UDC 633.111.1«324»:575.222.7:631.559 https://doi.org/10.31867/2523-4544/0306

THE DEGREE OF PHENOTYPIC DOMINANCE OF THE PRODUCTIVITY TRAITES AND THE LEVEL OF HETEROSIS IN F_1 COMMON WINTER WHEAT

[1] H. B. Volohdina, [2] A. L. Rysin
[1]The V. M. Remeslo Myronivka Institute of Wheat NAAS, 68 Tsentralna St., Tsentralne village, Obukhiv district, Kyiv region, 08853, Ukraine
[2]SPAC Stepova CO. LTD., 2a Tokova St., Vesele village, Synelnykove district, Dnipropetrovsk region, 52502, Ukraine

Topicality. *The studying heredity pattern of parameters of valuable economic traits, the degree of heterosis in hybrids of the first generation of common winter wheat is an urgent task for developing high-yielding varieties with high grain quality, as well as for predicting the selection and genetic effect of crosses.* ***Purpose.*** *To establish the degree of phenotypic dominance and the level of heterosis for the traits "number of productive stems", "number of kernels per spike", "1000 kernel weight" in F_1.* ***Materials and Methods.*** *Experiments were conducted in the 2018/19–2021/22 growing seasons on the fields of breeding crop rotation of the Laboratory of Winter Wheat Breeding at the V. M. Remeslo Myronivka Institute of Wheat NAAS. The research material was F_1–F_2 hybrid populations developed on the basis of varieties MIP Yuvileina, MIP Assol, Podolianka and promising breeding lines LUT 37519, LUT 55198, ER 55023 of common winter wheat (Triticum aestivum* L.*) of Myronivka breeding with a complex of agronomic traits. The analysis of hybrids and their parental forms was carried out individually according to productivity components, the degree of phenotypic dominance was determined.* ***Results.*** *The influence of year conditions on the level and frequency of manifestation of negative overdominance in terms of the number of productive stems was revealed. In 2021, 2022, depressed combinations were 26.7 % and 70.0 %, respectively, which is higher than in 2020 (16.7 %). It was established that the main inheritance pattern for number of kernel per main spike in F_1 was overdominance, namely 56.7 % (2020); 86.7 % (2021); 83.3 % (2022). Regardless of the conditions of the growing season, heterosis in grain size was found in the majority of F_1 by 1000 kernel weight: 17 (56.7 %) hybrid combinations in 2020, 18 (60.0 %) in 2021, and 25 (83.3 %) in 2022.* ***Conclusions.*** *It was proved that during three years with contrasting weather conditions, the first generation hybrids showed a sufficiently high degree of heterosis in terms of productivity elements, which is explained by the influence of parental components, the correct approach to their selection, considering the peculiarities of the formation of quantitative traits. In the selected hybrid combinations, a high level of heterosis (overdominance), partial positive dominance and intermediate inheritance were observed, which will ensure effective selection of highly productive forms in the next generations.*

Key words: *Triticum aestivum L., hybrid combination, overdominance, number of productive stems, grain content per spiker, 1000 kernel weight*

Introduction. Breeding programmes for the development of high-yielding varieties require scientific data on the optimal combination of traits and properties that are heritable. Hybridisation is a substantiated and effective method of developing source material for wheat breeding as well as a source of wheat genetic diversity [1, 2, 3]. At the beginning of breeding process, the selection of winter bread wheat trait system for hybridisation results analysis is important to ensure efficient selection of elite plants with the desired genotype to increase yield potential. Knowledge of the heritability patterns of valuable economic traits contributes to targeted selection in breeding work to increase productivity. Commonly, in hybrids of first filial generation, the quantitative parameters of plant productivity elements, the inheritance pattern, and the level of heterosis are determined by analysing various factor traits [4]. The study of quantitative traits controlled by polymeric genes is quite complicated due to their significant variability, which depends on environmental conditions, and the pattern of their inheritance and variability is ‘masked’ by the modi-

Author information:
Halyna B. Volohdina, *Candidate of Agricultural Sciences, Senior Researcher of the Winter Wheat Breeding Laboratory,* e-mail: galinavologdina27@gmail.com, https://orcid.org/0000-0002-3021-3643
Artur L. Rysin, *PhD, President of SPAC Stepova CO. LTD,* https://orcid.org/0000-0001-6356-4231

fying effect of heterosis in F_1 [5]. A high degree of heterosis in the first filial generation gives an opportunity to predict transgressive effects in the offspring [6]. Modern methods of common winter wheat breeding are based on the selection of recombinant biotypes from populations developed by using different source material [7]. Considerable formation of traits and properties that differ from the parental forms in hybrid populations occur [8–12]. Selection of new source material should be aimed at increasing its specific adaptation to the main elements of production intensification and resistance to various environmental factors [13]. Thus, the study of the inheritance pattern of valuable economic traits, the degree of heterosis in first filial generation hybrids of common winter wheat is relevant task for the development of high-yielding varieties with high grain quality, as well as for the prediction of the breeding and genetic effect of crosses.

The study was aimed at determining the degree of phenotypic dominance and the level of heterosis for such traits as number of productive stems, head grain content, 1000 kernel weight in F_1.

