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Adaptability and breeding value of soybean varieties of Poltava breeding

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Abstract

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There were identified soybean varieties that combine high genotype potential and stable yields being the best ones under a set of adverse conditions as well as a positive response to the improvement of growing conditions. The varieties were differentiated by the level of ecological potential in accordance with their response to the growing conditions in different soil and climatic conditions of research. Evaluation and differentiation by the plasticity and stability allowed us to identify environmentally adapted genotypes by the yield, length of the growing season, seed quality. Varieties Adamos, Alexandrite and Aquamarine appeared to have high plasticity by the yield, weight of 1000 seeds, growing season and high quality of seeds. They responded well to the improvement of growing conditions and, by the yield and quality of seeds, provided high stability of the manifestation of traits in various hydrothermal and edaphic conditions of Ukraine. Varieties Almaz, Anthracite and Avanturine appeared to be more conservative in their response to environmental changes having high stability.

Soybean varieties of Poltava breeding are highly adaptive and they can confidently provide efficient soybean production in different soil and climatic conditions of Ukraine.

Keywords: soybean; plasticity; stability; yield; seed quality; coefficient of plasticity; variance of stability

Introduction

One of the ways of preserving and increasing biodiversity is to grow sustainable and adaptive forms and species of plants, especially those that are more able to withstand negative environmental factors (Andresen & Gronau, 2007). Annual losses of productivity in the global agriculture that are caused by various stress factors equal 65-85% (Mittal et al., 2012).

Adaptation of living organisms to biotic and abiotic stress conditions is one of the most important indicators of their assessment, which is related, first of all, to the adaptive potential of higher plants, i.e. their ability to survive, reproduce and develop in the constantly changing environment (Lobell et al., 2014).

Plant resistance is based on the mechanisms of adaptability, which, despite a significant number of studies, attract more and more attention of foreign researchers (Tavares et al., 2015; Salari et al., 2015; Bita & Gerats, 2013; Nezhadahmadi et al., 2013; Lucas et al., 2011; Fu & Huang, 2001; Alonso-Peral et al., 2011; Thai, 1971; Field et al., 2014; Tavakol et al., 2014; Wei et al., 2009; Podolska & Sułek, 2012). Foreign scientists have deeply studied the sustainability of cultivated species to environmental conditions at the local levels (Lobell et al., 2014; Lonbani & Arzani, 2011).

Adaptability (from English "adaptive", from Latin "adapto" – adopt), as a property of living organisms, characterizes the adequacy (correspondence) of the plant genotype to the real conditions of existence throughout a rather long time period to maximize the fulfilment of potential opportunities (Kordyum et al., 2003; Vinnychenko et al., 2011).

Therefore, an adaptive variety is an environmentally-friendly genotype adapted to both optimal and minimal or maximal manifestation of environmental factors (Zhuchenko, 2012).

Plasticity is closely related to the concept of "ecological stability", which reflects the ability of plant populations to withstand stress factors, while plasticity is the ability of plants to combine economical and effective use of natural resources and nutrients in specific conditions of growing (Kordyum & Dubyna, 2015).

Adaptive plant potential involves not only a high level of seed productivity under favorable environmental factors but also a high lower threshold of it (Salari et al., 2015).

The general tendency towards adaptability of cultivated species to the growing conditions is determined by the coefficient of regression (Eberhart & Russel, 1966). The genotype stability is based on the difference between the maximum and minimum yield, and the smaller it is, the higher the stability (stress resistance) is. According to the definition (Eberhart & Russel, 1966; Thai, 1971), adaptability corresponds to the content of parameters of ecological plasticity.

The yield is the interaction of two components, i.e. productivity and stability (Atstsi, 1959). In the second half of the nineteenth century, there was offered a hypothesis on the existence of physiological mechanisms that support the stability of plants in the environment (Bernar, 1978). To characterize this process, Hangildin indicated the term homeostasis, which was first proposed by the foreign scientist A. U. Cannon (Hangildin, 1978). According to Pliuta (1998) and Zhuchenko (2012) "... homeostasis is a universal functional system of the organism that maintains optimal conditions for the growth and development and performs an evolutionary role in stabilizing the norm of adaptability" (Pliuta, 1998; Zhuchenko, 2012).

