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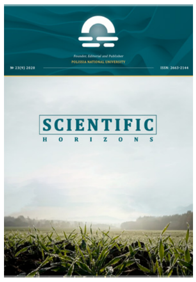

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Manifestation of Heterosis and Degree of Phenotypic Dominance by the Number of Grains from the Main Ear in the Hybridisation of Different Early-Maturing Varieties of Soft Winter Wheat

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Abstract. Winter wheat (*Triticum aestivum* L.) is the main food crop on a global scale, in the growth and stabilisation of yields, of which varietal resources are a significant factor. In practical breeding work, an essential role is played by a variety of thoroughly investigated source material. The purpose of this study was to determine hypothetical and true heterosis and establish the nature of inheritance of the number of grains from the main ear in hybrids of soft winter wheat. In 2018-2020, 45 combinations of cross-breeding of soft winter wheat varieties obtained from hybridisation of different growing season periods were investigated in the experimental field of the Research and Production Centre of the Belotserkovskyi National Agrarian University. Generally accepted methods were used to determine the hypothetical and true heterosis and the degree of phenotypic dominance by the number of grains in the main ear. Studies indicate that the number of grains in the ear of the main stem of the parent components of hybridisation is determined by genotype and considerably depends on the hydrothermal conditions of the year. The author of this paper established the influence of maternal cytoplasm on the manifestation of the trait under study. Thus, when used in hybridisation of early-maturing varieties with the mother form, the largest average number of grains in the main ear for hybrids (63.3 pcs.) was formed in 2019. At the same time, for the use of medium-early, medium maturing, and medium-late varieties in hybridisation, the maximum number of grains (64.8 pcs.) was marked in 2018. Therewith, all hybrids formed the minimum number of grains in 2020. The obtained experimental data indicate the influence of parental genotypes and year conditions on heterosis indicators and the degree of phenotypic dominance in first-generation hybrids. It is determined that the most common type of inheritance (85.6%) of the number of grains from the main ear is positive overdomination. Practical value for the selection of soft winter wheat are the selected cross-breeding combinations: Myronivska early / Zolotokolosa, Myronivska early / Cherniava, Bilotserkivska semi-dwarf / Cherniava, Bilotserkivska semi-dwarf / Antonivka, Kolchuha / Antonivka, Zolotokolosa / Charniava, Zolotokolosa / Yednist, Cherniava / Vidrada, Cherniava / Stolychna, Shchedra Nyva / Dobirna, Antonivka / Stolychna, Dobirna / Pyvna, which significantly exceeded the average number of grains from the main ear for F_1 in the changing fields under hydrothermal conditions the years of research

Keywords: parental components of cross-breeding, year conditions, inheritance, hybrids, true and hypothetical heterosis, degree of phenotypic dominance

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INTRODUCTION

Due to the rapid growth of the world's population [1; 2], Ukrainian crop producers, as one of the leading agricultural countries in the world, face an acute task of increasing production volumes and improving grain quality indicators that would meet the requirements of European standards [3-5]. An essential role in solving this issue belongs to winter wheat (*Triticum aestivum* L.), the leading world culture [6; 7], grain products of which form the basis of human nutrition [1; 2].

One of the most common ways to increase and stabilise yields is to create and introduce into production highly productive varieties and hybrids of soft winter wheat with high grain quality [8-10]. The genotype of the variety, as a means of production, should combine the maximum number of traits and properties contributing to a high level of yield. The potential of the variety is fulfilled when the genotype interacts with environmental conditions [11; 12]. Considering the transformation of environmental conditions [13], scientists are faced with the task of creating new varieties adapted to certain soil and climatic zones of cultivation [14; 15]. Improvement of varieties should be based on environmental stability, considering special interactions between the environment and the genotype, which will provide new approaches to the development of stable productivity [16; 17].

The main ear of soft winter wheat plays a critical role in increasing the productivity of the wheat plant [18]. Graininess of the ear constitutes an essential quantitative feature that is closely related to grain yield [19; 20] and is frequently used by scientists in practical breeding work.

One of the most common and effective methods in practical breeding work is hybridisation, wherein a new organism is born and formed from a zygote (fertilised egg), which is developed as a result of the fusion of female and male gametes. Hybridisation allows combining the necessary traits in one genotype, as well as due to genetic recombination and transgressive variability, obtaining qualitatively new source material [21] and information about the breeding and genetic features of parental forms involved in cross-breeding and their offspring [22]. It is also important to know how traits and properties are inherited by offspring under changing environmental conditions [23; 24].

The purpose of this study is to determine the effect of heterosis and the degree of phenotypic dominance in F_1 according to the number of grains in the main ear, when used in hybridisation of different early-maturing varieties of soft winter wheat.

