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Formation of stable soil-protective agrophytocenoses of essential oil plants in the conditions of the Southern Steppe of Ukraine

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Abstract. In the context of a significant environmental load on soil resources, the issue of restoring and maintaining the fertility of degraded and anthropogenically disturbed lands through phytoreclamation technology aimed at improving altered landscapes by creating a sustainable vegetation cover that can improve soil quality and restore its ecological functions is relevant. The aim of the study was to investigate the adaptive properties, growth and development processes, productivity formation and peculiarities of soil protection agrophytocenoses of English lavender and medicinal hyssop in anthropogenically transformed lands of the Southern Steppe of Ukraine. To achieve this goal, a field experiment was set up, phenological observations of plant development were carried out, and the peculiarities of the formation of soil-protective agrophytocenoses were studied. The survival rate of essential oil plants was high: English lavender – 89.7-92.5%, and medicinal hyssop – 85.9-90.5%. A high ability of lavender and hyssop to withstand adverse climatic conditions during wintering was found: during three years of cultivation, winter hardiness was 81.5-98.1%. Over the three years of vegetation, lavender plants formed shoots 50.7-51.3 cm high, the diameter of the bush was 62.4-89.6 cm, and the number of inflorescences was 594.9-650.3, which corresponds to their varietal characteristics. The highest yield of lavender plants was formed in the third year of vegetation – 5.29-5.84 t/ha at standard humidity. The maximum height of hyssop plants was reached in the third year of cultivation – 69.5-83.3 cm. The number of vegetative-generative shoots in the bush increased from the second year of vegetation, their number in the second year of cultivation was 54.5-67.1 pcs. and in the third year – 70.4-85.9 pcs. The highest yield of flower raw materials of hyssop was formed in the third year of cultivation – 10.94-12.43 t/ha. The highest rates of projective plant coverage were noted in the third year of cultivation: 75.2-83.7% in hyssop and 58.4-62.5% in English lavender, which allows to recommend the use of agrophytocoenoses of these essential oil plants for phytomelioration and reclamation of anthropogenically transformed territories in the Southern Steppe of Ukraine

Keywords: *Lavandula angustifolia* Mill.; *Hyssopus officinalis* L.; winter hardiness; performance; projective coating

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INTRODUCTION

In Ukraine, the priority tasks of the national environmental policy are the reclamation and rehabilitation of anthropogenically disturbed areas. Degraded soils, salt marshes, sloping lands, and technogenically contaminated areas are subject to restoration. The urgency of restoring agricultural land damaged by military operations has become particularly acute, particularly in the Southern region, where active hostilities took place and certain territories were occupied, and part of the Kherson region is still under occupation as of 2024. Researchers I. Bulba *et al*. (2024) found that the soils are currently contaminated with polutants, their structure is disturbed, erosion processes have intensified, and ammunition explosions have led to sinkholes, scrap metal accumulation, and heavy metal contamination.

Phytomelioration and reclamation are relevant ways to restore disturbed areas, which involve developing measures and carrying out comprehensive works to restore the productivity and aesthetic value of landscapes. The phytoremediation of such lands is aimed at improving anthropogenically altered landscapes by creating a sustainable vegetation cover that can improve soil quality. Phytomelioration plantations can have both practical (agrocenoses, forest plantations) and decorative purposes. Scientists A. Litalien & B. Zeeb (2020) consider the use of plants for soil restoration in the context of climate change. Since disturbed areas may contain polytunnels, it is not permissible to grow crops for human consumption. R. Dobrovolskyi *et al*. (2021) emphasise the expediency of using phytomeliorant soil consolidating plants, which include the perennial essential oil crops English lavender and medicinal hyssop, which are characterised by wide ecological plasticity. Agrophytocenoses from such crops can be economically profitable, as the demand for natural plant materials and essential oils is growing worldwide, and they can also be tourist attractions.

Lavandula angustifolia Mill. is a perennial evergreen shrub containing 1-3% of essential oils in its inflorescences. Lavender raw materials and essential oil are used in medicine, cosmetics, perfumery, and the food industry. Researchers K. Pokajewicz *et al*. (2021) and F. Radi *et al*. (2021) found that the main components of lavender essential oil are linalool (10-20%) and linalyl acetate (30-50%). The Southern Steppe zone of Ukraine with a temperate continental climate may be suitable for growing this crop due to its natural and climatic conditions. The study of N. Minev *et al*. (2022) and T. Manushkina *et al*. (2023) show that when applying optimal agrotechnological measures, lavender exhibits high adaptive properties, forms high-quality flower raw materials and is characterised by decorative qualities.

