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ENVIRONMENTAL PLASTICITY, STABILITY AND RESISTANCE TO DISEASES OF THE VARIETIES *PHASEOLUS VULGARIS* L.

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Наведено результати трирічних досліджень з вивчення сортозразків квасолі звичайної (Phaseolus vulgaris L.*) щодо екологічної пластичності, стабільності і стійкості до хвороб в умовах центральної підзони Правобережного Лісостепу. Виділено сортозразки квасолі, що проявили високу стійкість до фузаріозу, реакція яких на надлишкове зволоження на початкових та дію високих температур на завершальних фазах росту й розвитку була мінімальною – UD0303600 і UD0303528. Найвищу стійкість до бактеріозу забезпечили сортозразки – UD0303601, UD0303526, UD0303543 і UD0303557. Серед них UD0303601, UD0303526 були стійкішими за несприятливих умов вирощування. Найвищу стійкість до бактеріального в'янення в тому числі і за несприятливих умов вирощування забезпечили сортозразки – UD0300414, UD0301063 і UD0303543. За стійкістю до вірусної мозаїки виділили сортозразки: UD0303543, UD0303557 і UD0303610, вони були кращими за всіх умов вирощування.*

Ключові слова: *квасоля звичайна, сортозразок, екологічна пластичність, стабільність; стійкість до хвороб.*

Introduction. Beans take the second place in the world among the legume crops, but in Ukraine its cultivated areas are small and mostly concentrated in the private sector. One of the main reasons is the lack of varieties adapted to various soil and climatic conditions that are characterized by unstable crop yield and lack of technological ability to mechanized harvesting. In solving the problem of creating competitive varieties, a detailed study and adaptation to the specific conditions of the source material is relevant.

To create a new source material, which would be characterized by a complex of valuable economic and biological features, grain yield and adaptability, it is necessary to conduct a detailed assessment of the collection varieties at the micro-plots in the primary stages of the breeding process.

Analysis of recent research and publications. Plant growing conditions are important in forming their resistance to various diseases. In nature, the pathogens

and plants are influenced by the weather conditions that are constantly changing. A special influence on the plant's attack of disease excitant is the air temperature and precipitation [1].

On the one hand, weather conditions can promote or suppress the plant growth and development, prolonging or reducing their vegetative period. On the other hand, meteorological conditions also affect the development of pathogens of diseases – promote or limit their reproduction, distribution and penetration into plants [2]. The fusariosis manifests itself in beans in the form of root rot and plant wilting, which can be observed simultaneously. The root rot infestation is especially dangerous in the seadling stage – the plant ceases to develop and dies [3].

Therefore, the **objective** of our research is to determine the level of variability and to identify patterns of inheritance of valuable economic and biological features for the selection of productive and adaptive forms of common bean (*Phaseolus vulgaris* L.) by hybridological analysis.

To achieve this goal, it was necessary to **solve the task** of creating the source material for the selection of high-yielding and adaptive varieties of common beans for the Right-bank Forest-Steppe.

Research methodology. The research was conducted during 2014–2016 in the conditions of the research plot of the Department of Plant Production, Selection and Bioenergetic Cultures of Vinnytsia National Agrarian University.

The region where the research was conducted by its natural conditions refers to the central subzone of the Right Bank Forest-Steppe. It is characterized by the distribution of gray forest soils of light medium-loam mechanical composition. The hydrothermal conditions of the 2014 and 2016 surveys were typical of the average yearly indices of the research area. The year 2015 was marked by a significant deficiency of precipitation and high temperature air conditions.

The research material were the varieties of common beans provided by the National Center for Plant Genetic Resources of Ukraine [3] and hybrid combinations obtained as a result of intervarietal crossings.

