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Ecological plasticity of buckwheat varieties (*Fagopyrum esculentum Moench.)* Of different geographical origin according to productivity

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ABSTRACT. To determine the ecological plasticity of crop varieties, there are a number of methods that are based on the analysis of the variability of the trait by contrasting years under the conditions. The stability and plasticity of the studied traits of varieties are due to the ability of genetic mechanisms of plants to minimize the consequences of the negative impact of the environment, that is, to resist them. The researches on establishing regularities of manifestation of plasticity, stability and homeostaticity of buckwheat varieties of different ecological and geographical origin were carried out in the conditions of the central part of Ukraine during the period of 2016–2018. The low adaptability of modern buckwheat varieties is a determining factor for low production yields of potentially high-yielding varieties in the sharply contrasting (climatic factors) cultivation conditions. The level of yield (as a complex characteristic) and its main component, the individual productivity of the plant have been determined as the differentiative indicators of modern varieties and new promising breeding material consisting of 35 samples from 5 countries of the world. The analysis of research data has identified a group of varieties (SYN 3/02, Sofiia, Selianochka, Slobozhanka, Yelena, Roksolana, Populiatsiia 7/07, P-330, P-455, P-620, Ametist, Feniks, Ilishevskaia, Batyr and Arno), which have a value as a highly adaptable varietal material for the cultivation conditions and have an increased selective value according to abiotic adaptability indicators and can be used to create a more adaptable material as a potentially more productive as well as more plastic and stable resource for selection.

Key words: buckwheat, yield, plasticity, homeostaticity, stability, breeding value.

INTRODUCTION

Buckwheat is one of the most valuable crops, its importance for humans has recently been substantially redefined, and the areas of application have been greatly expanded (Chrungoo et al., 2016). A number of characteristics affect the value of buckwheat. Grain and plant of this crop contain a complex of compounds that have significant antioxidant properties, essential amino acids and a large vitamin complex (Skrabanja et al., 2004; Harifullina et al., 2010; Jacquemart et al., 2012). Non-waste production and various directions of processed products usage: for nutrition, feed production, pharmacy, as one of the best predecessors in crop rotation, as a fuel with a high heat transfer coefficient, etc are very important for buckwheat products producers (Li et al., 2001; Holasova et al., 2002; Alekseeva et al., 2005). Recently, the environmental aspect of buckwheat production has become very important. High sensitivity of buckwheat plants to most herbicides, even in the residual doses, prompts producers to refuse from toxic chemicals. Their application in buckwheat rotation has been significantly reduced too (Luzhinskaya, 2017; Modern technology, 2018).

The level of world buckwheat production has huge fluctuations over the years, which is associated with the climatic factors and policies of the certain states, macroeconomic and the strategic factors of world buckwheat producers (Kreft, 2001; Zeller, 2001). The final consumers of buckwheat products requires that the producers create products in quantities that can satisfy constant demand and ensure high quality of products (Kalinova et al., 2002; Zhygunov et al., 2016). In turn, in order to obtain certain quantities of buckwheat products of necessary quality, producers want varieties possesing a set of indicators and properties. They are the following: the ability of maximum adaptability to the cultivation conditions, adaptive characteristics, in particular drought resistance and heat resistance, resistance to lodging and simultaneousness of ripening as the factors of variety technological effectiveness (Alekseeva et al., 2005). Scientists from different countries have created varieties capable to satisfy a certain range of requirements, but the issue of abiotic adaptability still remains unsolved (Cawoy, 2006; Fesenko, 2006). A level of yields is an unstable indicator, and plasticity of varieties is low. The constant search for most suitable for practical use varieties is the solution to this problem (Tryhub, 2002; E et al., 2017; Marenych et al., 2019; Muhamedyarova et al., 2020). Such material is the collection ranges, which number more than five thousand samples of different ecological and geographical origin in the whole world (Rufa, 2004; Zhou, 2018). Ukraine has a collection of buckwheat, which consists of varieties and forms of folk selection, breeding varieties, linear material, mutant forms, etc., with a total quantity of more than 2.5 thousand samples originating from more than 30 countries of the world (Tryhub et al., 2018).

Comprehensive assessment of the wide genetic diversity of varieties of different ecological and geographical origin, different types of plants (by ploidy and type of growth) in contrasting environmental conditions allowed to identify genotypes with high levels of adaptive potential.

Factors of ecological plasticity, homeostaticity and stability of varieties are determining indicators of adaptive potential.

The aim of the research was to study the levels of ecological plasticity, homeostaticity and stability of new varieties and possibility to identify these indicators in order to select new varieties (Burdenyuk-Tarasevych et al., 2012).

