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ECOLOGICAL PLASTICITY AND STABILITY OF WINTER WHEAT VARIETIES IN THE CONDITIONS OF SOUTHERN UKRAINE

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Abstract

The aim of the research was to study the ecological plasticity and stability of winter wheat varieties under the arid conditions of the southern steppe of Ukraine. The research was conducted during 2015/16–2019/20 at the Institute of Irrigated Agriculture, NAAS, and the Askanian State Agricultural Research Station, Kherson region, Ukraine. The material for the research was 10 varieties of winter wheat which were sown under conditions of optimal (irrigation) and stress (without irrigation) moistening. The response of winter wheat cultivars to growing conditions was analyzed using regression coefficient, homeostatic parameters, general adaptability, variance of specific adaptability, selection value of genotype and others. The minimum yield of varieties varied from 2.02 t ha^{-1} to 3.72 t ha^{-1} and the maximum - from 8.10 to 9.81 t ha^{-1}. The obtained results are a contribution to the study of both theoretical and practical aspects of wheat drought resistance and can be used as elements of selection programs.

Key words*: irrigation, natural moistening, eco gradient, homeostatic, yield.*

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the most important crops in maintaining food security which ensures the existence of a large part of the world's population (Franco et al., 2018; Galetto et al., 2017). Scientific predictions suggest that while the world population is rapidly growing, food production will not keep pace with such growth and, given the current dynamics, it is possible that the food problem will cause a deep international crisis. The scientists' estimations show that at the current rate of population growth, the world grain production per capita will decline (Carlson, 2016; Tyshchenko et al., 2020[b]).

At present, the annual gross production of wheat increases by about 0.9%, but it is much slower than the population growth rate and, accordingly, insufficient to meet their needs (Lavrynenko et al., 2019[a], Ray, 2013). Therefore, humanity must find a solution to this problem because the rate of population growth remains too high (Lavrynenko, 2019[b]). Along with the population growth, in recent decades climate change, the so-called global warming, has been observed which leads to significant fluctuations in winter wheat yields (Anderson, 2020; Vozhehova et al., 2021[a]). Therefore, the efforts of breeders should be focused on creating not only high-yielding varieties, but also those that ensure crop stability in different agro-climatic conditions (Vozhehova et al., 2021[b]; Tyshchenko et al., 2020[a]). To date, scientists have studied the agronomic and physiological mechanisms responsible for crop stability (Ojha & Ojha, 2020). Thus, different varieties may show contrasting responses to environmental conditions due to their interaction.

The aim of the research was to study the ecological plasticity and stability of winter wheat varieties in the arid conditions of the southern steppe of Ukraine.

MATERIALS AND METHODS

The response of winter wheat cultivars to different cultivation conditions was studied at the Institute of Irrigated Agriculture, Kherson, Ukraine (46 ° 44'33 "N; 32 ° 42'28" E; 50 m above sea level) (location A) and at Askania State agricultural research station in the village of Tavrichanka, Kherson region (46° 33'12 "N; 33 ° 49'13" E; 39 m above sea level) (location B) during 2015/16-2019/20. The research was conducted under different conditions of soil: under irrigation and without irrigation. Under natural moisturing conditions, the yield strongly depended on the amount of precipitation during the growing season, especially in the critical growing season (April - May). Average temperatures and amount of precipitation for all experimental seasons are shown in Table 1 together with long-term averages (1961-2005). The 2018/19 season was the most favorable as to natural moistening, as the rainfall during the growing season contributed to the replenishment of soil moisture which ensures normal plant growth and development. The 2017/18 and 2019/20 seasons were very dry, especially the critical growing season (April - May) during which air and soil droughts were observed due to insufficient rainfall and high average daily temperatures.

