grekum1634/1	48.8±1.9	46.1±0.4	50.1±0.9	70
Atilla/Bolal	38.0±0.1	37.5±0.7	45.6±0.9	110
Maya74'S'/On//IIGo. 147/3/Bb/GII/4/Agaf S'/Bow'S'/ Erythrospermum2078/1	41.1±0.2	42.9±0.1	43.5±1.7	-30
Bow 'S'/Seri82//Erythrospermum1676/1	40.3±0.5	50.1±0.1	40.6±0.7	-50
Bow 'S'/Seri82//Lutescens 42	40.3±0.2	49.0±0.2	47.9±0.4	40
Mtl 'S'/Cham-4//N1038/1	44.2±0.8	42.3±0.4	41.6±0.6	-90
Cham-4//GH'S'/ Bow 'S' //Lutescens1557/1	43.1±0.3	48.4±0.3	45.8±2.7	2
Seri82//Shi#4414/Grow 'S'//Adyr	52.8±0.3	53.2±0.2	55.0±1.7	500
Seri82//Shi#4414/Grow 'S'//Grekum1634/1	51.9±0.1	46.5±2.1	44.7±2.4	-80
Vee'S'//CebeCo148/3/Ron/Cha//Bb/Nor67/5/HR138MA/4/477 7//Rei/y/3/KT/6/ Frunzenskaya 60	43.4±0.3	47.2±0.2	48.9±2.7	90
Cham-6/Frunzenskaya 60	41.1±2.2	48.2±0.4	47.0±0.4	40
Vee'S'//CebeCo148/3/Ron/Cha//Bb/Nor67/5/HR138MA/4/477 7//Rei/y/3/KT/6/Atay/Galvez87	32.2±2.0	47.3±1.0	47.1±2.6	70
Psn'S'/Bow'S'//Kauz'S'/3/Atay/Galvez87	38.8±0.1	41.3±0.1	39.1±0.3	-40
Moro//Roga/Una	24.9±0.1	53.8±1.3	49.1±1.7	20
Clement//Roga/Una	45.7±0.3	53.8±1.3	46.1±1.5	-40
Compare//Ah tymar/Frunzenskaya60	43.8±0.1	54.3±0.4	53.2±1.7	40
Acocet'S'//Roga/Una	51.9±0.8	53.8±1.2	57.1±1.5	230
Fed/Kavkaz//Ahtymar/Frunzenskaya 60	37.9±0.8	53.7±0.4	41.6±0.5	-30
Kalyansona//Ahtymar/Frunzenskaya 60	25.3±0.2	53.5±0.4	40.6±0.4	10
Cook//Ahtymar/Frunzenskaya 60	36.3±0.3	53.5±0.4	39.9±1.6	20

The indicators of the degree of phenotypic dominance (hp) have shown on this basis heterosis in 20% of hybrid combinations, the dominance of the signs of the best parent - 16%, intermediate inheritance - 24%, dominance of signs of the worst parent -24% and depression -16%. In 52% of hybrid F_1 combinations, the heritability (H^2) ratio is high, making 55.9 - 92.9%, and in F_2 this index is high in 60%, amounting to 51.5-83.7% (table 2).

