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PECULIARITIES OF INHERITANCE AND TRANSGRESSIVE VARIABILITY OF GRAIN NUMBER IN INTRASPECIFIC HYBRIDISATION OF WINTER BREAD WHEAT

Halyna USTYNOVA[1], Mykola LOZINSKYI[1], Mykola GRABOVSKYI[1], Igor POKOTYLO[1], Yurii FEDORUK[1],Valerii KHAKHULA[1], Oksana LUPITKO[2], Taras PANCHENKO[1], Anatolii ALDOSHYN[2], Vitalina KARAULNA[1], Nataliia PRYSIAZHNIUK[1], Lyudmyla YEZERKOVSKA[1], Yuliia BAZILIEVA[2]

[1]Bila Tserkva National Agrarian University, Sq. Soborna 8/1, 09100, Bila Tserkva, Ukraine, E-mail: ustinovaGL@ukr.net, lozinskk@ukr.net, nikgr1977@gmail.com, pokotuloi@ukr.net, fedoruky_4@ukr.net, valerii.khakhula@gmail.com, panchenko.taras@gmail.com, karaulnav@ukr.net, natasha.prisjazhnjuk@ukr.net, liudmilabc89@gmail.com
[2]State Enterprise Institute of Grain Crops of the National Academy of Agrarian Sciences of Ukraine, St. Volodymyr Vernadsky, 14, 49009, Dnipro, Ukraine, E-mail: tk170@ukr.net, anatoly.aldoshin@gmail.com, tk170@ukr.net

Corresponding author: nikgr1977@gmail.com

Abstract

In 2018-2020, the peculiarities of inheritance of grain number of the main spike in F_1 and transgressive variability in F_2 populations were studied in intraspecific hybridisation of early, medium early and medium late winter wheat (Triticum aestivum L.) varieties. It was found that in 97.5% of the hybrids the inheritance of grain number was based on positive superdominance with modification of phenotypic dominance (hp) depending on the selected hybridisation pairs and the year conditions. The excess of the extreme maximum grain number of the main spike over the parental forms in 18 (2019) and 14 (2020) F_2 populations of 20 crossing combinations with a positive degree of transgression (Td = 4.3-60.0%) and the frequency of breeding valuable recombinants (Tf = 3.3-66.7%) were studied. Positive correlations (r = 0.932; r = 0.977) between the positive degree and the frequency of transgressive recombinants were found to be very strong and close to functional correlations (r = 0.932; r = 0.977). The inclusion of varieties of different vegetation periods in hybridisation contributes to the formation of F_2 populations with the possibility of selecting economically valuable recombinants by the number of grains per main ear.

Key words: *soft winter wheat, number of grains, inheritance in F_1, degree and frequency of transgressions in F_2*

INTRODUCTION

The world's population has reached almost 7.8 billion people and is expected to reach 10 billion by 2050, requiring a significant increase in the amount of food, mainly cereals [24].
Worldwide and in Ukraine, winter wheat (*Triticum aestivum L.*) is one of the most widespread and productive crops [23, 6, 27].
Ukraine is one of the main wheat producers and exporters playing a important role in assuring food security and this is why grain yield need to be increased using high potential hybrids [8]. At the same time, production growth is severely constrained by agro-climatic resources. Under these conditions, predicting changes in wheat yields is important for maintaining global food security [29, 19]. To increase production potential and respond to climate change in a timely manner, increasing resistance to biotic and abiotic environmental factors should remain a priority for wheat genetic improvement [14].
The increase in grain yield and quality is largely due to the effectiveness of wheat breeding. This is achieved through the development and introduction of new varieties that produce high and stable grain yields under stressful growing conditions [3]. Only by cultivating winter wheat varieties that combine high yields with adaptability, can highly productive wheat agrophytocenoses be formed [12, 22].
In modern times, intraspecific hybridisation remains the primary method of generating genetic diversity in wheat [4, 16]. Under

certain conditions, first-generation hybrids may exhibit heterosis, which results in increased adaptability, productivity, viability, and stress resistance compared to their parental forms. It is important to note that this phenomenon only occurs when there is sufficient recombination of parental components [15]. The success of hybridisation relies on selecting appropriate parental pairs for crossing. Knowledge of the variability patterns of economically valuable traits that determine productivity enhances the efficiency of selecting initial forms for crossing and further selecting valuable genotypes in hybrid populations [21].