MATERIALS AND METHODS

The experimental part of this study was carried out in 2018-2020 on the experimental field of the Research and Production Centre of the Bilotserkivskyi National Agrarian University. The research material involved 45 combinations of F_1. Hybridisation involved varieties of soft winter wheat that differed in the duration of the growing season, namely early-maturing: Myronivska early (Myr. early), Kolchuha, Bilotserkivska semi-dwarf (B. Ts. s-d); medium-early: Zolotokolosa, Cherniava, Shchedra Nyva; medium-maturing: Stolychna, Vidrada, Myronivska 61, Antonivka, Yednist; mid-late: Dobirna, Pyvna, and Vdala.

F_1 seeds were sown manually according to the scheme: mother form (♀), hybrid (F_1), male form (♂). The hybrid generation was handled using the pedigree method. During the growing season of wheat, phenological observations were made, and after the onset of full maturing of the grain, biometric analysis of the material under study was performed on an average sample of 75 plants [25; 26]. The predecessor of soft winter wheat was mustard. The soil of the experimental field is typical deep low-humus chernozem, coarse-sawn medium and light loamy chernozem. According to the 2016 agrochemical survey, the content of humus is 3.4-3.8%, alkaline hydrolysed nitrogen – 118-134 mg/kg of soil, mobile phosphorus – 180-208 mg/kg of soil, and exchange potassium – 73-91 mg/kg of soil. The reaction of the soil solution is slightly acidic and close to the neutral. Phosphorus-potassium fertilisers of 60 kg/ha in the form of superphosphate and potassium salt were added to the main fertiliser. During the resumption of spring vegetation, ammonium nitrate was added in the active substance of 60 kg/ha. Herbicides and irrigation were not used in the breeding nursery.

Hypothetical (Ht) and true (Htb) heterosis by the number of grains in the head ear in F_1 was determined according to the developments made by D.F. Matzinger [27] S. Fonseca, F. Patterson [28]:

$$Ht\ (\%)=(F_1 - MP)/MP\ x\ 100$$
$$Hbt\ (\%)=(F_1 - BP)/BP\ x\ 100$$

where: F_1 is the arithmetic mean of the hybrid; BP is the highest manifestation of the trait of one of the parents; MR is the arithmetic mean of the indicator of both parent forms.

Degree of phenotypic dominance (h_p) according to method of B. Griffing [29]:

$$hp=(F_1 - MP)/\ (BP - MP)$$

where: hp is the degree of dominance; F_1 is the arithmetic mean of the hybrid; BP is the arithmetic mean of the parent component with a stronger manifestation of the feature; MR is the arithmetic mean of the indicator of both parent forms.

The obtained data were grouped according to the classification by G.M. Beil, R.E. Atkins [30]: positive superdomination (heterosis) hp>+1; partial positive dominance +0.5<hp≤+1; intermediate inheritance -0.5≤hp≤+0.5; partial negative inheritance -1≤hp<-0.5; negative superdomination (depression) hp<-1.

The number of grains in an ear of wheat is developed from the exit into the tube of the main ear (30th micro-stage) to the formation of grain – 70th micro-stage according to the international BBCH scale.

At the time of sowing (October 1), meteorological conditions in 2017-2019 contributed to the simultaneous germination and growth and development of soft winter wheat in the autumn period. The amount of precipitation during this period exceeded (2017) or was at the level of long-term average indicators. Soft winter wheat stopped growing in the autumn period on 20.11. (2017), 12.11. (2018) and 21.11. (2019), which contributed to the successful hardening of plants. Precipitation in the winter period considerably exceeded the long-term average (112 mm) in the 2017/2018 and 2018/2019 growing seasons and was slightly inferior to 2019/2020. The temperature regime that developed in winter contributed to the successful overwintering of plants (Table 1).

***Table 1**. Meteorological conditions in 2018-2020 (according to the Bilotserkivska Meteorological Station)*

Month	Decade	Precipitation, mm					Air temperature, °C				
		2017	2018	2019	2020	Multi-year data	2017	2018	2019	2020	Multi-year data
September		53.2	47.9	19.2		35	16.1	16.2	15.3		13.8
October		50.4	22.0	66.1		33	8.0	9.9	10.6		7.9
November		36.4	23.1	23.4		41	3.2	-0.1	5.0		2.0
December		92.3	71.1	35.1		44	1.6	-2.0	2.5		-2.4
January			30.5	56.8	22.6	35		-2.7	-4.8	0.4	-5.9
February			34.6	21.4	38.4	33		-4.2	0.4	2.2	-4.4
March			74.0	23.4	17.2	30		-2.1	4.7	5.9	0.3
April	I		1.5	–	–	14		10.3	9.6	7.9	7.0
	II		1.3	14.2	5.5	17		13.8	7.3	8.0	7.8
	III		5.3	31.3	7.7	16		15.7	13.2	11.7	10.4
May	I		3.7	26.7	30.8	16		20.4	12.1	12.8	13.3
	II		19.1	15.3	17.6	12		15.9	18.3	13.2	15.3
	III		–	12.0	53.9	18		18.8	19.3	11.5	15.8
June	I		2.2	35.3	7.1	23		19.4	21.1	18.5	17.3
	II		23.3	–	50.4	27		21.9	23.6	23.2	17.4
	III		33.2	43.9	3.2	23		19.1	21.4	22.0	18.7