We studied 10 varieties of winter wheat which are usually grown in southern Ukraine and entered in the State Register of Plant Varieties. The varieties were tested on plots of 50 m² in three replicates by randomized replicates (blocks), the sowing rate being 4.5 million viable seeds per hectare. The research was carried out according to the generally accepted methods, the amount of fertilizers and chemical treatments corresponded to the growing conditions and the occurance of diseases and pests. The studied varieties in both areas were sown in the first decade of October and harvested in July. Under irrigation conditions, watering was carried out at the pre-irrigation soil moisture level of 75% of the lowest moisture content (Table 1).

Table 1. Weather conditions during the research (2015-2020)

	1961-2005		2015/2016		2016/2017		2017/2018		2018/2019		2019/2020	
	T (°C)	P (мм)	T (°C)	P (мм)	T (°C)	P (мм)	T (°C)	P (мм)	T (°C)	P (мм)	T (°C)	P (мм)
Askania SARS												
October - December	4.8	98.0	6.0	81.2	3.4	42.0	5.9	75.0	5.5	53.4	7.4	67.9
January	-3.1	30.0	-3.1	59.9	-3.9	14.4	0.7	24.1	-0.3	33.8	1.0	18.3
February	-2.0	29.0	3.9	32.9	-0.9	22.0	0.1	47.0	1.1	10.6	2.2	59.6
March	2.2	26.0	6.1	20.3	6.6	10.2	1.5	35.1	5.5	5.7	7.5	3.5
April	9.6	28.0	12.4	50.5	8.5	81.8	12.9	2.7	10.3	38.9	9.5	7.5
May	15.6	38.0	15.9	95.7	15.5	25.8	19.5	13.0	17.4	72.4	14.9	42.4
June	20.0	46.0	21.5	76.2	21.7	8.0	22.4	23.0	24.5	14.1	22.2	59.3
January - June	7.1	197.0	9.5	335.5	7.9	162.2	9.5	144.9	9.8	175.5	9.6	190.6
October - June	6.0	295.0	7.8	416.7	5.7	204.2	7.7	219.9	7.7	228.9	8.5	258.5
IIA												
October – December	4.8	104.0	6.3	64.9	3.7	99.4	7.5	88.0	5.4	97.0	7.7	74.3
January	-3.0	33.0	-3.6	67.3	-4.7	27.5	-0.3	24.1	-0.6	23.0	0.9	17.3
February	-1.8	31.0	4.0	30.9	-0.8	13.2	-0.2	33.3	1.4	9.8	2.7	56.4
March	2.3	26.0	6.3	19.5	7.0	5.2	1.5	61.0	5.9	7.3	7.6	6.2
April	10.0	33.0	12.6	56.8	9.3	87.9	14.1	1.6	10.5	56.0	9.8	2.8
May	16.0	42.0	16.2	71.7	16.3	25.6	19.5	35.7	18.0	72.8	14.7	29.3
June	19.9	45.0	22.1	43.0	22.0	10.3	22.9	23.1	23.8	92.6	22.7	45.1
January - June	7.2	210.0	9.6	289.2	8.2	169.7	9.6	178.8	9.8	261.5	9.7	157.1
October - June	6.0	314.0	8.0	354.1	6.0	269.1	8.6	266.8	7.6	358.5	8.7	231.4

Source: Data of meteorological station "Askania Nova"

Statistical analysis. The response of winter wheat cultivars to growing conditions was studied using the index of environmental conditions (Ij), regression coefficient (b_i), predictable ecological stability, plasticity of the cultivar at different eco gradients (S_{di}^2) determined by Eberhart S.A., Russell W.A. (Eberhart & Russell, 1966), indicators of stress resistance (Ymin. - Ymax.) and genetic flexibility (Gf) according to the equations by Rosielle A.A., Hamblin J. (Rosielle & Hamblin, 1981), parameters of homeostatic (Hom) and selection value (Sc) according to Hangildin V.V. et al. (Hangiydyn & Lytvynenko, 1981), the adaptability coefficient (AC) by the method of Zhyvotkova L.A. et al.