Sowing was carried out by the temperature regime of soil 10–12 °C at the depth of seeding and stable increase of average daily air temperature. The placement of the plots was consistent, the varieties were sown in a six-time repetition. The wide-row sowing with a width of rows of 45 cm was used. The total area of the plots was 1.35 m², and the account one is 1.0 m². Sowing was carried out manually, with the seeding rate of 18 similar seeds per 1 linear meter, the standard was placed in 10 numbers.

Accounts, analyzes and observations are performed according to the generally accepted methods [4].

The general adaptability of the common bean varieties for years of research was determined by regression coefficient (b_i) and the stability variance (S_i^2) S. A. Eberhart, W. A. Rassel [5], interpreted by of V. Z. Pakudin and L. M. Lopatina [6].

Assessment of the morphological features variation was carried out by the variation coefficient (*V*, %) according to the scale [7]. The ecological variation coefficient (*Ve*, %) was determined by the ratio of the average sign to its standard

deviation (up to 10 % is low, 11–20 % is average, and 21 % is high).

The determination of ultrastability (*Nom*) and agronomic stability coefficient (*As*) was calculated according to the method [8].

The statistical processing of research results was performed using the dispersion and correlation-regression methods [9, 10].

Research results. The resistance of the studied varieties of common beans to fusariosis and the parameters of environmental plasticity and stability on average over the years of research were as follows (Table 1).

Table. 1.**Resistance of common beans varieties to fusariosis and parameters of ecological plasticity and stability**, **2014–2016**

National Catalog Number	Resistance to fusariosis, *%*	b_i	S_i^2	*V*	*Hom*	*As*
UD0300282	76.6	0.83	22.96	5.0	15.3	95.0
UD0300434	78.6	1.14	33.67	7.0	11.2	93.0
UD0301736	77.8	1.08	19.76	6.0	13.0	94.0
UD0303543	89.2	1.03	2.46	5.0	17.8	95.0
UD0303557	89.3	1.31	6.1	6.0	14.9	94.0
UD0303610	89.8	1.08	3.75	5.0	18.0	95.0
UD0303513	88.5	0.98	2.72	5.0	17.7	95.0
UD0303598	89.1	0.87	5.61	4.0	22.3	96.0
UD0303600	91.2	0.79	1.56	4.0	22.8	96.0
UD0303528	91.7	0.86	1.82	4.0	22.9	96.0
Medium	*86.18*					
LSD_{05}	*0.63–0.95*					

In conducting the analysis of this table, it should be noted that the stability of standard bean varieties depended on varietal characteristics, as well as on weather conditions during the years of growing. The highest on was observed in 2016, the rate of disease resistance varied from 81.0 to 95.2 %, and the lowest one in 2015, when there was a stressful situation due to a lack of moisture and high temperatures. Thus, in the second half of the vegetation of plants, high temperatures contributed to an increase in plant damage by fusariosis. The resistance of beans varieties to fusariosis in this year was in the range from 73.2 to 92.3 %. In 2014, when there was a higher rainfall amount, first of all, compared to the 2015 and 201, the resistance of common beans varieties varied from 75.4 to 87.9 %. That is, in 2014, the resistance to disease was more dependent on excess moisture in the initial stages of growth and development of plants of beans varieties.

We have selected varieties of beans, which showed high resistance to fusariosis. At the same time, their reaction to excess moisture in the initial stages of growth and development and the effect of high temperatures in the final stages

was minimal. These were UD0303600 and UD0303528 varieties, in which the plasticity coefficient was $b_i<0$, and the stability variation was the lowest, namely 1.56 and 1.82. Also the variation coefficient was the lowest among the presented varieties – 4 %. That is, these varieties belong to the first rank according to the coefficients of plasticity and stability variance; they have better results under adverse conditions and are unstable. The varieties belonging to the sixth rank should also be distinguished according to the coefficients of plasticity and stability variance, namely UD0303610, UD0303543 and UD0303557, in which the regression coefficient was $b_i>1$ and the stability variance $S_i^2>0$, these varieties provide higher stability under favorable growing conditions. The varieties UD0303600, UD0303528 had the highest ultrastability.

