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DETERMINATION OF THE DEPENDENCE OF ECONOMICALLY VALUABLE INDICATORS OF MOLDAVIAN DRAGONHEAD ON GROWING CONDITIONS

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Abstract

The study highlights the results of research into the phases of growth and development of the Moldavian dragonhead (Dracocephalum moldavica) depending on the timing of sowing and moisture conditions. The research was conducted in the agro-ecological conditions of the Central Forest-Steppe of Ukraine. The emergence of seedlings was noted on the 6th - 7th day, depending on the time of sowing. After 20 days from the beginning of the appearance of seedlings, the tillering phase was noted in plants of the first sowing period, and in the case of the second sowing period, after 28 days. In the phase of mass flowering, the height of plants reached 90-95 cm with indicators of above-ground mass of 200-240 g per plant. The mass fraction of essential oil in experiments in the phase of mass flowering varied from 0.08% to 0.16%. The yield of essential oil was the highest during the first sowing period with moderate moisture. Based on the results of the obtained values, a model of economically valuable indicators of the Moldavian dragonhead was built.

***Key words**: dracocephalum moldavica; sowing time; aboveground mass; fraction of essential oil; model of economically valuable indicators.*

INTRODUCTION

The importance of essential oils and medicinal plants as sources of biologically active substances is growing. The increasing demand for these substances can be met by expanding the raw material base of medicinal and essential oil plants through the search for and inclusion of new crops and potential areas for their cultivation. The successful introduction of promising plant species into cultivation is only possible if their developmental biology is understood, the processes of formation and accumulation of essential oil are studied, and the features of their cultivation and productivity are investigated to determine the feasibility of industrial cultivation (Ovechko, 2003).

One of the valuable and promising essential oil crops is *Dracocephalum moldavica* L. The native habitat of *Dracocephalum moldavica* is considered to be Southern Siberia and China, although it grows wild in Central Asia and Eastern Europe. This plant is cultivated in European and Asian countries both as an essential oil crop and as a valuable honey plant (Kotiuk, 2013; Boiko, 2023). *Dracocephalum moldavica* is an annual herbaceous plant of the Lamiaceae Martynov family. The root is thin and taprooted. The stem is upright, four-angled, and branched. The leaves are short-petioled, opposite, oblong-ovate or oblong-lanceolate, serrated at the edges, and dark green. Large essential oil glands are located on the underside of the leaf blade. The flowers are pale purple or white, collected in racemose inflorescences (Kotiuk, 2013).

The herb *Dracocephalum moldavica* is commonly consumed both as a food product and as a medicinal preparation due to its known therapeutic properties (Dastmalchi et al., 2007). The plant material of *Dracocephalum moldavica* contains essential oil, flavonoids, phenols, phenylpropanoids, lignans, terpenoids, vitamins, lipids, proteins, sugars, tannins, macro- and microelements, and other chemical components (Meng et al., 2024). Plants of this species have significant antioxidant and antimicrobial effects (Simea et al., 2023). It is used for medicinal purposes as an anti-inflammatory and sedative remedy, for treating colds, headaches, joint pain, neuralgia, rheumatism, tachycardia, hypertension, and insomnia (Yang et al., 2014). The above-ground part of *Dracocephalum moldavica* is used in the confectionery industry, for the production of absinthe, vermouth, kvass, compote, flavoring tea and vinegar, and as a seasoning for meat, fish, and vegetable dishes (Svidenko et al., 2018). *Dracocephalum moldavica* is a valuable honey and fodder plant (Shtakal, 2023). It has been shown that extracts of *D. moldavica* act as an effective and biologically safe insect repellent for food storage (Hussein et al., 2015).

