

# The study of the nature of the inheritance of quantitative traits in F<sub>1</sub> hybrids of winter soft wheat

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**Abstract.** In the conditions of the south of the Nonchernozem Zone, intraspecific hybridization of winter soft wheat was carried out. When selecting parental forms used in crossing, special attention was paid to such economically valuable traits as productive tillering capacity, the number of grains and the mass of grain per spike. The true (H<sub>tru</sub>) and hypothetical heterosis (H<sub>hyp</sub>) on the basis of "plant height", "length of the lower internode", "length of the upper internode", "general tillering capacity", "productive tillering capacity", "spike length", "number of spikelets", "number of grains" and "grain weight per spike" were determined. It was established that the inheritance of quantitative traits in hybrids of the first generation was distinguished by the complex nature of distribution by types. Studies have made possible to identify 5 hybrid combinations F<sub>1</sub>, in which the effect of heterosis manifests itself simultaneously on five quantitative characteristics (ear length, number of spikelets per ear, number of grains per ear, grain weight per ear, mass grain from a plant).

## 1 Introduction

One of the ways to increase the yield of winter wheat is to introduce high-yielding new varieties into production. According to scientists, the contribution of breeding to the annual increase in yield is about 1 % [1, 2]. At the same time, the value of the variety in increasing the yield is comparable to the value of cultivation technologies [2, 3].

To create popular varieties of winter wheat, a preliminary study of the gene pool of source material for selection on a set of economically valuable traits is required. As the results of research by a number of scientists show, such a study makes it possible to expand knowledge of ecological and geographical variability and to identify sources of valuable traits for specific conditions [4, 5].

The success of creating the source material of winter wheat with adaptive properties largely depends on a targeted search for sources of economically valuable traits [6].

Marking some valuable genotypes in selection work largely depends on the plant reproduction biology, characteristics of the character trait, hybrid generation, environmental conditions and other factors [7]. For selection efficiency, it is necessary to identify the genotype by phenotype accurately, but this is hampered by the fact that most of the economically valuable traits are quantitative and depend on environmental factors [8].

The breeding value of hybrid combinations can be determined from the results of testing them in early generations with relatively high accuracy [9]. However, intensive visual selection can lead to loss of some

valuable genotypes. Determining the combining ability of the source material makes it possible to get rid of a huge number of unpromising hybrid combinations and thereby dramatically increase the scale of crosses for the most valuable ones [8, 10, 11].

Thus, the study of patterns of inheritance of the most economically valuable traits does not lose its relevance even now.

The aim of the research was to study the degree of phenotypic domination and the effect of heterosis in inter-variety F<sub>1</sub> hybrids of winter soft wheat.

## 2 Materials and methods

Hybridization was carried out using the Krasnodar method of restricted free pollination. Varieties selected during the study of the VIR collection, which represented various ecological-geographical groups, took part as the maternal forms in the crossing.

F<sub>1</sub> hybrids were planted manually in meter rows, with a feeding area of 2–3 x 22.5 cm together with the parental forms according to the scheme: maternal form – F<sub>1</sub> – paternal form. Harvesting was manual. Then biometric analysis of F<sub>1</sub> hybrids and parental forms took place.

The nature of the inheritance of quantitative traits was determined by the Griffing method [12], the values of the true and hypothetical heterosis – according to D.S. Omarov [13].

Varieties Volzhskaya N, Danaya, Yesenia, Pavlovka, Donschina and Erythrospermum served as male parent forms 37 / 14.

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### 3 Results and discussion

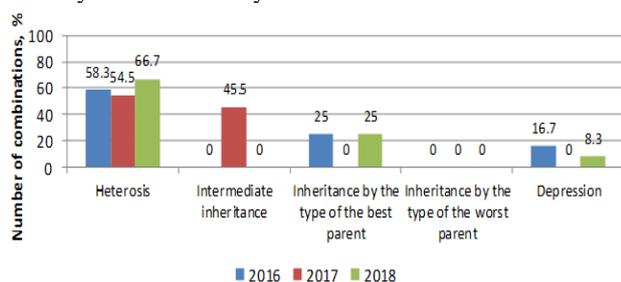
78 hybrid F1 combinations were selected for study for the period 2015–2017. The set of hybrid grains changed over the years and ecological-geographical groups significantly and varied from 0 to 76.0 %.

