

INHERITANCE OF GRAIN NUMBER PER MAIN SPIKE IN F₁ HYBRIDS OF *Hordeum vulgare* L.

Kuzmenko Yevhenii^{1,*}, Polishchuk Tetiana¹, Los Ruslan¹, Sukailo Mykhailo¹, Khomenko Tetiana², Zhytomyrets Oksana²

¹The V. M Remeslo Myronivka Institute of Wheat of National Academy of Agrarian Sciences of Ukraine, Tsentralne, Kyiv region, Ukraine

²Ukrainian Institute for Plant Variety Examination, Kyiv, Ukraine

*e-mail: evgeniy.anatoliyovich@gmail.com

Summary. The results of the inheritance of grain number per main spike in F₁ hybrids of winter barley under the conditions of the V.M. Remeslo Myronivka Institute of Wheat of NAAS are presented. Different types of trait inheritance were established depending on the combination of crossing. According to the type of positive overdominance ($h_p \geq +1.00$), 7 hybrid combinations of winter barley were selected. As genetic sources for increasing the grain productivity of plant, the variety KWS Tenor and the line Pallidum 5173 should be used as the maternal component.

Keywords: winter barley, hybridization, inheritance, heterosis, productivity.

Introduction

Winter barley (*Hordeum vulgare* L.) is a highly sought-after crop both in Ukraine and abroad. It is used as a forage crop, raw material for the production of flour, pearl barley and barley groats. In addition to the domestic market, Ukrainian producers constantly export barley to different countries of the world [1].

The distribution area of winter barley has an impact on a significant increase in forage grain production, but insufficient winter hardiness of varieties prevents the expansion of sowing areas [2]. An important component of ecological system of field is a variety that is adapted to natural and ecological conditions and, with a certain culture of zonal farming, affects an increase in productivity by 10-50%. Features of ecological adaptability of varieties include different growing season duration, high rates of frost resistance and winter hardiness, drought tolerance, high lodging and pathogen resistance, grain weight per spike, harvest index, resistance to harmful environmental factors etc. [3, 4]. Changes in environmental factors require selection of varieties and hybrids with high ecological adaptability, which will improve the quality of plant products. Stability of yield of crops varieties, in particular winter barley, under global climate change is no less important a property than their high genetic potential of productivity. The problem of adaptation has always occupied, and will occupy a key place in selection, as well as in the practice of agricultural production. Adaptive selection is aimed at creating macrosystems of cultivated plants, maximally focused on specific bioclimatic potential and biotic factors of the environment of their growing. The discrepancies between potential productivity and actual grain yield necessitate a more in-depth study and development of the theory and practice of breeding aimed at increasing productivity and adaptability [5].

The development of high-yielding varieties of winter barley depends on the existing genetic variation of traits that determine yielding capacity and directly its grain productivity. The parameters of genetic variation provide information on the possible expected response of yielding capacity and its main components to selection, which can be used to determine the most successful breeding strategy [6]. Today, to achieve this goal, scientists study the genetic potential of breeding lines and local varieties and their hybrid populations from crossing, which are the basis for a sustainable increase in productivity, in particular for winter barley [7]. Breeders note the importance of using genetic variability and diversity in breeding programs to meet the ever-growing need to improve hybrids and varieties. Selection of the majority of potential lines by biometric analysis and genetic diversity is very important for the success of breeding programs. The main factor limiting

the rate of progress in plant growing is the low heritability of such quantitative trait as yield [8]. When crossing two components, the phenotypic variability of F_1 , as well as of each parent, is determined by both genetic and non-hereditary factors. But the manifestation and degree of heterosis in F_1 make it possible to predict the emergence of transgressive lines in subsequent generations, which in turn increases the efficiency of selection in hybrid populations of samples with desired traits [9].

The aim of the research was to evaluate heterosis and inheritance of the trait "grain number per main spike" in F_1 hybrids of winter barley.