(Zhyvotkov et al., 1984). General adaptive capacity (GAC), specific adaptive capacity variance (σ^2_{SACV}), relative genotype stability (s_{gi}), genotype selection value (GSV), nonlinearity (l_{gi}) and destabilization compensation (K_{gi}) coefficients were determined according to A. Kilchevsky et al. (Kylchevskyi & Hotyleva, 1985).

A correlation analysis between grain yield and drought resistance indices was performed to determine the best drought resistant varieties and indices. The principal components analysis (PCA) was performed on the basis of observations. Both correlation and PCA were performed using Microsoft ® Excel 2013/ XLSTAT © -Pro (version 2015.6.01.23953, 2015, Addinsoft, Inc., Brooklyn, New York, USA).

RESULTS AND DISCUSSIONS

The obtained experimental data allow to single out the winter wheat varieties according to their maximum productivity. They are *Kokhana* (9.81 t ha^{-1}) and *Mariia* (9.7 t ha^{-1}), the *Koshova* variety being the least productive (3.72 t ha^{-1}).

The stress resistance of the studied winter wheat varieties is reflected by the index of the difference between the minimum and maximum yields (Ymin. - Ymax.), and the smaller this difference, the higher its resistance to stress. According to this indicator, the following winter wheat varieties were singled out: *Rosynka* (-5.08), *Ledia* (-5.20) and *Koshova* (-5.52), but the first two varieties were characterized by lower yields than the average variety (Table 2).

Table 2. Homeostasis, ecological plasticity and adaptability of winter wheat varieties on the basis of grain yield (average for 2016-2020)

Variety, population	Sign	Yield, t ha^{-1}		Adaptability parameters						
		Ymin. - Ymax.	Ymean	Ymin. - Ymax.	Sc	Gf	b_i	S_{di}^2	AC	Hom
Anatoliia	G1	3.24-9.40	6.65	-6.16	2.29	6.32	1.01	0.073	102.4	1.302
Burhunka	G2	2.79-9.20	6.53	-6.41	1.98	6.00	1.06	0.099	100.6	1.207
Konka	G3	2.78-8.68	6.50	-5.90	2.08	5.73	0.96	0.149	100.1	1.299
Kokhana	G4	3.21-9.81	6.65	-6.60	2.17	6.51	1.05	0.177	102.4	1.214
Koshova	G5	3.72-9.24	6.84	-5.52	2.75	6.48	1.00	0.179	105.3	1.536
Mariia	G6	3.19-9.70	6.78	-6.51	2.23	6.45	1.07	0.109	104.4	1.281
Ledia	G7	3.15-8.35	6.21	-5.20	2.34	5.75	0.94	0.100	95.6	1.344
Rosynka	G8	3.02-8.10	5.91	-5.08	2.20	5.56	0.92	0.053	91.1	1.248
Khersons`ka bezosta	G9	2.02-8.43	6.34	-6.41	1.52	5.23	0.96	0.235	97.6	1.136
Askaniis`ka	G10	270-8.70	6.53	-6.00	2.02	5.70	1.03	0.107	100.5	1.287
Average variety			**6.49**	**-5.98**	**2.16**	**5.97**	**1.00**	**0.128**	**100.0**	**1.285**
V, %			4.29	-9.17	14.42	7.49	5.29	43.52	4.27	8.27
$S\dot{x}_{absolute}$			0.09	0.17	0.10	0.14	0.02	0.02	1.35	0.03
$S\dot{x}_{relative}$			1.36	-2.90	4.56	2.37	1.67	13.76	1.35	2.61
$LSD_{0.01}$			0.28	0.55	0.31	0.45	0.05	0.06	4.28	0.11
$LSD_{0.05}$			0.20	0.40	0.23	0.32	0.04	0.04	3.09	0.08

Source: Authors' concept of the experiments

The selection value (Sc) reflects the average yield increase and the ratio between the minimum and maximum yields over the years of research.