The essential oil of *Dracocephalum moldavica* is used in the food industry, pharmaceuticals, perfumery, and cosmetology (Kotiuk, 2021). The widespread use of *Dracocephalum moldavica* herb necessitates the study of its agrobiological fundamentals for cultivation in the potential zones of Ukraine. One of the challenges of adapting plants to local agroclimatic conditions is determining the optimal levels of heat and moisture (Moiseyenko, 2019). The plant is resistant to low temperatures and prefers moisture (Kotiuk & Rakhmetov, 2017). Climate and agrotechnical measures during cultivation have a significant impact on the height of *Dracocephalum moldavica* plants and the size of the above-ground biomass (Moldovan et al., 2022). Due to climate change, particularly global warming and the unusual lack of rainfall, there has been a decline in biological and economically valuable indicators in agricultural crops (Khaleghnezhad et al., 2021). This has led to the necessity of artificial irrigation, even in regions where it was previously solely dependent on natural sources. Scientific literature provides data on the positive impact of irrigation on the yield of essential oil from plants, as observed in other regions of Ukraine and other essential oil crops (Kovalenko & Stebliichenko, 2020).

The aim of our work is to study the growth and development phases, as well as the formation of economically valuable traits of *Dracocephalum moldavica*, depending on the sowing dates and moisture conditions.

MATERIALS AND METHODS

The research was conducted in 2024 under the conditions of the Central Forest-Steppe of Ukraine, in the Lysyansky district of the Cherkasy region. The district is located on the Dnieper Upland of the Eastern European Plain, within the basin of the Hnylyi Tykich River. The soil at the study site is typical chernozem. According to its granulometric composition, the soil is heavy loam. The humus content in the plow layer is 4.58%. The material used for the research was a sample of *Dracocephalum moldavica*, variety "Yuvileinyi". The seeds of this sample were sown in two terms, with a row spacing of 50 cm. The first sowing was carried out in the third decade of April. Ten days later, the second sowing was carried out in the first decade of May. Irrigation of the crops was performed in three variants: intensive drip irrigation, moderate drip irrigation, and natural moisture.

Phenological observations were carried out on the crops according to established methods (Tkachyk, 2015; Tkachyk, 2016). The following phases were recorded: seedling emergence, tillering, bud formation, flowering (beginning, mass, end), and seed-setting (beginning, mass, end). Biometric measurements were taken every two weeks throughout the plant's growing season. Plant height and diameter were measured. During the plant's growing season, the aboveground biomass of the plant material was determined every two weeks. The mass fraction of essential oil in the plant material was determined according to the plant development phases using the Ginsberg method on a Clevenger apparatus and was calculated on a dry weight basis (Rabotyagov & Svidenko, 2010). Essential oil distillation was carried out 4-5 days after irrigation.

RESULTS AND DISCUSSIONS

Dracocephalum moldavica reproduces by seed. Under laboratory conditions, the seeds begin to germinate on the third day, and by the seventh day, the germination rate reaches 95%.

Under field conditions, during the first sowing (third decade of April), seedling emergence was recorded on the 6th day in both irrigation variants (intensive and moderate) and in the non-irrigated variant. This can be explained by the fact that during this period, the soil contained sufficient moisture for normal seed germination. During the second sowing (first decade of May), in the intensive and moderate irrigation variants, seedlings began to emerge on the 6th day, while in the non-irrigated variant emergence occurred on the 7th day. This difference is due to the reduced soil moisture reserves, which led to a lower seed germination rate in the non-irrigated variant.

The plants (seedlings) of *Dracocephalum moldavica* initially grew slowly. After 20 days from the emergence of the seedlings, the tillering phase was observed in the plants of the first sowing date. In the case of the second sowing date, the tillering phase was observed 28 days after the emergence of the seedlings. The onset of the bud formation phase was observed 44 days (in the first decade of July) after the beginning of the previous phase in the plants of the first sowing date. In the plants of the second sowing date, the onset of bud formation occurred earlier, after 34 days. The duration of the interphase period between bud formation and the beginning of flowering in the plants of the second sowing date was also shorter by 7 days. The beginning of flowering for both sowing dates was recorded in the second decade of July. The plants of the first sowing date flowered simultaneously across all watering treatments. The phase of end of flowering–beginning/start of seed-setting occurred at the beginning of the second decade of August. In the plants of the second sowing date, the duration of the developmental phases was 7-8 days shorter compared to those of the first sowing date.

