ECOLOGY, BIOTECHNOLOGY, AGRICULTURE AND FORESTRY

IN THE 21ST CENTURY

PROBLEMS AND SOLUTIONS

EDITED BY
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ECOLOGY, BIOTECHNOLOGY, AGRICULTURE AND FORESTRY IN THE 21ST CENTURY: PROBLEMS AND SOLUTIONS

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Mykola DOLYA, Ph.D., Prof., Head Department of Integrated Plant Protection and Quarantine of National University of Bioresources and Nature Management;
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The monograph is a collection of the results of scientists' achievements obtained directly in real conditions. The authors are recognized specialists in their fields, as well as young scientists and graduate students of Ukraine. The studies are conceptually grouped in sections: biotechnology, ecology, agriculture, forestry, sustainable development of the economy and the principles of effective agribusiness. The monograph will be of interest to specialists in biotechnology, ecology, breeding, plant protection, agrochemistry, soil science, forestry, agribusiness, etc., researchers, teachers, graduate students and students of specialized specialties of higher educational institutions, as well as everyone who is interested in sustainable development in the agricultural sphere and Green Deal Implementation strategies.

Keywords: sustainable development, modern technologies, agricultural production, biotechnology, ecology, plant protection, forestry, agribusiness.

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SECTION 1. BIOTECHNOLOGY

COMBINING ABILITY OF SOYBEAN PLANT HYBRIDIZATION COMPONENTS IN TWO-TESTER CROSSES

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Two-tester analysis of topcrosses of soybean varieties differing in valuable economic traits and ecological and geographical origin was used in the study. The purpose of the research was to determine the combinational ability of soybean varieties by elements of the yield structure. The subject of research is a set of valuable economic traits of soybean varieties. Research methods was to evaluate both the ZCZ and SCZ effects of the five varieties under study: Sawyer 2-95, Ustia, Medea, Kyivska 97, and Kharkivska Skoroglaya in full two-tester topcrosses.

In hybrid populations, the degree and frequency of positive transgressions have been determined, which is a breeding material for creating new varieties through hybridization.

The high effects of ZKZ on plant height and attachment of lower beans in the variety Sawyer 2-95 and tester KiVin; on the number of productive nodes - in the varieties Sawyer 2-95, Medea, Kyivska 97 and tester KiVin; on the number of beans per plant - in the varieties Ustia, Kyivska 97 and tester KiVin; by the number of seeds per plant - in varieties Medea, Kyivska 97 and tester Goverla; by the weight of 1000 seeds - in varieties Sawyer 2-95, Kyivska 97 and tester Goverla; by the weight of grain per plant - in varieties Medea, Kyivska 97 and tester Goverla; by the yield - in varieties Medea, Kyivska 97 and tester Goverla. It was found that additive effects of genes were dominant in the genetic control of plant height and lower bean attachment, elements of yield structure and yield, but there was also a significant non-additive effect. In terms of the number of beans per plant, number of seeds per plant, and weight of seeds per plant, in the vast majority of hybrid populations, inheritance by the type of superdominance and dominance of the parental form with a higher manifestation of the trait was observed.

Scientific novelty is to establish dominance indices, which allowed us to identify crossing combinations that are distinguished by the overdominance of these traits and have significant breeding value: Sawyer 2-95 × Hoverla, Kyivska 97 × Hoverla, Kharkivska Skoroglya × Hoverla, Sawyer 2-95 × KiVin, Kharkivska Skoroglya × KiVin, and the identified hybrid combinations are proposed for targeted use in breeding practice to create new soybean varieties.

Key words: features, tester, hybridization components, dominance, additive effects.

Introduction

Modern plant breeding science has a significant number of methods for creating varieties and hybrids of agricultural plants, from traditional to genetic engineering. But the simplest and most common is the hybridization method [1, 7].

At the initial stages of a breeding program, 60-90% of valuable genotypes are rejected and irretrievably lost from a large mass of breeding material [2, 15, 21-29].

Analysis of the latest research and publications.

Many modern varieties have common ancestors, and therefore a homogeneous genetic nature. The basis for the creation of new plant varieties is their genotypic variability, so it is important to expand the genetic basis of newly developed varieties [3, 16-18].

The knowledge of the patterns of inheritance of traits that operate in hybrid populations allows for more efficient selection, culling of low-value forms and preserve promising genotypes. Considerable attention is paid to the study of the degree and nature of heterosis in first-generation hybrids, determining the degree of inheritance of the corresponding quantitative trait by the dominance coefficient, which characterizes the degree of phenotypic manifestation of one or more dominant genes that determine this quantitative trait, shows how many times the value of the trait in F1 plants exceeds its average value in plants of parental forms.

Selection in F2 and F3 nursery breeding, based on both eyeballing and plant productivity or yield components, is inefficient and unreliable. The main traits for plant selection at the initial stages of breeding are the number of productive nodes, beans per node and number of seeds per bean, number of beans per plant, seeds per bean and weight of 1000 seeds [4-6, 19, 20].

The use of parental forms with a previously studied high combining ability (CA) in crosses will help to increase the efficiency of hybridization [7].

Combining ability interprets various actions and interactions of genes. It is expressed as general combining power (GCP) and specific combining power (SCP). GCV is used to determine the average value of a variety in hybrid combinations. SCV is used when characterizing individual combinations if they are better or worse than expected based on the average values of the tested varieties. The GCS is determined by the additive effects of genes, and the SCS is determined by epistasis and dominance of gene interactions [8].

Combining ability is determined using special schemes: full and incomplete diallel and topcross crosses. For a preliminary assessment of the source material, it is recommended to use topcrosses first [9].

Breeding work aimed at increasing yields requires the evaluation of varieties selected for hybridization by combining ability [10].

Material and methodology of the research

The relevance of the research is based on the tasks of the initiative topic: "Adaptive selection of legumes (beans, soybeans, chickpeas) in the Forest-Steppe of the Right Bank" (State registration number: 0121U110726).

The research was conducted in the experimental field of Vinnytsia National Agrarian University in 2019. This area is characterized by the distribution of gray forest soils of light medium loamy texture.

In our experiments, we evaluated both the ZPD and SCP effects of the five varieties under study: Sawyer 2-95, Ustia, Medea, Kyivska 97, and Kharkivska Skoroglaya in full two-tester topcrosses. Evaluation was carried out according to the following traits: plant height, lower bean attachment height, and elements of the yield structure. Varieties were used as maternal forms and testers as paternal forms.

The degree of phenotypic dominance was calculated by the formula [10, 11]:

$$hp= \frac{F1-Mp}{P\max-Mp}, \quad (1)$$

where hp – is the degree of dominance F 1 is the value of the trait in the hybrid;

Mr – is the average value of both parents;

P – max is the highest value of one of the parents.

The degree and frequency of transgression of quantitative traits according to the formulas proposed by [10-12]:

$$Tc= \frac{Пг-Пр}{Пр}*100\%, \quad (2)$$

where Tc – is the degree of transgression, %;

Pg – is the maximum value of the trait in the hybrid;

Pr – is the maximum value of the trait in the best parental form.

$$Tr = \frac{A}{B} * 100\%, \quad (3)$$

where Tr – is the frequency of transgressions, %;

A is the number of hybrid plants that prevailed on the trait of the best of the parental forms;

B is the number of hybrid plants analyzed on the trait in the combination of crosses.

Setting out the Basic Material

The presented research results are a continuation of our previous work.

The analysis of variance was carried out for the following traits: plant height, lower bean attachment, number of productive nodes, number of beans and seeds, weight of 1000 seeds and grain productivity obtained as a result of crossing these varieties, presented in Table 1 and Table 2. According to the results of the analysis, significant genotypic differences were found for the listed traits. In addition, significant effects of the general and specific combinational ability of the studied varieties were noted. The significant difference in the variation of the ZKZ and SKZ indicates that, along with the additive effects of genes, non-additive genes also have an important effect.

It should be noted that the mean square of the general combining ability for the listed traits exceeded the mean square of the specific combining ability, which varied from 12818 to 4.1, and the specific combining ability from 0.23 to 262 (Tables 1-8). The ratio of SCC to SCC was high and significant during the study period. It should be noted that the dominance of additive effects of genes in the control system of the studied traits, namely plant height and lower bean attachment, number of productive nodes, number of beans and seeds per plant, grain weight per plant, weight of 1000 seeds and yield.

Understanding the processes and mechanisms of controlling the inheritance of useful traits is the most important problem in breeding. The main thing in this matter is to unlock the genotypic potential of each parental form and its influence on the offspring. Although the role of both partners in hybridization is equivalent, it matters whether one of the crossing partners is active or passive in controlling the inheritance of certain traits. Thus, the parental form is responsible for improving quality traits is responsible for improving quality traits, while both parental forms are responsible for hereditary yield traits, although most often the maternal form is the donor of high yield. The influence of each of the parental forms on the inheritance of a trait can be observed during crossbreeding [13, 30-35].

Table 1 shows the results of the analysis of the combinational ability of soybean varieties by plant height in topcrosses.

Table 1

Plant height combinability of soybean varieties

Varieties	The effect of the ZKZ varieties	The effect of the SCZ		Constant
		Tester 1 Hoverla	Tester 2 KiVin	SCZ varieties
Sawyer 2-95	10.36	-1.58	1.58	4.99
Estuary	-14.2	-2.68	2.68	14.36
Medea	7.3	0.37	-0.37	0.27
Kyivska 97	4.96	1.32	-1.32	3.48
Kharkiv early ripening	-8.42	2.57	-2.57	13.2
Effects of short circuit testers		-0.42	0.42	
Variants of the testers' SCZ		4.39	4.39	
Nir 0.05 of varieties' SCZ		0.80		
NR 0.05 of testers' SCZ		0.50		

Analysis of variance						
Source of variation	Sum of squares	Number of degrees of freedom	Average square	Criterion F		
				actual	theoretical	
					0.05	0.01
Paternal forms of the drug	1.76	1	1.76	11.7	4.21	7.68
Maternal formulation ZKZ	917	4	229.3	1528	2.73	4.11
SCZ	36	4	9	60	2.73	4.11
Random deviations	4.1	27	0.15			

High reliable effects of general combinational ability (GCA) were found, which determine the tallness of plants in the varieties Sawyer 2-95 (+10.36), Medea (+7.3) and Kyivska 97 (+4.96). Negative effects of ZKZ were observed in the varieties Ustia (-14.2) and Kharkivska skoroglya (-8.42).

When conducting crosses, it should be taken into account that the KiVin tester provided a high significant effect of the IPM (+0.42), and the Goverla tester - low.

The tallness in the hybrid combination Sawyer 2-95 × KiVin is due to the combined effect of the additive effects of both the maternal form of ZKZ (+10.36) and the paternal form of ZKZ (+0.42). In addition, the height indices of of plants of this combination were influenced by the effects of non-additive interaction of genes (SCC = +1.58).