Subsequently, we carried out a comparative evaluation of common bean varieties for resistance to bacteriosis (Table 2).

Table. 2. Resistance of common bean varieties to bacteriosis and parameters of ecological plasticity and stability, 2014–2016

National Catalog Number	Resistance to bacteriosis, *%*	b_i	S_i^2	*V*	*Hom*	*As*
UD0300282	75.9	0.87	52.6	5.0	15.18	95.0
UD0300434	78.3	0.93	43.1	5.0	15.7	95.0
UD0301736	75.6	0.76	38.8	4.0	18.9	96.0
UD0303543	84.8	1.00	73.5	5.0	17.0	95.0
UD0303557	92.7	0.90	41.4	4.0	23.2	96.0
UD0303610	93.4	0.92	46.7	4.0	23.4	96.0
UD0303513	91.8	1.02	63.7	5.0	18.4	95.0
UD0303598	91.8	1.37	106.5	6.0	15.3	94.0
UD0303600	90.9	1.02	69.4	5.0	18.2	95.0
UD0303528	91.2	1.20	82.9	6.0	15.2	94.0
Medium	*86.7*					
LSD_{05}	*0.79–1.30*					

By conducting the analysis of the plants resistance to bacteriosis, it should be noted that the higher resistance to bacteriosis was typical for the best varieties of common bean in 2015, when the highest temperature conditions and a small amount of precipitation were observed.

So in 2015 the resistance to bacteriosis was high and ranged from 78.9 to 96.8 %, in 2016 – from 75.6 to 94.5 %. In 2014 the resistance to this disease was lower and ranged from 72.3 to 89.1 %.

The highest resistance to bacteriosis had such varieties as UD0303601 – 93.4 %, UD0303526 – 92.7 %, UD0303543 and UD0303557 – 91.8 %.

According to the coefficient of plasticity $b_i<1$, high resistance to bacteriosis

had such varieties as UD0303601 and UD0303526. The variation coefficient of these varieties was 4 % and the agronomic stability coefficient was 96 %. The specified common bean varieties were classified as the first rank ones by the coefficients of plasticity (b_i<1) and the stability variance ($S_i^2 > 0$), they have better results in adverse conditions and are unstable. Also, we selected the varieties belonging to the sixth rank according to the coefficients of plasticity (b_i<1), and the stability variance ($S_i^2 > 0$), namely UD0303543, UD0303557, UD0303513 and UD0303610, in which the regression coefficient (b_i<1), and ($S_i^2 > 0$) stability variance, these varieties provide higher resistance under favorable growing conditions.

The selected common bean varieties are characterized by high resistance to bacteriosis and belonged to the first and the sixth rank by the plasticity coefficient, as well as the stability variance coefficient, the variation coefficient was 4–6 %, the coefficient of agronomic stability As = 94–96 %.

The highest ultrastability index had such varieties as UD0303601, UD0303526, UD0301063.

For obtaining stable yields of common beans varieties, it is necessary to use the varieties, characterized by high drought tolerance. In addition to drought tolerance, such varieties should be resistant to bacterial wilting due to the moisture deficit. Low drought tolerance, damage by bacterial wilting will contribute to reducing the yield of beans varieties. It is known that bacterial wilting causes the greatest damage during the years of drought, at an air temperature of +16 to +28 °C [19].

Next we selected the common bean varieties, characterized by high resistance to bacterial wilting (Table 3).

