

SPIKE PERFORMANCE TRANSGRESSION DEGREE AND FREQUENCY IN F₂ WINTER BREAD WHEAT HYBRIDS

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Differences in transgressions upon crossings according to diallel and tester designs were detected. The positive transgression degree for spike length in F₂ hybrids from diallel crossing averaged 6.9%; the frequency was 52.6%; the spikelet number per spike was 7.8% (frequency = 44.8%); the kernel number per spike was 5.4% (21.4%); the spike weight was 6.3% (23.4%); the kernel weight per spike was 6.9% (22.5%); thousand kernel weight was 0.1% (31.2%). The positive transgression degree for spike length in F₂ hybrids from tester crossing averaged 4.6%; the frequency was 36.5%; the spikelet number per spike was 6.9% (30.5%); the kernel number per spike was 5.4% (26.0%); the spike weight was 10.0% (29.2%), the kernel weight per spike was 11.5% (29.3%); thousand kernel weight was 2.6% (31.6%).

Key words: *winter bread wheat, spike performance constituents, transgression frequency, transgression degree, diallel crossing, tester crossing*

Introduction. Winter bread wheat is the main food crop in Ukraine and worldwide [1]; it is characterized by high environmental plasticity and able to form productive agrobiocenoses in different geographical zones and climatic conditions. Its high nutritional value contributed to the spread of wheat as the main food product for half of the world's population [2].

It ranks first among all agricultural crops in terms of arable area. The main wheat belt stretches for many thousands of kilometers across the territory of Europe, Asia and North America [3]. Therefore, creation of new high-yielding winter wheat varieties for various purposes is one of breeders' primary objectives, since the variety is the most available and cheapest way to raise grain production and improve product quality both in domestic and global agricultural production [4].

Literature Review and Problem Articulation. Breeding for yield capacity is the most important and comprehensive trend, due to the fact that productivity depends not only on genotypes, but also on environments. Survival of plants and their performance, which consists of several elements, are the final criteria in evaluating breeding material. Under identical conditions, different varieties can yield differently because of different constituents of their performance. With correct selection of parents for crossing, it is possible to achieve a better combination of these constituents and to increase potential and harvested yields of new forms in comparison with original ones [5].

Vlasenko V.A. [6], Alabushev A.V. [7], Morhun V.V. [8], and Vasylykivskiy S.P., Hudzenko V.M., Kochmarskyi V.S., Kyrlylenko V.A. [9] claim that current breeding has achieved significant success in increasing the potential yield. Modern domestic and foreign varieties can potentially yield more than 10 t/ha. However, as practice shows, 30–50% of new varieties' potentials are only used, decreasing in some years to 24–26%, and in some regions even to 20% [10]. According to M.A. Lytvynenko [11], Bazalii V.V. [12] and Ivashchenko O.O., Rudnyk-Ivashchenko O.I. [13], winter wheat varieties realize up to 85% of their yield potentials on some farms only.

The yield potential of a variety is always used as its most important characteristic; therefore, studies of performance and yield constituents have been carried out for a long time.

The success of practical breeding largely depends on the genetic diversity of starting material [14].

Upon crossing parents, phenotypes with greater expression of traits than in either of parents may emerge in subsequent hybrid generations. The phenomenon of such phenotypes in hybrid generations (starting with the second) is called transgressive segregation [15].

Purpose. To analyze the spike performance transgression degree and frequency in F₂ winter bread wheat hybrids.

Materials and Methods. Thirty 30 F₂ hybrids from diallel crossings and 20 F₂ hybrids from tester crossings were investigated. Domestic varieties for different climatic zones were used diallel crossings: eastern forest-steppe was represented by Dyvo and Korovina (PPI); forest-steppe – by Ladyzhynka (IPPG) and Vodohrai Bilotserkivskiy (BTsES); steppe – by Khvala and Kubok (PBGI). For tester crossings, five domestic varieties (Dyvo, Korovina [PPI]; Ladyzhynka (IPPG); Vodohrai Bilotserkivskiy [BTsES]; Khvala [PBGI]) were used. Two accessions from Germany (Arktis and Kanada), one from Russia (Donera), and one from Slovakia (Viglanka) were taken as testers. The initial varieties differed in spike performance, growing period, and adaptability.

The study was carried out in the Laboratory of Genetic Resources of Cereals of the Plant Production Institute named after V.Ya. Yuriev of NAAS in 2019–2021. The experiments were carried out in accordance with the requirements for field experiments in breeding. F₂ hybrids and their parents were sown with a manual single-row planter within the optimal timeframe. The row length was 1 m; the interrow distance was 20 cm; the depth was 4–6 cm; wheat was sown after bare fallow. Twenty seeds per row were sown. Data were statistically processed, as B.A. Dospikhov recommended [16].