The combinations Medea × Hoverla and Kyivska 97 × Hoverla were tall due to the high effects of the maternal forms' ZKZ (+7.3 and +4.96) and high effects of non-additive gene interaction (SCC = +0.37 and +1.32). This is in contrast to the low effect of the paternal form (-0.42).

The high effects of the SCC (+0.42) and SCC (2.68) of the parental form Kivin (tester) in crossing with the maternal form Ustia, which is characterized by the additive effects of short stature genes, ensures tall plants. In addition, in the combination of crosses Kharkivska Skoroglya × Hoverla, despite the negative values of the maternal form (-8.42) and paternal form (-0.42), the non-additive effects of the paternal form genes increased tallness (SCC = 2.57).

However, the presented analysis of genotypic variability of plant height indicates that the dominant influence in the determination of this trait is the additive effects of maternal genes, the share of which was 95.48%, significantly lower influence was determined by the additive effects of testers genes - 3.78%, and only 0.73% by the non-additive effects of gene interaction (Fig. 1).

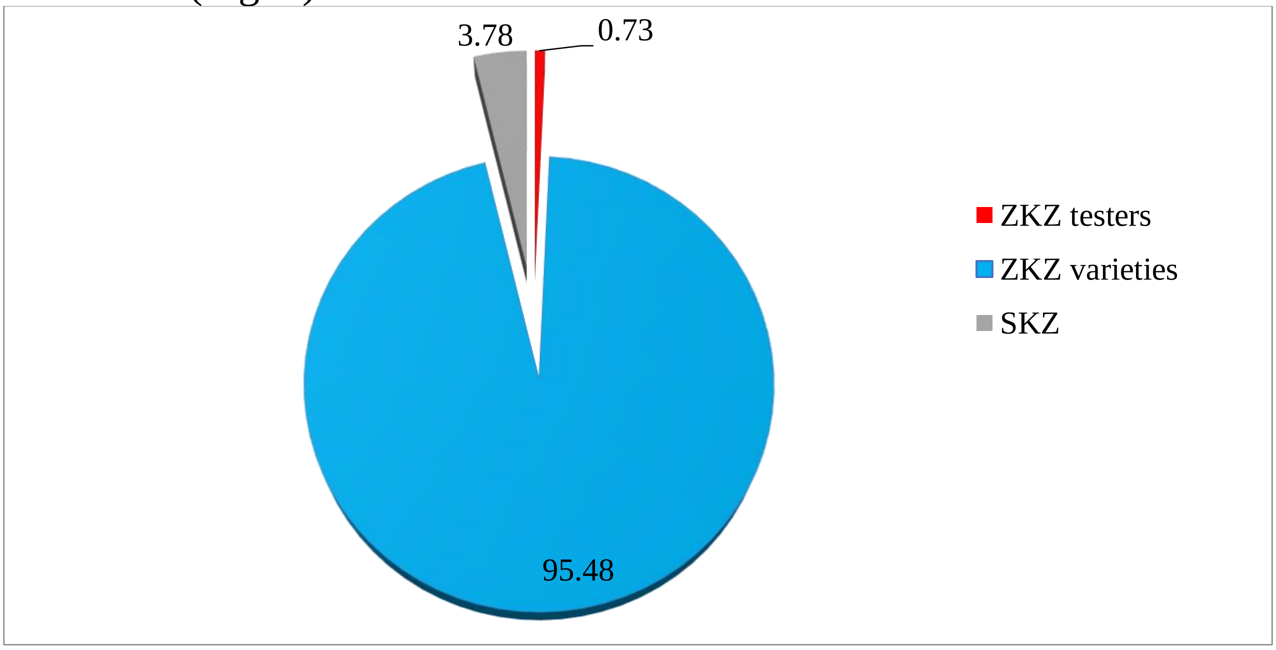

Fig. 1 Share of genotypic variation in plant height

In terms of the height of lower bean attachment, high significant effects of IPM were observed in Sawyer 2-95 (+1.21) and Kharkivska skoroglya (+0.71) (Table 2). Negative effects of the ZKZ were observed in the varieties Ustia (-0.74) and Kyivska 97 (-1.14).

When conducting crosses, it should be taken into account that a high significant effect of the IPM (+0.24) was observed in the KiVin tester, while the Goverla tester had a low effect.

Table 2

Combining ability for the height of attachment of the lower beans of soybean varieties

Varieties	The effect of the ZKZ varieties	The effect of the SCZ		Constant
		Tester 1 Hoverla	Tester 2 KiVin	SCZ varieties
Sawyer 2-95	1.21	-0.21	0.21	0.09
Estuary	-0.74	-0.06	0.06	0.007
Medea	-0.04	0.14	-0.14	0.04
Kyivska 97	-1.14	0.04	-0.04	0.003
Kharkiv early ripening	0.71	0.09	-0.09	0.02
Effects of short circuit testers		-0.42	-0.24	
Variants of the testers' SCZ		4.39	0.009	
Nir 0.05 of varieties' SCZ		0.16		
NR 0.05 of testers' SCZ		0.10		

Analysis of variance

Source of variation	Sum of squares	Number of degrees of freedom	Average square	Criterion F		
				actual	theoretical	
					0.05	0.01
Paternal forms of the drug	0.58	1	0.58	96.7	4.21	7.68
Maternal formulation ZKZ	7.63	4	1.91	318.3	2.73	4.11
SCZ	0.15	4	0.04	6.66	2.73	4.11
Random deviations	0.17	27	0.006			

High attachment of the lower beans was observed in the combination Sawyer 2-95 × KiVin due to the additive effects of the maternal form, ZKZ

(+1.21) and tester ZKZ (+0.24), along with high effects of non-additive gene interaction in pair crosses (SCZ = +0.21).

High effects of the SCC (+0.71) and the SCC (+0.09) were also noted in the hybrid combination Kharkivska Skoroglya × Hoverla, in pair crosses with the tester, that is, in determining the height of attachment of the lower beans, in addition to additive genes, there are also non-additive genes.

Pair combinations Medea × Goverla and Kyivska 97 × Goverla provided an increase in the height of lower bean attachment due to high effects of non-additive gene interaction (SCC = +0.14 and +0.04) despite the negative effects of maternal forms SCC (-0.04 and -1.14) and paternal forms SCC (-0.24).

In the paired combination Ustya × KiVin, the increase in the height of lower bean attachment is determined by the high effects of both the SCC (+0.24) and the SCS (0.06) of the paternal form, despite the negative effects of the SCC (-0.74) of the maternal form. This indicates a conditionality in the formation of the height of attachment

of the lower beans by both additive and nonadditive genes and their interaction. In the genotypic structure of variability of the height of lower bean attachment, the share of additive effects of genes of varieties was more significant compared to the testers, with the share of maternal forms being 75.64%, and the share of paternal forms - 22.82%, the influence of non-additive effects was only 1.52% (Fig. 2).

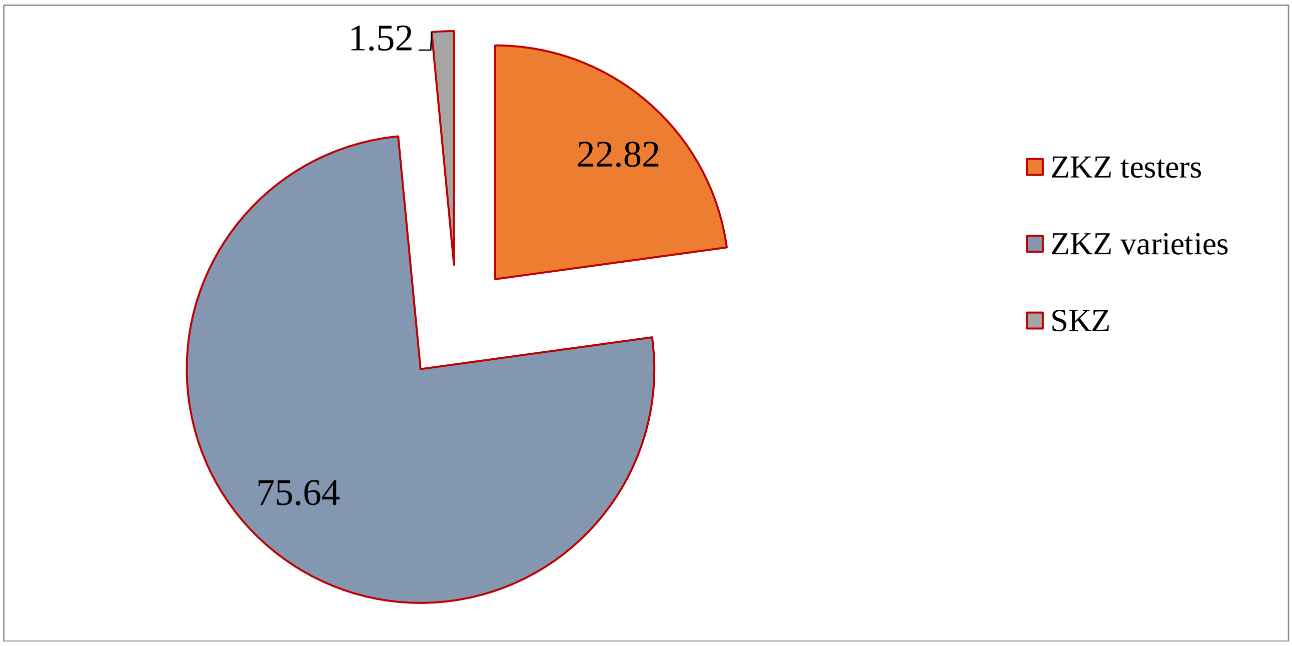

Fig. 2 Proportion of genotypic variation in the height of lower bean attachment

Source: compiled on the basis of own research

Thus, the additive effects of the genes of varieties (maternal forms) and testers (paternal forms) played a crucial role in the formation of the height of the lower bean attachment in hybrid combinations.

The value of the varieties was determined by the elements of the yield structure, in particular by the number of productive nodes on the main stem in topcrosses (Table 3).