The temperature regime after the resumption of vegetation in 2018 (April 4) was described by elevated temperatures, which accelerated the growth and development of soft winter wheat. The average monthly temperature for April (15.5°C) was significantly higher than the long-term average (8.4°C), and the average air temperature for May and June was higher by 3.5 and 2.3°C, respectively. Therewith, the amount of precipitation in April and May was less than the long-term figures by 17.1 and 21.6 mm, respectively.

Vegetation of soft winter wheat from the time of recovery (02.03. – 2019, 28.02. – 2020) occurred during the month at low average monthly temperatures with a gradual increase in them. The amount of precipitation in March (23.4 mm) and the first two decades of April (14.2 mm) in 2019 was considerably lower than the long-term average. In March and April 2020, 46.6 mm less precipitation fell than the long-term average. Thus, meteorological conditions in the years of study were described by contrasting indicators, temperature regime and precipitation distribution, which significantly affected the development of the number of grains in the main ear.

RESULTS AND DISCUSSION

The obtained experimental data in 2018-2020 indicate that the number of grains in the main ear of the parent components of hybridisation was from 34.1 pcs. (Yednist in 2020) up to 59.0 pcs. (Chorniava 2019) (Table 2). The conducted studies indicate that the development of the number of grains in the main ear of soft winter wheat is influenced by the genotype, the conditions of the year and the interaction between the genotype and the conditions of the year.

Other studies [31] found that the greatest influence (53.96%) on the development of the number of grains in the main ear was the interaction between the genotype and the conditions of the year, wherein the genotype influence was at 31.02%, while the conditions of the year only at 7.90%.

Table 2. *Number of grains in the main ear of parent hybridisation components, pcs.*

Varieties	2018	2019	2020
Myronivska early	39.1	39.8	42.3
Bilotserkivska semi-dwarf	37.7	39.5	49.5
Kolchuha	41.8	38.4	38.3
Zolotokolosa	42.2	39.8	37.9
Chorniava	54.4	59.0	52.1
Shchedra Nyva	45.5	47.4	43.7
Stolychna	40.5	38.9	39.0
Vidrada	37.2	37.6	35.9
Myronivska 61	41.4	40.7	39.7
Antonivka	41.1	40.6	38.1
Yednist	40.8	44.1	34.1
Dobirna	40.7	43.8	47.7
Pyvna	41.2	38.4	53.5
Vdala	39.9	40.7	39.8
HIP_{05}	2.2	2.6	1.9

Note: *SSD_{05} is the slightest significant difference*

For F_1 hybrids obtained for the use of early-maturing varieties by the mother form, the number of grains in the main ear in the years of research had a consideable differentiation – 30.1-76.5 pcs. It is established that the variability of the number of grains in F_1, for 2018-2020 is conditioned upon both the components of hybridisation and the conditions of the year (Table 3).

Table 3. *Number of grains in the head ear F_1 and parent forms for the use of early-maturing varieties by the mother form, pcs.*

