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INHERITANCE AND SELECTION EFFICIENCY IN HYBRID POPULATIONS OF SPRING BARLEY (*HORDEUM VULGARE* L.) UNDER GREENHOUSE CONDITIONS

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SUMMARY

The assessment of the inheritance and heritability of quantitative traits in 36 hybrid populations of barley (*Hordeum vulgare* L.) under greenhouse conditions was the presented study's focus. Results revealed the predominance of additive gene action for controlling the studied traits, indicating the possible effective selection in the F_2 generation. For selection in early generation, the most accessible traits were plant height, ear length, and grains per ear, with their variability due to an additive gene action, which is more helpful to conduct targeted breeding work. Barley hybrid populations' detection with the highest heritability coefficients for specific traits have shown in Rihane x Saule (for five traits) and three hybrids Syr Aruy x Donetskiy 8, Syr Aruy x Odesskiy 100, and Harmal x Saule (for four traits). This suggests selecting the highly productive hybrids adapted to stressful environmental conditions.

Keywords: Barley (*H. vulgare* L.), hybrid populations, breeding, selection, inheritance, heritability, additive gene action

Key findings: By studying barley (*H. vulgare* L.) hybrid populations under artificial climate conditions, the genetic criteria and intensive selection can be helpful for a comprehensive assessment of breeding material based on economic traits.

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INTRODUCTION

Barley (*Hordeum vulgare* L.) is an annual plant belonging to the cereal family with the chromosome number of 2n = 2x = 14 (Medimagh and El-Felah, 2019). Globally, barley ranks fourth among cereal crops for production after rice, wheat, and maize (Zhang *et al*., 2015). Barley is a well-known crop for its multiple uses, such as, human food, animal feed, malt, and fermentation material (Newton *et al*., 2011). It is an excellent source of nutrients, vitamins, minerals, and a common phenolic compound. Its cultivation can be under a wide variety of soil and environmental conditions, including salinity and drought with low inputs (Saisho and Takeda, 2011). Understanding the nature of gene action, such as, inheritance types and their magnitudes, and interaction is crucial to develop an effective breeding program to produce superior barley genotypes (Madakemohekar *et al.,* 2015).

Quantitative traits with enormous variation depend on the material used, and the traits with higher inheritance rates enable to select promising genotypes in early generations, in the F_2 generation, and with low rates in later generations. Such type of inheritance is important in planning the comprehensive breeding process. The coefficient of heritability in the narrow sense is particularly interesting for planning the selection, as well as, other breeding activities, as it is the differences in additive gene effects that serve as a genetic prerequisite for selection bias (Rohman *et al.,* 2024).

Drawing up a breeding program and choosing the appropriate breeding method are primarily based on the knowledge of genetic properties and variations of the source material used. The barley cultivars' development with a complex of economically valuable traits requires the breeder's knowledge of genetic variability and patterns of inheritance of various traits, and their genetic nature and correlative relationships. One of the main methods of studying the inheritance and variability of the growth and yield-related traits is genetic analysis. Plant productivity traits are quantitative variables determined by polymeric genes and characterized by a wide range of variability under the environment's influence (Majidi *et al.,* 2024).

Therefore, it is crucial to know how the economically valuable traits of parental genotypes are inherited into hybrids. Numerous studies showed inheriting quantitative traits can vary in barley hybrids (Atsbeha *et al*., 2023; Tekle *et al.,* 2024). This could be due to the used source material with different genetic background and the environmental conditions' effect on the crop crosses. The breeding material's response to environmental variations leads to changes in the traits' inheritance, revealed by comparing the expression of traits in F_1 hybrids and other generations (Zhang *et al.,* 2013; Fujimoto *et al.,* 2018; Pavlova *et al.,* 2019).

Improvement of barley genotypes requires manipulation of its genetic variability to ensure the scale of adaptation, the possibility of introducing new genes, and ultimately, increasing the genetic gain in subsequent generations (Bouchetata and Aissat, 2019). The goal of barley genetic enhancement is to maximize the desired genes in the same genotype with higher yield under existing environmental conditions.