Materials and Methods. The experiments were carried out on the fields of selective crop rotation of the winter wheat breeding laboratory of the V. M. Remeslo Myronivka Institute of Wheat of NAAS (MIP) in growing seasons 2018/19–2021/22. The fertility level of typical low-humus medium loamy chernozem on the experimental fields of the MIP contributes to high grain yields of common winter wheat, as well as to conducting research and obtaining objective data. All four growing seasons were characterised by a deviation of the average long-term temperature towards warming (+0.5–2.4 °C), with the maximum deviation in 2019/20. During the study period, agrometeorological conditions differed in terms of temperature, precipitation and their distribution by months from long-term indicators. These conditions are a feature of the Central Forest-Steppe zone of Ukraine, which significantly limits grain yields, especially in years with precipitation scarcity. The moisture content of the research area was characterised by uneven precipitation and its distribution by months.

The material for the research was F_1–F_2 hybrid populations based on varieties MIP Yuvileina, MIP Assol, and Podolianka and promising breeding lines LUT 37519, LUT 55198, ER 55023 of common winter wheat (*Triticum aestivum* L.) of Myronivka selection with a complex of valuable economic traits. The new source material was developed by the method of intraspecific hybridisation according to the complete diallel scheme. The structural analysis of 30 hybrid combinations of common winter wheat and their parental forms was carried out according to the main elements of plant productivity. The analysis of hybrids and their parental components was carried out individually by productivity elements [14]. The degree of phenotypic dominance in hybrids was determined by the conventional method [15].

Results and Discussion. According to the research results of 2020–2022, the productive tillering of the parental forms ranged on average from 3.10 stems in the breeding line LUT 55198 and Podolianka variety to 5.80 stems in the breeding line ER 55023. Depending on the year of study, the trait ranged from 2.50 stems (ER 55023 x MIP Yuvileina) to 4.10 stems (Podolianka x LUT 37519) in 2020; from 3.44 stems (Podolianka x MIP Yuvileina) to 5.56 stems (LUT 37519 x MIP Assol) in 2021; from 2.41 stems (Podolianka x LUT 37519 x MIP Assol) in 2021; from 2.41 (Podolianka x LUT 37519) to 5.57 (LUT 55198 x MIP Yuvileina) in 2022. The maximum (4.64 stems) average of productive tillering in F_1 was observed in 2021, the minimum (3.74 and 3.42 stems) – in 2022 and 2020, respectively.

In 2020, the degree of phenotypic dominance varied from -8.2 in the hybrid combination ER 55023 x MIP Yuvileina to 27.0 in MIP Assol x LUT 37519, and Podolianka x LUT 55198, which corresponds to inheritance of the trait from depression to overdominance (Table 1).

In the studies of other researchers, both positive [16] and negative overdominance [17] of productive tillering was also found. It was found that F_1 hybrids inherited the trait mainly by the type of dominance when the varieties MIP Yuvileina, MIP Assol and breeding lines LUT 37519, LUT 55198 were used as the maternal form. Overdominance was found in 18 hybrid combinations of common winter wheat: from hp = 7.0 (MIP Assol x MIP Yuvileina, MIP Assol x LUT 55198) to hp = 27.0 (MIP Assol x LUT 37519,

Table 1. Degree of phenotypic dominance for the trait 'number of productive stems' in F_1 common winter wheat

Hybrid combination	2020		2021		2022	
	hp	*	hp	*	hp	*
MIP Yuvileina x ER 55023	1.2	OD	0.4	II	-11.7	D
MIP Yuvileina x MIP Assol	2.3	OD	-0.1	II	-177.1	D
MIP Yuvileina x Podolianka	3.7	OD	-14.3	D	-11.0	D
MIP Yuvileina x LUT 37519	6.3	OD	0.1	II	-0.6	PND
MIP Yuvileina x LUT 55198	-0.3	II	-0.3	II	0.4	II
ER 55023 x MIP Yuvileina	-8.2	D	-8.6	D	-9.2	D
ER 55023 x MIP Assol	0.3	II	-0.6	PND	-1.1	D
ER 55023 x Podolianka	-1.4	D	-14.4	D	-8.8	D
ER 55023 x LUT 37519	-2.5	D	-0.1	II	-13.5	D
ER 55023 x LUT 55198	-2.4	D	-1.1	D	-15.9	D
MIP Assol x ER 55023	-0.7	PND	-0.8	PND	-0.9	PND
MIP Assol x MIP Yuvileina	7.0	OD	-2.4	D	-166.4	D
MIP Assol x Podolianka	3.5	OD	0.1	II	-5.7	D
MIP Assol x LUT 37519	27.0	OD	1.7	OD	-9.8	D
MIP Assol x LUT 55198	7.0	OD	1.6	OD	1.1	OD
Podolianka x ER 55023	-1.2	D	-0.6	PND	-9.5	D
Podolianka x MIP Assol	4.0	OD	0.4	II	-0.3	II
Podolianka x MIP Yuvileina	0.3	II	-33.7	D	-5.8	D
Podolianka x LUT 37519	13.0	OD	0.4	II	-7.1	D
Podolianka x LUT 55198	27.0	OD	0.2	II	-0.4	II
LUT 37519 x ER 55023	0.5	II	-0.8	PND	-1.3	D
LUT 37519 x MIP Assol	3.0	OD	2.7	OD	-5.7	D
LUT 37519 x MIP Yuvileina	5.7	OD	1.0	PPD	-3.7	D
LUT 37519 x Podolianka	3.0	OD	-0.6	PND	-0.3	II
LUT 37519 x LUT 55198	11.0	OD	8.6	OD	-3.8	D
LUT 55198 x ER 55023	-0.4	II	0.6	PPD	-9.0	D
LUT 55198 x MIP Assol	1.0	PPD	1.4	OD	-56.3	D
LUT 55198 x MIP Yuvileina	1.4	OD	-1.2	D	14.9	OD
LUT 55198 x Podolianka	9.0	OD	0.3	II	-14.1	D
LUT 55198 x LUT 37519	4.0	OD	-2.9	D	-0.9	PND