Hyssopus officinalis L. is grown as an essential oil and spice and flavour crop, used in medicine, canning and alcoholic beverage industries. F. Borrelli *et al*. (2019), V. Kumar *et al*. (2023) and G. Atazhanova *et al*. (2024) note that hyssop is characterised by medicinal properties, anti-inflammatory, astringent, tonic, wound healing, antioxidant and antimicrobial activity, as well as antifungal and antiviral properties in vitro. It is a perennial shrub, winter-hardy, a typical xerophyte, well adapted to drought, and undemanding to soil conditions. The positive results obtained in the work of P. Dobrovolskyi *et al*. (2021) indicate the prospects of research on hyssop cultivation in the Southern Steppe zone of Ukraine. However, the peculiarities of the formation of the productivity of English lavender and medicinal hyssop on depleted and degraded soils are still poorly understood. In this regard, it is relevant to determine the feasibility of using these species to create soil-protective agrophytocenoses on anthropogenically disturbed soils for their phytomelioration.

The aim of the research was to study the adaptive capabilities, peculiarities of growth, development, productivity formation and creation of soil-protective agrophytocenoses of English lavender and medicinal hyssop in the soil conditions of the Southern Steppe of Ukraine. The goal was achieved by solving the following tasks: to study the survival rate of plants and winter hardiness of English lavender and medicinal hyssop; to investigate the peculiarities of plant growth and development during three years of cultivation; to determine the yield of flower raw materials and the projected coverage of anthropogenically disturbed lands with plants in the Southern Steppe of Ukraine.

MATERIALS AND METHODS

The material for the research was English lavender *L. angustifolia* Mill. varieties Hemus and Imperial Gem and medicinal hyssop *H. officinalis* L. varieties Natsionalnyi and Markiz. The study was conducted in 2020-2023 on the basis of the farm Agrolife in Vitovskyi district of Mykolaiv region, a branch of the Department of Agriculture, Geodesy and Land Management of Mykolaiv National Agrarian University. The experimental plot of 0.45 hectares was an anthropogenically disturbed landscape due to the accumulation of construction waste and desolation. The soil of the experimental plot is Southern chernozem. The humus content in the topsoil is 2.75%, and the reaction of the soil solution is neutral (pH 6.6-6.8). The density of the topsoil is 1.12-1.20 g/cm^3, with a moisture content of 25.1-28.3%. In terms of the content of available forms of nutrients, the soil was characterised by low nitrogen availability, medium mobile phosphorus availability, and high exchangeable potassium availability. No excess of heavy metals, radionuclides, or pesticides was detected in the soil. Meteorological conditions during the growing season of the research were characterised by high temperatures and moisture deficit. In addition, the unfavourable conditions included late spring and early autumn frosts, which significantly affected the duration of the growing season. In general, the natural climatic conditions of this zone are suitable for growing essential oil crops.

The field experiment was conducted in a randomised design. During the research, phenological, biometric and laboratory methods were used according to generally accepted methods (Ushkarenko *et al.*, 2016). A survey of the disturbed area was carried out at the experimental site to determine its suitability for plant cultivation and application of $N_{60}P_{60}K_{60}$ mineral fertiliser. The seedlings were planted in October 2020. The planting scheme for lavender plants was 1.2 × 0.5 m, and for hyssop plants – 0.75 × 0.5 m. Plant care included loosening row spacing, weed control, and drip irrigation. Soil moisture in the 30-40 cm layer was maintained at 90-80-70% of the lowest moisture capacity, and irrigation was stopped 14 days before harvesting the flower raw materials. Harvesting was carried out at the stage of technical ripeness, when the presence of 50% of flowers in the ear was noted. The gross harvest was calculated by weighing raw materials from the entire plot. The yield per hectare was converted to a standard moisture content of 70%. The mass fraction of moisture in the plant material was determined using the thermostat-weight method. The authors followed the recommendations of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (1979) and the Convention on Biological Diversity (1992). Mathematical processing of the research results was carried out using descriptive statistics and analysis of variance in MS Excel.