Yesenia, Pavlovka, Donschina and Erythrosperrum 37 / 14 pollen varieties had earing 6-11 days earlier than late ripening varieties, which in some cases caused a low percentage of hybrid seeds. Varieties Moskovskaya 39, Volzhskaya 22 and Pavlovka did not give any hybrid grains for some combinations in 2016, which to some extent can be explained by genetic features and weather conditions during pollination.

The set of hybrid seeds was significantly higher in 2017 in combinations involving Yesenia and Erythrosperrum 37 / 14 (61.0–76.0 %).

The results of the analysis of F1 hybrids on the inheritance of quantitative traits in 2016–2018 made it possible to determine the superiority of individual hybrid combinations for most parameters.

The largest number of hybrid combinations had heterosis in F1 marked by the height of the plant during all the years of the study.



**Fig. 1.** The nature of the inheritance of plant height in F1 hybrids in 2016–2018

In most combinations, heterosis was observed (54.4–66.7 %) and inheritance according to the type of a taller parent (25 % in 2016 and 2018), which is undesirable for selection of highly productive forms (Fig. 1.). In 2018, most hybrid combinations lodged.

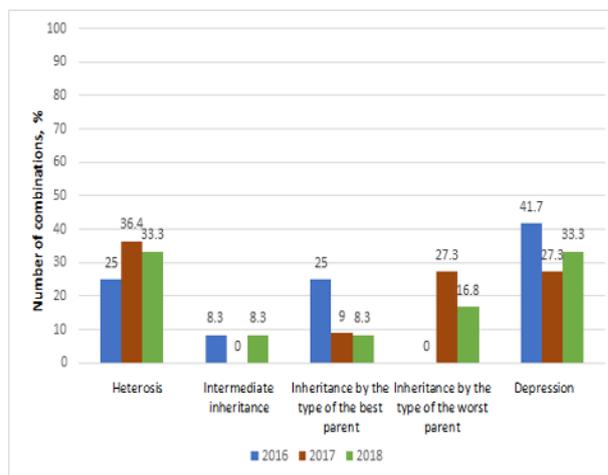
Some depression on the basis of “plant height” was observed in 8.3–16.7 % of the combinations for three years, which under the current conditions indicates their value in the selection to reduce the plant height.

The strong evasion of F1 hybrids towards the short component of crossing was observed in combinations Mironovskaya 808 x Viola and Guberniya x Eritrosperrum 37 / 14. The male parent form had larger effect in the combinations.

The tallest were hybrids, where varieties Volzhskaya 15, Glafira and Moskovskaya 56 were present as male parent forms.

Sharp fluctuations in the hydrothermal regime lead to a strong lodging of winter wheat crops, which affects the formation of the crop and leads to an increase in losses during mechanized harvesting.

Such conditions impose special requirements not only on plant height, but also on the size of individual internodes. Plants with the smallest length of the lower internode are considered more resistant to lodging.



**Fig. 2.** The nature of the inheritance of the length of the lower internode in F1 hybrids in 2016–2018

The conducted studies have established that the most promising for further breeding work are hybrid combinations involving varieties Volzhskaya K, Pavlovka, Volzhskaya N, Danaya. In the presence of these parental forms in combinations, inheritance of the length of the lower internode by type of depression is noted (Fig. 2). The smallest length of the lower internode was in plants from the hybrid combination Volzhskaya N x Donschina and it was 2 cm.

The value of true heterosis (Htrue) by feature “the length of the lower internode” was 74.07 % in the combination of Memory of Fedin x Mironovskaya 29.

