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COMPARATIVE CHARACTERISTICS OF SELECTED SAMPLES OF *Hyssopus officinalis* L. BY BIOMORPHOLOGICAL INDICATORS IN THE CONDITIONS OF THE SOUTHERN STEPPE OF UKRAINE

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Abstract

Hyssopus officinalis L has recently attracted particular attention as a valuable raw material for pharmaceuticals. To identify the biomorphological features of Hyssopus officinalis L., a field experiment was initiated in 2020 in the Kherson region, Ukraine. Samples of Hyssopus officinalis L of the local ecotype No. 108 were selected for the research. It was noted that seedlings in the flowering phase differ in terms of the timing of the beginning of flowering and flower colour. Plants of Sample 1-20 (pink-flowered) bloom first. After 3-4 days, the beginning of flowering is noted in sample 3-20 (blue-flowered), and after another 2 days, Sample 2-20 (white-flowered) begins to bloom. The height of first year plants ranged from 50 to 60 cm. The diameter of the bushes varied from 20 to 35 cm. The central shoot consisted of 17 to 38 first-order shoots. The largest size of the inflorescence of the first and second order shoots is in sample 3-20. Sample 2-20 has slightly higher average values of the length of the inflorescence of the first order shoots than in Sample 1-20.

Key words*: Hyssopus officinalis L., essential oil plants, biomorphological indicators, introduction, medicinal plants.*

INTRODUCTION

Due to climate change, significant damage and irreversible losses are observed in natural ecosystems. The acute situation in food security is becoming increasingly unstable for various reasons, such as the increase in the incidence of natural disasters, military conflicts between countries, economic crises, global epidemiological diseases, etc. (Chaika et al., 2021; Habibullah et al., 2022; Muluneh et al., 2021).

The increase in average temperatures and the uneven distribution of precipitation caused by global climate change may lead to a significant transformation of the majority of climatic and agricultural zones of Ukraine (Chaika et al., 2021). It is known that the most noticeable consequence of climate change will not be so much gradual warming, but an increase in the number and intensity of extreme weather events: droughts, floods, and the number of extremely hot days in summer (Habibullah et al., 2022; Muluneh et al., 2021).

This situation requires agricultural producers to introduce more drought-resistant plant species, among which essential oil crops occupy a special place.

Essential oil crops are mostly resistant to soil and air drought compared to other traditional agricultural crops for the region.

These plants are valuable raw materials for many industries. Natural essential oils are in demand on the domestic and international markets, as they have high antimicrobial activity (Vlase et al., 2014; Tahir et al., 2018). Many types of essential oil crops are used as non-food industrial products, pharmaceuticals, phytoproducts, cosmetics, plant protection products, etc. (Rabotyagov et al., 2003; Fathiazad et al., 2011; Hussein et al., 2015; Atazhanova et al., 2024).

One of the many species of essential oil plants, the products of which are widely used in the national economy, is *Hyssopus officinalis* L. (Stan et al., 2019; Tkachova et al., 2022).

H. officinalis L. is a valuable essential oil plant, a typical xerophyte, which is well adapted to drought and unpretentious in cultivation (Kovalenko et al., 2019; Dobrovolskyi et al., 2021).

H. officinalis L. (Family: *Lamiaceae* alt. *Labiatae*) is a perennial herbaceous, semievergreen shrub or subshrub and has a well-developed woody and twiggy taproot that penetrates to a depth of 2-2.5 m. *H. officinalis* L.

is native to Mediterranean and Western Europe and Central Asia (Chrysargyris et al., 2022; Preedy, 2015; Zawiślak, 2013). It is cultivated as a medicinal, ornamental, and aromatic plant in Ukraine, Moldova, Central Asia, and other countries (Druțu et al., 2014; Jangi et al., 2022; Lubbe et al., 2011; Riabchun et al., 2019).

The tops of stems up to 20 cm long, collected during flowering, are used. The yield of dry raw materials is 18-20%. The herb contains essential oil (0.6-2.0%) with a peculiar strong turpentine-camphor odour, tannins and bitter substances, resins, dyes, triterpenic acids, glycoside issopine, flavonoids (0.9-1.0%) pigments, vitamin C, macroelements K, Ca, Mg, Fe, microelements Mn, Cu, Zn, Co, Mo, Se, Ba (Ghanbari-Odivi et al., 2024; Mohammadi et al., 2020; Naderi et al., 2023).

H. officinalis L. is one of the most important pharmaceutical herbs widely cultivated in Romania. Romanian scientists studying the antioxidant and antimicrobial activity of *H. officinalis* L., note that it is a typical xerophyte and well adapted to drought and low humidity conditions. Their results confirm that *H. officinalis* L. can be considered a potential source of polyphenols with antioxidant and antimicrobial properties and emphasize further research on this crop with the aim of growing and preparing high-value natural pharmaceutical products (Aqeel et al., 2023).

