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Manifestation of stability and plasticity of varieties of hybrid clover (*Trifolium hybridum* L.) in the western region of Ukraine

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Hybrid clover (*Trifolium hybridum* L.) is one of the main legumes for meadow grass mixtures. One of the important research methods is the assessment of the plasticity and variance of its stability of variety samples, which we carried out according to S. A. Eberhart, W. A. Russel, V. Z. Pakudin and L. M. Lopatina. An assessment of the adaptive potential of new samples of clover hybrid selection of the Institute of agriculture of the Carpathian region NAAS was carried out. The results of a study of 26 samples of hybrid clover in terms of ecological parameters of plasticity and stability under the influence of environmental changes are presented. Revealed valuable genetic sources with high rates of basic traits.
Keywords: Hybrid clover (*Trifolium hybridum* L.); variety; ecological plasticity; yield; regression coefficient; stability variance; homeostasis

Introduction

Hybrid clover (*Trifolium hybridum* L.) is an important forage crop in the Carpathian region. It is characterized by high adaptability to the acidic soil and wet conditions. It is sown both in the pure sowing and in the mixture with other perennial grasses depending on the cultivation method (Babych, 2009). Hybrid clover has a number of advantages. It combines high yield potential with low nitrogen application due to the possibility of biological fixation, with a high protein content and good digestibility. It has a positive and multifaceted effect on the soil and its macro- and microbiota. It is considered as a complex agroecological reserve and contributes to the increase in the yield of all agricultural crops.

The efficiency increasing of the stable production is possible primarily due to improved plant breeding and accurate organization of seed production, since the variety plays a decisive role in the introduction and use of this crop (Paplauskiene, 2007). The study of genetic differences in the starting material under various environmental conditions makes it possible to create new varieties with increased ecological plasticity and stability, which are designed to maximize their productivity potential (Kozachenko, 2010; Kondratenko, 2014; Moskalets, 2014). Determination of the optimal type of plants capable of stably realizing their potential and at the same time adequately reacting to changes in growing conditions constantly attracts the attention of scientists (Belenikhina, 2014; Beznosyuk, 2013; Dospekhov, 1985; Eberhart, 1996; Vazhenina, 2013).

The study of breeding material in different hydrothermal conditions of the year provides information on the characteristics of the reaction of genotypes to changing environmental conditions. The concepts of "stability" and "plasticity" are interpreted differently in the scientific literature, which complicates the assessment of these parameters and their use in selection (Lamazhap, 2017; Marenyuk, 2014; Marukhnyak, 2010; Potanin, 2014). The ecological plasticity of the selection characteristics of a sample is its average response to changes in environmental conditions. The variation in the stability of the plasticity of the selection characteristics of the sample is the deviation of empirical data in specific environmental conditions from the ecological plasticity of the selection characteristics, that is, from the average response to a change in growing conditions. As a factor "conditions" can be years of research, terrain, fertilizer doses, plant density, and sowing time (Cheshkova, 2013). Among the factors of phenotypic variability of the resistance trait, a significant role belongs to the conditions of plant growing.

Materials and Methods

The studies were carried out in 2016-2019. On the experimental field of the Institute of agriculture of the Carpathian region NAAS (zone of the Carpathian region, 49°38' N, 23°45' E). The soil of the experimental field is typical for this region of soddy-

