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INHERITANCE OF FODDER AND SEED PRODUCTIVITY CHARACTERISTICS BY F_1 WINTER TRITICALE HYBRIDS

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Heterosis and inheritance of fodder and seed productivity characteristics by F_1 winter triticale hybrids in 20 combinations from crossing 9 parents were determined. Noticeable differences were observed in the studied productivity parameters between reciprocal hybrids, indicating the female form's cytoplasm's role. Complete, partial and intermediate inheritance of the traits was noted. Hybrid combinations with a strong heterosis effect were identified. Directions of selections for certain combinations were outlined.

Key words: *inheritance, winter triticale, hybrid, reciprocal crossing.*

Introduction. Economic realities, climatic changes and deterioration of the natural environment force us to develop new ways of the agricultural production development in Ukraine. In the coming years, scientific institutions plan to create state-of-art high-yielding varieties and hybrids of field crops that would resist climatic changes and realize 70-75% of their genetic potentials under industrial conditions [1]. Genetic-breeding improvement of varieties is an effective method to increase yield, resistance to abiotic and biotic factors of the environment, and energy efficiency of agricultural crops [2, 3]. Several studies established associations between expression of traits in early hybrid generations and frequency of emergence of valuable breeding forms in later generations, that is, it is an opportunity to predict further breeding results [4].

Literature Review and Objectives Setting. The need to create new starting materials with a set of valuable traits determines the annual need for a large number of crossings combinations. Hybrids are usually of unequal breeding value, which means great work with hybrids of subsequent generations. Therefore, it is necessary to develop methodical approaches to assessment and prediction of hybrids' breeding value in early generations [5]. Knowing the inheritance of traits by F_1, breeders can obtain the most complete information about genetic characteristics of varieties and prospects of their use in breeding [6, 7]. Phenotypic dominance is studied in many crops, including triticale. Studies of this indicator confirm that it is possible to use it for selection of crossing pairs and for express assessments of hybrid offspring [8].

Over the past decade, triticale has become a promising high-yielding cereal. Its areas are growing; the search for effective breeding methods and technologies for growing and processing triticale grain for various industries has intensified [9, 10]. Currently, hexaploid triticale breeding is developing rapidly; it is primarily aimed at increasing the stability of grain production, improving grain quality, enhancing winter hardiness and preserving adaptability of varieties [11].

A lot of breeders think that solving the current challenges of triticale breeding in the near future requires a wider use of heterosis [12]. It was proven that heterosis could be successfully used to increase yield and some indicators of grain quality [13]. Basing on recent experimental data from biology, one can assert that heterosis should be considered as a result of a complex action of genetic and physiological factors in a hybrid organism. This became the basis of our research.

Purpose and Objectives. To characterize the inheritance of fodder and seed productivity characteristics by F_1 winter triticale hybrids from reciprocal crossings. To select promising F_1 combinations that show strong heterosis in three or more performance traits.

Material and Methods. The study was carried out at the Department of Fodder, Grain and Technical Crops Breeding of the Institute of Fodder and Agriculture of Podillia of NAAS in 2021 and 2022. Winter triticale (*Triticosecale* Witt.) was sown in a seven-field breeding crop rotation, with white mustard as a forecrop. The farming techniques were traditional for the forest-steppe.

Parents and F_1 were sown in a hybrid nursery using a manual marker; the interrow distance was was 30 cm; the interplant distance in the rows was 10 cm [14].

Nine winter triticale varieties of different eco-geographical origins served as the starting material for direct and reverse crossings: Bozhych, Buzhanske, and Pavlodarskyi originating from Ukraine; Tornado, Khleborob, Soyuz, Sergiy, and Sibirskiy from Russia; and NTH 1933 from China.

The heterosis degree was determined according to Matzinger et al. [15] and S. Fonseca, F. Patterson [16].

Ht (%) = $(F_1 – MP) / MP \times 100$,

Hbt (%) = $(F_1 – BP) / BP \times 100$,

where: F_1 - mean trait value in the hybrid;

MP - mean trait value in both parents;

BP - mean trait value in the better parent.

Average heterosis (Ht) it is the heterosis where F_1 is superior to the mean of two parents [17]. Heterobeltiosis (Hbt) shows superiority of F_1 over the better parent and allows for assessment of the hybrid's breeding value [18].

To study the inheritance and interaction of genes, we determined the degree of phenotypic dominance (hp), using B. Griffing's formula [19]:

$hp = (F_1 – MP) / (BP – MP)$,

where: F_1 - mean trait value in the hybrid;

MP - mean trait value in both parents;

BP - mean trait value in the better parent.

Data was grouped according to G. M. Beil and R. E. Atkins's classification [20]: positive overdominance (hp > +1), positive dominance (+0.5 < hp ≤ + 1), intermediate inheritance (-0.5 ≤ hp ≤ 0, 5), negative dominance (-1 ≤ hp < -0.5), negative overdominance (hp < -1).

For better characterization of the weather, Selyaninov's hydrothermal coefficient (HTC) was calculated as follows [21]:

HTC=Σp•10/Σt,

where Σp - precipitation sum for the period with an air temperature of above 10°C;

Σt - sum of above 10°C temperatures for the same period.

The lower the HTC is, the drier the period is.

HTC < 0.4 – very severe drought;

HTC = 0.4 - 0.5 – severe drought;

HTC = 0.5 - 0.6 – moderate drought;

HTC = 0.7 - 0.9 – mild drought;

HTC = 1.0 - 1.5 – sufficiently wet;

HTC > 1.6 – waterlogged.

For a more detailed description of the vegetation period of winter triticale plants (2022), the hydrothermal coefficient was calculated by month (Table 1).

The weather during the spring-summer periods differed between the study years. The HTC fluctuated from 0.49 (severe drought) in June to 1.3 (sufficiently wet) in July.

For the winter triticale plant development in spring, the hydrothermal profile in April and the average temperature in May are of great importance, because it is during this period vegetative mass intensively grows and plants transit from vegetative to reproductive development [22]. In our study, the April HTC was 0.73 (mild drought) and the average air temperature in May was 14.2°C. These conditions slowed down the growth and development of triticale plants.