Table 2

Inheritance of 1000 grain's weight in hybrid combinations

Hybrids	hp	H^2	
	Fi	Fi	F2
Intens ivnaya/Grekum634/1	-0.9	38.5	56.6
Mironovskaya61// Khersonskaya ostistaya/Skifyanka	4.3	36.1	44.5
4777/2/Fkn/Gb/3/Vee' S '/Pvn' S '/5 /Ald'S '/3 /Cc//Inia/Bb/6/Gerek79	1.5	44.5	73.6
4777/2/Fkn/Gb/3/Vee' S '/Pvn' S '/5 /Ald'S '/3 /Cc//Inia/Bb/6/GRK	-0.1	69.8	42.0
71St2956/Grow'S'/3/Agaf//MCX/Tob/4/Gerek79	0.9	41.5	76.3
Ducula/Grekum1634/1	0.7	55.9	19.8
Atilla/Bolal	1.1	92.9	83.7
Maya74'S'/On//IIGo. 147/3/Bb/GII/4/Agaf S'/Bow'S'/ Erythrospermum2078/1	-0.3	66.5	32.9
Bow 'S'/Seri82//Erythrospermum1676/1	-0.5	33.2	2.2
Bow 'S'/Seri82//Lutescens 42	0.4	40.9	79.3
Mtl 'S'/Cham-4//N1038/1	-0.9	67.4	58.0
Cham-4//GH'S'/ Bow 'S' //Lutescens1557/1	0.02	9.9	51.5
Seri82//Shi#4414/Grow 'S'//Adyr	5.0	48.5	15.2
Seri82//Shi#4414/Grow 'S'//Grekum1634/1	-0.8	78.9	16.6
Vee'S'//CebeCo148/3/Ron/Cha//Bb/Nor67/5/HR138MA/4/4777//Rei/y /3/KT/6/Frunzenskaya 60	0.9	70.5	39.7
Cham-6/Frunzenskaya 60	0.4	35.4	50.0
Vee'S'//CebeCo148/3/Ron/Cha//Bb/Nor67/5/HR138MA/4/4777//Rei/y /3/KT/6/ Atay/Galvez 8 7	0.7	67.4	57.3
Psn' S '/B ow' S '//Kauz' S '/3/Atay/Gal vez 87	-0.4	62.3	73.1
Moro//Roga/Una	0.2	65.2	12.2
Clement//Roga/Una	-0.4	30.6	61.9
Compare//Ahtymar/Frunzenskaya60	0.4	78.4	59.5
Acocet' S '//Roga/Una	2.3	72.9	72.9
Fed/Kavkaz//Ahtymar/Frunzenskaya 60	-0.3	53.4	67.3
Kalyansona//Ahtymar/Frunzenskaya 60	0.1	36.7	58.9
Cook//Ahtymar/Frunzenskaya 60	-0.3	29.0	34.3

The F2 plants are segregated into three phenotypic classes: 13.2% of plants had a mass of 1000 grains less than the lowest values of plants in their parental forms; 72.2% of the F2 plants are distributed in the same phenotypic classes as the plants of the parent forms, and 6.6% of the F2 plants had a large mass of 1000 grains than the parent forms. The segregation of the hybrid combinations of F2 was 13.2: 72.2: 6.6 (3: 12: 1), with the compliance criterion being $\%^2 = 0.94$. This shows that the anticipated deviation (13.2: 79.6: 6.6) from the actual data is not high.

Positive transgression (T) by weight of 1000 grains is obtained in 56% of hybrid combinations. The degree (TL) of this indicator ranged from 0.8 to 25.9, and its frequency (TF) is 6.7-26.7, this proves that selection on this basis is of some importance (table 3).

The distribution of plants by weight of 1000 grain mass is considered using the hybrid combination Seri82 // Shi # 4414 / Grow'S '/ 3 / Adyr. Plants F_1 exceed the parameters of parental forms, i.e. heterosis is observed in this indicator (Fig.1).