In the majority of combinations, inheritance of productive tilling capacity by the type of heterosis was noted in 66.7 % of combinations in 2018. Some depression in productive tilling capacity was observed in 8.3–41.8 % of the combinations. The highest percentage of heterosis was observed in combinations of Gileya x Yesenia and Glafira x Erythrosperrum 37 / 14.

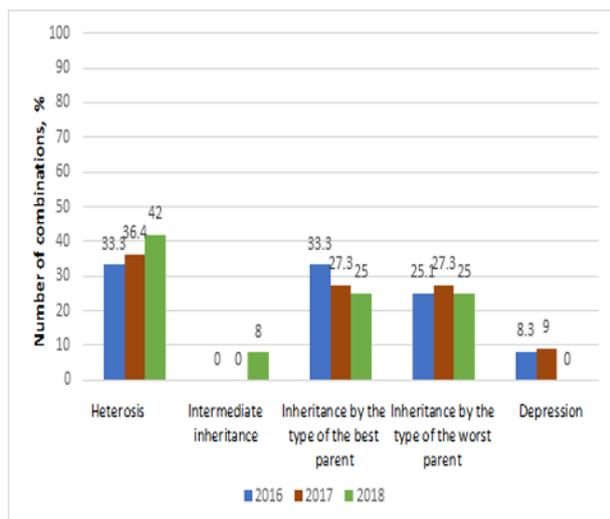
The greatest effect of heterosis on productive tilling capacity was noted in combinations where Volzhskaya 15, Volzhskaya N and Yesenia varieties were used as the male parent form.

On the basis of the length of the spike, all types of inheritance were marked. Inheritance by the type of heterosis (in 58.3 % of combinations) was observed most often, as well as by the type of intermediate inheritance, better parent and depression (8.3 %).

As for the length of the ear, the greatest effect of heterosis in 2016 was noted in combinations Viola x Erythrosperrum 37 / 14 and Erythrosperrum 37 / 14 x Eseniya. In 2017, the greatest effect of heterosis was in combinations with the participation of Mironovskaya bearded, Erythrosperrum 37 / 14, Volzhskaya N and Pavlovka.

As for the length of the ear, the greatest effect of heterosis in 2018 was observed in combinations involving Khortitsa variety. The average length of the ears of hybrids was 9.5–10.1 cm.

It should be noted that under adverse vegetation conditions, hybrids with heterosis and intermediate type of inheritance prevail as for the length of the ear.



**Fig. 3.** The nature of the inheritance of the length of the upper internode in F1 hybrids in 2016-2018

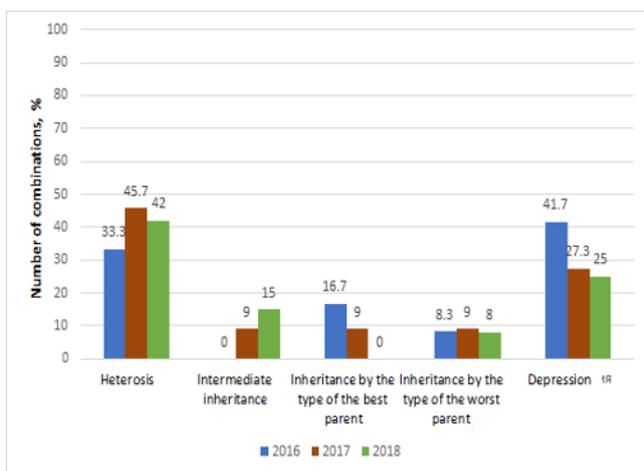
The length of the upper internode has an effect on a whole complex of attributes to varying degrees: plant height, resistance to lodging and drought, and productivity. This feature can be used in the selection of highly productive forms in low and medium growth forms.

It should be noted that the nature of the inheritance of the feature during the research period ranged from depression to heterosis (Fig. 3). The greatest length of the upper internode was observed in F1 hybrids in 2016 in combinations Mironovskaya 808 x Viola (45.3 cm), Tarasovskaya 29 x Glafira (45.3 cm).