As a result of studies conducted by Zelensky and Klyuka (2014), they found when growing rice in artificial conditions, the biometric parameters of plants change: their height increases, productive bushiness decreases, and empty grain increases. Additionally, the growing season shortened for most studied rice varieties and hybrids. The weakly varying signs on slight variability of rice plant varieties and hybrids indicate fairly normal conditions prevailing in greenhouse conditions for each plant's growth and development. It is vital to know this in practical breeding, especially when working with complex hybrid populations.

The generalized results of the conducted research and the breeding practice of the spring barley breeding laboratory indicate when growing hybrid populations of spring barley in the phytotron «Agricola» in winter, it is possible and advisable to select elite plants. They must be better in efficiency to conventional field plants. The use of artificial climate for conducting assessments of breeding material and selections can accelerate the process of creating new varieties and increase the efficiency of expensive artificial climate facilities (Sharakhov, 1991).

The novelty of the presented investigations was to study the genetic parameters in 36 barley hybrid populations under greenhouse conditions. Moreover, the management of three barley generations was under the greenhouse complex conditions of the Kyzylorda Bolashak University. The main purpose of the promising research was to identify the possibility and feasibility of carrying out selection in hybrid populations of spring barley grown in winter under artificial climate conditions.

MATERIALS AND METHODS

Barley (*H. vulgare* L.) parental genotypes and their F_1 hybrids incurred manual sowing on two-row subplots, with 20 seeds per a meter row length and row spacing of 15 cm. The sown F_2 populations have seven rows with 70 grains per a meter of row length. The experiment commenced in the greenhouse complex of the Kyzylorda Bolashak University, Kyzylorda, Kazakhstan (Figure 1). Thirty-six F_1 to F_2 hybrid populations were the object of study. At the stage of physiological maturity and complete grains ripeness, all the uprooted hybrid plants sustained tying into sheaves separately. In the laboratory, a structural analysis used the method of parsing the sheaf. It recorded the data on the traits, viz., plant height, total and productive tillering, grains per plant, grains per spike, grain weight per plant, and 1000-grain weight, with the physical properties of the barley grains visually assessed (Dospekhov, 1973; Loskutov *et al.,* 2012).

Figure 1. Breeding work in the University's greenhouse complex (A - Sowing hybrid barley populations, B - Tillering phase, C - Barley booting phase, D - Full heading phase).

Phenological observations of the initial phases of barley ontogenesis under the greenhouse complex conditions (artificial climate) revealed the lengthening of the tillering-tubing phase (17 days). However, under the natural field conditions, this duration was less or equal to 10 days. The tillering-tubing phase is critical in any grain crop, as this growth period is the basis for generative organs and its lengthening and uniformity has positive effects on the grains' filling in the spikes. It takes 15–20 years to develop one variety; but, the use of greenhouse complex allowed getting three generations of hybrid material in autumn-winter period. By using greenhouse conditions, scientists managed to reduce the period from hybridization to line selection by 4–5 years.

The inheritance determination proceeded as the degree of dominance according to the formula (Griffing, 1956):

$$hp = \frac{F - Mp}{Hp - Mp}$$

Where, Mp = the average of parental forms, Hp = the best parental form by the studied trait, and F = average value of hybrids.

The Hp = 0 value characterizes the absence of dominance of the trait, hp = 0.1–0.5 (partial dominance), hp = 0.6–0.9 (incomplete dominance), hp = 1 (complete dominance), hp > 1 (overdominance of the trait – heterosis), hp = -0.1 – -0.5 (partial dominance of the smallest value of the trait), hp = -0.6 – -0.9 (incomplete dominance of the smallest value of the trait), and hp > -1 (depression of the trait). For calculating the inheritance coefficient, the study used the formulas of Allard (1956):

$$H2 = \frac{Var(G)}{Var(P)}$$

Where, Var(G) = the variance of the genotype and Var(P) = the variance of the phenotype in the population.