Improving the efficiency of the breeding process and creating new varieties that meet the required production parameters largely depend on the diversity and study of the source material [13].

The importance of a comprehensive study of the source material has been highlighted by many scientists [9, 16, 22]. The breeding charter experience demonstrates that in numerous instances, changes in breeding are linked to a diverse array of source material [10].

The growth and development of winter wheat are determined by the physiological functions of the genotype and the interaction of the plant organism with the environment. This is primarily due to the dynamics of meteorological conditions and the impact of stress factors of the year. Wheat goes through generative phases during its development, which determine plant productivity [18].

The number of grains in the ear is a crucial element in the structure of wheat yield. It is formed during the IV-IX stages of organogenesis and is determined by pollen fertility during fertilisation [1, 20]. The processes that occur are determined by the genotype and weather conditions during flowering, as well as their interaction. Therefore, the study of grain formation in the ear of hybrids and their descendants has become widely used in wheat breeding practice to increase its adaptive and productive potential [5].

The number of grains in the ear depends on the ear's genetic potential for productivity. The realization of this potential is conditioned by the genotype's reaction to environmental conditions during the formation of the ear, spikelets, flowers, and fertilization [17].

Therefore, it is important to investigate the influence of parental forms and meteorological conditions on the number of grains in the main spike of F1 and F2 populations. This trait is commonly used as a marker by breeders during the selection process to create new source material and wheat varieties, making it a crucial area of research.

The research aimed to determine the characteristics of grain number formation and inheritance in the main ear of F_1 and transgressive variability in F_2 populations resulting from intraspecific hybridisation of early, medium early, medium late, and late winter wheat varieties.

MATERIALS AND METHODS

In 2018-2020, the Research Center of Bila Tserkva National Agrarian University conducted a study on 36 cross combinations in their experimental field. The parental components of hybridisation included early maturing varieties such as Mironovskaya early ripening (Mir. early), Kolchuga and Belotserkovskaya semi-dwarf (B.Ts. s/d.). For mid-early varieties Zolotokolosa (Zolotokol.), Chernyava, and Shchedra niva were used. For medium ripening varieties, Antonovka, Vidrada, Yednist and Stolichna were used. Finally, for medium-late ripening varieties Dobirna and Vdalawere used.Seeds of the original forms, F_1 and F_2 populations, were sown using a manual sowing machine in the following order: mother form, hybrid (F_2 populations), male form. Biometric analysis of the studied material was conducted using an average sample of 25 plants in triplicate [28]. Agricultural technology is commonly used for growing soft winter wheat in the Forest-Steppe region of Ukraine. Its predecessor was mustard for grain.

The arithmetic mean (x) and its error ($\bar{x} \pm S\bar{x}$) were used to estimate the number of grains from the main spike. The range (*min-max*) and coefficient of variation were used to determine the variability (*V, %*) [7]. The coefficient of variation determines the level of variability. If V is less than 10%, the variability is considered insignificant. If V is greater than 10% but less than 20%, the variability is medium. If the coefficient of variation exceeds 20%, the variability is significant.

To determine the degree of phenotypic dominance (hp) the following was used method Griffing (1950) [11]. The data obtained were classified according to Beil & Atkins (1965) [2], positive dominance (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 dominance (depression) –*hp*< –1.

The degree (Td) and frequency (Tf) of positive transgression in F_2 populations were determined by the following method Vasylkivskyi & Kochmarskyi (2016) [26].