Table 1

Average air temperature, precipitation amount, active temperature sum and hydrothermal coefficient in April–July, 2022

Indicator	April	May	June	July
Average air temperature, °C	7.6	14.2	19.9	19.6
Precipitation amount, mm	10.5	34.3	29.5	81
Active (> 10°C) temperature sum	142.9	435.6	596.2	621.3
Selyaninov's hydrothermal coefficient	0.73	0.79	0.49	1.30

Water deficit (HTC = 0.79) during the earing-anthesis (May) of winter triticale plants directly affected the kernel number per spike, and high temperature negatively affected the performance due to decreased growth intensity and early death of lower leaves. During kernel filling (June), a small amount of precipitation (HTC = 0.49) and high temperature led to a decrease in the thousand kernel weight. During the first 10 days of July, winter triticale was harvested under fairly favorable weather conditions. The high HTC in July (1.3) was caused by abundant precipitation from July 10 to July 31.

Results and Discussion. Breeding for performance cannot be based on one indicator; thus, it is important to know optimal parameters for all features and traits. Correct evaluation of contributions of individual constituents of the performance to yield helps breeders achieve the set goal [23].

Productive tillering capacity is one of the most important elements of the yield: it is determined both by heredity and environmental factors [24–26]. In our study, parental varieties differed in the number of productive stems. The maximum number was recorded for Khleborob (8.1±1.1), and the minimum – for Sibirskiy (6.1±1.1). In F_1 winter triticale hybrids, the maximum value of the "productive tillering capacity" trait was noted in two combinations: NTH 1933 / Khleborob (8.40±1.9) derived from backcrossing of its parents and Khleborob / Pavlodarskyi (8.40± 1.8) derived from direct crossing. The minimum value of this trait was seen in Buzhanske / Pavlodarskyi hybrid (5.50±1.5) derived from direct crossing; in the female form had fewer productive stems than the male form (Table 2).

Analysis of inheritance in F_1 hybrids showed that the productive tillering capacity was inherited by different types (Table 2), with negative overdominance (55%) and heterosis (20%) prevailing. Our results disagreed with M.V. Lozinska's results on productive tillering in winter bread wheat. According to her data, positive overdominance, which was observed in 95.1% of hybrids, was the most common type of inheritance. At the same time, the phenotypic dominance of this trait in the study years was determined by hybridization components and year's conditions [27]. This may be caused by differences in the productive tillering between cereal species as well as by genetic differences between the studied materials and development rates of the selected varieties in autumn and spring.

We noted high coefficients of average heterosis and heterobeltiosis in the following combinations: Khleborob / Pavlodarskyi (hp = 4.0; Ht = 5.0; Hbt = 3.7), Bozhych / NTH 1933 (hp = 7.0; Ht = 14 ,9; Hbt = 12.5), NTH 1933 / Khleborob (hp = 1.7; Ht = 9.8; Hbt = 3.7), and NTH 1933 / Bozhych (hp = 5.7; Ht = 12.1 ; Hbt = 9.7), which, together with considerable productive tillering in F_1 hybrids, corresponds to overdominance caused by interactions of allelic and non-allelic genes. Due to intra-allelic interactions of genes functioning in a heterozygous state only, selection of genotypes in early hybrid generations may be ineffective. However, there is a high probability of identification of transgressions of increased tillering in later hybrid generations.

A combination with positive dominance, Khleborob / NTH 1933 (hp = 0.6; Ht = 3.3%; Hbt = -2.5%), is worth of special attention for selection of genotypes that would have increased tillering capacity. Combinations with negative overdominance (depression) are of little value in breeding for enhanced tillering.

Spike length is an important constituent of its performance. Spike length can be changed under the influence of environmental factors and farming techniques, but relative differences in this characteristic remain in the same under identical agro-ecological conditions. Therefore, it can be used for genotype identification [28].

Table 2

Expression and variability of the "productive tillering capacity" train in F_1 winter triticale hybrids, 2022

Hybrid combination	Productive tillering capacity			Ht, %	Hbt, %	hp
	P_1	F_1	P_2			
Khleborob / NTH 1933	8.1±1.1	7.9±1.7	7.2±1.0	3.3	-2.5	0.6
NTH 1933 / Khleborob	7.2±1.0	8.4±1.9	8.1±1.1	9.8	3.7	1.7
NTH 1933 / Pavlodarskyi	7.2±1.0	5.9±1.1	7.9±1.3	-21.9	-25.3	-4.7
Pavlodarskyi / NTH 1933	7.9±1.3	7.0±1.3	7.2±1.0	-7.3	-11.4	-1.6
Khleborob / Pavlodarskyi	8.1±1.1	8.4±1.8	7.9±1.3	5.0	3.7	4.0
Pavlodarskyi / Khleborob	7.9±1.3	7.3±2.3	8.1±1.1	-8.8	-9.9	-7.0
Bozhych / NTH 1933	6.9±1.1	8.1±2.4	7.2±1.0	14.9	12.5	7.0
NTH 1933 / Bozhych	7.2±1.0	7.9±2.0	6.9±1.1	12.1	9.7	5.7
Sergiy / Pavlodarskyi	7.3±1.1	6.4±1.0	7.9±1.3	-15.8	-19.0	-4.0
Pavlodarskyi / Sergiy	7.9±1.3	6.9±2.1	7.3±1.1	-9.2	-12.7	-2.3
Pavlodarskyi / Bozhych	7.9±1.3	6.3±0.8	6.9±1.1	-14.9	-20.3	-2.2
Bozhych / Pavlodarskyi	6.9±1.1	7.4±1.6	7.9±1.3	0.0	-6.3	0.0
Pavlodarskyi / Sibirskiy	7.9±1.3	6.6±1.3	6.1±1.1	-5.7	-16.5	-0.4
Sibirskiy / Pavlodarskyi	6.1±1.1	6.9±1.4	7.9±1.3	-1.4	-12.7	-0.1
Pavlodarskyi / Tornado	7.9±1.3	5.6±0.7	7.5±0.8	-27.3	-29.1	-10.5
Tornado / Pavlodarskyi	7.5±0.8	5.8±0.5	7.9±1.3	-24.7	-26.6	-9.5
Soyuz / Pavlodarskyi	6.9±0.8	5.6±0.7	7.9±1.3	-24.3	-29.1	-3.6
Pavlodarskyi / Soyuz	7.9±1.3	6.9±1.9	6.9±0.8	-6.8	-12.7	-1.0
Buzhanske / Pavlodarskyi	6.7±1.3	5.5±1.5	7.9±1.3	-24.7	-30.4	-3.0
Pavlodarskyi / Buzhanske	7.9±1.3	6.6±1.8	6.7±1.3	-9.6	-16.5	-1.2

Note: P_1 – female form, P_2 – male form, F_1 – hybrid, Ht – average heterosis, Hbt – heterobeltiosis, hp – phenotypic dominance

Serhiy (12.5 cm), Tornado (12.2 cm), and Buzhanske (11.9 cm) varieties as well as Pavlodarskyi / Tornado (12.4 cm), Tornado / Pavlodarskyi (12.1 cm), and NTH 1933 / Bozhych (12.1 cm) combinations had the longest spikes. Bozhich / NTH 1933 hybrid had the shortest spikes (9.85±0.6 cm) (Table 3).