Cross-breeding combinations	2018			2019			2020		
	♀	F_1	♂	♀	F_1	♂	♀	F_1	♂
♀ early maturing / ♂ early maturing									
Myr. early* / B. Ts. s-d**	39.1	63.5	37.7	39.8	61.8	39.5	42.3	53.1	49.5
Myr. early / Kolchuha	39.1	59.5	41.8	39.8	61.3	38.4	42.3	42.2	38.3
B. Ts. s-d / Kolchuha	37.7	55.6	41.8	39.5	67.8	38.4	49.5	51.0	38.3
♀ early maturing / ♂ mid-early									
Myr. early / Zolotokolosa	39.1	63.8	42.2	39.8	72.7	39.8	42.3	47.2	37.9
Myr. early / Chorniava	39.1	64.9	54.4	39.8	67.0	59.0	42.3	50.9	52.1
B. Ts. s-d / Zolotokolosa	37.7	60.2	42.2	39.5	59.2	39.8	49.5	51.4	37.9
B. Ts. s-d / Cherniava	37.7	76.5	54.4	39.5	60.2	59.0	49.5	53.6	52.1
Kolchuha / Chorniava	41.8	53.6	54.4	38.4	60.8	59.0	38.3	47.9	52.1
♀ early maturing / ♂ medium maturing									
Myr. early / Antonivka	39.1	53.6	41.1	39.8	65.7	40.6	42.3	30.1	38.1
Myr. early / Yednist	39.1	64.2	40.8	39.8	62.0	44.1	42.3	52.8	34.1
B. Ts. s-d / Antonivka	37.7	60.1	41.1	39.5	69.3	40.6	49.5	55.1	38.1
B. Ts. s-d / Yednist	37.7	69.0	40.8	39.5	58.3	44.1	49.5	44.1	34.1
B. Ts. s-d / Vidrada	37.7	55.4	37.2	39.5	63.7	37.6	49.5	44.9	35.9
Kolchuha / Antonivka	41.8	62.6	41.1	38.4	69.2	40.6	38.3	50.1	38.1
Kolchuha / Yednist	41.8	49.0	40.8	38.4	55.9	44.1	38.3	44.7	34.1
Kolchuha / Vidrada	41.8	51.0	37.2	38.4	53.0	37.6	38.3	38.0	35.9
Kolchuha / Stolychna	41.8	64.8	40.5	38.4	62.9	38.9	38.3	49.2	39.0
♀ early maturing / ♂ mid-late									
Myr. early / Vdala	39.1	69.1	39.9	39.8	67.5	40.7	42.3	37.6	39.8
Myr. early / Dobirna	39.1	63.1	40.7	39.8	69.1	43.8	42.3	48.8	47.7
B. Ts. s-d / Dobirna	37.7	58.2	40.7	39.5	64.9	43.8	49.5	45.0	47.7
HIP_{05}	2.4	2.1	2.3	3.8	2.0	2.8	2.1	2.4	2.2

Note: ** – Myronivska early, ** – Bilotserkivska semi-dwarf, ♀ – mother form, F_1 – hybrid, ♂ – male form, SSD_{05} – the slightest significant difference*

The largest average number of grains for hybrids (63.3 pcs.) in the main ear was formed in 2019. Slightly lower indicators (60.9 pcs.) were noted in 2018. Low number of grains (46.9 pcs.) was formed by hybrids in the conditions of 2020.

By average F_1 variability in the number of grains in the main ear (18.5 pcs.), in years of research, stable manifestation (8.8-12.9 pcs.) were established among the following: B. Ts. s-d / Zolotokolosa; Myr. early / B. Ts. s-d; Kolchuha / Yednist; Myr. early / Yednist; Kolchuha / Chorniava. Therewith, the number of grains higher than the average for hybrids for 2018-2020 (57.1 pcs.) was determined in Myr. early / Yednist (59.6 pcs.) and Myr. early / B. Ts. s-d (59.5 pcs.). A high amplitude of variability in the number of grains from the ear was established in hybrids Myr. early/ Antonivka (35.6 pcs.), Myr. early / Vdala (31.5 pcs.), Myr. early / Zolotokolosa (25.5 pcs.), B. Ts. s-d / Yednist (24.9 pcs.), B. Ts. s-d / Chorniava (22.9 pcs.).

In 2018-2020, the use of medium-early, medium-maturing, medium-late varieties for hybridisation yielded the number of grains in the main ear F_1 amounting to 38.6-87.8 pcs. The obtained experimental data indicate considerable variability depending on the selection of parent hybridisation pairs. In addition, most hybrids have a significant influence on the manifestation of the indicators of the year conditions (Table 4).

***Table 4**. Number of grains in the head ear F1 and parent forms for use in hybridisation of medium-early, medium-maturing and medium-late varieties, pcs.*