MATERIALS AND METHODS

The research tasks are the following: to determine the level of productivity and plant individual productivity in varietal material of different ecological and geographical origin; to apply a complex of mathematical and statistical analyzes in order to identify the level of plasticity, homeostaticity and stability of varietal material; to determine the best varieties according to the studied characteristics and recommend them to be used in production and selection studies as a highly adaptive source material.

Thirty-five breeding varieties originating from Ukraine, the Republic of Belarus, the Russian Federation, China and Canada were used for the research. They included the material widely used in production and promising breeding numbers. The researches were carried out at Ustymivska experimental station of plant production in the conditions of the central part of Ukraine (climate is moderate continental with elevated temperatures and unevenly distributed precipitation during the spring-summer period) during 2016–2018. The material was sown by a selection seeder with a row spacing of 45 cm, the seeding rate of 1.8 mln grains per 1 ha, with an area of 15 m^2 in three repetition in the optimal terms - the first decade of May. The mid ripening diploid variety Yelena has been taken as the standard. This variety has increased stability of the yield level and productivity of the plant and high simultaneousness of ripening. In order to obtain a reasonable evaluation of the wide biological diversity of varietal material, diploid and tetraploid varieties of the ordinary and determinate type have been involved in the research. As a differentiating factor for the analysis, the level of grain yield of the experimental samples has been taken, as the resulting indicator of the complex of factors, and its main component is the individual plant productivity in the contrasting environmental conditions. This indicator was determined from a selected sample of 25 plants.

Statistical analysis

The research results have been analyzed in accordance with Eberhart and Rassell methodology (Eberhart & Rassell, 1966), field experiment (with the fundemantals of statistical processing of the research results). Experimental data was also statistically analyzed for the Analysis of variation (ANOVA) and least significant difference (*LSD*) with the determination of the limiting environmental factors X_{opt} and X_{lim}) and the variability level (*R* and *V*), as the characteristics of plasticity, homeostaticity (*Hom*1 and *Hom*2), stability (σ) and breeding value (*Sc*):

$$\text{range of variation } R = X_{opt} - X_{lim}, \text{ (g m}^{-2}\text{)}; \quad (1)$$

$$\text{coefficient of variation } V = \frac{S}{x} \cdot 100, \text{ (\%)}; \quad (2)$$

S – standard deviation; *x* – arithmetic mean.

As characteristics of plasticity homeostatic index:

$$Hom = \frac{x^2}{\sigma}; \quad (3)$$

σ – stability index, which is determined by the level of the linear regression coefficient, index of selection value

$$\text{Breeding value: } S_c = \frac{X \cdot X_{lim}}{X_{opt}}; \quad (4)$$

Hydrothermal coefficient (*HTC*) was calculated by the formula:

$$HTC = \frac{\sum R \cdot 10}{\sum t > 10}; \quad (5)$$

$\sum R$ – amount of precipitation, mm; $\sum t > 10$ – sum of active temperatures (Hangil'din et al., 1981; Iodkovskyy, 1999; Maruhnyak et al., 2010; Man'ko et al., 2012).

RESULTS

The results of studies of the yield level and individual productivity of buckwheat varieties are shown in Table 1. The table describes the average yield and individual productivity of varieties over the research years. It has been determined that the most favorable conditions for buckwheat varieties prevailed in 2016, and the parameters of 2017 and 2018 were more contrasting. Table 2 and 3 describe in each sample the parameters of the limiting factors (X_{opt} and X_{lim}) the level of variability (*R*) and the coefficient of variation (*V*, %), and the level of variation (*R* and *V*), as the characteristics of plasticity, homeostaticity (Hom_1 *ma* Hom_2), stability (σ) and breeding value (*Sc*) (Table 1–3).

Table 1. Characteristics of the level of yield and individual productivity of buckwheat [*Fagopyrum esculentum. Moench*] varieties of different ecological and geographical origin in the contrasting environmental conditions