***Notes**: hp - degree of phenotypic dominance; * - type of inheritance; OD - heterosis (overdominance); PPD - partial positive dominance; II - intermediate inheritance; PND - partial negative inheritance; D - depression; ER - erythrospermum; LUT - lutescens.*

Podolianka x LUT 55198) and a positive value of hypothetical (Ht = 7.3–31.2 %) and true (Hbt = 6.5–28.1 %) heterosis. Positive values of hypothetical and negative values of true heterosis were observed in three combinations, where the degree of phenotypic dominance was intermediate. Other hybrids had negative values of both hypothetical and true heterosis.

In the favourable conditions of 2021, a different nature of inheritance was revealed: overdominance was observed in five (16.7 %) combinations, partial positive dominance in two (6.7 %), intermediate inheritance in 10 (33.3 %), partial negative inheritance in five (16.7 %), and depression in eight (26.6 %) combinations. Overdominance and intermediate inheritance were characteristic of 50.0 % of hybrid combinations of common winter wheat: LUT 37519 x LUT 55198, hp = 8.6; LUT 37519 x MIP Assol, hp = 2.7; MIP Assol x LUT 37519, hp = 1.7; MIP Assol x LUT 55198, hp = 1.6; LUT 55198 x MIP Assol, hp = 1.4; MIP Yuvileina x ER 55023, hp = 0.4; Podo-

lianka x MIP Assol, hp = 0.4; Podolianka x LUT 37519, hp = 0.4; LUT 55198 x Podolianka, hp = 0.4, etc., where varieties MIP Assol, MIP Yuvileina, Podolianka and breeding lines LUT 37519 and LUT 55198 were used as maternal forms (Table 1).

It should be noted that a positive value of hypothetical (Ht = 13.7–32.7 %) and true (Hbt = 0.0–27.8 %) heterosis in F_1 was found only for the trait 'number of productive stems', where the type of inheritance corresponded to overdominance and partial positive dominance. Changes in the ratio of hybrid combinations by inheritance type and, in particular, an increase in the percentage of depressed combinations depended on the weather conditions of the year. The depression (26.7 %) in F_1 of common winter wheat was significantly lower (70.0 %) compared to the dry conditions of 2022, but higher (16.7 %) than in the extremely dry 2020 (Table 1). The highest negative values of hypothetical (Ht = -13.7 to -37.0 %) and true (Hbt = -14.1 to -37.7 %) heterosis were found in hybrid combinations: Podolianka x MIP Yuvileina, LUT 55198 x MIP Yuvileina, MIP Yuvileina x Podolianka, ER 55023 x Podolianka, ER 55023 x MIP Assol, ER 55023 x Podolianka, ER 55023 x LUT 55198.

In the dry conditions of 2022, the hybrids also showed a different pattern of inheritance: from depression to overdominance. The largest (5.57 pcs.) number of productive stems was observed in the hybrid combination LUT 55198 x MIP Yuvileina (hp = 14.9), the smallest (2.41 pcs.) – Podolianka x LUT 37519 (hp = -7.1). Depression was observed in 70.0 % of combinations, which were characterised by negative values of both hypothetical and true heterosis. The combination LUT 55198 x MIP Assol showed depression, and in 2020, 2021 it was characterised by overdominance. Only two hybrids LUT 55198 x MIP Yuvileina and MIP Assol x LUT 55198 with positive values of heterosis (Ht = 15.3 %, 15.1 % and Hbt = 14.2 %, 3.8 %, respectively) were identified, which inherited the trait by the overdominance type. The intermediate type of phenotypic dominance was observed in four (13.3 %) combinations of F_1, where Podolianka variety was used as a parental component. The combination MIP Yuvileina x LUT 55198 with an intermediate type of inheritance (hp = 0.4), with a positive (Ht = 4.4 %) value of hypothetical heterosis and a negative value (Hbt = -4.8 %) of true heterosis was found.

In 2020 and 2021, overdominance and partial positive dominance for the trait 'number of productive stems' was found in hybrid combinations: LUT 55198 x MIP Assol, LUT 37519 x LUT 55198, LUT 37519 x MIP Assol, MIP Assol x LUT 55198, MIP Assol x LUT 37519, LUT 37519 x MIP Yubileina, with the highest positive values of hypothetical and true heterosis. In 2022, the same trend was observed for hybrids LUT 55198 x MIP Yuvileina, MIP Assol x LUT 55198. Thus, it was found that the formation of the trait in F_1 largely depended on the selected parental components and the weather conditions of year.

The productivity of the variety is able to improve by increasing the number of kernels in the spike [18]. According to O. M. Riabchenko [19], the number of kernels per main spike is the most stable trait. Heritability for the number of kernels per spike is more reliable and selection for this trait is effective. This trait is largely determined by the influence of various environmental conditions, especially meteorological ones [20]. It was found that overdominance (56.7 % in 2020; 86.7 % in 2021; 83.3 % in 2022) is the main type of inheritance for the number of kernels per main spike in F_1 (Table 2).