Cross-breeding combinations	2018			2019			2020		
	♀	F_1	♂	♀	F_1	♂	♀	F_1	♂
♀ mid-early / ♂ mid-early									
Zolotokolosa / Chorniava	42.2	62.2	54.4	39.8	64.1	59.0	37.9	61.6	52.1
Zolotokolosa/ Shchedra Nyva	42.2	62.2	45.5	39.8	58.8	47.4	37.9	53.9	43.7
Cherniava / Shchedra Nyva	54.4	63.9	45.5	59.0	53.3	47.4	52.1	46.2	43.7
♀ mid-early / ♂ medium maturing									
Zolotokolosa / Antonivka	42.2	53.3	41.1	39.8	62.5	40.6	37.9	54.3	38.1
Zolotokolosa / Yednist	42.2	70.5	40.8	39.8	73.3	44.1	37.9	48.5	34.1
Zolotokolosa / Vidrada	42.2	60.9	37.2	39.8	63.0	37.6	37.9	53.7	35.9
Zolotokolosa / Stolychna	42.2	57.2	40.5	39.8	64.6	38.9	37.9	61.2	39.0
Cherniava / Antonivka	54.4	70.3	41.1	59.0	41.0	40.6	52.1	43.7	38.1
Cherniava / Yednist	54.4	62.0	40.8	59.0	48.4	44.1	52.1	42.3	34.1
Cherniava / Vidrada	54.4	71.0	37.2	59.0	62.5	37.6	52.1	53.1	35.9
Cherniava / Stolychna	54.4	77.4	40.5	59.0	61.4	38.9	52.1	56.2	39.0
Shchedra Nyva / Antonivka	45.5	64.1	41.1	47.4	43.3	40.6	43.7	50.3	38.5
Shchedra Nyva / Stolychna	-	-	-	47.4	68.4	38.9	43.7	60.1	39.0
Shchedra Nyva / Vidrada	45.5	65.9	37.2	47.4	38.6	37.6	43.7	50.3	35.9
♀ mid-early / ♂ mid-late									
Shchedra Nyva / Dobirna	45.5	71.4	40.7	47.4	60.6	43.8	43.7	56.4	47.7
♀ medium maturing / ♂ medium maturing									
Antonivka / Yednist	41.1	52.0	40.8	40.6	61.3	44.1	38.1	51.4	34.1
Antonivka / Vidrada	41.1	65.0	37.2	40.6	48.5	37.6	38.1	50.5	35.9
Antonivka / Stolychna	41.1	68.2	40.5	40.6	60.2	38.9	38.1	55.9	39.0
Antonivka / Myronivska 61	-	-	-	40.6	69.2	40.7	38.1	56.4	39.7
Myronivska 61 / Yednist	41.4	62.7	40.8	40.7	66.1	44.1	39.7	42.5	34.1
Yednist / Vidrada	40.8	63.5	37.2	44.1	66.5	37.6	34.1	47.9	35.9
♀ medium maturity / ♂ mid-late									
Yednist / Dobirna	40.8	67.2	40.7	44.1	60.8	43.8	34.1	44.3	47.7
♀ mid-late / ♂ medium maturity									
Vdala / Stolychna	39.9	61.0	40.5	40.7	64.6	38.9	39.8	51.9	39.0
♀ mid-late / ♂ mid-late									
Vdala / Pyvna	-	-	-	40.7	87.8	38.4	39.8	62.3	53.5
Dobirna / Pyvna	40.7	74.5	41.2	43.8	80.5	38.4	47.7	50.8	53.5
HIP_{05}	1.5	1.7	2.3	2.7	1.5	2.1	1.6	1.2	2.2

***Note**: ♀ is the female form, F_1 is the hybrid, ♂ is the male form, SSD_{05} is the slightest significant difference*

The most favourable year for the formation of the average number of grains for F_1 in the main ear (64.8 pcs.) was established in 2018. In the conditions of 2019, the number of grains was considerably smaller – 61.2 pcs., and the minimum (52.2 pcs.) was formed by hybrids in 2020.

The average variability of the number of grains from the ear in these hybrids is determined at the level of 16.9 pcs. With a slight variation of the attribute (2.5-12.3 pcs. of grain), the hybrids Antonivka / Stolychna (64.1 pcs.), Zolotokolosa / Stolychna (61.0 pcs) were described by a consistently high reliable manifestation of the number of grains in 2018-2020.

High variability of the attribute was determined in the following hybrids: Dobirna / Pyvna (29.7 pcs.), Chorniava / Antonivka (29.3 pcs.), Shchedra Nyva / Vidrada (27.3 pcs.), Vdala / Pyvna (25.5 pcs.), Zolotokolosa / Yednist (24.8 pcs.), Myronivska 61 / Yednist (23.6 pcs.), Yednist / Dobirna (22.9 pcs.), Chorniava / Stolychna (21.2 pcs.), Shchedra Nyva / Antonivka (20.8 pcs.).

A special feature of hybrids of the first generation is the manifestation of the effect of heterosis in certain quantitative and qualitative characteristics, primarily due to the heterozygous state of the body [32; 33]. The manifestation of heterosis is explained by an increase in heterozygosity [34; 35], and its indicators F_1 vary widely.

In most F_1's the authors of this study determined a positive hypothetical heterosis from 0.2% (Chorniava / Shchedra Nyva) to 122.0% (Vdala / Pyvna). Therewith, the true heterosis varied from 0.2% (Shchedra Nyva / Dobirna) to 115.7% (Vdala / Pyvna). A considerable influence of hybridisation components and year conditions on the manifestation of the heterosis effect was established. Thus, depending on the selection of parent pairs for cross-breeding, the indicators of hypothetical and true heterosis in the years of research have substantial differences (Tables 5, 6).