Problem-solving on the adaptability of cultivated plants is based on the involvement of adaptive forms with the enhanced recombination processes of gene interaction. In the gene pool of the population, in the process of recombination there takes place is a mutual adaptation of different genes, which forms more pronounced features and properties in a number of genotypes, compared to the parent forms, due to the influence of a limiting factor (or several of them) (Jones et al., 1995).

It has been emphasized that low demand for some soybean varieties in agricultural production is not caused by the decrease in their productive potential, but the lack of their environmental sustainability and adaptability (Adamenko, 2006), which is becoming even more important due to climate change such as higher aridity of the growing season, sharp fluctuations of temperatures (Biliavska et al., 2018; Biliavska et al., 2018; Biliavska, 2010; Bilyavska & Diyanova, 2016; Mazur et al., 2018; Mazur, 2018, Pantsyreva, 2019; Didur et al., 2019; Mazur et al., 2018; Telekalo et al., 2019; Mazur et al., 2019).

According to some scientists (Petrychencko et al., 2013; Arnoldi, 2013; Miladinovic et al., 2013; Akande et al., 2013; Lavrinenko & Kuzmich, 2015; Fasoyiro et al., 2006), growth of the yield and adaptive potential of soybean with the simultaneous improvement of quality indicators is an important task.

The research was aimed to evaluate soybean genotypes of the domestic breeding from the standpoint of the potential of ontogenetic adaptation taking into account a complex of their farming traits and properties.

Materials and Methods

The research was carried out in different soil and climatic provinces of Ukraine in the so-called Soybean Belt, which includes regions with the growing season of 100-140 days, where the sum of effective temperatures is 1800-3000°C, annual precipitation is 500-600 mm and more (Babych & Babych-Poberezhna, 2010).

According to the peculiarities of landscape distribution, the Forest-Steppe zone of Ukraine is divided into four provinces: Western Ukraine, Dniester-and-Dnieper, Left-Bank Dnieper, and Middle Russian (Masliak, 2004).

The Dniester-Dnieper Forest-Steppe province is located within the boundaries of Kyiv, Zhytomyr, Cherkasy, Vinnytsia, Kirovohrad, Khmelnytskyi and Odesa regions. The Right-Bank province includes Poltava region. Within the Middle Russian province there can be distinguished two physical and geographical regions, namely, Sumy region and Kharkiv region.

Kyiv region is located in the central northern part of Ukraine.

Sumy region is located in the north-eastern part of the Left-Bank of Ukraine. Poltava region is located in the middle part of the Left Bank of Ukraine. Vinnytsia region is located in the Forest-Steppe zone of the central part of the Right-Bank Ukraine (Masliak, 2004).

The trial sites were located in different soil and climatic provinces of Ukraine, which ensured the study of the response of varieties to a wide range of environmental factors. The research involved the specialists from scientific institutions, agrarian enterprises and universities, e.g. Institute of Agriculture of the Northeast – Sumy region; Ustymivka Research Station – Poltava Region; Vinnytsia National Agrarian University – Vinnytsia Region; Astarta-Kyiv agroholding – Kyiv region.

The object of the research was soybean varieties Adamos, Alexandrit, Avanturin, Aquamarin, Almaz, Anthracite, which are included in the State Register of Plant Varieties Applicable for the Distribution in Ukraine (State Register of Plant Varieties Applicable for the Distribution in Ukraine in 2016; State Register of Plant Varieties Suitable for the Distribution in Ukraine in 2017). Breeding of these varieties was performed by the breeder Liudmyla Biliavska.

The soils were gray forest soils at Vinnytsia National Agrarian University, typical black soils at Ustymivka Research Station and the Institute of Agriculture of the Northeast and the black podzol soils in the Astarta-Kyiv agroholding.

The research was carried out according to the standard method: the seeding rate was 600 thousand germinating seeds, the registration area of the trial site was 25 m², the total area was 30 m², and the replication was fourfold (Methodology of qualification (technical) examination of plant varieties for the determination of the applicability to distribution in Ukraine, 2011).

Parameters of the environmental adaptability of varieties were calculated according to the specific methods (Eberhart & Russel, 1966; Tai, 1971) and Pakudin & Lopatina (1984).

Determination of homeostatic capacity and agronomic stability coefficient (As) was calculated according to the methodology by Hangildin (Hangildin & Litvinenko, 1981; Hangildin, 1978). Laboratory studies on the determination of biochemical and technological parameters of the seed quality were conducted according to the Methodology of state scientific and technical examination of plant varieties and methods for determination of the quality indicators of plant products (2011).

