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CONTENTS

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AGROECOLOGICAL STABILITY OF CULTIVARS OF SPARSELY DISTRIBUTED LEGUMES IN THE CONTEXT OF CLIMATE CHANGE

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Abstract. A prerequisite for increasing the area of sparsely distributed leguminous crops lies in the analysis of their cultivars according to agroecological indicators. Therefore, the purpose was to develop the State Register of plant cultivars suitable for distribution in Ukraine for 2021 and Official descriptions of plant cultivars and indicators of economic suitability, highlighted in the information and reference system "Sort" (cultivar) regarding the assessment of agroecological resistance of cultivars of sparsely distributed legumes. The highest potential seed yield, according to the State Register of plant cultivars of Ukraine, is attributed to horse bean cultivars Tiffani and Fanfare, lentil cultivars YeS Maksymum, Blondi and SNIM 18, chickpea cultivars Goksu, Aras, Zehavit, YeS Alunt and a cultivar of grass pea Ivolha. The highest resistance to diseases is attributed to the cultivars of horse beans Birgit, Apollo, and Stella, cultivars of lentils Blondi, Khryzolit, SNIM 18, Harri, Linza, cultivars of chickpeas Odysei, Zodiak, Rodin, Oven, Stepovyi velet, and all cultivars of grass pea. The most resistant to pests are horse beans Sirius and Fanfare, lentil cultivars Harri, Blondi, Khryzolit, SNIM 18, cultivars of chickpea Dostatok, Zodiak, Lara, Yaryna, YeS Alunt, Rodin, Stepovyi velet, Kozeroh and Odysei. The most drought-resistant is the cultivar of grass pea Ivolha, as well as most cultivars of horse beans, except Sirius and Fanfare, lentil cultivars, except YeS Maksymum, Antonina, and Harri, chickpeas, except Zehavit and Budzhak cultivars. Analysis of agroecological resistance of cultivars of sparsely distributed leguminous plants and their potential seed yield showed that to a large extent, high productivity is ensured by resistance to adverse agroecological factors: the influence of diseases, pests, and drought. The practical value of the study is to recommend the production of cultivars of sparsely distributed legumes with the highest indicators of resistance to diseases, pests, and drought with the highest potential yield

Keywords: horse beans, lentils, chickpea, grass pea, cultivar, drought resistance, yield

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INTRODUCTION

Leguminous crops are valuable in the food, fodder, and agroecological significance of agricultural plants in Ukraine. However, their acreage is very low. In general, in Ukraine, the acreage under leguminous crops in 2019 amounted to 566.0 thousand hectares, which is approximately 2% of the structure of the sown area and is a very low indicator [1]. Of the total area of leguminous crops in Ukraine, over 84% belongs to peas and soybeans. These two crops are the main ones among legumes. At the same time, under conditions of the climate change, the potential of other legumes, such as chickpeas, lentils, grass peas, beans, etc. is not fully utilised, which can provide higher yields in extreme weather conditions at a lower cost.

The determining factor in the expansion of acreage under sparsely distributed leguminous crops is the correct selection of cultivars, taking into account modern environmental conditions. One of the main indicators in the selection of leguminous varieties for certain soil and climatic conditions is their potential yield and manufacturability of cultivation [2]. The main indicators of the manufacturability of leguminous crops are the resistance of plants to lodging, shedding of beans, the suitability of plants for direct combining, the height of attachment of lower beans, and the height of plants. It is also necessary to consider the maturation time of cultivars, their reaction to weather and soil conditions [3]. Climate change in recent years has led to the fact that some varieties of legumes have become severely suppressed by drought, and this has affected their resistance to diseases, pests, and most importantly – their productivity [4]. Therefore, the ecological indicators of the suitability of leguminous cultivars should include their drought resistance, as well as resistance to the most common diseases and pests.

The fulfilment of the genetic potential of leguminous crops requires not only optimisation of environmental factors, but also an appropriate cultivation technology adapted to a specific cultivar [5]. The issue of optimal selection of leguminous cultivars for growing in certain ecological conditions is covered in the studies of V. F. Kaminskyi [6], H. Hing, H. Jiang, K. Zhou, N. Hing [7], H. Zhao, H. Cao, P. Ming-Zhen, I. Song [8], R.A. Guntyansky [9], M.A. Vishnyakova [10], N.E. Novikova [11], O.L. Kirilesko [12] and others.