According to literature data, 40% ethanol extract of *H. officinalis* L. grown in the conditions of Polissya (Ukraine) had high biological activity against *Escherichia coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Candida albicans*, which are pathogenic against other organisms (Kotiuk et al., 2015).

Scientists have found that *H. officinalis* L. essential oil has high antioxidant, antifungal and fungicidal effects (Zawiślak, 2013; Vlase et al., 2014; Tahir et al., 2018).

H. officinalis L. is a valuable honey plant. The honey belongs to the best varieties. This plant has a long flowering period and can be used to close non-harvesting periods during the beekeeping season (Fathiazad et al., 2011; Riabchun et al., 2019; Tkachova et al., 2022).

Despite the significant importance of this plant for various sectors of the national economy, its cultivation has not yet reached significant scales. Currently, scientists from different countries are constantly improving the *H. officinalis* L. growing technology by optimizing individual technological measures and studying their impact on product quality (Gholamreza et al., 2015; Amini et al., 2019; Kovalenko et al., 2019; Naderi et al., 2023).

Today, the production of raw materials for essential oil crops, in particular, *H. officinalis* L., does not fully meet the needs of consumers of essential oil products in Ukraine.

To introduce a particular crop into production, it is first necessary to study its biological characteristics in a given region. Therefore, scientists introduce plant species, select promising samples and on this basis create varieties that would be promising for cultivation in new conditions (Riabchun et al., 2019; Svyrydovskyi et al., 2024).

MATERIALS AND METHODS

The research was conducted in the Kherson region on the basis of the State Enterprise Research Farm "Novokakhovske" of the Institute of Climate Smart Agriculture of NAAS of Ukraine, in 2020-2022.

The soil and climatic conditions of the Kherson region contribute to the cultivation of introduced essential oil and aromatic plants, especially those species that are suitable for cultivation in conditions of insufficient soil moisture and air humidity in southern Ukraine (Dobrovolskyi et al., 2021; Kovalenko et al., 2019; Svyrydovskyi et al., 2024). The experimental site is located in the first, northern agroclimatic region of the Kherson region, which is characterized by a temperate continental climate with a short spring, and relatively long hot and dry summer, and a mild winter with frequent thaws. The sum of temperatures above 10°C is 3200-3300°C, the amount of precipitation during this period is 215-220 mm, the annual amount of precipitation is 380-430 mm, and the hydrothermal coefficient is 0.7. The average duration of the period with positive temperatures is 175-180 days, the vegetation period is 215-225 days. Spring frosts stop mostly in the third decade of April. The average time of the onset of autumn frosts is the second decade of October, occasionally at the end of September. The Kherson region is characterized by annual droughts, 40% of which are very intense.

The plot where the experiments were carried out was located on chernozem light loamy soils with a humus layer thickness of 76 cm and a humus content in the arable layer of 1.33%.

The material for the research was samples of *Hyssopus officinalis* L., selected from seeds of the local ecotype №108. Ecological and phenological observations and biometric measurements were carried out on the plants according to generally accepted methods (Kyienko et al., 2015; Kyienko et al., 2016). All measurements were carried out for the mass flowering phase.

RESULTS AND DISCUSSIONS

It is well known that *H. officinalis* L. is well propagated by seeds, lignified and green cuttings and division of the shrub. In early spring (first decade of April) we sowed seeds of *H. officinalis* L. ecotype No. 108 (seeds of local reproduction).

We received shoots after 12 days. At first, the plants grew slowly, but after 45-50 days the growth noticeably accelerated and in the first decade of August, the plants of the first year of development began to bloom. The maximum growth of plants was observed in the budding phase and in the phase of the beginning of flowering.

It was noted that seedlings in the flowering phase had differences in terms of flowering onset and flower color. Samples with white, pink, and purple flower colors were selected (Figures 1, 2).