The variance analysis of data was carried out according to Dospehov (1985).

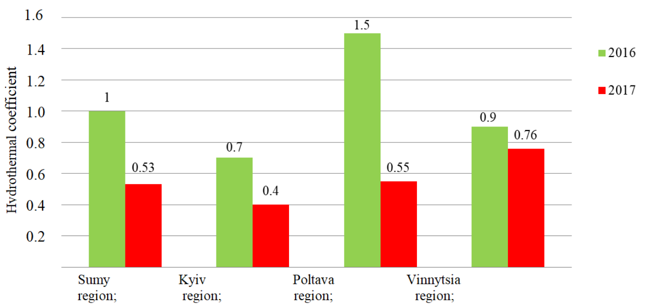

Fig. 1. Hydrothermal regime of the growing season of soybean varieties in different regions of Ukraine in 2016-2017

Results and Discussion

A reliable assessment of the variety adaptability and plasticity requires the study of the peculiarities of its yield formation under the changes of the abiotic factors during the growing season (Adamenko, 2006). In our studies, this essential requirement is completely met, and a significant difference in hydrothermal conditions is established (Figure 1).

In general, during the period of observations and records, the year of 2017 was the most arid with a hydrothermal coefficient (HTC) ranging within 0.4-0.76, and the year of 2016 was the most humid (0.7 to 1.5). According to HTC parameter, the years of research could be characterized as follows: 2016 was close to the mean long-term typical, 2017 was arid.

The results of the given hydrothermal regime were reflected in the formation of the index of conditions of the year and implementation of the interaction of genotype - environment (Table 1), in particular, the significance (according to Fisher's criterion) of the interaction of the variety genotype and soil and hydrothermal conditions as well as hydrothermal and edaphic conditions in a separate variance of the dispersive treatment of results of yield records.

The above-mentioned factors allow us to evaluate soybean varieties using different approaches and methods for assessing their environmental plasticity and stability (Table 1).

Therefore, environmental plasticity is treated as a response of the genotype to external conditions and stability of its features in a certain range of environmental situations. The regression coefficient (bi) characterizes mean response of the variety to environmental changes and gives an opportunity to predict the change of the investigated trait, within the conditions available in the experiment. A higher value of the regression coefficient indicates a higher rate of the variety response under the change of the growing conditions. The value of bi that is close to 0 indicates that the variety does not respond to the changing conditions of growing. The coefficient of regression of the variety trait from the environmental conditions is called the coefficient of environmental plasticity, and the variance with respect to regression is called stability.

According to the calculations of parameters of plasticity (bi) and stability (Si^2) for the varieties, the following grouping ranges are distinguished:

1) indicators bi < 1, $Si^2 > 0$ – have better results under unfavorable conditions, unstable;

2) indicators bi < 1, $Si^2 = 0$ – have better results under unfavorable conditions, stable;

3) indicators b = 1, $Si^2 = 0$ – respond well to improvement of conditions, stable;

Table 1. Parameters of environmental plasticity and soybean varieties of yields (t/ha), 2016-2017

Variety	Year, trial sites								Coefficient		Variance of stability (Si^2)	Homeostatic ability
	2016	2017	2016	2017	2016	2017	2016	2017				
	Sumy region		Kyiv region		Poltava region		Vinnytsia region		Environmental plasticity (bi)	Agronomic stability (As), %		
Adamos	2.5	1.7	2.1	1.6	3.0	2.4	2.4	2.2	1.16	78.3	0.04	0.1
Alexandrite	2.7	2.0	2.2	1.8	3.2	2.1	2.5	2.1	1.13	79.4	0.05	0.1
Avanturine	2.9	1.8	2.4	2.0	2.6	2.3	2.5	2.3	0.92	84.3	0.01	0.2
Aquamarine	2.8	1.8	2.9	1.7	2.5	2.1	2.5	2.0	1.10	79.4	0.06	0.1
Almaz	2.7	1.9	2.6	2.0	2.6	2.4	2.6	2.4	0.81	86.6	0.01	0.2
Anthracite	2.5	1.6	2.2	1.8	2.4	2.1	2.5	2.2	0.87	83.8	0.01	0.1
Mean, xj	2.7	1.8	2.4	1.8	2.7	2.2	2.5	2.2	Factor		F a	F t
									Variety		213.0	2.3
Index of conditions, lj	0.4	-0.5	0.1	-0.5	0.4	-0.1	0.2	-0.1	Conditions		8.8	2,1
									Interaction variety – conditions		7.9	1.5

4) indicators b = 1, $Si^2 > 0$ – respond well to improvement of conditions, unstable;

5) indicators b > 1, $Si^2 = 0$ – have better results under favorable conditions, stable;

6) indicators b > 1, $Si^2 > 0$ – have better results under favorable conditions, unstable.

