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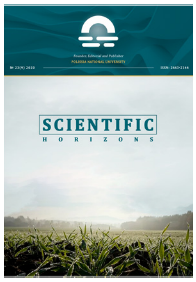

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Transgressive variation in productivity traits in F_2 naked oat hybrids

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Abstract. One of the most effective methods for increasing yield and resistance to abiotic and biotic factors in the environment is genetic selection and improvement of varieties. Solving these tasks is possible using positive transgressions, which are of great practical importance at this stage of selection. The aim of the research was to determine the coefficient of heritability in the broad sense (H^2) and the degree and frequency of transgressions for productivity traits in second-generation hybrids of naked oat, created by crossing based on the eco-geographical principle and selection of economically valuable biotypes for further breeding work. During 2021, research

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was conducted on 15 intervarietal hybrids. F_2 and parental components were analysed for traits such as plant height, spike length, number of spikelets per spike, number of grains per spikelet, and grain weight per spikelet. Field research methods (phenological observations), laboratory methods (structural analysis of the material under study), and mathematical-statistical methods (objective evaluation of the experimental data obtained) were used. A prominent level of the coefficient was observed for the trait "grain weight per spikelet", ranging from 0.66 to 0.88 in hybrid populations OM 11-3007/Abel, OM 2803/Abel, Percy Can/Inermis, Percy Can/Abel. The analysis of the second-generation F_2 intervarietal hybrids of naked oat allowed the identification of transgressions for all the studied traits. The highest number of positive transgressions was found for the following productivity traits: spike length (*Tf* 31.82 – 59.09%, *Td* 7.53 – 15.49%); number of spikelets per spike (*Tf* 27.30 – 54.50%, *Td* 8.85 – 26.49%); number of grains per spikelet (*Tf* 45.50 – 77.27%, *Td* 16.63 – 27.62%); and grain weight per spikelet (*Tf* 63.64 – 81.80%, *Td* 18.12 – 25.36%). The selection-genetic analysis of studying the nature of heritability, frequency, and degree of transgressive variation in spikelet productivity traits of F_2 naked oat hybrids allowed the identification of a considerable number of transgressive forms, in which productivity elements vary widely, indicating successful selection work in creating promising high-yielding breeding material

Keywords: naked oat; productivity traits; hybrid combinations; parental components; heritability, transgression

INTRODUCTION

Naked oat is a relatively new grain crop that is currently perceived as niche. However, with each passing year, the demand for products made from naked oat is increasing, as more people seek to consume quality and healthy food. The rising demand for healthy food products, such as organic, bio, fitness, and farmer's products, produced in limited quantities, has been observed (Tinker *et al.*, 2022). L.O. Udova (2018) also confirms this trend in Ukraine.

Nevertheless, it remains a tradition to primarily cultivate hulled oats, while naked oat occupies insignificant areas in production. However, this makes naked oat a unique crop in its own way. Some opinions attribute the limited use of naked oat in modern production to its insufficient study, higher demands for cultivation conditions, and certain biological drawbacks that ultimately affect its yield and quality (Hoptsiy & Kravchenko, 2023).

According to Necheporenko and Orlov (2020), increasing oat yield through selection is the most challenging task. T.P. Lozinska (2019) believes that addressing this challenge, along with enhancing resistance to abiotic and biotic factors, is possible through genetic and selective improvement of varieties, which, in turn, depends on the availability of suitable starting material with valuable breeding traits (Bilyavska & Rybalchenko, 2020). Incorporating valuable genotypes into the breeding process to create new varieties allows for the combination of valuable agricultural traits in hybrids, improves grain quality, and ultimately enhances the economic efficiency of oat cultivation (Haleem *et al.*, 2022). To achieve this goal, breeders employ various selection methods, but interspecific hybridization remains the most effective method (Lozinsky *et al.*, 2021). According to Nimbala Anisa and Neik Rudra (2021), the creation of hybrids should be purposeful, and knowledge of the patterns of trait "heritability" enables more efficient selection, elimination of low-value forms, and preservation of promising genotypes.