In F₂ hybrids, segregation was observed for spike performance traits. Combinations with high and stable frequencies and degrees of transgressions are most valuable for breeding. The transgression degrees and frequencies for quantitative traits were determined by the formulae proposed by H.S. Voskresenskaya and V.I. Shpota [17].

The transgression degree was calculated by the following formula:

$$Td = ((Pg - Pr) / Pr) \times 100\%,$$

where Td – degree of superiority over the better parent for this trait, %;

Pg – value of the trait in selected plants of a given generation;

Pb – value of the trait in the better parent in this crossing (mean for 10 best plants).

The transgression frequency was calculated by the following formula:

$$Tf = (A / B) \times 100\%,$$

where Tf – transgression frequency, %;

A – the number of hybrid plants that are superior to the better parent;

B – the total number of hybrid plants analyzed for this trait in the combination.

Superiority by >5% over the better parent was considered significant.

Results and Discussion. Analyzing the F₂ hybrids from diallel crossings, positive transgressions of spike length were found in all the analyzed hybrids. The greatest degree of transgression was recorded for the following combinations: Ladyzhynka / Dyvo (Td = 18.0%), Vodohrai Bilotserkivskiy / Ladyzhynka (Td = 12.1%), Kubok / Dyvo (Td = 11.8%), Khvala / Vodohrai Bilotserkivskiy (Td = 11.6 %), Korovina / Dyvo (Td = 11.2 %), Khvala / Dyvo (Td = 11.1 %), Kubok / Korovina (Td = 11.0 %), and Korovina / Ladyzhynka (Td = 10, 9 %). The highest frequency of transgression for this trait was observed in the following hybrids: Ladyzhynka / Dyvo (Tf = 89.7%), Khvala / Dyvo (Tf = 85.0%), Korovina / Dyvo (Tf = 83.7%), Korovina / Ladyzhynka (Tf = 83.3 %), and Dyvo / Ladyzhynka (Tf = 83.0 %) (Table 1).

Table 1

Spike performance transgression degrees and frequencies in F₂ winter bread wheat hybrids from diallel crossings (2019–2021), %

Combination	Spike length		Spikelet number per spike		Kernel number per spike		Spike weight		Kernel weight per spike		Thousand kernel weight	
	Td	Tf	Td	Tf	Td	Tf	Td	Tf	Td	Tf	Td	Tf
Korovaina / Dyvo	11.2	83.7	9.7	73.7	2.6	26.3	10.2	40.3	8.5	30.0	1.2	17.3
Korovaina / Ladyzhynka	10.9	83.3	2.0	19.0	2.5	15.0	4.1	19.0	0.7	10.7	0.7	11.7
Korovaina / Vodohrai	8.0	21.0	7.2	46.7	2.5	14.3	6.2	24.3	3.9	8.0	1.0	44.7
Bilotserkivskiy												
Korovaina / Kubok	4.2	44.7	4.7	39.3	0.1	1.3	8.6	38.0	8.2	25.0	3.6	50.0
Korovaina / Khvala	9.2	65.3	7.5	42.7	3.4	19.7	1.2	0.7	5.5	9.3	1.1	10.0
Dyvo / Korovaina	2.4	37.7	4.6	44.7	0.9	8.7	7.6	41.7	6.8	31.3	4.1	55.0
Dyvo / Ladyzhynka	8.1	83.0	5.3	35.0	8.3	38.0	13.5	41.3	12.5	36.3	1.7	41.7
Dyvo / Vodohrai	5.8	50.7	10.5	83.7	8.3	32.7	13.7	48.7	11.2	29.7	0.6	18.0
Bilotserkivskiy												
Dyvo / Kubok	4.9	39.0	5.3	29.0	1.3	22.7	3.2	10.3	1.7	0.7	2.0	39.0
Dyvo / Khvala	2.9	36.7	7.8	43.7	4.2	9.7	1.2	2.3	3.8	5.7	0.0	42.0
Ladyzhynka / Dyvo	18.0	89.7	7.4	42.3	8.8	28.0	18.5	30.30	14.1	43.7	0.7	28.0
Ladyzhynka / Korovaina	1.4	26.7	2.0	6.3	2.5	9.3	11.4	35.3	8.4	33.0	2.8	34.3
Ladyzhynka / Vodohrai	5.6	55.3	2.3	7.0	7.5	15.0	11.1	42.7	11.1	39.7	2.8	55.7
Bilotserkivskiy												
Ladyzhynka / Kubok	4.7	17.0	5.1	39.3	7.1	31.3	10.2	35.7	10.7	28.3	1.6	22.3
Ladyzhynka / Khvala	4.2	43.3	13.0	59.7	9.4	22.3	-8.6	0.0	-5.8	0.0	-7.1	0.0
Vodohrai												
Bilotserkivskiy . / Korovaina	3.7	14.3	4.7	36.0	-2.5	0.0	13.7	33.7	10.2	17.7	0.7	35.7
Vodohrai												
Bilotserkivskiy / Dyvo	5.1	25.7	7.9	47.3	3.1	21.3	6.9	11.3	3.1	20.3	0.4	42.0
Vodohrai												
Bilotserkivskiy / Ladyzhynka	12.1	66.7	7.9	36.3	11.8	42.7	9.9	36.3	9.5	29.7	0.1	11.3
Vodohrai												
Bilotserkivskiy / Kubok	0.3	24.7	8.0	76.3	5.2	21.0	9.5	34.0	4.5	28.7	0.5	32.3
Vodohrai												
Bilotserkivskiy / Khvala	9.4	74.3	18.6	88.7	12.9	37.7	11.5	49.0	15.8	34.3	0.5	32.3

