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IMPACT OF IRRIGATION AND CULTIVAR TRAITS ON MORPHO-BIOLOGICAL PARAMETERS OF *MONARDA FISTULOSA* L.

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Goal *was to determine the dependencies of the duration of phenological developmental stages and the formation of morphometric and quantitative parameters on the irrigation method and cultivar characteristics of Monarda fistulosa L. during the first year of growth in the Central Forest-Steppe of Ukraine.*

Methods. *M. fistulosa L. cultivars 'Premiera' and 'Fortuna' were studied. Field, laboratory, and measurement-weight research methods were employed. Statistical analysis of the results was performed using Agrostat software.*

Results. *Under natural moisture conditions, the flowering period lasted 29 days for 'Premiera' and 30 days for 'Fortuna', whereas under irrigation, it extended to 38 days for 'Premiera' and 46 days for 'Fortuna'. Depending on the irrigation method, plant height ranged from 68 cm to 80.5 cm for 'Premiera' and from 74.7 cm to 85 cm for 'Fortuna'. Plant diameter varied from 56.20 cm to 70.20 cm for 'Premiera' and from 61.30 cm to 76.80 cm for 'Fortuna'. The irrigation method also influenced the number and length of primary and secondary shoots, as well as the number of inflorescences. It was established that 'Premiera' developed 5.0-7.5 primary shoots (58-69 cm long) and 34.8-53.8 secondary shoots (23.4-27.6 cm long). Plants of this cultivar produced 37.0-59.5 inflorescences. 'Fortuna' plants developed 8.7-9.3 primary shoots (62-73 cm long) and 46-62.5 secondary shoots (23-31.7 cm long), which enabled the formation of 42.7-74.3 inflorescences.*

Conclusions. *The irrigation method had a profound impact on the duration of the flowering stage in M. fistulosa. Under natural moisture, the flowering period lasted 29–30 days, while under irrigation, it reached 38-46 days (depending on the cultivar). Irrigation positively affected the morphometric and quantitative parameters of the plants. The highest values were observed in wild bergamot plants receiving drip irrigation. The use of irrigation resulted in a height increase of 15.53% for 'Premiera' and 12.12% for 'Fortuna'. Simultaneously, plant diameter increased by 19.94% for 'Premiera' and 20.18% for 'Fortuna'. Irrigation led not only to an increase in the number of shoots but also to their elongation: primary shoots increased by 15.94% and secondary shoots by 15.22% for 'Premiera', and by 15.07% and 19.35%, respectively, for 'Fortuna'. The number of inflorescences increased by 37.82% for 'Premiera' and 42.53% for 'Fortuna'.*

Key words: *essential oil plants, Monarda fistulosa, development phases, vegetative and generative organs, irrigation, variety.*

Свиденко С.В., Валентюк Н.О. Залежність біологічних, морфометричних та кількісних показників Monarda fistulosa L. від способу зволоження та сортових особливостей рослин

Мета. *Визначити залежності тривалості фенологічних фаз розвитку та формування морфометричних та кількісних показників від способу зволоження та сортових особливостей рослин Monarda fistulosa L. першого року розвитку в умовах Центрального Лісостепу.*

Методи. *Досліджували рослини M. fistulosa L. сортів Прем'єра та Фортуна. Використовували польові, лабораторні та вимірювально-вагові методи досліджень. Математичну обробку результатів проводили за програмним забезпеченням Agrostat.*