Table 3

Combining ability by the number of productive nodes on the main stem of soybean varieties

Varieties	The effect of the ZKZ varieties	The effect of the SCZ		Constant
		Tester 1 Hoverla	Tester 2 KiVin	SCZ varieties
Sawyer 2-95	0.78	-0.12	0.12	0.03
Estuary	-2.67	0.43	-0.43	0.37
Medea	0.98	-0.02	0.02	0.001
Kyivska 97	1.53	-0.17	0.17	0.06
Kharkiv early ripening	-0.62	-0.12	0.12	0.03
Effects of short circuit testers		0.42	-0.42	
Variants of the testers' SCZ		0.036	0.036	
Nir 0.05 of varieties' SCZ		0,37		
NR 0.05 of testers' SCZ		0,23		

Analysis of variance						
Source of variation	Sum of squares	Number of degrees of freedom	Average square	Criterion F		
				actual	theoretical	
					0,05	0,01
Paternal forms of the drug	1.76	1	1.76	54.4	4.21	7.68
Maternal formulation ZKZ	22.8	4	5.7	176	2.73	4.11
SCZ	0.49	4	0.12	3.74	2.73	4.11
Random deviations	0.88	27	0.03			

Source: compiled on the basis of own research

According to the effects of ZKZ, the varieties Sawyer 2-95 (+0.78), Medea (+0.98), and Kyivska 97 (+1.53) stood out. In the varieties Ustia and Kharkivska skoroglaya, negative effects of IPM (-2.67) and (-0.62) were observed.

When creating new soybean varieties, it should be taken into account that the Hoverla tester provided a high significant effect of the ZPK (+0.42), and the KiVin tester - a low one.

A high number of productive nodes was noted in the hybrid combination Sawyer 2-95 × KiVin due to the high additive effect of the maternal form genes, ZKZ (+0.78) and non-additive effect of genes in pair crosses (+0.12).

In addition, Medea and Kyivska 97 varieties showed an increase in the number of productive nodes in pair crosses with KiVin tester due to high effects of maternal forms' ZKZ (+0.98 and +1.53) and non-additive gene interaction (SCZ = +0.02 and +0.17).

Despite the negative values of the effects of the parental form (-2.67), the hybrid combination Ustia × Hoverla increased the number of productive nodes due to high effects of the tester (+0.42) and non-additive effects of the gene interaction of SCZ (+0.43) in pair crosses. In the hybrid combination Kharkivska skoroglya × Kivin, an increase in the number of productive nodes was observed due to the influence of non-additive interaction of the SCZ genes (+0.12) in pair crosses, despite the negative values of the effects of the maternal and paternal forms of SCZ (-0.62) and SCZ (-0.42).

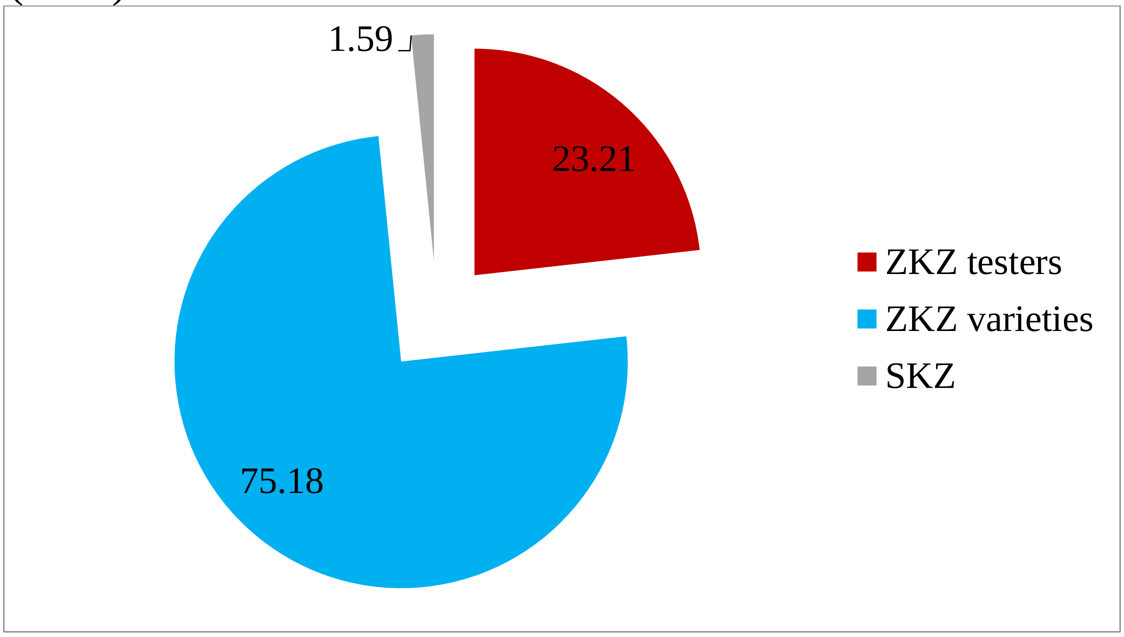

Fig. 3 Share of genotypic variability in the number of productive nodes

Thus, despite the dominant influence of the additive effects of the maternal and paternal PKD genes, the influence of non-additive gene interaction in pair crosses is still noted.

In the structure of genotypic variability of the number of productive nodes, the additive effects of varietal genes were significantly higher compared to the testers, the share of the former was 75.18%, and the share of the latter - 23.21%, the influence of non-additive effects - 1.59% (Fig. 3).

Table 4

Combining ability by number of beans per plant in soybean varieties

Varieties	The effect of the ZKZ varieties	The effect of the SCZ		Constant
		Tester 1 Hoverla	Tester 2 KiVin	SCZ varieties
Sawyer 2-95	0.08	0.24	-0.24	0.12
Estuary	0.61	-1.02	1.02	2.08
Medea	0.32	-0.82	0.82	1.34
Kyivska 97	2.82	-0.42	0.42	0.35
Kharkiv early ripening	-3.83	2.02	-2.02	8.14
Effects of short circuit testers		0.75	-0.75	
Variants of the testers' SCZ		1.24	1.24	
Nir 0.05 of varieties' SCZ		0.45		
NR 0.05 of testers' SCZ		0.46		

Analysis of variance

Source of variation	Sum of squares	Number of degrees of freedom	Average square	Criterion F		
				actual	theoretical	
					0,05	0,01
Paternal forms of the drug	5.72	1	5.72	47.7	4.21	7.68
Maternal formulation ZKZ	46.38	4	11.6	96.7	2.73	4.11
SCZ	12.05	4	3.0	25	2.73	4.11
Random deviations	3.39	27	0.12			

Varieties Kyivska 97, Medea and Sawyer 2-95 contain favorable additive genes that control the number of productive nodes on the main stem and should be purposefully included in hybridization when creating new soybean varieties.

Kyivska 97 (+2.82) and Ustia (+0.61) varieties stood out for high effects of ZKZ on the number of beans per plant, while Medea (+0.32) was characterized by slightly lower ZKZ effects (Table 4).

When conducting hybridization to increase the number of beans per plant, it should be taken into account that the Hoverla tester provided a high significant effect of IPM (+0.75), and the KiVin tester - low.

The hybrid combination Sawyer 2-95 × Hoverla against the background of the tester with high SCD (+0.75) showed high SCD effects (+0.24). The hybrid combination Kharkivska Skoroglya × Hoverla due to the high additive effect of the genes of the parental component of the SCD (+0.75) and the effects of non-additive interaction of the SCD genes (+2.02) provided an increase in the number of beans per plant in pair crosses.

The increase in the number of beans per plant in the hybrid combinations Ustia × KiVin and Medea × KiVin is mainly due to the effects of non-additive interaction of SCZ genes (+1.02 and (+0.82), as well as the effects of maternal forms (+0.61 and (+0.32).

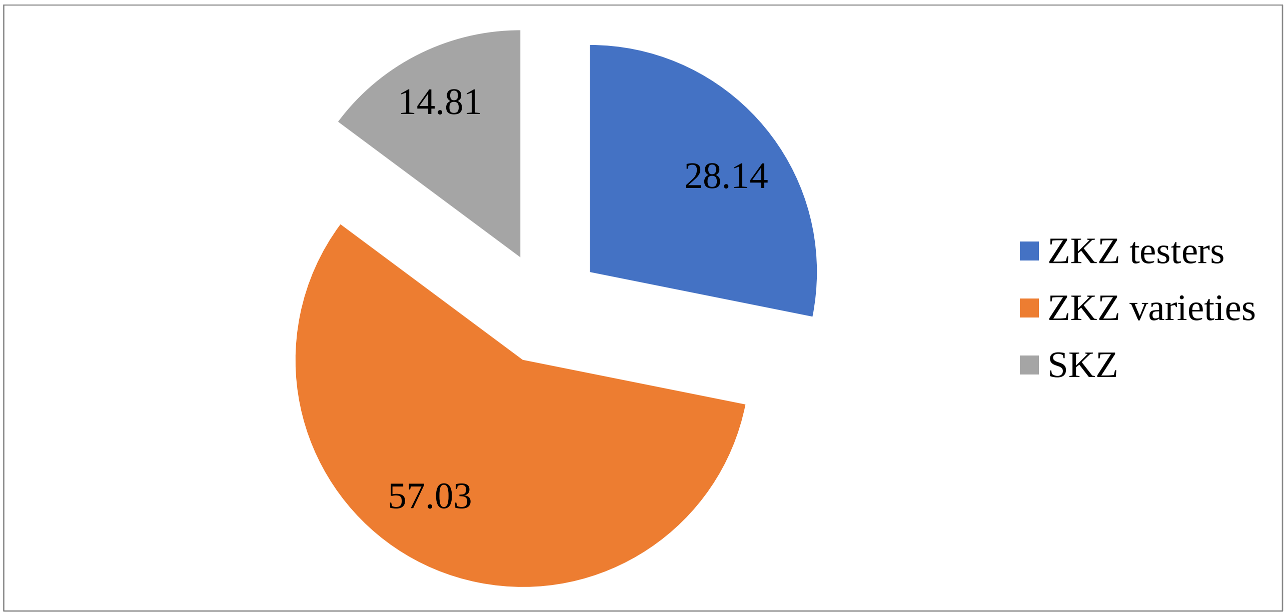

Fig. 4 Share of genotypic variability in the number of beans per plant

In the hybrid combination Kyivska 97 × KiVin, an increase in the number of beans per plant was associated with high effects of the maternal form's SCA (+2.82), high effects of the paternal form's SCA (0.42), despite negative values of the tester's SCA (-0.75). In determining the genotypic variability of the number of beans per plant, the dominant role of additive interaction was established accounted for the lion's share (57.03%) (Fig. 4).

The proportion of additivity of parental forms was also high - 28.14%, and the proportion of non-additive gene interaction was lower - 14.81%.

Similar to the number of beans, high general combining ability (GCA) was also found for the number of seeds per plant in Kyivska 97 (+10.48) and Medea (+1.45). The low total combining ability (TCA) was observed in varieties Kharkivska skoroglya (-6.93), Sawyer 2-95 (-3.92), Ustia (-1.08) and (Table 5).