RESULTS AND DISCUSSION

Formation of agrophytocenosis *L. angustifolia* Mill. The survival rate of lavender plants of the Hemus variety was 92.5%, and of the Imperial Gem variety – 89.7%. In the areas where the seedlings did not take root, they were replanted, as it is necessary to form an optimal plant density from the first year of life, as plantation repairs are usually ineffective in the future, and the empty spaces left behind create favourable conditions for weeds to grow. The autumn and winter periods during the years of research were favourable for the growth and overwintering of lavender plants. The winter hardiness of plants was determined in the spring during the spring regrowth phase as the percentage of plants that did not die during the winter (Fig. 1; Table 1). Adaptation of plants to low temperatures is a complex physiological process that includes morphological and biochemical changes. First of all, adaptation is manifested in the adaptation of plant ontogeny to seasonal temperature conditions. The analysis of the data obtained shows that the winter hardiness of lavender plants was quite high – 82.7-98.1%. There was no significant difference in winter hardiness between the studied varieties. The obtained results allow to conclude that English lavender has high adaptive capabilities to negative environmental factors of the winter period in the research area.

***Figure 1.** English lavender plants in the first year of cultivation, 2021*
***Source:** authors' photo*

***Table 1.** Winter hardiness of English lavender plants depending on the year of cultivation, 2021-2023*

Variety	Year of cultivation	Winter hardiness, % of viable plants
Hemus	First	90.5
	Second	92.3
	Third	98.1
Imperial Gem	First	82.7
	Second	95.0
	Third	96.5

***Source:** authors' development*

English lavender is a perennial evergreen semi-bushy plant that forms a spherical bush 35-60 cm high. The results of determining the biometric parameters of English lavender are shown in Table 2.

Table 2. *Biometric parameters of English lavender plants, 2021-2023*

Variety	Year of cultivation	Bush height, cm	Bush diameter, cm	Number of inflorescences, pcs./bush
Hemus	First	31.0 ± 2.7	51.3 ± 4.8	81.2 ± 9.1
	Second	37.1 ± 2.3	73.4 ± 6.8	334.8 ± 37.0
	Third	50.7 ± 3.7	89.6 ± 9.4	650.3 ± 20.0
Imperial Gem	First	38.9 ± 4.0	44.7 ± 5.3	53.7 ± 8.8
	Second	45.3 ± 4.7	50.1 ± 5.3	297.3 ± 32.3
	Third	51.3 ± 1.4	62.4 ± 6.8	594.9 ± 30.3

Source: *authors' development*

The greatest increase in shoot height was observed in the first year of vegetation. The height of the shoots of the seedlings was 15.0 cm, so the growth in the first year in the studied varieties was 16.0-23.9 cm. During the second year of vegetation, the increase in bush height was 6.1-6.4 cm, and in the third year – 6.0-13.6 cm. The total increase in bush height during the cultivation period was 35.7-36.3 cm. Comparing the varieties with each other, it can be concluded that in the first two years of vegetation, the plants of Imperial Gem variety were taller than Hemus variety, and in the third year of vegetation, according to this parameter, the varieties did not differ significantly from each other, their height was 50.7-51.3 cm, which corresponds to their varietal characteristics.

Indicators of bush diameter for all years of research were significantly higher in the variety Hemus. The increase in the diameter of the bush in this variety in the second year of vegetation was 22.1 cm, and in the third year – 16.2 cm. In the Imperial Gem variety, the increase in the studied indicator was 5.4 cm in the second year of vegetation, and 12.3 cm in the third year. The diameter of the bush of Hemus variety compared to Imperial Gem variety was larger: in the first year of vegetation – by 6.6 cm (the difference is insignificant), in the second and third years of vegetation – by 23.3 cm and 16.2 cm, respectively, which is a significant difference between the varieties and is due to their genetic characteristics.

The analysis of the dynamics of the number of inflorescences in lavender plants showed that in the first year of vegetation 53.7-81.2 inflorescences per bush were formed, which is 9.0-12.5% of the number of inflorescences formed in the third year of vegetation. During the second year of vegetation, 4.1-5.5 times more inflorescences were formed compared to the first year, and compared to the third year, their number was 49.9-51.5%. When comparing the studied varieties, it was found that in all years of cultivation the number of inflorescences in the variety Hemus was significantly higher compared to the variety Imperial Gem. Thus, the largest number of inflorescences was formed in the third year of cultivation. The parameters of the yield structure of English lavender were determined during three years of cultivation (Table 3).