Indicators of the genotype response to the changing environmental conditions characterize the properties of the variety, i.e. its plasticity and stability in the implementation of the level of development of its traits.

According to this grouping, Avanturine, Almaz and Anthracite varieties belong to the second rank by their yields and their coefficient of regression (b 1) is less than 1 and the variance of stability of the trait is $Si^2 = 0$.

Adamos, Alexandrite and Aquamarine varieties belong to the fifth rank and their coefficient of regression is bi> 1 and the variance of stability is $Si^2 = 0$, so that these varieties have better results under favorable growing conditions and they are stable. In highly plastic varieties, the deviation from the mean group constant is at the top of the scale (Figure 2).

From the point of view of breeding value, genotypes with relatively high stability (homeostatic capacity) of yield are of great significance. The coefficient of stability from an agronomic point of view (As) characterizes the farming value of the source material: therefore, variety samples, in which the coefficient of stability exceeds 70% are considered to be the most valuable for production. According to this criterion, all varieties are stable that is confirmed by a similar sequence of the distribution of varieties by homoeostatic capacity (Hom), however, the highest indices were in varieties Avanturine and Almaz – 0.2.

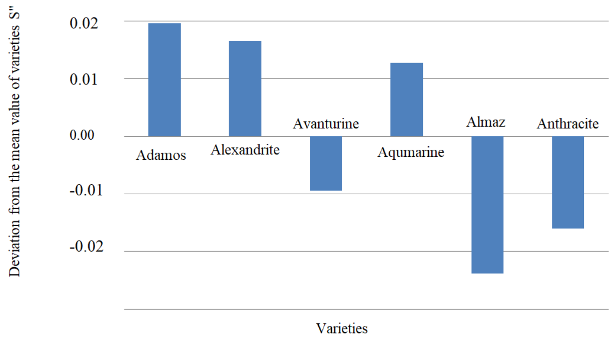

Fig. 2. Yield stability and plasticity of soybean varieties depending on the environmental conditions of growing

The highest yields in different soil and climatic conditions were provided by such soybeans varieties as Alexandrite – 2.3 t/ha; Avanturine – 2.4 t/ha, Aquamarine – 2.3 t/ ha and Almaz – 2.4 t/ha. By the variance of stability, these varieties appeared to be stable – $Si^2 = 0$, and by the coefficient of plasticity Alexandrite and Aquamarine varieties were highly plastic – (bi> 1), so they respond well to improvement of growing conditions of ensuring high stability of the yield. Avanturine and Almaz varieties are characterized by lower plasticity, but their coefficient of plasticity is close to 1, so they are responsive to improvement of growing conditions, although their response to high farming background is somewhat conservative, however the stability of these varieties is higher.

Then soybean varieties were studied by the weight of 1000 seeds (Table 2, Figure 3). The most integral indicator

Table 2. Parameters of environmental plasticity and soybean varieties by the weight of 1000 seeds (g), 2016-2017

Variety	Year, trial sites								Coefficient		Variance of stability (Si^2)	Homeostatic capacity
	2016	2017	2016	2017	2016	2017	2016	2017				
	Sumy region		Kyiv region		Poltava region		Vinnytsia region		Environmental plasticity (bi)	Agronomic stability (As), %		
Adamos	127	125	121	125	170	157	167	151	1.69	84.7	52.8	9.3
Alexandrite	130	127	120	129	170	157	163	148	1.60	85.8	27.1	10.1
Avanturine	148	145	138	127	170	141	151	134	0.88	90.8	87.1	15.7
Aquamarine	132	126	138	126	161	144	145	136	0.94	91.0	31.1	15.4
Almaz	145	142	131	145	164	140	140	135	0.62	93.0	63.3	20.3
Anthracite	137	129	124	142	150	160	135	151	0.73	91.2	101.1	16.1
Mean, xj	137	132	129	132	164	150	150	143	Factor		F a	F t
									Variety		4020	2.3
Index of conditions, lj	-6	-10	-13	-10	22	8	8	0.4	Conditions		81	2.1
									Interaction variety - conditions		303	1.5