Statistical parameters, in particular, correlation coefficients (r) and determination coefficients (r^2_{xy}) were calculated using the Statistica 12.0 software. When determining the strength of the relationship between the traits, the scale r < 0.3 was used: weak relationship between the traits, 0.3 < r < 0.5 – moderate, 0.5 < r < 0.7 – significant, 0.7 < r < 0.9 – strong, r > 0.9 – very strong, close to functional.

RESULTS AND DISCUSSIONS

During the sowing period (last decade of September), the meteorological conditions in 2017-2019 were favourable for the simultaneous germination and growth of soft winter wheat in autumn. The amount of precipitation during the autumn growing season exceeded the long-term average indicators in 2017 (124.1 mm) and 2019 (147.4 mm), and was slightly lower in 2018 (70.3 mm) at 82.5 mm (2018) (Fig. 1).

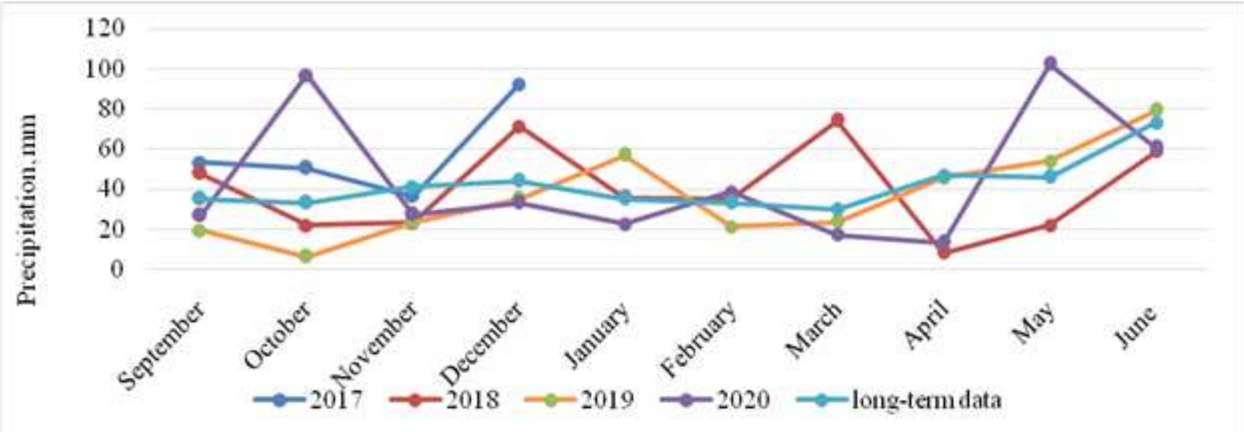

Fig. 1. Distribution of precipitations in 2017-2020, mm
Source: The Bila Tserkva meteorological station [25].

On 20.11 (2017), 12.11 (2018) and 21.11 (2019), the vegetative growth of soft winter wheat ceased, which aided in the successful hardening of the plants. Winter precipitation exceeded the long-term average of 112 mm in 2017/2018 (247.2 mm) and 2018/2019 (172.2 mm), and was slightly lower in 2019/2020 (97.3 mm).

The temperature regime during the winter months also contributed to the successful overwintering of the plants (Fig. 2).

Following the resumption of the growing season in 2018 on 4th April, the temperature regime was characterised by elevated values, which accelerated the growth and development of soft winter wheat. In April, the average monthly temperature was 13.3°C, significantly higher than the long-term average of 8.4°C.

However, the amount of precipitation was significantly below the normal 47 mm, with only 8.1 mm recorded.

The vegetation of soft winter wheat during the recovery period (02.03.2019 - 28.02.2020) occurred over the course of a month, with low average monthly temperatures gradually increasing.