Table 3. Bacterial wilting of common bean varieties and parameters of ecological plasticity and stability, 2014–2016

National Catalog Number	Resistance to bacterial wilting, %	b_i	S_i^2	*V*	*Hom*	*As*
UD0300282	94.0	0.65	38.45	3.0	31.3	97.0
UD0300434	80.0	0.99	82.1	6.0	13.3	94.0
UD0301736	90.4	1.16	135.9	6.0	15.1	94.0
UD0303543	79.0	1.08	105.7	6.0	13.2	94.0
UD0303557	77.5	1.14	137.8	7.0	11.1	93.0
UD0303610	75.3	0.93	71.1	6.0	12.6	94.0
UD0303513	81.1	0.98	82.4	5.0	16.2	95.0
UD0303598	78.1	1.08	97.4	6.0	13.0	94.0
UD0303600	79.5	0.94	71.7	5.0	15.9	95.0
UD0303528	79.2	1.04	97.5	6.0	13.2	94.0
Medium	*81.4*					
LSD_{05}	*0.91–1.28*					

The varieties had the highest resistance to bacterial wilting in 2016 – 79.8 to 96.7 %. Somewhat lower resistance was in 2014 from 74.7 to 94.5 %, and the lowest one in 2015 – from 71.3 to 90.9 %.

The highest resistance to bacterial wilting had the variety UD0300414 – 94.0 %, as well as UD0301063 – 90.4 % and UD0303543 – 81.1 %.

Analyzing the indices that determine the adaptability of common bean varieties, it should be noted that the coefficient of plasticity and the stability variance in these varieties significantly differed. So bythe variety UD0300414 the coefficient of ecological plasticity was 0.65, and in the varieties UD0301063 – 1.16 and UD0303543 – 0.98 %. The stability variance in all the best-resistant bacterial wilting varieties was higher.

The variation coefficient was at the level of 3–6 %. The agronomic stability coefficient was high and varied from 94 to 97 %. The highest ultrastability indices were in UD0300414, UD0303543, UD0303610, UD0301063. These varieties are highly valuable to further breeding work.

Further we distinguished the common bean varieties, characterized by high resistance to the damage to plants by variegation (Table 4).

Table 4. Variegation of common bean varieties and parameters of ecological plasticity and stability, 2014–2016

National Catalog Number	Resistance to variegation, *%*	b_i	S_i^2	*V*	*Hom*	*As*
UD0300282	73.0	1.09	111.2	6.0	12.2	94.0
UD0300434	73.8	1.52	221.7	9.0	8.2	91.0
UD0301736	74.4	1.01	97.38	6.0	12.4	94.0
UD0303543	75.0	1.35	174.2	8.0	9.4	92.0
UD0303557	73.1	0.75	52.92	4.0	18.3	96.0
UD0303610	71.8	0.91	78.31	5.0	14.4	95.0
UD0303513	89.6	1.31	162.1	6.0	14.9	94.0
UD0303598	84.4	0.92	81.8	5.0	16.9	95.0
UD0303600	83.7	1.41	186.9	7.0	12.0	93.0
UD0303528	79.1	-0.27	44.45	6.0	13.2	94.0
Medium	*77.8*					
LSD_{05}	*0.81–0.98*					

The harmfulness of viral diseases depends on the susceptibility of the variety to the virus, the age of the damaged plant and weather conditions. The agent of the usual retains its properties as long as it remains a viable seed. In the period of vegetation, the infection is transmitted by aphids, sometimes by inoculation with juice, pollen, and also in contact with a diseased plant. The fatal development of the virus is observed at temperatures above 30 °C [19].

It should be noted that the highest resistance to variegation manifested itself in 2014, when the lowest temperature conditions were observed during the vegetation period. The worst attack of variegation was in 2015, when there were high temperatures during the vegetation period of bean plants. In 2014 the resistance to variegation was in the range from 74.2 to 94.6 %, and in 2015 the resistance indices were significantly lower and varied from 66.4 to 83.4 %. The typical intermediate value of the variegation resistance of the varieties in 2016 ranged from 73.2 – 90.9 %. According to the variegation resistance the following varieties were distinguished: UD0303543 – 89.6 %, UD0303557 – 84.4 %, UD0303610 – 83.7 %.