Table 3. *Crop structure parameters of English lavender, 2021-2023*

Variety	Year of cultivation	Inflorescence length, cm	Number of rings per inflorescence, pcs.	Number of flowers per half-ring, pcs.
Hemus	First	2.9 ± 0.3	4.3 ± 0.3	3.8 ± 0.4
	Second	4.1 ± 0.2	5.1 ± 0.5	4.7 ± 0.5
	Third	5.5 ± 0.5	6.4 ± 0.8	5.2 ± 0.1
Imperial Gem	First	3.9 ± 0.4	3.5 ± 0.4	2.9 ± 0.3
	Second	5.1 ± 0.7	4.2 ± 0.2	4.0 ± 0.1
	Third	6.8 ± 0.7	5.2 ± 0.1	6.4 ± 0.8

Source: *authors' development*

The parameters of the yield structure of lavender plants increased with increasing age of plants and in the third year of cultivation were as follows: inflorescence length 5.5-6.8 cm, number of rings in the inflorescence 5.2-6.4 pcs, number of flowers in the semi-ring 5.2-6.4 pcs. Differences between varieties in terms of yield structure were also found. In the third year of cultivation, the Imperial Gem variety formed inflorescences of the longest length – 6.8 cm and the number of flowers in a semi-ring – 6.4 pcs; the Hemus variety had the largest number of rings in an inflorescence – 6.4 pcs. The lavender inflorescences were harvested in such a way that the length of the spikelet with the cut shoot was no more than 18 cm. Weighing and determination of the yield and moisture content of the raw materials were immediately carried out and the yield at standard moisture content was recalculated. The results are shown in Table 4.

Table 4. *Yield of English lavender, 2021-2023*

Variety	Year of cultivation	Yields, t/ha at standard moisture content	Increase by the first year, t/ha
Hemus	First	0.78	-
	Second	3.04	2.26
	Third	5.84	5.06
Imperial Gem	First	0.67	-
	Second	2.75	2.08
	Third	5.29	4.62
LSD_{05}	by variety factor	0.41	-
	by year of cultivation factor	1.87	-
	by the interaction of factors	2.07	-

Source: *authors' development*

Based on the results of studying the parameters of lavender productivity in the first year of vegetation, it can be concluded that the yield of Hemus and Imperial Gem varieties did not differ significantly and was low. In the second year of vegetation, this trend continued. The highest yield of lavender plants was formed in the third year of vegetation, and the yield of Hemus variety was significantly higher than that of Imperial Gem. In the first year of vegetation, the yield of plants was 12.7-13.4% of the yield in the third year, and in the second year – 52.0%.

Formation of agrophytocenosis *H. officinalis* L. The survival rate of medicinal hyssop plants in variety Natsionalnyi was 90.5%, variety Markiz – 85.9%. Winter hardiness in all years of the research was quite high, in the first year – 81.5-83.7%, and increased in the second and third years – 87.1-96.4%, which indicates high adaptive properties of the crop to a complex of adverse winter conditions (Table 5). Based on the study of the dynamics of growth processes of medicinal hyssop during three years of vegetation, it was found that the maximum plant height was reached in the third year of cultivation (69.5-83.3 cm), while the minimum plant height was recorded in the first year – 30.0-41.5 cm. The number of vegetative-generative shoots in the bush increased from the second year of life. In the second year, their average number was 54.5-67.1, and in the third year – 70.4-85.9 (Table 6; Fig. 2).

Table 5. *Winter hardiness of medicinal hyssop plants depending on the year of cultivation, 2021-2023*

Variety	Year of cultivation	Winter hardiness, % of viable plants
Natsionalnyi	First	81.5
	Second	87.1
	Third	96.4
Markiz	First	83.7
	Second	91.5
	Third	95.0

Source: *authors' development*

Table 6. *Biometric parameters of medicinal hyssop plants, 2021-2023*

Variety	Year of cultivation	Bush height, cm	Bush diameter, cm	Number of inflorescences, pcs./bush
Natsionalnyi	First	30.0 ± 2.5	18.6 ± 1.7	37.1 ± 3.1
	Second	49.1 ± 4.3	28.9 ± 3.0	54.5 ± 5.0
	Third	69.5 ± 7.0	39.7 ± 3.7	70.4 ± 6.7
Markiz	First	41.5 ± 4.0	24.3 ± 2.3	41.5 ± 3.8
	Second	58.2 ± 5.7	33.8 ± 3.3	67.1 ± 5.3
	Third	83.3 ± 7.4	42.1 ± 6.8	85.9 ± 7.3