Table 3

Transgression indexes of 1000 grain's weight in hybrid materials of F

Hybrids	**The maximum expression of the trait, g**		**Transgression level**	
	parental forms	F2	level, T_L	frequency T_F
Intensivnaya/Grekum634/1	56.0	50.0	-2.8	-
Mironovskaya61// Khersonskaya ostistaya/Skifyanka	47.9	68.7	22.7	10.0
4777/2/Fkn/Gb/3 Wee'S'/Pvn'S V5/Ald'S V3/Cc//Inia/Bb/6/Gerek7 9	56.0	56.3	17.5	16.7
4777/2/Fkn/Gb/3/Vee'S '/Pvn' S '/5 /Ald'S V3 /Cc//Inia/Bb/6/GRK	50.5	55.8	10.5	23.3
71 st2956/Grow' S V3 / Agaf//MCX/Tob/4/Gerek79	50.0	52.1	3.2	10.0
Ducula/Grekum 163 4/1	59.0	59.5	0.8	6.7
Atilla/Bolal	48.0	548	14.2	20.0
Maya74'SVOn//IIGo.l47/3/Bb/GII/4/AgafS'/Bow'S'/ Erythros permum2078/1	53.6	50.8	-5.2	-
Bow 'S'/Seri82//Erythrospermum1676/1	54.8	69.0	25.9	13.3
Bow 'S'/Seri82//Lutescens 42	55.8	60.4	8.2	10.0
Mtl 'S'/Cham-4//TM1038/l	53.6	53.2	-0.7	-
Cham-4//GH'S'/ Bow 'S' //Lutescens1557/1	53.5	52.9	-1.1	-
Seri82//Shi#4414/Grow 'SV/Adyr	54.0	62.8	16.3	23.3
Seri82//Shi#4414/Grow 'SV/Grekuml634/l	58.2	59.5	2.2	6.7
Vee'S V/CebeCol 48/3/Ron/Cha//Bb/Nor67/5/HR138MA/4/4777/ /Rei/y/3/KT/6/Frunzenskaya 60	54.0	53.2	-1.5	-
Cham-6/Frunzenskaya 60	51.9	53.3	2.7	16.7
Vee'S'//CebeCol48/3/Ron/Cha//Bb/Nor67/5/HR138MA/4/4777/ /Rei/y/3/KT/6/Atay/Galvez 87	49.6	47.1	-5.0	-
Psn 'S '/B ow' S V/Kauz'S '/3/Atay/Galvez87	49.0	48.6	-0.8	-
Moro//Roga/Una	44.5	52.8	18.6	23.3
Clem ent//Roga/Una	56.1	54.8	-2.3	-
Compare//Ahtymar/Frunzens кауаб О	60.6	68.7	13.4	26.7
Acocet'S V/Roga/Una	53.8	57.1	6.1	20.0
Fed/Kavkaz//Ahtymar/Frunzens kaya 60	53.7	46.4	-13.6	-
Kalyansona//Ahtymar/Frunzenskaya 60	53.5	48.6	-9.1	-
Cook//Ahtymar/Frunzens kaya 60	53.5	52.6	-1.7	-

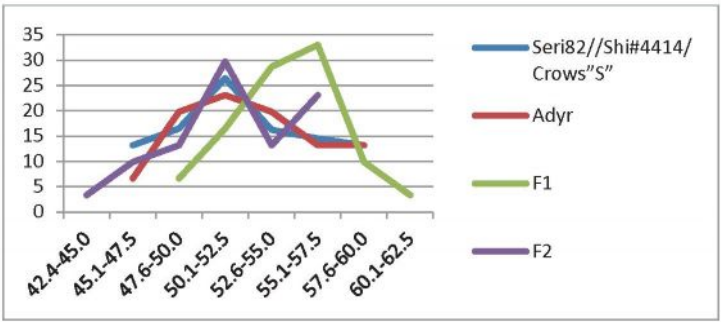

Fig.1. Distribution of plants by weight of 1000 grains in combination Seri82//Shi # 4414/Grow'S '/ 3 /Adyr: 0-35 – % of plants having 1000 grains' mass; 42.4-62.5 – the masses of 1000 grains in gram.

Conclusion

1. Hybrids obtained from crossing selected samples of CIMMYT-ICARDA and varieties of Kyrgyz breeding are characterized by different types of inheritance: heterosis, dominance of the signs of a better parent, intermediate inheritance, dominance of the signs of the worst parent and depression.
2. The mass of 1000 grains and the mass of grain from the main spike are highly inherited traits and their variability is hereditarily caused.
3. The development of a hybrid material by the dominant effects of the action of genetic systems and the presence of transgressions on these grounds should contribute to an increase in the efficiency of the selection process.
4. The nine prospective winter wheat lines for rainfed conditions were transferred to the Selection and Primary Seed Production Department of Kyrgyz Agricultural Research Institute for further breeding.

Literature

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