Studying the dynamics of growth and development in *Dracocephalum moldavica*, we determine that the plants initially grew very slowly for both sowing dates. A noticeable acceleration in plant growth occurred during the tillering phase. In this phase, the height of the plants for the first sowing date ranged from 10 to 16 cm, with a diameter ranging from 9.5 to 11 cm. The above-ground biomass of a single plant ranged from 1.5 to 8 g. After two weeks, the height of the plants ranged from 26 to 50 cm, with a diameter ranging from 20 to 50 cm.

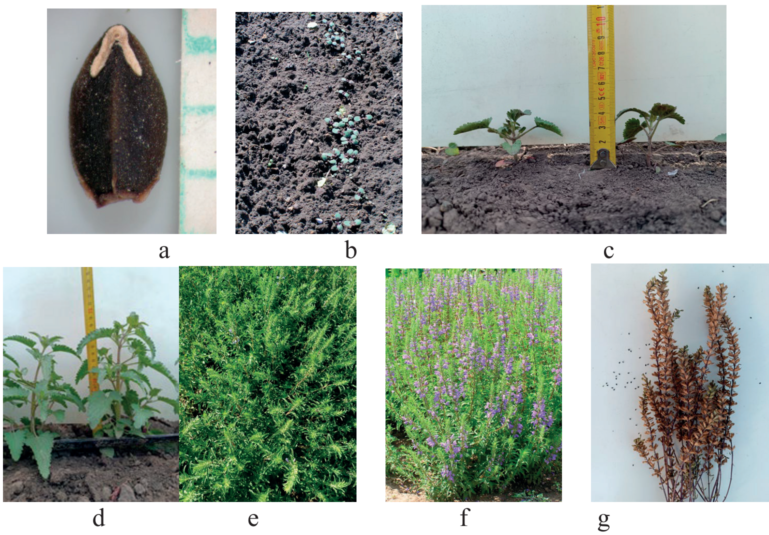

Figure 1. Development stages of *Dracocephalum moldavica*: a - seed; b - seedling emergence; c - seedling (two true leaves stage); d - tillering (formation of lateral shoots); e - budding; f - flowering; g - seed-setting

The above-ground biomass also increased, ranging from 22 to 138 g. In the bud formation–early flowering phase, the height of the plants ranged from 69 to 95 cm, with a diameter ranging from 44 to 56 cm. The above-ground biomass ranged from 55.3 to 197 g. The plant height further increased in the mass flowering phase, ranging from 75 to 95 cm, with a diameter ranging from 50 to 80 cm. In this phase, the above-ground biomass ranged from 140 to 240 g per bush. For the first sowing date, under both intensive and moderate watering conditions, the plants exhibited nearly identical measurements for plant height and above-ground biomass.

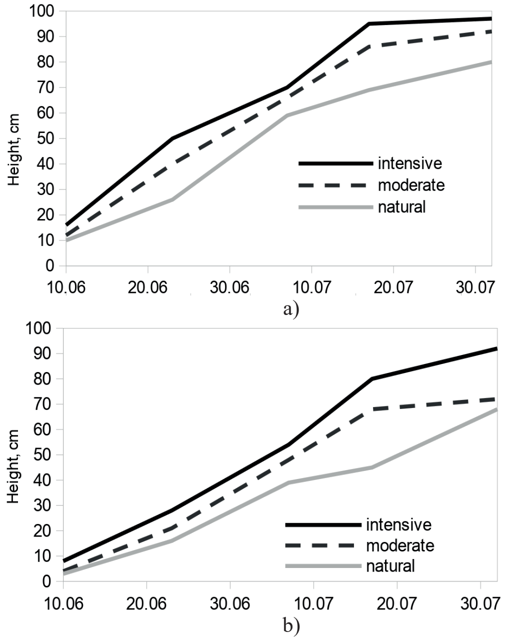

Figure 2. Growth dynamics of *Dracocephalum moldavica* plants under different irrigation variants: a - first sowing (third decade of April), b - second sowing (first decade of May)

During the development of the plants for the second sowing date, a gradual increase in both height and diameter of the plants was observed, continuing until the mass flowering phase. In the mass flowering phase, the plants for the second sowing date had a height ranging from 65 to 90 cm, with a diameter ranging from 35 to 55 cm. The above-ground biomass ranged from 60 to 200 g per bush. The highest values for the second sowing date were observed in plants that received intensive soil irrigation. The lowest values for above-ground biomass were found in plants that grew without irrigation. In these plants, during the mass flowering phase, a noticeable decrease in leaf turgor was observed, indicating insufficient soil moisture.

