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Feed and seed productivity of alfalfa in the conditions of the Southern Forest Step of Ukraine

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Alfalfa is one of the oldest perennial leguminous crops used for animal feed. It is well eaten in its pure form and in a mixture with perennial cereal grasses. This grass is a source of high-protein feed, rich in vitamins, carbohydrates, macro- and microelements. In terms of feed value, this plant is an unsurpassed crop. It contains over 200 g of digestible protein in 1 feed unit of leaf and stem mass. Alfalfa has a high yield of green mass, namely 50–60 t/ha and hay 10–12 t/ha. The unique biological features of alfalfa are its perennial and multi-mowing use as a herbage. Alfalfa also improves soil fertility and structure. Therefore, the relevance of the study was to analyze collection samples of alfalfa and bastard lucerne for feed and seed productivity in the conditions of the Southern Forest-Steppe of Ukraine. The aim of the study is to determine the biological potential of alfalfa collection samples. The experiment studied 19 collection samples of bastard lucerne (*Medicago varia* Martyn) and 3 collection samples of alfalfa (*Medicago sativa* L.) – UJ070001, UJ700003 and UJ700456. The studies were conducted on crops of the second and third years in 2022 and 2023 at the Ustymivka Experimental Station of Plant growing of the Institute of Plant growing named after V. Ya. Yuriev of NAAS of Ukraine (Ustymivka ESP).The station is located in the southern part of the Forest-Steppe of Ukraine. The largest total weight of green mass for two slopes in 2023 was given by collection samples of alfalfa UJ070001 (5280 g/m^2), UJ700003 (5350 g/m^2) and bastard lucerne UJ700053 (5430 g/m^2), UJ700518 (5240 g/m^2), UJ700486 (5230 g/m^2). The highest hay yield for two slopes in 2023 was also shown by the collection samples of alfalfa UJ070001 (1520 g/m^2), UJ700003 (1340 g/m^2) and the bastard lucerne UJ700053 (1550 g/m^2), UJ700518 (2480 g/m^2), UJ700486 (1460 g/m^2). The seed yield per plot of all collection samples of alfalfa was higher in 2023. So, the best over the years of research on feed and seed productivity were the collection samples of alfalfa (*Medicago sativa* L.) UJ070001 and UJ700003 and the collection samples of bastard lucerne (*Medicago varia* Martyn) UJ700053, UJ700518, UJ700486.

Keywords: alfalfa, bastard lucerne, collection samples, weight from the plot of green mass, hay and seeds.

Кормова і насіннєва продуктивність люцерни в умовах Південного Лісостепу України

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Люцерна є однією з найстародавніших багаторічних бобових культур, що використовуються на корм тваринам. Вона добре поїдається у чистому вигляді та у сумішці з багаторічними злаковими травами. Ця трава є джерелом високобілкового корму, багата на вітаміни, вуглеводи, макро- та мікроелементи. За кормовою цінністю ця рослина є неперевершеною культурою. У неї в 1 кормовій одиниці листостеблової маси міститься понад 200 г перетравного протеїну. Люцерна має високу урожайність зеленої маси, а саме 50–60 т/га та сіна 10–12 т/га. Унікальними біологічними особливостями люцерни є багаторічне і багатоукісне використанням травостою. Також люцерна покращує родючість і структуру грунту. Тому актуальність дослідження полягала в аналізі колекційних зразків люцерни посівної і люцерни мінливої на кормову і насіннєву продуктивність в умовах Південного Лісостепу України. Метою дослідження є з'ясування біологічного потенціалу колекційних зразків люцерни. В експерименті вивчали 19 колекційних зразків люцерни мінливої *(Medicago varia* Martyn) і 3 колекційних зразки люцерни посівної (*Medicago sativa* L.) – UJ070001, UJ700003 and UJ700456. Дослідження проводилися на посівах другого і третього років у 2022 і 2023 на Устимівській дослідній станції рослинництва Інституту рослинництва імені В. Я. Юр'єва НААН України (Устимівська ДСР). Станція розташована у південній частині Лісостепу України. Найбільшу сумарна вагу зеленої маси за два укоси у 2023 році дали колекційні зразки люцерни посівної UJ070001 (5280 г/м^2), UJ700003 (5350 г/м^2) та люцерни мінливої UJ700053 (5430 г/м^2), UJ700518 (5240 г/м^2), UJ700486 (5230 г/м^2). Найбільшу урожайність сіна за два укоси у 2023 році також показали колекційні зразки люцерни посівної UJ070001 (1520 г/м^2), UJ700003 (1340 г/м^2) та люцерни мінливої UJ700053 (1550 г/м^2), UJ700518 (2480 г/м^2), UJ700486 (1460 г/м^2). Урожайність насіння з ділянки у всіх колекційних зразків люцерни була вищою у 2023 році. Отже, найкращими за роки досліджень щодо кормової і насіннєвої продуктивності були колекційні зразків люцерни посівної (*Medicago sativa* L.) UJ070001 і UJ700003 та колекційні зразки люцерни мінливої (*Medicago varia* Martyn) UJ700053, UJ700518, UJ700486.