A 2016–2021 study at the Institute of Irrigated Agriculture of NAAS showed that irrigated F_1 winter wheat hybrids inherited the "spike length" trait mainly by intermediate type and dominance of shorter length [29]. N.S. Dubovyk investigated the inheritance of the primary spike length by 30 F_1 *Triticum aestivum* L. hybrids originated from varieties – carriers of wheat-rye translocations 1AL.1RS and 1BL.1RS. They reported that this trait was inherited by overdominance in eight hybrids (26.7%), by partial positive dominance in three hybrids (10.0%), by intermediate inheritance in seven hybrids (23.3%), by partially negative inheritance in one hybrid (3.3%), and by depression in 11 hybrids (36.7%) [30]. Analyzing F_1 winter wheat reciprocal hybrids, M.V. Lozinskyi discovered a complex nature of genetic determination of the primary spike length. The dominance degree (hp) ranged from -0.6 (negative dominance) to 6.0

(positive overdominance) [31]. R.V. Kryvoruchenko also found a significant differentiation between F_1 hybrids for the "spike length" trait. Inheritance of this trait in combinations was characterized by strong dominance of the worse parent and weak heterobeltiosis (-20%). Depression was observed in five combinations, which may indicate close relatedness of the original parental forms for this trait [5]. Our data on winter triticale demonstrated that the spike length inheritance by F_1 hybrids had a wide spectrum: 10% of hybrid combinations showed positive overdominance (heterosis), 25% – positive dominance, 35% – intermediate inheritance, 15% – negative dominance, and 20% – negative overdominance (depression). This is attributed to different geographical and genetic origins of varieties selected for crossing.

Table 3

Expression and variability of the "spike length" trait in F_1 winter triticale hybrids, 2022

Hybrid combination	Spike length, cm			Ht, %	Hbt, %	hp
	P_1	F_1	P_2			
Khleborob / NTH 1933	10.0±0.5	10.0±0.8	10.4±1.4	-2.0	-3.8	-1.0
NTH 1933 / Khleborob	10.4±1.4	10.4±0.8	10.0±0.5	2.0	0.0	1.0
NTH 1933 / Pavlodarskyi	10.4±1.4	11.0±0.8	11.3±0.8	1.4	-2.7	0.3
Pavlodarskyi / NTH 1933	11.3±0.8	11.0±1.2	10.4±1.4	1.4	-2.7	0.3
Khleborob / Pavlodarskyi	10.0±0.5	11.0±1.2	11.3±0.8	3.3	-2.7	0.5
Pavlodarskyi / Khleborob	11.3±0.8	10.5±0.9	10.0±0.5	-1.4	-7.1	-0.2
Bozhych / NTH 1933	11.0±0.4	9.8±0.6	10.4±1.4	-7.5	-10.0	-2.7
NTH 1933 / Bozhych	10.4±1.4	12.1±0.9	11.0±0.4	13.1	10.0	4.7
Sergiy / Pavlodarskyi	12.5±0.6	11.5±0.9	11.3±0.8	-3.4	-8.0	-0.7
Pavlodarskyi / Sergiy	11.3±0.8	11.6±1.2	12.5±0.6	-2.5	-7.2	-0.5
Pavlodarskyi / Bozhych	11.3±0.8	11.1±0.6	11.0±0.4	-0.4	-1.8	-0.3
Bozhych / Pavlodarskyi	11.0±0.4	11.3±0.7	11.3±0.8	1.3	0.0	1.0
Pavlodarskyi / Sibirskiy	11.3±0.8	11.2±0.8	11.4±0.7	-1.3	-1.8	-3.0
Sibirskiy / Pavlodarskyi	11.4±0.7	11.4±0.5	11.3±0.8	0.4	0.0	1.0
Pavlodarskyi / Tornado	11.3±0.8	12.4±1.1	12.2±1.0	5.5	1.6	1.4
Tornado / Pavlodarskyi	12.2±1.0	12.1±0.9	11.3±0.8	3.0	-0.8	0.8
Soyuz / Pavlodarskyi	10.2±0.9	10.3±0.8	11.3±0.8	-4.2	-8.8	-0.8
Pavlodarskyi / Soyuz	11.3±0.8	11.2±1.2	10.2±0.9	4.2	-0.9	0.8
Buzhanske / Pavlodarskyi	11.9±0.8	10.9±0.8	11.3±0.8	-6.0	-8.4	-2.3
Pavlodarskyi / Buzhanske	11.3±0.8	11.0±0.9	11.9±0.8	-5.2	-7.6	-2.0

Note: P_1 – female form, P_2 – male form, F_1 – hybrid, Ht – average heterosis, Hbt – heterobeltiosis, hp – phenotypic dominance

Positive overdominance (heterosis) of the spike length was highly manifested in a direct hybrid combination (Pavlodarskyi / Tornado (hp = 1.4; Ht = 5.5%; Hbt = 1.6%)) and in a reciprocal one (NTH 1933 / Bozhych (hp = 4 .7, Ht = 13.1%, Hbt = 10.0%)). Positive dominance was noted in five reciprocal combinations: NTH 1933 / Khleborob (hp = 1.0; Ht = 2.0%; Hbt = 0.0%), Bozhych / Pavlodarskyi (hp = 1.0; Ht = 1, 3 %; Hbt = 0.0 %), Sibirskiy / Pavlodarskyi (hp = 1.0; Ht = 0.4 %; Hbt = 0.0 %), Tornado / Pavlodarskyi (hp = 0.8; Ht = 3, 0%; Hbt = -0.8%), and Pavlodarskyi / Soyuz (hp = 0.8; Ht = 4.2%; Hbt = -0.9%). The female cytoplasm's contribution to this trait was apparent in the following combinations: NTH 1933 / Khleborob, Sibirskiy / Pavlodarskyi, Tornado / Pavlodarskyi, and Pavlodarskyi / Soyuz. The selected hybrid combinations are valuable to generate winter triticale plants with long spikes, especially in those cases where the spike elongation is associated with an increased number of spikelets per spike, as a result, kernel number per spike.

The kernel number per spike is an important element yield in spiked cereals, significantly affecting the grain productivity. This trait is controlled by many genes, the action and interaction of which are considerably modified by environmental conditions [32].

