EEET ECOLOGICAL ENGINEERING & ENVIRONMENTAL TECHNOLOGY

*Ecological Engineering & Environmental Technology*, 2025, 26(7), 186–195
https://doi.org/10.12912/27197050/205208
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Received: 2025.04.29
Accepted: 2025.05.30
Published: 2025.06.15

# Variability of soybean varieties in terms of yield components and yield in the conditions of the forest-steppe of right-bank Ukraine

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## ABSTRACT

The article presents the results of long-term studies of soybean variety variability in terms of valuable economic traits (yield components) and yield under different hydrothermal growing conditions. Varieties that ensured high stability of yield components were identified using mathematical and statistical analysis methods. The highest repeatability coefficients for the number of productive nodes were observed in the Desna variety – 0.82, with a coefficient of variation of 12.7% and 16.1 productive nodes; in the Bilyavka variety – 0.81, with a coefficient of variation of 12.4% with an average value of 16.7 units. The variability of the yield level during the years of research was high, with the repeatability coefficient ranging from 0.55 to 0.75, which is quite natural given the large number of formative traits that contribute to its determination. The highest repeatability coefficients were observed in the varieties Femida – 0.75, coefficient of variation – 10.7%, and yield – 1.88 t/ha; Amethyst – 0.73, coefficient of variation – 11.4%, yield – 1.88 t/ha; Vezha – 0.72, coefficient of variation – 11.4%, yield – 1.89 t/ha. It should be noted that these varieties were distinguished by high values of repeatability coefficients for the weight of 1.000 seeds, in particular, Femida – 0.91, Ametist – 0.93, Vezha – 0.80; as well as for the number of productive nodes, pods, and seeds: Femida – 0.69; 0.52 and 0.55, and Vezha – 0.68; 0.56 and 0.57, respectively. Thus, ensuring a stable level of soybean yield is determined by the formation of stable indicators of the elements of the soybean yield structure of each variety in particular.

**Keywords:** soybean, variety, variability, yield components, yield, repeatability coefficient.

## INTRODUCTION

Soybean (*Glycine max* (L) Merrill) is a unique protein-oil crop characterized by high adaptability to growing conditions, versatility of use, and balanced protein amino acid composition and functional activity. Thanks to its ability to biologically fix atmospheric nitrogen, soybean cultivation also improves the nitrogen balance of the soil and its fertility, increases the amount of nutrients available for subsequent crops, produces environmentally friendly products, and increases the productivity of a unit of crop rotation area. Due to these characteristics and high productivi-ty, soybeans, compared to other annual legumes and oil crops, rank first in the world in terms of both acreage and gross grain yield (Babych and Babych-Poberezhna, 2012; Melnyk and Romanko, 2016; Kaletnik at al., 2020; Korobko at al., 2024). Determining the level of plant response to changing environmental factors in order to select the most promising breeding material that ensures stable expression of the trait under study is the main task of breeding institutions (Honcharuk et al., 2023).

Modern breeding tasks include the creation of adaptive systems with developed self-regulating mechanisms that can ensure the stability of functioning and the stability of the final product in specific environmental conditions. The management of adaptive systems is qualitatively different – not through the regulation of the external environment, but through influencing internal processes, i.e., managing the biological processes of organic matter synthesis, its conversion into useful products of growth and development, and, in general, the genotypic expression of genetic information (Lituun et al., 2004).

Therefore, the primary task is to create varieties that combine high yield with relatively high resistance to adverse soil and climatic conditions and have a sufficiently high level of adaptability to the conditions of the growing region. The negative impact of unfavorable abiotic environmental factors can be offset by expanding the diversity of varieties and increasing their adaptive potential (Grebennikova et al., 2011; Biliavska at al., 2021; Mazur, 2023).

High variability of traits, caused by the diversity of genotypes, indicates the possibility of changing them in the desired direction at different stages of the breeding process. Environmental variability causes genetic adaptations in plants to specific conditions. Constantly exposed to adverse environmental factors such as temperature fluctuations, drought, excessive moisture, salinity, etc., each specific plant organism is able to adapt to these conditions only within the limits determined by its genotype. The higher the ability of a species to change its metabolism (metabolism) in accordance with the range of changing conditions, the wider the range of its response and the higher its ecological and adaptive capacity (Mazur, 2024).