The use of positive transgressions is common in the creation and improvement of self-pollinating plants (Shchuts, 2019; Rauf *et al.*, 2020). Researchers emphasize the significance of transgressions and consider positive transgressions to be the most effective approach in working with breeding materials. Positive transgressions resulting from recombination of different economically valuable traits are particularly valuable in breeding (Tomaszewska & Kosina, 2019; Lozinsky *et al.*, 2021).

Tromsiuk and Bugayov (2021) highlight the importance of obtaining positive transgressions through the application of the ecogeographic principle in selecting parental pairs for hybridization. However, in their studies, Koroluk *et al.* (2022) pointed out that the genetic divergence of parental components can yield both positive and negative results. On one hand, it allows obtaining hybrid populations with certain traits that significantly exceed those of the parental forms. On the other hand, the hybrids may not conform to the desired model.

The analysis of breeding and genetic research shows that scientists have achieved some results in understanding the occurrence of transgressive variability to some extent. However, there is still no unified theory of trait transgression and adequate explanations for this genetic phenomenon (Lekhman, 2019; Lozinsky, 2021). Therefore, the question of the heritability of productivity elements and their transgressive variability in F_2 hybrids of naked oat remains relevant, as its resolution can enhance the selection value of hybrid combinations and contribute to the development of promising genotypes. Hence, this study was conducted to determine the coefficient of heritability and the frequency and degree of transgression for key productivity elements in F_2 hybrid generation of naked oats.

MATERIALS AND METHODS

The research was conducted from 2018 to 2021 at the Scientific-Educational Production Centre "Experimental

Field" of V.V. Dokuchaev Kharkiv National Agrarian University (since September 2021, State Biotechnological University). The soil cover of the experimental field consisted of typical chernozem, slightly eroded, low humus content, heavy loamy on forest loam. According to the Department of Soil Science at V.V. Dokuchaev Kharkiv National Agrarian University, the humus content in one soil layer (according to Turin) was 5.0%.

During 2018, the collection samples of naked oat obtained from the National Plant Genetic Resources Centre were studied and analysed for key agronomic traits. Based on the analysis, nine varieties were selected: Skarb Ukrainy, Inermis, Pushkinskyi, Holz, Vandrounik, Marafon, Samuel, Percy Can, Abel, and four inbred lines: OM 11-3007, OM 28-03, TR 12-115, and w/o No. Ren Nuda, of naked oat from domestic and foreign breeding, were selected for hybridization. Parental components for crossing were selected based on the level of expression of key agronomic traits and the ecological-geographical principle, which formed three groups: 1) hybridization of varieties and inbred lines of domestic origin among themselves; 2) hybridization of varieties and inbred lines of domestic origin with varieties from different ecological-geographical groups (foreign origin); 3) hybridization of varieties from different ecological-geographical groups (foreign origin) among themselves.

In 2019, hybridization was conducted through mechanical castration of flowers of the maternal plant, followed by forced pollination after 2 days using the Shishlov method. Plant isolation was ensured with paper bags. Based on the selected parental material, 15 hybrid combinations were created and studied in the hybrid nursery in 2020. In the F_1 hybrids, the level of phenotypic dominance, true and hypothetical heterosis were determined.

In 2021, the second-generation hybrid populations were studied to establish the coefficients of heritability and the frequency and degree of transgressive variation for key productivity elements. The sowing of F_2 hybrid population seeds and parental forms was carried out in the second decade of April in the hybrid nursery using the "parental form – F_2 – parental form" scheme with a row width of 15 cm. Throughout the vegetation period, phenological observations were conducted. Plant harvesting was done at full maturity, with all oat plants harvested with their roots. Structural analysis of hybrid plants and parental forms was conducted individually for traits such as spike length, number of spikes and grains per spike, grain weight per spike, and plant height.

The coefficient of heritability in the "broad sense" (H^2) was determined in F_2 using A.A. Zhuchenko's formula (1980), which is considered a quantity that reflects the real situation and can be used for the effective selection of transgressive forms. According to O.Ya. Ala's classification (1976), the coefficients of heritability were divided into: high – H^2=0.66-1.00; medium – 0.33-0.65; low – 0.00-0.32. The degree (*Td*) and frequency (*Tf*) of transgression were calculated using the Voskresenska-Shpot method (1967).

