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FEATURES OF GROWTH AND DEVELOPMENT OF *Hyssopus officinalis* L. IN THE CONDITIONS OF THE SOUTHERN STEPPE OF UKRAINE

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Abstract

Each year, the pharmaceutical industry`s demand for high-quality medicinal raw materials increases, leading to the need for the cultivation of the most commonly used medicinal plants. According to statistics, over 40% of all drugs, including 75% of medicines, are produced from medicinal plants. In the southern regions of Ukraine, the cultivation of stress-resistant crops with high productivity and enhanced quality characteristics of raw materials is essential, especially those that can thrive under high temperatures and low relative humidity conditions. Medicinal and essential oil crops could be suitable for this region. Hyssop (Hyssopus officinalis L.) is a non-traditional plant from the Lamiaceae family, which has been cultivated in Ukraine over the past decade. The article presents the results of phenological observations and biological growth and development characteristics of Hyssopus officinalis L. under introduction conditions. The growth dynamics of the plants are studied, and three developmental stages are considered: the latent stage, the vegetative stage, and the generative stage. The obtained results can be used in breeding work and in providing practical recommendations for the cultivation and propagation of hyssop.

Key words*: introduction, Hyssopus officinalis L., medicinal hyssop, ontogenesis periods, phenological observations.*

INTRODUCTION

In the face of global climate change, a critical task worldwide is the enrichment and preservation of plant biodiversity. Enriching biological diversity of plants and expanding the assortment of valuable plants can be achieved through the introduction and cultivation of new, non-traditionally grown species.

Many plants of the *Lamiaceae* Martynov family are valuable for their aromatic, essential oil, medicinal, vitamin, and decorative properties. One of the most common species in the *Hyssopus* L. genus of the *Lamiaceae* Martynov family is *Hyssopus officinalis* L. Its native region is the Mediterranean and Western Europe (Druțu et al., 2014). It is cultivated for medicinal, decorative, and aromatic purposes (Kovalenko & Andriychenko, 2018; 2019; Kovalenko, 2022; Dobrovolskyi, 2021; Dumitru et al., 2020). It is used in medicine in various countries.

The herb of *Hyssopus* is included as an official raw material in the pharmacopeias of France, Portugal, Romania, Sweden, and Germany. In Indian medicine, the herb is used for asthma, coughs, as a digestive and digestive aid. Bulgarian medicine recommends an infusion of the herb for chronic bronchitis, intestinal catarrh, and as an antiseptic. Locally, hyssop decoctions are used for eye rinses, gargles for stomatitis, for soothing hoarseness, as compresses for bruises and as a wound-healing agent (Rabotyagov et al., 2003). Hyssop essential oil has antimicrobial properties and is used for purulent skin infections of staphylococcal origin (Svidenko and Derevjanko, 2005; Svidenko, 2005). Additionally, the plant is used as a culinary raw material for the production of fish products, pickling cucumbers and tomatoes, as well as in the preparation of meat and vegetable soups, sauces, stews, roasts, salads (Nair, 2022). Hyssop essential oil and extracts are used in winemaking, canning, and the perfume-cosmetic industry (Wesolowska et al., 2010; Judžentienė, 2016; Kazazi, et al., 2007). *Hyssop officinalis* L. is a valuable honey plant, and the honey produced from it is of high quality.

The widespread use of *Hyssopus officinalis* L. in medicine, essential oil, and the food industry necessitates the expansion of its cultivation areas (Kizil et al., 2016; Salachna, 2023; Stan et

al., 2019). The success of its introduction largely depends on a comprehensive study of the process, which thoroughly characterizes the individual development of the plant during specific calendar periods, known as the ontogenesis of the plant. In this study, we investigated the age periods and stages that *H. officinalis* undergoes under the conditions of introduction.

MATERIALS AND METHODS

The study utilized seed populations of *Hyssopus officinalis* L., specifically the 'Nikit'sky Bily' variety. Research on the growth and development characteristics of hyssop was conducted in the conditions of the South Steppe. Ecological and phenological observations were carried out on the plants, along with biometric measurements using commonly accepted methodologies. The study examined three developmental stages: the latent stage, the vegetative stage, and the generative stage. Based on these stages, the annual growth cycle was divided into four phenophases with corresponding subphases: the vegetative phase, the budding phase, the flowering phase (initiation of flowering, full flowering, wilting), and the fruiting phase (initiation of fruit formation, initiation of seed setting, seed setting).