middle-podzolic soddy-middle-podzolic, surface-gleyed, middle-oxides, loamy, typical for this region, formed on deluvial deposits. The lands are characterized by the following agrochemical indicators: humus content - 1.22-1.88%, salt extract pH - 4.6, hydrolytic acidity - 4.23, Hr (the amount of absorbed bases) - 11.8 meq. per 100 g of soil, mobile forms of phosphorus - 11.8 mg, potassium - 8.2 mg, nitrogen - 10.8 mg per 100 g of soil.
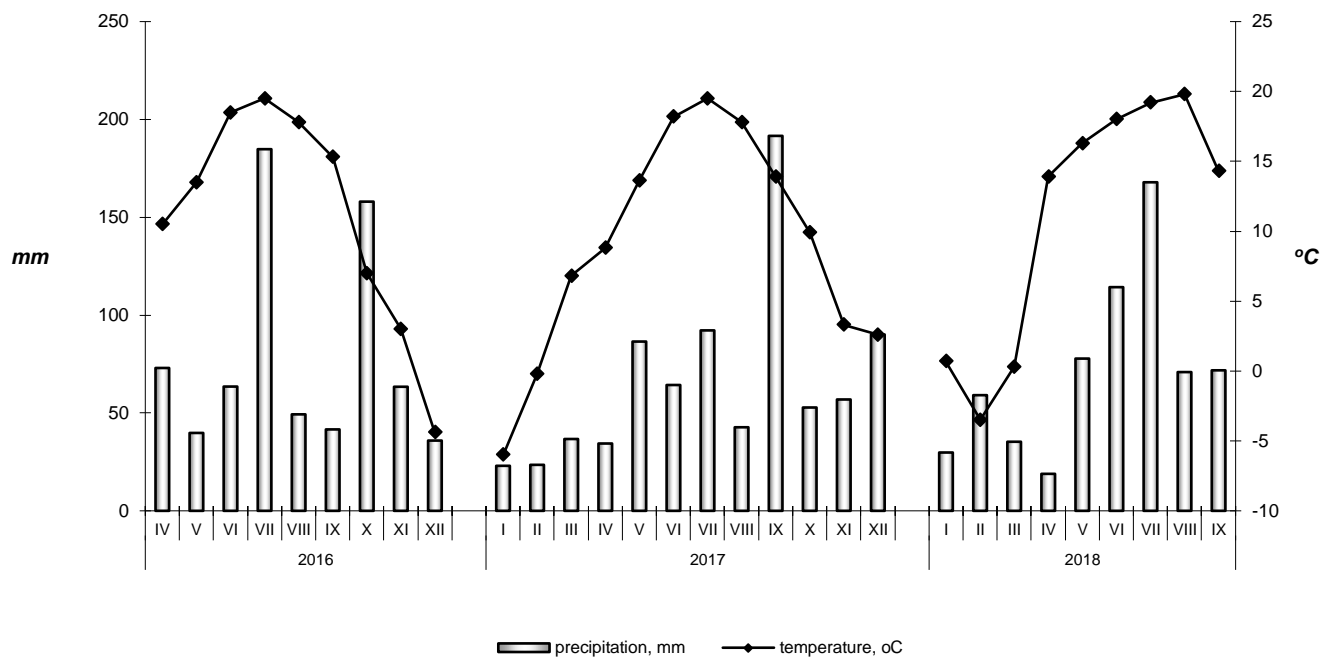

Fig. 1. Meteorogical conditions, 2016–2018.

Some 26 collection samples of hybrid clover of various ecological and geographical origin served as material for research. Field research, observations, counts and measurements were carried out in accordance with the guidelines (Konik, 2015) and statistical processing of initial data – by the method of analysis of variance according to B.A. Dospekhov (1985). Assessment of environmental plasticity and options for stable work was done according to S.A. Eberhart, W.A. Russel (Eberhart, Russel, 1996), V.Z. Pakudin and L.M. Lopatina (Pakudin, Lopatina, 1984). Homeostasis (Hom) was calculated using the formulas proposed by V.V. Hangildin and N.A. Litvinenko (Hangildin, Litvinenko, 1981).

Results and Discussion

The method for assessing the ecological plasticity and variance of its stability of varieties, based on variance and regression analysis, makes it possible to assess their responses under different growing conditions.

The regression coefficients (bi) characterize the average response of the breeding trait of the samples to changes in environmental conditions and show the plasticity of the breeding trait, which makes it possible to predict the change in the studied trait within the framework of the changing conditions of the years. The higher the bi value, the more sensitive the cultivar to changes in growing conditions over the years. If the regression coefficient approaches one, then the feature reacts to changes in environmental conditions. A negative bi value indicates a decrease in the indicator of signs due to lodging or disease. A bi value of zero or close to zero indicates that the variety does not respond to changing growing conditions.

According to V.V. Hangildin and N.A. Litvinenko (Hangildin, 1981), the best varieties are those with high and average values of traits and the least variation in different growing conditions, that is, they are stable or homeostasis varieties. Weather conditions 2016-2019. They had a number of features. Over the years of research, significant differences from the long-term average data of the amount of precipitation and temperatures during the summer months were noted, which made it possible to more comprehensively assess the growth and development of hybrid clover during the growing season and the effect of unfavorable environmental conditions on their forage and seed productivity (Fig. 1).

The variation in plasticity stability (Si^2) shows how reliably the selection characteristic of a sample corresponds to the plasticity estimated by the regression coefficient (bi). The closer Si^2 is to zero, the less the empirical values differ from the theoretical ones. Varieties with a high value of plasticity and low value of stability have high indicators of breeding characteristics. The stability of the manifestation of the level of a trait is expressed at low coefficients of regression (plasticity) and low fluctuations in their stability variance (Homyak, 2019; Litun, 2009). According to the yield of seeds, high plasticity was noted in the cultivars of Prydnistrovka (bi = 0.96, Si^2 = 0.18), No 18 (bi = 1.08, Si^2 = 0.41), Poliai (bi = 1.14, Si^2 = 0.21), Rozheva 27 (bi = 1.01, Si^2 = 0.38), that is, these are those varieties that have high plasticity and low stability (Table 1).