Separate studies are needed to determine the genetic basis for increasing yield and improving stress resistance to climatic factors (Voronyansky et al., 2018). The main criterion for evaluating the effectiveness of legume cultivation is yield. However, yield indicators can only be determined fairly accurately when a variety is grown over a large area. Breeders deal with the productivity of individual plants or small numbers of them, and due to the significant modification variation of this indicator, it is not possible to identify genotypes clearly enough. In a breeding population, genotypic differences in plant productivity reach 20%, while the coefficient of modification variability for this indicator can be as high as 50–60% (Bilyavska and Rybachenko, 2019).

High productivity is the result of the most optimal combination of structural elements, therefore, when selecting for productivity, attention should be paid to the following traits: number of pods, number of seeds, number of productive nodes per plant, stem length, and number of pods per node (Ivanyuk and Temchenko, 2011). An important place in the characterization of plant productivity is occupied by the relationship with quantitative traits that characterize the contribution of individual traits to seed yield at the species (subspecies) level. Selection of plants based on absolute quantitative traits is largely ineffective, as it is not able to fully reproduce the productivity of the genotype (Kaletnik at al, 2020).

It is usually impossible to achieve significant breeding results by enhancing a single productivity element. A plant is a biological system whose individual components are closely interrelated, so a change in one factor greatly affects the state of another. Therefore, in breeding work, the combination of productivity elements must be approached with great care, avoiding levels that would cause negative changes in others. As a rule, these are average values of traits or slightly higher. Breeding progress is achieved by gradual movement due to positive changes in individual plant traits that affect productivity. In addition, promising source material should have individual stages of ontogenesis that are consistent with the dynamics of environmental factors in a particular region. Valuable breeding material has its own adaptive mechanisms that provide a buffer against unfavorable environmental conditions (Sichkar, 2014).

The identified correlation between traits or indices is widely used in solving various breeding problems. Significant variability in genetic correlations of the main traits that determine yield has been established, depending on environmental conditions, which vary greatly (Tkachuk et al., 2021). Thus, genotypic deviations that are valuable for breeding are masked by modifications. The most accurate identification of genotypes is possible using indicators with low ecological dispersion, since in this case practically all phenotypic variability is determined by genotypic differences (Babych et al., 2013). Studying the degree of variability of traits elements of crop structure in specific soil and climate conditions is of great importance for the creation of high-yielding varieties (Rybachenko, 2018; Okrushko et al., 2025).

The variability of a plant organism is determined by genetic predisposition and depends on the characteristics of the growing season. In conducting research, information about the nature of the manifestation of variability of quantitative traits characterizing genotypes that have the desired combination of traits is of great importance. For this purpose, an analysis of the strength of variability of quantitative traits of soybeans with the establishment of its intensity is used (Bilyavska and Rybachenko, 2019).

According to the results of the studies, the repeatability coefficient is determined as the correlation between the mean values of a certain trait of a group of genotypes obtained in different years of research. Based on the value of the correlation coefficient, it is possible to determine the stability or degree of agreement of trait changes under the influence of environmental conditions in different years. High values of the repeatability coefficient indicate that this indicator is stable under different environmental conditions (does not change across the entire set of genotypes studied) or, more likely, that this indicator changes to the same extent and in the same direction across the entire set of genotypes under the influence of external conditions. If the repeatability coefficient is close to zero, then this trait changes inadequately in different genotypes when environmental conditions change. When repeatability coefficients vary significantly over years, this indicates the diversity of environmental influences on this trait (Ivanyuk and Glyavin, 2012).

The effectiveness of selection largely depends on traits that are weakly modified under the influence of cultivation factors. One of the most accessible methods for assessing plant productivity in the breeding process is the identification of genotypes by quantitative traits (Ivanyuk and Temchenko, 2011).

The implementation of breeding programs aimed at creating crop varieties with high and stable seed productivity requires the study of genotypic differences and the selection of source material based on the expression of economically valuable plant traits (Marchenko, 2012; Pantsyreva et al., 2023).