During the research, the meteorological conditions in 2021 were favourable for the growth and development of the obtained oat hybrids, although there were certain deviations in some periods both in terms of air temperature and precipitation. For instance, May to June, the period when productive stems and the number of grains in the spike are actively formed, characterized by an adequate amount of precipitation with slight deviations from the monthly norm. The amount of precipitation in April was 37.3 mm, in May – 52.1 mm, and in June – 82.0 mm (compared to the long-term norms of 34.9 mm, 43.7 mm, and 65.7 mm, respectively). The air temperature was also close to the average long-term indicators. However, July and August were dry months, with air temperatures of +24.5°C and +24.1°C, and precipitation of 26.6 mm and 12.9 mm, respectively.

RESULTS AND DISCUSSION

Special attention was paid to analysing the investigated F_2 populations, focusing on the manifestation of positive transgressive forms of productivity traits. Understanding the mechanisms of their heritability can lead to the creation of valuable parental material for future new cultivar development.

Regarding the length of the panicle, the manifestation of positive transgression was observed in 12 (80%) F_2 combinations (Table 1). However, their frequency and degree varied significantly. The frequency of transgressions ranged from 4.55% to 59.09%, while the degree of transgression ranged from 1.41% to 15.49%. Three combinations showed no transgression. The most promising populations were as follows: Samuel/Percy Can (*Tf* – 59.09%, *Td* – 15.49%), Skarb Ukrainy/Abel (*Tf* – 40.91%, *Td* – 10.53%), Skarb Ukrainy/w/o No. Ren Nuda (*Tf* – 36.36%, *Td* – 8.95%), OM 11-3007/TR 12-115 (*Tf* – 27.27%, *Td* – 9.85%), OM 2803 / Abel (*Tf* – 31.82%, *Td* – 8.37%), and Marafon/Abel (*Tf* – 45.45%, *Td* – 7.53%).

The heritability coefficient, which exceeded 0.50, was observed in the population of Samuel/Percy Can, with a value of 0.51. In the populations of OM 11-3007/Pushkinskyi, TR 12-115/Vandrounik, and Holz/TR 12-115, no manifestation of transgressive forms was observed.

Table 1. *The heritability coefficient, frequency, and degree of transgression for panicle length in F_2 naked oat populations (2021)*

Crossing combinations	♀	X±Sx	♂	H^2	*Tf*, %	*Td*, %
Skarb Ukrainy/w/o No. Ren Nuda	17.70	18.9±0.5	17.00	0.18	36.36	8.95

Table 1, Continued

Crossing combinations	♀	X±Sx	♂	H^2	Tf, %	Td, %
Skarb Ukrainy/Abel	17.7	18.6±0.7	17.2	0.42	36.36	10.53
OM 11-3007/TR 12-115	18.90	19.4±0.7	17.7	0.37	27.27	9.85
OM 11-3007/Holz	18.90	19.3±0.6	18.5	0.15	18.18	8.95
OM 11-3007/Pushkinskyi	18.90	18.88±0.5	18.6	0.00	–	–
OM 11-3007/Samuel	18.9	19.8±0.5	19.1	0.15	31.82	1.48
OM 11-3007/Abel	18.9	19.6±0.6	17.2	0.28	40.91	6.90
OM 2803/Marafon	18.10	18.9±0.7	15.6	0.28	22.73	4.93
OM 2803/Abel	18.10	20.0±0.6	17.2	0.24	31.82	8.37
TR 12-115/Vandrounik	17.70	17.6±0.4	17.1	0.00	–	–
Holz/TR 12-115	18.50	18.5±0.6	17.7	0.00	–	–
Marafon/Abel	15.6	18.6±0.4	17.2	0.01	36.36	7.53
Samuel/Percy Can	19.1	21.4±0.9	19.7	0.50	54.55	15.49
Percy Can/Intermis	19.7	20.0±0.5	18.4	0.24	13.64	1.88
Percy Can/Abel	19.70	19.7±0.5	17.2	0.08	4.55	0.00