No	The origin of variety		Name	Yield, g m^{-2}				Plant productivity, g			
	country	region		2016	2017	2018	average	2016	2017	2018	average
1	St	Khmelnytskyi	Yelena	283.4	216.8	174.2	224.8	2.5	1.9	1.6	2.0
2	Ukraine	Kyiv	Olha	274.0	200.1	178.1	217.4	2.4	1.8	1.7	2.0
3		Kyiv	Nadiina	232.0	169.3	130.8	177.4	2.1	1.4	1.2	1.6
4		Kyiv	Ruta	195.6	152.7	117.1	155.1	1.7	1.3	0.9	1.3
5		Kyiv	SYN 3/02	322.0	245.0	189.3	252.1	2.4	1.9	1.7	2.0
6		Kyiv	Sofiia	287.0	219.5	176.5	227.7	2.5	1.9	1.5	2.0
7		Sumy	Yaroslavna	288.0	210.2	187.2	228.5	2.7	1.8	1.6	2.1
8		Sumy	Sumchanka	272.0	198.5	177.8	216.1	2.3	1.6	1.4	1.8
9		Sumy	Selianochka	294.4	224.6	201.3	240.1	2.6	2.0	1.8	2.1
10		Sumy	Ruslana	272.6	208.9	177.2	219.6	2.2	1.6	1.4	1.7
11		Sumy	Slobozhanka	276.0	201.4	199.4	225,6	2.3	1.7	1.8	1.9
12		Khmelnytskyi	Podolianka	253.2	184.8	181.5	206.5	2.2	1.6	1.7	1.8
13		Khmelnytskyi	Roksolana	305.0	232.4	208.2	248.5	2.8	2.1	1.8	2.2
14		Khmelnytskyi	Populiatsiia7/07	284.5	217.6	197.9	233.3	2.5	1.9	1,6	2.0
15		Khmelnytskyi	Akademichna	237.0	183.0	131.4	183.8	2.0	1.5	1.0	1.5
16		Poltava	P-330	342.3	250.7	212.4	268.5	3.0	2.2	1.8	2.3
17		Poltava	P-332	271.6	208.2	203.1	227.6	2.2	1.7	1.8	1.9
18		Poltava	P-455	298.0	227.2	207.5	244.2	2.6	2.1	1.8	2.2
19		Poltava	Determinantna 8	257.6	178.8	177.4	204.6	2.1	1.6	1.7	1.8
20		Poltava	P-620	297.6	227.2	203.4	242.7	2.7	2.2	1.8	2.2
21	Belarus	Minsk	Ametist	312.0	237.7	202.8	250.8	2.7	2.1	1.7	2.2
22		Minsk	Lakneia	267.5	195.2	183.3	215.3	2.3	1.8	1.6	1.9
23		Minsk	Feniks	282.0	215.8	162.4	220.1	2.6	1.8	1.3	1.9
24		Minsk	Vlada	264.0	209.7	161.7	211.8	2.1	1.8	1.4	1.8
25		Minsk	Marta	251.7	183.7	173.6	203.0	2.1	1.5	1.6	1.7
26	Russia	Bashkortostan	Ufimskaia	247.0	190.3	170.5	202.6	2.1	1.8	1.6	1.8
27		Bashkortostan	Inzierskaia	196.0	153.0	127.4	158.8	1.7	1.4	1.1	1.4
28		Bashkortostan	Chishminskaia	213.6	155.9	128.8	166.1	1.9	1.3	1.0	1.4
29		Bashkortostan	Ahidel	237.0	173.0	170.4	193.5	2.1	1.5	1.6	1.7
30		Bashkortostan	Ilishevskaia	301.0	229.6	202.1	244.2	2.6	2.1	1.7	2.1
31		Novosybirsk	Natasha	242.6	187.0	147.6	192.4	2.1	1.7	1.3	1.7
32		Tatarstan	Batyr	290.6	211.2	184.6	228.8	2.5	1.8	1.5	2.0
33		Tatarstan	Nikolskaia	221.0	171.6	152.4	181.7	1.9	1.4	1.3	1.5
34	China		BaiChen	214.0	156.2	139.1	169.8	1.9	1.5	1.1	1.5

Table 1 (continued)

35 Canada	Arno	275.6	211.1	197.2	228.0	2.4	1.8	1.6	1.9
Target group									
average		267.4	201.1	175.3	214.6	2.3	1.7	1.5	1.9
min		195.6	152.7	117.1	155.1	1.7	1,3	0.9	1.3
max		342.3	250.7	212.4	268.5	3.0	2.2	1.8	2.3
V		10.3	10.9	12.0	18.3	11,3	11.9	14.3	12.5
R		146.7	98.0	95.3	113.3	1.3	0.9	0.9	1.0
σ		27.5	22.0	21.0	39.2	0.3	0.2	0.2	0.2

Table 2. The expression level of plasticity, stability, homeostaticity and breeding value according to buckwheat varieties yields [*Fagopyrum esculentum. Moench.*]