It is known that changes in the growing conditions of soybean plants can significantly affect not only the form of expression of a specific quantitative morphological trait, but also the nature of its relationship with other traits, which can cause significant differences between varieties in terms of final grain yield. It should be noted that reducing the negative impact of environmental factors that limit soybean yield involves selecting varieties whose plasticity best suits a specific growing area (Yatsenko et al., 2023).

Variability as a normal response to changes in environmental conditions and the degree of its inheritance are the basis for adaptive adaptations of organisms, which are preserved in generations through natural selection. Changes that are inherited under certain conditions can express the degree of adaptive adaptation to changes in growing conditions. The greater the range of variability, the more effective is the selection aimed at survival, spread of the species, i.e., adaptation to new environmental conditions (Babych et al., 2013).

The soybean gene pool is characterized by significant heterogeneity in its ability to adapt to growing conditions, as evidenced by varying degrees of variability in quantitative traits. Knowledge of the patterns of variability in the expression of economically valuable traits is an important factor in the creation of new varieties, as it allows the identification of ecologically stable forms with stable expression of traits under different growing conditions (Bilyavska and Korneeva, 2012; Ivanyuk and Glyavin, 2012).

On the one hand, production requires stable varieties that minimize productivity losses under unfavorable conditions but are also capable of realizing their high potential under intensive environmental factors, which is one of the most important tasks of breeding. In addition, it is necessary to have highly specialized varieties for specific ecological zones of the country (Sichkar et al., 2014; Mostovenko et al., 2022).

The goal of the research was to compare soybean varieties based on how much their yield components and yield varied, and to pick the best ones to use in hybridization when creating new soybean varieties, as well as for growing in production conditions.

## MATERIALS AND METHODS

The research was conducted on the experimental plot of the Department of Plant Growing, Selection, and Bioenergy Crops of Vinnytsia National Agrarian University during 2012–2021, which differed significantly in terms of hydrothermal regime (Figure 1). Soil types on the experimental plot were represented by gray forest soils.

The study of collection samples was carried out in accordance with the "Methodological recommendations for the study of genetic resources of grain legumes" (Kobyzeva, 2016), as well as (Vovkodav, 2001; Moiseichenko and Yeshchenko, 1994).

The arithmetic mean was calculated using formula 1:

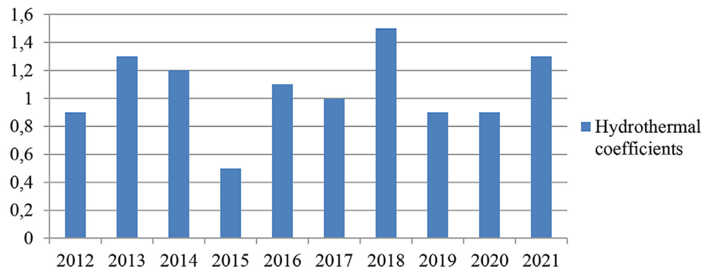


**Figure 1.** Hydrothermal coefficients during the growing season (BBCH-10-99) (May–September) 2012–2021

$$X\ average = \frac{\Sigma(fx)}{n} \quad (1)$$

where: *x* average – arithmetic mean; ∑(*fx*) – sum of all variants; *n* – number of all variants.

Dispersion was determined using formula 2:

$$S^2 = \sum(X\text{-}x\ average)^2/n\text{-}1 \quad (2)$$

where: $S^2$ – variance; *X* – variant; *X average* – arithmetic mean; *n*−1 – number of degrees of freedom.

The number of degrees of freedom is the number of freely variable quantities, or the number of all measurements minus one. V = n−1, where: n – number of all variants, or measurements. The standard deviation was calculated using formula (3):

$$S = \sqrt{S^2} \quad (3)$$

where: *S* – standard deviation; $S^2$ – variance.

The coefficient of variation was calculated using formula (4):

$$V = \frac{S}{X\ \text{average}} \times 100\% \quad (4)$$

where: *V* – coefficient of variation; *S* – standard deviation; *X average* – arithmetic mean.

The coefficient of variation is a relative measure of variability. The use of the coefficient of variation is only relevant when studying a feature that has a positive value. When *V* is less than 10%, the variation is weak and indicates stability of indicators; V=11-20% – moderate; V = 21 – 50% – significant; V > 50% – high. The repeatability coefficient (*Rn*) of a trait was determined using formula (5):

$$Rn = \frac{g_v^2}{g_v^2 + g_p^2} \quad (5)$$

where: $g^2_v$ – variability of a trait between plants; $g^2_p$ – variability of a trait in plants over years (Ivanyuk and Hlyavin, 2012).