RESULTS AND DISCUSSION

The study based on the quantitative traits inheritance makes it possible to determine the breeding value of source material and evaluate and select the promising breeding material at early stages. Assessment of quantitative traits inheritance in barley enables to approach the scientifically based selection of parental forms in breeding programs. Numerous past studies showed quantitative traits inheritance can be in different ways. Nikitina (2005) studied the barley F_1 and F_2 populations for plant height, ear length, spikelets per spike, grain weight of lateral shoots, total and productive bushiness, inherited mainly by the type of depression and multidirectional dominance. Meanwhile, grain weight per plant and main ear bore control by overdominance and depression. However, Cuesta-Marcos *et al.* (2016) believed the genetic system including additive and dominant effects participated in the inheritance of stem height in first-generation of barley hybrids.

The presented studies enunciated plant height inheritance in barley hybrids was mainly by the type of complete dominance of the worst parent and overdominance. In a somewhat lesser extent, the inherited plant height was intermediate, with the frequency of its manifestation of 25% in F_1 and an increase in F_2 (33.4%) (Table 1). The promising hybrid populations with high heritability values were also notable in Spring x Odesskiy 100, Syr Aruy x Donetskiy 8, Rihane x Saule, Steploe x Odesskiy 100, Marni x Odesskiy 100, ICARDA 75 x Donetskiy 8, Altyn arai x Odesskiy 100, Harrington x Odesskiy 100, Harmal x Saule, and ICARDA 4 x Odesskiy 100. They can further undergo studies through intensive selection in early generations and with greater efficiency.

The general analysis of the nature of inheritance of plant height in spring barley hybrids indicates mainly the intermediate type of inheritance. It is characteristic of hybrids obtained from crossing sharply differing parental forms' studied traits. Likewise, it is the superdominance of hybrids obtained from crossing close to the value of plant height of

Table 1. Spring barley F1 and F2 hybrids with types of dominance for plant height.

Types of inheritance	F_1S		F_2S	
	Number of hybrids	%	Number of hybrids	%
-1 < hp < 1	9	25.0	12	33.4
hp = 1	2	5.6	4	11.1
hp = -1	11	30.6	13	36.1
hp > 1	14	38.8	4	11.1
hp < -1	-	-	3	8.3
Total	36	100	36	100

Table 2. Inheritance of morphobiological traits of spring barley.

Variety samples	Plant height			Spike length			Upper internode length		
	Saule	Odesskiy 100	Donetskiy 8	Saule	Odesskiy 100	Donetskiy 8	Saule	Odesskiy 100	Donetskiy 8
Scarlett	0,42	0.40	0.49	0.51	0.56	0.32	0.08	0.16	0.32
Harrington	0.39	0.58	0.48	0.36	0.43	0.41	0.07	0.11	0.14
Rihane	0.59	0.40	0.50	0.43	0.45	0.45	0.09	0.16	0.10
Harmal	0.54	0.53	0.43	0.54	0.50	0.41	0.07	0.17	0.09
Steploe	0.45	0.59	0.51	0.58	0.38	0.36	0.33	0.13	0.09
Spring	0.46	0.57	0.50	0.40	0.39	0.39	0.19	0.10	0.31
ICARDA 75	0.40	0.46	0.53	0.48	0.52	0.33	0.14	0.12	0.10
Marni	0.47	0.53	0.49	0.34	0.41	0.50	0.09	0.11	0.13
Kharkovskiy 73	0.59	0.41	0.51	0.46	0.40	0.37	0.30	0.39	0.08
ICARDA 4	0.45	0.51	0.47	0.35	0.54	0.41	0.08	0.09	0.18
Altyn arai	0.46	0.58	0.39	0.34	0.38	0.34	0.18	0.08	0.06
Syr Aruy	0.49	0.40	0.58	0.46	0.37	0.54	0.17	0.31	0.08

varietal samples. The trait is illustrative of high inheritability and amounts to 0.49%. The obtained results agree with the data of Garkavy *et al.* (1980) and Nikitenko (1978), who noted the manifestation of heterosis and overdominance in plant height in F_1 and high inheritability of stem height in hybridization. The authors believe selection in early generations could be ineffective for traits, wherein, the effects of overdominance predominate in genetic control because intra-allelic effects operate only in the heterozygous state.