No	Name	Average, g m^{-2}	Variation level X_{opt} (g m^{-1})	X_{lim} (g m^{-2})	R (X_{opt}-X_{lim}) (g m^{-2})	V, %	Homeostaticity Hom_1	Hom_2	Stability, σ	Breeding value, S_c
1	Yelena	224.8	283.4	174.2	109.2	21.7	1,036.2	9.5	48.8	138.2
2	Olha	217.4	274.0	178.1	95.9	20.7	1,047.9	10.9	45.1	141.3
3	Nadiina	177.4	232.0	130.8	101.2	22.6	785.8	7.8	40.0	100.0
4	Ruta	155.1	195.6	117.1	78.5	22.3	696.7	8.9	34.5	92.9
5	SYN 3/02	252.1	322.0	189.3	132.7	22.3	1,129.9	8.5	56.2	148.2
6	Sofiia	227.7	287.0	176.5	110.5	21.7	1,049.9	9.5	49.4	140.0
7	Yaroslavna	228.5	288.0	187.2	100.8	20.8	1,100.9	10.9	47.4	148.5
8	Sumchanka	216.1	272.0	177.8	94.2	20.7	1,044.4	11.1	44.7	141.3
9	Selianochka	240.1	294.4	201.3	93.1	20.0	1,199.3	12.9	48.1	164.2
10	Ruslana	219.6	272.6	177.2	95.4	20.9	1,052.9	11.0	45.8	142.7
11	Slobozhanka	225.6	276.0	199.4	76.6	19.5	1,154.6	15.1	44.1	163.0
12	Podolianka	206.5	253.2	181.5	71.7	19.6	1,052.0	14.7	40.5	148.0
13	Roksolana	248.5	305.0	208.2	96.8	20.0	1,240.4	12.8	49.8	169.7
14	Populiatsiia 7/07	233.3	284.5	197.9	86.6	19.8	1,180.2	13.6	46.1	162.3
15	Akademichna	183.8	237.0	131.4	105.6	23.3	789.2	7.5	42.8	101.9
16	P-330	268.5	342.3	212.4	129.9	21.2	1,264.9	9.7	57.0	166.6
17	P-332	227.6	271.6	203.1	68.5	18.6	1,222.7	17.8	42.4	170.2
18	P-455	244.2	298.0	207.5	90.5	19.7	1,238.2	13.7	48.2	170.1
19	Determinantna 8	204.6	257.6	177.4	80.2	20.7	988.2	12.3	42.4	140.9
20	P-620	242.7	297.6	203.4	94.2	20.0	1,211.6	12.9	48.6	165.9
21	Ametist	250.8	312.0	202.8	109.2	20.8	1,205.8	11.0	52.2	163.0
22	Lakneia	215.3	267.5	183.3	84.2	20.2	1,068.4	12.7	43.4	147.6
23	Feniks	220.1	282.0	162.4	119.6	22.7	971.0	8.1	49.9	126.7
24	Vlada	211.8	264.0	161.7	102.3	22.1	959.3	9.4	46.8	129.7
25	Marta	203.0	251.7	173.6	78.1	20.1	1,011.0	12.9	40.8	140.0
26	Ufimskaia	202.6	247.0	170.5	76.5	20.0	1,015.1	13.3	40.4	139.9
27	Inzierskaia	158.8	196.0	127.4	68.6	21.0	755.5	11.0	33.4	103.2
28	Chishminskaia	166.1	213.6	128.8	84.8	21.6	769.6	9.1	35.8	100.2
29	Ahidel	193.5	237.0	170.4	66.6	19.6	987.5	14.8	37.9	139.1
30	Ilishevskaia	244.2	301.0	202.1	98.9	20.3	1,202.7	12.2	49.6	164.0
31	Natasha	192.4	242.6	147.6	95.0	21.9	878.0	9.2	42.2	117.1
32	Batyr	228.8	290.6	184.6	106.0	21.1	1,086.2	10.2	48.2	145.3
33	Nikolskaia	181.7	221.0	152.4	68.6	20.0	906.3	13.2	36.4	125.3
34	BaiChen	169.8	214.0	139.1	74.9	20.8	818.0	10.9	35.2	110.3
35	Arno	228.0	275.6	197.2	78.4	19.3	1,179.4	15.0	44.1	163.1

Table 3. The expression level of plasticity, stability, homeostaticity and breeding value according to individual plant productivity in varietal buckwheat material [*Fagopyrum esculentum Moench.*]