***Note**: Max ♀♂ – maximum value of the trait in parental forms, X±Sx – mean value of the trait in F_2, H^2 – coefficient of heritability in the broad sense, Tf – transgression frequency, Td – transgression degree*
***Source:** compiled by the authors of this study*

According to the trait "number of spikes per panicle", positive transgressive forms were observed in all the combinations analysed within the F_2 hybrid populations (Table 2). Among them, the population of Holz/TR 12-115 exhibited a high degree of expression of the heritability coefficient (0.69), eleven populations showed a moderate level (0.34-0.60), and three combinations, OM 11-3007/Pushkinskyi, Skarb Ukrainy/w/o No. Ren Nuda, OM 2803 / Marafon, displayed a low heritability coefficient (0.26, 0.18, and 0.14, respectively).

The frequency of transgressive expression ranged from 4.50% to 54.50%, while the degree of transgression varied from 5.67% to 26.49%. The populations with the highest frequency and degree of transgression were OM 2803 / Abel (*Tf* – 54.50%, *Td* – 24.88%), Marafon/Abel (*Tf* – 50.0%, *Td* – 8.85%), Samuel/Percy Can (*Tf* – 31.80%, *Td* – 26.49%), OM 11-3007/Pushkinskyi (*Tf* – 31.80%, *Td* – 13.33%), OM 11-3007/Samuel (*Tf* – 27.3%, *Td* – 20.75%), and Skarb Ukrainy/Abel (*Tf* – 27.30%, *Td* – 15.84%).

***Table 2.** Heritability coefficient, frequency, and degree of transgression for the number of spikes per panicle in F_2 naked oat (2021)*

Crossing combinations	♀	X±Sx	♂	H^2	Tf, %	Td, %
Skarb Ukrainy/w/o No. Ren Nuda	37.8	41.0±1.8	33.6	0.18	18.20	4.46
Skarb Ukrainy/Abel	37.8	39.2±2.3	36.7	0.48	27.30	15.84
OM 11-3007/TR 12-115	37.8	38.4±1.8	31.3	0.36	22.75	6.09
OM 11-3007/Holz	37.8	38.5±2.5	37.1	0.38	27.30	12.68
OM 11-3007/Pushkinskyi	37.8	42.9±2.3	38.0	0.26	31.80	13.33
OM 11-3007/Samuel	37.8	38.2±4.0	37.8	0.60	27.30	20.75
OM 11-3007/Abel	37.8	39.3±1.8	36.7	0.34	22.30	8.43
OM 2803/Marafon	36.2	39.7±2.1	34.4	0.14	18.20	10.07
OM 2803/Abel	36.2	42.3±2.5	36.7	0.47	54.50	24.88
TR 12-115/Vandrounik	31.3	39.7±1.8	36.4	0.39	13.60	5.67
Holz/TR 12-115	37.1	38.3±4.1	31.3	0.69	22.70	23.17
Marafon/Abel	34.4	38.3±1.8	36.7	0.41	50.0	8.85

Table 2, Continued

Crossing combinations	♀	X±Sx	♂	H^2	*Tf*, %	*Td*, %
Samuel/Percy Can	37.8	40.8±4.6	32.8	0.54	31.80	26.49
Percy Can/Inermis	32.8	39.9±3.5	37.7	0.37	22.70	17.90
Percy Can / Abel	32.8	39.8±2.3	36.7	0.34	4.50	19.66

***Note**: Max ♀♂ – maximum value of the trait in parental forms, X±Sx – mean value of the trait in F_2, H^2 – coefficient of heritability in the broad sense, Tf – transgression frequency, Td – transgression degree*
***Source:** compiled by the authors of this study*

The number of grains in the best parental plants ranged from 37.5 to 52.5 pcs. In F_2, this parameter varied from 49.5 to 64.0 grains (Table 3). Positive transgressions were observed in all F_2 combinations. The heritability coefficient in most investigated populations (67.6%) was moderate, ranging from 0.34 to 0.64, while the other five populations exhibited a low coefficient value. The frequency of transgressions ranged from 18.2% in the population Marafon/Abel to 77.27% in the population OM 2803/Abel. The degree of transgression for this trait ranged from 4.63% to 40.15%. The highest degree of transgression was observed in the populations OM 11-3007/Samuel (40.15%), Holz/TR 12-115 (29.42%), OM 2803/Marafon (27.62%), Skarb Ukrainy/w/o No. Ren Nuda (25.25%), and OM 2803/Abel (22.85%).