Khvala / Korovaina	7.6	75.7	7.5	29.7	5.9	12.7	1.2	1.3	5.8	12.0	1.1	11.3
Khvala / Dyvo	11.1	85.0	7.8	44.0	5.8	19.7	1.2	7.3	7.3	10.3	2.1	48.0
Khvala / Ladyzhynka	8.3	64.3	7.9	15.3	6.0	14.3	-5.2	5.2	0.5	5.3	-1.2	38.0
Khvala / Vodohrai	11.6	76.3	13.1	52.3	7.8	46.0	-4.6	1.0	-2.1	0.0	-	0.0
Bilotserkivskiy											10.8	
Khvala / Kubok	0.7	27.0	8.1	29.0	5.3	14.7	-7.2	0.0	-3.8	0.0	-5.2	0.0
Kubok / Korovaina	11.0	65.3	9.7	67.7	2.6	12.7	16.1	45.0	14.2	54.3	5.9	78.7
Kubok / Dyvo	11.8	79.0	10.5	66.7	4.9	24.7	25.7	54.3	27.7	54.0	12.4	82.7
Kubok / Ladyzhynka	6.1	69.0	10.6	47.3	12.6	50.7	-4.0	0.0	9.3	42.7	-4.4	0.0
Kubok / Vodohrai	1.0	7.3	8.0	42.3	2.7	8.3	12.4	19.0	11.2	35.7	2.3	58.3
Bilotserkivskiy												
Kubok / Khvala	5.3	46.3	10.8	55.0	7.8	20.0	-10.1	0.0	-8.0	0.0	-7.6	0.0

The maximum advantage over the better parent in terms of the spikelet number per spike was noted in the following hybrids: Vodohrai Bilotserkivskiy / Khvala (Td = 18.6%), Khvala / Vodohrai Bilotserkivskiy (Td = 13.1%), and Ladyzhynka / Khvala (Td = 13.0%). The maximum frequency of transgressions of this trait was noted in Vodohrai Bilotserkivskiy / Khvala (Tf = 88.7%), Dyvo / Vodohrai Bilotserkivskiy (Tf = 83.7%), Vodohrai Bilotserkivskiy / Kubok (Tf = 76.3%), and Korovaina / Dyvo (Tf = 73.7%).

The maximum degree of transgression for the kernel number per spike was observed in such hybrids as Vodohrai Bilotserkivskiy / Khvala (Td = 12.9%), Kubok / Ladyzhynka (Td = 12.6%), and Vodohrai Bilotserkivskiy / Ladyzhynka (Td = 11.8%). The maximum frequency of transgressions of this trait was seen in Kubok / Ladyzhynka (Tf = 50.7%), Khvala / Vodohrai Bilotserkivskiy (Tf = 46.0%), and Vodohrai Bilotserkivskiy / Ladyzhynka (Tf = 42.7%).