The maximum number of kernels per spike was noted for Soyuz (80), Bozhych (78), and Sibirskiy (75). Among the hybrid combinations, the maximum number of kernels per spike was recorded for Pavlodarskyi / Sergiy (56±8.4) derived from backcrossing of its parents; the minimum – for Khleborob / NTH 1933 (45±5.6) (direct crossing) (Table 4).

Table 4

Expression and variability of the "kernel number per spike" trait in F_1 winter triticale hybrids, 2022

Hybrid combination	Kernel number per spike			Ht, %	Hbt, %	hp
	P_1	F_1	P_2			
Khleborob / NTH 1933	62±7.8	45±5.6	68±13.7	-30.8	-33.8	-6.7
NTH 1933 / Khleborob	68±13.7	49±6.4	62±7.8	-24.6	-27.9	-5.3
NTH 1933 / Pavlodarskyi	68±13.7	49±6.1	56±8.4	-21.0	-27.9	-2.2
Pavlodarskyi / NTH 1933	56±8.4	55±10.9	68±13.7	-11.3	-19.1	-1.2
Khleborob / Pavlodarskyi	62±7.8	45±7.1	56±8.4	-23.7	-27.4	-4.7
Pavlodarskyi / Khleborob	56±8.4	46±7.9	62±7.8	-22.0	-25.8	-4.3
Bozhych / NTH 1933	78±6.4	46±9.9	68±13.7	-37.0	-41.0	-5.4
NTH 1933 / Bozhych	68±13.7	62±9.2	78±6.4	-15.1	-20.5	-2.2
Sergiy / Pavlodarskyi	65±13.9	56±6.5	56±8.4	-7.4	-13.8	-1.0
Pavlodarskyi / Sergiy	56±8.4	66±4.1	65±13.9	9.1	1.5	1.2
Pavlodarskyi / Bozhych	56±8.4	51±4.4	78±6.4	-23.9	-34.6	-1.5
Bozhych / Pavlodarskyi	78±6.4	56±5.1	56±8.4	-16.4	-28.2	-1.0
Pavlodarskyi / Sibirskiy	56±8.4	59±6.8	75±5.5	-9.9	-21.3	-0.7
Sibirskiy / Pavlodarskyi	75±5.5	64±7.3	56±8.4	-2.3	-14.7	-0.2
Pavlodarskyi / Tornado	56±8.4	59±5.3	66±12.3	-3.3	-10.6	-0.4
Tornado / Pavlodarskyi	66±12.3	62±7.0	56±8.4	1.6	-6.1	0.2
Soyuz / Pavlodarskyi	80±8.6	60±13.1	56±8.4	-11.8	-25.0	-0.7
Pavlodarskyi / Soyuz	56±8.4	68±3.5	80±8.6	0.0	-15.0	0.0
Buzhanske / Pavlodarskyi	66±7.3	66±15.6	56±8.4	8.2	0.0	1.0
Pavlodarskyi / Buzhanske	56±8.4	61±18.5	66±7.3	0.0	-7.6	0.0

Note: P_1 – female form, P_2 – male form, F_1 – hybrid, Ht – average heterosis, Hbt – heterobeltiosis, hp – phenotypic dominance

The "kernel number per spike" trait was inherited mainly by depression (45%) and intermediate type (25%). R.V. Kryvoruchenko showed that the kernel number per spike was directly related to the kernel number per spikelet and spikelet number per spike. Since weak heterosis was observed for these traits, depression for the "kernel number per spike" trait was noted in almost all crossing combinations – 78.6% [5].

Heterosis was manifested in the Pavlodarskyi / Serhiy hybrid (hp = 1.1; Ht = 8.3%; Hbt = 0.8%) derived from backcrossing of its parents. Positive dominance was detected in a direct combination, Buzhanske / Pavlodarskyi (hp = 1.0; Ht = 8.2%; Hbt = 0.0%). Buzhanske / Pavlodarskyi hybrid had a greater number of kernels per spike in the case when the female form had more kernels per spike than the male form, which indicating the female cytoplasm's influence on this characteristic.

It should be noted that the Pavlodarskyi / Serhiy and Buzhanske / Pavlodarskyi hybrid combinations inherited spike length by depression. That is, it is possible to select winter triticale plants with relatively short spikes but with increased numbers of kernels among the distinguished hybrid combinations.

Kernel weight per spike, an important element of yield and a complex indicator characterizing both the weight of a single kernel and the total number of kernels in a spike, is of great interest to every breeder [33, 34].

In our study, the maximum weight of kernels per spike was recorded for NTH 1933 (4.40 g), Bozhych (4.15 g), and Sibirskiy (4.06 g) varieties. The maximum weight of kernels per spike was noted in a reverse combination, Pavlodarskyi / Soyuz (4.44±0.7); the minimum – in Khleborob / NTH 1933 (2.88±0.4), a combination derived from direct crossing of its parents (Table 5).

Table 5

Expression and variability of the "kernel weight per spike" trait in F_1 winter triticale hybrids, 2022

Hybrid combination	Kernel weight per spike, g			Ht, %	Hbt, %	hp
	P_1	F_1	P_2			
Khleborob / NTH 1933	3.75±0.5	2.88±0.4	4.40±1.1	-29.3	-34.5	-3.7
NTH 1933 / Khleborob	4.40±1.1	3.25±0.6	3.75±0.5	-20.2	-26.1	-2.5
NTH 1933 / Pavlodarskyi	4.40±1.1	3.22±0.5	3.84±0.7	-21.8	-26.8	-3.2
Pavlodarskyi / NTH 1933	3.84±0.7	3.81±0.6	4.40±1.1	-7.5	-13.4	-1.1
Khleborob / Pavlodarskyi	3.75±0.5	3.52±0.6	3.84±0.7	-7.2	-8.3	-6.1
Pavlodarskyi / Khleborob	3.84±0.7	3.28±0.7	3.75±0.5	-13.6	-14.6	-11.4
Bozhych / NTH 1933	4.15±0.5	3.22±0.7	4.40±1.1	-24.7	-26.8	-8.4
NTH 1933 / Bozhych	4.40±1.1	4.42±1.0	4.15±0.5	3.4	0.5	1.2
Sergiy / Pavlodarskyi	3.57±0.9	3.94±0.7	3.84±0.7	6.3	2.6	1.7
Pavlodarskyi / Sergiy	3.84±0.7	4.54±1.2	3.57±0.9	22.5	18.2	6.2
Pavlodarskyi / Bozhych	3.84±0.7	3.66±0.5	4.15±0.5	-8.4	-11.8	-2.2
Bozhych / Pavlodarskyi	4.15±0.5	3.72±0.6	3.84±0.7	-6.9	-10.4	-1.8
Pavlodarskyi / Sibirskiy	3.84±0.7	3.71±0.4	4.06±0.3	-6.1	-8.6	-2.2
Sibirskiy / Pavlodarskyi	4.06±0.3	4.26±0.6	3.84±0.7	7.8	4.9	2.8
Pavlodarskyi / Tornado	3.84±0.7	3.71±0.4	3.60±0.8	-0.3	-3.4	-0.1
Tornado / Pavlodarskyi	3.60±0.8	3.86±0.6	3.84±0.7	3.8	0.5	1.2
Soyuz / Pavlodarskyi	4.28±0.5	3.64±0.9	3.84±0.7	-10.3	-15.0	-1.9
Pavlodarskyi / Soyuz	3.84±0.7	4.44±0.7	4.28±0.5	9.4	3.7	1.7
Buzhanske / Pavlodarskyi	3.67±0.6	3.68±0.9	3.84±0.7	-2.0	-4.2	-0.9
Pavlodarskyi / Buzhanske	3.84±0.7	3.60±1.4	3.67±0.6	-4.1	-6.2	-1.8