Over the years of research, this trait in the parental components averaged from 34.60 kernels in the breeding line LUT 37519 to 58.69 kernels in LUT 55198. In hybrid combinations, the number of kernels per main spike ranged from 37.64 (Podolianka x MIP Yuvileina, hp = -2.0) in 2021 to 66.06 (LUT 37519 x MIP Yuvileina, hp = 20.1) in 2022. The maximum (60.38 pcs) average number of kernels in hybrids was in 2022 compared to 53.25 pcs in 2020 and 41.70 pcs in 2021. No significant differentiation in the degree of phenotypic dominance was found depending on the growing conditions. In 2020, the number of kernels per main spike in F_1 winter wheat ranged from 46.60 (MIP Yuvileina x LUT 37519) to 61.40 (MIP Assol x MIP Yuvileina). The following types of inheritance were established: overdominance was observed in 17 (56.7 %) combinations (maximum

Table 2. Degree of phenotypic dominance for the trait 'number of kernels per main spike' in F_1 common winter wheat

Hybrid combination	2020		2021		2022	
	hp	*	hp	*	hp	*
MIP Yuvileina x ER 55023	0.9	PPD	4.9	OD	1.3	OD
MIP Yuvileina x MIP Assol	-0.4	II	1.6	OD	0.9	PPD
MIP Yuvileina x Podolianka	1.4	OD	0.7	PPD	1.7	OD
MIP Yuvileina x LUT 37519	-3.4	D	1.1	OD	0.2	II
MIP Yuvileina x LUT 55198	2.6	OD	3.1	OD	1.8	OD
ER 55023 x MIP Yuvileina	3.0	OD	2.2	OD	3.2	OD
ER 55023 x MIP Assol	0.0	II	1.3	OD	1.2	OD
ER 55023 x Podolianka	5.5	OD	10.0	OD	9.7	OD
ER 55023 x LUT 37519	0.1	II	5.9	OD	2.0	OD
ER 55023 x LUT 55198	2.4	OD	8.6	OD	1.9	OD
MIP Assol x ER 55023	1.5	OD	2.6	OD	2.0	OD
MIP Assol x MIP Yuvileina	3.1	OD	4.3	OD	4.1	OD
MIP Assol x Podolianka	0.2	II	2.8	OD	3.9	OD
MIP Assol x LUT 37519	2.3	OD	1.5	OD	4.5	OD
MIP Assol x LUT 55198	2.7	OD	0.9	PPD	0.8	PPD
Podolianka x ER 55023	6.4	OD	5.6	OD	7.2	OD
Podolianka x MIP Assol	0.3	II	2.0	OD	2.1	OD
Podolianka x MIP Yuvileina	-0.2	II	-2.0	D	2.2	OD
Podolianka x LUT 37519	2.2	OD	3.2	OD	1.5	OD
Podolianka x LUT 55198	2.9	OD	5.1	OD	5.0	OD
LUT 37519 x ER 55023	0.6	PPD	6.7	OD	3.7	OD
LUT 37519 x MIP Assol	0.6	PPD	2.3	OD	7.9	OD
LUT 37519 x MIP Yuvileina	0.9	PPD	1.9	OD	20.1	OD
LUT 37519 x Podolianka	0.9	PPD	3.1	OD	3.8	OD
LUT 37519 x LUT 55198	2.9	OD	16.3	OD	1.1	OD
LUT 55198 x ER 55023	3.4	OD	10.4	OD	1.3	OD
LUT 55198 x MIP Assol	0.7	PPD	1.7	OD	1.0	PPD
LUT 55198 x MIP Yuvileina	3.9	OD	0.9	PPD	0.0	II
LUT 55198 x Podolianka	2.4	OD	2.0	OD	1.5	OD
LUT 55198 x LUT 37519	9.3	OD	19.8	OD	3.5	OD

***Notes**: hp - degree of phenotypic dominance; * - type of inheritance; OD - heterosis (overdominance); PPD - partial positive dominance; II - intermediate inheritance; PND - partial negative inheritance; D - depression; ER - erythrospermum; LUT - lutescens.*

value – LUT 55198 x LUT 37519, hp = 9.3), partial positive dominance and intermediate inheritance were observed in 6 (20.0 %) combinations, one combination showed depression. In the first generation hybrids of LUT 37519 x Podolianka, MIP Assol x Podolianka, LUT 37519 x MIP Yubileynaya, the level of the trait was inferior to the maternal form, exceeded the paternal form, with partial positive dominance and intermediate inheritance. Hybrid combinations that showed overdominance and partial positive dominance had also positive values of hypothetical and true heterosis, and combinations with intermediate inheritance and depression had negative values (MIP Yuvileina x LUT 37519, Ht = -8.5 %; Hbt = -10.7 % and LUT 55198 x MIP Yuvileina, Ht = -0.4 %; Hbt = -3.7 %). Positive hypothetical and negative true heterosis values were found in F_1 with partial positive dominance and intermediate inheritance.