Результати. *За природного зволоження період цвітіння тривав 29 діб у сорту Прем'єра і 30 діб у сорту Фортуна, а за зрошення – 38 діб у сорту Прем'єра і 46 діб у сорту Фортуна. Залежно від способу зволоження висота рослин коливалася від 68 см до 80,5 см у сорту Прем'єра та від 74,7см до 85см у сорту Фортуна. Діаметр рослин варіював від 56,20 см до 70,20 см у сорту Прем'єра та від 61,30 см до 76,80 см у сорту Фортуна. Спосіб зволоження позначився і на формуванні кількості та довжині пагонів I та II порядків та кількості суцвіть. Встановлено, що у сорту Прем'єра налічувалось 5,0-7,5 штук пагонів I порядку 58-69 см завдовжки та 34,8-53,8 штук пагонів II порядку 23,4-27,6 см завдовжки. Рослини даного сорту мали 37,0-59,5 штук суцвіть. У рослин сорту Фортуна налічувалось 8,7-9,3 штук пагонів I порядку 62-73 см завдовжки та 46-62,5 штук пагонів II порядку 23-31,7 см завдовжки, що дало можливість сформувати 42,7-74,3 штуки суцвіть.*

Висновки. *Великий вплив на тривалість фази цвітіння у рослин M. fistulosa мав спосіб зволоження. За природного зволоження період цвітіння тривав 29-30 діб, а за зрошення – 38-46 діб (в залежності від сорту). Зрошення позитивно вплинуло на морфометричні та кількісні показники рослин. Найбільші їх значення було сформовано у рослин монарди трубчастої, які отримували крапельне зрошення. Застосування зрошення дозволило збільшити висоту у рослин сорту Прем'єра на 15,53%, а у сорту Фортуна на 12,12 %. При цьому діаметр рослин збільшився на 19,94% у сорту Прем'єра та на 20,18% у сорту Фортуна. Застосування зрошення призвело не тільки до збільшення кількості пагонів, але і до їх подовження: I порядку на 15,94% та II порядку на 15,22% у сорту Прем'єра та на 15,07 і 19,35% відповідно у сорту Фортуна. Кількість суцвіть збільшилася на 37,82% у сорту Прем'єра та на 42,53% у сорту Фортуна.*

Ключові слова: *ефіроолійні рослини, Monarda fistulosa, фази розвитку, вегетативні та генеративні органи, зрошення, сорт.*

Statement of the problem. The rapid development of various sectors of the national economy (light, processing, and food industries) requires a significant supply of raw materials and oils from essential oil crops. Currently, this demand is primarily met through imports [1]. One of the factors prompting researchers and agricultural producers to seek promising crops is global climate change characterized by gradual warming, accompanied by a series of negative effects, such as reduced precipitation, decreased air humidity, and rising temperatures, among others [2].

Along with such common aromatic crops as lavender, dill, parsley, celery, fennel, anise, there are many non-traditional crops that contain oil, but are used less often, and research on their introduction, biochemical composition, and economic value has not been conducted [3]. Such are plants of the genus *Monarda*, which are a source of a valuable component of essential oil (thymol) [4].

Analysis of recent studies and publications. The genus *Monarda* (Lamiaceae) comprises 15-20 species, which are most widely distributed across North America [5, 6, 7]. Numerous species occupy a vast geographical range, from the Canadian prairies in the north to Michigan in the south, and across the entire width of the North American continent. They are also found in diverse habitats, ranging from Mount Durango (at an altitude of 2000 m) to sea level along the Atlantic coast in the southern United States. Taxa can be found from the jungles of Veracruz to the Chihuahuan deserts, as well as from geologically ancient regions like the Appalachians to the shifting sand dunes of the most recent Quaternary continental deposits near Corpus Christi, Texas, where in some localities these plants survive even in salt spray [8]. Such a wide range of natural adaptation and ecological plasticity of the genus Monarda provides a high potential for its successful introduction and cultivation in Ukraine, particularly in the face of increasing climate fluctuations.

The species *Monarda fistulosa* is considered by scientists in many countries to be promising for both research and practical application [9]. Extracts and essential oil of *M. fistulosa* possess high bactericidal, antiviral, antifungal, antimycoplasmal, and anthelmintic activities, as well as antioxidant, radioprotective, antisclerotic, desensitizing, anticancer, anti-inflammatory, and analgesic properties [10]. *Monarda* has found widespread use in the food industry. The dried herb of *Monarda* has a pleasant floral-spicy aroma with a thymol note and is used for making teas, while extracts from the aerial biomass are utilized in vermouth production and for flavoring non-alcoholic beverages [11]. In dried spice blends, due to its pungent flavor, *Monarda* is recommended as a substitute for imported black pepper [6].