The characteristics of the samples with regard to stress are supplemented by the indicator of genetic flexibility (Gf), which shows the average yield of varieties in contrasting (optimal and limiting) conditions. High values of this indicator testify to a high degree of correspondence between the variety genotype and environmental factors. According to this indicator, the varieties of winter wheat such as *Kokhana* (6.51), *Koshova* (6.48), *Mariia* (6.45) and *Anatoliia* (6.32) which form a higher yield under contrasting conditions compared to other varieties have been singled out.

The regression coefficient (b_i) is a criterion (index) for assessing the level of ecological plasticity and indicates the genotype response to changes in environmental conditions, the varieties with $b_i > 1$ are more sensitive to changes in growing conditions. The best varieties of intensive type were *Mariia* (b_i =

1.07) and *Burhunka* (b_i = 1.06). The genotypes with $b_i < 1$ are less responsive to changes in the eco-gradient than the average of the studied varieties and they are important because of their sufficient productivity at a minimum cost. In our research, such varieties include *Rosynka* (0.92) and *Ledia* (0.94). If $b_i = 1$, the genotype is well adapted to different growing conditions and is universal, this is typical of the *Koshova* variety.

On analyzing winter wheat cultivars according to their deviation variance from the S_{di}^2 regression line, the *Rosynka* cultivar with its highest predictable stability of S_{di}^2 equaling 0.053 was selected.

The adaptability coefficient (AC) reflects the ratio of the variety average yield to the average yield of all varieties. High variety adaptability ensures stable yield under different growing conditions, so an important characteristic of the variety is its ability to stably realize the yield potential. The *Koshova* (105.3) and *Mariia* (104.4) varieties were characterized by the highest values.

An indicator of plant resistance to adverse environmental factors is homeostasis (Hom) which characterizes the ability of plants to develop normally under adverse environmental conditions. The *Koshova* variety was characterized by the highest value of homeostasis (1.536).

The greatest values of general adaptability (GAC) were observed in such winter wheat varieties as *Koshova* (0.34) and *Mariia* (0.29), while the *Rosynka* variety was characterized by the lowest value (0.58) (Table 3).

Table 3. Adaptivity parameters of winter wheat varieties based on grain yield (average for 2016-2020)

Variety, population	Sign	Yield, t ha^{-1}		Adaptability parameters						
		Ymin. - Ymax.	Ymean	GAC	$\sigma^2_{(G\times E)gi}$	σ^2_{SACV}	s_{gi}	GSV	K_{gi}	l_{gi}
Anatoliia	G1	3.24-9.40	6.65	0.16	0.03	3.72	29.0	3.40	1.04	0.008
Burhunka	G2	2.79-9.20	6.53	0.04	0.07	4.10	31.0	3.12	1.14	0.016
Konka	G3	2.78-8.68	6.50	0.01	0.11	3.43	28.5	3.38	0.96	0.032
Kokhana	G4	3.21-9.81	6.65	0.15	0.14	4.14	30.6	3.21	1.15	0.033
Koshova	G5	3.72-9.24	6.84	0.34	0.13	3.76	28.4	3.57	1.05	0.035
Mariia	G6	3.19-9.70	6.78	0.29	0.08	4.23	30.3	3.31	1.18	0.020
Ledia	G7	3.15-8.35	6.21	-0.29	0.07	3.27	29.1	3.16	0.91	0.021
Rosynka	G8	3.02-8.10	5.91	-0.58	0.04	3.07	29.6	2.96	0.86	0.012
Khersons`ka bezosta	G9	2.02-8.43	6.34	-0.16	0.19	3.55	29.7	3.16	0.99	0.053
Askaniis`ka	G10	270-8.70	6.53	0.03	0.07	3.91	30.3	3.19	1.09	0.017
Average variety			**6.49**	**0.00**	**0.09**	**3.72**	**29.7**	**3.25**	**1.04**	**0.025**
V, %			4.29	-278.19	52.93	10.44	3.01	5.31	10.29	54.65
$S\dot{x}_{absolute}$			0.09	0.09	0.02	0.12	0.28	0.05	0.03	0.01
$S\dot{x}_{relative}$			1.36	-87.97	16.74	3.30	0.95	1.68	3.25	17.28
$LSD_{0.01}$			0.28	0.28	0.05	0.39	0.90	0.17	0.11	0.01
$LSD_{0.05}$			0.20	0.20	0.04	0.28	0.65	0.12	0.08	0.01