Ключові слова: люцерна посівна, люцерна мінлива, колекційні зразки, вага з ділянки зеленої маси, сіна і насіння.

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Introduction

Russia's aggressive war against Ukraine led to the destruction of territories where natural forage lands were located. Their restoration after the end of the war is possible due to perennial leguminous grasses. Growing these crops will significantly increase the productivity, protein content and energy saturation of newly created hayfields and pastures. Perennial leguminous grasses are the main source of crude protein. Compared to cereal crops, they are better absorbed by animals and are balanced in amino acid composition. In Ukraine, the harvest of digestible protein from 1 ha of perennial grass crops is 5.3–6.9 centners. According to V. Zharinov, the yield of green mass of perennial grasses in the Forest-Steppe zone is 215 centners/ha [1].

Since ancient times, the people have grown forage grasses to feed animals. Even at the creation of the world, God said to man: «I have given you every herb bearing seed, which is upon the face of all the earth … and to every beast of the earth, and to every fowl of the air, and to every thing that creepeth upon the earth, wherein there is life, I have given every green herb for meat» [2].

Among the perennial grasses that are promising in Ukraine, the leading place belongs to alfalfa. This crop has high fodder qualities, as well as useful agrotechnical properties. At the current stage of development of feed production, it creates a strong and complete feed base for animals. Alfalfa is eaten well by all types of animals, even fur-bearing ones. Krishna B. Bhandari, Hannah L. Ruschand Deborah J. Heuschele note, that the alfalfa leaf cell walls are highly digestible, but stem cell walls of alfalfa are not readily digestible. The cell wall component of alfalfa has a large source of dietary energy, but ruminant animals can digest less than half of this component due to the presence of high lignin content. They discuss the potential future strategies for improving alfalfa cell wall digestibility [3].

This grass is a source of high-protein feed, rich in vitamins, carbohydrates, macro- and microelements. *Medicago sativa* L. is used to treat many diseases and has anti-inflammatory and antioxidant effects. 100 kg of alfalfa hay contains 43.3–62.8 feed units and 10.3–13.7 kg of digestible protein, and 100 kg of green mass contains 21.7–72.8 feed units and 4.1–10.2 kg of digestible protein" [4]. "This crop in different soil and climatic conditions makes it possible to obtain up to 35–40 c/ha of cheap feed protein" [5]. N. Getman, M. Kvitko and V. Tsygansky note that alfalfa can show sufficient feed productivity for about eight years. The grass has a high yield of green mass – 50–60 t/ha and hay – 10–12 t/ha, good eating in pure form and in a mixture with perennial cereal grasses. Alfalfa proteins are classified as physiologically active, unlike the reserve proteins of most cereals [6].

Due to the significant decrease in the number of cattle in recent years in Ukraine, O. Kulinich recommends using alfalfa as a green fertilizer in intensive grain production technologies, since this legume absorbs 200 kg/ha of nitrogen from the air during the year [7]. Ammara Latif, Ying Sun, Ali Noman note that «this crop also has eco-friendly behavior since it controls soil erosion by binding the soil particles together and makes atmospheric nitrogen available to the plants by fixing it in the soil» [8]. «Atmospheric nitrogen fixation makes it an indispensable precursor for other agricultural crops» [9].