The best populations, which exhibited a higher degree and frequency of transgressions for the number of grains per panicle, were OM 2803 / Abel (*Tf* – 77.27%, *Td* – 22.85%), Skarb Ukrainy / w/o No. Ren Nuda (*Tf* – 59.10%, *Td* – 25.25%), OM 11-3007 / Abel (*Tf* – 45.50%, *Td* – 17.15%), OM 2803/Marafon (*Tf* – 50.00%, *Td* – 27.62%), and OM 11-3007/Holz (*Tf* – 50.00%, *Td* – 16.63%), OM 2803 /Abel (*Tf* – 77.27%, *Td* – 22.85%).

***Table 3.** Heritability coefficient, frequency, and degree of transgression for the number of grains per panicle in F_2 of naked oat (2021)*

Crossing combinations	♀	X±Sx	♂	H^2	*Tf*, %	*Td*, %
Skarb Ukrainy/w/o No. Ren Nuda	41.6	54.2±2.8	46.2	0.52	59.10	25.25
Skarb Ukrainy/Abel	41.6	54.9±2.2	52.5	0.39	27.30	5.66
OM 11-3007/TR 12-115	48.4	51.8±1.4	41.2	0.12	40.91	7.65
OM 11-3007/Holz	48.4	54.2±1.8	46.0	0.18	50.00	16.63
OM 11-3007/Pushkinskyi	48.4	53.33±2.4	46.2	0.51	54.60	18.55
OM 11-3007/Samuel	48.4	58.3±3.7	46.7	0.64	50.00	40.15
OM 11-3007/Abel	48.4	62.6±1.7	52.5	0.17	45.50	17.15
OM 2803/Marafon	45.3	58.1±1.5	40.2	0.09	50.00	27.62
OM 2803/Abel	45.3	62.6±1.6	52.5	0.28	77.27	22.85
TR 12-115/Vandrounik	41.2	49.5±2.3	47.8	0.40	40.90	8.07
Holz/TR 12-115	46.0	52.2±3.9	41.2	0.63	22.73	29.42
Marafon/Abel	40.2	48.6±2.7	52.5	0.44	18.20	4.63
Samuel/Percy Can	46.7	51.4±2.8	37.5	0.49	41.00	19.81
Percy Can/Inermis	37.5	54.1±25	50.5	0.50	36.40	17.64
Percy Can/Abel	37.5	56.2±28	52.5	0.46	31.80	14.24

***Note**: Max ♀♂ – maximum value of the trait in parental forms, X±Sx – mean value of the trait in F_2, H^2 – coefficient of heritability in the broad sense, Tf – transgression frequency, Td – transgression degree*
***Source:** compiled by the authors of this study*

The grain weight per panicle in the best parental varieties ranged from 1.11 to 1.33 g. In F_2, this trait ranged from 1.24 to 1.52 g. Analysis of the mean values of parental forms and F_2 populations revealed the presence of positive transgressive variability in all (100%) hybrid combinations of F_2 (Table 4). In 10 populations, the heritability coefficient was high, ranging from 0.66 in the population of OM 11-3007/TR 12-115 to 0.88 in the populations of OM 2803/Abel and Percy Can/Abel. High values of the heritability coefficient may indicate high genotype variability for this trait, which resulted in relatively high values of heritability coefficient, frequency, and degree of transgression.