The inheritance pattern of the number of kernels per main spike in 2021 did not differ significantly from 2020, 2022. Overdominance was observed in 26 combinations (maximum values – LUT 55198 x LUT 37519, hp = 19.8; LUT 37519 x LUT 55198, hp = 16.3), with a positive value of hypothetical (1.7–41.7 %) and true (0.7–37.6 %) heterosis. Their highest values were in the combination LUT 55198 x ER 55023 - Ht = 41.7 %; Hbt = 37.6 %. Partial positive dominance was observed in three combinations, where positive hypothetical and negative true heterosis values were found, and depression in one combination (Table 2). In 2020 and 2021, the highest values of overdominance were observed for the hybrid combination LUT 55198 x LUT 37519. The depression was found in the hybrid combination Podolianka x MIP Yuvileina, hp = -2.0 with negative values of hypothetical (Ht = -6.1%) and true (Hbt = -8.9%) heterosis, while in the dry year 2022, overdominance was observed, which confirms the influence of abiotic factors on the heritability pattern of the trait.

In 2022, F1 common winter wheat formed a higher number of kernels per main spike compared to 2020 and 2021. Overdominance was found in 25 hybrid combinations (hp = 1.1–20.1), with positive values of hypothetical (Ht = 4.7–39.7 %) and true (Hbt = 0.5–29.3 %) heterosis. Partial positive dominance was observed in three combinations (LUT 55198 x MIP Assol, hp = 1.0; MIP Yuvileina x MIP Assol, hp = 0.9; MIP Assol x LUT 55198, hp = 0.8), with a positive value of hypothetical and negative value of true heterosis (Table 2). Intermediate inheritance was observed in two combinations: MIP Yuvileina x LUT 37519, hp = 0.2 and LUT 55198 x MIP Yuvileina, hp = 0.0. Negative values of both hypothetical (Ht = -0.1 %) and true (Hbt = -7.2 %) heterosis were observed in the hybrid combination MIP Yuvileina x LUT 37519.

The inheritance of the number of kernels per main spike was based on the type of overdominance during the years of research. The hybrid combinations of common winter wheat were of particular value, in which overdominance was observed from year to year with a positive value of hypothetical and true heterosis: LUT 55198 x LUT 37519, LUT 55198 x ER 55023, ER 55023 x Podolianka, Podolianka x LUT 55198, MIP Assol x LUT 37519, etc.

It is known that the productivity of common winter wheat is determined by the number of productive stems, grain content of the spike and grain size. The 1000 grain weight is a genetically reliable component of the yield in breeding work, has high heritability and is an effective trait in selections at the early stages of the breeding process, and allows predicting the breeding value of hybrid combinations. The results of the hybridological analysis revealed differentiation by types of inheritance in the first generation hybrids for the trait ‘1000 grain weight’ (Table 3).

Regardless of the growing conditions of the year, heterosis was found in most F_1 hybrids: 17 (56.7 %) of hybrid combinations in 2020, 18 (60.0 %) in 2021, 25 (83.3 %) in 2022, which is explained by the dominance of grain size. However, partial positive and negative dominance, intermediate inheritance and depression were observed in other combinations, which confirm the influence of the growing season on the heritability pattern of the trait.

In 2020, the degree of phenotypic dominance of hp ranged from -9.6 in the hybrid combination MIP Yuvileina x Podolianka to 44.9 in MIP Assol x LUT 55198. It should be noted that when using breeding lines LUT 37519, LUT 55198 as maternal components in all hybrids, except for LUT 37519 x MIP Assol, overdominance was observed (hp = 1.1–12.9; 1.9–34.4, respectively), and the 1000 grain weight varied from 38.50 to 42.00 g and exceeded the parental forms (38.40; 39.30 g, respectively). In 2021 and 2022, all hybrid combinations with the involvement of the breeding line LUT 55198 also showed overdominance (hp = 1.9–88.7; 3.0–52.2, respectively), which indicates the high donor properties of the breeding line LUT 55198 for increasing the spike productivity. The greatest effect of both hypothetical and true heterosis was observed in combinations: Podolianka x LUT 37519 (Ht = 23.3 %; Hbt = 20.6 %), Podolianka x LUT 55198 (Ht = 17.0 %; Hbt = 13.2 %), MIP Yuvileina x LUT 37519 (Ht = 12.0 %; Hbt = 11.2 %), LUT 37519 x MIP Yuvileina (Ht = 9.2 %; Hbt = 8.4 %), MIP Assol x LUT 55198 (Ht = 7.7 %; Hbt = 7.5 %). In seven hybrid combinations, the depression type

Table 3. Degree of phenotypic dominance for the trait '1000 grain weight' in F_1 common winter wheat