Source: *authors' development*

Figure 2. *Hyssop plants of the first year of life, 2021*
Source: *authors' photo*

As a result of the research, it was found that the yield of medicinal hyssop flower raw materials increased from the first to the third years of cultivation (Table 7). The highest yield of hyssop flower raw materials was formed in the third year of cultivation 10.94-12.43 t/ha, with the yield of the Markiz variety being significantly higher than that of the Natsionalnyi variety – by 13.6%. In the first year of vegetation, the yield of plants was 21.5-28.4% of the yield in the third year, and in the second year – 61.0-66.7%.

Thus, in the conditions of the Southern Steppe of Ukraine, the success and prospects of growing medicinal hyssop (*Hyssopus officinalis*) varieties Natsionalnyi and Markiz were evaluated. These varieties were characterised by high seedling survival and winter hardiness. The maximum biometric parameters of plants were formed in the third year of life.

Soil-protective properties of agrophytocenoses *L. angustifolia* Mill. and *H. officinalis* L. These crops are perennial plants capable of growing on stony, unproductive soils, and have anti-erosion properties due to their powerful root system and long life span. To determine the soil protection properties, the indicators of the projected coverage of the area by lavender and hyssop plants were determined (Table 8; Fig. 3-4).

Table 7. *The yield of medicinal hyssop, 2021-2023*

Variety	Year of cultivation	Yields, t/ha at standard moisture content	Growth by the first year, t/ha
Nationalnyi	First	2.35	-
	Second	6.68	4.33
	Third	10.94	8.59
Markiz	First	3.53	-
	Second	8.30	4.77
	Third	12.43	8.90
LSD_{05}	by variety factor	0.53	-
	by year of cultivation factor	1.93	-
	by the interaction of factors	2.24	-

Source: *authors' development*

Table 8. *Projected area coverage with essential oil plants*

Year of cultivation	*L. angustifolia* Mill.		*H. officinalis* L.	
	Variety Hemus	Variety Imperial Gem	Variety Nationalnyi	Variety Markiz
First	37.2	41.2	42.4	45.7
Second	47.8	52.1	63.8	69.0
Third	58.4	62.5	75.2	83.7

Source: *authors' development*

Figure 3. *Phytocoenosis of English lavender in the third year of cultivation, 2023*
Source: *authors' photo*

Figure 4. *Phytocoenosis of medicinal hyssop in the third year of cultivation, 2023*
Source: *authors' photo*

Based on the results obtained, it was found that the biometric parameters of plants increased from the first to the third years of cultivation, and thus the soil-protective properties of phytocenoses increased. The highest indicators of projected plant cover were formed in the third year of cultivation of medicinal hyssop and reached 75.2-83.7%, the density of bushes and the degree of overgrowth of disturbed areas were high, the bushes closed together, forming a dense plant cover. In English lavender, the projected cover in the third year of cultivation was slightly lower compared to hyssop – 62.5-58.4%, which is due to the planting scheme, as the experimental plot after reclamation is planned to be used not only for the collection of plant materials, but also for ecological tourism and photo shoots, for which the formation of clearly defined rows of plants is important.

For research on the formation of sustainable soil-protective agrophytocenoses on anthropogenically transformed lands, English lavender have been chosen as a valuable essential oil crop that can grow and produce stable yields on low-productive soils and can be used for phytoremediation, essential oil production, agritourism, and medicinal hyssop, which has been shown to be able to produce valuable plant material in a wasteland abandoned territory. The analysis of the adaptive properties of essential oil plants in the natural and climatic conditions of the Southern Steppe of Ukraine showed a high survival rate of 89.7-92.5% for lavender plants, 85.9-90.5% for hyssop, and 81.5-98.1% for winter hardiness. R. Kremenchuk & O. Kytaiev (2017) also found a high ability of lavender to withstand low temperatures. Of the eight lavender varieties studied, not a single plant died under the influence of low temperatures. Frost-resistant varieties were identified, with core damage not exceeding 2.5 points when grown in the Forest-Steppe of Ukraine, which is characterised by lower winter temperatures than in the Steppe zone. S. Küçük *et al.* (2018) successfully cultivated English lavender in four provinces of Turkey, which indicates the wide ecological plasticity of this species. B. Kiprovski *et al.* (2023) determined that the climatic conditions of Central and Northern Serbia did not affect the quality of lavender, which shows the possibility of cultivating it in different zones.