In the food industry, the practical application of *M. fistulosa* is multifaceted. Essential oils and oleoresins are extracted from the flowering aerial parts through steam distillation or CO_2 extraction to be used as high-grade natural flavorings. The high concentration of thymol and carvacrol allows the use of these extracts as natural preservatives to extend the shelf life of meat and dairy products. Furthermore, the alcoholic and aqueous extracts are employed in the formulation of bitters, liqueurs, and functional beverages, while the finely ground dried leaves serve as a botanical ingredient in the production of specialized spice mixtures and seasoned salts [9-11].

Considerable work on the introduction of Monarda was carried out in the 1980s by scientists from Ukraine, Moldova, Uzbekistan, Azerbaijan, etc. There are many works on the study of the biological characteristics of Monarda tubular in different climatic zones [6, 10, 12].

According to literature data, the biological characteristics of *Monarda fistulosa* classify it as a relatively cold-hardy plant that easily adapts to new environments and is undemanding regarding cultivation conditions, capable of growing in both shaded and sunny locations. However, it achieves optimal development and high ornamental value in well-lit ecotopes with fertile soils and adequate moisture. In terms of its water regime, *Monarda* is a mesophyte. The aerial part of the plant is characterized by a highwater content in the leaves during the growing season and a low water deficit, which increases only during the summer months. The plants are capable of producing high green biomass and seed yields, while exhibiting resistance to diseases and pests [13, 14]. In this context, the application of artificial irrigation becomes a crucial agrotechnical measure to mitigate the summer water deficit, ensuring stable physiological processes and maximizing the productive potential of *M. fistulosa* in arid regions.

A comprehensive study of the patterns of growth, development and yield formation of plants is possible only on the basis of a quantitative and qualitative assessment of the influence of meteorological conditions, the correct selection of high-yielding varieties and agrotechnical cultivation methods [15].

The study of changes in the main biometric indicators of essential oil plants depending on agrotechnical measures is of great importance for analyzing the influence of the studied factors on the production processes of the crop [16].

Goal was to determine the dependence of the duration of phenological phases of development and the formation of morphometric and quantitative indicators on the method of moistening and varietal characteristics of Monarda fistulosa L. plants of the first year of development in the conditions of the Central Forest-Steppe.

Methods. The research was conducted in 2025 under the conditions of the Central Forest-Steppe of Ukraine, specifically in the Lysianka district of the Cherkasy region. The region is located on the Dnieper Upland of the East European Plain, within the Hnylyi Tikych river basin [17]. The climate of the Central Forest-Steppe is temperate continental, characterized by relatively mild winters with little snow and warm, moderately humid summers. The average annual air temperature in the Cherkasy region is approximately 7.6°C, with significant deviations in certain years. The average temperature in January ranges from -5 to -6°C, while in July it is +19 to +20°C. Extreme temperatures reach a minimum of -34 to -37°C and a maximum of +38 to +41°C. The average annual precipitation is 508 mm.

In the studied region during 2025, the amount of precipitation per year was 545.2 mm. The average air temperature per year was +10.5°C. In the summer months, it ranged from +8.6 to +35.6°C, with an average of 20.7°C.

The soil of the experimental plot is a typical chernozem. According to its texture, the soil is classified as heavy-loamy. The humus content in the arable layer is 4.58%.

A two-factor experiment was established using a randomized split-plot design. Factor A involved the moisture supply method, comprising two variants: natural moisture and drip irrigation. Factor B included two cultivars of *M. fistulosa*: ‘Premiera’ and ‘Fortuna’. The area of each elementary plot was 30 m², with a harvest (record) area of 25 m². The experiment was conducted in four replicates. Each plot contained 50 individual plants.

Irrigation regime control was carried out using a tensiometer [18,19]. In the variants with irrigation, soil moisture was maintained at 80% of the relative humidity.

Field, laboratory and measuring-weighting research methods were used.