## RESULTS AND DISCUSSION

The formation of soybean seed yield is an extremely complex process due to the weak ability of plants to regulate the number of fruiting stems, the long differentiation of generative organs, and the significant dependence of their development on external conditions. That is why yield is an integral indicator that allows assessing the effectiveness of the cultivation technology of this crop and its compliance with the biological requirements of the variety. To a large extent, the level of soybean productivity is determined by the structure and individual productivity of individual plants (Lavrynenko et al., 2015).

The formation of legume crops, including soybeans, is an extremely complex process, much more complex than in other crops. This is due to the weak ability to regulate the number of fruiting stems, the sequential and prolonged differentiation of generative organs, and, in particular, the significant dependence of their development on external conditions (Pavlenko, 2015; Petrychenko and Ivanyuk, 2000). An important component of soybean yield formation is its structure (Babych and Novokhatsky, 2002). Each variety has certain manifestations and interrelationships of the elements of plant seed productivity, the degree of variability, and the presence of the most characteristic ones, which vary the least within the variety.

The grain productivity of soybean plants is formed during the period of vegetative development (growth and development of vegetative organs of plants) and generative development (budding, flowering, formation of fruit elements, and seed filling). During the generative period, the elements of grain productivity (number of pods and seeds, as well as the corresponding seed size) per unit area are formed, while in the third period, the seed size (coarseness) is formed. The longer the second period, the more pods and seeds are formed, while the seed size decreases. The length of the growing season for soybeans consists of two phases: "emergence-flowering" and "flowering-ripening." Soybean breeding should be aimed at early maturity, but with an extended "flowering-ripening" period. This contributes to the creation of optimal conditions for the formation of fruit elements (pods and seeds), as well as grain filling. The prolongation of the generative period helps to compensate for losses due to adverse abiotic conditions that may occur during this period. The duration of the flowering-ripening phase can be 60–70 days. Thus, prolonging this period will partially compensate for crop losses after drought when optimal conditions return. This will help reduce flower and pod abortion and result in the formation of large grains. It should be noted that during individual development, soybeans form a large number of fruit elements, most of which subsequently fall off. Therefore, prolonging the generative period, during which optimal conditions can be restored after drought, compensates to some extent for the yield level due to less fruit drop. Therefore, the selection of such varieties indicates their increased drought resistance (Sichkar, 2014; Sichkar et al., 2014; Kvitko et al., 2021). The number of productive nodes is an important characteristic that determines the structural elements of the yield in soybean varieties (Table 1). The number of productive nodes affects the number of pods and seeds per plant, which are one of the main formative characteristics of grain productivity in soybean varieties. A significant number of productive nodes on a plant, which is characterized by high resistance to realization under changing environmental conditions, will ensure the selection of source material for the creation of new soybean varieties with high adaptability.

It should be noted that the highest repeatability coefficients were observed in soybean varieties in which the number of productive nodes was not high according to the arithmetic mean.

The highest repeatability coefficient was observed in the Desna variety – 0.82, with a coefficient of variation of 12.7% and 16.1 productive nodes. High repeatability coefficients were observed in the Bilyavka variety – 0.81, with a coefficient of variation of 12.4% and an average value of 16.7.

High resistance to changing environmental conditions was also noted in the Dion and Kabott varieties, with repeatability coefficients of 0.78 and coefficients of variation of 13.9 and 12.1%, with average arithmetic values of 16.7 and 18.9. It should be noted that the highest number of productive nodes was observed in varieties with lower stability indices under different hydrothermal conditions compared to the

