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Exploring Global Genebank Resources to Introduce and Assess Cultivation Potential of Moldavian Dragonhead in Armenia

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The increasing interest in spicy plants for their diverse applications in functional foods and as melliferous plants highlight a wide array of species valued for their distinctive flavours, nutritional benefits, and therapeutic properties. *Dracocephalum moldavica* L., commonly known as Moldavian dragonhead, is a noteworthy candidate due to its nutritional value, high essential oil content, antioxidant capacity, and adaptability. Various plant genetic resources information systems and national genebank databases were explored to identify suitable varieties to be cultivated in Armenia. Key insights from this assessment revealed a limited availability of *D. moldavica* accessions across global genebanks, with significant gaps in accession data, particularly regarding characterization and evaluation. This lack of comprehensive information impeded the selection process. Based on publicly available data, national genebank records, and literature on valuable traits, two cultivars – Gorynych and Moldavia - were selected for study and potential introduction in Armenia. Minimal differences were observed in growth stages and morphological traits, with cv. Gorynych showing taller inflorescences and cv. Moldavia slightly larger floral features. Both varieties demonstrated extended flowering periods, indicating high melliferous potential in Armenia's valley conditions. These cultivars are recommended for cultivation and further research on their biochemical properties.

Keywords: *Dracocephalum moldavica*, *ex situ*, morphometric indicators, phenological stages

Introduction

In recent years, there has been a surge in interest surrounding spicy plants and their diverse applications in functional foods and natural remedies. This growing fascination encompasses a wide range of plant species valued not only for their unique flavours but also for their potential health benefits. This trend reflects a broader movement towards incorporating more diverse and health-promoting ingredients into our diets and wellness routines. The introduction of new species and varieties of plants with spicy, honey and medicinal properties into Armenia will enhance the diversification of agricultural systems and promote the

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use of these plants in functional foods and honey production.

Dracocephalum moldavica L., commonly known as Moldavian dragonhead, is a fascinating herbaceous plant that has garnered increasing interest from botanists and horticulturists alike. Native to the steppes of Eastern Europe and Asia, it grows in nature in the European part of Russia, the Baltic States, Moldova, Central Asia, Siberia, China, and the Far East (Gryaznov et al., 2019). *D. moldavica* is already known to grow in Armenia. The natural habitat of Moldavian dragonhead is documented in weedy areas within the Echmiadzin region of the Yerevan floristic zone (Flora of Armenia, 1987). This perennial member of the Lamiaceae family is celebrated for its striking appearance and unique characteristics. Moldavian dragonhead features vibrant, tubular flowers that range from blue to violet, creating a dramatic visual display in gardens and natural landscapes (Eong et al., 2016). In several countries, *D. moldavica* grows as a honey-bearing plant; flowers can yield 15.33–17.56 mg of nectar per plant during 2.5 days, with 49.4–51.5% sugar content (Dmitruk et al., 2018).

Essential oil content in above-ground parts, depending on the plant part, growing technology, and phenological stages, varies between 0.03 and 0.12% (Borghei et al., 2015; Hegazy et al., 2016; Kotyuk and Rakhmetov, 2017). Besides essential oil, *D. moldavica*'s aerial parts also contain flavonoids, iridoids, tannins, and hydroxycinnamic and carboxylic acids (Popova et al.; 2008; Aprotosoaie et al*.,* 2016; Weremczuk-Jeżyna et al., 2023). The seeds of Moldavian dragonhead are a good source of fatty oil, which is spicy and has an aromatic odor (Bijani and Madandoust, 2023). Total phenolic content ranges from 4.97 to 5.32 mg GAE/g, while the antioxidant capacity of *D. moldavica* seed averages about 40% (Dziki et al., 2013). These valuable characteristics make Moldavian dragonhead seeds suitable for nutraceuticals, supplements, and functional food applications. Medicinally, the plant is used in tea blends and infusions (Zhan et al., 2024). Additionally, the dried leaves of *D. moldavica* hold promise as a functional ingredient in extruded crisps, thanks to their high nutritional value. Their content of dietary fiber and rosmarinic acid contributes to strong antioxidant properties and desirable sensory qualities, making them a valuable addition to such products (Simea et al., 2023; Aćimović et al., 2019; Wojtowicz et al., 2017).