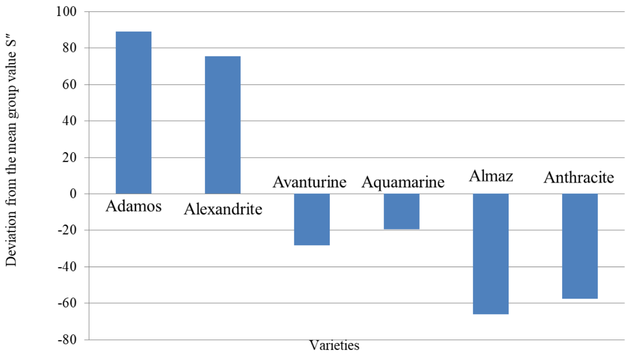

Fig. 3. Stability and plasticity of the weight of 1000 seeds of soybean varieties depending on the environmental conditions of growing

of the drought resistance is high productivity of varieties, which is determined not by one trait or quality, but by the entire genetic system of plants. Under arid conditions, the highest yield is formed when the optimal combination of the individual elements of productivity and farming characteristics, among which the most important are the leaf mass of plants, number of beans and seeds per plant as well as a slight decrease in the weight of 1000 seeds (Sichkar et al., 2014).

According to the research results, there were identified soybean varieties, e.g. Almaz, Anthracite, Avanturine and Aquamarine, which slightly reduced the weight of the formed seeds due to deterioration of moisture conditions, and the coefficient of plasticity was bi <1.

Thus, the selected varieties responded less to the changes in the farming background and provided a stable weight of 1000 seeds during the years of research that differed in their hydrothermal regime, and they were more conservative in response to the changing environmental conditions. However, Adamos and Alexandrite varieties belong to the genotypes that are highly responsive to the changes in the hydrothermal and edaphic conditions (Figure 3), so they should be recommended to be grown in conditions of high farming culture.

The coefficient of agronomic stability in drought tolerant varieties Almaz, Anthracite, Avanturine, and Aquamarine was high and varied from 90.8 to 93.0%. The highest homeostatic capacity was observed in varieties Almaz (20.3) and Anthracite (16.1).

The highest weight of 1000 seeds in different soil and climatic conditions was provided by Avanturine variety (144.0 g), Almaz and Alexandrite varieties (143 g). Among them, Alexandrite variety appeared to be highly plastic with the coefficient of plasticity of bi> 1; while Avanturine and Almaz varieties had lower plasticity by absolute values and variance of stability of Si^2> 0.

Length of the growing season is one of the most important features determining the degree of plant adaptability to the growing conditions.

The rhythm of fluctuations of abiotic factors, especially highly active and low temperatures as well as the amount of precipitation, constitute a certain tension in the implementation of physiological processes of production formation (Korniienko, 2014). Therefore, nowadays identification of statistical criteria for controlling the variability of traits is an urgent scientific issue. It is known that formation of phenophases of plant development is interconnected with the effect of weather conditions and it is the basis of their productiv-

Table 3. Parameters of environmental plasticity and soybean varieties on the length of the growing season (days), 2016-2017

Variety	Year, trial sites								Coefficient		Variance of stability (Si^2)	Homeostatic capacity
	2016	2017	2016	2017	2016	2017	2016	2017				
	Sumy region		Kyiv region		Poltava region		Vinnytsia region		Environmental plasticity (bi)	Agronomic stability (As), %		
Adamos	115	110	114	112	95	99	112	106	1.26	92.7	6.7	14.8
Alexandrite	112	107	106	107	89	102	103	105	1.19	93.0	3.5	14.9
Avanturine	110	103	107	105	98	104	106	104	0.57	96.4	2.5	29.4
Aquamarine	120	115	115	113	100	105	111	110	1.13	93.9	1.6	18.3
Almaz	110	105	108	107	101	99	106	103	0.57	96.3	4.4	28.3
Anthracite	113	109	110	109	89	105	100	107	1.27	92.2	10.9	13.5
Mean, xj	113	108	110	109	95	102	106	106	Factor		F a	F t
									Variety		1009	2.3
Index of conditions, lj	7	2	4	3	-11	-4	-0.4	-0.4	Conditions		173	2.1
									Interaction variety - conditions		34	1.5

ity. The output of the latter is controlled by the response of the samples to the conditions of growing, which depends on their adaptability.