Hybrid combination	2020		2021		2022	
	hp	*	hp	*	hp	*
MIP Yuvileina x ER 55023	1.0	PPD	-0.6	PND	6.2	OD
MIP Yuvileina x MIP Assol	0.4	II	0.2	II	7.0	OD
MIP Yuvileina x Podolianka	-9.6	D	-0.3	II	0.4	II
MIP Yuvileina x LUT 37519	16.7	OD	0.8	PPD	0.3	II
MIP Yuvileina x LUT 55198	1.0	PPD	2.9	OD	4.3	OD
ER 55023 x MIP Yuvileina	1.7	OD	1.1	OD	9.1	OD
ER 55023 x MIP Assol	0.3	II	0.3	II	0.4	II
ER 55023 x Podolianka	3.6	OD	3.1	OD	1.9	OD
ER 55023 x LUT 37519	-1.7	D	1.9	OD	3.6	OD
ER 55023 x LUT 55198	0.9	PPD	6.9	OD	6.1	OD
MIP Assol x ER 55023	0.0	II	1.2	OD	-0.8	PND
MIP Assol x MIP Yuvileina	-3.1	D	-1.8	D	9.4	OD
MIP Assol x Podolianka	0.4	II	0.0	II	5.8	OD
MIP Assol x LUT 37519	-4.3	D	0.8	PPD	6.7	OD
MIP Assol x LUT 55198	44.9	OD	2.1	OD	1.7	OD
Podolianka x ER 55023	-2.3	D	3.6	OD	8.9	OD
Podolianka x MIP Assol	1.2	OD	1.0	PPD	1.0	PPD
Podolianka x MIP Yuvileina	-1.2	D	-1.4	D	2.3	OD
Podolianka x LUT 37519	10.5	OD	3.1	OD	3.2	OD
Podolianka x LUT 55198	5.1	OD	119.1	OD	81.0	OD
LUT 37519 x ER 55023	1.1	OD	7.7	OD	5.0	OD
LUT 37519 x MIP Assol	-4.1	D	0.6	PPD	5.6	OD
LUT 37519 x MIP Yuvileina	12.9	OD	0.9	PPD	6.2	OD
LUT 37519 x Podolianka	1.2	OD	1.1	OD	1.9	OD
LUT 37519 x LUT 55198	1.4	OD	5.4	OD	42.4	OD
LUT 55198 x ER 55023	1.9	OD	8.6	OD	8.1	OD
LUT 55198 x MIP Assol	34.4	OD	1.9	OD	7.9	OD
LUT 55198 x MIP Yuvileina	4.7	OD	2.6	OD	14.1	OD
LUT 55198 x Podolianka	1.9	OD	88.7	OD	3.0	OD
LUT 55198 x LUT 37519	2.5	OD	5.5	OD	52.2	OD

***Notes**: hp - degree of phenotypic dominance; * - type of inheritance; OD - heterosis (overdominance); PPD - partial positive dominance; II - intermediate inheritance; PND - partial negative inheritance; D - depression; ER - erythrospermum; LUT - lutescens.*

of inheritance was noted with negative values of hypothetical (Ht = -1.1 – -14.4 %) and true (Hbt = -1.6 – -15.7 %) heterosis.

In 2021, F_1 common winter wheat showed a different pattern of phenotypic inheritance of 1000 grain weight: overdominance was observed in 18 (60.0 %) combinations, partial positive dominance – in five (16.7 %), intermediate inheritance – in four (13.3 %), partial negative inheritance – in one (3.3 %), depression – in two (6.7 %) combinations. It should be noted that the positive values of hypothetical (Ht = 3.2–30.6 %) and true (Hbt = 0.2–30.3 %) heterosis were observed in heterotic combinations close to the best parental form. Partial positive dominance was observed in combinations: Podolianka x MIP Assol, hp = 1.0; LUT 37519 x MIP Yuvileina, hp = 0.9; MIP Assol x LUT 37519, hp = 0.8; MIP Yuvileina x LUT 37519, hp = 0.8; LUT 37519 x MIP Assol, hp = 0.6. In 2020, and 2021, the first generation hybrids LUT 37519 x MIP Yuvileina, MIP Assol x LUT 37519, and LUT 37519 x MIP Assol demonstrated this inheritance type consistently. In 2020 and 2021, the hybrid MIP Assol x MIP Yu-

vileina had a depressed type of inheritance with hp = -1.9; -1.8, respectively, and with negative values of heterosis effects (Ht = -4.1 %; Hbt = -6.3 %). Also, depression (hp = -1.4) was noted for the hybrid combination of Podolianka x MIP Yuvileina with negative values of hypothetical (Ht = -5.9 %) and true (Hbt = -9.6 %) heterosis, while overdominance (hp = 1.1) was observed in the dry year 2020. It was found that the main type of inheritance for the trait '1000 grain weight' for most (83.3 %) of the hybrid combinations was overdominance (hp = 1.7–52.2), with positive values of both hypothetical and true heterosis in 2022 (Table 3). The maximum (57.82 g) indicator level was formed by the combination LUT 37519 x LUT 55198 (hp = 42.4), the lowest (47.82 g) – Podolianka x MIP Yuvileina (hp = 2.3), with the variation of the trait in the parental forms from 40.19 g to 46.00 g. Positive values of hypothetical (Ht = 1.9–2.3 %) and negative values of true (Hbt = -1.0– -4.3 %) heterosis were observed in combinations with intermediate inheritance: MIP Yuvileina x Podolianka, MIP Yuvileina x LUT 37519, ER 55023 x MIP Assol. The hybrid combinations of common winter wheat were of the greatest value for breeding practice, in which the overdominance of the trait '1000 grain weight' was studied during three years of research: LUT 55198 x Podolianka, LUT 55198 x LUT 37519, Podolianka x LUT 55198, ER 55023 x Podolianka, LUT 55198 x MIP Assol, ER 55023 x MIP Yubileina, LUT 37519 x Podolianka, etc. It was found that the degree of manifestation of the trait is influenced by the selection of parental components and the growing conditions.