Table 5

Combining ability by the number of seeds per plant in soybean varieties

Varieties	The effect of the ZKZ varieties	The effect of the SCZ		Constant
		Tester 1 Hoverla	Tester 2 KiVin	SCZ varieties
Sawyer 2-95	-3.92	0.47	-0.47	0.43
Estuary	-1.08	0.12	-0.12	0.026
Medea	1.45	0.09	-0.09	0.016
Kyivska 97	10.48	0.365	-0.365	0.266
Kharkiv early ripening	-6.93	-1.04	1.04	2.14
Effects of short circuit testers		1.54	-1.54	
Variants of the testers' SCZ		0.203	0.203	
Nir 0.05 of varieties' SCZ		0.94		
NR 0.05 of testers' SCZ		0.60		

Analysis of variance

Source of variation	Sum of squares	Number of degrees of freedom	Average square	Criterion F		
				actual	theoretical	
					0,05	0,01
Paternal forms of the drug	23.56	1	23.56	113.73	4.21	7.68
Maternal formulation ZKZ	352.69	4	88.17	425.6	2.73	4.11
SCZ	2.88	4	0.721	3.48	2.73	4.11
Random deviations	5.59	27	0.21			

The high effect of general combinational ability (GCA) was provided by the tester Hoverla (+1.54). The high number of seeds per plant was noted in the hybrid combination Kyivska 97 × Hoverla due to the dominant effect of the additive effects of the maternal form of GCV (+10.48) and the paternal form, the value of the GCV effect (+1.54). Along with the additive effects in this combination, the number of seeds depended on the effects of non-additive gene interaction (SCC = +0.365). Against the background of the tester with high SCC (+1.54), the hybrid combination Medea × Hoverla provided positive effects of SCC (+0.09).

In addition, it is worth noting the hybrid combination Kharkivska skoroglya × KiVin, in which the increase in the number of seeds per plant was exclusively

due to the influence of non-additive effects of genes (SCR = 1.04) against the background of negative effects of both the maternal and paternal forms (-6.93).

The number of seeds per plant is determined by the additive effects of genes of varieties - 78.4%. In addition, the additive effects of testers' genes also play a somewhat lower but high share - 20.95%, while non-additive effects of genes in the structure of genotypic variability accounted for the smallest share - 0.64% (Fig. 5).

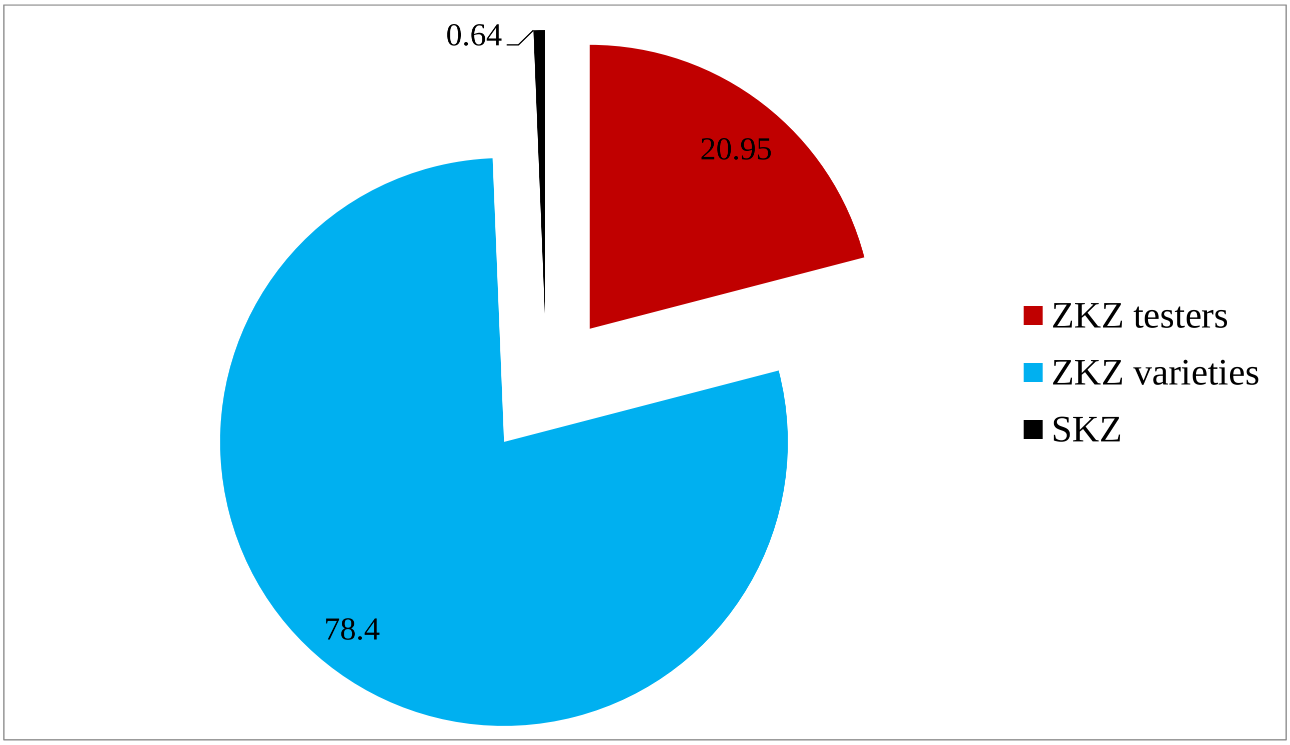

Fig. 5 Share of genotypic variability in the number of seeds per plant

According to the weight of 1000 seeds, significant differences in the effects of IPM of varieties were found (Table 6).

Table 6

Combining ability by weight of 1000 seeds in soybean varieties

Varieties	The effect of the ZKZ varieties	The effect of the SCZ		Constant
		Tester 1 Hoverla	Tester 2 KiVin	SCZ varieties
Sawyer 2-95	10.1	1.05	-1.05	2.2
Estuary	-13.8	0.93	-0.93	1.7
Medea	13.6	-2.7	2.7	14.6
Kyivska 97	7.68	0.93	-0.93	1.7
Kharkiv early ripening	-17.58	-0.2	0.2	0.08
Effects of short circuit testers		2.7	-2.7	
Variants of the testers' SCZ		-0.34	-0.34	
Nir 0.05 of varieties' SCZ		2.43		
NR 0.05 of testers' SCZ		1.53		

Analysis of variance

Source of variation	Sum of squares	Number of degrees of freedom	Average square	Criterion F		
				actual	theoretical	
					0,05	0,01
Paternal forms of the drug	72.9	1	72.9	51.8	4.21	7.68
Maternal formulation ZKZ	1678.3	4	419.6	298.3	2.73	4.11
SCZ	20.3	4	5.1	3.6	2.73	4.11
Random deviations	37.97	27	1.4			

In particular, high significant effects of ZPK were observed in varieties: Soyer 2-95 (+10.1), Medea (+13.6) and Kyivska 97 (+7.68). In varieties Kharkivska skoroglya and Ustia, low effects of IPM were observed, respectively (-17.58) and Ustia (-13.8).

When selecting parental pairs for hybridization by weight of 1000 seeds, it should be taken into account that the best of the testers was the variety Goverla, which had a ZKZ effect of +2.7.

Along with the high effects of ZKZ of varieties Sawyer 2-95 (+10.1), Kyivska 97 (+7.68) in pair combinations with the tester Goverla ZKZ (+2.7), a significant effect of SCZ for varieties Sawyer 2-95 (1.05) and

Kyivska 97 (0.93) was found, indicating the influence of the formation of 1000 seeds weight along with additive and non-additive effects of genes.

In the hybrid combination Kharkivska skoroglya × KiVin, the increase in the weight of 1000 seeds is associated exclusively with the influence of non-additive effects of genes in pair crosses. Since the SCC of both maternal and paternal forms was found to have negative values.

In the genetic control of 1000-seed weight, both additive effects of varietal genes (84.32%) and additive testers' genes (14.65%) prevailed, while non-additive effects of gene interaction amounted to only 1.01% (Fig. 6).

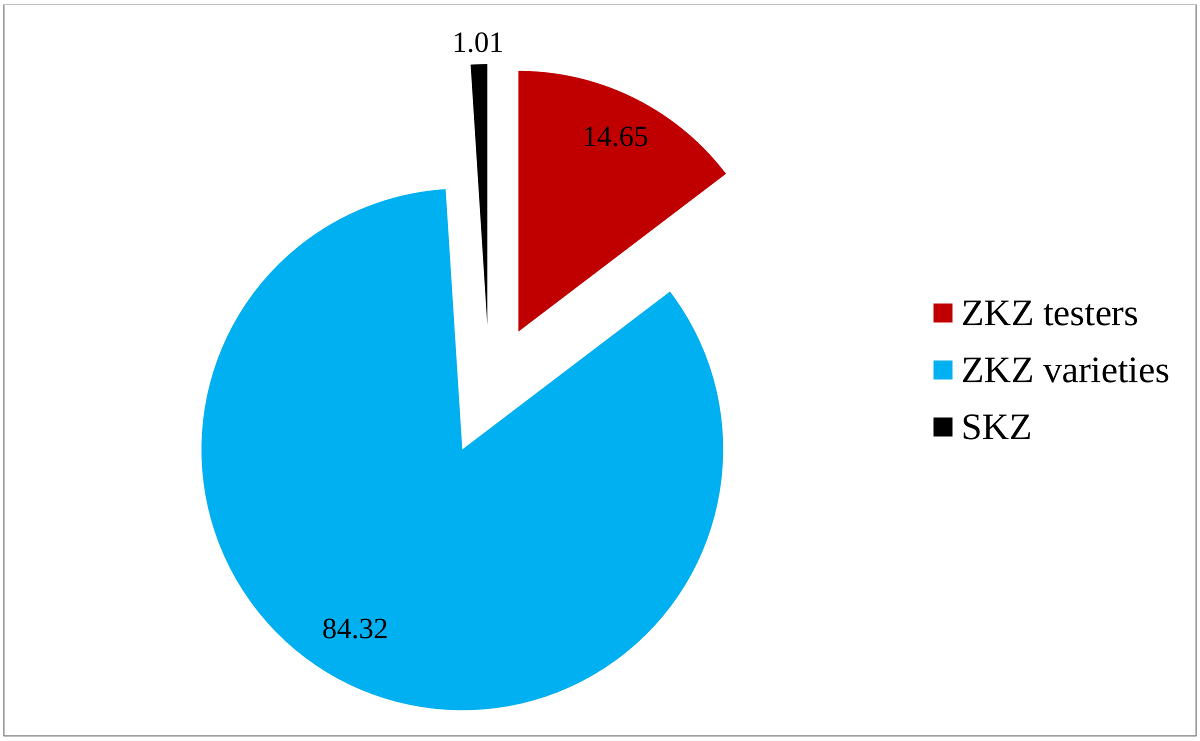

Fig. 6. The share of genotypic variability in the weight of 1000 seeds

In terms of grain weight per plant, Kyivska 97 (+2.34), Medea (+1.72) and Sawyer 2-95 (+0.91) were characterized by high additive effects, while Ustia (-1.93) and Kharkivska Skoroglya (-3.04) had low additive effects (Table 7).