Modern cultivars of leguminous crops are capable of realising approximately 50% of their productive potential [13]. One of the main reasons for this is an incorrectly selected cultivar for specific ecological growing conditions [14]. Therefore, the *purpose* and *objective* of the study is to analyse the current assortment of sparsely distributed leguminous crops included in the State Register of plant cultivars suitable for cultivation in Ukraine in terms of their potential productivity and resistance to drought, pests, and diseases.

MATERIALS AND METHODS

The assessment of agroecological stability of leguminous crops was carried out by processing the State Register of plant cultivars suitable for distribution in Ukraine for 2021 [15] and official descriptions of plant cultivars and indicators of economic suitability, submitted in the official bulletins "Protection of rights to plant cultivars", which are placed in the information and reference system "Sort" [16-26]. The authors of the study analysed materials on such leguminous crops, which, according to official data of the State Statistics Service of Ukraine, have the smallest acreage in 2019: horse beans (*Vicia faba* L.), lentils (*Lens culinaris* Medik.), chickpea (*Cicer arietinum* L.) and grass pea (*Lathyrus sativus* L.).

Cultivars of leguminous plant species according to the state qualification examination for determining indicators of suitability for distribution in Ukraine, among other things, are evaluated by grain yield, resistance (tolerance) to diseases, pest damage, adverse meteorological conditions, and other indicators. The parameters of agroecological resistance covered in official documents are the ratio of plants to the effects of pests, diseases, and droughts. Quantitatively, stability is determined on a relative nine-point scale (1-9 points), where 9 points correspond to the highest stability, and 1 point corresponds to the lowest stability. Therewith, the following gradation of cultivars is used by points: 9 points – the cultivar is excellent; 7 points – the cultivar is good; 5 points – the cultivar is satisfactory; 3 points – the cultivar is bad; 1 point – the cultivar is very bad [27]. Potential levels of seed yield of the studied leguminous crops were also analysed. The studied indicators were compared with each other using mathematical and statistical correlation and regression analysis.

These indicators of sparsely distributed leguminous crops were established based on the methodology of conducting an expert examination of plant varieties of the group of grains, cereals, and legumes for suitability for distribution in Ukraine. All experiments are carried out on plots of 10-25 m^2 in size with four-fold repetition [27]. Identification of the resistance of leguminous crops to the main pests is carried out according to the following parameters: bruchid – a month after harvesting according to the percentage of damaged grains; pod borer – before harvesting according to the percentage of damaged grains; bean aphid – with a noticeable population on plants as a percentage; pea leaf weevil – with noticeable damage to plant seedlings as a percentage [27].

Determination of plant resistance to diseases is carried out according to the following methods: bacteriosis – during the filling of the main mass of beans and before harvesting according to the percentage of the affected surface; fusariosis – 10 days after germination according to the percentage of affected plants; ascochytosis – during the filling of the main mass of beans and before harvesting according to the percentage

of damage to leaves, stems, and beans; stripe disease – before harvesting according to the percentage of affected plants; bacterial wilting, root rot – in the phase of full flowering according to the percentage of affected plants [27]. Assessment of the resistance of cultivars to adverse meteorological conditions, in particular drought, is carried out in accordance with general guidelines. During the growing season, leguminous cultivars are visually evaluated for drought resistance. To determine the yield of plants, they are collected separately or by direct combining [27].

RESULTS AND DISCUSSION

As of 2021, the State Register of plant cultivars suitable for distribution in Ukraine includes 10 cultivars of horse beans (*Vicia faba* L.) [15]. The main diseases of horse beans are bacteriosis (*Bacterium phaseoli* E.F.Sm), fusariosis (*Fusarium oxysporum* Sch.), ascochytosis (*Ascochyta viciae* Libert.) and stripe disease (*Bacterium lathyri* (Mann. et Taub.) Burgw.). The most common pests of horse beans are the bruchid (*Bruchus rufimanus* Boh.), the pod borer (*Etiella zinckenella* Tr.), the stem borer (*Lixus algirus* L.).