V. Petrichenko, N. Getman and Yu. Veklenko noted that "during three years of research, alfalfa provided the highest yield of leaf and stem mass – 47.03 t/ha, dry matter yield – 11.09 t/ha and crude protein – 2.07 t/ha during the early spring sowing period" [10]. N. Getman and B. Danylyuk noted that "mowing three slopes of alfalfa at the beginning of the flowering phase contributes to the effective use of the light regime of the growing season as the main factor in increasing productivity" [11]. N. Getman, L. Burko and I. Svystunova established that the highest productivity of alfalfa was provided by the third mode of using the grass stand "three slopes at the beginning of the flowering phase" [12]. N. Telekalo and M. Melnyk found that "due to the use of pre-sowing treatment of alfalfa seeds and crops with growth stimulants and microfertilizers, the conditions for growth and development of the crop are improved and the yield of green mass is increased" [13]. Hungarian scientists note that «sustainable management of potassium nutrition in alfalfa crop production is one of the major key factors for achieving optimum seed and biomass yields» [14].

R. Vozhegova, A. Tyshchenko, O. Tyshchenko, K. Fundyrat and V. Konovalova focus on the modern continuous selective process with its constant improvement to ensure stability and growth of alfalfa fodder and seed productivity by creating and introducing new varieties [15]. Ukrainian scientists assessed the reactions of alfalfa populations of the second year of life to fodder use and identified the best not only in terms of drought resistance, but also in terms of productivity under stress conditions for further use in the selective process [16]. Brazilian scientists also studied alfalfa with the objective of evaluating and selecting genotypes using methods of adaptability and phenotypic stability, for the production of dry matter in harvests during the rainy and drought seasons [17].

Moroccan scientists studied on the adverse effects of salinity on growth, nodulation, and some physiological parameters in 4 symbiotic combinations involving 2 Moroccan alfalfa (*Medicago sativa* L.) populations (Demnate and Tata) and 2 rhizobial strains (rhLAr 1 and rhLAr 4). The results showed that salinity significantly reduced the height of plants, their dry biomass, and nodulation [18]. L. Mykhalkiv, S. Kots, R. Yakymchuk noted that "the use of plant growth regulators PS-K, PS-A-6 and TMFP in the latent budding phase intensifies nitrogen fixation in alfalfa of the Yaroslavna variety inoculated with *S. meliloti* M6. PS-K and PS-A-6 have a significant impact on growth processes in case of insufficient water» [19].

Alfalfa adapts well to various climatic conditions, however, is sensitive to acidic soils. «Aluminium toxicity is one of the factors limiting alfalfa (*Medicago sativa* L.) production on acid soils» [20]. Lithuanian scientists and Vasily Buhaiov evaluated the reaction of alfalfa genotypes to acidic soils. The main feature of these acidic soils is the toxic concentration of mobile aluminum [21].

An important aspect in growing alfalfa is increasing its seed productivity. This problem is solved by creating new high-yielding varieties and improving existing crop cultivation technologies. Modern scientists are developing a set of agrotechnical techniques that improve the processes of plant growth and development and promote the formation of generative organs. These technologies significantly increase the seed productivity of alfalfa. A. Tyshchenko notes that "the use of the growth regulator Plantafol 30 contributed to a significant increase in the yield of alfalfa seeds" [22].

Therefore, the relevance of the topic lies in the importance of analyzing collection samples of alfalfa for fodder and seed productivity in the conditions of the Southern Forest-Steppe of Ukraine. This is necessary for selecting good starting material in analytical breeding and solving the problem of seed production.

The aim of the study

The aim of the research is to determine the biological potential of alfalfa collection samples.

In order to achieve the set goal, the following tasks must be solved:

1) to evaluate the collection samples of alfalfa for green mass and hay yield;

2) to evaluate the collection samples for seed yield.