No	Name	Average, g	Variation level				Homeostaticity		Stability, σ	Breeding value, S_c
			X_{opt} (g)	X_{lim} (g)	R (X_{opt}-X_{lim}) (g)	V, %	Hom_1	Hom_2		
1	Yelena	2.0	1.6	2.5	0.9	20.9	9.5	11.0	0.4	1.3
2	Olha	2.0	1.7	2.4	0.7	19.3	10.2	14.9	0.4	1.4
3	Nadiina	1.6	1.2	2.1	0.9	23.4	6.7	7.5	0.4	0.9
4	Ruta	1.3	0.9	1.7	0.8	24.0	5.4	6.8	0.3	0.7
5	SYN 3/02	2.0	1.7	2.4	0.7	19.8	10.1	14.4	0.4	1.4
6	Sofiia	2.0	1.5	2.5	1.0	21.7	9.1	9.5	0.4	1.2
7	Yaroslavna	2.1	1.6	2.7	1.1	22.6	9.1	8.5	0.5	1.2
8	Sumchanka	1.8	1.4	2.3	0.9	22.1	8.0	8.9	0.4	1,1
9	Selianochka	2.1	1.8	2.6	0.8	20.1	10.4	12.3	0.4	1.4
10	Ruslana	1.7	1.4	2.2	0.8	21.0	8.2	10.3	0.4	1.1
11	Slobozhanka	1.9	1.7	2.3	0.6	19.0	10.2	18.0	0.4	1.5
12	Podolianka	1.8	1.6	2.2	0.6	19.1	9.6	15.4	0.4	1.3
13	Roksolana	2.2	1.8	2.8	1.0	20.7	10.8	10.9	0.5	1.4
14	Populiatsiia 7/07	2.0	1.6	2.5	0.9	20.9	9.5	10.9	0.4	1.3
15	Akademichna	1.5	1.0	2.0	1.0	24.5	6.1	6.1	0.4	0.8
16	P-330	2.3	1.8	3.0	1.1	21.2	11.0	9.7	0.5	1.4
17	P-332	1.9	1.7	2.2	0.5	18.7	10.2	20.3	0.4	1.5
18	P-455	2.2	1.8	2.6	0.8	20.3	10.7	13.6	0.4	1.5
19	Determinantna 8	1.8	1.6	2.1	0.5	19.3	9,3	18.5	0.3	1.4
20	P-620	2.2	1.8	2.7	0.9	21.3	10.4	11.2	0.5	1.5
21	Ametist	2.2	1.7	2.7	1.0	21.4	10.1	10.0	0.5	1.4
22	Lacneya	1.9	1.6	2.3	0.7	20.1	9.5	12.9	0.4	1.3
23	Feniks	1.9	1.3	2.6	1.3	24.3	7.8	6.0	0.5	1.0
24	Vlada	1.8	1.4	2.1	0.7	21.5	8.2	11.9	0.4	1.2
25	Marta	1.7	1.5	2.1	0.6	19.3	9.0	15.2	0.3	1.2
26	Ufimskaya	1.8	1.6	2.1	0.5	19.5	9.5	17.3	0.4	1.4
27	Inzerskaya	1.4	1.1	1.7	0.6	21.5	6.5	11.0	0.3	0.9
28	Chishminskaya	1.4	1.0	1.9	0.9	23.4	5.9	6.9	0.3	0.7
29	Agidel’	1.7	1.5	2.1	0.6	19.1	9.0	15.5	0.3	1.2
30	Ilishevskaya	2.1	1.7	2.6	0.9	21.3	10.1	11.0	0.5	1.4
31	Natasha	1.7	1.3	2.1	0.8	22.3	7.6	9.2	0.4	1.0
32	Batyr	2.0	1.5	2.5	1.0	21.8	9.0	8.7	0.4	1.2
33	Nikol’skaya	1.5	1.3	1.9	0.6	20.1	7.7	12.9	0.3	1.1
34	BaiChen	1.5	1.1	1.9	0.8	22.7	6.5	8.6	0.3	0.9
35	Arno	1.9	1.6	2.4	0.8	20.4	9.5	11.9	0.4	1.3

The research of the parameters of plasticity, stability and homeostaticity, as factors determining the level of yield and individual productivity of the plant varieties, was carried out in the contrasting (according to heat and moisture availability) environmental conditions in 2016, 2017 and 2018. It has been defined that the conditions were more extreme in 2017 and 2018, when the level of hydro-thermal coefficient (*HTC*) of the vegetation period ranged from 0.51to 0.68, ‘growth above ground-flowering’ period - 0.37–0.42, ‘flowering- early ripening’ period - 0.56–0.78, ‘early ripening -full ripening’ period - 0.61–0.85 (Table 4). In this case, not only *HTC* level is important, but also the sum of precipitation, and especially the distribution of precipitation by periods.