Resistance to major diseases in horse bean cultivars is 5.3-7.8 points. Birhit cultivar has the highest resistance to a complex of diseases – 7.8 points, Apollo and Stella cultivars – 7.5 points each. The least resistant to diseases is the Fanfare cultivar – 5.3 points. For the Bakhus cultivar, there is no information on its resistance to diseases (Table 1). The most resistant to pests are the cultivars of horse beans Sirius – 7 points and Fanfare – 6.3 points. The most vulnerable to pests are the cultivars Apollo, Stella, Birhit – all with a resistance score of 5. At the same time, there is no information on pest resistance of Vivat, Bakhus and Peremozhets' cultivars.

***Table 1**. Indicators of agroecological resistance of horse bean cultivars according to the State Register of plant cultivars of Ukraine*

Cultivar	*Resistance to diseases, points*	*Pest resistance, points*	*Drought resistance, points*	*Grain yield, t/ha*
Aleksiia	6.0	6.0	7.0	4.5
Apollo	7.5	5.0	7.0	5.2
Vivat	6.0	no data available	no data available	4.5
Stella	7.5	5.0	7.0	5.3
Sirius	7.0	7.0	5.0	4.2
Fanfare	5.3	6.3	6.0	5.7
Birhit	7.8	5.0	7.0	5.0
Bakhus	no data available	no data available	no data available	no data available
Tiffani	6.3	6.0	7.0	5.9
Peremozhets'	7.0	no data available	7.0	no data available

***Source**: [16; 17; 19; 23-25]*

Drought resistance of all cultivars of horse beans is in the range of 5-7 points. Most cultivars have a drought tolerance score of 7, only the Sirius cultivar has 5 points, and the Fanfare cultivar has 6 points. There is no information on the drought resistance of Vivat and Bakhus cultivars. The potential yield of horse bean seeds is in the range of 4.2-5.9 t/ha. The highest yield is attributed to the Tiffani cultivar – 5.9 t/ha and Fanfare – 5.7 t/ha. The lowest yield is attributed to Sirius – 4.2 t/ha, Vivat and Alexia – 4.5 t/ha each. There is no information on the yield of horse bean cultivars Bakhus and Peremozhets'.

An average positive correlation was established between the drought resistance score of plants and the yield of horse bean seeds (r = 0.432). A graphical representation of the correlation and regression relationship between the yield of horse bean seeds and the drought resistance score of plants, as well as the regression equation and the approximation confidence value (R^2) between the studied values are presented in Fig. 1.

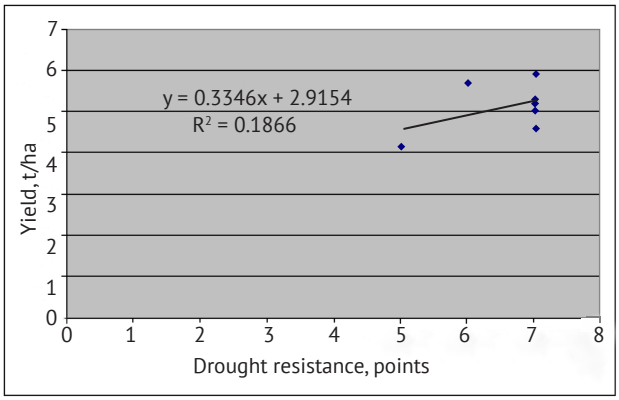

***Figure 1**. Correlation and regression relationship between drought resistance score (X) and seed yield (y) of horse beans*

***Source**: [16; 17; 19; 23-25]*

For 2021, the State Register of plant cultivars suitable for distribution in Ukraine includes 9 cultivars of lentils (*Lens culinaris* Medik.) [15]. The main diseases of food lentils are ascochytosis (*Ascochyta ervicola* Syd.), fusariosis (*Fusarium oxysporum* Schlecht.), bacterial wilt (*Corynebacterium insidiosuna* (Mc Cull.) Jons.). The most common pests of lentils are bean aphids (*Aphis fabae* Scopoli.) and pea leaf weevil (*Sitona lineatus* L.). The highest resistance to diseases is attributed to the following cultivars of lentils: Blondi, Khryzolit, SNIM 18 – 8 points each, Harri – 7.7, Linza – 7.5 points. The least resistant to diseases are the following varieties: YeS Maksymum – 6.3 points, Antonina – 6.7 points (Table 2).