Materials and methods

The experiments were planned on the Ustymivka Experimental Station of Plant growing of the Institute of Plant growing named after V. Ya. Yuriev of NAAS of Ukraine (Ustymivka ESP) in 2021. The studies were conducted on second and third year alfalfa stands in 2022 and 2023. The station is located in the southern part of the Forest Steppe of Ukraine. The soils are represented by medium loamy, saline, powerful chernozem with a humus content of up to 3.84 %. The Ustymivka ESP is located on the border of the central warm zone of insufficient moisture and the southern warm arid zone. The climate at the station is moderately continental, with unstable humidity. The average long-term air temperature is 8.2 ^{0}C. The amount of precipitation varies from 253.8 mm to 777.4 mm per year.

The object of the research is 19 collection samples of the bastard lucerne *(Medicago varia Martyn)* and 3 collection samples of the alfalfa (*Medicago sativa* L.) – UJ070001, UJ700003 and UJ700456. The length of the plot, on which the collection samples grew, was 5 m, the width was 1.4 m. Sowing took place in a row method with a row spacing of 0.70 m. The yield of green mass and hay was determined from the first and second slopes. The mowing was carried out at the beginning of flowering. The seed productivity was determined from the first slope in individual plots. The biometric analysis of collection samples was organized according to the method of conducting examination of plant varieties [23].

Results and discussion

In a market economy, almost 75 % of crop production in the agricultural sector is directly or indirectly used for feed needs. Therefore, modern feed production must provide animal husbandry with a sufficient amount of high-quality feed, balanced in terms of nutrient content. At the XIV International Congress on Grassland, the slogan was: "Grasses feed humanity!" It reflects the importance attached to natural forage lands worldwide [4].

A. Babich notes that alfalfa is one of the oldest perennial legumes, grown only for animal feed. It has deservedly earned the reputation of the queen among perennial legumes because it forms the highest yields of hay and vegetable protein and provides the soil with nitrogen and animals with high-quality feed [24]. S. Antoniv, S. Kolisnyk and O. Zapruta claim that alfalfa is the most widespread and most useful fodder plant. The total area of cultivation of this crop on arable lands of the planet is 33 million hectares. In Ukraine, the area of alfalfa ranges from 0.57 to 1.8 million hectares [25].

N. Getman, M. Kvitko and V. Tsygansky note that the problem of producing feeds balanced in amino acid composition has been and remains one of the priority directions of development of field feed production. Alfalfa is an extremely valuable legume grass, which is widely used in field grass sowing and improvement of natural forage lands mainly in the Forest-Steppe and Steppe zones [6].

To improve the feed base of Ukraine, modern agricultural production puts forward reasonable requirements for new varieties of alfalfa. As a result of the study, the assessment of the feed and seed productivity of collection samples of alfalfa for 2022–2023 showed that ecological conditions in 2023 were more favorable for the realization of the biological potential of the crop. The data in Table 1 show that in 2023, almost all indicators of feed and seed productivity of collection samples of *Medicago varia* Martyn and *Medicago sativa* L. were higher than in 2022.

The largest total weight of green mass for two slopes in 2023 were given by the collection samples of alfalfa UJ070001 (5280 g/m^2), UJ700003 (5350 g/m^2) and bastard lucerne UJ700053 (5430 g/m^2), UJ700518 (5240 g/m^2), UJ700486 (5230 g/m^2). In 2022, the collection sample of the bastard lucerne UJ700053 of all samples gave the largest total weight of green mass for two slopes (4500 g/m2). Analysis of green mass yield by years showed that in 2023, the weight of green mass from the first slope in all collection samples of alfalfa was greater compared to 2022.

But in 2022, the weight of green mass from the second slope in all collection samples of alfalfa was greater compared to 2023, except for sample UJ700003. It had a green mass yield of 1180 g/m^2 from the second slope in 2022, and 1850 g/m^2 in 2023. If we compare the green mass yield by slopes, then in 2022, 11 collection samples on the second slope had a higher yield. In 2023, all collection samples had a higher green mass yield on the first slope.