Materials and methods

The studies were conducted during 2022-23 at Barley Breeding Laboratory of the V.M. Remeslo Myronivka Institute, NAAS of Ukraine. For crossing according to an incomplete diallelic scheme, 7 lines and 1 variety of Ukrainian origin and 2 varieties of winter barley of German origin were involved. Biometric analysis of the studied material was carried out on an average sample of 25 plants [10]. Agrotechnics was conventional for growing winter barley in the Central Forest-Steppe zone of Ukraine. Soybean was the preceding crop. Statistical processing of the obtained biometric data was performed according to the Methods of breeding experiment (in plant science [11]. Indicators of hypothetical (Ht) and true (Htb) heterosis for grain number per main spike were calculated according to the methods of Matzinger D. F. [12] and S. Fonseca, F. Patterson [13] using the following formulas:

$$Ht (\%) = \frac{F_1 - MP}{MP} \times 100, \quad (1)$$

$$Htb (\%) = \frac{F_1 - BP}{BP} \times 100, \quad (2)$$

where F_1 – arithmetic mean of the hybrid trait; Ht – hypothetical heterosis; Htb – true heterosis; MP – mean of both parental forms; BP – the best parental trait.

The degree of phenotypic dominance (hp) was determined according to the method of B. Griffing [14] using the following formula:

$$hp = \frac{F_1 - MP}{BP - MP}, \quad (3)$$

The data were grouped according to the classification of G. M. Beil, R. E. Atkins [15] (Table 1):

Table 1

Classification of phenotypic dominance of traits

Dominance class	Numerical value of hp
Positive overdominance (heterosis)	$hp > 1.00$
Partial positive dominance	$+0.50 \leq hp < 1.00$
Intermediate inheritance	$-0.50 \leq hp < +0.50$
Partial negative dominance	$-1.00 \leq hp < -0.50$
Negative overdominance (depression)	$hp < -1.00$

Hypothetical heterosis (Ht) indicates the excess of the manifestation of a quantitative trait in the F_1 hybrid over the average value of the parental components. At the same time, true heterosis (Hbt) allows us to calculate the manifestation of a trait in F_1 compared to the best parental form and to evaluate the breeding value of the hybrid. This method of evaluating hybrids is widely used in plant science [16, 17].

Results and discussion

Hybridization is one of the main methods of creating the source material for winter barley breeding; it ensures the production of new samples that combine in their genotype the characteristics and properties planned in accordance with selection program. Involvement in crossing biotypes from different ecological and geographical groups contributes to a wider formation in hybrid populations, which increases the efficiency of breeding work. Improvement of the productivity of the variety is possible due to an increase in grain number per main spike.

The inheritance of grain number per spike has a higher reliability, and therefore selection for this trait is more effective, since it is largely determined by the influence of various environmental conditions, primarily meteorological [17].

According to the trait grain number per spike, 7 the best hybrid combinations were found in comparison with the original parental forms (Table 2).

Table 2
Heterosis effect and degree of phenotypic dominance for the trait “grain number per main spike” in F₁ winter barley (2023)