The hybrid combinations that showed heterosis for several traits simultaneously in F_1 and F_2 are well known to be of particular breeding value. The phenomenon of positive overdominance in terms of productivity traits was mainly observed in first-generation hybrids, while the number of heterotic combinations decreased in the second generation hybrids. Stable manifestation of heterosis in two generations of hybrids was observed for the productivity trait '1000 grain weight'. The predominant part of the hybrids exceeded the best parental form or was close to it in grain size: on average, the proportion of heterotic combinations was 75 % (F_1) and 78 % (F_2), respectively. Such inheritance indicates an equivalent manifestation of traits when using a genotype able to form large kernels as a maternal form or pollinator. The decay of the heterotic effect in terms of the number of kernels per main spike was observed, so the proportion of hybrids with overdominance decreased from 83 % (F_1) to 44 % (F_2). It was found that the main type of inheritance in terms of the number of productive stems for F_2 (48 %) was intermediate, and the majority (58 %) of the first generation hybrids were depressed or with a shift towards the worse parental component. The best hybrid combinations with simultaneous inheritance of several productivity traits by the type of overdominance in F_1 and F_2 were identified: LUT 37519 x LUT 55198, LUT 55198 x LUT 37519, ER 55023 x LUT 55198, LUT 55198 x ER 55023, Podolianka x LUT 55198, ER 55023 x LUT 37519, MIP Assol x LUT 37519.

Conclusions. Thus, it was found that the degree of phenotypic dominance of productivity elements in F_1 hybrid winter wheat varied depending on environmental conditions and the selection of pairs for hybridisation. Most of the first generation hybrids showed a sufficiently high degree of heterosis in terms of productivity elements for three years with contrasting weather conditions, which can be explained by the influence of parental components selected with consideration of the peculiarities in formation of quantitative traits. The influence of the weather conditions on the level and frequency of negative overdominance in terms of the number of productive stems was revealed: in 2021 and 2022, the number of depressive combinations (26.7 % and 70.0 %, respectively) was higher than in 2020 (16.7 %). It was noted that the proportion of heterotic combinations in F_2 decreased for all traits. High level of heterosis and overdominance, a shift towards the best parental component and intermediate inheritance were observed in the selected hybrid combinations, which will ensure effective selection of highly productive forms in generations of offspring, as well as transgressions.

References

1. Burdeniuk-Tarasevych, L. A., Lozinski, M. V. (2015). Pair selection principles for hybridization of *Triticum aestivum* L. winter on adaptability to environmental comditions. *Faktory eksperymentalnoi evoliutsii orhanizmiv* [Factors in Experimental Evolution of Organisms], *16*. 92–96. [in Ukrainian].
2. Shcherbakova, Yu. (2021). Inheritance of economically valuable characteristics in intervarious hybrids of wheat in soft winter under Forest steppe. *Norwegian Journal of Development of the International Science*, *55 (2)*. 16–20.
3. Juraev, D. T., Amanov, O. A., Dilmurodov, S. D., Meyliev, A. K., Boysunov, N. B., Kayumov, N. S., Azizov, B. G., Ergashev, Z. B. (2021). Heritability of valuable economic traits in the hybrid generations of bread wheat. *Annals of the Romanian Society for Cell Biology*, *25 (4)*. 2008–2019.
4. Haridy, M. H. (2017). Combining ability in F_1 generation for diallel crosses for yield and yield components in wheat (*Triticm aestivum* L.). *Journal of Plant Production, 8 (12)*. 1417–1420. doi: 10.21608xjpp.2017.42021
5. Molotskyi, M. Ya., Vasylkivskyi, S. P., Kniaziuk, V. I. (2008). *Selektsiia ta nasinnytstvo polovykh kultur: praktykum* [Plant breeding and seed growing fielf crops: practical manual]. Bila Tserkva. [in Ukrainian].
6. Ibrahim, A. U., Yadav, B., Anusha, R., Magashi, A. I. (2020). Heterosis studies in durum wheat (*Triticum durum* L.). *Journal of Genetics, Genomics and Plant Breeding*, *4 (1)*. 2–8.
7. Bazalii,V. V., Bazaliy, H. H., Larchenko O. V. (2006). Features of formation and nature of variability of signs of productivity of winter wheat under different growing conditions. *Factors in Experimental Evolution of Organisms*, *3*. 174–176. [in Ukrainian].
8. Lozinskyi, M. V., Varnava, N. S. (2010). Determination of the number of ears of the main ear by reciprocal hybrids of winter wheats. *Ahrobiolohiшa* [Agrobiology], *4 (80)*. 69–72. [in Ukrainian].
9. Lozinsky, M., Ustinova, H. (2020). Inheritance in F_1 and transgressive variability in F_2 of the main ear length by crossing wheat varieties with different maturity. *Ahrobiolohiшa* [Agrobiology], *2*. 70–78. [in Ukrainian].
10. Dubovyk, N. S., Humeniuk, O. V., Kyrylenko, V. V., Volohdina, H. B. (2018). Inheritance of productivity elements and their transgressive variation in bread winter wheat hybrids derived from crossing varieties-carriers of wheat-rye translocations. *Myronivskyш visnyk* [Myronivka Bulletin], *7*. 26–38. [in Ukrainian].
11. Vlasenko, V. A., Bakumenko, O. M. (2017). Genetic control of productivity elements in bread winter wheat F_1 and F_2 hybrids created by involving carriers of introgressive components. Myronivskyш visnyk [Myronivka Bulletin], *4*. 88–101. [in Ukrainian].
12. Bazaliy, V. V., Domaratskyy, Ye. O., Boychuk, I. V., Teteruk, O. V., Kozlova, O. P., Bazaliy, H. H. (2020). Genetic control and recombination of the features of lodging resistance in winter wheat hybrids under different growing conditions. *Ahrarni innovatsii* [Agrarian Innovations], *4*. 87–93. [in Ukrainian].
13. Bazalii, V. V., Boichuk, I. V., Lavrynenko, Yu. O., Bazalii, H. H., Domaratskyш, Ye. O., Larchenko O. V. (2020). Features of the formation of productivity signs of the Yielding Capacity in Winter Wheat Varieties Under Different Growing Conditions. *Faktory eksperymentalnoi evolutsii orhanizmiv* [Factors in Experimental Evolution of Organisms], *27*. 29–34. [in Ukrainian].
14. Didora, V. H., Smahlii, O. F., Ermantrautm E. R., Gudz, V. P., Moiseienko, V. V. (2013). *Metodyka naukovykh doslidzhen v ahronomii: navchalnyi posibnyk* [Methodology of scientific research in agronomy: manual]. Kyiv: Tsentr uchbovoi literatury. [in Ukrainian].
15. Griffing, V. (1950). Analysis of quantitative gene action by constant parent regression and related techniques. *Genetics*, *35*. 303–321.
16. Lozinskiy, M. (2015). Inheritance and transgressive variability of general and productive tillering of intraspecific hybrids of winter wheat. *Ahrobiolohiшa* [Agrobiology], *2*. 53–56. [in Ukrainian].
17. Luchnaya, I. S. (2013). Inheritance of the main productivity elements in winter wheat F_1 hybrids during creation of original material resistant to diseases. *Plant Breeding and Seed Production*, *103*. 153–159. doi: 10.30835x2413-7510.2013.54085 [in Ukrainian].
18. Shelepov, V. V., Havryliuk, M. M., Chebakov, M. P., Honchar, O. M., Verhunov, V. A. (2007). *Selektsiia, nasinnytstvo ta sortoznavstvo pshenytsi* [Wheat breeding, seed growing, and variety science]. Myronivka. [in Ukrainian].
19. Riabchenko, A. N. (2004). Using the principles of adaptive breeding in the creation of drought-resistant wheat varieties. *News of Dnipropetrovsk State Agrarian University*, *2*. 60–64. [in Russian].
20. Prosunko, V. M. (2004). Consequences of global climate warming in agriculture. *Agronom Magazine*, *4*. 67–69. [in Ukrainian].