During the growing season, phenological observations were carried out on the studied plants according to generally accepted methods. The following phases were noted: spring regrowth, budding (beginning, mass), flowering (beginning, mass, end), fruiting (beginning, mass, end). The beginning of the phase was noted when 15% of the plants entered this phase, and the full phase was noted when 75% of the plants were in this phase [20].

Biometric measurements were conducted during the full flowering stage. Parameters measured included plant height and diameter, as well as the length of primary and secondary shoots. The number of inflorescences per plant was also recorded. Each set of measurements was performed on 10 plants [20, 21].

Statistical analysis of the research results was carried out using Agrostat software.

Results. ***Phenology.*** In the first year of development, the agricultural technology of growing *M. fistulosa*: in the conditions of the Central Forest-Steppe was aimed at obtaining full-fledged healthy plants with well-developed vegetative organs.

In the conditions of the Central Forest-Steppe, spring vegetation of wild bergamot cultivars typically begins in the second decade of March, depending on the annual weather patterns. However, in 2025, due to low temperatures in the second decade of March and the first decade of April (when nighttime air temperatures dropped to -3.2°C… -3.7°C) the spring regrowth of vegetatively propagated first-year plants was delayed.

The increase in air temperature in the second decade of April contributed to the beginning of the vegetation of *M. fistulosa* plants in all variants of the experiment. The beginning of spring regrowth was recorded on 16.04 (Table 1).

Table 1

Effect of moisture supply and cultivar specificity on the phenology of *Monarda fistulosa* L. in the first year of ontogeny

Factor A, Irrigation method	Factor B, Cultivars of *M. fistulosa*	Spring regrowth	Budding		Flowering			Fruiting		
			Start	Full	Start	Full	Start	Full	Start	Full
Natural moisture	Premiera	16.04	14.06	20.06	1.07	11.07	29.07	25.07	14.08	24.08
	Fortuna	16.04	19.06	27.06	10.07	17.07	9.08	3.08	20.08	10.09
Irrigation	Premiera	16.04	14.06	20.06	1.07	11.07	7.08	2.08	19.08	4.09
	Fortuna	16.04	19.06	27.06	10.07	17.07	15.08	9.08	24.08	16.09

The beginning of the budding phase was noted in the 'Premiera' variety at the beginning of the first decade of June in both variants of moisture supply method (which was facilitated by a sufficient amount of precipitation (60 mm) in May).

For the 'Fortuna' variety this phase of development began 5 days later, at the end of the first decade of June also in both variants of moisture supply method.

The duration from the onset of budding to the beginning of flowering in the 'Premiera' cultivar was 16 days under both moisture regimes. For the 'Fortuna' cultivar, the budding-to-flowering interphase period lasted longer, reaching 21 days in both variants.

The onset of full flowering under natural moisture conditions was observed in 'Premiera' (Figure 1 a) at the end of the first and the beginning of the second decade of July, while in 'Fortuna' (Figure 1 b), it occurred at the end of the second decade of July. Similar timing for this phase was recorded for both cultivars under drip irrigation