Note: P_1 – female form, P_2 – male form, F_1 – hybrid, Ht – average heterosis, Hbt – heterobeltiosis, hp – phenotypic dominance

The "kernel weight per spike" trait was inherited mainly by negative overdominance (60%) and heterosis (30%). According to M.V. Lozinskyi data, the prevailing type of inheritance of the "kernel weight from the primary spike" trait by F_1 winter bread wheat was positive overdominance (in 82.5% of hybrids) [35]. A. K. Niniieva indicated that spring spelt

(*T. spelta* L.) / spring bread wheat hybrids more often inherited spike performance traits by hybrid depression, less often – by incomplete dominance [4]. R.V. Kryvoruchenko revealed that 35.7% of hybrids inherited the “kernel weight per spike” trait by complete dominance of the worse parent; 21.4% – by intermediate inheritance, and 21.4% - by depression. The author thought that paucity of heterotic hybrids might be associated with strong dominance of the worse parent form and a low percentage of heterobeltiosis for the "spikelete number per spike" trait [5].

Positive overdominance and prominent heterosis for the “kernel weight per spike” trait was noted in one direct combination (Serhiy / Pavlodarskyi (hp = 1.7; Ht = 6.3%; Hbt = 2.6%)), and in five reverse combinations (NTH 1933 / Bozhych (hp = 1.2; Ht = 3.4%; Hbt = 0.5%), Pavlodarskyi / Sergiy (hp = 6.2; Ht = 22.5%; Hbt = 18.2 %), Sibirskiy / Pavlodarskyi (hp = 2.8; Ht = 7.8 %; Hbt = 4.9 %), Tornado / Pavlodarskyi (hp = 1.2; Ht = 3.8 %; Hbt = 0.5%), and Pavlodarskyi / Soyuz (hp = 1.7; Ht = 9.4%; Hbt = 3.7%)). The female cytoplasm’s effect on this trait was noted in two combinations: NTH 1933 / Bozhych and Sibirskiy / Pavlodarskyi.

Analysis in the Pavlodarskyi / Sergiy hybrid population proved that it was possible to select genotypes that would combine a relatively increased number of kernels per spike with an increased weight of kernels per spike. In the Sibirskiy / Pavlodarskyi, Tornado / Pavlodarskyi and Pavlodarskyi / Soyuz hybrid combinations with intermediate inheritance of the “kernel number per spike” trait (Table 4), it was possible to select genotypes with small numbers of kernels, but kernels were heavier compared to those in the parental forms.

Kernel weight per plant reflects the individual performance of a plant. The maximum kernel weight per plant was recorded for Tornado (20.91 g), Sergiy (20.64 g), and NTH 1933 (20.57 g) varieties (Table 6). The maximum expression of this trait was noted in a reverse combination, Pavlodarskyi / Soyuz (21.4 ± 4.1, g); the minimum – in the Pavlodarskyi / Bozhych (11.01 ± 2.6, g) combination derived from direct crossing of its parents (Table 6).

Analyzing the inheritance of grain productivity by F_1 hybrids, we found depression in most combinations (60%).

Prominent heterosis and positive overdominance for the "kernel weight per plant" was noted in four reverse combinations: NTH 1933 / Bozhych (hp = 1.7; Ht = 8.6%; Hbt = 3.2%); Bozhych / Pavlodarskyi (hp = 4.6; Ht = 15.9%; Hbt = 12.0%); Sibirskiy / Pavlodarskyi (hp = 2.5; Ht = 5.8%; Hbt = 3.4%), and Pavlodarskyi / Soyuz (hp = 2.7; Ht = 16.3%; Hbt = 9.7%). The NTH 1933 / Bozhych and Bozhych / Pavlodarskyi combinations showed higher grain productivity in the case when the female form had a stronger expression of this trait compared to the male one, indicating the female cytoplasm’s effect on this trait.

Plant performance is a multicomponent and compensatory trait. That is, in cereals, it depends on contributions of its individual constituents and their abilities to be realized under certain conditions. Thus, performance of plants with small productive tillering can be due to increased seed productivity, etc. Our data demonstrated that, in the NTH 1933 / Bozhych hybrid combination with positive predominance of the “kernel weight per plant” trait, there was positive overdominance of the “productive stem number” trait, the “kernel weight per spike” trait and the “spike length” trait, but the “kernel number per spike” trait was inherited by depression. It is possible to predict that, in this hybrid combination, it is possible to select genotypes that would perform due to increased numbers of productive stems, kernel weight per spike, but have looser spikes compared to the parents.

The Bozhych / Pavlodarskyi and Sibirskiy / Pavlodarskyi hybrid combinations with positive dominance of the “kernel weight per plant” trait had intermediate inheritance of the “productive stem number” trait, the “spike length” trait and the “kernel number per spike” trait. Selection for increased weight of thousand kernels and, consequently, for increased weight of kernels per plant will be more effective in these combinations. It should be said that it is possible to generate genotypes with elongated spikes from these hybrid combinations.

Negative dominance of the “productive stem number” trait, intermediate dominance of the “spike length” and “kernel number” traits, but little positive overdominance of the “kernel weight per spike” and the “kernel weight per plant” traits were intrinsic to the Pavlodarskyi / Soyuz hybrid combination. It is possible to identify genotypes with small numbers of productive stems and kernel numbers similar to those in a parent, but with an increased weight of thousand kernels.