High potential of adaptability to the growing conditions, which differ by the hydropower regime and soil variations, was observed in such varieties as Almaz, Avanturine, and Aquamarine, which provided the highest indices of homeostatic capacity (18.3-29.4) (Table 3). The coefficient of agronomic stability varied from 93.9 to 96.4%. It should be noted that these varieties are classified as those having a high response to the improvement of growing conditions and as varieties that are more conservative to the change of the hydrothermal regime and edaphic conditions. The length of the growing season in the presented soybean varieties ranged from 104 to 111 days, i.e. the varieties belong to the early-ripening group according to a 9-grade scale of the Wide Uniform Classifier (Kobyzieva et al., 2004).

Analysis of the deviation of the stability index is also informative for determination of the mean group constant. This is due to the conditionality of the stability index against the background of plasticity, since the best and the worst soybean varieties can be distinguished in the group when compared with the norm of response of other genotypes (Figure 4).

The degree of stability is characterized by a deviation from the total mean group value: the more negative the deviation from the mean value is, the more stable the variety is; a variety with the deviation that is approaching to 0 is plastic; those with a positive value and substantially distant

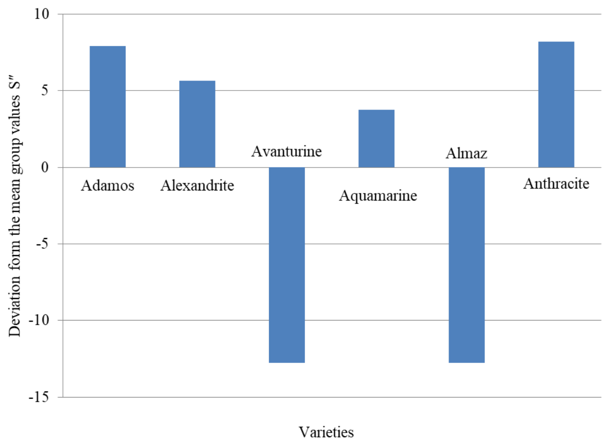

Fig. 4. Stability and plasticity of length of the growing season of soybean varieties depending on the environmental conditions of cultivation

from 0 are highly plastic. Therefore, Avanturine and Almaz soybean varieties are the sources of resistance to changing hydrothermal conditions and different soil variations, which is confirmed by the deviation from the mean group constant located at the bottom of the scale and the highest index of homeostatic capacity – 28.3-29.4.

A modern soybean variety must be characterized both by high yields and high quality (Kaletnik et al., 2018). Soybean quality indicators include two main parameters: crude protein content and oil content. The studied varieties are characterized by high parameters of grain quality: protein content

Table 4. Parameters of environmental plasticity and soybean varieties by the protein content, %

Variety	Year, trial sites								Coefficient		Variance of stability (Si^2)	Homeostatic capacity
	2016	2017	2016	2017	2016	2017	2016	2017				
	Sumy region		Kyiv region		Poltava region		Vinnytsia region		Environmental plasticity (bi)	Agronomic stability (As), %		
Adamos	40.5	38.5	40.5	37.8	40.1	37.9	40.3	37.7	1.48	96.8	0.43	12.3
Alexandrite	40.4	38.4	40.4	37.2	39.3	37.2	40.2	37.1	1.61	96.3	0,77	10.5
Avanturine	39.8	37.8	39.8	40.2	39.6	40.0	39.2	40.0	0.37	97.9	0.59	19.4
Aquamarine	41.4	39.4	41.4	40.3	40.1	39.6	40.7	39.9	0.89	98.0	0.13	20.4
Almaz	39.9	37.9	39.9	38.8	39.9	38.8	39.7	38.7	0.95	98.0	0.03	19.6
Anthracite	39.0	37.0	39.6	39.3	39.6	39.3	39.5	39.4	0.7	97.6	0.53	16.5
Mean, xj	40.2	38.2	40.3	38.9	39.8	38.8	39.9	38.8	Factor		F a	F t
									Variety		48.0	2.3
Index of conditions, lj	0.8	-1.2	0.9	-0.4	0.4	-0.6	0.6	-0.6	Conditions		16.0	2.1
									Interaction variety - conditions		6.0	1.5

ranges within 37.0-41.4%, oil content – 18.4-22.0%, which classifies these varieties as highly technological in terms of further processing and reuse.