***Table 5**. Heterosis and degree of phenotypic dominance in F_1 according to the number of grains in the main ear, given the use of early maturing varieties with the mother form*

Cross-breeding combinations	2018			2019			2020		
	Heterosis, %		h_p	Heterosis, %		h_p	Heterosis, %		h_p
	Ht	Hbt		Ht	Hbt		Ht	Hbt	
♀ early-maturing / ♂ early-maturing									
Myr. early* / B. Ts. s-d**	65.4	62.4	35.9	55.9	55.3	147.7	15.7	7.3	2.0
Myr. early / Kolchuha	46.9	42.3	14.5	56.8	54.0	31.7	4.7	-0.2	0.9
B. Ts. s-d / Kolchuha	39.7	33.0	7.9	74.1	71.6	52.5	15.9	3.0	1.3
♀ early maturing / ♂ mid-early									
Myr. early / Zolotokolosa	56.8	51.2	15.4	82.6	82.6	1644.0	17.7	11.6	3.2
Myr. early / Chorniava	38.7	19.3	2.4	35.6	13.6	1.8	7.8	-2.3	3.1
B. Ts. s-d / Zolotokolosa	50.5	42.7	9.2	49.3	48.7	130.3	17.6	3.8	1.3
B. Ts. s-d / Cherniava	65.9	40.6	22.1	21.2	2.0	1.1	5.5	2.9	2.2
Kolchuha / Chorniava	11.43	-1.5	0.9	24.9	3.0	1.2	6.0	-8.1	0.4
♀ early maturing / ♂ medium maturing									
Myr. early / Antonivka	33.7	30.4	13.5	63.4	61.8	63.8	-2.5	-28.8	-4.8
Myr. early / Yednist	60.5	57.4	30.3	47.8	40.6	9.3	38.2	24.8	3.6
B. Ts. s-d / Antonivka	52.5	45.2	12.2	73.0	70.7	53.2	25.8	11.3	2.0
B. Ts. s-d / Yednist	75.6	69.1	19.8	39.5	32.2	7.2	5.5	-10.9	0.3
B. Ts. s-d / Vidrada	47.7	47.0	89.5	68.7	61.3	27.9	5.2	-9.3	0.3
Kolchuha / Antonivka	50.8	49.8	70.3	75.2	70.4	27.0	31.3	30.8	79.7
Kolchuha / Yednist	18.6	17.2	15.4	35.5	26.8	5.1	23.5	16.7	4.0
Kolchuha / Vidrada	29.1	22.0	5.0	65.8	38.0	62.5	2.4	-0.8	0.8
Kolchuha / Stolychna	57.3	55.0	39.3	62.7	61.7	97.0	27.3	26.2	30.1
♀ early maturing / ♂ mid-late									
Myr. early / Vdala	74.9	73.2	74.0	67.7	65.8	60.6	-8.4	-11.1	-2.8
Myr. early / Dobirna	58.1	55.0	29.0	65.3	57.8	13.6	8.4	2.3	1.4
B. Ts. s-d / Dobirna	48.5	43.0	12.7	55.8	48.2	10.8	-7.4	-9.1	-4.0

***Note**: * – Myronivska early, ** – Bilotserkivska semi-dwarf, Ht – hypothetical heterosis, Htb – true heterosis, hp – degree of dominance, ♀ – maternal form, ♂ – male form*

Table 6. Heterosis and degree of phenotypic dominance in F_1 according to the number of grains in the main ear given the use of medium-early, medium-maturing and medium-late varieties for hybridisation