Source: Authors' concept of the experiments

The stability of the genotype response as to its productivity is determined by the value of the σ^2_{SACV} parameter. The variance parameter (σ^2_{SACV}) characterizes the specific adaptive ability, that is, under favorable environmental conditions a variety with a high value of this indicator forms a relatively high yield. The following varieties were determined as the most stable: *Rosynka* (σ^2_{SACV} = 3.07), *Ledia* (σ^2_{SACV} = 0.27) and *Konka* (σ^2_{SACV} = 3.43). The *Mariia* variety with the value of σ^2_{SACV} equaling 4.23 is determined as unstable.

The relative stability parameter of the genotype (s_{gi}) is not related to its overall adaptive capacity and is relative. The lowest relative stability values of the genotype were determined in the following varieties: *Koshova* (28.4), *Konka* (28.5) and *Anatoliia* (29.0), which characterizes them as the most stable.

The *Anatoliia* variety was characterized by the lowest value (0.03) of the genotype variance and the environment interaction $\sigma^2_{(G \times E)gi}$, but it was unstable, which testifies to the manifestation of a destabilizing effect. The compensation coefficient varied from 0.86 to 1.18. In such varieties as *Anatoliia, Burhunka, Kokhana, Koshova, Mariia* and *Askaniis'ka* it was more than one, which testifies to the predominance of the destabilizing effect. When selecting stable varieties, preference should be given to varieties with $K_{gi} < 1$.

The genotype selection value (GSV) is used for selecting simultaneously as to general adaptive ability and stability. High genotype selection value (GSV) characterizes such varieties: as *Koshova, Anatoliia and Konka,* their values being 3.57, 3.40 and 3.38, respectively. Varieties of this type are the most valuable and can produce maximum yields even in adverse conditions.

The adaptability coefficient (AC) and general adaptability (GAC) had a high correlation (r = 0.857) with maximum productivity and medium correlation (r = 0.402 and 0.401, respectively) with minimum productivity (Table 4). A number of researchers (Aniskov & Safonova, 2020, Khabibullin et al., 2020, Lozynskyi, 2018) studying the adaptability of different crops believed that these indicators can identify a stable variety. However, in our studies, the highest values of these indicators characterized the varieties of intensive type.

The regression coefficient (b_i) had a high correlation (r = 0.864) with the maximum yield and low correlation (r = 0.196) with the minimum one. Studies by S. A. Eberhart and W. A. Russell presented a gradation: $b_i > 1$ - intensive type varieties, $b_i < 1$ - stable type varieties and $b_i = 1$ - plastic type varieties. Our research and studies by a number of authors (Aseieva & Zenkina, 2019, Buhaiov & Horenskyi, 2017, Ivaniuk et al., 2017, Vozhehova et al., 2022[c]) confirm this regularity.

The specific adaptive capacity variance (σ^2_{SACV}) was characterized by high correlation (r = 0.869) with maximum yield and low correlation (r = 0.144) with minimum yield. A number of authors (Gudzenko, 2019; Ignatiev & Regidin 2019; Lavrynenko, 2019[b]; Lozynskyi, 2018; Vozhehova et al., 2021[b]) believe that the smaller the value of the specific adaptive capacity, the more stable the variety. This is confirmed by our research, but if the value of σ^2_{SACV} variance tends to the maximum, then such varieties should be considered as intensive type.