Results of the hydrothermal regime have reflected in the formation of the index of the growing conditions and implementation of the interaction of the genotype – environment in terms of formation of seed quality of soybean varieties, in particular, the significance (according to Fisher's criterion) of the interaction of the variety genotype, soil and hydrothermal conditions, hydrothermal and edaphic conditions in a separate variance of the dispersion analysis.

The above-mentioned factors enable to evaluate soybean varieties by the seed quality using different approaches and methods for assessing their ecological plasticity and stability (Table 4).

Analysis of the variety stability according to these parameters shows that both protein content and fat content depended on the growing conditions, as indicated by the coefficient of correlation (d) of the dependence on the index of growing conditions and its HTC.

Expression of the correlation dependences of the seed protein and oil content on the hydrothermal coefficient is heterogeneous, though the dominant negative direction is (r = -0.02 to -0.83); for the oil – from r = 0.24 to r = -0.45 from the weak positive to the inverse mean force of dependence. This can be explained, firstly, by the theory of synthesis of stress proteins under decrease in HTC, and secondly – from the standpoint of polydetermination of the biochemical component of grain formation. This is also directly indicated by

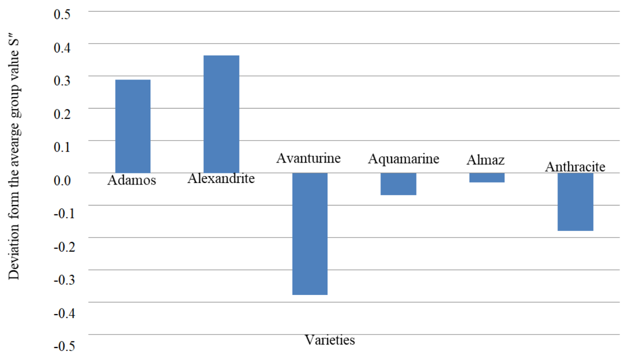

Fig. 5. Stability and plasticity of protein content in soybean varieties depending on the environmental conditions of growing

the values of coefficients of plasticity and variance of stability (Table 4, Figure 5, Table 5, Figure 6).

Soybean varieties Aquamarine, Almaz and Anthracite provided stable protein content in seeds that was less dependent on the growing conditions, and they were ranked second by a regression coefficient (bi < 1) and variance of stability ($Si^2 = 0$) and they provided better indicators under adverse conditions of growing being stable. Adamos and Alexandrite varieties were referred to the fifth rank by the coefficient of regression and variance of stability, and their regression coefficient was above 1, and variance of stability was close to 0.

Table 5. Parameters of environmental plasticity and soybean varieties by the oil content, %

Variety	Year, trial sites								Coefficient		Variance of stability (Si^2)	Homeostatic capacity
	2016	2017	2016	2017	2016	2017	2016	2017				
	Sumy region		Kyiv region		Poltava region		Vinnytsia region		Environmental plasticity (bi)	Agronomic stability (As), %		
Adamos	20.8	20.9	20.8	22.0	20.3	21.0	20.5	21.0	0.8	97.4	0.15	8.1
Alexandrite	18.4	18.7	18.4	20.1	18.7	20.1	18.6	20.2	1.77	96.0	0.1	4.8
Avanturine	19.6	19.9	19.6	20.0	19.6	20.0	19.7	20.1	0.48	99.1	0	20.8
Aquamarine	18.7	19.7	18.7	20.0	18.7	21.0	18.6	20.5	2.05	95.3	0.12	4.1
Almaz	20.7	21.7	20.7	21.3	20.7	21.4	22.0	21.7	0.69	97.5	0.21	8.5
Anthracite	21.2	21.8	21.4	21.4	21.3	21.3	21.2	21.6	0.21	99.0	0.04	22.2
Mean, xj	19.9	20.5	19.9	20.8	19.9	20.8	20.1	20.9	Factor		F a	F t
									Variety		12.5	2.3
Index of conditions, lj	-0.4	0.1	-0.4	0.5	-0.5	0.5	-0.2	0.6	Conditions		40	2.1
									Interaction variety - conditions		2.3	1.5