Dry matter weight per winter triticale plant can vary significantly depending on many factors, such as growing conditions, varieties and harvest time. This indicator is important for fodder production, as it allows assessing the potential productivity and quality of fodder.

Table 6

Expression and variability of the "kernel weight per plant" trait in F_1 winter triticale hybrids, 2022

Hybrid combination	Kernel weight per plant, g			Ht, %	Hbt, %	hp
	P_1	F_1	P_2			
Khleborob / NTH 1933	15.54±3.7	13.72±2.0	20.57±5.6	-24.0	-33.3	-1.7
NTH 1933 / Khleborob	20.57±5.6	17.58±4.5	15.54±3.7	-2.6	-14.5	-0.2
NTH 1933 / Pavlodarskyi	20.57±5.6	12.41±2.7	17.29±2.6	-34.4	-39.7	-4.0
Pavlodarskyi / NTH 1933	17.29±2.6	12.54±2.6	20.57±5.6	-33.8	-39.0	-3.9
Khleborob / Pavlodarskyi	15.54±3.7	15.18±5.5	17.29±2.6	-7.5	-12.2	-1.4
Pavlodarskyi / Khleborob	17.29±2.6	13.92±7.2	15.54±3.7	-15.2	-19.5	-2.9
Bozhych / NTH 1933	18.54±6.1	12.46±3.2	20.57±5.6	-36.3	-39.4	-7.0
NTH 1933 / Bozhych	20.57±5.6	21.23±4.5	18.54±6.1	8.6	3.2	1.7
Sergiy / Pavlodarskyi	20.64±5.9	15.88±5.0	17.29±2.6	-16.3	-23.1	-1.8
Pavlodarskyi / Sergiy	17.29±2.6	17.78±3.4	20.64±5.9	-6.2	-13.9	-0.7
Pavlodarskyi / Bozhych	17.29±2.6	11.01±2.6	18.54±6.1	-38.5	-40.6	-11.0
Bozhych / Pavlodarskyi	18.54±6.1	20.77±4.3	17.29±2.6	15.9	12.0	4.6
Pavlodarskyi / Sibirskiy	17.29±2.6	16.53±4.6	16.52±5.8	-2.2	-4.4	-1.0
Sibirskiy / Pavlodarskyi	16.52±5.8	17.88±7.2	17.29±2.6	5.8	3.4	2.5
Pavlodarskyi / Tornado	17.29±2.6	15.31±2.0	20.91±7.4	-19.8	-26.8	-2.1
Tornado / Pavlodarskyi	20.91±7.4	15.16±4.3	17.29±2.6	-20.6	-27.5	-2.2
Soyuz / Pavlodarskyi	19.50±6.4	12.73±5.0	17.29±2.6	-30.8	-34.7	-5.1
Pavlodarskyi / Soyuz	17.29±2.6	21.40±4.1	19.50±6.4	16.3	9.7	2.7
Buzhanske / Pavlodarskyi	20.54±6.2	11.82±4.8	17.29±2.6	-37.5	-42.5	-4.4
Pavlodarskyi / Buzhanske	17.29±2.6	17.88±5.9	20.54±6.2	-5.5	-13.0	-0.6

Note: P_1 – female form, P_2 – male form, F_1 – hybrid, Ht – average heterosis, Hbt – heterobeltiosis, hp – phenotypic dominance

The maximum weight of dry matter per plant was recorded for a reverse combination (NTH 1933 / Bozhych (65.16 ± 7.1, g)); the minimum – for the NTH 1933 / Pavlodarskyi (29.65 ± 5.2 g) derived from direct crossing (Table 7).

The "dry matter weight per plant" trait was inherited by negative overdominance (55%) and heterosis (20%).

Table 7

Expression and variability of the "dry matter weight per plant" trait in F_1 winter triticale hybrids, 2022

Hybrid combination	Dry matter weight per plant, g			Ht, %	Hbt, %	hp
	P_1	F_1	P_2			
Khleborob / NTH 1933	44.30±9.2	38.34±11.4	52.53±16.2	-20.8	-27.0	-2.4
NTH 1933 / Khleborob	52.53±16.2	57.04±5.4	44.30±9.2	17.8	8.6	2.1
NTH 1933 / Pavlodarskyi	52.53±16.2	29.65±5.2	50.17±17.1	-42.3	-43.6	-18.4
Pavlodarskyi / NTH 1933	50.17±17.1	40.43±5.1	52.53±16.2	-21.3	-23.0	-9.3
Khleborob / Pavlodarskyi	44.30±9.2	51.17±10.0	50.17±17.1	8.3	2.0	1.3
Pavlodarskyi / Khleborob	50.17±17.1	49.75±10.9	44.30±9.2	5.3	-0.8	0.9
Bozhych / NTH 1933	57.65±21.9	43.04±11.3	52.53±16.2	-21.9	-25.3	-4.7
NTH 1933 / Bozhych	52.53±16.2	65.16±7.1	57.65±21.9	18.3	13.0	3.9
Sergiy / Pavlodarskyi	63.81±16.9	43.67±12.4	50.17±17.1	-23.4	-31.6	-2.0
Pavlodarskyi / Sergiy	50.17±17.1	48.36±10.2	63.81±16.9	-15.1	-24.2	-1.3
Pavlodarskyi / Bozhych	50.17±17.1	40.11±10.1	57.65±21.9	-25.6	-30.4	-3.7
Bozhych / Pavlodarskyi	57.65±21.9	56.00±15.1	50.17±17.1	3.9	-2.9	0.6
Pavlodarskyi / Sibirskiy	50.17±17.1	53.02±12.0	53.08±15.8	2.7	-0.1	1.0
Sibirskiy / Pavlodarskyi	53.08±15.8	57.34±17.0	50.17±17.1	11.1	8.0	3.9
Pavlodarskyi / Tornado	50.17±17.1	43.42±10.4	73.82±33.3	-30.0	-41.2	-1.6
Tornado / Pavlodarskyi	73.82±33.3	49.34±9.1	50.17±17.1	-20.4	-33.2	-1.1
Soyuz / Pavlodarskyi	70.75±18.6	43.53±15.2	50.17±17.1	-28.0	-38.5	-1.6
Pavlodarskyi / Soyuz	50.17±17.1	54.20±15.5	70.75±18.6	-10.4	-23.4	-0.6
Buzhanske / Pavlodarskyi	68.78±29.3	35.67±9.2	50.17±17.1	-40.0	-48.1	-2.6
Pavlodarskyi / Buzhanske	50.17±17.1	54.37±18.6	68.78±29.3	-8.6	-21.0	-0.5