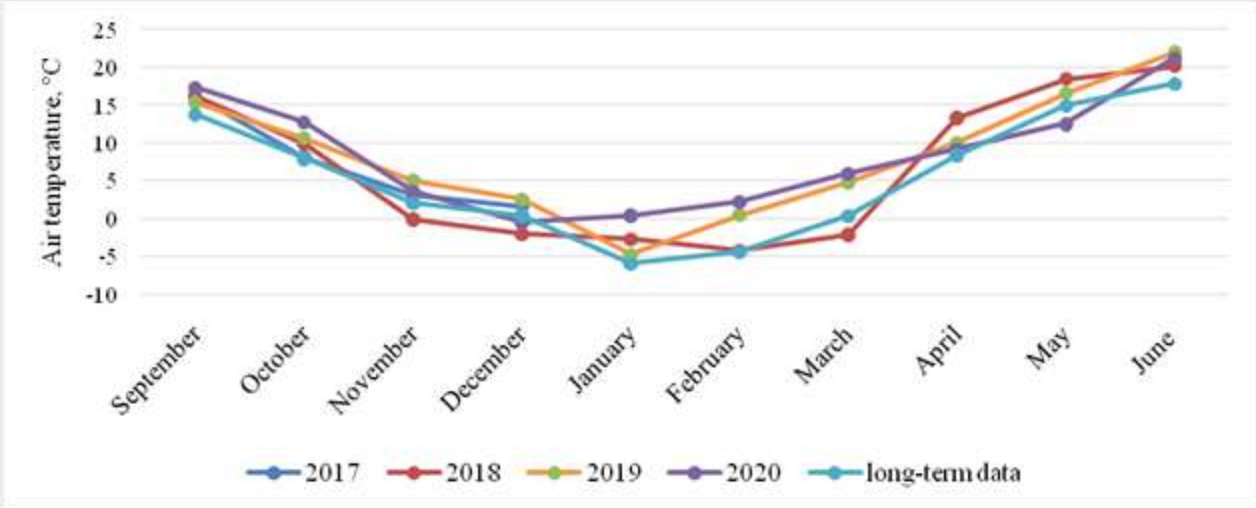

Fig. 2. Temperature regime in 2017-2020, ºC
Source: The Bila Tserkva meteorological station [25].

The precipitation levels in March and the first two decades of April 2019 were significantly lower than the long-term average of 61 mm, with only 23.4 mm and 14.2 mm respectively. In 2020, the precipitation level was even lower, with only 22.7 mm over the same period. However, in the third ten-day period of April 2019, the moisture supply of wheat plants improved with 31.3 mm of precipitation. In contrast, in 2020, the precipitation level was only 7.7 mm, which was lower than the long-term average of 16 mm. The average monthly air temperature in April was 1.6°C above normal in 2019 and 0.8°C in 2020.

In May 2018, the average air temperature was 18.4°C, which exceeded the long-term average of 14.9°C. However, in May 2019, the temperature dropped to 16.6°C, and in 2020 it was even lower at 12.5°C. The amount of precipitation during this period was also noteworthy. In 2019 and 2020, the precipitation exceeded the norm of 46.0 mm, with 54.0 mm and 102.3 mm respectively. In contrast, in 2018, the precipitation was only 22.8 mm.

The meteorological conditions during the research years were characterised by contrasting temperature and precipitation distribution.

These conditions significantly influenced the formation of the number of grains in the main ear of winter wheat. This allowed for a comprehensive assessment of the experimental material.

During the research period, the parental forms were differentiated by the number of grains in the main spike. According to the international classifier of the genus *Triticum* (1986), in 2019, only the medium-early variety Chernyava had more than 55 grains in the ear.A large number of grains of group II (43-55 pcs.) was formed by the medium-late variety Dobirna in 2019 and 2020. Meanwhile, the varieties Mironovskaya early ripening, Kolchuga (early ripe group), Zolotokolosa, Stolichna and Vdalawere observed to have a high number of grains group I (36-42 pcs.) from 2018 to 2020. In 2018 and 2019 the early-ripening variety Belotserkovskaya semi-dwarf had a large number of grains in group I, while in 2020, it had a large number of grains in group II. Similarly, in 2019, the mid-ripening variety Yednist had a large number of grains in group II (Table 1).