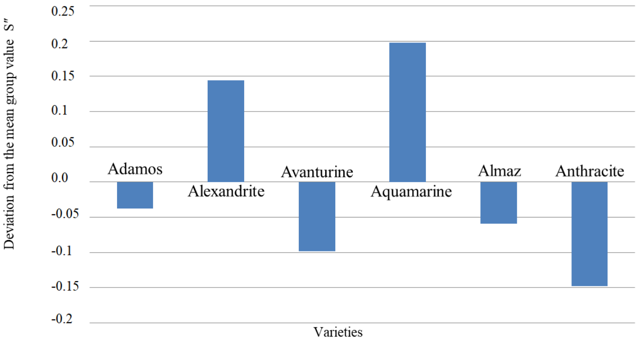

Fig. 6. Stability and plasticity of oil content in soybean varieties depending on the environmental conditions of growing

The highest homeostatic capacity was observed in the following varieties: Aquamarine – 20.4, Alma – 19.6, Avanturine – 19.4. The higher this indicator was, the greater the probability of involving these varieties in the new breeding programs was. By the agronomic stability, Almaz, Aquamarine, Avanturine and Anthracite varieties were the best ones; agronomic stability varied from 97.6 to 98.0%; that was confirmed by a deviation from the overall mean group value at the bottom of the scale (Figure 5).

The highest protein content was provided by such varieties as Aquamarine, Avanturine – 40.0%; Adamos, Almaz, Anthracite – 39.0%.

Adamos and Alexandrite varieties appeared to be highly plastic and stable by the protein content, so they responded well to the improvement of growing conditions and provided stable protein content. Almaz and Aquamarine varieties were characterized by lower plasticity and their regression coefficient was almost 1. Avanturine and Anthracite varieties were more conservative in their response to the changes in hydrothermal conditions and soil heterogeneity.

The results of variety testing of soybean varieties in contrast agrometeorological conditions have shown that implementation of the potential of oil content in seeds is largely limited to the growing conditions. The genotypes, in which oil content remained almost the same in the years that were unfavorable for oil accumulation, are considered to be valuable for selection for increased oil content (Riabukha et al., 2014).

According to the research results, a vast majority of soybean varieties ensured implementation of a stable oil content regardless of the influence of hydrothermal and edaphic conditions including Avanturine, Anthracite, Adamos, Almaz. These varieties provided the highest agronomic stability coefficient that ranged within 97.4-99.1%. The highest average oil content in seeds was provided by varieties Adamos, Almaz and Anthracite (21.0%).

One of the important indicators that characterize plant resistance to adverse environmental factors is homeostasis, i.e. ability of the genotype to minimize the effects of adverse environmental conditions. It is a universal property in the system of relationships between the genotype and environment (Hangildin & Biryukov, 1984).

Ability of the variety to maintain low variability of the traits of productivity can be regarded as a criterion of its homeostatic capacity. Thus, the relationship of homoeostatic ability *(Hom)* with the coefficient of variation *(V)* characterizes stability of the trait in the changing environment.

The highest homeostatic capacity was observed in such varieties as Anthracite (22.2) and Avanturine (20.8). According to the calculations of the parameters of plasticity (bi) and stability (Si^2), the above-mentioned varieties are referred to the second rank – bi <0 and $Si^2 = 0$ and they are conservative in their response to the changing environmental conditions, providing a stable oil content in the seeds under adverse growing conditions. However, the highest breeding value by the response to the improvement of hydrothermal and soil conditions of growing were provided by Alexandrite and Aquamarine varieties that are highly plastic by this trait. In these varieties, the coefficient of plasticity was above 1, and the variance of stability was maximally close to 0. So, they belong to the sixth rank by the parameters of plasticity and stability.

Conclusions

Parameters of ecological adaptability and stability by the yield, length of the growing season and grain quality enable to differentiate soybean varieties by the response to the environmental changes.

Adamos, Alexandrite and Aquamarine varieties appeared to be highly resistant to a vast majority of characteristics, e.g. yield, weight of 1000 seeds, length of the growing season, and qualitative indicators of seeds. They respond well to the improvement of growing conditions, and by the yield and seed quality they provide high stability of manifestation of traits in various hydrothermal and edaphic conditions of Ukraine.

Almaz, Anthracite and Avanturine varieties appeared to be more conservative in their response to changing environmental conditions having high stability.

Soybean varieties of Poltava breeding are highly adaptive and can ensure efficient soybean production in different soil and climatic conditions of Ukraine.

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