***Table 2**. Indicators of agroecological resistance of lentil cultivars according to the State Register of plant cultivars of Ukraine*

Cultivar	*Resistance to diseases, points*	*Pest resistance, points*	*Drought resistance, points*	*Grain yield, t/ha*
YeS Maksymum	6.3	7.0	7.0	2.81
Blondi	8.0	8.0	8.0	2.60
Khryzolit	8.0	8.0	8.0	2.00
Svitanok	7.0	no data available	8.2	2.04
Antonina	6.7	6.0	7.0	2.10
Darynka	7.0	6.0	8.0	2.14
Linza	7.5	no data available	no data available	1.74
SNIM 18	8.0	8.0	8.0	2.60
Harri	7.7	9.0	7.0	2.30

***Source**: [18-22]*

The highest pest resistance is attributed to the Harry cultivar – 9 points, Blondi, Khryzolit, SNIM 18 – all 8 points each. The most vulnerable to pests are the cultivars Antonina and Darynka – 6 points each. There are no data on pest resistance of the Svitanok and Linza cultivars. Most cultivars of lentils have a high drought resistance – 8.0-8.2 points. Less drought-resistant are the YeS Maksymum, Antonina, and Harri cultivars, which have a drought resistance score of 7. The highest potential yield of lentil seeds is attributed to the YeS Maksymum cultivars – 2.81 t/ha, Blondi and SNIM 18 – 2.60 t/ha each, and the least productive is the Linza cultivar – 1.74 t/ha.

As of 2021, the State Register of plant cultivars suitable for distribution in Ukraine includes 19 varieties of chickpeas (*Cicer arietinum* L.) [15]. The main pest of chickpeas is the bruchid (*Bruchus rufimanus* Boh.), and diseases – ascochytosis (*Ascochyta ervicola* Syd.) and root rot (*Bipolaris sorokiniana* Shoem). The highest resistance to diseases among the cultivars of chickpeas is attributed to Odysei – 8.7 points, Zodiak, Rodin, Oven, Stepovyi velet – all 8.5 points each The least resistant to diseases are the cultivars Zehavit – 5.5 points, Goksu and Budzhak – 6 points each. Data on disease resistance of Triumf and Pehas varieties are not available (Table 3). Chickpea cultivars YeS Alunt and Oven have increased resistance to pests – 9 points each. The most vulnerable to pests are Aras, Zehavit, and Goksu cultivars – 5 points each. There is no information on pest resistance of Triumf, Pehas, Fahot, Odysei and Budzhak cultivars.

***Table 3**. Indicators of agroecological resistance of lentil cultivars according to the State Register of plant cultivars of Ukraine*

Cultivar	*Resistance to diseases, points*	*Pest resistance, points*	*Drought resistance, points*	*Grain yield, t/ha*
Triumf	no data available	no data available	8.0	1.69
Aras	7.5	5.0	8.0	4.00
Dostatok	7.0	8.0	9.0	2.00
Zodiak	8.5	8.0	9.0	2.80
Lara	7.0	7.0	9.0	3.40
Yaryna	8.0	8.0	9.0	1.80
Pehas	no data available	no data available	no data available	1.89
YeS Alunt	8.0	9.0	9.0	3.89

Continuation of table 3

Rodin	8.5	7.0	9.0	2.80
Zehavit	5.5	5.0	5.0	3.90
Eve	7.5	7.0	8.0	3.20
Oven	8.5	9.0	8.0	2.00
Fahot	7.1	no data available	8.7	2.64
Stepovyi velet	8.5	8.0	9.0	1.80
Goksu	6.0	5.0	7.0	4.10
Kira	7.0	7.0	8.0	3.30
Kozeroh	8.0	8.0	9.0	2.70
Odysei	8.7	no data available	9.0	2.25
Budzhak	6.0	no data available	5.0	2.00