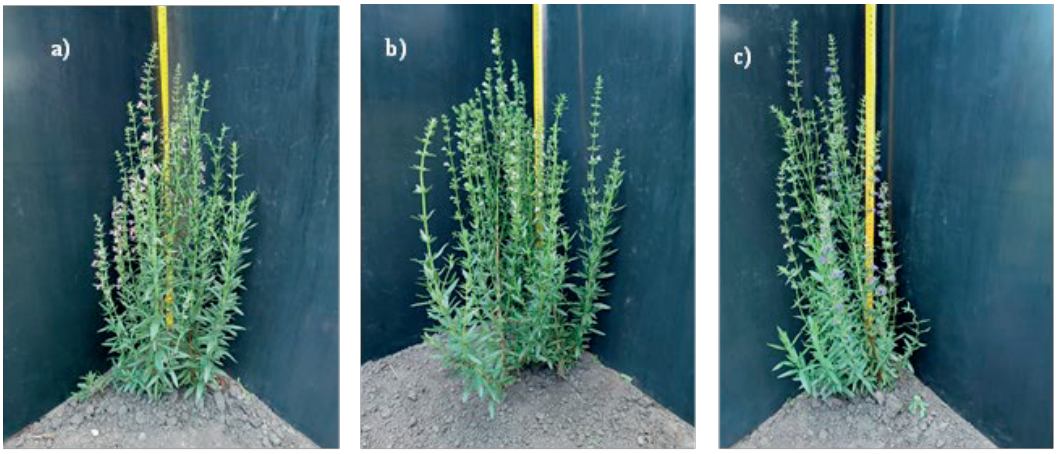

Figure 1. Selected samples of *Hyssopus officinalis* L. (plants of the first year of development in the phase of the beginning of flowering): a - Sample 1-20 (pink-flowered form); b - Sample 2-20 (white-flowered form); c - Sample 3-20 (blue-flowered form)

Figure 2. Inflorescence coloration of *Hyssopus officinalis* L. samples: 1-20 (pink-flowered form); 2-20 (white-flowered form); 3-20 (blue-flowered form)

The plants of Sample 1-20 (pink-flowered) bloomed first. After 3-4 days, the beginning of flowering was noted for Sample 3-20 (blue-flowered), and after another 2 days for Sample 2-20 (white-flowered). In addition to the diverse color of flowers, the selected samples also had differences in the growth habit (Table 1).

The first-year development plants reached 50-60 cm tall a height of 56-60 cm. At the same time, the plants of Sample 3-20 (blue-flowered form) reached the greatest height (60 cm) and were per 1.67% higher than the plants of Sample 2-20 (white-flowered form) and per 6.67% higher than Sample 1-20 (pink-flowered form).

The diameter of these plants varied from 20 to 35 cm. The largest plant diameter was achieved by the plants of Sample 2-20 (white-flowered form). The plant diameter of Sample 3-20 (blue-flowered form) was per 6.25% smaller, and the plant diameter of Sample 1-20 (pink-flowered form) was per 25.00% smaller than the plant diameter of Sample 2-20 (white-flowered form). That is, the plants of Sample 1-20 on the first year of development formed a smaller growth habit. The first-year development plants of Sample 2-20 (white-flowered form) and Sample 3-20 (blue-flowered form) had insignificant differences in the growth habit.

Table 1. Habit of the bushes and characteristics of vegetative-generative shoots of *Hyssopus officinalis* L.

Indicators	Sample 1-20 (pink-flowered form)			Sample 2-20 (white-flowered form)			Sample 3-20 (blue-flowered form)		
	Year of development								
	I	II	III	I	II	III	I	II	III
Plant height, cm	56	75	80	59	78	85	60	79	87
Plant diameter, cm	24	85	88	32	95	98	30	90	95
Number of first-order shoots	13	85	96	14	105	123	13	94	115
Number of second-order shoots	6	170	220	8	220	240	8	251	260
Length of first-order shoots, cm	19	72	79	28	77	77	32	79	82
Length of second-order shoots, cm	12	25	30	17	27	35	24	36	45

In addition to the growth habit, the plants of the selected samples of *H. officinalis* L. on the first year of development had differences in the number and length of the first and second order shoots. Despite the fact that the plants formed almost the same number (13-14) of the first-order shoots on the central shoot, their length differed depending on the biological characteristics of the samples. Thus, the greatest length of the first-order shoots (32 cm) on the first year of development was formed by plants of the Sample 3-20 (blue-flowered form). The length of the first-order shoots of Sample 2-20 (white-flowered form) was per 12.50% less, and for Sample 1-20 (pink-flowered form) it was per 40.63% less than the similar indicator of Sample 2-20 (white-flowered form).

H. officinalis L. plants on the first year of development had 6-8 second-order shoots, which also differed in length depending on the biological characteristics of the samples. Thus, the plants of Sample 3-20 (blue-flowered form) had the greatest length (24 cm) of the second-order shoots. The plants of Sample 2-20 (white-

flowered form) had the length of the second-order shoots per 29.17% less, and plants of Sample 1-20 (pink-flowered form) had the length of the second-order shoots per 50.00% less than the similar indicator of Sample 2-20 (white-flowered form).

The vegetation of *H. officinalis* L. plants on second year of development begins in second or third decade of March. The beginning of budding was observed in first half of June. The beginning of flowering was in late June.