**Table 1.** Repeatability coefficients (Rn) and variation coefficients (V, %) of soybean varieties by number of productive nodes, 2012–2021

| Variety | X | Swing min–max | S² | V,% | Rn |
|---|---|---|---|---|---|
| Desna | 16.1 | 12.3–19.7 | 2.04 | 12.7 | 0.82 |
| Bilyavka | 16.7 | 11.7–19.3 | 2.07 | 12.4 | 0.81 |
| Diona | 16.7 | 13.1–21.1 | 2.32 | 13.9 | 0.78 |
| Kabott | 18.9 | 13.6–22.1 | 2.28 | 12.1 | 0.78 |
| Vinnichanka | 19.2 | 12.6–20.6 | 2.38 | 12.4 | 0.77 |
| Omega Vinnitsa | 21.8 | 16.1–24.3 | 2.42 | 11.1 | 0.76 |
| Fea | 20.7 | 15.1–25.0 | 2.46 | 11.9 | 0.76 |
| Mif | 20.9 | 15.3–23.9 | 2.41 | 11.5 | 0.76 |
| Zolotista | 16.3 | 11.6–19.8 | 2.43 | 14.9 | 0.76 |
| Viktoryna | 21.7 | 15.6–24.7 | 2.53 | 11.7 | 0.75 |
| Knyazhna | 21.6 | 16.2–26.7 | 2.63 | 12.2 | 0.73 |
| Podilska 1 | 20.7 | 13.6–23.5 | 2.73 | 13.2 | 0.72 |
| Roksolana | 24.5 | 17.7–28.7 | 2.72 | 11.1 | 0.72 |
| Terek | 22.5 | 16.9–27.6 | 2.67 | 11.9 | 0.72 |
| Amethyst | 20.1 | 13.9–24.1 | 2.85 | 14.2 | 0.70 |
| Alexandrite | 23.2 | 16.9–27.5 | 2.87 | 12.4 | 0.69 |
| Femida | 24.3 | 17.2–27.3 | 2.93 | 12.1 | 0.69 |
| Vezha | 21.7 | 15.2–25.4 | 2.94 | 13.6 | 0.68 |

varieties presented. These included Roksolana, with a repeatability coefficient of 0.72, a coefficient of variation of 11.1%, and an arithmetic mean of 24.5 units; Femida, with a repeatability coefficient of 0.69, a coefficient of variation of 12.1%, the arithmetic mean was 24.3; Alexandrite, with a repeatability coefficient of 0.69, a coefficient of variation of 12.4, and the number of productive nodes was 23.2.

The number of beans per plant is significantly influenced by environmental conditions. The potential of soybeans allows for the formation of 3 to 35 flowers in the leaf axil, but during ontogenesis, unfavorable abiotic conditions lead to significant abortion (36 to 81%), which can significantly reduce the number of formed pods to 12, and in the apical raceme to 30 (Table 2).

The number of pods per plant compared to the number of productive nodes was more variable under the influence of hydrothermal growing conditions. This is confirmed by lower repeatability coefficients, which varied from 0.51 to 0.63 among the selected varieties. The highest repeatability coefficients were observed in the varieties Bilyavka – 0.63, coefficient of variation – 12.4%, with an average value of 43.3; Fey, repeatability coefficient – 0.6, coefficient of variation – 11.9% with an average value of 47.6 pieces, Omega Vinnitsa with a repeatability coefficient of 0.59 and a coefficient of variation of 11.1%, with an average value of 52.4 pieces. The highest number of beans was recorded in the varieties Roksolana – 58.8 pieces, Knyazhna – 56.2 pieces, Femida – 55.9 pieces, while the repeatability coefficients were lower, in particular Roksolana – 0.53, coefficient of variation – 11.1%; Knyazhna – 0.51, coefficient of variation – 12.2%; Femida – 0.52, coefficient of variation – 12.1%, respectively.

The study found that the number of seeds per plant was regularly dependent on the number of beans per plant. The number of seeds per plant was also more variable than the number of productive nodes, with a repeatability coefficient ranging from 0.55 to 0.68 (Table 3).