At the highest level, inheritance of the length of the upper internode by the type of heterosis was observed in 42 % of combinations in 2018. Depression was noted in 2016 and 2017 in 8.3 – 9.0 % of combinations.

The highest percentage of heterosis was noted in combinations Inna x Yesenia, Danaya x Volzhskaya N, Volzhskaya K x Pavlovka.

The true heterosis ( $H_{true}$ ) was 17.8 % in combinations Volzhskaya N x Danaya and Pavlovka x Volzhskaya N.

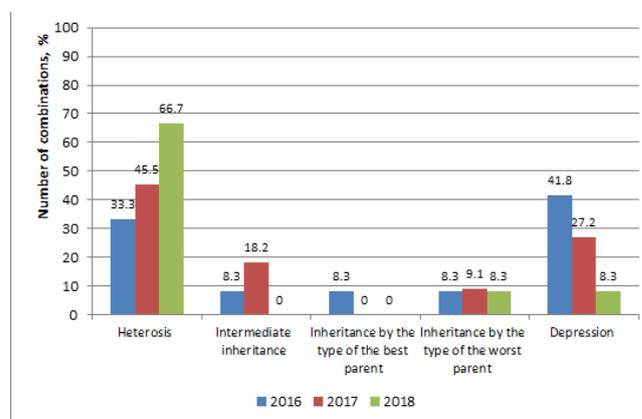


**Fig. 4.** The nature of the inheritance of general tilling capacity in F1 hybrids in 2016-2018

Inheritance of general tilling capacity in the studied combinations proceeded mainly in the type of over domination (heterosis) (33.3–45.7 %). In 2016, the prevalence of combinations with negative over domination (depression) was 41.7 % (Fig. 4).

The high effect of heterosis was in combinations involving varieties of Memory of Fedin, Mironovskaya 29, Volzhskaya K, Pavlovka, Inna.

The true heterosis ( $H_{true}$ ) was 54.1 % in the combination of Memory Fedin x Mironovskaya 29.



**Fig. 5.** The nature of the inheritance of productive tilling capacity in F1 hybrids in 2016-2018

At the highest level, inheritance of productive tilling capacity by heterosis type was observed in 66.7 % of combinations in 2018 (Fig. 5). In 8.3–41.8 % of combinations, depression in productive tilling capacity was observed. The highest percentage of heterosis was noted in combinations of Gilea x Yesenia and Glafira x Erythrospermum 37 / 14.

The greatest effect of heterosis in productive tilling capacity was noted in combinations where varieties Volzhskaya 15, Volzhskaya N, Yesenia were used as the paternal form.

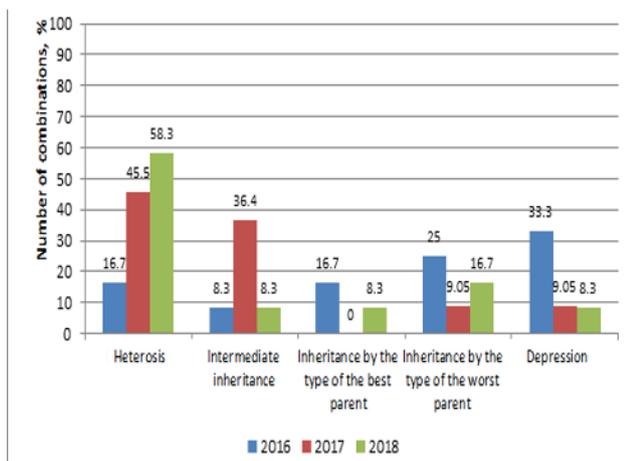
According to the spike length, all types of inheritance are noted. Most often, inheritance was observed by the type of heterosis (in 58.3 % of combinations), equally – by the type of intermediate inheritance, the best parent and depression (8.3 %) (Fig. 6).

The greatest heterosis effect in 2016 along the spike length was noted in combinations Viola x Erythrospermum 37 / 14 and Erythrospermum 37 / 14 x Esenia. In 2017, the greatest effect of heterosis was in combinations with MironovskayaOstistaya, Erythrospermum 37 / 14, Volzhskaya N, Pavlovka.