In cereal crops, the spike length is a considered stable varietal trait, as determined by genetic factors; however, its size and structure also depends on the growing conditions up to some extent (Singh *et al.,* 2021). Past research reported the trait with low heritability and inheritance potential, considerably depending on the vegetation conditions and genotype and environment interaction, significantly affected the level of realization of genetic potential for the said affected trait (Zhang *et al.,* 2015; Fujimoto *et al.,* 2018). However, in the latest studies, based on the degree of dominance, inheriting the spikelet length mainly relied on the intermediate inheritance type and complete dominance of the best parent. It includes some of their attenuation in the second generation by 7% and 2%, with an increase in the incidence of depression by 11%.

The hybrid populations recorded with the highest inheritance coefficients were Scarlett x Saule, ICARDA4 x Odesskiy 100, Harmal x Donetskiy 8, Harmal x Odesskiy 100, Harmal x Saule, ICARDA75 x Odesskiy 100, Steploe x Saule, Syr Aruy x Donetskiy 8, ICARDA 4 x Odesskiy 100, and Scarlett x Odesskiy 100 (Table 2). The average value of the inheritance coefficient of the considered trait was 0.42%. In general, the trait spike length showed minimum variability and a high enough inheritability, one of the important traits on which purposeful research work can proceed to enhance the barley productivity.

The stem height and the second (basal) internode are critical components used for lodging resistance in barley. It is usually long-stemmed genotypes with a long upper internode, exhibiting as non-resistant to lodging in spring barley (Tokhetova *et al.,* 2022). Other studies also revealed a significant influence of environmental factors on the upper internode length, noting this trait is quite sensitive to unfavorable environmental conditions in bread wheat (Tsilke, 2005; Lepekhov and Korobeinikov, 2013). Relatedly, the determination of each internodal length often comes from different genes in barley and other crop plants (Kocherina, 2009; Franckowiak *et al.,* 2012). Therefore, it is possible to select the high-yielding lines differing in plant height depending on the breeding needs.

In barley, the additive gene effects were dominant in the inheritance of the second internode length in the F_1 generation (Madic *et al.*, 2016). Both additive and dominant gene effects played an important role in the F_2 generation. In the presented studies, on dominance, the chief inheritance of upper internode length was by the types of intermediate inheritance, negative overdominance, and overdominance, with the latter increasing by 5.6% and 8.3% in F_2 (Table 3). The inheritance coefficients ranges from 0.07% to 0.39%, categorized as low inheritance. Some correlation of the inheritability of the said trait with the ecological and geographical origin of the parental forms used in hybridization surfaced.

The number of spikelets per spike was the trait relatively less subject to variability than other components of productivity. Its value depends on the species, cultivar, years of research, and the growing conditions. In these studies, the trait number of spikelets per spike had a high inheritance coefficient, which could be due to the medium variation type of variability. Similarly, it may refer as inherited equally by both types of overdominance and intermediate inheritance, which slightly decreased in F_2 by 2.8% and 8.3%. The frequency of negative overdominance increased from 19.5% in F_1 to 33.3% in F_2 (Table 4). According to populations, the hybrids Harrington x Odesskiy 100, ICARDA 75 x Odesskiy 100, Kharkovskiy 73 x Saule,

Table 3. Spring barley F1 and F2 hybrids with types of dominance for length of the upper internode.

Types of inheritance	F_1S		F_2S	
	Number of hybrids	%	Number of hybrids	%
-1 < hp < 1	17	47.2	14	38.9
hp = 1	1	2.8	-	-
hp = -1	1	2.8	-	-
hp > 1	9	25.0	12	33.3
hp < -1	8	22.2	10	27.8
Total	36	100	36	100

Table 4. Spring barley F1 and F2 hybrids with types of dominance for number of spikelets in an ear.

Types of inheritance	F_1S		F_2S	
	Number of hybrids	%	Number of hybrids	%
-1 < hp < 1	13	36.1	10	27.8
hp = 1	4	11.1	2	5.6
hp = -1	-	-	1	2.8
hp > 1	12	33.3	11	30.5
hp < -1	7	19.5	12	33.3
Total	36	100	36	100

Rihane x Saule, ICARDA 4 x Donetskiy 8, ICARDA 4 x Saule, and Harrington x Saule, have the highest inheritance value (0.52%), on average, with intermediate type of inheritance. Therefore, the study recommended carrying out the selection in the early generations.