This is due to the greater influence of hydrothermal conditions on the formation of the number of seeds per plant. The highest repeatability coefficients were observed in the varieties Bilyavka – 0.68, coefficient of variation – 10.4%, and number of seeds – 94.1 pcs; Feya – 0.66, coefficient of variation – 9.8%, with an average number of seeds of 102.9; Kabott and Terek – 0.64, with coefficients of variation of 9.8 and 9.5%, with an average number of seeds per plant of 107.9 and 112.5, respectively. It should be noted that these soybean varieties did not show a high number of seeds per plant, i.e., a more stable expression of the phenotype under the influence of environmental conditions is realized at lower quantitative indicators of their formation on the plant. The highest number of seeds per plant was observed in the varieties Roksolana – 127.8 seeds, Knyazhna – 122.1 seeds, and Femida – 121.5 seeds, which had lower repeatability coefficients, in particular

**Table 2.** Repeatability (Rn) and variation (V, %) coefficients of soybean varieties by number of beans, 2012–2021

| Variety | X | Swing min–max | S² | V,% | Rn |
|---|---|---|---|---|---|
| Bilyavka | 43.3 | 30.4–50.4 | 5.37 | 12.4 | 0.63 |
| Fea | 47.6 | 32.1–80.9 | 5.66 | 11.9 | 0.60 |
| Omega Vinnitsa | 52.4 | 38.7–82.6 | 5.81 | 11.1 | 0.59 |
| Kabott | 49.3 | 35.2–57.5 | 5.94 | 12.1 | 0.58 |
| Viktoryna | 52.1 | 37.5–59.3 | 6.08 | 11.7 | 0.57 |
| Vinnychanka | 50.0 | 32.8–53.3 | 6.19 | 12.4 | 0.56 |
| Terek | 51.8 | 38.8–63.5 | 6.14 | 11.9 | 0.56 |
| Vezha | 45.5 | 31.8–53.4 | 6.17 | 13.6 | 0.56 |
| Mif | 54.4 | 39.8–62.2 | 6.26 | 11.5 | 0.55 |
| Osoblyva | 50.9 | 34.2–55.9 | 6.46 | 12.7 | 0.54 |
| Podilska 1 | 49.9 | 32.7–56.5 | 6.54 | 13.2 | 0.53 |
| Roksolana | 58.8 | 42.6–68.8 | 6.53 | 11.1 | 0.53 |
| Alexandrite | 53.2 | 38.9–63.2 | 6.61 | 12.4 | 0.53 |
| Femida | 55.9 | 39.5–62.7 | 6.75 | 12.1 | 0.52 |
| Ustya | 53.7 | 40.1–61.1 | 6.86 | 12.8 | 0.51 |
| Knyazha | 56.2 | 42.1–69.3 | 6.83 | 12.2 | 0.51 |

**Table 3.** Repeatability coefficients (Rn) and variation coefficients (V, %) of soybean varieties by seed number, 2012–2021

| Variety | X | Swing min−max | S² | V,% | Rn |
|---|---|---|---|---|---|
| Bilyavka | 94.1 | 72.9−105.8 | 9.79 | 10.4 | 0,68 |
| Fea | 102.9 | 83.0−120.8 | 10.14 | 9.8 | 0.66 |
| Kabott | 107.9 | 88.1−126.6 | 10.61 | 9.8 | 0.64 |
| Terek | 112.5 | 93.0−133.3 | 10.69 | 9.5 | 0.64 |
| Podilska 1 | 108.9 | 81.8−119.0 | 11.32 | 10.4 | 0.61 |
| Canatto | 113.9 | 90.5−136.0 | 11.51 | 10.1 | 0.61 |
| Roksolana | 127.8 | 102.2−151.4 | 11.72 | 9.2 | 0.60 |
| Osoblyva | 111.2 | 82.1−117.9 | 11.83 | 10.6 | 0.59 |
| Knyazha | 122.1 | 101.0−145.6 | 11.73 | 9.6 | 0.59 |
| Vinnychanka | 108.2 | 75.5−117.9 | 12.34 | 11.4 | 0.57 |
| Vezha | 100.2 | 79.6−117.5 | 12.45 | 12.43 | 0.57 |
| Omega Vinnitska | 113.6 | 89.1−128.2 | 12.49 | 11.0 | 0.57 |
| Femida | 121.5 | 94.8−131.8 | 12.85 | 10.6 | 0.55 |

in the Roksolana variety – 0.6, Knyazhna – 0.59, and Femida – 0.55. Thus, achieving a higher number of seeds per plant and stable expression in plants is realized to a lesser extent than their insignificant number with a higher phenotypic level of expression.