For example, according to the level of *HTC* during the 'flowering - early ripening' period in 2016, which is generally recognized as optimal, this period is much more arid (0.64) than generally recognized as arid 2017, when the level of *HTC* was 0.78. But such level of *HTC* determined a lower temperature level in 2017 and a slightly higher level of precipitation. Rainfall during the 'flowering - early ripening' period of this year consisted of two heavy rains, with strong winds and had a negative effect on plants.

Table 4. Parameters of weather and climate conditions and level of hydro-climatic coefficient over the research years

Year	Phases of vegetation period											
	'growth above ground-flowering'			'flowering-early ripening'			'early ripening -full ripening'			'growth above ground - full ripening'		
	∑t air	∑ precip	*HTC*	∑t air	∑ precip	*HTC*	∑t air	∑ precip	*HTC*	∑t air	∑ precip	*HTC*
2016	560.6	39.6	0.71	694.4	44.7	0.64	471.6	31.4	0.67	1,726.6	115.7	0.67
2017	531.9	22.5	0.42	621.6	48.5	0.78	432.1	36.6	0.85	1,585.6	107.7	0.68
2018	558.2	20.8	0.37	620.2	34.9	0.56	454.4	27.9	0.61	1,632.8	83.6	0.51

Yields of varieties

The level of research material yields varied in the range of 117.1 to 342.3 g m^{-2} (from 115.1 to 268.5 g m^{-2} according to average data) due to the significant diversity of buckwheat varietal material by ecological and geographical origin and adaptability of certain genotypes to the local environmental conditions.

The most favorable conditions for buckwheat cultivation were in 2016, when the average yield of the target group was 267.4 g m^{-2} with a range of 195.6 to 342.3 g m^{-2}, the least favorable conditions were in 2018, the average yield was 175.3 g m^{-2} with a range of 117.1 to 212.4 g m^{-2}.

According to three-year data, the most yielding varieties were SYN 3/02 (252.1 g m^{-2}), Selianochka (240.1), Roksolana (248.5), Populatsiia 7/07 (233.3), P-330 (268.5), P-455 (244.2), P-620 (242.7), Ametist (250.8), Ilishevskaia (244.2).

Individual productivity of the plant: this indicator, as one of the main components of the characteristics of buckwheat varieties yield, over the years highly repeats tendencies which were established for the previous characteristic. Higher individual productivity was observed in varieties in more favorable weather conditions in 2016 (2.3 g) and a significant decrease was observed in unfavorable 2017 and 2018 (respectively, 1.7 and 1.5 g per plant). For the most part, in the target group, varieties showed greatest variation in the level of this indicator expression in 2018 (V = 14.3%). The highest average productivity (over 2.0 g $plant^{-1}$) was observed in the samples Yelena, Olha, SYN 3/02, Sofiia, Populatsiia 7/07 and Batyr (2.0 g each), Yaroslavna (2.1 g), P-330 (2.3g), Roksolana, P-455, P-620 and Ametist (2.2 g each).

Plasticity (variability level)

Yield (g m^{-2}): the plasticity level of buckwheat varieties was determined by the level of indicator variation in the contrasting environmental conditions. Hence, the factor of yield change was more important than its physical parameter. The coefficient of variation (V), determined by B.A. Dospekhov's method (1974), was applied in order to get the greater reliability. Varieties Ruta (78.5 g m^{-2}), Slobozhanka (76.6), Podolianka

(71.7), P-332 (68.5), Ufimskaia (76.5), Inzierskaia (68.6), Ahidel (66.6), Nikolskaia (68.6), BaiChen (74.8), Arno (78.4) were the least variable according to the yield level (R).

It has been determined that varieties Slobozhanka (19.5), Podolianka (19.6), Populiatsiia 7/07 (19.8), P-332 (18, 6), P-455 (19.7), Ahidel (19.6), Arno (19.3) had higher plasticity (according to the coefficient of variation) in the contrasting environmental conditions.

Individual plant productivity (g/plant): most varieties had significant fluctuations in the level of indicator expression by years, which is explained by the rather contrasting conditions of the cultivation years.

The highest plasticity (the slightest productivity fluctuation in years with the limiting conditions compared to the optimal ones) was observed in varieties Slobozhanka, Podolianka, P-332, Determinantna 8, Marta, Ufimskaia, Inzerskaya, Ahidel and Nikolskaia. Most of these varieties had a slight level of coefficient variation (*V*) – from 18.7 to 19.5%, with the exception of Inzierskaia (21.5%) and Nikolskaia (20.1%).