UDK 633.111.1“324”:575.222.7:631.559

[1]Вологдіна Г. Б., [2]Рисін А. Л. Ступінь фенотипового домінування ознак продуктивності та рівень гетерозису в F_1 пшениці м’якої озимої. *Зернові культури. 2024. 8 (1). 11–20.*

[1]Миронівський інститут пшениці імені В. М. Ремесла НААН, вул. Центральна, 68, с. Центральне, Обухівський район, Київська область, 08853, Україна

[2]ТОВ Україна «НВАК «Степова», вул. Токова, б. 2а, с. Веселе, Синельниківський район, Дніпропетровська область, 52502, Україна

Актуальність. Дослідження характеру успадкування параметрів цінних господарських ознак, ступеня гетерозису в гібридів першого покоління пшениці м'якої озимої є актуальним завданням при створенні високопродуктивних сортів з високою якістю зерна, а також для прогнозування селекційно-генетичного ефекту схрещувань. **Мета досліджень.** Встановити ступінь фенотипового домінування та рівень гетерозису за ознаками «кількість продуктивних стебел», озерненість колосу, «маса 1000 зерен» у F_1. **Матеріали та методи.** Досліди проводили в 2018/19–2021/22 вегетаційних роках на полях селекційної сівозміни в лабораторії селекції озимої пшениці Миронівського інституту пшениці імені В. М. Ремесла НААНУ. Матеріалом для досліджень були гібридні популяції F_1–F_2, створені за участі сортів (МІП Ювілейна, МІП Ассоль, Подолянка) та перспективних селекційних ліній (ЛЮТ 37519, ЛЮТ 55198, ЕР 55023) пшениці м'якої озимої (*Triticum aestivum* L.) миронівської селекції з комплексом цінних господарських ознак. Аналіз гібридів і їх батьківських форм проводили індивідуально за елементами продуктивності, визначали ступінь фенотипового домінування. **Результати.** Виявлено вплив умов року на рівень і частоту прояву від'ємного наддомінування за кількістю продуктивних стебел: в 2021, 2022 рр. була більша (26,7 % і 70,0 % відповідно) кількість депресивних комбінацій, ніж у 2020 р. (16,7 %). Установлено, що основним типом успадкування кількості зерен у головному колосі в F_1 було наддомінування – 56,7 % (2020 р.); 86,7 % (2021 р.); 83,3 % (2022 р.). Незалежно від умов року вирощування вбільшості F_1 виявили гетерозис за масою 1000 зерен: у 2020 р. – 17 (56,7 %) гібридних комбінацій, у 2021 р. – 18 (60,0 %), у 2022 р. – 25 (83,3 %). **Висновки.** Доведено, що впродовж трьох років з контрастними погодними умовами у гібридів першого покоління спостерігали достатньо високий ступінь гетерозису за елементами продуктивності, що можна пояснити впливом батьківських компонентів, правильним підходом до їх вибору з урахуванням особливостей формування кількісних ознак. У виокремлених гібридних комбінаціях відмічали високий рівень гетерозису (наддомінування), часткове позитивне домінування та проміжне успадкування, що забезпечить у поколіннях нащадків ефективний добір високопродуктивних форм.

Ключові слова: *Triticum aestivum* L.*, гібридна комбінація, наддомінування, кількість продуктивних стебел, озерненість колоса, маса 1000 зерен*