Table 1
Productivity of collection samples of the alfalfa for 2022–2023

No. according to the national catalog	Years	Weight of green mass, g/m²			Hay weight, g/m²			Seed weight from the plot, g/m²
		First slope	Second slope	Together on the slopes	First slope	Second slope	Together on the slopes	
UJ070001	2022	1930	2100	4030	490	530	1020	3.09
	2023	4040	1240	5280	1160	360	1520	9.25
UJ700003	2022	850	1180	2030	200	270	470	1.7
	2023	3500	1850	5350	960	380	1340	8.46
UJ700456	2022	1400	1500	2900	340	350	690	5.9
	2023	3500	800	4300	1000	250	1250	11.96
UJ700053	2022	2150	2350	4500	520	600	1120	3.03
	2023	3750	1680	5430	1050	500	1550	6.4
UJ700064	2022	2100	2390	4490	550	580	1130	2.09
	2023	3650	1070	4720	1010	310	1320	3.94
UJ700058	2022	1900	1930	3830	440	450	890	3.01
	2023	3450	1020	4470	990	300	1290	4.1
UJ700060	2022	1900	2100	4000	480	500	980	6.08
	2023	3650	1050	4700	860	460	1320	10.32
UJ700576	2022	1650	1680	3330	390	370	760	5.03
	2023	3500	830	4330	950	240	1190	13.39
UJ700073	2022	2250	2150	4400	590	540	1130	2.07
	2023	3500	1080	4380	1040	300	1340	9.11
UJ700518	2022	2100	2000	4100	470	450	920	2.06
	2023	3900	1340	5240	2100	380	2480	7.76
UJ700531	2022	2000	1800	3800	410	410	820	5.08
	2023	3320	800	4120	1150	220	1370	12.43
UJ700450	2022	2200	1940	4140	480	380	860	1.6
	2023	3740	1170	4910	1050	330	1380	8.62
UJ700528	2022	1750	1700	3450	400	360	760	6.6
	2023	3550	1130	4680	1150	300	1450	10.43
UJ700486	2022	1800	2000	3800	420	420	840	2.5
	2023	4050	1180	5230	1130	330	1460	8.84
UJ700523	2022	1300	1080	2380	300	250	550	5.5
	2023	2200	570	2770	660	180	840	9.04
UJ700153	2022	1350	1350	2700	310	290	600	5.7
	2023	1750	280	2030	520	110	630	10.95
UJ700081	2022	1850	2180	4030	420	480	900	1.9
	2023	2870	820	3690	960	260	1220	7.31
UJ700090	2022	2000	2400	4400	470	570	1040	1.2
	2023	3620	400	4020	1110	300	1410	7.21
UJ700652	2022	1920	1800	3720	460	460	920	2.6
	2023	2680	620	3300	830	190	1020	8.72
UJ700588	2022	2000	1100	4100	500	530	1030	2.2
	2023	2850	800	3650	870	240	1110	8.59
UJ700664	2022	1770	1600	3370	410	350	760	2.7
	2023	2850	500	3350	810	150	960	7.1
UJ700569	2022	1550	1420	2970	400	330	730	5.39
	2023	2900	520	3420	880	290	1170	9.2

Analyzing the data in ***Table 1***, it can be seen that the highest total hay weight for two slopes in 2023 was shown by the collection samples of alfalfa UJ070001 (1520 g/m²) and bastard lucerne UJ700053 (1550 g/m²), UJ700518 (2480 g/m²), UJ700486 (1460 g/m²). The collection sample of alfalfa UJ700003 also showed a good result in 2023. It had a total hay weight for two slopes of 1340 g/m² compared to the lowest result, which was shown by the collection sample of bastard lucerne UJ700153 (630 g/m²). Analysis of hay yield by years showed that in 2023, the weight of hay from the first slope in all alfalfa collection samples was greater compared to 2022.

In 2022, all alfalfa collection samples from the second slope gave a greater weight of hay compared to 2023, except for sample UJ700003. This alfalfa sample had a hay yield of 270 g/m² from the second slope in 2022, and 380 g/m² in 2023. Comparing hay yield by slopes, the result shows that in 2022, 11 collection samples on the second slope also had a higher yield. In 2023, all collection samples had a higher hay yield on the first slope.

The seed weight per plot in all alfalfa collection samples was higher in 2023, especially in samples that showed high results in green mass and hay yield on slopes.

Therefore, analyzing the data in Table 1, it is worth noting the feed and seed productivity of the collection samples of alfalfa *Medicago sativa* L. UJ070001 and UJ700003. The collection samples of bastard lucerne *Medicago varia* Martyn UJ700053, UJ700518, UJ700486 stand out significantly among all the samples.