Homeostaticity

Yield (g m^{-2}): the indicator determines the genotype response under the variable environmental conditions according to a particular feature. Homeostaticity indicator of the varieties was determined by two methods (Hangil'din et al.,1981; Iodkovskyy, 1999) for more complete description of the material. Most of the research results, regardless of the applyied method, considered varieties Nadiina (Hom_1 - 785.8/Hom_2 - 7.8), Ruta (696.7/8.9), Sofiia (1,049.9/9.5), Yelena (1,036.2/9.5), Academichna (789.2/7.5), Feniks (971.0/8.1), Vlada (959.3/9.4), Chishminskaia (769.6/9.1), Natasha (878.0/9.2), BaiChen (818.0/10.9) to be distinguished by a low rate of response to the changing cultivation conditions.

Some genotypes that had a significant difference in the indicators by the different methods were not taken into account - SYN 3/02 (Hom_1 - 1,129.9/Hom_2 - 8.5), Determinantna 8 (988.2/12.3), Inzierskaia (755.5/11.0), Ahidel (987.5/14.8), Nikolskaia (906.3/13.2).

Individual plant productivity (g/plant): the expression levels of both indicators were quite similar for most varieties. A slight response of the genotype to the environmental factors was observed in the varieties Nadiina (Hom_1 - 6.7/Hom_2 - 7.5), Ruta (5.4/6.8), Sofiia (9.1/9.5), Yaroslavna (9.1/8.5), Sumchanka (8.0/8.9), Ruslana (8.2/10.3), Populiatsiia 7/07 (9.5/10.9), Academichna (6.1/6.1), P-330 (11.0/9.7), Feniks (7.8/6.0), Vlada (8.2/11.9), Inzierskaia (6.5/11.0), Chishminskaya (5.9/6.9), Natasha (7.6/9.2), Batyr (9.0/8.7), BaiChen (6.5/8.6), Arno (9.5)/11.9). Samples Podolianka (9.6/15.4), P-332 (10.2/20.3), Determinantna 8 (9.3/18.5), Lakneia (9.5/12.9), Marta (9.0/15.2), Ufimskaia (9.5/17.3), Ahidel (9.0/15.5), Nikolskaia (7.7/12.9) showed the significant differences in the expression levels of the homeostaticity indicator by the different methods.

Stability

Yield (g m^{-2}): stability of the feature manifestation is a concomitant or additory variety characteristic to plasticity. This indicator describes the organism natural ability to maintain a certain level of expression in the variable environmental conditions, a certain buffer or body strength reserves (Maruhnyak, 2010). According to the obtained data, the varieties SYN 3/02 (56.2), Sofiia (49.4), Selianochka (48.1), Yelena (48.8), Roksolana (49.8), P-330 (57.0), P-455 (48.2), P-620 (48.6), Ametist (52.2), Feniks (49.9), Ilishevskaia (49.6), Batyr (48, 2) produced higher stability over the research years.

Individual plant productivity (g/plant): high level of homogeneity of the target group was observed in terms of the stability of the manifestation level of plant productivity indicator. Only a small number of varieties had an advantage over other samples involved in the research ($\sigma = 0.5$) - Yaroslavna, Roksolana, P-330, P-620, Ametist, Feniks, and Ilishevskaia.

Breeding value

Yield (g m^{-2}): breeding value is an important characteristic of varieties or breeding numbers. It determines the potential material suitability to be involved into breeding process for the creation of new varieties (Klimova, 2013). The distribution of the studied material was carried out according to the breeding value. Varieties - SYN 3/02 (148.2), Selianochka (164.2), Slobozhanka (163.0), Podolianka (148.0), Roksolana (169.7), Populiatsiia 7/07 (162.3), P-330 (166.6), P-332 (170.2), P-455 (170.1), P-620 (165.9), Ametist (163.0), Lakneia (147.6), Ilishevskaia (164.0), Arno (163.1) were included in the group of varieties with the highest level of manifestation.

Individual plant productivity (g $plant^{-1}$): the level of indicator expression in the varieties of the target group ranged from 0.7 to 1.5. The highest indicators were recorded in the varieties Olha, SYN 3/02, Selianochka, Roksolana, P-330, Determinantna 8, Ametist, Ufimskaia, Ilishevskaia (1.4 each), Slobozhanka, P-332, P-455 and P-620 (1.5 each).

DISCUSSION

The scope of research involves the evaluation of the modern varieties both for breeding usage and for use in the production conditions. For this purpose, the integral indicator of plants grain productivity, as the final characteristic of the interaction of the complex of natural biological properties of the organism, and its main component - individual plant productivity was used in the course of the analysis. Taking into account the complexity and interaction of various factors in the formation of the yields, the study of this indicator is only the first step in the evaluation of varietal material suitability for selective introduction and using the level of breeding value as a necessary condition for the initial evaluation of the source material. Recognition of the high breeding value of varieties in terms of yield and individual plant productivity requires a detailed study and description of the biological, morphological and economic characteristics of the samples in the future. For producers, the potential yield in the contrasting environmental conditions is the main indicator of the variety evaluation and its suitability for economic use.