Studies within the framework of the tested method of phytomelioration on anthropogenically transformed lands of the Southern Steppe of Ukraine showed the yield of lavender flower mass in the third year of cultivation at the level of 5.29-5.84 t/ha. Such data can be compared with the previously obtained results for lavender cultivation on agricultural plots. In the work of O. Markovska *et al.* (2020), the yield was 5.0 t/ha, and in the work of T. Manushkina *et al.* (2023) – 5.45-6.45 t/ha. The dependence of yield on the variety was established, which in the Third Year of cultivation in the Hemus variety was 9.4% higher compared to the Imperial Gem variety. The results of research by E. Détár *et al.* (2020) and S. Demasi *et al.* (2021) also confirmed that, based on intraspecific variability, it is necessary to take into account the specific requirements and characteristics of lavender varieties to optimise their cultivation and use.

Along with a sufficiently high productivity on the anthropogenically transformed plot, lavender plants formed an agrophytocenosis with a projective cover of 58.4-62.5% already in the third year of cultivation, which allows to characterise it as soil-protective. Taking into account the morphological and biological characteristics of lavender (Lis-Balchin, 2002), the area of projective cover will increase in the following years of vegetation, which will contribute to phytomelioration. L. Mykhalska *et al*. (2018) also showed that English lavender plants can be used as a crop for phytoremediation due to its ability to accumulate significant amounts of metals from the soil. At the same time, lavender essential oil contains residual amounts of metals, the content of which was below the detection level (DL) of ICPMS Agilent 7700x. I. Crișan *et al*. (2023) note that *L. angustifolia* Mill. remains one of the most valuable essential oil plant species, the area under which can be expanded without competing for productive land, instead using marginal, contaminated or unproductive land. B. Kiprovski *et al*. (2023) emphasise that lavender cultivation would be an innovative approach to further increase the income of smallholder farmers and primary producers in a time of climate change, while K.L. Adam (2018) points to the growing popularity of lavender agritourism and lavender value-added products.

The cultivation of medicinal hyssop on an anthropogenically transformed site allowed the plants to form a yield of 10.94-12.43 t/ha and a phytocoenosis with a projected cover of 75.2-83.7% in the third year of vegetation. Such yields are 22.4-36.6% higher than those obtained in the studies of P. Dobrovolskyi *et al*. (2021), which indicates the high adaptive capacity of hyssop when grown in the soil and climatic conditions of the Southern Steppe of Ukraine. S. Kizil *et al*. (2016) concluded that hyssop can be successfully grown in the semi-arid climatic conditions of Southern Turkey. G. Duschanova *et al*. (2022) also determined the structural and adaptive characteristics of *H. officinalis* L. based on a comparative analysis of anatomical features in vegetative organs and showed that the species fully passes all stages of development in Tashkent and Jizzakh (Uzbekistan), which also confirms the adaptation of plants to hot and arid climates, which is relevant in the context of climate change for the Steppe zone of Ukraine. S. Sorokina & N. Hnatiuk (2017) found that the soil of the rhizosphere and row spacing accumulates kolinium during the growing season, the content of which depends on environmental factors and the excretory function of plants. Researchers have shown that at the beginning of plant development and in the budding phase, there are practically no phytotoxic substances, and in the flowering phase, on the contrary, there is an increase in the content of inhibitory compounds. This fact should be taken into account when growing subsequent crops after phytomelioration of anthropogenically altered soils.

Essential oil crops are in the focus of research due to their growing economic importance and market demand is expected to continue to increase. At the same time, perennial essential oil plants of the *Lamiaceae* Lindl. family have soil protection and reclamation value, and can be grown without competing for productive soils, and can be used on marginal lands. In addition, the cultivation of drought-resistant essential oil crops will contribute to the expansion of agricultural biodiversity and further diversification of agriculture in the face of climate change.