The frequency of transgression ranged from 18.20% to 81.80%. The degree of transgression ranged from 2.31% to 25.36%. The most valuable populations for selection based on grain weight per panicle are Samuel/Percy Can (*Tf* – 81.80%, *Td* – 20.30%), Percy Can/Inermis (*Tf* – 72.73%, *Td* – 18.12%), Percy Can/Abel (*Tf* – 68.20%, *Td* – 25.36%), Marafon/Abel (*Tf* – 63.64%, *Td* – 19.97%), and others. Variation in plant height in the F_2 populations ranged from 75.4 cm (Holz/TP 12-115) to 99.3 cm (Samuel/Percy Can). Transgressions for this trait were absent in 10 (67.7%) populations. In the populations Skarb Ukrainy/w/o No. Ren Nuda, OM 11-3007/Holz, Marafon/Abel, Skarb Ukrainy/Abel, the frequency of transgressions ranged from 0.19% to 0.61%.

Table 4. *Heritability coefficient, frequency, and degree of transgression for grain weight per panicle in F_2 of naked oat (2021)*

Crossing combinations	♀	X±Sx	♂	H^2	*Tf*, %	*Td*, %
Skarb Ukrainy/w/o No. Ren Nuda	1.20	1.24±0.02	1.11	0.31	22.73	2.31
Skarb Ukrainy/Abel	1.20	1.31±0.01	1.31	0.55	27.30	4.62
OM 11-3007/TR 12-115	1.31	1.33±0.02	1.28	0.66	18.20	4.41
OM 11-3007/Holz	1.31	1.31±0.02	1.25	0.20	40.90	2.94
OM 11-3007/Pushkinskyi	1.31	1.32±0.02	1.25	0.65	31.80	2.94
OM 11-3007/Samuel	1.31	1.40±0.03	1.30	0.72	54.55	11.76
OM 11-3007/Abel	1.31	1.38±0.03	1.31	0.81	59.10	10.29
OM 2803/Marafon	1.29	1.36±0.03	1.25	0.69	45.45	8.89
OM 2803/Abel	1.29	1.39±0.04	1.31	0.88	36.40	11.76
TR 12-115/Vandrounik	1.28	1.30±0.03	1.27	0.69	40.90	5.93
Holz/TR 12-115	1.25	1.28±0.05	1.28	0.55	31.82	9.63
Marafon/Abel	1.25	1.42±0.04	1.31	0.76	63.64	19.97
Samuel/Percy Can	1.30	1.52±0.05	1.33	0.72	81.80	20.30
Percy Can/Inermis	1.33	1.38±0.05	1.25	0.81	72.73	18.12
Percy Can/Abel	1.33	1.49±0.06	1.31	0.88	68.20	25.36

Note: *Max ♀♂ – maximum value of the trait in parental forms, X±Sx – mean value of the trait in F_2, H^2 – coefficient of heritability in the broad sense, Tf – transgression frequency, Td – transgression degree*
Source: *compiled by the authors of this study*

Table 5. *Coefficient of inheritance, frequency, and degree of transgression for plant height in F_2 of naked oat (2021)*

Crossing combinations	♀	X±Sx	♂	H^2	*Tf*, %	*Td*, %
Skarb Ukrainy/w/o No. Ren Nuda	86.3	88.5±0.8	77.6	0.19	18.20	5.90
Skarb Ukrainy/Abel	86.3	87.6±1.4	80.6	0.61	36.40	8.40
OM 11-3007/TR 12-115	98.7	90.0±0.7	92.6	–	–	–
OM 11-3007/Holz	98.7	98.9±0.9	89.4	0.33	27.30	5.15
OM 11-3007/Pushkinskyi	98.7	88.4±0.9	94.4	–	–	–
OM 11-3007/Samuel	98.7	95.2±0.7	94.9	0.01	18.20	0.29
OM 11-3007/Abel	98.7	86.8±1.3	80.6	–	–	–
OM 2803/Marafon	92.8	79.0±1.3	78.6	–	–	–
OM 2803/Abel	92.8	93.6±0.6	80.6	–	–	–
TR 12-115/Vandrounik	92.6	88.0±0.8	91.0	–	–	–
Holz/TR 12-115	89.4	75.4±0.9	92.6	–	–	–
Marafon/Abel	78.6	79.0±0.9	80.6	0.35	9.10	0.82
Samuel/Percy Can	104.7	99.3±1.5	104.7	–	–	–