Kubok / Dyvo (Td = 25.7%), Ladyzhynka / Dyvo (Td = 18.5%), and Kubok / Korovaina (Td = 16.1%) were distinguished due to transgression degree for spike weight, while Kubok / Dyvo (Tf = 54.3%), Vodohrai Bilotserkivskiy / Khvala (Tch = 49.0%), Dyvo / Vodohrai Bilotserkivskiy (Tf = 48.7%), Kubok / Korovaina (Tf = 45.0%), Ladyzhynka / Vodohrai Bilotserkivskiy (Tf = 42.7%), Dyvo / Korovaina (Tf = 41.7%), Dyvo / Ladyzhynka (Tf = 41.3%), and Korovaina / Dyvo (Tf = 40.3%) stood out due to frequency of transgressions of this trait.

The maximum advantage over the better parent in terms of kernel weight per spike was recorded for Kubok / Dyvo (Td = 27.7%), Vodohrai Bilotserkivskiy / Khvala (Td = 15.8%), Kubok / Korovaina (Td = 14.2%), and Ladyzhynka / Dyvo (Td = 14.1%). The highest transgression frequency was observed in Kubok / Korovaina (Tf = 54.3%), Kubok / Dyvo (Tf = 54.0%), Ladyzhynka / Dyvo (Tf = 43.7%), and Kubok / Ladyzhynka (Tf = 42.7%).

As to transgression degree for the thousand kernel weight, Kubok / Dyvo (Td = 12.4%) was highlighted. Kubok / Dyvo (Tf = 82.7%) and Kubok / Korovaina (Tf = 78.7%) were noticeable for transgression frequency of this trait.

Among the combinations, those that combine the maximum values of transgression frequency and degree were identified. For spike length, these are combinations in which one of the parent was an eastern forest-steppe variety, namely those that had been bred in Kharkiv: Ladyzhynka / Dyvo, Korovaina / Dyvo, Khvala / Dyvo, and Korovaina / Ladyzhynka. As to the spikelet and kernel numbers per spike, combinations derived from central forest-steppe and

steppe varieties were selected. For the spikelet number, these were Vodohrai Bilotserkivskiyi / Khvala, Khvala / Vodohrai Bilotserkivskiyi; for the kernel number, such combinations included Vodohrai Bilotserkivskiyi / Khvala and Kubok / Ladyzhynka. Combinations in which one of the parents was a variety bred at the Plant production Institute were selected because of spike weight: Kubok / Dyvo, Kubok / Korovaina, and Ladyzhynka / Dyvo. Genotypes in which parentals from the steppe and forest-steppe were combined were distinguished due to kernel weight per spike and thousand kernel weight. For kernel weight per spike, these were Ladyzhynka / Dyvo, Kubok / Dyvo, and Kubok / Korovaina. For thousand kernel weight, such combinations included Kubok / Dyvo and Kubok / Korovaina.

Our data summarized in Table 2 show that it is possible to predict how to generate lines with increased spike performance. Thus, from the Kubok / Korovaina and Kubok / Dyvo hybrid combinations, it is highly probable to select lines with increased spike performance attributed to longer spikes and greater thousand kernel weights. In direct and reverse crossings of Vodohrai Bilotserkivskiyi and Khvala, one should expect to obtain lines that combine longer spikes with greater numbers of spikelets and kernels per spike. From the Vodohrai Bilotserkivskiyi / Ladyzhynka hybrid combination, it is likely to obtain lines with elongated and looser spikes and more kernels per spike. There is no such tendency in reverse crossing. When crossing Ladyzhynka with Dyvo, plants with significantly longer and heavier spikes can be produced.

Analyzing the F₂ hybrids from tester crossings, we distinguished the Khvala / Kanada (T_d = 10.7%) and Dyvo / Arktis (T_d = 10.6%) hybrids due to their spike length transgression degree and Khvala / Kanada (T_f = 79.7%), Dyvo / Donera (T_f = 71.7%) and Ladyzhynka / Viglanka (T_f = 66.3%) due to transgression frequencies.

As to the spikelet number per spike, the greatest degree of transgressions was observed in Khvala / Viglanka (T_d = 16.4%), Ladyzhynka / Viglanka (T_d = 16.3%), Dyvo / Viglanka (T_d = 10.5%), Vodohrai Bilotserkivskiyi / Arktis (T_s = 10.5%), and Vodohrai Bilotserkivskiyi / Kanada (T_s = 10.2%). The highest frequency of transgressions of this trait was noted in Khvala / Viglanka (T_f = 51.3%) and Vodohrai Bilotserkivskiyi / Arktis (T_f = 51.3%).

The maximum advantage over the better parent in terms of the kernel number per spike was detected in Ladyzhynka / Arktis (T_d = 13.6%), Ladyzhynka / Viglanka (T_d = 13.0%) and Dyvo / Viglanka (T_d = 10.1%). The maximum frequency of transgressions of this trait was recorded for Ladyzhynka / Arktis (T_f = 47.0%), Ladyzhynka / Viglanka (T_f = 46.0%), Dyvo / Arktis (T_f = 45.3%), and Dyvo / Viglanka (T_f = 45.3%).