CONCLUSIONS

On the basis of the conducted scientific research, the adaptive properties and processes of growth, development, formation of productivity of lavender and medicinal hyssop were studied, and soil-protective agrophytocenoses were created in the conditions of anthropogenically transformed lands of the Southern Steppe of Ukraine. High indicators of adaptive capacity of lavender and hyssop plants were revealed. The survival rate of lavender was 89.7-92.5%, and that of hyssop – 85.9-90.5%. Winter hardiness during the three years of cultivation was 81.5-98.1%. During the three years of vegetation, lavender plants formed bushes with a diameter of 62.4-89.6 cm, shoots with a height of 50.7-51.3 cm, the number of inflorescences 594.9-650.3 pcs, which corresponds to their varietal characteristics. The largest parameters of the lavender yield structure were formed in the third year of vegetation: inflorescence length 5.5-6.8 cm, number of rings in the inflorescence 5.2-6.4 pcs, number of flowers in the half-ring 5.2-6.4 pcs. These parameters provided the highest yield: in the Hemus variety it was 5.29 t/ha, in the Imperial Gem variety – 5.84 t/ha at standard humidity. In the first year of vegetation, the yield was 12.7-13.4%, in the second year – 52.0% of the yield in the third year. Hyssop plants reached a maximum height of 69.5-83.3 cm in the third year of cultivation. The number of vegetative-generative shoots in the bush increased from the second year of life, when the number was 54.5-67.1 pcs. and in the third year increased to 70.4-85.9 pcs. The highest yield of hyssop flower raw materials was formed in the Third year of cultivation (10.94-12.43 t/ha), with the yield of Markiz variety being significantly higher than that of Natsionalnyi variety – by 13.6%. In the first year of vegetation, the yield was 21.5-28.4% of the yield in the third year, and in the second year – 61.0-66.7%. Essential oil plants formed an agrophytocenosis with sufficiently high projective coverage in the third year of cultivation: 75.2-83.7% in medicinal hyssop, 62.5-58.4% in English lavender, which allows the use of these essential oil plants for phytomelioration of anthropogenically transformed areas in the Southern Steppe of Ukraine. Prospects for further research are to study the growth, development, productivity of plants and the quality of raw materials during the next years of vegetation and to determine the ability to phytoremediation.

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CONFLICT OF INTEREST

None.

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Формування стійких ґрунтозахисних агрофітоценозів ефіроолійних рослин в умовах Південного Степу України

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Анотація. В умовах значного екологічного навантаження на ґрунтові ресурси актуальним є питання відновлення та підтримки родючості деградованих і антропогенно порушених земель за рахунок технології фітомеліорації, що спрямована на покращення змінених ландшафтів шляхом створення стійкого рослинного покриву, який може поліпшувати якісні характеристики ґрунту та відновлювати його екологічні функції. Мета дослідження – вивчити адаптаційні властивості, процеси росту і розвитку, формування продуктивності та особливості створення ґрунтозахисних агрофітоценозів лаванди вузьколистої та гісопу лікарського в умовах антропогенно трансформованих земель Південного Степу України. Для досягнення цієї мети було закладено польовий дослід, здійснено фенологічні спостереження за розвитком рослин та вивчено особливості формування грунтозахисних агрофітоценозів. Приживлюваність ефіроолійних рослин була високою: лаванди вузьколистої – 89,7-92,5 %, гісопу лікарського – 85,9-90,5 %. Виявлено високу здатність лаванди та гісопу протистояти несприятливим кліматичним умовам під час перезимівлі: упродовж трьох років культивування зимостійкість становила 81,5-98,1 %. За три роки вегетації рослини лаванди сформували пагони висотою 50,7-51,3 см, діаметр куща становив 62,4-89,6 см, кількість суцвіть – 594,9-650,3 шт., що відповідає їх сортовим характеристикам. Найбільша врожайність рослин лаванди сформувалася на третьому році вегетації – 5,29-5,84 т/га при стандартній вологості. Максимальної висоти рослини гісопу досягали на третій рік вирощування – 69,5-83,3 см. Кількість вегетативно-генеративних пагонів у кущі зростала починаючи з другого року вегетації, їх кількість на другий рік вирощування становила 54,5-67,1 шт., а на третій – 70,4-85,9 шт. Найбільша урожайність квіткової сировини гісопу формувалася на третій рік культивування – 10,94-12,43 т/га. Найвищі показники проєктивного покриття рослин відмічено у третій рік вирощування: у гісопу – 75,2-83,7 %, у лаванди вузьколистої – 58,4-62,5 %, що дозволяє рекомендувати використовувати агрофітоценози цих ефіроолійних рослин для фітомеліорації та рекультивації антропогенно трансформованих територій в умовах Південного Степу України

Ключові слова: *Lavandula angustifolia* Mill.; *Hyssopus officinalis* L.; зимостійкіть; продуктивність; проєктивне покриття