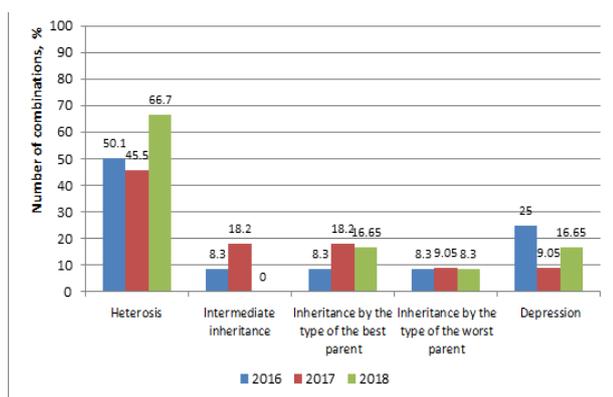
In 2018, the greatest effect of heterosis along the length of the spike was manifested in combinations involving the Khortitsa variety. The length of ears in hybrids was on average 9.5–10.1 cm.

It should be noted that under adverse growing conditions hybrids with heterosis and some intermediate type of inheritance prevail.

The value of true heterosis ( $H_{true}$ ) was 11.8–21.2 %. The length of hybrid ears of more than 10 cm was noted in combinations involving varieties Khortytysya, Gilea and Yesenia.



**Fig. 6.** The nature of the inheritance of spike length in F1 hybrids in 2016-2018



**Fig. 7.** The nature of the inheritance of the number of spikelets per ear in F1 hybrids in 2016-2018

All types of inheritance were noted (Fig. 7) by the number of spikelets in the ear. Inheritance by the type of heterosis was most often observed (in 45.5–66.7 % of combinations), noticeably to a lesser extent – by the type of the worst parent (8.3–9.05 %). Inheritance by the type of a better parent and depression were equally manifested (9.05–25 %).

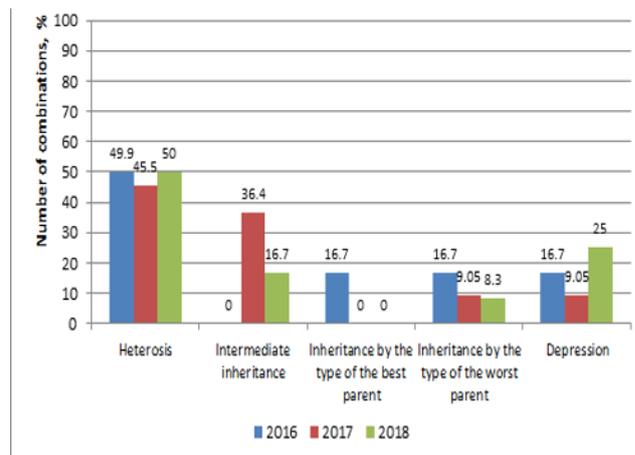
In combinations, a low  $H_{tru}$  was observed, the value of which varied from 1.8 to 15.6 %. The highest values of true heterosis were noted in the combinations of crosses, where varieties Khortitsa, Yeseniya and Danaya were the parent components.

According to the number of grains per ear, heterosis combinations prevailed in F1 hybrids (50 %). By the number of grains per ear and ear productivity in F1 hybrids, heterosis prevailed in 2016 (Fig. 8). The greatest heterosis value was observed in combinations Mironovskaya 33 x Volzhskaya 15, Pavlovka x Viola, Angelina x Viola and Ershovskaya 10 x Glafira.

In 2017, combinations with Volzhskaya 15, Pavlovka, In Memory of Fedin and Danaya were heterotic. In 2018 the largest number of grains per ear of F1 hybrids was observed in combination Khortitsa x Yeseniya, Khortitsa x Erythrosperrum 37 / 14, STRG 806015 x Yeseniya.