In 2018 the average number of grains per genotype (41.4) was significantly exceeded only by the mid-early variety Chernyava (+13.0).

The average number of grains (42.0) in 2019 was significantly higher than the average number of grains (42.0) in 2019 which was significantly higher than Chernyava (+17.0), Yednist (+2.1) and Dobirna (+1.8).

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Table 1. Statistical parameters of the manifestation and variability of the number of grains of the main ear

Variety	2018				2019				2020			
	(x ± S x), pcs.	Lim (pcs.)		V,%	(x ± S x), pcs.	Lim (pcs.)		V,%	(x ± S x), pcs.	Lim (pcs.)		V,%
		min	max			min	max			min	max	
early ripening												
Mir. early.	39.1±0.82	28	55	18.1	39.8±1.60	28	55	20.1	42.3±2.09	30	56	19.2
B.Ts. s/d	37.7±0.91	25	60	18.9	39.5±1.64	27	60	18.6	49.5±1.42	39	58	11.1
Kolchuga	41.8±0.93	21	60	21.4	38.4±1.83	21	60	23.2	38.4±1.68	29	50	16.9
mid-early												
Zolotokolosa	42.4±1.29	26	70	26.3	39.8±2.36	26	65	29.7	37.9±2.14	25	62	21.9
Chernyava	54.4±1.30	34	82	20.7	59.0±2.21	37	82	18.7	52.1±2.71	30	69	20.2
medium-ripening												
Antonovka	41.1±0.94	27	57	19.7	40.6±1.73	28	55	21.3	42.7±1.84	32	57	16.7
Vidrada	37.2±0.73	27	51	17.1	37.6±1.35	27	49	18.0	35.9±2.38	20	51	25.7
Yednist	40.8±1.01	23	67	21.5	44.1±1.88	27	67	21.3	34.1±1.53	27	51	17.3
Stolichna	40.5±0.83	27	58	17.9	38.9±1.37	27	54	17.6	39.0±1.89	30	59	18.1
medium late												
Vdala	39.9±1.00	26	59	21.6	40.7±1.68	26	58	20.7	39.8±2.08	30	57	20.3
Dobirna	40.7±1.15	26	60	24.6	43.8±1.81	29	60	20.6	47.7±2.76	32	70	22.4
LSD (P≤0.05)	1.96	–			1.34	–			1.68	–		

Source: Authors own results.

In 2018-2020 intra-varietal variability in the number of grains of the main spikelet by the coefficient of variation varied from medium to significant. The average coefficient of variation was observed in the early-ripening variety Belotserkovskaya semi-dwarf (11.1-18.9%) and the mid-ripening variety Stolichna (17.6-18.1%) (Table 2).

Table 2. Number of grains, degree of phenotypic dominance, degree and frequency of positive transgressions by number of grains