These varieties of common bean according to the ecological plasticity coefficient and the stability variance were classified as the first and the sixth rank. So the plasticity coefficient of the variety UD0303543 was 1.31, and of the variety UD0303610 – 1.41. That is, these varieties refer to the sixth rank, and the variety UD0303557 – 0.92 to the first rank. In the presented varieties, the stability variance is $S_i^2 > 0$. The variation coefficient in these varieties was between 5 and 8 %. The agronomic stability coefficient of these varieties was between 92 and 95 %. The highest ultrastability had the varieties UD0303526, UD0303557.

Conclusions. As a result of the three-year research of common bean varieties in the conditions of the central subzone of the Right-Bank Forest-Steppe, the following is established.

1. The common bean varieties were selected that showed high resistance to fusariosis, the reaction of which to excess moisture on the initial and the influence of high temperatures on the final stages of growth and development was minimal – UD0303600 and UD0303528. The highest resistance to bacteriosis had the varieties UD0303601, UD0303526, UD0303543 and UD0303557. Among them, UD0303601, UD0303526 were more resistant to adverse cultivation conditions.

2. The highest resistance to bacterial wilting, including under adverse cultivation conditions had the varieties UD0300414, UD0301063 and UD0303543.

3. According to the resistance to variegation the following varieties were distinguished: UD0303543, UD0303557 and UD0303610, they were better under all conditions of cultivation.

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Аннотация

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Экологическая пластичность, стабильность и устойчивость к болезням сортообразцов Phaseolus vulgaris L.

Условия выращивания растений имеют важное значение в формировании их устойчивости к различным болезням. В природе на патогены и растения действуют погодные условия, которые постоянно меняются. Целью исследований было определении уровня изменчивости и выявлении закономерностей наследования ценных хозяйственно-биологических признаков для селекции продуктивных и адаптивных форм фасоли обыкновенной (Phaseolus vulgaris L.) путем гибридологического анализа. Методика исследований. Исследования проводились в течение 2014–2016 годов в условиях опытного участка кафедры растениеводства, селекции и биоэнергетических культур Винницкого национального аграрного университета. Регион проведения исследований по характеру природных условий относят к центральной подзоне Правобережной Лесостепи. Гидротермические условия 2014 и 2016 лет исследований были типичными до среднемноголетних показателей зоны, а 2015 год отличился значительным дефицитом осадков и высоким температурным режимом воздуха. Материалом для исследований были сортообразцы фасоли обыкновенной предоставлены Национальным центром генетических ресурсов растений Украины и гибридные комбинации полученные в результате проведенных межсортовых скрещиваний. Сев осуществляли на фоне температурного режима почвы 10–12 °С на глубине заделки семян и устойчивого повышения среднесуточных температур воздуха. Размещение участков последовательное, шестикратная повторность. Способ сева – широкорядный, с шириной междурядий 45 см. Общая площадь участков составила – 1,35 м², учетная – 1,0 м². Сев осуществляли с нормой высева 18 схожих семян на 1 погонный метр, вручную, стандарт размещали через 10 номеров. Общую адаптивность сортообразцов фасоли обыкновенной по годам исследований определяли по коэффициенту регрессии (b_i) и вариансе стабильности (S_i^2). Оценку варьирования морфологических признаков осуществляли по коэффициенту вариации (V, %). Экологический коэффициент вариации (Ve, %) определяли по отношению средней признака к его стандартному отклонению. Проводили определение гомеостатичности (Hom) и коэффициента агрономической стабильности (As). Выводы. В результате трехлетних исследований установлено: наивысшую устойчивость к бактериозу обеспечили сортообразцы UD0303601, UD0303526, UD0303543 и UD0303557, а UD0303601, UD0303526 – были устойчивыми при неблагоприятных условиях выращивания; наивысшую устойчивость к бактериальному увяданию в том числе и при неблагоприятных условиях выращивания обеспечили сортообразцы UD0300414, UD0301063 и UD0303543; по устойчивости к вирусной мозаики выделили сортообразцы UD0303543, UD0303557 и UD0303610 (они были лучше при всех условиях выращивания).