***Source**: [19; 21; 23-26]*

Most cultivars of chickpeas have the highest drought resistance, with a score of 9. These are Dostatok, Zodiak, Lara, Yaryna, YeS Alunt, Rodin, Stepovyi velet, Kozeroh and Odysei. The lowest drought resistance is attributed to the cultivars Zehavit and Budzhak – 5 points each. There is no information on the drought resistance of the Pehas cultivar. The highest potential seed yield is attributed to chickpea cultivars Goksu – 4.10 t/ha, Aras – 4.00 t/ha, Zehavit – 3.90 t/ha, YeS Alunt – 3.89 t/ha. The lowest yield is observed in the cultivars Triumf – 1.69 t/ha, Yaryna and Stepovyi velet – 1.80 t/ha each and Pehas – 1.89 t/ha.

An average negative correlation was established between the score of resistance of chickpea plants to diseases and seed yield (r = -0.429), and a strong negative correlation was found between the score of resistance of chickpea plants to pests and seed yield (r = -0.674). This indicates that during the creation of breeding cultivars of chickpeas, cultivars with high potential seed productivity are described by reduced resistance to diseases and pests. As of 2021, two cultivars of the grass pea (*Lathyrus sativus* L.) were introduced in the State Register of plant cultivars of Ukraine. The Ivolha cultivar has a higher seed yield – 3.69 t/ha and higher drought resistance – 9 points than the Spodivanka cultivar (Table 4).

***Table 4**. Indicators of agroecological resistance of grass pea cultivars according to the State Register of plant cultivars of Ukraine*

Cultivar	*Resistance to diseases, points*	*Pest resistance, points*	*Drought resistance, points*	*Grain yield, t/ha*
Ivolha	8.0	no data available	9.0	3.69
Spodivanka	8.0	no data available	5.0	3.10

***Source**: [16]*

Analysis of agroecological resistance of cultivars of sparsely distributed leguminous plants and their potential seed yield showed that to a large extent, high productivity is ensured by resistance to adverse agroecological factors. It is established that the increased yield of horse beans of the Fanfare cultivar is combined with its high resistance to pests, and Tiffani cultivar – with drought resistance; considerable productivity of lentil cultivars Blondi and SNIM 18 is combined with increased resistance to diseases, pests and drought; all high-yielding cultivars of chickpeas – Goksu, Aras, Zehavit, YeS Alunt are marked by an increased score of drought resistance, and the YeS Alunt cultivar also has a high score of resistance to pests; the productivity of the grass pea cultivar Ivolha is combined with drought and disease resistance.

At the same time, the Fanfare horse bean cultivar, despite its high productivity, has a low score of drought resistance and resistance to diseases; the YeS Maksymum lentil cultivar combines high seed yield with low drought resistance and a low score of disease resistance; the high-performance chickpea cultivar Zehavit is marked by low scores of resistance to diseases, pests and drought, the Goksu cultivar – by low resistance to diseases and pests, the Aras cultivar – by low resistance to pests.

Comparison of the studied types of leguminous crops according to the value of the disease resistance score indicated that the most resistant to them are chickpea cultivars with the highest score of 8.7, lentils and grass pea had a resistance score of 8, and horse beans – 7.8 points. The most resistant to pest damage among the studied leguminous crops are some cultivars of food lentils and chickpeas with the highest score

of 9. At the same time, horse bean cultivars had the lowest pest resistance score of 7. The highest drought resistance among the studied types of leguminous crops was attributed to cultivars of chickpeas and grass peas – 9 points each, lentils – 8.2 points, and horse beans – 7 points. Horse bean cultivars have the highest potential for seed productivity among the studied leguminous crops – 5.9 t/ha. The maximum yield of chickpea seeds reaches 4.1 t/ha, grass peas – 3.7 t/ha, and lentils – only 2.8 t/ha.