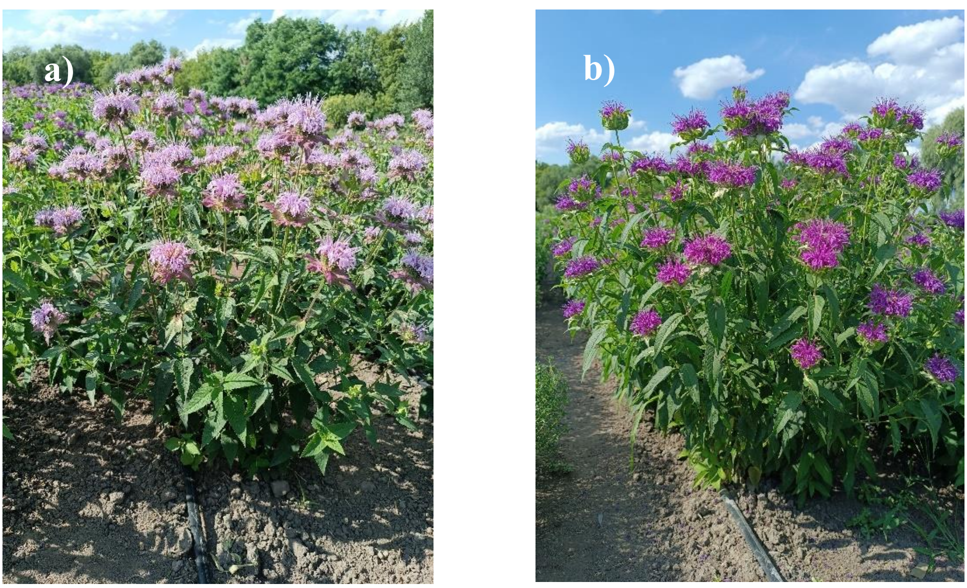

Fig. 1. Plants of M. fistulosa in flowering phase: a – 'Premiera', b – 'Fortuna'

Differences in the timing and duration of phenological stages depending on the irrigation method became noticeable at the end of the flowering period. Specifically, in 'Premiera' plants under natural moisture, the end of flowering was recorded in the third decade of July, whereas in the irrigated variant, it occurred in the first decade of August. The total flowering duration for 'Premiera' under natural moisture was 29 days, while under irrigation, it extended to 38 days. Thus, the difference in flowering duration for the 'Premiera' cultivar depending on the irrigation method amounted to 9 days.

In the 'Fortuna' cultivar, the end of flowering occurred in the first decade of August under natural moisture conditions and in the second decade of August in the irrigated variant. The duration of the flowering stage for 'Fortuna' plants under natural moisture was 30 days, while for those under drip irrigation, it reached 46 days. The difference in flowering duration for this cultivar, depending on the irrigation method, amounted to 16 days.

Since the flowering stage is the primary period for harvesting wild bergamot, it is essential to determine its timing in relation to all influencing factors. Overall, the flowering stage across the experiment lasted from 29 to 46 days, depending on both the availability of irrigation and the biological characteristics of the cultivar. Under natural moisture, the flowering period of the cultivars varied within a narrow range with a difference of only one day (29-30 days). However, under irrigation, the difference in flowering duration between the cultivars increased to 8 days (38-46 days).

The onset of the fruiting stage was observed in the late third decade of June for 'Premiera' plants under natural moisture conditions, while in the irrigated variant of the same cultivar, it occurred 7 days later. For the 'Fortuna' cultivar, the onset of fruiting was recorded in the first decade of August. This stage began 6 days earlier in plants under natural moisture compared to those under drip irrigation.

The period from the beginning of spring vegetation to the end of fruiting in first-year plants lasted 130 days for 'Premiera' and 146 days for 'Fortuna' under natural moisture, whereas in the irrigated variants, it extended to 140 days for 'Premiera' and 162 days for 'Fortuna'.

The vegetation of M. fistulosa plants ends with the onset of low temperatures.

Our research established that after the budding stage, which occurred in early June, the number of inflorescences per plant remained unchanged throughout the growing season. Although plants regrow after the aerial biomass is harvested for essential oil or raw material production, a second flowering stage does not occur.

Morphological and quantitative characteristics. The main morphological characteristics that affect the yield of *M. fistulosa* are the plants height, the number of shoots, the intensity of their branching, the number and size of leaves and flowers, which are the most valuable organs of the plant in the accumulation of essential oil.

To study the dependence of *Monarda fistulosa* growth and development on the irrigation method, measurements of the bush habit and plant organs, along with their quantitative counts, were conducted during the full flowering stage for wild bergamot cultivars in their first year of development (Table 2).

According to the analysis of variance (ANOVA), Factor A (irrigation method) exerted the most significant influence on the morphometric and quantitative traits of *M. fistulosa*, accounting for 75.54-87.26% of the total variance. The most pronounced effect of this factor was observed in the development of primary shoot length. The contribution of Factor B (cultivar), determined by the biological characteristics of the studied varieties, ranged from 11.54% to 23.74%.