Table 5, Continued

Crossing combinations	♀	X±Sx	♂	H^2	*Tf*, %	*Td*, %
Percy Can/Inermis	104.7	87.1±1.9	99.1	–	–	–
Percy Can/Abel	104.7	91.4±0.7	80.6	–	–	–

Note: *Max ♀♂ – maximum value of the trait in parental forms, X±Sx – mean value of the trait in* F_2*,* H^2 *– coefficient of heritability in the broad sense, Tf – transgression frequency, Td – transgression degree*
Source: *compiled by the authors of this study*

The conducted selection-genetic analysis of studying the nature of inheritance, frequency, and degree of transgressive variability of productivity traits in F_2 of naked oat helped identify transgressive forms in which productivity elements varied widely. The hybrid populations differed in the frequency and degree of transgression. Notably, the nature of heritability H^2 had a considerable influence on the transgression parameters, which is determined, to a greater extent, by the genotype-specific characteristics of the parental components.

In the studies of Ukrainian and foreign scientists, the results of research on transgressive variability in various agricultural crops have been presented (Lozinsky *et al.*, 2021; Cazzola *et al.*, 2020; Al-Bakry, 2021). In most studies, breeding lines and varieties were obtained that were characterized by certain quantitative traits more pronounced compared to the parental forms (Ahamad *et al.*, 2022). For instance, A. Koroluk *et al.* (2022) observed a prominent level of variability in productivity traits in F_2 hybrid populations.

In their research, L.P. Necheporenko and S.D. Orlov (2020) emphasized the importance of focusing on hybrid generations, starting from F_2, in the initial stages of the selection process. The scientists involved genetically diverse domestic and foreign varieties and samples of different ecological and geographical origins in the breeding process to ensure a wide range of formative processes in hybrid generations. As a result of crosses, the oat breeding material significantly differed in key indicators during the research.

N.I. Vasko (2018) notes that the study of ear length is essential for breeding improvement, and selection based on this trait allows the creation of the desired length in combination with a greater number of ears, grains, and larger grain size. Research by several scientists has provided numerous facts about the emergence of new forms in ear length and other characteristics not present in the parental plants, which can be attributed to transgression.

In their research on oat ear productivity in second-generation hybrids (F_2), Petrov *et al.* (2017) determined that the coefficient of heritability (H^2) for this trait exhibited high values in all hybrid populations, along with positive transgressions. However, concerning the trait of the number of grains in the ear, the scientists observed a segregation towards the inferior parental component when parents with different levels of this trait were involved in the crossbreeding. On the other hand, when the parental components had mostly similar values for this trait, the manifestation of negative transgression occurred. During the investigation of the inheritance pattern of this trait, the researchers obtained high heritability coefficients (H^2), which ranged from 53.2 to 68.2, depending on the specific hybrid combination.

A.A. Trushko and S.P. Khaletsky (2019), during their research, identified transgressive forms in all F_2 crossing combinations. In their studies, the scientists paid special attention not only to the inheritance pattern and manifestation of transgressions concerning ear productivity traits but also to the plant height. However, regarding the latter trait, they were interested in both positive and negative transgressions. Meanwhile, N.I. Vasko (2018), studying barley, notes that selecting for plant height is promising, although its impact on productivity is indirect. However, in the breeding process, the level of expression of this trait must be considered, as a reduction in plant height may lead to a loss of yield due to a decrease in vegetative mass and nutrient assimilation. Nevertheless, the aforementioned researchers identified high transgressions both among tall and short forms in their studies. The analysis of yield elements such as "number of grains in the ear" and "grain weight per ear" allowed them to identify transgressions in 60% of hybrid combinations obtained through crossbreeding local ecotypes of oats with geographically distant ones.

Scientific literature has accumulated a wealth of evidence regarding transgressive variability and inheritance patterns of quantitative traits in crops such as wheat, barley, and rye. However, oats, in genetic terms, are still relatively understudied, necessitating a more detailed analysis of trait characteristics and transgressive variability.

CONCLUSIONS

The most valuable hybrid combinations for breeding work aimed at increasing yield are those that exhibit positive transgression in productivity traits. Productivity is the result of the integrated interaction of genes that control all its structural elements, which, in turn, can be inherited independently of each other. Thus, productivity has numerous variations in the interaction of plant traits, resulting in a wide spectrum of manifestations.