Cross-breeding combinations	2018			2019			2020		
	Heterosis, %		h_p	Heterosis, %		h_p	Heterosis, %		h_p
	Ht	Hbt		Ht	Hbt		Ht	Hbt	
♀ mid-early / ♂ mid-early									
Zolotokolosa / Chorniava	28.5	14.3	2.3	29.8	8.64	1.5	36.9	18.2	2.3
Zolotokolosa/ Shchedra Nyva	41.4	36.7	12.1	34.9	24.1	4.0	32.1	23.3	4.5
Cherniava / Shchedra Nyva	27.8	17.5	3.2	0.2	-9.7	0.02	-3.5	-11.3	-0.4
♀ mid-early / ♂ medium maturing									
Zolotokolosa / Antonivka	27.8	26.3	23.2	55.5	53.9	55.8	42.9	42.5	163.0
Zolotokolosa / Yednist	69.9	67.1	41.4	74.7	66.2	14.6	34.7	28.0	6.6
Zolotokolosa / Vidrada	53.4	44.3	8.5	62.8	58.3	2.2	45.5	41.7	16.8
Zolotokolosa / Stolychna	38.2	35.5	19.8	64.2	62.3	56.1	59.2	56.9	41.4
Cherniava / Antonivka	47.1	29.2	3.41	-17.7	-30.5	-1.0	-3.1	-16.1	-0.2
Cherniava / Yednist	30.3	14.0	2.1	-6.1	-18.0	-0.4	-1.9	-18.8	-0.09
Cherniava / Vidrada	55.0	30.5	2.0	29.4	5.9	1.3	20.7	1.9	1.1
Cherniava / Stolychna	62.9	12.3	4.3	25.4	4.0	1.2	23.4	7.9	1.6
Shchedra Nyva / Antonivka	48.0	40.9	9.5	-1.6	-8.6	0.2	23.0	15.1	3.4
Shchedra Nyva / Stolychna	-	-	-	58.5	44.3	5.9	45.3	37.5	16.4
Shchedra Nyva / Vidrada	59.2	44.8	6.0	-9.2	-18.6	-0.8	26.4	15.1	2.7
♀ mid-early / ♂ mid-late									
Shchedra Nyva / Dobirna	65.7	56.9	11.8	32.9	27.6	8.3	23.4	0.2	5.4
♀ medium maturing / ♂ medium maturing									
Antonivka / Yednist	27.0	26.5	73.7	44.7	39.0	10.8	42.4	34.9	7.7
Antonivka / Vidrada	65.8	58.2	13.9	24.0	19.5	6.3	36.5	32.5	12.3
Antonivka / Stolychna	67.2	65.9	91.3	51.4	48.3	24.1	45.0	43.3	38.6
Antonivka / Myronivska 61	-	-	-	69.7	70.0	4.2	45.0	42.1	21.9
Myronivska 61 / Yednist	52.6	51.5	72.0	55.9	49.9	13.9	15.2	7.1	2.0
Yednist / Vidrada	62.8	55.6	13.6	62.8	50.8	7.9	36.9	33.4	14.3
♀ medium maturity / ♂ mid-late									
Yednist / Dobirna	64.9	64.7	529.0	38.3	37.9	112.3	8.3	-7.1	0.5
♀ mid-late / ♂ medium maturity									
Vdala / Stolychna	51.7	50.6	69.3	62.3	58.7	27.6	31.7	30.4	31.3
♀ mid-late / ♂ mid-late									
Vdala / Pyvna	–	–	–	122.0	115.7	42.0	33.5	16.4	2.3
Dobirna / Pyvna	81.9	80.8	134.2	62.3	83.3	14.6	0.4	-5.0	0.07

***Note**: Ht – hypothetical heterosis, Htb – true heterosis, hp – degree of dominance, ♀ – maternal form, ♂ – male form*

Stable high manifestation of hypothetical (27.0-75.2%) and true (26.2-70.4%) heterosis in the years of research was determined in Myr. early / Yednist, Kolchuha / Antonivka, Kolchuha / Stolychna, Zolotokolosa / Antonivka, Zolotokolosa / Yednist, Zolotokolosa / Vidrada, Zolotokolosa / Stolychna, Antonivka / Yednist, Antonivka / Stolychna, Yednist / Vidrada, Vdala / Stolychna. A certain level of heterosis does not always allow predicting the emergence of valuable forms in subsequent generations of splitting, since interallelic interactions may occur that are not passed on to descendants. Therefore, it is better to use heterosis with other performance characteristics that yield more efficient selection [36-38].

Analysis of the degree of phenotypic dominance in the years of research indicates that the inheritance of the number of grains from the main ear in most hybrids (85.6%) occurred with positive over-dominance. Intermediate inheritance is typical for 8.3% of cross-breeding combinations. For positive dominance and negative overdomination, inheritance of the trait occurred in the same amount – 4.6%. The least common type of inheritance is negative dominance – 1.5%.

In similar studies for crossing varieties of soft winter wheat of different origin inheritance of the number of grains from the ear in F_1 was followed by partial positive dominance, positive over-dominance, and intermediate Inheritance [39]. During hybridisation of various ecotypes of soft winter wheat under the conditions of the Bilotserkivska Experimental Station, the number of grains from the main ear in 9 out of 10 hybrids was determined by positive over-dominance [40].

The conducted studies demonstrate that the indicator of the degree of phenotypic dominance in F_1 depends on both the selection of hybridisation components and the year conditions. In 2018-2020, positive over-dominance was detected in 26 out of 42 cross-breeding combinations. As a result of the study, hybrids with positive overdomination were identified, which formed a high number of grains in the main ear (55.1-77.4 pcs.), namely: B. Ts. s-d / Antonivka, Zolotokolosa / Cherniava, Zolotokolosa / Stolychna, Cherniava / Stolychna, Shchedra Nyva / Dobirna, Antonivka / Stolychna.