RESULTS AND DISCUSSIONS

In the cultivation of *Hyssopus officinalis* in the South Steppe conditions, the plants typically reach a height of 70-80 cm and a bush diameter of 100-130 cm. The stems are four-angled and become woody at the base. Each shrub may have up to 100 flowering shoots. The leaves are sessile, linear-lanceolate, opposite, and entire. The leaf blade is pubescent on both sides, measuring 3.0-3.5 cm in length and 0.7-0.9 cm in width. Essential oil glands on the upper and lower leaf plate are clearly visible (Figure 1, a) The small flowers are clustered in false whorls in the leaf axils and form spike-type inflorescences at the upper part of the stem (Figure 1, b and c). The flower corolla (7.5-10.5 mm in length) is usually blue-violet, but there are also white and pink-colored forms. The calyx is tubular-bell-shaped with five pointed teeth.

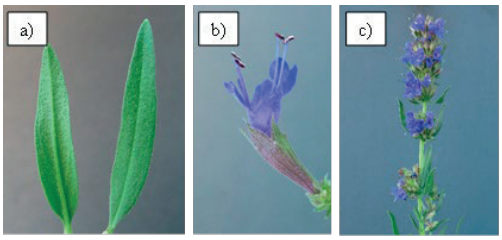

Figure 1. Morphological features of organs of *Hyssopus officinalis* L.: a - leaf plate (lower and upper part); b - flower; c - inflorescence

Hyssopus officinalis plants can be propagated through seeds, woody and green cuttings, or by dividing the shrub. Seed propagation is commonly preferred.

In the context of our study on the introduction of *H. officinalis*, we identified three age periods of ontogenesis: the latent period, vegetative, and generative. Within these, we distinguished six age states of the species: seeds, seedlings, juvenile, immature, vegetative, and generative.

Latent Period. This period spans from the moment the seeds fully mature until they germinate. It typically lasts for a minimum of 8-9 months. The seeds have an elongated-ovate shape, ranging from dark brown to black, with three angles, and are approximately 2.5-3.0 mm long and 1.0-1.2 mm wide (Figure 2, a-c). Along the seed, the seed scar is well visible. On average, the weight of 1000 seeds is 0.96 g. At a temperature of 20°C, the seeds begin to germinate on the 3rd to 4th day. Laboratory germination rates range from 90-95%. Seed germination decreases after three years.

Vegetative Period. This period starts with the emergence of seedlings and ends with the formation and development of generative shoots. During this time, the seedlings undergo several morphological changes and eventually resemble adult plants. This period is divided into multiple age states.

Seedlings. During the germination process, the cotyledons swell, and the embryo increases in size. Initially, the root appears, followed by round cotyledonal leaves (Figure 2, b and c). On experimental plots where seeds are sown in the spring (first to second decade of April) at a depth of 1.0-1.5 cm, seedlings emerge after 14 days (in dry spring years, it might take up to 20-25 days). Field seedling similarity is 75%.

Juvenile state. The appearance of the first true leaf corresponds to the beginning of the juvenile age state. At this stage, juvenile plants still retain their cotyledonal leaves. The first pair of true leaves appears in seedlings after 5-7 days, approximately 18-20 days from sowing. They are elongated-ovate and dark green in color, measuring 1.3-1.5 cm in height, with a root length of 1.7-1.9 cm. The stem is rounded in cross-section and has an anthocyanin coloration. During the third decade of growth, the second pair of true leaves emerges (Figure 2, h). At this point, the plants reach a height of 4.0-4.3 cm, and the root length increases to 2.3-2.8 cm. The first pair of true leaves measures 1.7-2.0 cm in length and 0.7-0.8 cm in width. The leaves are pubescent, especially on the lower side, and the essential oil glands are visible to the naked eye on the leaf blade. Towards the end of the third decade in May, the third pair of true leaves appears, followed by the fourth pair within 5-6 days. After the emergence of the third pair of true leaves, the plant's growth accelerates.

In the leaf axils of the central (main) shoot, the formation of first-order lateral shoots begins (Figure 2, e). At this stage, the seedlings reach a height of 8.0-8.5 cm. In the bushing phase (first decade of July), the plants reach heights of 15-20 cm with a bush diameter of 10-15 cm. In the leaf axils of the central shoot, starting from the 3rd-4th pair and above, first-order lateral shoots develop, ranging from 2 to 5 cm in length, which, in turn, give rise to second-order shoots.

Immature state. The beginning of the immature age state is characterized by the withering of cotyledonal leaves, the development of leaves resembling those of adult individuals, and intensive root system growth. One significant change in leaf shape becomes more prominent in immature individuals. Unlike juvenile elongated-ovate leaves, immature individuals have lanceolate leaf blades.