Combination	Grain number, pcs			Ht, %	Hbt, %	hp
	P ₁	P ₂	F ₁			
Pallidum 5173 / Pallidum 5192	70.57	72.00	73.86	9.53	4.66	2.05
Pallidum 5173 / Pallidum 5131	70.57	55.43	73.57	13.06	4.25	1.55
Pallidum 5173 / MIP Atlas	70.57	68.57	71.43	16.55	10.13	2.84
Pallidum 5173 / Pallidum 5184	70.57	64.29	70.86	11.59	8.53	4.12
KWS Tenor / Pallidum 5131	62.29	55.43	69.86	16.71	8.67	2.26
Titus / Pallidum 5141	62.14	64.29	67.71	1.61	-8.32	0.15
Titus / Pallidum 5131	62.14	55.43	67.29	2.39	-6.55	0.25
Pallidum 5173 / Pallidum 5121	70.57	59.43	66.00	7.32	1.09	1.19
KWS Tenor / Pallidum 5121	62.29	59.43	66.00	-2.74	-10.29	-0.33
Titus / Pallidum 5192	62.14	72.00	65.86	-1.81	-8.53	-0.25
Pallidum 5200 / MIP Atlas	47.29	68.57	65.43	-3.07	-3.38	-9.67
Titus / MIP Atlas	62.14	68.57	65.29	-0.87	-6.54	-0.14
KWS Tenor / Pallidum 5141	62.29	64.29	64.86	0.44	0.00	1.00
Pallidum 5200 / Pallidum 5192	47.29	72.00	64.86	11.96	-5.42	0.65
KWS Tenor / MIP Atlas	62.29	68.57	62.57	-15.12	-15.28	-78.00
Pallidum 5173 / Pallidum 5141	70.57	64.29	62.14	-6.65	-7.64	-6.20
KWS Tenor / Pallidum 5192	62.29	72.00	61.86	5.10	-0.69	0.87
Pallidum 5200 / Pallidum 5121	47.29	59.43	61.71	-5.26	-8.86	-1.33
Titus / Pallidum 5121	62.14	59.43	61.71	-8.38	-11.66	-2.26
KWS Tenor / Pallidum 5184	62.29	64.29	60.86	-4.59	-6.99	-1.78
Pallidum 5200 / Pallidum 5131	47.29	55.43	57.71	-11.50	-15.83	-2.23
Titus / Pallidum 5184	62.14	64.29	57.57	-15.51	-19.40	-3.22

Note: P₁ – maternal form, P₂ – parental form, F₁ – hybrid, Ht – hypothetical heterosis, Hbt – true heterosis, hp – degree of phenotypic dominance

These are the hybrid combinations: Pallidum 5173/Pallidum 5184 (hp = 4.12, Ht - 11.59%, Hbt - 8.53%); Pallidum 5173 / MIP Atlas (hp = 2.84, Ht - 16.55%, Hbt - 10.13%); KWS Tenor / Pallidum 5131 (hp = 2.26, Ht - 16.71%, Hbt - 8.67%); Pallidum 5173 / Pallidum 5192 (hp = 2.05, Ht - 9.53%, Hbt - 4.66%); Pallidum 5173 / Pallidum 5131 (hp = 1.55, Ht - 13.06%, Hbt - 4.25%); Pallidum 5173 / Pallidum 5121 (hp = 1.19, Ht - 7.32%, Hbt - 1.09%); KWS Tenor / Pallidum 5141 (hp = 1.00, Ht - 0.44%, Hbt - 0.00%).

In total, out of 22 hybrid combinations of winter barley, 7 (31.8%) combinations showed positive overdominance (heterosis), 2 (9.1%) – partially positive dominance, 5 (22.7%) – intermediate inheritance, and 8 (36.4%) – negative overdominance (depression).

It is recommended to use the line Pallidum 5173 and the variety KWS Tenor as the maternal component, since hybrids created with their participation had the highest indicators of grain number per spike.

Conclusions

The inheritances by the degree of phenotypic dominance were determined and the indices of hypothetical and true heterosis were determined in F₁ winter barley hybrids by the trait “grain number per main spike”. A significant variation in the degree of phenotypic dominance (*hp*) was found depending on the crossing combination, namely from positive overdominance ($hp \geq +1.00$) to negative overdominance ($hp \leq -1.00$).

In more than 1/3 (31.8%) of the studied hybrid combinations, inheritance by the type of positive overdominance (heterosis) was noted, which allows for effective selections for this trait. Hybrid combinations with high indices of true heterosis (4.25–10.13%) based on grain number per main spike were identified, namely Pallidum 5173 / MIP Atlas, KWS Tenor / Pallidum 5131, Pallidum 5173 / Pallidum 5184, Pallidum 5173 / Pallidum 5131.

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