By spike weight transgression degree, we selected the following hybrids: Ladyzhynka / Arktis (T_d = 26.2%), Vodohrai Bilotserkivskiyi / Kanada (T_d = 22.5%), Dyvo / Viglanka (T_d = 19.6%), and Dyvo / Donera (T_d = 19.5%); by frequency of transgressions of this trait, - Vodohrai Bilotserkivskiyi / Kanada (T_f = 60.7%) and Korovaina / Arktis (T_f = 55.7%).

The maximum transgression degree for kernel weight per spike was recorded for Ladyzhynka / Arktis (T_d = 29.7%), Vodohrai Bilotserkivskiyi / Kanada (T_d = 20.7%), Dyvo / Donera (T_d = 19.9%), and Dyvo / Viglanka (T_d = 19.5%); the maximum frequency of transgressions of this trait – for Ladyzhynka / Arktis (T_f = 53.3%).

As to transgression degree for thousand kernel weight, Ladyzhynka / Kanada (T_d = 10.6%) and Dyvo / Donera (T_c = 11.9%) were distinguished. The transgression frequency for this trait was prominent in Vodohrai Bilotserkivskiyi / Viglanka (T_f = 92.0%) and Korovaina / Kanada (T_f = 79.3%).

Among the F₂ hybrids from tester crossings, hybrids combining the maximum frequencies and degrees of transgressions were also identified. By spike length, hybrids in which the tester was a German variety were selected: Khvala / Kanada, Dyvo / Arktis, and Vodohrai Bilotserkivskiyi / Kanada. As to the spikelet number per spike, we distinguished genotypes in which the tester was Viglanka: Khvala / Viglanka, Ladyzhynka / Viglanka, and Dyvo / Viglanka. Combinations in which Ladyzhynka was the female form were distinguished by the kernel number: Ladyzhynka / Arktis and Ladyzhynka / Viglanka. By spike weight and kernel weight per spike, hybrids in which the tester was a German variety were selected: spike weight -

Ladyzhynka / Arktis and Vodohrai Bilotserkivskiy / Kanada; by kernel weight per spike - Ladyzhynka / Arktis, Ladyzhynka / Kanada, Dyvo / Arktis, and Vodohrai Bilotserkivskiy / Kanada. By thousand kernel weight, we also distinguished genotypes in which the tester was a German variety: Korovina / Kanada, Ladyzhynka / Kanada, Ladyzhynka / Arktis, and Dyvo / Arktis.

Table 2

Spike performance transgression degrees and frequencies in F₂ winter bread wheat hybrids from tester crossings (2019–2021), %

Combination	Spike length		Spikelet number per spike		Kernel number per spike		Spike weight		Kernel weight per spike		Thousand kernel weight	
	Td	Tf	Td	Tf	Td	Tf	Td	Tf	Td	Tf	Td	Tf
Korovina / Donera	6.8	57.3	2.1	34.0	2.7	5.3	6.6	29.0	10.9	11.7	0.2	4.7
Korovina / Viglanka	2.5	12.7	7.3	41.7	0.2	2.3	1.4	5.3	4.2	4.7	-9.4	0.0
Korovina / Arktis	0.9	32.0	5.0	19.0	8.3	9.0	11.4	55.7	19.3	26.7	0.2	3.7
Korovina / Kanada	4.1	46.7	2.7	9.0	-6.2	0.0	2.5	26.0	5.8	11.3	7.6	79.3
Ladyzhynka / Donera	-0.9	0.7	-2.1	0.7	3.5	10.3	2.2	16.0	1.3	34.0	6.9	46.0
Ladyzhynka / Viglanka	7.6	66.3	16.3	49.3	13.0	46.0	12.8	42.7	14.2	46.0	0.5	32.7
Ladyzhynka / Arktis	5.5	24.7	5.5	21.3	13.6	47.0	26.2	45.7	29.7	53.3	9.8	54.7
Ladyzhynka / Kanada	6.0	18.3	2.7	6.0	1.5	7.7	11.7	30.7	14.4	47.0	10.6	49.3
Dyvo / Donera	8.4	71.7	5.0	16.7	6.3	30.3	19.5	48.7	19.9	42.0	11.9	47.3
Dyvo / Viglanka	2.5	40.0	10.5	39.7	10.1	45.3	19.6	35.0	19.5	35.0	7.9	54.0
Dyvo / Arktis	10.6	44.0	8.1	39.3	7.4	45.3	16.6	48.3	17.5	46.7	10.1	55.7
Dyvo / Kanada	5.1	48.0	5.2	16.0	4.3	8.3	8.7	29.0	10.6	45.0	1.7	40.0
Vodohrai Bilotserkivskiy / Donera	2.7	11.3	2.9	31.3	1.8	15.7	4.8	11.3	4.5	31.0	1.1	30.3
Vodohrai Bilotserkivskiy / Viglanka	5.4	41.3	9.1	43.3	5.7	39.3	15.6	32.0	16.0	41.3	4.2	43.0
Vodohrai Bilotserkivskiy / Arktis	4.7	10.7	10.5	51.3	7.7	41.0	13.7	23.0	13.6	45.0	1.9	35.0
Vodohrai Bilotserkivskiy / Kanada	8.6	51.3	10.2	33.3	5.8	32.7	22.5	60.7	20.7	43.7	1.4	35.7
Khvala / Donera	2.9	36.0	7.3	36.3	8.6	39.3	1.2	11.0	3.2	8.3	-3.5	2.0
Khvala / Viglanka	2.0	21.7	16.4	51.3	3.4	29.7	1.2	8.3	0.0	0.0	-6.8	0.0
Khvala / Arktis	0.1	15.7	2.9	32.7	6.0	37.3	-0.3	10.3	-0.4	5.0	-1.0	16.3
Khvala / Kanada	10.7	79.7	9.9	38.0	6.8	28.0	2.6	16.0	5.4	7.7	-6.8	2.0