Conclusions

The results of the study of the feed and seed productivity of collection samples of alfalfa *Medicago sativa* L. and bastard lucerne *Medicago varia* Martyn will be used to increase the productivity of natural meadows and pastures in Ukraine. Alfalfa is also advisable to use in field feed production, namely for the creation of cultivated pastures and hayfields and their restoration after the war. As a result of research in 2022–2023, the biological potential of collection samples of alfalfa was

determined. Collection samples of alfalfa were assessed for the yield of green mass, hay and seeds. For 2022–2023, the best collection samples of alfalfa UJ070001 and UJ700003 and bastard lucerne UJ700053, UJ700518, UJ700486 were selected for the yield of green mass and hay for two slopes and seeds.

Selected collection samples of alfalfa and bastard lucerne are recommended as starting material for analytical selection to improve the feed and seed productivity of this unique perennial legume.

Conflict of interest

The authors state that there is no conflict of interest.

References

1. Iermakova, L.M., Ivanovska, R. T., & Shevnikov, M. Ia. (2008). *Kormovyrobnytstvo*. Kyiv: Intas [in Ukrainian]
2. King James Version of the Bible. (n.d.). [dataset]. In *Religion Past and Present*. Brill. https://doi.org/10.1163/1877-5888_rpp_dum_11577
3. Bhandari, K. B., Rusch, H. L., & Heuschele, D. J. (2023). Alfalfa stem cell wall digestibility: Current knowledge and future research directions. *Agronomy*, 13 (12), 2875. https://doi.org/10.3390/agronomy13122875
4. Hryhoriev, V. I., Ohurtsov, Ye. M., Bobro, M. A., & Mikhieiev, V. H. (2021). *Kormovyrobnytstvo ta lukivnytstvo.* Kharkiv: KhNAU [in Ukrainian]
5. Antonets, O. A. (2007), Istorychne znachennia vprovadzhennia liutserny u vyrobnytstvo. *Pytannia Istorii Nauky i Tekhniky*, 3–4, 14–18. [in Ukrainian]
6. Hetman, N. Ia., Kvitko, M. H., & Tsyhanskyi, V. I. (2021). *Liutserna posivna*. Vinnytsia: TVORY [in Ukrainian]
7. Kulinich, O. M. (2005). Vnosymo azot z bobovymy. *Propozytsiia*, 5, 50. [in Ukrainian]
8. Latif, A., Sun, Y., & Noman, A. (2023). Herbaceous Alfalfa plant as a multipurpose crop and predominant forage specie in Pakistan. *Frontiers in Sustainable Food Systems*, 7. https://doi.org/10.3389/fsufs.2023.1126151
9. Tishchenko, A. V., Tishchenko, O. D., Kuts, G. M., Piliarska, O. O., Liuta, Yu. O., & Galchenko, N. M. (2021). Seed productivity of alfalfa in the first year of life, depending on pest control measures. *Agrarian Innovations*, 6, 69–81. https://doi.org/10.32848/agrar.innov.2021.6.12
10. Petrychenko, V., Getman, N., & Veklenko, Ju. (2020). Justification of productivity of lucerne in long-term use of grass biomass in the context of climate change. *Visnyk Agrarnoi Nauky*, 98 (3), 20–26. https://doi.org/10.31073/agrovisnyk202003-03
11. Hetman, N. Y., & Danyliuk, B. M. (2024). Scientific substantiation of the productivity of sowing alfalfa depending on soil and climatic conditions of the Forest-Steppe of Ukraine. *Naukovì Dopovìdì Nacìonal'nogo Unìversitetu Bìoresursiv ì Prirodokoristuvannâ Ukraïni*, 2024 (1/107). https://doi.org/10.31548/dopovidi.1(107).2024.003
12. Hetman, N., Burko, L., & Svystunova, I. (2023). Productivity of alfalfa in the system of organic production under the conditions of climate change. *Scientific Reports of the National University of Life and Environmental Sciences of Ukraine*, 19 (2). https://doi.org/10.31548/dopovidi2(102).2023.006