In the selection of parental pairs for hybridization by grain weight per plant, it is necessary to use the tester Hoverla, which had a ZKZ effect of (+0.63). Against the background of the tester (Goverla), the effects of varieties' SCZ were significant in pair crosses with varieties Medea (+0.036) and Kyivska 97 (+0.52).

The varieties Sawyer 2-95 and Kharkivska skoroglaya stood out in pair combinations with the tester (KiVin), the SCZ of these combinations was +0.37 and +0.2.

Table 7

Combining ability by grain weight per plant in soybean varieties

Varieties	The effect of the ZKZ varieties	The effect of the SCZ		Constant
		Tester 1 Hoverla	Tester 2 KiVin	SCZ varieties
Sawyer 2-95	0.91	-0.37	0.37	0.028
Estuary	-1.93	0.023	-0.023	0.001
Medea	1.72	0.036	-0.036	0.003
Kyivska 97	2.34	0.52	-0.52	0.54
Kharkiv early ripening	-3.04	-0.20	0.20	0.08
Effects of short circuit testers		0.63	-0.63	
Variants of the testers' SCZ		0.078	0.078	
Nir 0.05 of varieties' SCZ		0.44		
NR 0.05 of testers' SCZ		0.28		

Analysis of variance

Source of variation	Sum of squares	Number of degrees of freedom	Average square	Criterion F		
				actual	theoretical	
					0,05	0,01
Paternal forms of the drug	4.09	1	4.1	82.0	4.21	7.68
Maternal formulation ZKZ	44.5	4	11.1	222	2.73	4.11
SCZ	0.9	4	0.23	4.6	2.73	4.11
Random deviations	1.25	27	0.05			

The proportion of genotypic variability in grain weight per plant indicated the main influence of additive effects of varietal genes (72.04%), and on parental (testers) - 26.48%, along with a slight influence of non-additive effects of genes - 1.47%. In terms of yield, the following varieties stood out for their high effects of general combinational ability: Kyivska 97 (+79.39), Medea (+58.56), Sawyer 2-95 (+30.94), and negative negative effects of the GCV were observed in varieties Kharkivska skoroglya (-102.93) and Ustia (-65.96) (Table 8).

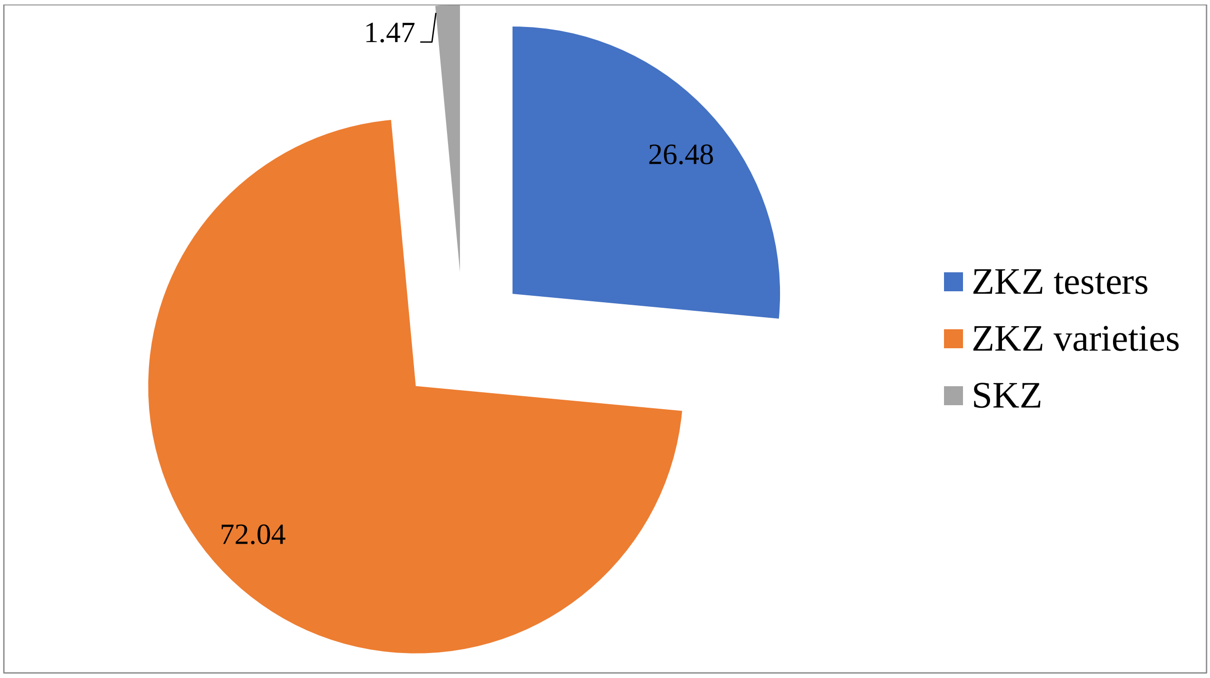

Fig. 7. The proportion of genotypic variability by grain weight per plant

In the selection of parental pairs for hybridization, the tester Goverla proved to be the best for the formation of high yields in topcrosses, with a significantly high SCC (+21.84) (Table 8). In pair combinations with tester 1 (Goverla), Kyivska 97 (+17.7), Medea (+1.11) and Ustia (+0.68) varieties were characterized by high SCZ. It is necessary to note the hybrid combination Sawyer 2-95 × KiVin, in the formation of which the additive effects of the genes of the mother form (+30.94) and non-additive effects of the genes of the pair combination of SCZ (+12.92) played a decisive role in the formation of the yield level. In addition, it is necessary to note the hybrid combination Kharkivska skoroglya × KiVin, the increase in the yield level of which was determined exclusively by the influence of non-additive effects of genes of the paired combination of SCZ (+6.54), and the influence of the additive component for both maternal and paternal components was negative.

The analysis of the structure of genotypic variability in yield showed that the contribution of non-additive effects was insignificant (1.46%), and the share of variance of parental forms (testers) was much higher - 26.73%. The high proportion of genotypic variability of hybrids depended on the additive genes of the maternal forms by 71.8 % (Fig. 8).

Taking into account the results of our research, it should be noted that high effects of ZPD on the vast majority of elements of the yield structure were observed in soybean varieties Sawyer 2-95, Medea and Kyivska 97 and tester 1 (Goverla), high effects of ZPD were observed in soybean variety Sawyer 2-95 and tester 2 (KiVin) in terms of grain productivity and yield.

Table 8

Combining ability for plant yield in soybean varieties

Varieties	The effect of the ZKZ varieties	The effect of the SCZ		Constant
		Tester 1 Hoverla	Tester 2 KiVin	SCZ varieties
Sawyer 2-95	30.94	-12.92	12.92	333.9
Estuary	-65.96	0.68	-0.68	0.92
Medea	58.56	1.11	-1.11	2.44
Kyivska 97	79.39	17.7	-17.7	625.2
Kharkiv early ripening	-102.93	-6.54	6.54	85.7
Effects of short circuit testers		21.84	-21.84	
Variants of the testers' SCZ		90.54	90.54	
Nir 0.05 of varieties' SCZ		15.00		
NR 0.05 of testers' SCZ		9.48		

Analysis of variance

Source of variation	Sum of squares	Number of degrees of freedom	Average square	Criterion F		
				actual	theoretical	
					0,05	0,01
Paternal forms of the drug	4772.0	1	4772	89.2	4.21	7.68
Maternal formulation ZKZ	51272.5	4	12818	239.6	2.73	4.11
SCZ	1048	4	262	4.9	2.73	4.11
Random deviations	1445.8	27	53.5			

The study of the inheritance of quantitative traits showed that F1 hybrids usually have an intermediate, compared to the parental components, the value of the trait. Its deviation from the average values of the parental forms is primarily due to the degree of dominance of the hereditary factors of one of the parents. If the genetic formula of a quantitative trait is dominated by dominant genes, the average value of the trait in F1 approaches the average value of one of the parental forms. If there is complete dominance, then the phenotypic value of the trait in F1 is equal to the phenotypic value of the best parental form. However, there are also transgressive forms whose traits have a significant advantage over the parental forms. The reason for this is obviously the effect of the total action of polymerase genes, which is manifested in a steady increase (positive transgression) or decrease (negative transgression) in the value of any trait in individuals in the offspring compared to the extreme values of the trait in the parental forms [13, 14, 36-48].

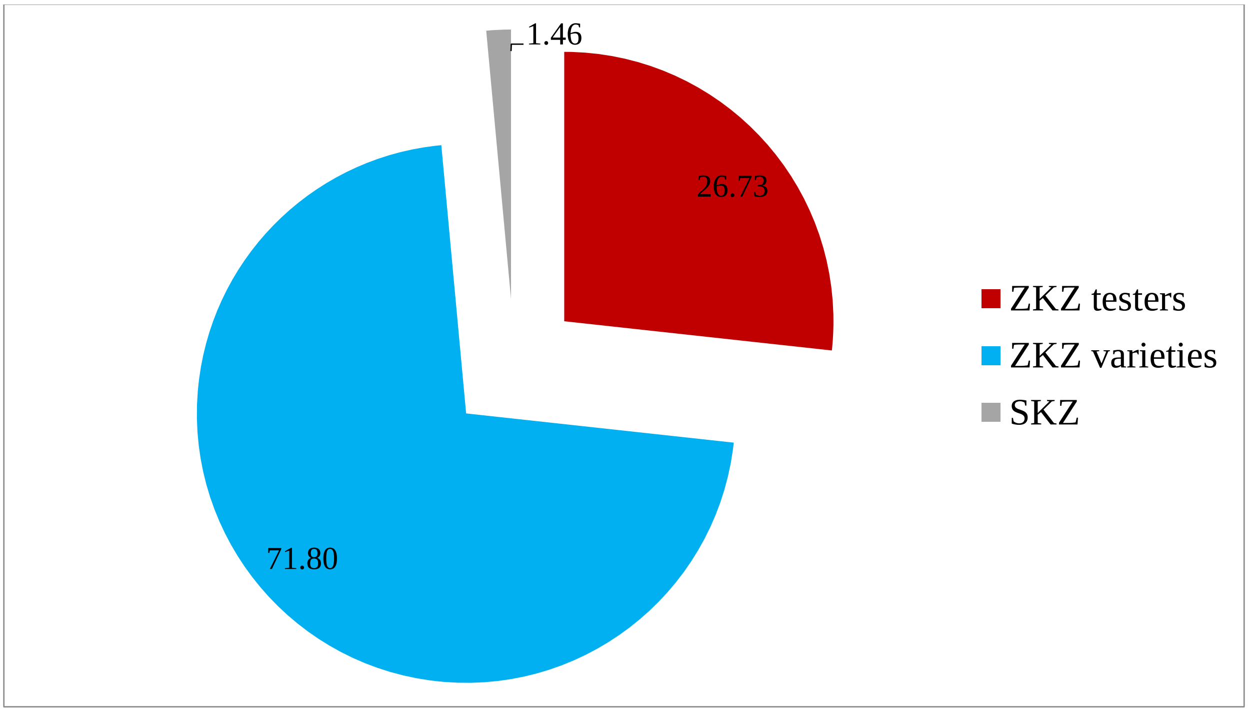

Fig. 8. Share of genotypic variability in yield

To quantitatively interpret this phenomenon, the concepts of frequency and degree of transgression were introduced. It should be noted that there is still no generally accepted theory of trait transgression that would explain the nature of this phenomenon, although in practical breeding transgressive forms are quite common and are promising material for further selection to create both donors of valuable traits and new highly productive varieties.