Vegetative state. This stage is characterized by significant height growth and the accumulation of reserve plastic substances necessary for plants to transition into flowering and fruiting. There is an intensive development of lateral shoots, and the base of the shoots becomes four-angled. Within a decade, the plants reach a height of 35 cm and a bush diameter of 27 cm. Vegetative plants have significantly larger organ sizes. In the first year of development, a shrub is formed with a main shoot, 8-13 pairs of first-order shoots, and 26-32 pairs of second-order shoots.er.

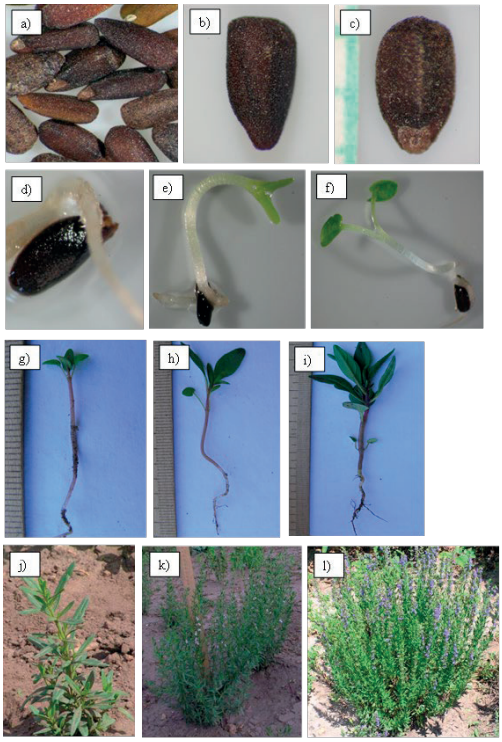

Figure 2. Seedling development:

a…c - latent period (seeds); d…j - virginal period: d - root germination, e…f - appearance of cotyledon leaves, g…i - juvenile plants, j - immature plants; k…l - generative period: j…k - budding, the beginning of flowering in a seedling of the first year of life, *F. rosea*, l - mass flowering in a seedling of the second year of life, *F. coeruleus*

Generative period. In the first year of the plant's life, it forms inflorescences. Both lateral and central shoots become generative with a closed type of development. In young generative individuals, the phase of budding begins at the end of the second decade of July. The beginning of flowering is observed at the end of the first decade of August. Mass flowering of the experimental plants in their first year is noted at the end of the second and the beginning of the third decade of August.

During the mass flowering phase, first-year plants reach a height of 55 cm and a shrub diameter of 51 cm. Seedlings grown from seeds have a well-developed root system, and the

bushes branch well. During the spring and summer, they require good care, including soil loosening and watering in hot months.

The vegetative recovery of plants in the second year begins in the third decade of March. The budding phase begins in the second to third decade of June. The phase of initial flowering occurs in the first decade, and mass flowering begins in the second decade of July. The phase of initial flowering in forms with white flowers usually occurs 3-4 days earlier. Flowering begins with the central (main) inflorescence and then the lateral ones bloom.

The end of the flowering phase occurs in the third decade of August, with a total flowering duration of two months. During this time, the stems become woody in the middle and lower parts. The seeds ripen in September, and they are easily shed. The plants dry up in November. The average duration of the vegetative period is 195 days.

When studying the growth dynamics of hyssop, it was established that the maximum growth of plants is observed during the budding phase and the beginning of flowering. After that, plant growth almost stops (Figure 3).

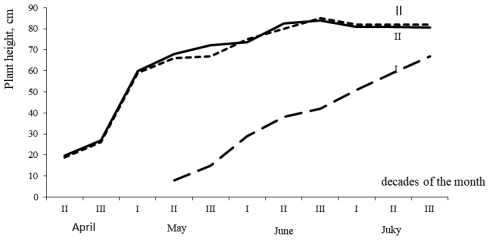

Figure 3. Dynamics of growth and development of *H. officinalis* in the conditions of the Kherson region:

I - plants of the first year of life; II - plants of the second year of life; III - plants of the third year of life

CONCLUSIONS

We have examined three age periods of *H. officinalis* (latent, vegetative, generative), each of which consists of distinct age stages. At the initial stages, seedlings undergo a series of morphological changes associated with plant height and biomass accumulation. The maximum plant growth occurs at the beginning of the generative period during the budding and early flowering phase. Additionally, we have found that in the conditions of introduction, the plants go through all the phenological development phases and produce viable seeds. During the first year of their life, *H. officinalis* seedlings have a single branching shoot that flower and bears fruit. Starting from the second year of life, the number of vegetative and generative shoots in the bush increases. The obtained results can be utilized in breeding work and in providing practical recommendations for cultivation and propagation.

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