The variability of the weight of 1,000 seeds over the years can characterize the biological plasticity of a variety and its adaptability to the conditions of the region. The less this indicator changes, the more suitable the variety is in terms of stability for this region (Rybachenko, 2018).

The most integral indicator of drought resistance is the high productivity of varieties, which is determined not by a single trait or quality, but by the entire genetic system of plants. Under arid conditions, the highest yield is formed under the optimal combination of individual elements of productivity and economically valuable traits, among which the most important are the above-ground mass of plants, the number of pods and seeds per plant, as well as a slight decrease in the weight of 1000 grains (Sichkar et al., 2014).

The weight of 1,000 seeds affects grain productivity, and, as already noted, varieties with low variability in the weight of 1,000 seeds are drought-resistant (Table 4).

Selection for drought resistance is a very important component of ensuring stable and high soybean yields. This is particularly relevant in the current climate change, when high temperatures and moisture deficits are increasingly common. The lowest variability to environmental conditions was observed in soybean varieties with a thousand-seed weight of 1000 seeds. This is confirmed by the highest values of the repeatability coefficients of soybean varieties for this trait, which ranged from 0.8 to 0.93.

The lowest variability to environmental conditions was observed in soybean varieties with a weight of 1000 seeds. This is confirmed by the highest values of the repeatability coefficients of soybean varieties for this trait, which ranged from 0.8 to 0.93. This is determined by compensatory mechanisms that appear during the formation of the components of grain productivity, namely: when the weight of 1,000 seeds increases, their number decreases, and vice versa. If there is a moisture deficit and elevated temperatures during the filling phase, this leads to a decrease in the weight of 1000 seeds relative to their previously formed quantity and contributes to a reduction in yield. The yield of soybean varieties is a polygenic trait that depends on the elements of grain productivity. The difference in soybean varieties in terms of yield in years with different hydrothermal conditions can reach 20% or more, while the coefficient of variation for this indicator is at the level of 50–60%. The variability of yield levels over the years of research was quite high, with a repeatability coefficient ranging from 0.55 to 0.75, which is quite natural given the large number of formative traits involved in its determination, which are influenced by unfavorable abiotic and biotic environmental factors (Table 5).

The coefficient of variation in the best selected soybean varieties ranged from 10.7 to 13.5%. The highest repeatability coefficients were observed

**Table 4.** Repeatability coefficients (Rn) and variation coefficients (V, %) of soybean varieties based on 1.000 seeds, 2012–2021

| Variety | X | Swing min–max | S² | V,% | Rn |
|---|---|---|---|---|---|
| Ametyst | 152.2 | 145–156 | 3.39 | 22 | 0.93 |
| Howerla | 155.4 | 150–162 | 3.86 | 25 | 0.91 |
| Femida | 140.6 | 138–145 | 3.81 | 27 | 0.91 |
| Zolotysta | 146.5 | 141–151 | 3.84 | 26 | 0.91 |
| Knyazha | 134.7 | 128–141 | 4.37 | 32 | 0.89 |
| Canatto | 145.8 | 140–151 | 4.37 | 30 | 0.89 |
| Roksolana | 150.8 | 143–155 | 4.13 | 27 | 0.89 |
| Podilska 1 | 149.7 | 139–154 | 4.81 | 32 | 0.87 |
| Artemida | 139.1 | 130–145 | 4.72 | 34 | 0.87 |
| Kyivska-98 | 148.9 | 139–154 | 4.43 | 29 | 0.86 |
| Osoblyva | 158.2 | 149–165 | 5.12 | 32 | 0.85 |
| Kabott | 151.6 | 143–158 | 5.02 | 33 | 0.85 |
| Pysanka | 152.1 | 143–162 | 5.78 | 38 | 0.82 |
| Vinnychanka | 153.8 | 137–158 | 5.95 | 39 | 0.81 |
| Vezha | 145.7 | 131–152 | 6.16 | 42 | 0.80 |