The selection value of the variety (Sc) and homeostasis (Hom) had low correlation (r = 0.298 and 0.117, respectively) with maximum yield and high correlation (r = 0.972 and 0.781, respectively) with minimum yield. A number of authors (Demydov et al., 2019; Mel'nyk et al., 2020; Postolati et al., 2017) believe that the higher the value, the more stable the variety, which was confirmed by our research.

The relative stability of the genotype (s_{gi}) had a medium negative correlation (r = -0.302) with the minimum yield and the average (r = 0.312) with the maximum yield, i.e. the smaller the value of the relative stability of the variety genotype, the higher its productivity under limiting moisture conditions.

The genotype selection value (GSV) has a medium correlation (r = 0.508-0.509) with minimum and maximum yield.

The compensation coefficient (K_{gi}) had a high correlation (r = 0.871) with the maximum yield, but there was no correlation with the minimum yield (r = 0.148). That is, when selecting varieties of intensive type, preference should be given to varieties with a destabilizing effect ($K_{gi} > 1$), while as for stable varieties the $K_{gi} < 1$ (compensating effect) should be preferred.

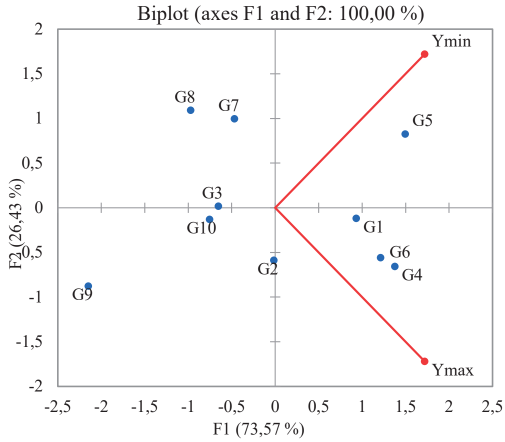
Table 4. Matrix of correlations between maximum and minimum yields of winter wheat varieties and homeostatic, ecological plasticity and adaptability parameters (average for 2016-2020)