The trait grains per spike is an essential breeding variable, considerably contributing to plant productivity. Under greenhouse conditions, the trait grains per spike in the F_1 generation's inheritance appeared by the type of intermediate inheritance (38.9%), overdominance (25%), and complete dominance of the worst parent (19.4%). However, in the subsequent generation, the intermediate type of inheritance sharply decreases by 11.1%, slightly the overdominance by 5.6%, with an increase in the type of negative overdominance and depression by 22.3% (Table 5). The said trait's distinction was to be, of greater extent, by hereditary properties of the variety, and especially with soil and air moisture during the period of spike formation. Under drought conditions, the number of grains per spike and the absolute grain weight per spike decreased, and the said parameters can serve as indicators of drought resistance of the cultivar under water-deficit conditions (Singh *et al.,* 2018; Kamal *et al.,* 2022). Compared with the trait number of spikelets per spike, the coefficient of inheritance of this trait was higher (0.41%) and belonged to the categories of highly inherited traits. The hybrid populations with the highest heritability values also appeared (Table 6).

The trait 1000-grain weight reached equal inheritance by the type of intermediate inheritance and negative overdominance (36.1%). However, in the F_2 generation, an observed attenuation of the latter (25%) emerged, with an increased frequency of manifestation by the type of intermediate inheritance (13.9%) and overdominance (16.7%) (Table 7). Inheritance of 1000-grain weight by the degree of overdominance was characteristic of hybrids obtained by crossing the genotypes with the highest grain size. Singh *et al.* (2018) also reported inheriting the 1000-grain weight was by the type of intermediate inheritance (Np = -0.5 to +0.5) in most hybrid combinations. The inheritance coefficient was 0.37%, which means the said trait seemed highly inherited.

The barley hybrid populations with the highest values identified were Harmal x Odesskiy 100, 5-137 x Donetskiy 8, Rihane x Odesskiy 100, Rihane x Saule, 26/83 x Odesskiy 100, Spring x Donetskiy 8, ICARDA75 x Odesskiy 100, Marni x Odesskiy 100, Spring x Odesskiy 100, Syr Aruy x Saule, and ICARDA4 x Odesskiy 100, which could be effective for further selection in early generations.

Grain weight per spike and per plant are the attributes signifying the summation of their components, i.e., grains per spike and 1000-grain weight. The primary components of the grain yield are the number of spikes per unit area and productivity per crop season, which, in turn, depends on the number of grains and the grain weight. These components result in the interaction of genetic factors and agroecological conditions, and their variations cause variability in barley grain yield. The studies further revealed half of the F_1 hybrids have shown overdominance for grain weight per spike (55.6%), while the analysis showed overdominance was the hybrids' characteristic derived from crosses of closely related cultivars. The number of populations inherited by the type of overdominance decreases, and the depressed populations appear up to 41.7% (Table 8).

Past studies recognized the grain weight per plant gained control from numerous genes and varies greatly under the influence of the environment, which complicates the selection of lines (Eshghi and Akhundova, 2010; Hama-Amin, 2019). According to this trait, the inheritance types of intermediate (36%), complete dominance of the best parent and overdominance (16.7%), and negative overdominance (25%) were manifestations by the barley hybrids in the F_1 generation. In the F_2 generation, the frequency of manifestation by the type of intermediate inheritance slightly increases (5.7%), while the frequency of expression by other types of inheritance was approximately the same in the F_2 generation

Table 5. Spring barley F1 and F2 hybrids with types of dominance for number of grains in an ear.

Types of inheritance	F_1S		F_2S	
	Number of hybrids	%	Number of hybrids	%
-1 < hp < 1	14	38.9	10	27.8
hp = 1	2	5.6	3	8.3
hp = -1	7	19.4	4	11.1
hp > 1	9	25.0	7	19.4
hp < -1	4	11.1	12	33.4
Total	36	100	36	100

Table 6. Heritability of spring barley productivity traits.