Conclusions. Diallel design gave more meaningful results in terms of increased spike performance.

We found that the degree of positive transgressions of spike length among F₂ hybrids from diallel crossings averaged 6.9% and the frequency – 52.6%; for the spikelet number per spike the corresponding parameters were 7.8% and 44.8%; for the kernel number per spike – 5.4% and 21.4%; for spike weight – 6.3% and 23.4%; for kernel weight per spike – 6.9% and 22.5%; and for thousand kernel weight – 0.1% and 31.2%.

The degree of positive transgressions of spike length among F₂ hybrids from tester crossings averaged 4.6% and the frequency – 36.5%; for the spikelet number per spike the corresponding parameters were 6.9% and 30.5%; for the kernel number per spike – 5.4% and 26.0%; for spike weight – 10.0% and 29.2%; for kernel weight per spike – 11.5% and 29.3%; and for thousand kernel weight – 2.6% and 31.6%.

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СТУПІНЬ І ЧАСТОТА ТРАНСГРЕСІЙ ЕЛЕМЕНТІВ ПРОДУКТИВНОСТІ КОЛОСА У ГІБРИДІВ F₂ ПШЕНИЦІ М'ЯКОЇ ОЗИМОЇ

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Мета і задачі дослідження. Метою дослідження було проаналізувати питання прояву ступеня та частоти трансгресії гібридів F₂ пшениці м'якої озимої за елементами продуктивності колоса.

Матеріали та методи. Дослідження проведено в лабораторії генетичних ресурсів зернових культур Інституту рослинництва імені В.Я. Юр'єва НААН у 2019–2021 рр. Матеріалом для дослідження виступали 30 гібридів F₂ створених в результаті проведення прямих та зворотніх діалельних схрещувань та 20 гібридів F₂ створених в результаті проведення тестерних схрещувань. Досліди було закладено відповідно до вимог селекційних польових експериментів. Ручною саджалкою висівали гібриди F₂ та їх батьківські форми у оптимальні строки. Довжина рядка – 1 метр, міжряддя – 20 см, глибина 4–6 см, попередник – чорний пар. У рядок висівали 20 зерен. Статистичну обробку результатів проведено за методикою Б.А. Доспехова. Ступінь та частоту трансгресії кількісних ознак визначали за формулами, запропонованими Г.С. Воскресенською та В.І. Шпота.