Due to the presence of numerous lateral shoots of the first and second order, the plants of selected samples on second year of development took on the appearance of a sprawling bush, the height of which varied, on average, from 75 to 79 cm, and their diameter varied, on average from 85 to 95 cm. The number of first-order shoots varied from 85 to 105 pieces. The number of the second-order shoots had significantly increased, which ranged from 170 to 251 shoots (Table 1).

At the same time, the smallest plant sizes (height – 75 cm, diameter – 85 cm) were in exemplaries of Sample 1-20 (pink-flowered form). Plants of this sample also formed the smallest number of the first-order shoots (85 pcs.) and second-order shoots (170 pcs.). The length of shoots of both first and second order of this sample was also the smallest in the experiment equal to 72 and 25 cm, respectively.

Plants of Sample 3-20 (blue-flowered form) formed the greatest height (79 cm), and had the greatest number of second-order shoots (251 pcs) with the greatest length (36 cm). The length of the first-order shoots in plants of this sample was also the greatest in the experiment and was 79 cm. Plants of Sample 2-20 (white-flowered form) were per 1.27% lower than plants of Sample 3-20 (blue-flowered form), but at the same time they had a 5.27% larger diameter due to a 10.41% larger number of first-order shoots.

There were also changes in the size of the hyssop plants on the third year of development. Compared to the second-year plants, the height of the plants and the number of shoots increased. In the third year of development, the plants were 80-87 cm high and had diameter of 88-98 cm. The number of second-order shoots varied from 220 to 260 shoots (Table 1).

Mass flowering of the plants on second and third years of development lasted from the second decade of July to the first decade of August. Flowering began from the central peduncle, then the lateral peduncles bloomed. The flowering end was on the third decade of August – the first decade of September. The total duration of flowering was two months.

According to literature data, the leaves and inflorescences of *H. officinalis* L. are the most important organs, because they accumulate the largest amount of biologically active substances (Fathiazad et al., 2011; Atazhanova et al., 2024). During the growing season of *H. officinalis* L., there was a gradual increase in the number of leaves due to the elongation of shoots.

The size of the leaves can be evaluated by the measurement results (Table 2).

The largest indicators of the length (3.7 cm) and width (0.9 cm) of the leaf blade were in Sample 3-20 (blue-flowered form). Plants of Sample 1-20 (pink-flowered form) had the smallest values of the length (3.5 cm) of the leaf blade.

Table 2. Morphometric characteristics of leaves and inflorescences of *Hyssopus officinalis* L. samples on the second year of development

Indicators	Sample 1-20 (pink-flowered form)	Sample 2-20 (white-flowered form)	Sample 3-20 (blue-flowered form)
Leaf length, cm	3.5	3.6	3.7
Leaf width, cm	0.9	0.8	0.9
Length of the first-order shoot inflorescence, cm	28	29	30
Length of the second-order shoot inflorescence, cm	23	22	24
Number of rings of the first-order shoot inflorescence, pcs	17	18	17
Number of rings of the second-order shoot inflorescence, pcs	15	16	16
Number of flowers in a semi-ring of the first-order shoot inflorescence, pcs.	10,5	10	9
Number of flowers in a semi-ring of the second-order shoot inflorescence, pcs.	9	9	8

The studied samples differed not only in leaf size, but also in the length of the inflorescence of the first and second order shoots (Table 2).

The largest inflorescences of the first -order shoots (30 cm) and second-order shoots (24 cm) had Sample 3-20. Sample 2-20 had slightly higher average values of the length of the first-order shoots inflorescence than Sample 1-20. On the contrary, the inflorescence length of the second-order shoots was higher in Sample 1-20. It was noted that the selected samples of *H. officinalis* L. differed in the number of whorls in the inflorescence and flowers in the semi-whorls in the shoots of the first and second orders.

The same number of whorls of the first-order shoots was recorded on samples 1-20 and 3-20. The smallest number (8) of flowers in the semi-whorl in the shoots of the first and second orders was noted on Sample 3-20 (blue-flowered form).

CONCLUSIONS

The samples selected from seed generation of *H. officinalis* L. (biotype № 108) had differences in biomorphological indicators (plant size, number and length of shoots, inflorescence color) and timing of phenological phases of development.

Sample 1-20 had early flowering and pink flower color. The most height of the plant and blue flower color were characteristic of Sample 3-20. The maximum plant diameter, white flower color and the latest flowering date were characteristic of Sample 2-20. Sample 2-20 had the largest number of first-order shoots, and Sample 3-20 has the largest number of second-order shoots. Differences between samples of *H. officinalis* L. were also in the size of the leaf and inflorescence. The maximum indicators of leaf length and inflorescence length were recorded in Sample 3-20.

The plants developed well and can be successfully grown in the agroclimatic conditions of the Southern Steppe of Ukraine, which will allow to satisfy the country's needs in the corresponding medicinal raw materials and contribute to the preservation of the region's biodiversity.

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