Crossing combinations	F_1, 2018				F_2, 2019				
	(x ± S x), pcs.	Lim (pcs.)		h_p	(x ± S x), pcs.	Lim (pcs.)		Td, %	Tf, %
		min	max			min	max		
Mir. early/B.Ts. s/d.	63.5±2.95	45	82	35.9	59.2±1.56	43	81	35.0	33.3
Mir. early/Kolchuga	59.5±2.46	39	76	14.1	62.4±1.68	46	81	35.0	53.3
B.Ts. s/d./ Kolchuga	55.6±2.90	44	66	7.7	52.2±1.53	39	72	20.0	16.7
Mir. early/Zolotokol.	63.8±2.19	48	78	14.9	62.4±2.25	42	84	29.2	30.0
Mir. early/ Chernyava	64.9±3.46	59	73	2.4	61.2±1.76	46	89	21.7	26.4
B.Ts. s/d./Zolotokol.	60.2±8.58	29	77	9.0	55.7±1.64	42	72	10.8	16.7
B.Ts. s/d./ Chernyava	76.5±8.23	66	101	3.6	56.7±1.29	44	69	-	-
Kolchuga/ Chernyava	53.6±3.87	39	68	0.9	50.9±1.53	31	64	-	-
Mir. early/Antonovka	53.6±2.50	39	71	13.5	60.6±2.07	40	88	60.0	66.7
Mir. early /Yednist	64.2±3.03	55	73	28.5	53.0±2.57	30	89	32.8	13.3
B.Ts. s/d./ Antonovka	60.1±1.81	43	78	12.2	63.6±1.82	49	83	38.3	50.0
B.Ts. s/d./ Yednist	69.0±4.15	53	91	19.2	66.8±2.42	43	94	25.4	41.4
B.Ts. s/d./ Vidrada	55.4±2.38	38	71	71.8	57.1±1.62	41	75	25.0	33.3
Kolchuga /Antonovka	62.6±3.19	46	79	60.4	60.8±1.63	46	82	36.7	43.3
Kolchuga / Yednist	49.0±2.66	34	68	15.4	67.0±1.44	41	71	6.0	6.7
Kolchuga / Vidrada	51.0±2.99	36	74	5.0	56.4±2.65	32	86	43.3	37.0
Kolchuga / Stolichna	64.8±2.20	53	77	36.4	59.9±1.78	43	83	38.3	40.0
Mir. early / Vdala	69.1±2.35	61	78	74.0	59.2±2.22	42	91	56.9	50.0
Mir. early / Dobirna	63.1±2.85	41	84	29.0	58.7±2.26	41	84	40.0	35.7
B.Ts. s/d./ Dobirna	58.2±2.25	45	75	12.7	56.9±1.74	35	72	20.0	40.0

Source: Authors own results.

Significant variation (20.3-29.7 %) in 2018-2020 was found in medium-late varieties and medium-early Zolotokolosa.

The number of grains of the studied hybrids in 2018 was determined at the level of 49.0-76.5 pcs. and with the exception of Kolchuga/Chornyava, significantly exceeded the indicators of the original parental forms (Table 2).

In 2018 the number of grains on the main spike was higher than the F_1 average (60.9 pcs.) in the following varieties: Belotserkovskaya semi-dwarf /Chernyava (76.5 pcs.), Mironovskaya early ripening/Vdala (69.1

pcs.), Belotserkovskaya semi-dwarf /Ednist (69.0 pcs.), Mironovskaya early ripening/Chernyava (64.9 pcs.), and Kolchuga/Stolichna (64.8 pcs.).

Mironovskaya early ripening yielded the highest number of fruits per plant with an average of 64.2 pieces, followed by Zolotokolosa with 63.8 pieces, Belotserkovskaya semi-dwarf with 63.5 pieces, and Dobirna with 63.1 pieces. Kolchuga and Antonovka had the lowest yield with an average of 62.6 pieces per plant. Based on the data obtained, it can be concluded that most F_1 hybrids produce a large number of grains when crossed with a parental form that has the ability to produce a large or very large number of grains.

With the exception of the Belotserkovskaya semi-dwarf/Zolotokolosa hybrid, which showed partial positive dominance (hp = 0.9) all other hybrids exhibited positive superdominance in determining the number of grains per main ear (hp = 3.6–74.0).

In 2019, the hybrid F_2 populations under study exhibited a significant increase in grain number. In most cases, both the average and maximum values exceeded those of the parental forms, except for Belotserkovskaya semi-dwarf / Chernyava and Kolchuga/ Chernyava. The percentage of positive transgressions in the number of grains in the studied F_2 populations ranged from 6.0% to 60.0% with a recombinant frequency of 6.7% to 66.7%.