Combinations with Khortitsa, Yeseniya and Erythrosperrum 37 / 14 varieties differed by positive

super dominance ( $H_{tru} = 18.6–20.7$  and  $H_{hyp} = 28.8–29.5$ ). The average number of grains according to the hybrid combinations was 44–47 pieces.

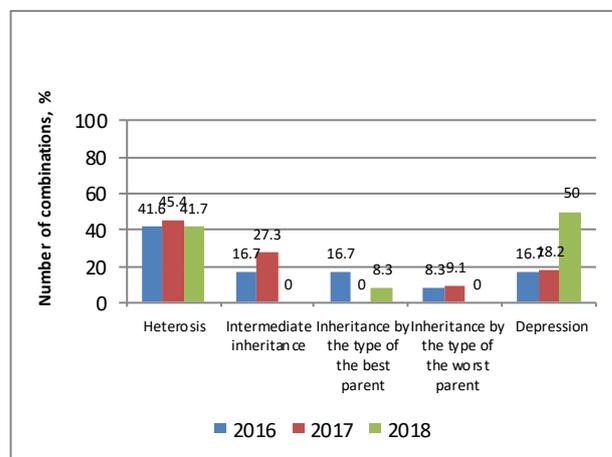


**Fig. 8.** The nature of the inheritance of the number of grains per ear in F1 hybrids in 2016–2018

In 2018, the weight of grain from an ear in F1 hybrids was dominated by depression (Fig. 9). Over the years of research, heterosis was noted in 41.6–45.4 % combinations.

The value of the trait in hybrids of the first generation varied from 1.63 to 2.8 g. The maximum effect of true heterosis ( $H_{tru} = 39.9$ ) was noted in combination with STRG 806015 and Yeseniya varieties.

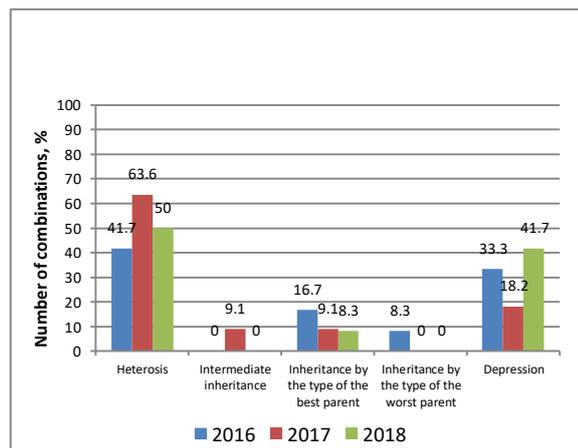
Its highest values were in 2018 in combinations of STRG 806015 x Erythrosperrum 37 / 14, STRG 806015 x Eseniya, Gileya x Yeseniya and Khortitsa x Erythrosperrum 37 / 14. The grain weight per spike was 2.6–2.8 g.



**Fig. 9.** The nature of the inheritance of the mass of grain from the ear in F1 hybrids in 2016–2018

Heterosis was noted by the weight of grain from a plant in 41.7–63.6 % of combinations, and depression – in 18.2–50 %. By mass of grain from a plant, heterosis was observed in 50 % of combinations and depression – in 41.7 %. The weight of grain from a plant in F1 hybrids

varied within 3.53–8.23 g. Combinations with varieties STRG 806015, Yeseniya and Erythrospermum line 37 / 14 had high rates of true heterosis ( $H_{tru} = 23.0\text{--}45.9$ ).



**Fig. 10.** The nature of the inheritance of grain mass from the plant in F1 hybrids in 2016-2018

## 4 Conclusion

As a result of the research, it was established that the inheritance of quantitative traits in hybrids of the first generation was distinguished by the complex nature of distribution by type.

Thus, studies have made it possible to identify 5 hybrid combinations of F1, in which the effect of heterosis manifests itself simultaneously on five quantitative characteristics (spike length, number of spikelets per ear, number of grains per ear, grain weight per ear, weight of grain per plant). The resulting hybrid combinations and the best sources of economically valuable traits will be used in further breeding work.

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