Our calculation of the degree of transgressive variability in the elements of the yield structure, namely the number of beans and seeds, and grain weight per plant in F3 soybean hybrid populations showed that they varied depending on the hybrid genotype (Fig. 9).

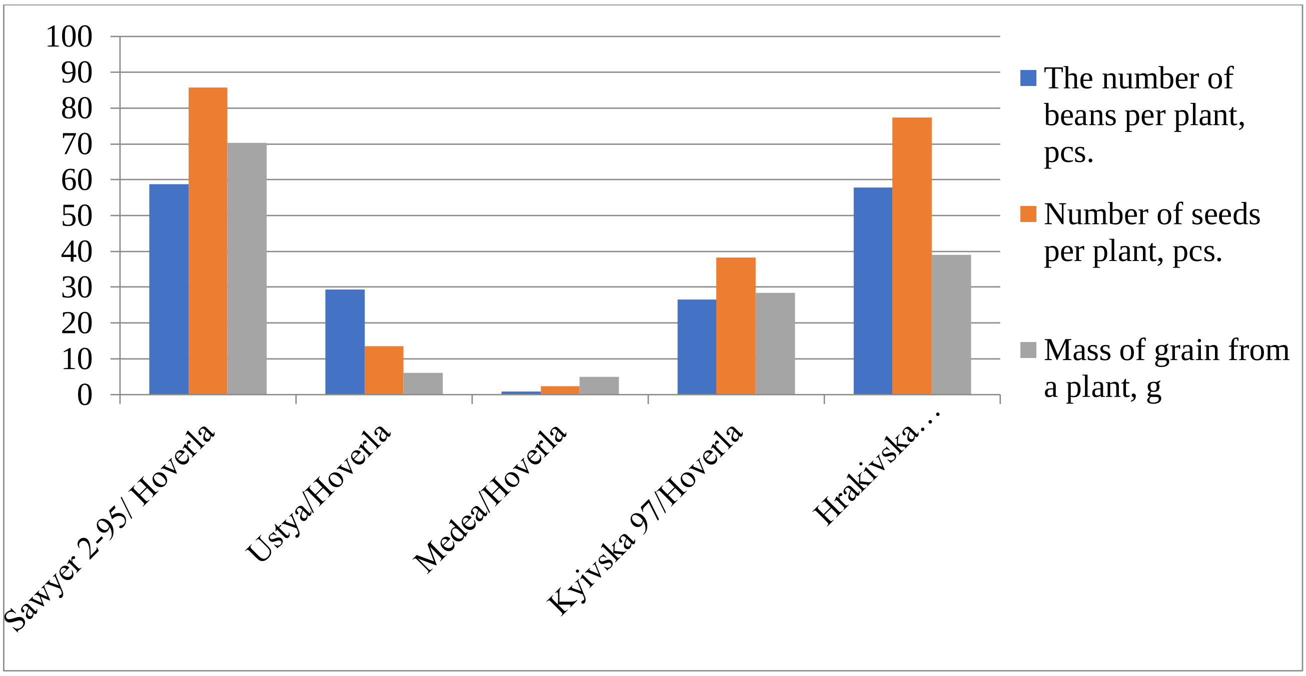

Fig. 9. Degree of transgression in hybrid progeny of soybean F 3

It was found that the highest value in terms of transgressive variability was the hybrid combination Sawyer-2-95 × Hoverla, so in terms of the number of beans per plant - 58.8%, the number of seeds - 85.8% and the weight of grain per plant - 70.3%. Also, the hybrid combination Kharkivska Skoroglya × Hoverla had a relatively high degree of transgressive variability, with the number of beans per plant being 57.8%, the number of seeds being 77.3%, and the weight of grain per plant being 39.0%. A somewhat lower degree of transgressive forms was observed in the hybrid combination Kyivska 97 × Hoverla, with the number of beans per plant being 26.6%, the number of seeds per plant being 38.2%, and the weight of grain per plant being 28.4%.

The frequency of occurrence of transgressive forms by elements of the yield structure depended on the genotype. Fig. 10 shows the frequency of transgressions in hybrid populations that split**.**

According to the results of data analysis, in two hybrid combinations: Soyer 2-95 × Goverla and Kharkivska Skoroglya × Goverla, high rates of transgression frequency in F 3 were observed, in particular, in the number of beans per plant - 34 and 35%; in the number of seeds per plant - 45 and 34%; in the weight of grain per plant - 41 and 25%.

In another topcross scheme, a high degree of transgressive variability was identified in the hybrid combination Sawyer-2-95 × KiVin, in terms of the number of beans per plant - 53.6%, the number of seeds per plant - 89.2% and the weight of grain per plant - 81.1% (Fig. 11).

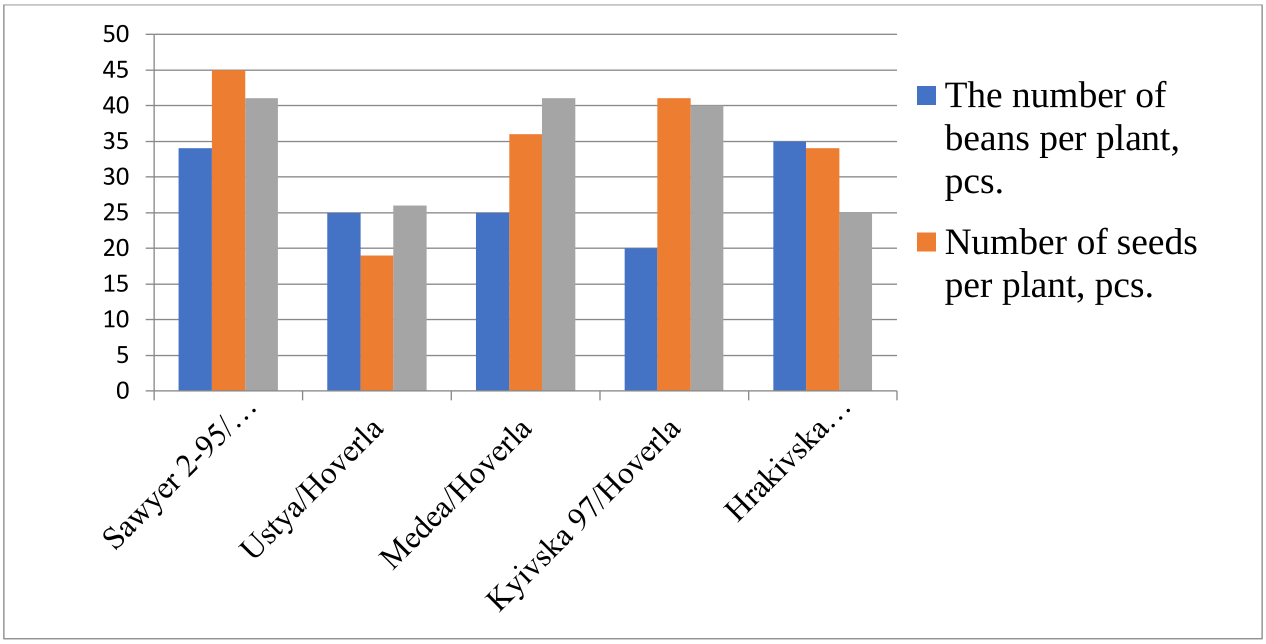

Fig. 10. Frequency of transgression in hybrid progeny of soybean F 3

The lowest degree of transgressive variability was observed in the hybrid combination Kharkivska skoroglya × KiVin, with the number of beans per plant being 42.8%, the number of seeds being 75.7%, and the weight of grain per plant being 32.5%.

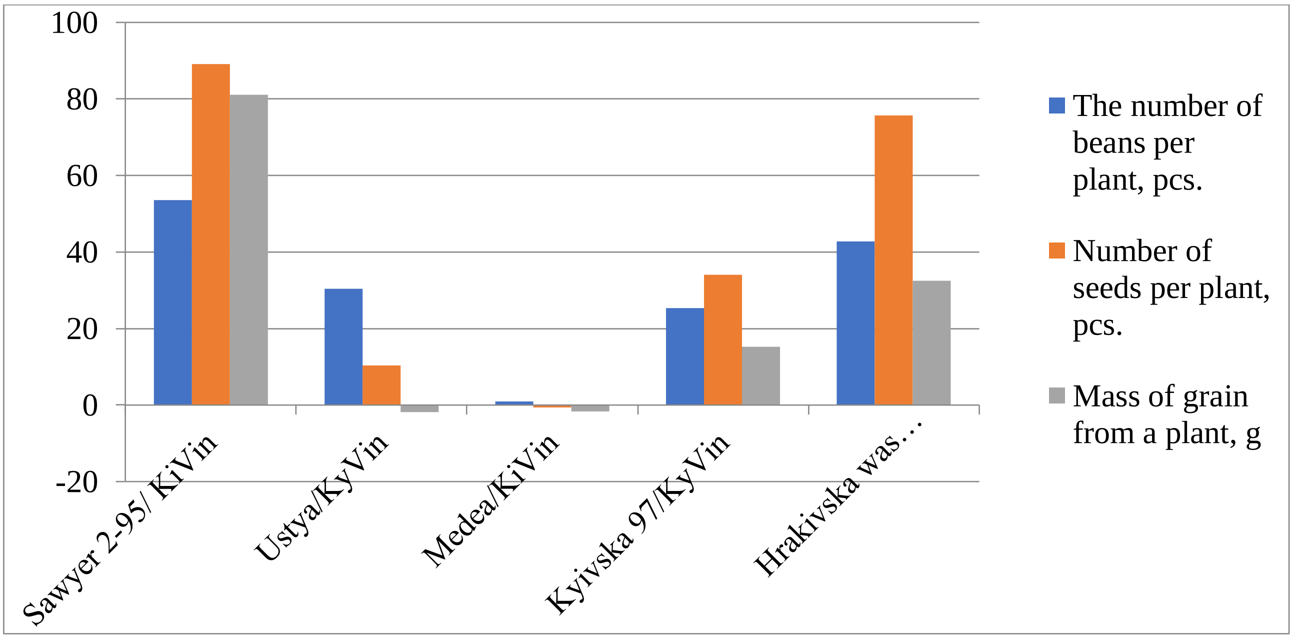

Fig. 11. Degree of transgression in hybrid progeny of soybean F 3

The lowest degree of transgressive variability was found in the hybrid combination Kyivska 97 × KyVin, in terms of the number of beans per plant - 25.3%, the number of seeds per plant - 34.1% and the weight of grain per plant - 15.2%.