Variety samples	Number of grains in an ear			Grain weight per ear			Grain weight per plant		
	Saule	Odesskiy 100	Donetskiy 8	Saule	Odesskiy 100	Donetskiy 8	Saule	Odesskiy 100	Donetskiy 8
Scarlett	0.38	0.57	0.49	0.22	0.45	0.25	0.05	0.39	0.17
Harrington	0.41	0.55	0.40	0.31	0.38	0.32	0.14	0.38	0.35
Rihane	0.53	0.31	0.25	0.48	0.28	0.46	0.13	0.10	0.15
Harmal	0.55	0.52	0.28	0.26	0.49	0.21	0.39	0.07	0.14
Steploe	0.31	0.39	0.40	0.21	0.45	0.35	0.12	0.16	0.18
Spring	0.32	0.24	0.39	0.25	0.24	0.33	0.10	0.39	0.09
ICARDA 75	0.52	0.37	0.29	0.33	0.18	0.21	0.39	0.14	0.12
Marni	0.41	0.45	0.15	0.37	0.19	0.19	0.10	0.39	0.14
Kharkovskiy 73	0.51	0.35	0.35	0.37	0.16	0.21	0.11	0.15	0.19
ICARDA 4	0.37	0.43	0.38	0.31	0.48	0.45	0.39	0.09	0.39
Altyn arai	0.35	0.38	0.54	0.27	0.46	0.44	0.11	0.18	0.08
Syr Aruy	0.47	0.51	0.55	0.20	0.44	0.44	0.10	0.39	0.09

Table 7. Spring barley F1 and F2 hybrids with types of dominance for 1000-grain weight.

Types of inheritance	F_1S		F_2S	
	Number of hybrids	%	Number of hybrids	%
-1 < hp < 1	13	36.1	18	50
hp = 1	2	5.6	1	2.8
hp = -1	4	11.1	3	8.3
hp > 1	4	11.1	10	27.8
hp < -1	13	36.1	4	11.1
Total	36	100	36	100

Table 8. Spring barley F1 and F2 hybrids with types of dominance for grain weight per ear.

Types of inheritance	F_1S		F_2S	
	Number of hybrids	%	Number of hybrids	%
-1 < hp < 1	7	19.4	10	27.8
hp = 1	4	11.1	3	8.3
hp = -1	5	13.9	6	16.6
hp > 1	20	55.6	2	5.6
hp < -1	-	-	15	41.7
Total	36	100	36	100

Table 9. Spring barley F1 and F2 hybrids with types of dominance for grain weight per plant.

Types of inheritance	F_1S		F_2S	
	Number of hybrids	%	Number of hybrids	%
-1 < hp < 1	13	36.0	15	41.7
hp = 1	6	16.7	5	13.8
hp = -1	2	5.6	2	5.6
hp> 1	6	16.7	4	11.1
hp < -1	9	25.0	10	27.8
Total	36	100	36	100

Table 10. Spring barley F1 and F2 hybrids with types of dominance for productive bushiness.

Types of inheritance	F_1S		F_2S	
	Number of hybrids	%	Number of hybrids	%
-1 < hp < 1	9	25.0	6	16.7
hp = 1	-	-	2	5.6
hp = -1	7	19.4	-	-
hp > 1	14	38.9	17	47.2
hp < -1	6	16.7	11	30.6
Total	36	100	36	100

(Table 9). As characterized by low values of inheritability caused by the considerable influence of environmental conditions on the development of this trait, the outcome suggested the selection should continue in later generations.

The opposite picture was visible for the trait productive bushiness. The frequency of occurrence by type of overdominance in F_2 increased by 8.3% compared with the F_1 generation, and the frequency of occurrence by type of intermediate inheritance decreased by 8.3% (Table 10). An increase in the F_2 populations by the negative type of overdominance (depression) revealed as associated with non-allelic interaction of genes causing inhibition of the development processes of the traits under consideration. The selection for this trait will be more effective in later generations, when most of the loci became homozygous. The genetic variability share of the productive bushiness was a nonsignificant part of phenotypic variability. It considerably reacts to the influence of the environment, as weakly inherited (0.12%); therefore, the selection in the F_2 generation will be ineffective.

Notably, in the study of Lozinskyi and Ustinova (2022), it was evident the most common type of inheritance of productive bushiness is positive overdominance, as observed in 95.1% of hybrids. However, the authors state the indicators of phenotypic dominance of productive bushiness in the years of research reached detection by the selected hybridization components and year conditions. Consequently, the authors conclude, given the high variability and low inheritability of the trait "productive bushiness," it is unsuitable to specifically select parental pairs and carry out selection to improve this trait.