High levels of transgression and frequency of economically valuable recombinants were observed in the populations: Belotserkovskaya semi-dwarf / Dobirna (Td = 20.0%; Tf = 40.0%); Belotserkovskaya semi-dwarf / Yednist (Td = 25.4%; Tf = 41.1%); Belotserkovskaya semi-dwarf / Vidrada (Td = 25.0%; Tf = 33. 3 %); Mironovskaya early ripening / Zolotokolosa (Td = 29.2 %; Tf = 30.0 %); Mironovskaya early ripening / Belotserkovskaya semi-dwarf (Td = 35.0 %; Tf = 33.0 %); Mironovskaya early ripening / Kolchuga (Td = 35. 0 %; Tf = 53.3 %); Kolchuga / Antonovka (Td = 36.7 %; Tf = 43.3 %); Kolchuga / Stolichna (Td = 38.3 %; Tf = 40.0 %); Belotserkovskaya semi-dwarf / Antonivka (Td = 38.3 %; Tf = 50.0 %); Mironovskaya early ripening / Dobirna (Td = 40. 0 %; Tf = 35.7 %); Kolchuga / Vidrada (Td = 43.3 %; Tf= 37.0 %); Mironovskaya early ripening / Vdala (Td = 56.9 %; Tf = 50.0 %); Mironovskaya early ripening / Antonovka (Td = 60.0 %; Tf = 66.7 %).

The study found that crossing combinations with a larger number of grains in F1 resulted in higher rates of positive recombinants. Strong positive correlations (r = 0.932±0.035) were observed between the degree and frequency of transgressive recombinants, with a coefficient of determination $r^2_{xy} = 0.869$.

When hybridising different early maturity varieties, the average number of grains in the F1 generation was slightly higher in 2019 (63.6) compared to 2018, with a range of 53.0-72.7 grains (Table 3). It is worth noting that the parental forms also had the highest average number of grains in 2019.

Hybridization was used to determine which varieties exceeded the F1 average (63.6 grains) indicator. The following combinations produced higher yields: Mironovskaya early ripening/Zolotokolosa (72.7), Belotserkovskaya semi-dwarf/Antonivka (69.3), Kolchuga/Antonovka (69.2), Mironovskaya early ripening/Dobirna (69.1), and Belotserkovskaya semi-dwarf/Kolchuga (67).

These hybrids include Mironovskaya early ripening/Vdala (67.5 pcs), Mironovskaya early ripening/Chernyava (67.0 pcs), Mironovskaya early ripening/Antonovka (65.7 pcs), Belotserkovskaya semi-dwarf/Dobirna (64.9 pcs.), and Belotserkovskaya semi-dwarf / Vidrada (63.7 pcs.).

In 2019, the average F_1 values of five hybrids selected based on the number of grains in 2018 were exceeded. It indicates a successful selection of hybridization parent pairs.

Analysing the indicators of the degree of phenotypic dominance of F1 in 2019, it was found that all the obtained hybrids determined the number of grains per main ear by positive superdominance (hp = 1.1-1644.0).

Table 3. Number of grains, degree of phenotypic dominance, degree and frequency of positive transgressions by number of grains