Table 2

Effect of irrigation on morphological and quantitative characteristics of vegetative and generative organs in first-year *Monarda fistulosa* L.

Factor A, Irrigation method	**Factor B, Cultivars of *M. fistulosa***	**Biometric traits**						
		Plant height, cm	**Bush diameter, cm**	**Number of primary shoots, pcs**	**Number of secondary shoots, pcs**	**Length of primary shoot, cm**	**Length of secondary shoot, cm**	**Number of inflorescences, pcs**
Natural moisture	Premiera	68.00	56.20	5.00	34.80	58.00	23.40	37.00
	Fortuna	74.70	61.30	6.70	46.00	62.00	25.00	42.70
Irrigation	Premiera	80.50	70.20	8.10	53.80	69.00	27.60	59.50
	Fortuna	85.00	76.80	9.00	62.50	73.00	31.00	74.30
Assessment of the materiality of partial differences								
LSD_{05}	A =	2.779	1.230	1.757	0.527	3.337	1.932	0.176
	B =	3.619	0.807	1.026	0.409	1.491	1.139	2.496
Assessment of the materiality of average (main) effects								
LSD_{05}	A =	1.965	0.869	1.242	0.373	2.360	1.366	0.124
	B =	2.559	0.571	0.726	0.289	1.054	0.805	1.765
Share of factors influence, %	A	77.30	85.38	75.88	75.54	87.26	76.93	85.17
	B	18.99	13.43	17.59	23.74	11.54	18.49	12.23
	AB	0.72	0.24	1.67	0.37	0.00	2.40	2.41
	Residual	2.99	0.95	4.86	0.35	1.20	2.19	0.19

The application of irrigation positively impacted the growth and development of both cultivars, enhancing all studied parameters. Specifically, for the ‘Premiera’ cultivar, irrigation resulted in a 15.53% increase in height, a 19.94% increase in bush diameter, and a rise in the number of primary and secondary shoots by 38.27% and 35.32%, respectively. The length of primary shoots increased by 15.94%, secondary shoots by 15.22%, and the number of inflorescences by 37.22%.

For the ‘Fortuna’ cultivar, irrigation led to a 12.12% increase in height and a 20.18% increase in bush diameter. The number of primary and secondary shoots rose by 25.56% and 26.40%, respectively. Shoot length increased by 15.07% for primary and 19.35% for secondary shoots, while the number of inflorescences showed the highest gain of 42.53%.

Discussion. *Monarda fistulosa* is a perennial herbaceous plant with annual senescing aerial shoots. Its height depends on the cultivar, plant age, and soil-climatic conditions of cultivation. The stem is rounded-quadrangular and glabrous at the base, becoming pubescent only from the middle of the shoot with very short, appressed, downward-pointing hairs, distributed uniformly on all four sides. In the upper part, the stem is quadrangular and densely pubescent across the entire surface [6,10]. The leaves are simple, oblong-ovate in shape, serrated, and up to 8.0–8.5 cm long. The leaf blade is glabrous or covered with short hairs (up to 0.1 cm) on the abaxial side, while on the adaxial side, pubescence is noticeable along the veins. The lilac-colored flowers are small and arranged in axillary false whorls, which in turn form compact spherical heads located at the ends of the primary and lateral shoots.

The first year in the ontogeny of perennials is crucial for their productivity. During this period, the formation and development of a robust root system and rhizome occur, accumulating the nutrient reserves necessary for successful overwintering and the subsequent production of aerial biomass in the following growing seasons [22].

Researchers working with the Monarda culture emphasize its great polymorphism when propagated by seeds [6], therefore, they planted the plot with vegetatively propagated seedlings.

The results of our study indicate that the phenological development of *Monarda fistulosa* in the Central Forest-Steppe is highly dependent on both genetic characteristics and environmental factors, particularly moisture availability. The stability of the initial growth stages (spring regrowth and budding) in 2025 across all variants suggests that during the early vegetation period, temperature and internal biological rhythms are the primary drivers of ontogeny. This aligns with the findings of Luchian et al. [23], who emphasized that the early stages of *Monarda* development are largely governed by species-specific adaptation mechanisms to local thermal conditions.