	Ymax.	Ymin.	Ymean	Ymin. - Ymax.	Sc	Gf	b_i	S_{di}^2	AC	Hom	GAC	$\sigma^2_{(G\times E)gi}$	σ^2_{SACV}	s_{gi}	GSV	K_{gi}	l_{gi}
Ymax	**1.000**	0.471	0.854	-0.691	0.298	0.898	0.864	0.119	0.857	0.117	0.857	0.064	0.869	0.312	0.509	0.871	-0.067
Ymin	0.471	**1.000**	0.400	0.312	0.972	0.811	0.196	-0.322	0.402	0.781	0.401	-0.365	0.144	-0.302	0.508	0.148	-0.398
Ymean	0.854	0.400	**1.000**	-0.592	0.331	0.766	0.771	0.321	1.000	0.384	1.000	0.223	0.799	0.019	0.804	0.805	0.132
Ymin. - Ymax.	-0.691	0.312	-0.592	**1.000**	0.475	-0.302	-0.770	-0.392	-0.593	0.515	-0.594	-0.369	-0.817	-0.584	-0.131	-0.817	-0.254
Sc	0.298	0.972	0.331	0.475	**1.000**	0.682	0.044	-0.307	0.332	0.895	0.331	-0.356	-0.006	-0.456	0.545	-0.002	-0.359
Gf	0.898	0.811	0.766	-0.302	0.682	**1.000**	0.671	-0.082	0.769	0.467	0.768	-0.139	0.648	0.057	0.590	0.652	-0.243
b_i	0.864	0.196	0.771	-0.770	0.044	0.671	**1.000**	0.029	0.773	-0.068	0.774	-0.009	0.988	0.630	0.257	0.988	-0.159
S_{di}^2	0.119	-0.322	0.321	-0.392	-0.307	-0.082	0.029	**1.000**	0.318	-0.072	0.310	0.988	0.180	-0.103	0.316	0.176	0.973
AC	0.857	0.402	1.000	-0.593	0.332	0.769	0.773	0.318	**1.000**	0.384	1.000	0.221	0.800	0.021	0.803	0.806	0.129
Hom	0.117	0.781	0.384	0.515	0.895	0.467	-0.068	-0.072	0.384	**1.000**	0.381	-0.147	-0.087	-0.647	0.704	-0.081	-0.114
GAC	0.857	0.401	1.000	-0.594	0.331	0.768	0.774	0.310	1.000	0.381	**1.000**	0.213	0.800	0.020	0.804	0.806	0.122
$\sigma^2_{(G\times E)gi}$	0.064	-0.365	0.223	-0.369	-0.356	-0.139	-0.009	0.988	0.221	-0.147	0.213	**1.000**	0.145	-0.037	0.197	0.139	0.985
σ^2_{SACV}	0.869	0.144	0.799	-0.817	-0.006	0.648	0.988	0.180	0.800	-0.087	0.800	0.145	**1.000**	0.616	0.286	1.000	-0.006
s_{gi}	0.312	-0.302	0.019	-0.584	-0.456	0.057	0.630	-0.103	0.021	-0.647	0.020	-0.037	0.616	**1.000**	-0.578	0.607	-0.168
GSV	0.509	0.508	0.804	-0.131	0.545	0.590	0.257	0.316	0.803	0.704	0.804	0.197	0.286	-0.578	**1.000**	0.296	0.200
K_{gi}	0.871	0.148	0.805	-0.817	-0.002	0.652	0.988	0.176	0.806	-0.081	0.806	0.139	1.000	0.607	0.296	**1.000**	-0.010
l_{gi}	-0.067	-0.398	0.132	-0.254	-0.359	-0.243	-0.159	0.973	0.129	-0.114	0.122	0.985	-0.006	-0.168	0.200	-0.010	**1.000**

* - Confidence interval (%): 95

Source: Authors' concept of the experiments

According to the results of GGE biplot analysis, such winter wheat varieties as *Anatoliia* (G1), *Kokhana* (G4), *Koshova* (G5) and *Mariia* (G6), which are between the vectors of yield level, can be distinguished as plastic, i.e. those that form high yields under different growing conditions (Figure 1).



Source: Authors' concept of the experiments

Figure 1. Genotype-environmental interaction of winter wheat varieties and environments (biplot analysis method). The lines show the eigenvectors of the leading factor loads for the environments:
● - yield level; ● - varieties.

The *Ledia* (G7) and *Rosynka* (G8) winter wheat varieties are in quarter IV and are characterized by the smallest decrease in yield under deteriorating conditions, they can be considered the most stable, i.e. those that are tolerant to changes in moisture conditions.

The *Burhunka* winter wheat variety (G2) located on the border of the second and third quarters is characterized by high productivity (9.20 t ha^{-1}) under optimal conditions and average productivity (2.79 t ha^{-1}) under unfavorable ones. This variety can be defined as an intensive type, i.e. one that responds well to improving moisture conditions but is characterized by a sharp decrease in productivity under stressful conditions.

CONCLUSIONS

According to homeostasis, ecological plasticity, parameters of adaptability and biplot-analysis, winter wheat varieties are divided into groups according to different growing conditions:

– the *Ledia* and *Rosynka* varieties are stable (extensive type), i.e. those that respond poorly to changes in moisture conditions and are recommended for natural moisture conditions;
– the *Anatoliia* and *Koshova* varieties are plastic (they form a high yield under different growing conditions) and recommended for cultivation both under irrigation and natural moisture;
– the *Burhunka, Kokhana* and *Mariia* varieties are of intensive type (they form the highest yield under optimal conditions) and are recommended for cultivation under irrigation.

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