**Table 5.** Repeatability coefficients (Rn) and variation coefficients (V, %) of soybean varieties by yield in 2012–2021

| Сорт | X | Swing min–max | S² | V,% | Rn |
|---|---|---|---|---|---|
| Femida | 1.88 | 1.47–2.1 | 0.21 | 10.7 | 0.75 |
| Ametyst | 1.88 | 1.52–2.2 | 0.21 | 11.4 | 0.73 |
| Vezha | 1.89 | 1.5–2.2 | 0.22 | 11.4 | 0.72 |
| Zolotysta | 1.79 | 1.42–2.1 | 0.23 | 12.7 | 0.70 |
| Oriana | 1.73 | 1.38–2.0 | 0.23 | 13.1 | 0.70 |
| Artemida | 2.0 | 1.55–2.46 | 0.26 | 13.1 | 0.64 |
| Roksolona | 2.51 | 1.9–3.05 | 0.28 | 11.1 | 0.61 |
| Fea | 2.11 | 1.57–2.69 | 0.28 | 13.5 | 0.60 |
| Podilska 1 | 2.29 | 1.65–2.56 | 0.29 | 12.6 | 0.59 |
| Knyazha | 2.47 | 1.94–3.08 | 0.29 | 11.9 | 0.59 |
| Osoblyva | 2.29 | 1.59–2.54 | 0.29 | 12.8 | 0.59 |
| Canatto | 2.49 | 1.9–3.06 | 0.29 | 11.9 | 0.58 |
| Kabott | 2.46 | 1.9–3.0 | 0.31 | 12.6 | 0.56 |
| Vinnychanka | 2.47 | 1.71–2.76 | 0.32 | 12.8 | 0.55 |

in the varieties Femida – 0.75, coefficient of variation – 10.7%, and yield – 1.88 t/ha; Amethyst – 0.73, coefficient of variation – 11.4%, yield – 1.88 t/ha; Vezha – 0.72, coefficient of variation – 11.4%, yield – 1.89 t/ha; Zolotista – 0.70, coefficient of variation – 12.7%, and yield – 1.79 t/ha; Oriana – 0.70, coefficient of variation – 13.1%, yield – 1.73 t/ha; Artemida – 0.64, coefficient of variation – 13.1%, yield – 2.0 t/ha. As with the elements of the yield structure, the yield of soybean varieties was lower throughout the years of research, particularly in the varieties Femida, Ametist, Vezha, Zolotista, Oriana, and Artemida, which were characterized by higher stability in the expression of genotypic variability, ensuring a stable yield level.

Soybean varieties with higher yields, namely Roksolana (2.51), Kniazhna (2.47), Canatto (2.49), Kabott (2.46), and Vinnichanka (2.47 t/ha), did not show high repeatability coefficients, which indicates significantly lower potential of these varieties to form high yields or yields close to their mean values in years with significantly different hydrothermal conditions. In particular, the repeatability coefficients for these varieties were significantly lower, and the coefficients of variation were significantly higher: Roksolana – 0.61, and the coefficient of variation – 11.1%; Knyazhna – 0.59, and the coefficient of variation – 11.9%; Canatto – 0.58, coefficient of variation – 11.9%; Kabott – 0.56, coefficient of variation – 12.6%; and Vinnichanka – 0.55, coefficient of variation – 12.8%, respectively.

## CONCLUSIONS

The variability of yield levels during the research period was quite high, with a repeatability coefficient ranging from 0.55 to 0.75, which is quite natural given the large number of formative traits involved in its determination, which are influenced by unfavorable abiotic and biotic environmental factors. The coefficient of variation in the best selected soybean varieties ranged from 10.7 to 13.5%. The highest repeatability coefficients were observed in the Femida variety – 0.75, coefficient of variation – 10.7%, and yield – 1.88 t/ha; Ametist – 0.73, coefficient of variation – 11.4%, yield – 1.88 t/ha; Vezha – 0.72, coefficient of variation – 11.4%, yield – 1.89 t/ha. It should be noted that these varieties were distinguished by high values of repeatability coefficients for the weight of 1,000 seeds, in particular, Femida – 0.91, Amethyst – 0.93, Vezha – 0.80; as well as for the number of productive nodes, pods, and seeds: Femida – 0.69; 0.52 and 0.55, and Vezha – 0.68; 0.56 and 0.57, respectively. That is, ensuring a stable level of soybean yield is determined by the formation of stable indicators of the elements of the soybean yield structure of each variety in particular. These varieties are recommended for inclusion in targeted hybridization when creating new soybean varieties, as well as for introduction for sustainable soybean production.

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