Обговорення результатів. Аналізуючи гібриди F₂ створені шляхом діалельної схеми схрещування за ознакою довжина колоса в усіх проаналізованих гібридів було виявлено позитивні трансгресії. Найбільшу ступінь трансгресії виділено у комбінацій Ладижинка / Диво (Тс = 18,0 %) та Водограй білоцерківський / Ладижинка (Тс = 12,1 %), Найбільша частота трансгресії за даною ознакою була у гібридів Ладижинка / Диво (Тч = 89,7 %) та Хвала / Диво (Тч = 85,0 %). Максимальний ступінь трансгресії за кількістю зерен у колосі виявлено в гібриду Водограй білоцерківський / Хвала (Тс = 12,9 %), а максимальна частота трансгресії даної ознаки – Кубок / Ладижинка (Тч = 50,7 %). За ступенем трансгресії маси колоса виділено гібрид Кубок / Диво (Тс = 25,7 %), а за частотою трансгресії даної ознаки – Кубок / Диво (Тч = 54,3 %). Максимальну перевагу над кращою батьківською формою за кількістю колосків у колосі мав гібрид Водограй білоцерківський / Хвала (Тс = 18,6 %), а максимальну частоту трансгресій за цією ознакою – Водограй білоцерківський / Хвала (Тч = 88,7 %). Максимальну перевагу над кращою батьківською формою за масою зерна з колоса виявлено у Кубок / Диво (Тс = 27,7 %). Найбільша частота трансгресії була у гібриду Кубок / Коровайна (Тч = 54,3 %). За ступенем трансгресії маси 1000 зерен ідентифіковано Кубок / Диво (Тс = 12,4 %), а за ступенем трансгресії даної ознаки – Кубок / Диво (Тч = 82,7 %). Аналізуючи гібриди F₂ створені шляхом схрещування за тестерною схемою за ступенем трансгресії довжини колоса виділено гібриди Хвала / Kanada (Тс = 10,7 %) та Диво / Arktis (Тс = 10,6 %), а за частотою трансгресії – Хвала / Kanada (Тч = 79,7). За кількістю колосків у колосі найбільша частота трансгресії спостерігалась у Хвала / Viglanka (Тс = 16,4 %). Найбільша частота трансгресії даної ознаки була у Хвала / Viglanka (Тч = 51,3 %) та Водограй білоцерківський / Arktis (Тч = 51,3 %). Максимальну перевагу над кращою батьківською формою за кількістю зерен у колосі виявлено в Ладижинка / Arktis (Тс = 13,6 %), а максимальну частоту трансгресій за цією ознакою – Ладижинка / Arktis (Тч =

47,0 %). За ступенем трансгресії маси колоса виділено гібрид Ладжинка / Arktis ($T_c = 26,2\%$), за частотою трансгресії даної ознаки – Водограй білоцерківський / Kanada ($T_c = 60,7\%$). Максимальний ступінь трансгресії маси зерна з колоса спостерігався в Ладжинка / Arktis ($T_c = 29,7\%$), максимальна частота трансгресії – Диво / Viglanka ($T_c = 55,0\%$). За ступенем трансгресії маси 1000 зерен виділено Диво / Донэра ($T_c = 11,9\%$) та Водограй білоцерківський / Viglanka ($T_c = 11,2\%$), а за частотою трансгресії – Водограй білоцерківський / Viglanka ($T_c = 92,0\%$).

Висновки. Встановлено, що ступінь позитивних трансгресій за довжиною колоса серед гібридів F_2 , створених за діалельною схемою схрещування, становив у середньому 6,9 %, частота – 52,6 %; кількість колосків у колосі – 7,8 %, частота – 44,8 %; кількість зерен у колосі – 5,4 %, частота – 21,4 %; маса колоса – 6,3 %, частота – 23,4 %, маса зерна з колоса – 6,9 %, частота – 22,5 %; маса 1000 зерен – 0,1 %, частота – 31,2 %. Ступінь позитивних трансгресій за довжиною колоса серед гібридів F_2 , створених за тестерною схемою, схрещування становив у середньому 4,6 %, частота – 36,5 %; кількість колосків у колосі – 6,9 %, частота – 30,5 %; кількість зерен у колосі – 5,4 %, частота – 26,0 %; маса колоса – 10,0 %, частота – 29,2 %, маса зерна з колоса – 11,5 %, частота – 29,3 %; маса 1000 зерен – 2,6 %, частота – 31,6 %.

Ключові слова: пшениця м'якої озима, елементи продуктивності колоса, частота трансгресії, ступінь трансгресії

SPIKE PERFORMANCE TRANSGRESSION DEGREE AND FREQUENCY IN F_2 WINTER BREAD WHEAT HYBRIDS

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Purpose and Objectives. To analyze the spike performance transgression degree and frequency in F_2 winter bread wheat hybrids.