The lowest degree of transgressive variability was found in the hybrid combination Ustia × Kyvin in terms of the number of beans per plant - 30.4%, the number of seeds per plant - 10.4%, and the weight of grain per plant - (-1.78%).

High rates of transgression frequency in F3 were observed in the best two hybrid populations: Soybean 2 - 95 × KiVin, Kharkivska skoroglaya × KiVin (Fig. 10). In particular, by the number of beans per plant - 31 and 32%; by the number of seeds per plant - 42 and 31%; and by the weight of grain per plant - 34 and 42%.

Among the indicators characterizing the inheritance of traits in Fn, the most widely used is the degree of phenotypic dominance. This indicator determines the nature of the manifestation of a particular trait. After obtaining the value of the trait in Fn, it is possible to qualitatively describe the pattern of its inheritance. A stable fall of the degree of dominance into one of the ranges provides information about the mechanism of formation of trait values.

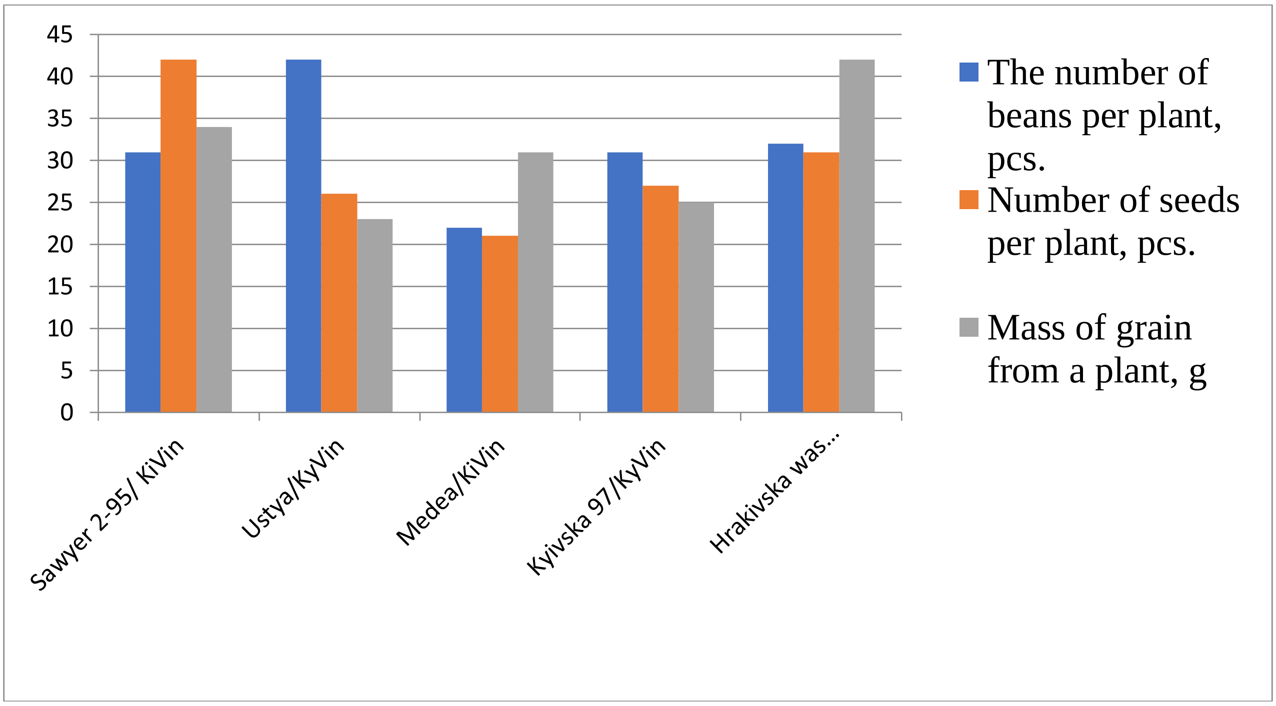

Fig. 12. Frequency of transgression in hybrid progeny of soybean F 3

In the nursery for testing hybrids in 2019, we determined the height of plants, the height of the lower bean attachment, the number of of productive nodes, number of beans, number of seeds per plant, number of seeds per bean, weight of seeds per plant, weight of 1000 seeds, and yield. For the entire general population of the studied forms, the distribution of the nature of the degree of dominance in the evaluated hybrid combinations Fn was carried out according to the linear measurements of plant height and the height of the lower bean attachment and elements of the yield structure. According to the data presented in Table 9, in hybrid combinations the degree of dominance for the studied.

Table 9

Distribution of F3 soybean hybrids by the degree of dominance of productivity traits, 2019

Characteristic	Of these, they have a degree of dominance, %.				
	<- 1,0	from -1.0 to -0.5	from -0.5 to +0.5	from +0.5 to +1.0	> +1.0
Plant height	60.0	20.0	20,0	-	-
Attachment height of the lower bean	70.0	-	30,0	-	-
Number of productive nodes	20.0	10.0	40,0	10.0	20.0
Number of beans	-	-	-	-	100.0
Number of seeds per plant	-	-	-	10.0	90.0
Number of seeds per bean	40		-	30.0	30.0
Weight of seeds per plant	-	-	-	20.0	80.0
Weight of 1000 seeds	70.0	-	20.0		10.0
Yield of beans	10.0	-	40.0	30.0	20.0
Average by gradations	30.0	3.3	16.7	11.1	38.9
Total for the aggregate	33.3		16.7	50.0	

The correlation between linear measurements of plant height and lower bean attachment and components of grain productivity was in the range from < - 1 to > +1.

These traits are dominated by positive dominance (> 1.0). The manifestation of effects by gradations for the entire set of traits that were studied correlates as follows: 38.9% of hybrids had positive dominance, 11.1% of hybrids had dominance, 16.7% had intermediate dominance, 3.3% had negative dominance and 30.0% had negative dominance (depression).

At the same time, the total number of positive dominance and overdominance effects was 50.0%, i.e. exactly half of the hybrids. The positive degree of dominance was observed for such traits as the length of the growing season, the number of seeds per bean, and the type of plant (20.0-40.0%). Positive dominance was mainly characterized by the number of beans and seeds per plant, seed weight per plant (80.0-100%).

Intermediate inheritance (from -0.5 to +0.5) was noted in 16.7% of these hybrids, the number of these cases reflects the figures of the same order of 20.0-40.0%, in particular, plant height - 20.0%, height of lower bean attachment - 30.0%, number of productive nodes - 40.0%, weight of 1000 seeds - 20%, yield - 40%, i.e., the action of genes is additive for these traits. Negative dominance was observed in 3.3% of hybrids, and negative overdominance was observed in 30.0% of hybrids. First of all, for such traits as the height of the lower bean attachment, weight of 1000 seeds, and plant height.

Conclusions

The high effects of IPM on plant height and attachment of lower beans in Sawyer 2-95 and KiVin tester were established; on the number of productive nodes - in Sawyer 2-95, Medea, Kyivska 97 and KiVin tester; on the number of beans per plant - in Ustia, Kyivska 97 and KiVin tester; by the number of seeds per plant - in varieties Medea, Kyivska 97 and tester Goverla; by the weight of 1000 seeds - in varieties Sawyer 2-95, Kyivska 97 and tester Goverla; by the weight of grain per plant - in varieties Medea, Kyivska 97 and tester Goverla; by the yield - in varieties Medea, Kyivska 97 and tester Goverla.

It was found that additive effects of genes were dominant in the genetic control of plant height and lower bean attachment, elements of yield structure and yield, but there was also a significant non-additive effect. In terms of the number of beans per plant, number of seeds per plant, and seed weight per plant, in the vast majority of hybrid populations, inheritance by the type of superdominance and dominance of the parental form with a higher manifestation of the trait was observed.

The analysis of dominance indices made it possible to identify crossing combinations that are distinguished by the dominance of these traits and have significant breeding value: Sawyer 2-95 × Goverla, Kyivska 97 × Goverla, Kharkivska skoroglya × Goverla, Sawyer 2-95 × KiVin, Kharkivska skoroglya × KiVin.

References

1. Horsun I.A., Lavrova G.D., Sichkar V.I. Purposeful selection of parental pairs for the creation of new soybean source material. *Collection of*

scientific papers of the SGA - NCSC. Odesa, 2010. Issue 15 (55). 184 p. (in Ukrainian).

2. Litun P.P., Manziuk V.T., Barsukov P.N. Methods of genotype identification by plant productivity at early stages of breeding. In: Problems of selection and evaluation of breeding material. Kyiv: Naukova Dumka, 1980. p. 16-28. (in Ukrainian).
3. Babych A.O., Babych-Pobezhna A.A. World resources of vegetable protein. *Breeding and seed production.* 2008. Issue 96. p. 215-222. doi.org/10.30835/2413-7510.2008.77228. (in Ukrainian).
4. Carroll B.J., McNeil D.L., Gresshoff P.M. Isolation and properties of soybean (*Glycine max (L.) Merr*.). mutants that nodulate in the presence of high nitrate concentrations. *Proc. Natl. Acad. Sci. U.S.A.* 1985. № 82. P. 4162–4166. (In English).
5. Didur I., Chynchyk O., Pantsyreva H., Olifirovych S., Olifirovych V., Tkachuk O. Effect of fertilizers for Phaseolus vulgaris L. productivity in Western Forest-Steppe of Ukraine. *Ukrainian Journal of Ecology*. 2021. Vol. 11 (1). P. 419–424 DOI: 10.15421/2021_61 (in Ukrainian).
6. Babych A.O., Ivanyuk S.V., Kokhanyuk N.V. Evaluation of first generation hybrids based on hybridological analysis. *Feed and feed production.* 2012. Issue 74. p. 8-13. (in Ukrainian).
7. Mazur O.V. Heterosis, the degree of dominance of grain productivity traits in soybean varieties. *Agriculture and forestry.* 2017. №5. p. 91-98. (in Ukrainian).
8. Rojas B.A., Sprague G.P. A comparison of variance components in corn yield trials : General and specific combining ability and their interaction with location and years. Agron. Jorn. 1952. 44. P. 462–466. (In English).
9. Bilyavska L.G., Korneeva M.O. Variability of quantitative traits of soybean in the offspring of intervarietal crosses F2 and F3. *Bulletin of the Ukrainian Society of Geneticists and Breeders.* Kyiv, 2012. T. 10. №1. p. 3-12. (in Ukrainian).
10. Griffing B. Analysis of guatitative gene-acrion by constant parent regression and related technigues. *Genetics.*1950. V. 35. P. 303–321. (In English).
11. Beil G.M., Atkins R.E. Inheritance of guantitative characters in grain sorghum. *lova State Jornal*. 1965. N 39. P. 3. (In English).
12. Kolot V.M., Kolot V.V., Mikhailov V.O., Klubuk V.V., Churkina T.Y. Results and prospects of soybean breeding under irrigation conditions

in the South of Ukraine. *Genetics and breeding in Ukraine on the verge of millennium*. K.: Logos, 2001. T. 3. p. 134-138. (in Ukrainian).