Table 1. Plasticity coefficients and stability variances of hybrid clover samples based on the "seed yield".

No. catalogue	Variety samples	Yield, c/ha			middle, X	Regression coefficient (bi)	Stability variance (Si^2)
		2016	2017	2018			
00543	Prydnistrovska	1.82	2.25	1.97	2.01	0.96	0.18
01716	No 18	1.90	2.30	1.93	2.04	1.08	0.41
01713	BN-1	1.87	2.17	1.82	1.95	1.03	1.37
01718	Dykorosla No1718	1.91	2.19	1.67	1.92	0.47	1.80
01715	No 22	1.80	2.24	1.87	1.97	0.53	1.97
01720	No 7	2.01	2.45	2.13	2.20	0.84	0.41
01719	Levada	1.93	2.20	2.07	2.07	0.75	0.35
01714	Dykorosla No 1714	1.67	1.97	2.01	1.88	0.68	0.32
01717	Willia	1.87	2.13	1.90	1.97	0.65	0.40
01712	BN-3	1.91	2.07	2.00	1.99	0.91	0.75
00706	Poliai	1.83	2.14	2.04	2.00	1.14	0.21
00710	No 205	1.97	2.20	2.18	2.12	1.13	2.45
00709	Daubiai	2.01	2.47	2.07	2.18	1.15	2.71
00708	No 213	1.91	2.38	1.93	2.07	1.24	0.90
01810	No 1820	1.84	2.40	2.05	2.10	0.84	0.47
00707	No 247	1.93	2.17	2.01	2.04	0.95	0.35
00973	Rozheva 27	1.97	2.21	1.92	2.03	1.01	0.38
01744	No 1744	1.84	2.18	1.94	1.99	0.87	0.29
01325	Dykorosla No 1325	1.84	2.18	1.91	1.98	0.54	0.41
01810	No 1810	1.90	2.31	1.99	2.07	1.14	2.47
01312	No 1312	1.67	1.98	2.02	1.89	1.31	0.36
01812	No 1812	1.93	2.14	2.13	2.07	0.91	0.68
01811	No 1811	1.87	2.38	2.07	2.11	0.87	0.74
00546	Dykorosla No 546	1.97	2.18	2.00	2.05	0.48	0.65
01759	No 1759	1.83	2.21	1.83	1.96	0.63	1.25
01758	No 1758	1.97	2.30	1.96	2.08	1.18	0.48

We have divided plants with genetic flexibility into stress-resistant (from -0.01 to -0.24), medium-resistant (from -0.25 to -0.35) and unstable (below 0.35). Based on the studies carried out, it was found that the highest resistance to stress is possessed by varieties BN-3 (-0.16), No. 247 (-0.24), No. 205 (-0.23), No. 1812 (-0.21), No. 546 (-0.21). The average value of this indicator is noted for the variety of samples BN-1 (-0.35), Levada (-0.27), Viliya (-0.26), Poliai (-0.31), Rozheva 27 (-0.29), No1312 (-0.35), No1758 (-0.34) (Table 2).

A variety as a genetic system specifically reacts to environmental factors. A characteristic feature of any variety is a set of properties that determine its suitability for a particular area, and therefore the correct choice of variety is of paramount importance when growing crops. According to the parameters of adaptability of hybrid clover varieties in the Western region of Ukraine, an important indicator of varieties is their resistance to stress, the level of which is defined as the difference between the minimum and maximum yield (У2 - У1). This parameter has a negative sign, and the smaller it is, the higher the stress resistance of the variety.

The average yield of variety samples under contrasting (stress and stress) conditions (U1+U2)/2 characterizes their genetic flexibility (Dospekhov, 1985). High values of this indicator indicate a high degree of correspondence between the genotype of the variety and environmental factors (NPS). In the conditions of the Carpathian region, varieties were identified with the maximum ratio between the genotype and the NPS factors. These are No. 7 (2.23), Daubiai (2.24), No. 213 (2.15), No. 1820 (2.12), No. 1811 and No. 1758 (2.13).

One of the important indicators characterizing the resistance of plants to the effects of unfavorable environmental factors is homeostasis, which is a universal property in the system of interaction between the genotype and NPS. Homeostasis is the ability of a genotype to minimize the effects of exposure to adverse conditions of various origins. The criterion for the homeostasis of varieties can be considered their ability to maintain low variability of productivity traits. Thus, the relationship between homeostasis (Hom) and the coefficient of variation (V) characterizes the stability of a trait under changing environmental conditions (Dospekhov, 1985).