In general, the study of the nature of inheritance and heritability of quantitative traits of spring barley under greenhouse conditions showed the inheritance of traits were mainly by the type of intermediate inheritance and overdominance (Table 11).

In the presented study, the promising hybrid populations identified have the highest inheritance coefficients and an intermediate type of inheritance. In such hybrid combinations, where the additive gene action is a combination with the high inheritance

Table 11. Types of dominance (%) and average values of inheritance coefficients of quantitative traits.

Signs	-1 < hp < 1		hp = 1		hp = -1		Hp > 1		hp < -1		H^2
	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	
Plant height	25.0	33.4	5.6	11.1	30.6	36.1	38.8	11.1	-	8.3	0.49
Productive bushiness	25.0	16.7	-	5.6	19.4	-	38.9	47.2	16.7	30.6	0.12
Upper internode length	47.2	38.9	2.8	-	2.8	-	25.0	33.3	22.2	27.8	0.15
Spike length	50.0	41.7	25.0	16.7	5.6	5.6	19.4	25.0	-	11.0	0.42
Number of spikelets in an ear	36.1	27.8	11.1	5.6	-	2.8	33.3	30.5	19.5	33.3	0.39
Number of grains in an ear	38.9	27.8	5.6	8.3	19.4	11.1	25.0	19.4	11.1	33.4	0.41
Weight of 1000 grains	36.1	50	5.6	2.8	11.1	8.3	11.1	27.8	36.1	11.1	0.37
Grain weight with ear	19.4	27.8	11.1	8.3	13.9	16.6	55.6	5.6	-	41.7	0.32
Grain weight per plant	36.0	41.7	16.7	13.8	5.6	5.6	16.7	11.1	25.0	27.8	0.19

coefficient for three traits, viz., plant height, ear length, and grains per spike. For such situation, the selection can be conducive in the early generation of the hybrids, i.e., Rihane x Odesskiy 100, Harmal x Odesskiy 100, Harmal x Donetskiy 8, Rihane x Saule, 26/83 x Odesskiy 100, Harrington5 x 137/80, 5-137 x Donetskiy 8, Spring x Donetskiy 8, ICARDA 75 x Odesskiy 100, Marni x Odesskiy 100, Spring x Odesskiy 100, and Syr Aruy x Saule. The hybrids Harrington x Odessky 100, Scarlett x Saule, Scarlett x Odessky 100, and Syr Aruy x Odesskiy 100 also revealed of practical interest with heterotic effects and dominance for the majority of quantitative traits. This was of practical importance for breeding for obtaining transgressive forms.

The most available traits for selection in early generations are: plant height, ear length, and number of grains in the ear. These traits had high values of inheritance coefficient and acquire little effect from the environment. It means their variability comes from genetic factors, in particular, by the action of additive genes. They are one of the vital traits necessary to carry out purposeful selection work to increase barley productivity in this region. Hybrid populations with high values of inheritance coefficient for specific traits and for their complex are Rihane x Saule (for five traits), Syr Aruy x Donetskiy 8, Syr Aruy x Odesskiy 100, and Harmal x Saule (for four traits). Hence, they are necessary to select highly productive forms adapted to stressful environmental conditions.

Thus, in barley hybrid populations, the genetic study and selection of quantitative traits allowed to determine the type and level of inheritance (Patial *et al*., 2016; Baimuratov and Sariev, 2024). It will also allow further optimal combination and selection of parental genotypes in hybridization programs, as well as, carry out targeted selection for traits improvement in the breeding of spring barley cultivars.

CONCLUSIONS

The prevalence of additive gene action in controlling studied traits indicates the possibility of effective selection in the F_2 generation. Consequently, the genetic contribution of additive and non-additive gene effects in the determination and inheritance of the studied traits significantly depend on the growing conditions of spring barley genotypes. Thus, the use of an artificial climate for assessing breeding material and selection can hasten the process of developing new cultivars and enhance the efficiency of greenhouse structure.

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