The research revealed that the heritability coefficient varied from low to high depending on the genotype, but for most studied oat traits, an intermediate value predominated. Transgressions were observed in all studied traits of F_2 naked oat hybrids. Among the F_2 hybrid populations, the best ones were identified based on the degree and frequency of positive transgression: for ear length – Samuel/Percy Can, Skarb Ukrainy/Abel, Skarb Ukrainy/w/o No. Ren Nuda, OM 11-3007/TR 12-115, OM 2803/Abel, and Marafon/Abel; for the number of ears in the panicle – OM 2803/Abel, Marafon/Abel, Samuel/Percy Can, OM 11-3007/Pushkinskyi, OM 11-3007/Samuel, and Skarb Ukrainy/Abel; for the number of grains per ear – OM 2803/Abel, Skarb Ukrainy/w/o No. Ren Nuda, OM 11-3007/Holz, OM 2803/Marafon, and OM 11-3007/Abel; for grain weight per ear – Samuel/Percy Can, Percy Can/Inermis, Percy Can/Abel, and Marafon/Abel.

The obtained initial material of naked oats will facilitate the continuation of breeding work to create new high-yielding and adapted varieties for the conditions of the eastern Forest-Steppe of Ukraine and to expand the existing genetic diversity.

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CONFLICT OF INTEREST

The authors of this study declare no conflict of interest.

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Прояв трансгресивної мінливості елементів продуктивності у гібридів F_2 вівса голозерного

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Анотація. Одним з найефективніших методів підвищення врожайності, стійкості до абіотичних та біотичних чинників середовища є генетично-селекційне поліпшення сортів. Вирішення цих задач можливе з використанням позитивних трансгресій, які на даному етапі селекції мають важливе практичне значення. Метою досліджень було встановлення коефіцієнту успадковуваності в широкому сенсі (H^2), ступеня і частоти трансгресій за елементами продуктивності у гібридів другого покоління вівса голозерного, створених в результаті схрещування за еколого-географічним принципом та добір господарсько-цінних біотипів для подальшої селекційної роботи. Протягом 2021 року проводили дослідження 15 міжсортових гібридів. Аналізували F_2 та батьківські компоненти за ознаками: висота рослин, довжина волоті, кількість колосків в колосі, кількість зерен з волоті та маса зерна з волоті. Використовували польовий метод дослідження (проведення фенологічних спостережень), лабораторний (структурний аналіз досліджуваного матеріалу) та математично-статистичний (об'єктивна оцінка одержаних експериментальних даних). Високий рівень коефіцієнта спостерігався за ознакою «маса зерна з волоті» в межах 0,66 – 0,88 у гібридних популяцій ОМ 11-3007/Abel, ОМ 2803/Abel, Percy Can/Инермис, Percy Can/Abel. Аналіз другого покоління F_2 міжсортових гібридів вівса голозерного дозволив виділити трансгресії за всіма досліджуваними ознаками. Найбільша кількість позитивних трансгресій встановлено за такими елементами продуктивності: довжина волоті (Тч 31,82 – 59,09 %, Тс 7,53 – 15,49 %); кількість колосків у волоті (Тч 27,30 – 54,50 %, Тс 8,85 – 26,49 %), кількість зерен з волоті (Тч 45,50 – 77,27 %, Тс 16,63 – 27,62 %.) та маса зерна з волоті (Тч 63,64 – 81,80 %, Тс 18,12 – 25,36 %). Селекційно-генетичний аналіз вивчення характеру успадковуваності, частоти і ступеня трансгресивної мінливості ознак продуктивності волоті F_2 вівса голозерного, дозволив виділити значну кількість трансгресивних форм, в яких елементи продуктивності варіюють в широких межах, що свідчить про успішне проведення селекційної роботи в створенні перспективного високопродуктивного селекційного матеріалу

Ключові слова: овес голозерний; елементи продуктивності; гібридні комбінації; батьківські компоненти; успадкування; трансгресія