To assess the stability of hybrid clover cultivars in our studies, the homeostasis index (Hom) was determined, which characterizes the value of the cultivar genotype. The higher its value, the higher the variety is assessed for suitability for growing conditions. The highest value of this indicator is obtained in breeding numbers Levada (Hom = 94.4), Daubiai (Hom = 71.4), No 213 (Hom = 80.6), No 1820 (Hom = 79.5), No 1325 (Hom = 74.3), No 1810 (Hom = 94.7).

Table 2. Parameters of adaptability of seed yield of hybrid clover selection samples (average for 2016-2018).

Variety samples	The parameters of adaptability			
	Y2 – Y1	(Y1 + Y2) / 2	V, %	Hom
Prydnistrovska	-0.43	2.04	15.1	44.9
No 18	-0.40	2.10	13.8	22.5
BN-1	-0.35	2.00	12.7	54.3
Dykorosla No1718	-0.52	1.93	18.7	62.1
No22	-0.44	2.02	15.8	68.2
No7	-0.44	2.23	14.1	35.1
Levada	-0.27	2.07	9.2	94.4
Dykorosla No1714	-0.34	1.84	12.8	51.8
Willia	-0.26	2.00	9.3	24.6
BN-3	-0.16	1.99	5.7	28.5
Poliai	-0.31	1.99	11.0	47.9
No205	-0.23	2.09	7.7	67.3
Daubiai	-0.46	2.24	14.9	71.4
No213	-0.47	2.15	16.1	80.6
No1820	-0.56	2.12	18.9	69.5
No247	-0.24	2.05	8.3	48.3
Rozheva 27	-0.29	2.07	10.1	45.6
No1744	-0.34	2.01	12.1	59.8
Dykorosla No1325	-0.34	2.01	12.1	64.3
No1810	-0.41	2.11	14.0	94.7
No1312	-0.35	1.85	13.1	43.8
No 1812	-0.21	2.04	7.2	49.1
No1811	-0.51	2.13	17.1	37.8
Dykorosla No 546	-0.21	2.08	7.2	45.4
No1759	-0.38	2.02	13.7	51.8
No1758	-0.34	2.13	11.6	54.3

Y1 - maximum yield, Y 2 - minimum yield, (Y1 + Y2) / 2 - genetic flexibility, t/ha, Y2 -Y1 – stress resistance, t/ha, V - coefficient of variation,%, Hom – homeostasis.

The ecological coefficient of variation (V,%) shows the degree of variability of the arithmetic mean (up to 10% - low variegation, 10-20% - average and more than 20% - high). The highest yield variability was observed in the following cultivars: Pridnistrovska (V= 15.1%), Dikorosla No 1718 (V= 18.7 %), No 22 (V = 15.8 %), No 213 (V = 16.1 %) and No 1820 (V = 18.9 %), No 1811 (V = 17.1 %). Hybrid clover numbers had the smallest yield variability: Levada (V = 9.2 %), BN-3 (V = 5.7 %), No 205 (V = 7.7 %), No 247 (V = 8.3 %) and No 1812 (V = 7.2 %), No 546 (V = 7.2 %).

 In our studies, the most stable selection number was Levada. This is evidenced by the lowest value of the coefficient of variation (9.2%) and high homeostasis (94.4). High variability and low homeostasis were noted in No. 1812 (V = 17.1%; Hom = 37.8), which indicates the instability of this variety and low adaptability to the conditions of the Carpathian region. The optimal variety is characterized by a high general adaptive capacity, gives the highest yield in favorable environmental conditions and provides maximum stability in unfavorable conditions.

Conclusion

The method of assessing the ecological plasticity and variance of its stability was used to determine the average response of collection samples of hybrid clover to changes in environmental conditions. Highlighted varieties with high plasticity, which have high regression coefficients and low fluctuations in their stability. Samples with a stable manifestation of the trait "seed yield" were revealed - No. 7, Daubiai, No. 213, No. 1820, No. 1811 and No. 1758. Because of the studies, the effectiveness of evaluating the adaptability of hybrid clover samples as a starting material for recombination selection by the level of homeostasis has been shown. Assessment of homeostasis should be a mandatory component of the study of the source material. For the high level of homeostasis among the studied samples, selection numbers were allocated: Levada, Daubiai, No. 213, No. 1820, No. 1325, and No. 1810, which are a valuable source material for the selection of hybrid clover for these indicators.
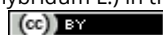
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