13. Telekalo, N. V., & Melnyk, M. V. (2020). Feed productivity of medic (Medicago sativa) depending on agroecological growing methods. *Agroecological Journal*, 2, 76–83. https://doi.org/10.33730/2077-4893.2.2020.207684
14. Appiah, E. A., Balla-Kovács, A., Ocwa, A., Csajbók, J., & Kutasy, E. (2024). Enhancing Alfalfa (*Medicago sativa* L.) Productivity: Exploring the Significance of Potassium Nutrition. *Agronomy*, 14 (8), 1806. https://doi.org/10.3390/agronomy14081806
15. Vozhehova, R. A., Tyshchenko, A. V., Tyshchenko, O. D., Fundyrat, K. S., & Konovalova, V. M. (2023). Adaptyvni oznaky ta yikh proiav u populiatsii liutserny druhoho roku za kormovoho vykorystannia. *Ahrarni Innovatsii*, 18, 143–155. https://doi.org/10.32848/agrar.innov.2023.18.20 [in Ukrainian]
16. Vozhehova, R. A., Tyshchenko, A. V., Tyshchenko, O. D., Piliarska, O. O., Fundyrat, K. S., & Konovalova, V. M. (2023). Posukhostiikist populiatsii liutserny druhoho roku za kormovoho vykorystannia. *Ahrarni Innovatsii*, 17, 25–36. https://doi.org/10.32848/agrar.innov.2023.17.4 [in Ukrainian]
17. Vasconcelos, E. S. de, Barioni Júnior, W., Cruz, C. D., Ferreira, R. D. P., Rassini, J. B., & Vilela, D. (2008). Seleção de genótipos de alfafa pela adaptabilidade e estabilidade Da produção de matéria seca. *Acta Scientiarum. Agronomy*, 30 (3). https://doi.org/10.4025/actasciagron.v30i3.3511
18. Latrach, L., Farissi, M., Mauradi, M., Makoudi, B., Bouizgaren, A., & Ghoulam, C. (2014). Growth and nodulation of alfalfa-rhizobia symbiosis under salinity: electrolyte leakage, stomatal conductance, and chlorophyll fluorescence. *Turkish Journal of Agriculture and Forestry*, 38, 320–326. https://doi.org/10.3906/tar-1305-52
19. Mykhalkiv, L. M., Kots, S. Ya., & Yakimchuk, R. A. (2008). The alfalfa productivity under conditions of insufficient water supply and treatment with plant growth regulators. *Agricultural Microbiology*, 7, 115–121. https://doi.org/10.35868/1997-3004.7.115-121
20. Buhaiov, V., Horenskyy, V., & Liatukienė, A. (2018). The response of Medicago sativa to aluminium toxicity under laboratory and field conditions. *Zemdirbyste-Agriculture*, 105 (2), 141–148. https://doi.org/10.13080/z-a.2018.105.018
21. Liatukienė, A., Skuodienė, R., Kemešytė, V., & Buhaiov, V. (2024). Crops of alfalfa genotypes in the soil with very low and very toxic concentrations of mobile aluminium. *Cogent Food & Agriculture*, 10 (1). https://doi.org/10.1080/23311932.2023.2294543
22. Tyshchenko, A. V. (2014). Nasinnieva produktyvnist liutserny zalezhno vid umov zvolozhennia ta zastosuvannia rehuliatora rostu Plantafol 30 u Pivdennomu stepu. *Tavriiskyi Naukovyi Visnyk*, 90, 102–107. [in Ukrainian]
23. Tkachyk, S. O. (Red.). (2017). *Metodyka provedennia ekspertyzy sortiv roslyn hrupy tekhnichnykh ta kormovykh na prydatnist do poshyrennia v Ukraini: 3-tie vydannia, vypravlene i dopovnene*. Vinnytsia: FOP Korzun D. Yu. [in Ukrainian]
24. Babych, A. O. (1996). *Kormovi i likarski roslyny v XX i XXI stolittiakh*. Kyiv: Ahrarna nauka [in Ukrainian]
25. Antoniv, S., Kolisnyk, S., & Zapruta, O. (2023). Alfalfa: history of the name origin, agroecological importance, basis for high-protein feed. *Feeds and Feed Production*, 96, 208–214. https://doi.org/10.31073/kormovyrobnytsvo202396-19

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