The methods for determining indicators of heterosis and the degree of phenotypic dominance to assess F_1 used in this study are widely used by scientists in the breeding of winter wheat [4; 41], winter rye [42], winter triticale [43], spring barley [44], spring rapeseed [45]. Thus, by attracting to hybridisation, in the conditions of the forest-steppe of Ukraine, varieties of soft winter wheat that differ in precocity, the authors of this study managed to obtain hybrids of the first generation, which in comparison with the parent forms are described by a statistically significantly larger number of grains in the main ear. The analysis of the obtained experimental data allows predicting the influence of pairs selected for hybridisation and hydrothermal conditions of the year on the manifestation of the number of grains in the main ear F_1 and the nature of inheritance of the attribute under study.

CONCLUSIONS

1. The manifestation and variability of the number of grains in the main ear in hybrids of the first generation of soft winter wheat is considerably influenced by both the parent pairs of hybridisation and the year conditions.

2. A significant influence of the genotypes of the parent components of cross-breeding and the year conditions on the indicators of heterosis and the degree of phenotypic dominance in F_1 was established.

3. The most common type of inheritance (85.6%) of the number of grains in the main ear is positive over-dominance.

4. Cross-breeding combinations were singled out, which on average for three years statistically significantly exceeded the average number of grains from hybrids from the main ear: Myr. early / Zolotokolosa, Myr. early / Cherniava, B. Ts. s-d / Cherniava, B. Ts. s-d / Antonivka, Kolchuha / Antonivka, Zolotokolosa / Cherniava, Zolotokolosa / Yednist, Cherniava / Vidrada, Chernyava / Stolychna, Shchedra Nyva / Dobirna, Antonivka / Stolychna, Dobirna / Pyvna.

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Прояв гетерозису і ступеню фенотипового домінування за кількістю зерен з головного колосу при гібридизації різних за скоростиглістю сортів пшениці м'якої озимої

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Анотація. Пшениця (*Triticum aestivum* L.) озима є головною продовольчою культурою світового масштабу, в зростанні і стабілізації врожайності якої вагомим фактором є сортові ресурси. В практичній селекційній роботі важливу роль відіграє різноманітний досконало вивчений вихідний матеріал. Метою досліджень передбачалося визначення гіпотетичного та істинного гетерозису і встановлення характеру успадкування кількості зерен з головного колосу в гібридів пшениці м'якої озимої. У 2018–2020 рр. в умовах дослідного поля науково виробничого центру Білоцерківського НАУ досліджували 45 комбінацій схрещування отриманих від гібридизації різних за тривалістю вегетаційного періоду сортів пшениці м'якої озимої. Для визначення гіпотетичного та істинного гетерозису і ступеню фенотипового домінування за кількістю зерен у головному колосі використовували загальноприйняті методики. Проведені дослідження свідчать, що кількість зерен у колосі головного стебла батьківських компонентів гібридизації обумовлена генотипом та значно піддається впливу гідротермічних умов року. Встановлено вплив материнської цитоплазми на прояв досліджуваної ознаки. Так, за використання в гібридизації ранньостиглих сортів материнською формою найбільша середня по гібридах кількість зерен у головному колосі (63,3 шт.) формувалася у 2019 р. Водночас за використання в гібридизації середньоранніх, середньостиглих і середньопізніх сортів максимальна кількість зерен (64,8 шт.) відмічена в 2018 р. При цьому мінімальну кількість зерен усі гібриди формували у 2020 р. Отримані експериментальні дані свідчать про вплив батьківських генотипів і умов року на показники гетерозису і ступеню фенотипового домінування у гібридів першого покоління. Визначено, що найбільш поширеним типом успадкування (85,6 %) кількості зерен з головного колосу є позитивне наддомінування. Практичну цінність для селекції пшениці м'якої озимої становлять виділені нами комбінації схрещування: Миронівська рання / Золотоколоса, Миронівська рання / Чорнява, Білоцерківська напівкарликова / Чорнява, Білоцерківська напівкарликова / Антонівка, Кольчуга / Антонівка, Золотоколоса / Чорнява, Золотоколоса / Єдність, Чорнява / Відрада, Чорнява / Столична, Щедра нива / Добірна, Антонівка / Столична, Добірна / Пивна, які в мінливих за гідротермічними умовами роки досліджень достовірно перевищували середню по F_1 кількість зерен з головного колосу

Ключові слова: батьківські компоненти схрещування, умови року, успадкування, гібриди, істинний і гіпотетичний гетерозис, ступінь фенотипового домінування