13. Mikhailov V.G., Shcherbyna O.Z., Romaniuk L.S., Starichenko V.M. Characterization of early and mid-season soybean varieties for the Forest-Steppe and Polissya zones of Ukraine. *Selection and seed production.* 2011. Issue 100. p. 306-314. doi.org/10.30835/2413-7510.2011.66659. (in Ukrainian).
14. Beaver AF, Povydalo M. Transgression of traits of seed and fodder productivity in interspecific hybrids of alfalfa. *Collection of scientific works* of the Institute of Agriculture of the National Academy of Sciences of Ukraine. 2011. Issues 1-2. p. 214-219. (in Ukrainian).
15. Biliavska L., Biliavskiy Y., Mazur O., Mazur O. Adaptability and breeding value of soybean varieties of Poltava breeding. *Bulgarian Journal of Agricultural Science*. 2021. Vol. 27. № 2. P. 312-322. (In English).
16. Mazur O., Kupchuk I., Voloshyna O., Matviiets V., Matviiets N., Mazur O. Genetic determination of elements of the soybean yield structure and combining ability of hybridization components. *Acta Fytotechnica et Zootechnica.* 2023. Vol. 26 (2). P. 163–178. DOI: 10.15414/afz.2023.26.02.163-178. (In English).
17. Mazur O.V., Mazur O.V., Mazur V.A., Sherepitko V.V. Breeding material for the creation of hybrids of corn and soybean varieties suitable for mechanized harvesting: *monograph*, Vinnytsia: VNAU, 2013. 206 p. (in Ukrainian).
18. Mazur O.V. Source material for selection of leguminous crops with increased adaptability and grain productivity in the conditions of the Right-Bank Forest-Steppe. *monograph*, Vinnytsia: VNAU, 2019. 345 p. (in Ukrainian).
19. Alekseev O.O., Mazur O.V. Formation and functioning of the symbiotic system soybean - Bradyrhizobium Japonicum under conditions of bacterial and viral infections in the conditions of the Right-Bank Forest-Steppe: *monograph*, Vinnytsia: VNAU. Publishing house "Druk" LLC, 2023. 256 p. (in Ukrainian).
20. Mazur O.V. Soybean is a valuable bioenergy crop. *Collection of scientific works* of VNAU. 2011. Issue 8 (48). p. 39-43. (in Ukrainian).
21. Mazur O.V., Sherepitko V.V. Genotypic differences of soybean plant varieties by variability of quantitative traits under experimental

sowing conditions of VNAU. *Collection of scientific works* of VNAU. 2011. Issue 9 (49). p. 159-166. (in Ukrainian).

22. Mazur O.V. Study of the relationship between the duration of the growing season and the yield of soybean varieties. *Collection of scientific works* of VNAU. 2012. Issue 10 (50). p. 159-166. (in Ukrainian).
23. Mazur O.V. Prospects of soybean production in Ukraine. *Collection of scientific works of* Vinnytsia National Agrarian University. 2012. Issue 1 (57). p. 57-61. (in Ukrainian).
24. Mazur O.V. Genotypic differences of soybean plant varieties by oil content in seeds. *Collection of scientific works* of VNAU. 2014. Issue 6 (83). p. 108-112. (in Ukrainian).
25. Ostapchuk M.O., Polishchuk I.S., Mazur O.V., Maksimov A.M. The use of biological products is a promising direction of technology improvement. *Agriculture and forestry.* 2015. № 2 (2). p. 5-17. (in Ukrainian).
26. Ostapchuk M.O., Polishchuk I.S., Mazur O.V., Palamarchuk V.D. Microbiological bases of agrotechnologies. *Agriculture and forestry*. 2016. № 3 (3). p. 32-43. (in Ukrainian).
27. Kaletnyk H.M., Branitskyi Y.Y., Gunko I.V., Mazur O.V. Genotypic differences of soybean varieties in terms of oil content and yield for biodiesel production. *Agriculture and forestry.* 2018. № 4 (11). p. 5-14. (in Ukrainian).
28. Polishchuk I.S., Polishchuk M.I., Mazur O.V., Yurchenko N.A. Field germination of soybean seeds depending on the terms of sowing by soil temperature regime. *Agriculture and forestry.* 2018. № 4 (11). p. 36-43. (in Ukrainian).
29. Mazur O.V., Mazur O.V. Differences of leguminous crops by plasticity and stability of economically valuable traits. *Agriculture and forestry.* 2019. № 1 (12). p. 69-86. DOI: 10.37128/2707-5826-2019-1-6 (in Ukrainian).
30. Mazur O.V., Mazur O.V. Plasticity and stability of leguminous crops by economically valuable traits and breeding indices. *Agriculture and forestry*. 2019. № 4 (15). p. 111-136. DOI: 10.37128/2707-5826-2019-3-4-10 (in Ukrainian).
31. Mazur O.V. Plasticity and stability of soybean by breeding indices. *Agriculture and forestry*. 2020. № 4 (19). p.243-250. DOI: 10.37128/2707-5826-2020-4-20 (in Ukrainian).

32. Mazur O.V., Poltoretskyi S.P. Evaluation of soybean varieties by breeding indices. *Agriculture and forestry*. 2021. № 1 (20). p. 170-178. DOI: 10.37128/2707-5826-2021-1-13 (in Ukrainian).
33. Bilyavska L.G., Bilyavskyi V.G., Mazur O.V., Mazur O.V. Adaptability and breeding value of soybean varieties for cultivation in different soil and climatic conditions of Ukraine. *Agriculture and forestry.* 2021. № 3 (22). p. 96-107. DOI: 10.37128/2707-5826-2021-3-8 (in Ukrainian).
34. Mazur O.V. Adaptive value of soybean varieties under different growing conditions. *Agriculture and forestry*. 2022. № 4 (27). p. 74-92. DOI: 10.37128/2707-5826-2022-4-7 (in Ukrainian).
35. Mazur O.V., Mazur O.V. Adaptive value of soybean varieties for cultivation in different ecogradients. *Agriculture and forestry*. 2023. №2 (29). p. 172-180. DOI: 10.37128/2707-5826-2023-2-15. (in Ukrainian).
36. Mazur V.A., Didur I.M., Mazur O.V., Mazur O.V. Features of the manifestation of economic and biological traits of common bean (Phaseolus Vulgaris L.) in the conditions of the Right-Bank Forest-Steppe: *monograph*, Vinnytsia: Druk LLC, 2021. 256 p. (in Ukrainian).
37. Mazur O.V. Evaluation of soybean varieties by a complex of valuable economic traits. *Agriculture and forestry.* 2019. № 1 (12). p. 98-115. DOI: 10.37128/2707-5826-2019-1-8 (in Ukrainian).
38. Mazur O.V., Poltoretskyi S.P., Poltoretska N.M., Yatsenko A.O., Kravchenko V.S., Bilonozhko V.Y.. Environmental plasticity, stability and resistance to diseases of the varieties of phaseolus vulgaris l. *Collection of scientific works* of Uman National University of Horticulture. 2019. Issue 94. T. 1. p. 17-26. DOI: 10.31395/2415-8240-2019-94-1-17-26 (In English).
39. Mazur O.V., Mazur O.V. Genotypic differences of common bean varieties by parameters of plasticity and stability. *Agriculture and forestry.* 2018. № 2 (9). p. 115-124. (in Ukrainian).
40. Mazur O.V., Mazur O.V. Breeding value of common bean varieties for resistance to disease damage. *Agriculture and forestry.* 2018. № 3 (10). p. 98-105. (in Ukrainian).
41. Mazur O.V., Poltoretskyi S.P., Poltoretska N.M., Kononenko L.M., Inheritance of yield formula in F1 hybrids and hybrid swarms F2 Phaseolus vulgaris L. *Collection of scientific works* of Uman National

University of Horticulture. 2019. Issue 95. T. 1. p.19-30. DOI 10.31395/2415-8240-2019-95-1-19-30. (In English).
42. Mazur O.V., Mazur O.V. Plasticity and stability of grain productivity of common bean varieties. *Agriculture and forestry*. 2019. № 2 (13). p. 154-171. DOI: 10.37128/2707-5826-2019-2-13. (in Ukrainian).
43. Mazur O.V., Mazur O.V. Adaptability and breeding value of common bean accessions. *Agriculture and forestry*. 2019. № 2 (13). p. 119-142. DOI: 10.37128/2707-5826-2019-2-11 (in Ukrainian).
44. Mazur O.V., Palamarchuk V.D., Mazur O.V. Comparative evaluation of common bean varieties by economic and valuable traits. *Agriculture and forestry*. 2017. № 6 (T. 1). p. 116-124. (in Ukrainian).
45. Mazur O.V., Porokhovnyk I.I. Evaluation of the source material for common bean breeding for early maturity and yield. *Agriculture and forestry*. 2017. № 6 (T. 2). p. 51-59. (in Ukrainian).
46. Mazur O.V., Roik M.V. Differences of common bean varieties by signs of manufacturability and productivity. *Agriculture and forestry*. 2017. № 6 (T. 2). p. 60-66. (in Ukrainian).
47. Mazur O.V., Kolisnyk O.M., Telekalo N.V. Genotypic differences of common bean varieties by technological efficiency. *Agriculture and forestry*. 2017. № 7 (T. 2). p. 33-39. (in Ukrainian).
48. Mazur O.V. Identification of traits of leguminous plants by breeding indices. *Agriculture and forestry*. 2020. № 1 (16). p. 119-133. DOI: 10.37128/2707-5826-2020-1-9 (in Ukrainian).