***Ключевые слова**: фасоль обыкновенная, сортозразок, экологическая пластичность, стабильность; устойчивость к болезням.*

Annotation

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Environmental plasticity, stability and resistance to diseases of the varieties Phaseolus vulgaris L.

Plant growing conditions are important in forming their resistance to various diseases. In nature, pathogens and plants are affected by the weather conditions that are constantly changing. The research objective was to determine the variability level and to identify the patterns of inheritance of valuable commercial-biological traits for the selection of productive and adaptive forms of common bean (Phaseolus vulgaris L.) by hybridologic analysis. The research was conducted during 2014–2016 in the conditions of the research plot of the Department of Plant Production, Selection and Bioenergetic Cultures of Vinnytsia National Agrarian University. The region of the research by its natural conditions refers to the central subzone of the Right Bank Forest-Steppe. The hydrothermal conditions of the 2014 and 2016 surveys were typical of the average yearly indices of the research area and the year 2015 was

characterized by a significant deficiency of precipitation and high temperature air conditions. The research material were the varieties of common bean provided by the National Center for Plant Genetic Resources of Ukraine [3] and hybrid combinations obtained as a result of intervarietal crossings. Sowing was carried out by the temperature regime of soil 10–12 °C at the depth of seeding and stable increase of average daily air temperature. The placement of the plots was consistent, the varieties were sown in a six-time repetition. The wide-row sowing with a width of rows of 45 cm was used. The total area of the plots was 1.35 m², and the account one is 1.0 m². Sowing was carried out with the seeding rate of 18 similar seeds per 1 linear meter, the standard was placed in 10 numbers. The general adaptability of the common bean varieties for the research years was determined by regression coefficient (b_i) and the stability variance (S_i^2). Assessment of the morphological features variation was carried out by the variation coefficient (V, %). The ecological variation coefficient (Ve, %) was determined by the ratio of the average sign to its standard deviation. The determination of ultrastability (Nom) and agronomic stability coefficient (As) was made. Conclusions. As a result of the three year research, it was established that the highest resistance to bacteriosis had such varieties as UD0303601, UD0303526, UD0303543 and UD0303557. The varieties UD0303601, UD0303526 were resistant under adverse growing conditions; the highest resistance to bacterial wilding, including under adverse growing conditions, was provided by the varieties UD0300414, UD0301063 and UD0303543; according to the resistance to variegation the following varieties were selected: UD0303543, UD0303557, and UD0303610 (they were better under all growing conditions).

Key words: *common bean, variety, ecological plasticity, stability; disease resistance.*

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РЕАКЦІЯ СОЇ НА ЗАБУР'ЯНЕНІСТЬ ЇЇ ПОСІВІВ НА ФОНІ РІЗНОЇ ІНТЕНСИВНОСТІ ЗЯБЛЕВОГО ОБРОБІТКУ

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Висвітлено результати польових досліджень стосовно реакції сої на забур'яненість посівів, сформованої під впливом основного зяблевого обробітку чорнозему опідзоленого різної інтенсивності. Встановлено, що заміна оранки менш енергоємним безполицевим обробітком, як і зменшення глибини обробітку під сою супроводжується зростанням забур'яненості та зменшенням зернової продуктивності культури.

Ключові слова*: соя, оранка, плоскорізне розпушування, глибина обробітку, забур'яненість посівів, урожайність.*

Аналіз останніх досліджень і публікацій. Бур'яни в сільськогосподарському виробництві завдають величезної шкоди, перехвачуючи від культурних рослин ґрунтову вологу та поживу, різко знижуючи цим самим їх продуктивність. Так, за повідомленням Ю.І. Ткаліча