Note: P_1 – female form, P_2 – male form, F_1 – hybrid, Ht – average heterosis, Hbt – heterobeltiosis, hp – phenotypic dominance

We distinguished a direct hybrid combination with prominent heterosis and positive overdominance (Khleborob / Pavlodarskyi (hp = 1.3; Ht = 8.3%; Hbt = 2.0%)) and reverse hybrids with similar indicators (NTH 1933 / Khleborob (hp = 2.1; Ht = 17.8 %; Hbt = 8.6 %), NTH 1933 / Bozhych (hp = 3.9; Ht = 18.3 %; Hbt = 13, 0%) and Sibirskiy / Pavlodarskyi (hp = 3.9; Ht = 11.1%; Hbt = 8.0%)). Positive dominance was noted in a direct combination (Pavlodarskyi / Sibirskiy (hp = 1.0; Ht = 2.7%; Hbt = -0.1%)) and two reverse ones (Pavlodarskyi / Khleborob (hp = 0.9; Ht = 5.3 %; Hbt = -0.8%) and Bozhych / Pavlodarskyi (hp = 0.6; Ht = 3.9%; Hbt = -2.9%)). The female cytoplasm's contribution to the formation of the "dry matter weight per plant" trait was noted in three combinations: NTH 1933 / Khleborob, Bozhych / Pavlodarskyi and Sibirskiy / Pavlodarskyi.

Differences in the inheritance of fodder and seed productivity traits in reciprocal crossings of winter triticale accessions depended not only on nuclear inheritance, but also on cytoplasmic one.

Conclusions. Analysis of the variability of the fodder and seed productivity traits in F_1 winter triticale hybrids established that hybrid combinations differed significantly in terms of heterosis level and inheritance type. All possible variants of phenotypic dominance, from positive to negative overdominance, were identified. For such traits as the productive tillering, kernel weight per spike, kernel weight per plant, and dry matter weight per plant, depression was noted in most combinations (55–60%).

Analysis of heterosis and inheritance in reciprocal F_1 hybrids showed unequal contributions of female and male forms to their offspring genotypes for the investigated traits.

Reciprocal crossings of nine winter triticale parents yielded 20 combinations; of them, three F_1 hybrids showed prominent heterosis and positive overdominance for three or four traits: NTH 1933 / Khleborob, NTH 1933 / Bozhych and Sibirskiy / Pavlodarskyi. From the NTH 1933 / Bozhych, Bozhych / Pavlodarskyi, and Sibirskiy / Pavlodarskyi hybrid combinations, it is possible to select genotypes that combine both high performance and high dry matter weight.

Hybrid combinations with prominent heterosis and positive overdominance for the main characteristics of fodder and grain productivity were identified: productive tillering – NTH 1933 / Khleborob, Khleborob / Pavlodarskyi, Bozhych / NTH 1933 and NTH 1933 / Bozhych; spike length – NTH 1933 / Bozhych and Pavlodarskyi / Tornado; kernel number per spike – Pavlodarskyi / Sergiy; kernel weight per spike – NTH 1933 / Bozhych, Sergiy / Pavlodarskyi, Pavlodarskyi / Seghiy, Sibirskiy / Pavlodarskyi, Tornado / Pavlodarskyi, and Pavlodarskyi / Soyuz; kernel weight per plant – NTH 1933 / Bozhych, Bozhych / Pavlodarskyi, Sibirskiy / Pavlodarskyi, and Pavlodarskyi / Soyuz; dry matter weight per plant – NTH 1933 / Khleborob, Khleborob / Pavlodarskyi, NTH 1933 / Bozhych and Sibirskiy / Pavlodarskyi.

Hybrid combinations derived from such varieties as NTH 1933, Khleborob, Pavlodarskyi, Bozhych, Sergiy, Soyuz and Sibirskiy showed increased values of performance traits and potentials to increase yields.

The research prospect consists in further selection and evaluation of the obtained winter triticale hybrids for the fodder and seed productivity traits in subsequent generations.

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УСПАДКУВАННЯ ОЗНАК КОРМОВОЇ ТА НАСІННЄВОЇ ПРОДУКТИВНОСТІ ГІБРИДІВ F_1 ТРИТИКАЛЕ ОЗИМОГО

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Мета та завдання досліджень. Визначити ступінь прояву та характер успадкування ознак кормової та насіннєвої продуктивності гібридів F_1 тритикале озимого при реципрокних схрещуваннях. Виділити перспективні комбінації F_1, які мають високий прояв гетерозису за трьома і більше ознаками продуктивності.

Матеріали та методи. Дослідження проводили в 2021, 2022 рр. у відділі селекції кормових, зернових колосових та технічних культур Інституту кормів та сільського господарства Поділля НААН. Технологія вирощування загальноприйнята для зони Лісостепу. Батьківські компоненти та F_1 висівали у гібридному розсаднику з використанням ручного маркера, ширина міжрядь 30 см, відстань між рослинами в рядку – 10 см. Вихідним матеріалом для проведення прямих і зворотних схрещувань слугувало дев'ять сортів тритикале озимого різного еколого-географічного походження: Божич, Бужанське, Павлодарський походженням з України; Торнадо, Хлебороб, Союз, Сергий, Сибирський – Росії та NTH 1933 – Китаю. Ступінь гетерозису визначали за Matzinger et al. та S. Fonseca, F. Patterson.