Involvement of representatives of different ecological and geographical groups, various types of ploidy and biology of the plant itself (determinants and indeterminants) into the study allows us to evaluate not only the involved varieties, but also to identify general tendencies and make conclusions about the reasonability of using one or another selection material as the initial varieties and forms. Especially for use in selection, which main tasks are to create new varieties for areas with risky farming (insufficient or unstable moisture availability, uneven distribution of precipitation during the vegetation period, etc.).

Due to the described level of *HTC* during the vegetation period of buckwheat plants, the conditions of the research years made it possible to fully eveluate the yield and productive potential of the varieties and identify varieties, capable of having their high levels in the optimal environmental conditions - Olha, SYN 3/02, Sofiia, Yaroslavna, Selianochka, Slobozhanka, Yelena, Roksolana, Populiatsiia 7/07, P-330, P-455, P-620, Ametist, Feniks, Ilishevskaia, Batyr, Arno. This characteristic is very important for producers and shows the potential opportunities of the realization of yield and productive potential.

It indicates the ability of varieties to produce yields and form plant productivity, subject to the optimal cultivation conditions, that is, to ensure the economic attractiveness of the variety for production.

Another equally important characteristic is the level of variation of the studied parameters, that is, the identification of material with high placticity and stability, as the ability to lower the level of yield and individual productivity to a lesser extent in the extreme limiting environmental conditions (Slobozhanka, Podolianka, P-455) and have an increased expression level of the evaluated characteristics - SYN 3/02, Ruta, Sofiia, Selianochka, Yelena, Roksolana, P-330, P-620, Ametist, Feniks, Ilishevskaia, Batyr, P-332, Ufimskaia, Inzierskaia, Ahidel, Nikolskaia, BaiChen and Arno. Samples, which combine high yield and plant productivity with a high level of plasticity and stability, as a more potentially attractive material for production and selection are of particular value - SYN 3/02, Sofiia, Selianochka, Slobozhanka, Yelena, Roksolana, Populiatsiia 7/07, P-330, P-455, P-620, Ametist, Feniks, Ilishevskaia, Batyr, Arno. An additional characteristic of the resistance or tolerance to the environmental factors is a homeostaticity of the variety, which determines the response rate to such factors.

The research has identified a group of samples that had an increased level of homeostaticity according to variety yield and plant individual productivity - Nadiina, Ruta, Sofiia, Akademichna, Feniks, Vlada, Chishminskaia, Natasha, BaiChen. These varieties are a potential genetic resource for further selection researches.

In the research, the breeding value of the variety material was evaluated according to the yield and individual productivity of the plant, as a characteristic that takes into account the whole range of indicators and descriptions of the plant material and is the final factor for determining the most suitable variety for further breeding use. The group with high level of breeding value includes varieties of different ecological and geographical origin: from Ukraine - SYN 3/02, Selianochka, Slobozhanka, Podolianka, Roksolana, Populiatsiia 7/07, P-330, P-332, P-455, P-620, the Republic of Belarus - Ametist and Lakneia, the Russian Federation - Ilishevskaia, Canada - Arno.

CONCLUSIONS

Comprehensive evaluation of the wide genetic diversity of varieties of different ecological and geographical origin, different types of plants (according to ploidy and type of growth) in the contrasting environmental conditions made it possible to identify genotypes with an increased level of adaptive potential. It has been established that varieties SYN 3/02, Selianochka, Roksolana, Populiatsiia 7/07, P-330, P-455, P-620, Ametist, Ilishevskaia are more attractive for practical use, in observance of the production technology that will significantly eliminate the negative impact of environmental factors and realize the yield and productive potential.

Taking into account the complexity of forming the indicator of yield and significant influence of plant individual productivity on its level, the necessity of applying a number of parameters, in particular, plasticity, homeostaticity and stability for selection practice has been proved. The varieties, which combine a high manifestation level of the studied parameters and can be recommended for further study and use as a valuable starting material, have been identified in the target group - SYN 3/02, Sofiia, Selianochka, Slobozhanka, Yelena, Roksolana, Populiatsiia 7/07, P-330, P-455, P-620, Ametist, Feniks, Ilishevskaia, Batyr, Arno. Most of these varieties have a high breeding value as a result of breeding attractiveness and are recommended for being introduced into the selection practice.

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