Crossing combinations	F1, 2019				F2, 2020				
	(x ± Sx), pcs.	Lim (pcs.)		h_p	(x ± Sx), pcs.	Lim (pcs.)		Td, %	Tf, %
		min	max			min	max		
Mir. early/B.Ts. s/d.	61.8±3.43	48	75	147.7	50.9±1.63	32	71	22.4	20.0
Mir. early/Kolchuga	61.3±3.36	53	76	31.7	47.3±2.09	18	64	14.3	17.2
B.Ts. s/d./ Kolchuga	67.8±2.39	64	74	52.5	50.4±1.22	34	62	6.9	13.3
Mir. early/Zolotokol.	72.7±2.85	51	86	1644.0	49.9±1.43	39	68	9.7	10.0
Mir. early/ Chernyava	67.0±3.08	59	85	1.8	56.3±2.47	39	85	23.2	16.7
B.Ts. s/d./Zolotokol.	59.2±2.49	42	76	130.3	53.3±1.48	35	69	11.3	13.3
B.Ts. s/d./ Chernyava	60.2±3.07	50	73	1.1	40.8±1.72	31	59	-	-
Kolchuga/ Chernyava	60.8±3.33	54	69	1.2	39.3±1.16	28	58	-	-
Mir. early/Antonovka	65.7±3.17	40	94	63.8	44.6±1.09	35	56	-	-
Mir. early /Yednist	62.0±3.77	40	93	9.3	50.1±1.28	39	70	25.0	16.7
B.Ts. s/d./ Antonovka	69.3±2.26	50	81	53.2	45.2±1.35	30	65	12.1	6.7
B.Ts. s/d./ Yednist	58.3±3.05	40	67	7.2	42.1±0.96	28	51	-	-
B.Ts. s/d./ Vidrada	63.7±1.54	54	72	26.5	41.5±1.07	30	52	-	-
Kolchuga /Antonovka	69.2±3.39	53	87	27.0	47.3±1.55	28	65	14.0	6.7
Kolchuga / Yednist	55.9±3.61	38	76	5.1	52.9±1.28	40	67	31.4	53.3
Kolchuga / Vidrada	53.0±2.57	35	72	37.5	43.2±1.08	28	55	7.8	6.7
Kolchuga / Stolichna	62.9±3.84	38	89	97.0	51.7±1.55	35	72	22.0	16.7
Mir. early / Vdala	67.5±3.28	50	86	60.6	60.5±1.59	46	74	29.8	56.7
Mir. early / Dobirna	69.1±3.98	59	87	13.7	50.1±1.46	35	69	-	-
B.Ts. s/d./ Dobirna	64.9±3.80	40	80	10.8	50.6±1.54	33	73	4.3	3.3

Source: Authors own results.

In 2020, 14 out of 20 F_2 populations exhibited a positive degree (4.3-31.4%) with a frequency of upcrossing of breeding valuable recombinants ranging from 3.3% to 56.7%. With the exception of Belotserkovskaya semi-dwarf/Chernyava, Kolchuga/Chernyava, as well as Mironovskaya early ripening/Antonovka, Belotserkovskaya semi-dwarf/Yednist, Belotserkovskaya semi-dwarf/Vidrada, Mironovskaya early ripening /Dobirna, the majority of populations exceeded the corresponding values of the parental forms in terms of the extreme maximum number of grains.

In 2019, high indicators of the degree and frequency of transgressions were noted in the populations of Mironovskaya early ripening/Vdala (Td = 29.8%; Tf = 56.7%), Mironovskaya early ripening/Belotserkovskaya semi-dwarf (Td = 22.4%; Tf = 20.0%) and Kolchuga/Yednist (Td = 31.4%; Tf = 53.3%).

In 2020, a study found very strong positive correlations (r = 0.977±0.036) between the degree and frequency of transgressions. The study also established a coefficient of determination (r^2_{xy} = 0.955) to measure these correlations objectively.

CONCLUSIONS

In crossing combinations where one of the components is a parental form capable of producing a large number of grains, most F_1 forms a large number of grains. It is important to note that this statement is based on objective evidence and does not contain any subjective evaluations.

In hybridisation of early, medium early, medium late varieties of winter bread wheat, the inheritance of the number of grains on the main spike in F1 was predominantly positive dominance (97.5%), with variations in the phenotypic dominance index depending on the crossing components and meteorological conditions of the year.

In most F_2 populations, higher rates of positive recombinants were observed in crossing combinations that produced a larger number of grains in F_1.

The involvement of varieties with different vegetation periods in hybridisation contributes to the formation of F_2 populations, allowing for the selection of economically valuable recombinants based on the number of grains per main ear.

In 32 out of 40 F_2 populations in 2019 and 2020, the number of grains per main ear showed a

positive degree of transgression (Td= 4.3-60.0%) with a recombinant frequency of 3.3-66.7%.
Strong positive correlations (r = 0.932; r = 0.977) were found between the positive degree and the frequency of transgressive recombinants, indicating a close to functional relationship (r = 0.932; r = 0.977).

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