Результати і обговорення. Аналіз успадкування у гібридів F_1 показав, що продуктивна кущистість мала різні типи успадкування (табл. 2), переважало негативне наддомінування (55 %) та гетерозис (20 %). З-за внутрішньоалельних взаємодій генів, що діють тільки в гетерозиготному стані, добір генотипів у ранніх гібридних поколіннях може бути малоефективним. Але є висока вірогідність ідентифікації трансгресій підвищеної кущистості у більш пізніх гібридних поколіннях. Особливу увагу для добору генотипів, що мали б підвищену кущистість, можна приділити комбінації з позитивним домінуванням Хлебороб / NTH 1933 (hp = 0,6; Ht = 3,3 %; Hbt = -2,5 %). Комбінації, що мали негативне наддомінування (депресію), в селекції на підвищення кущистості є малоцінними. Нашими даними на тритикале озимім було визначено, що успадкування довжини колосу гібридами F_1 має широкий спектр, 10 % гібридних комбінацій мали позитивне наддомінування (гетерозис), позитивне домінування – 25 %, проміжне успадкування – 35 %, негативне домінування – 15 %, негативне наддомінування (депресія) –20 %. Причиною тому є те, що для схрещувань були дібрані сорти різного географічного та генетичного походження. Гібридні комбінації Павлодарський / Сергий та Бужанське / Павлодарський мали депресію в успадкуванні довжини колосу. Тобто в обраних гібридних комбінаціях можливий добір рослин тритикале озимого із порівняно невеликим колосом але із збільшеною кількістю насіння. За аналізом наших досліджень в гібридній популяції Павлодарський / Сергий можливий добір генотипів, які б поєднували у собі порівняно підвищену кількість зерен у колосі з підвищеною вагою зерна з колоса. В гібридних комбінаціях Сибирский / Павлодарський, Торнадо / Павлодарський, Павлодарський / Союз, що мали проміжне успадкування кількості зерен в колосі, можливий добір генотипів порівняно із батьківськими компонентами з невеликою кількістю зерен, але більш важкого. Гібридні комбінації Божич / Павлодарський та Сибирский / Павлодарський на фоні позитивного наддомінування ваги зерна з рослини мали проміжне успадкування кількості продуктивних стебел, довжини колосу та кількості зерен в колосі. Більш результативний добір в цих комбінаціях буде в напряму підвищення маси 1000 насінин і, як наслідок, ваги зерна з рослини. Слід сказати, що у цих гібридних комбінаціях є можливим формування генотипів із подовженим колосом. Характерним для гібридної комбінації Павлодарський / Союз негативне домінування ознаки у формуванні кількості продуктивних стебел, проміжного домінування у формуванні довжини колоса та кількості зерен, але мало позитивне наддомінування у формуванні ваги зерен в колосі та ваги зерна з рослини. Можливим є ідентифікація генотипів з невеликою кількість продуктивних стебел з колосом та озерненістю на рівні батьківського компонента, але з підвищеною масою 1000 насінин.

Висновки. У результаті проведеного аналізу мінливості ознак кормової та насіннєвої продуктивності в гібридів F_1 тритикале озимого встановлено, що гібридні комбінації суттєво відрізняються між собою за рівнем прояву гетерозису та особливостями характеру успадкування. Виявлено всі можливі варіанти фенотипового домінування від позитивного до негативного наддомінування. За таким ознаками, як продуктивна кущистість, вага зерен із колосу, вага зерен із рослини та вага сухої речовини однієї рослини у більшості комбінацій відмічено депресію (55–60 %).

Ключові слова: *успадкування, тритикале озиме, гібрид, реципрокне схрещування.*

INHERITANCE OF FODDER AND SEED PRODUCTIVITY CHARACTERISTICS BY F_1 WINTER TRITICALE HYBRIDS

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Purpose and Objectives. To characterize the inheritance of fodder and seed productivity characteristics by F_1 winter triticale hybrids from reciprocal crossings. To select promising F_1 combinations that show strong heterosis in three or more performance traits.

Materials and Methods. The study was carried out at the Department of Fodder, Grain and Technical Crops Breeding of the Institute of Fodder and Agriculture of Podillia of NAAS in 2021 and 2022. The farming techniques were traditional for the forest-steppe. Parents and F_1 were sown in a hybrid nursery using a manual marker; the interrow distance was was 30 cm; the interplant distance in the rows was 10 cm. Nine winter triticale varieties of different eco-geographical origins served as the starting material for direct and reverse crossings: Bozhych, Buzhanske, and Pavlodarskyi originating from Ukraine; Tornado, Khleborob, Soyuz, Sergiy, and Sibirskiy from Russia; and NTH 1933 from China. The heterosis degree was determined according to Matzinger et al. [15] and S. Fonseca, F. Patterson.

Results and Discussion. Analysis of inheritance in F_1 hybrids showed that the productive tillering capacity was inherited by different types, with negative overdominance (55%) and heterosis (20%) prevailing. Due to intra-allelic interactions of genes functioning in a heterozygous state only, selection of genotypes in early hybrid generations may be ineffective. However, there is a high probability of identification of transgressions of increased tillering in later hybrid generations. A combination with positive dominance, Khleborob / NTH 1933 (hp = 0.6; Ht = 3.3%; Hbt = -2.5%), is worth of special attention for selection of genotypes that would have increased tillering capacity. Combinations with negative overdominance (depression) are of little value in breeding for enhanced tillering. Our data on winter triticale demonstrated that the spike length inheritance by F_1 hybrids had a wide spectrum: 10% of hybrid combinations showed positive overdominance (heterosis), 25% – positive dominance,

35% – intermediate inheritance, 15% – negative dominance, and 20% – negative overdominance (depression). This is attributed to different geographical and genetic origins of varieties selected for crossing. It should be noted that the Pavlodarskyi / Serhiy and Buzhanske / Pavlodarskyi hybrid combinations inherited spike length by depression. That is, it is possible to select winter triticale plants with relatively short spikes but with increased numbers of kernels among the distinguished hybrid combinations. Analysis in the Pavlodarskyi / Sergiy hybrid population proved that it was possible to select genotypes that would combine a relatively increased number of kernels per spike with an increased weight of kernels per spike. In the Sibirskiy / Pavlodarskyi, Tornado / Pavlodarskyi and Pavlodarskyi / Soyuz hybrid combinations with intermediate inheritance of the "kernel number per spike" trait, it was possible to select genotypes with small numbers of kernels, but kernels were heavier compared to those in the parental forms. The Bozhych / Pavlodarskyi and Sibirskiy / Pavlodarskyi hybrid combinations with positive dominance of the "kernel weight per plant" trait had intermediate inheritance of the "productive stem number" trait, the "spike length" trait and the "kernel number per spike" trait. Selection for increased weight of thousand kernels and, consequently, for increased weight of kernels per plant will be more effective in these combinations. It should be said that it is possible to generate genotypes with elongated spikes from these hybrid combinations. Negative dominance of the "productive stem number" trait, intermediate dominance of the "spike length" and "kernel number" traits, but little positive overdominance of the "kernel weight per spike" and the "kernel weight per plant" traits were intrinsic to the Pavlodarskyi / Soyuz hybrid combination. It is possible to identify genotypes with small numbers of productive stems and kernel numbers similar to those in a parent, but with an increased weight of thousand kernels.

Conclusions. Analysis of the variability of the fodder and seed productivity traits in F_1 winter triticale hybrids established that hybrid combinations differed significantly in terms of heterosis level and inheritance type. All possible variants of phenotypic dominance, from positive to negative overdominance, were identified. For such traits as the productive tillering, kernel weight per spike, kernel weight per plant, and dry matter weight per plant, depression was noted in most combinations (55–60%).

Key words: *inheritance, winter triticale, hybrid, reciprocal crossing.*