We conducted a study on the dynamics of essential oil accumulation across the developmental phases of *Dracocephalum moldavica* plants, depending on the intensity of drip irrigation and natural moisture (no irrigation). According to our findings, throughout the growing season, the essential oil content in the plant material gradually increased, reaching its peak during the mass flowering phase in all experimental variants.

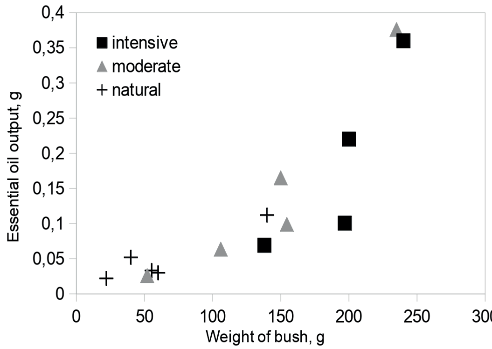

Figure 3. Comparison of wet mass of single bush and essential oil output per bush under diffferent irrigation conditions during growth of plants

We conducted a study on the dynamics of essential oil accumulation across the developmental phases of *Dracocephalum moldavica* plants, depending on the intensity of drip irrigation and natural moisture (no irrigation). According to our findings, throughout the growing season, the essential oil content in the plant material gradually increased, reaching its peak during the mass flowering phase in all experimental variants.

Considering all experimental variants, the mass fraction of essential oil in plants during the mass flowering phase ranged from 0.08% to 0.16%. The highest mass fraction of essential oil in the current year was obtained in plants from the first sowing date under the moderate irrigation variant. In contrast, plants with intensive irrigation, both for the first and second sowing dates, exhibited less mass fraction values of essential oil.

The total essential oil yield per plant (productivity) was highest for the first sowing date with moderate moisture, amounting to 0.38 g. This can be explained by the fact that plants from the first sowing date with moderate moisture exhibited high aboveground biomass and average essential oil content, which together contributed to higher plant productivity.

Based on one year of observations, an essential oil output can be described by simple equation:

$$Oil = e^{1.118 \cdot ln(W) - 7,699}$$

where: *Oil* - output of essential oil, gramm; *W* - weight of single bush, gramm.

Described model is suited for full valuable range of plant grows stages and have $R^2 = 0.79$ with p-value of coeficients on level less than 0.001. It should be noted that the described model are primitive and take into account only data by single year. In the future it is planned to take into account various plant growth factors, which will allow for a full assessment of the dynamics of bush growth along with the yield of essential oil.

CONCLUSIONS

We investigated the dynamics of growth and development, as well as the formation of economically valuable traits in *Dracocephalum moldavica* plants under the conditions of the Central Forest-Steppe of Ukraine, with two sowing dates and three irrigation treatments: intensive drip irrigation, moderate drip irrigation, and natural moisture (no irrigation). The greatest height and diameter were observed in plants under the first sowing date and intensive drip irrigation. The smallest height was recorded in plants under the second sowing date and natural moisture (no irrigation). The maximum aboveground biomass values were obtained for the first sowing date with intensive irrigation, while the minimum values were noted for the second sowing date with moderate moisture. The highest essential oil content per plant in production ready plant development stages was found in plants from the first sowing date under moderate irrigation, while the lowest was observed for plants from the second sowing date with intensive drip irrigation. Collected data give an opportunity to build models of economically valuable indicators of *Dracocephalum moldavica* and spread its cultivation in the Central Forest-Steppe of Ukraine.

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