Materials and Methods. The study was carried out in the Laboratory of Genetic Resources of Cereals of the Plant Production Institute named after V.Ya. Yuriev of NAAS in 2019–2021. Thirty 30 F_2 hybrids from diallel crossings and 20 F_2 hybrids from tester crossings were investigated. The experiments were carried out in accordance with the requirements for field experiments in breeding. F_2 hybrids and their parents were sown with a manual single-row planter within the optimal timeframe. The row length was 1 m; the interrow distance was 20 cm; the depth was 4–6 cm; wheat was sown after bare fallow. Twenty seeds per row were sown. Data were statistically processed, as B.A. Dospikhov recommended. The transgression degrees and frequencies for quantitative traits were determined by the formulae proposed by H.S. Voskresenskaya and V.I. Shpota.

Results and Discussion. Analyzing the F_2 hybrids from diallel crossings, positive transgressions of the “pike length” trait were found in all the analyzed hybrids. The highest degree of transgressions was recorded for Ladyzhynka / Dyvo ($T_d = 18.0\%$) and Vodohrai Bilotserkivskiyi / Ladyzhynka ($T_d = 12.1\%$); the highest frequency of transgressions of this trait was observed in Ladyzhynka / Dyvo ($T_f = 89.7\%$) and Khvala / Dyvo ($T_f = 85.0\%$). The maximum degree of transgressions for the kernel number per spike was detected in Vodohrai Bilotserkivskiyi / Khvala ($T_d = 12.9\%$), and the maximum frequency of transgressions of this trait was noted in Kubok / Ladyzhynka ($T_f = 50.7\%$). Kubok / Dyvo was selected due to degree and frequency of spike weight transgressions ($T_d = 25.7\%$; $T_f = 54.3\%$). The maximum advantage over the better parent in terms of the spikelet number per spike and the

maximum frequency of transgressions of this trait were noted in Vodohrai Bilotserkivskiyi / Khvala (Td = 18.6%; Tf = 88.7%). The maximum advantage over the better parent in terms of kernel weight per spike was detected in Kubok / Dyvo (Td = 27.7%); but the highest frequency of transgressions of this trait was recorded for Kubok / Korovaina (Tf = 54.3%). As to thousand kernel transgression degree and frequency, Kubok / Dyvo was distinguished (Td = 12.4%; Tf = 82.7%). Analyzing the F₂ hybrids from tester crossings, the Khvala / Kanada (Td = 10.7%) and Dyvo / Arktis (Td = 10.6%) hybrids were distinguished by spike length transgression degree; Khvala / Kanada was noticeable for transgression frequency for this trait (Tf = 79.7%). As to the spikelet number per spike, the highest degree of transgressions were observed in Khvala / Viglanka (Td = 16.4%) and the highest frequency of transgressions - in Khvala / Viglanka (Tf = 51.3%) and Vodohrai Bilotserkivskiyi / Arktis (Tf = 51.3%). The maximum advantage over the better parent in terms of the kernel number per spike was detected in Ladyzhynka / Arktis (Td = 13.6%); this combination was also noticeable for the maximum frequency of transgressions of this trait (Tf = 47.0%). By spike weight transgression degree, Ladyzhinka / Arktis was distinguished (Td = 26.2%); by transgression frequency for this trait – Vodohrai Bilotserkivskiyi / Kanada (Tf = 60.7 %). The maximum degree of transgressions of kernel weight per spike was observed in Ladyzhynka / Arktis (Td = 29.7%) and the maximum frequency of transgressions of this trait - in Dyvo / Viglanka (Tf = 55.0%). By thousand kernel weight transgression degree, Dyvo / Donera (Td = 11.9%) and Vodohrai Bilotserkivskiyi / Viglanka (Td = 11.2%) were selected and by transgression frequency for this trait - Vodohrai Bilotserkivskiyi / Viglanka (Tf = 92.0%).

Conclusions. The degree of positive transgressions of spike length among F₂ hybrids from diallel crossings averaged 6.9% and the frequency – 52.6%; for the spikelet number per spike the corresponding parameters were 7.8% and 44.8%; for the kernel number per spike – 5.4% and 21.4%; for spike weight – 6.3% and 23.4%; for kernel weight per spike – 6.9% and 22.5%; and for thousand kernel weight – 0.1% and 31.2%. The degree of positive transgressions of spike length among F₂ hybrids from tester crossings averaged 4.6% and the frequency – 36.5%; for the spikelet number per spike the corresponding parameters were 6.9% and 30.5%; for the kernel number per spike – 5.4% and 26.0%; for spike weight – 10.0% and 29.2%; for kernel weight per spike – 11.5% and 29.3%; and for thousand kernel weight – 2.6% and 31.6%.

Key words: *winter bread wheat, spike performance constituents, transgression frequency, transgression degree, diallel crossing, tester crossing*