However, the transition to reproductive stages revealed a significant response to irrigation. The extension of the flowering period by 9-16 days under drip irrigation is a crucial finding. This prolonged flowering not only increases the decorative value of the cultivars but also significantly expands the "technological window" for raw material harvesting. Similar patterns were observed by Moghaddam et al. [24], who noted that optimal moisture supply prevents premature senescence and maintains the physiological activity of the floral apparatus in *Lamiaceae* species.

The differences between 'Premiera' and 'Fortuna' in their response to irrigation (an 8-day difference in flowering duration under irrigation versus only 1 day under natural moisture) highlight the varying adaptive potential of these cultivars. The delayed onset of fruiting in the irrigated variants further confirms that adequate moisture supply slows down the aging processes of the tissues, redirecting energy from rapid seed maturation back into vegetative and floral maintenance. As stated by Omidbaigi et al. [25], such phenological shifts in essential oil crops are often correlated with a more prolonged accumulation of secondary metabolites, which justifies the use of irrigation not only for biomass increase but also for extending the period of maximum essential oil yield.

The significant increase in all morphometric parameters under drip irrigation demonstrates the high responsiveness of *Monarda fistulosa* to moisture availability during its first year of ontogeny. Our findings regarding the dominant influence of the irrigation factor (75.54-87.26%) on plant height and bush diameter are consistent with the general biological patterns observed in the *Lamiaceae* family. As noted by Moghaddam et al. [24], optimal moisture supply directly correlates with enhanced cell turgor and intensified photosynthetic activity, which ultimately leads to a substantial increase in both linear growth and total aboveground biomass.

Specifically, the 12.12–15.53% increase in plant height and over 20% increase in bush diameter observed in our study suggest that irrigation effectively mitigates the typical mid-summer water deficit of the Central Forest-Steppe. The most pronounced response was recorded for the number of primary and secondary shoots, which rose by 25-38%. This intensification of branching is a key adaptive trait; it not only increases the photosynthetic surface area but also multiplies the potential sites for inflorescence formation. Similar results were reported by Omidbaigi et al. [25], who emphasized that balanced environmental factors (nutrition and moisture) shift the plant's energy allocation toward lateral shoot development, thereby increasing the overall raw material yield.

Conclusions. *Monarda fistulosa* L., introduced into the conditions of the Central Forest-Steppe, successfully undergoes all developmental stages and produces viable seeds. The timing of the onset and the duration of these phenological stages are significantly influenced by both the irrigation method and cultivar characteristics. In 2025, the duration of the initial developmental stages depended solely on the cultivar, which is attributed to sufficient precipitation during this period. Specifically, for the 'Premiera' cultivar, the budding stage occurred 5 days earlier, and the flowering stage began 10 days earlier compared to the 'Fortuna' cultivar under both moisture regimes. The irrigation method had a profound impact on the flowering duration. Under natural moisture, the flowering period lasted 29-30 days, whereas under irrigation, it extended to 38-46 days, depending on the cultivar.

The highest values for morphometric and quantitative traits were recorded in wild bergamot plants receiving drip irrigation. The application of irrigation resulted in a height increase of 15.53% for the 'Premiera' cultivar and 12.12% for the 'Fortuna' cultivar. Simultaneously, plant diameter increased by 19.94% for 'Premiera' and 20.18% for 'Fortuna'. Irrigation also led to a rise in the number of primary and secondary shoots by 38.27% and 35.32%, respectively, for 'Premiera', and by 25.56% and 26.40%, respectively, for 'Fortuna'. Along with the increased shoot count, irrigation promoted greater shoot length, which in turn enabled the plants to form a larger number of inflorescences (an increase of 37.22% for 'Premiera' and 42.53% for 'Fortuna') compared to plants grown under natural moisture conditions.

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