CONCLUSIONS

According to the State Register of plant cultivars of Ukraine, the highest potential seed yield is attributed to horse bean cultivars Tiffani and Fanfare, lentil cultivars YeS Maksymum, Blondi and SNIM 18, chickpea cultivars Goksu, Aras, Zehavit, YeS Alunt and a cultivar of grass pea Ivolha. Among the cultivars of horse beans, the most resistant to diseases such as bacteriosis, fusariosis, ascochytosis and stripe disease are Birhit, Apollo, and Stella, lentil cultivars Blondi, Khryzolit, SNIM 18, Harri, Linza are resistant to ascochytosis, fusariosis and bacterial wilt, among the cultivars of chickpeas resistant to ascochytosis and root rot are Odysei, Zodiak, Rodin, Oven, Stepovyi velet, all cultivars of grass pea have increased resistance to its diseases.

The most resistant cultivars of horse beans to pests such as bruchid, pod borer and stem borer are Sirius and Fanfare, lentil cultivars Harri, Blondi, Khryzolit, SNIM 18 are resistant to damage by bean aphids and pea leaf weevils, chickpea cultivars Dostatok, Zodiak, Lara, Yaryna, YeS Alunt, Rodin, Stepovyi velet, Kozeroh and Odysei have increased resistance to bruchids. The most drought-resistant is the cultivar of grass pea Ivolha, as well as all cultivars of horse beans, except Sirius and Fanfare, all lentil cultivars, except YeS Maksymum, Antonina, and Harri, and all cultivars of chickpea, except Zehavit and Budzhak.

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АГРОЕКОЛОГІЧНА СТІЙКІСТЬ СОРТІВ МАЛОПОШИРЕНИХ ЗЕРНОБОБОВИХ КУЛЬТУР В УМОВАХ ЗМІНИ КЛІМАТУ

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Анотація. Передумовою збільшення площ малопоширених зернобобових культур є аналіз їх сортів за агроекологічними показниками. Тому метою було опрацювання Державного реєстру сортів рослин, придатних для поширення в Україні на 2021 рік та Офіційних описів сортів рослин і показників господарської придатності, висвітлених в Інформаційно-довідковій системі «Сорт» щодо оцінки агроекологічної стійкості сортів малопоширених зернобобових культур. Найвищою потенційною урожайністю насіння, за даними Державного реєстру сортів рослин України, відзначаються сорти бобів кінських Тіффані та Фанфаре, сорти сочевиці харчової ЄС Максимум, Блонді та CHIM 18, сорти нуту звичайного Гоксу, Арас, Зехавіт, ЄС Алунт і сорт чини посівної Іволга. Найвищою стійкістю до хвороб характеризуються сорти бобів кінських Біргіт, Аполло та Стелла, сорти сочевиці харчової Блонді, Хризоліт, CHIM 18, Гаррі, Лінза, сорти нуту звичайного Одисей, Зодіак, Родін, Овен, Степовий велет та усі сорти чини посівної. Найбільш стійкими до шкідників є сорти бобів кінських Сіріус та Фанфаре, сорти сочевиці харчової Гаррі, Блонді, Хризоліт, CHIM 18, сорти нуту звичайного Достаток, Зодіак, Лара, Ярина, ЄС Алунт, Родін, Степовий велет, Козерог та Одисей. Найбільш посухостійким є сорт чини посівної Іволга, а також більшість сортів бобів кінських, крім Сіріусу та Фанфаре, сортів сочевиці харчової, крім ЄС Максимум, Антоніни та Гаррі, нуту звичайного, крім сортів Зехавіт і Буджак. Аналіз агроекологічної стійкості сортів малопоширених зернобобових рослин та їхньої потенційної урожайності насіння показав, що значною мірою висока продуктивність забезпечується стійкістю до несприятливих агроекологічних чинників: впливу хвороб, шкідників і посухи. Практична цінність досліджень полягає у рекомендації виробництву сортів малопоширених зернобобових культур із найвищими показниками стійкості до впливу хвороб, шкідників і посухи з найбільшою потенційною урожайністю

Ключові слова: боби кінські, сочевиця харчова, нут звичайний, чина посівна, сорт, посухостійкість, урожайність

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