One of the intriguing aspects of *D. moldavica* is its adaptability and resilience, making it a potential candidate for introduction to diverse climates and regions. Armenia with varied climate, mix of arid and temperate zones, could benefit from the Moldavian dragonhead's drought tolerance and ability to thrive in well-drained soils. Furthermore, the plant's adaptability to different environmental conditions and its aesthetic qualities make it an excellent choice for enhancing local gardens, landscaping projects, and cultivation as a medicinal, spicy, and melliferous crop (Moldovan et al., 2022). Despite this great potential, this species remains underutilized in Armenia, and breeding activities towards developing varieties have not been implemented.

The introduction of *D. moldavica* cultivars to Armenia presents an opportunity to explore its cultivation practices and potential uses for medicinal, spicy, and melliferous purposes. To introduce cultivars of *D. moldavica*, the study of available genetic resources through global and National Genebanks' information systems was carried out to identify promising cultivars. The seeds of the selected cultivars were multiplied, and the plants were cultivated to characterize their morphological parameters and phenological stages. The experiment aimed to evaluate the adaptability, growth and development characteristics of Moldavian dragonhead cultivars in Armenia, with the goal of identifying those best suited to local climatic conditions for sustainable cultivation.

Materials and methodology

Cultivars selection

To identify and assess Moldavian dragonhead *ex situ* collections globally in terms of existing modern breeding varieties, their characterization data, and accessibility for stakeholders with the purpose of selection suitable for local climatic and soil conditions cultivars, various plant genetic resources information systems and national genebank's internet posted databases were explored. The selection of International and National Genebanks databases was done to cover different regions of the world. The studied plant genetic resources global and regional information systems include European Search Catalogue for Plant Genetic Resources (https://eurisco.ipk-gatersleben.de/apex/eurisco_ws/r/eurisco/home), GENESYS portal (https://www.genesys-pgr.org/), Global Biodiversity Information Facility, (https://www.gbif.org/), Mediterranean Germplasm Database, https://www.ibbr.cnr.it/mgd/, NARO Genebank (https://www.naro.go.jp/english/laboratory/ngrc/database/index.html),, and Nordic-Baltic Genebanks Information System (https://www.nordgen.org/our-work/plants/). Among explored national genebank databases were Genetic Resources Information System

of Slovakia (https://griss.vurv.sk), Genebank Information System of the Federal Ex situ Gene Bank (https://www.ipk-gatersleben.de/en/research/genebank), Millennium Seed Bank Seed List, (https://apps.kew.org/seedlist/SeedlistServlet, U.S. National Plant Germplasm System (https://www.ars-grin.gov/Collections#plant-germplasm, CGN Germplasm, Netherlands (https://cgngenis.wur.nl/), National Research Institute for Agriculture, Food and the Environment, France (https://urgi.versailles.inra.fr/siregal/siregal/accessionSimpleAction.do), Crop Research Institute, Czech Republic (https://grinczech.vurv.cz/gringlobal/search.aspx), and some others.

Biological material and experimental site

Two cultivars (Gorynych and Modavia) of Moldavian dragonhead were studied during the 2023–2024 growing seasons at the experimental farm of the Scientific Centre of Vegetable and Industrial Crops of the Ministry of Economy of the Republic of Armenia, located in the Darakert community of Ararat Marz, Armenia (40.1058333°N, 44.4138899°E; altitude 650–700 m). The farm is in the Ararat Valley, where average temperatures range from -2.6 °C in January to 26.2 °C in July, with an annual precipitation of 289 mm.

Morphometric analysis

To evaluate morphometric indicators, *D. moldavica* cultivars were initially grown from seeds to produce seedlings, which were then transplanted to the field for further growth and assessment. The seeds were sown in cells at the end of March and placed in the germination chamber. After germination seedlings were grown under greenhouse conditions and planted in the open field in the middle of May. The planting scheme for Moldavian dragonhead seedlings was as follows: the width of the streams is 60 cm, and the distance between the plants is 35 cm. The experiment was set up in 3 replications**.**

A total of five quantitative parameters were assessed in the plants of two cultivars, and four quantitative characteristics were measured in their flowers and leaves. In total, 60 plants were evaluated during 2023 and 2024, with 30 plants assessed each year. The parameters measured included: shoot height (cm), number of lateral shoots (pcs), length of the leaf blade (cm), and width of the leaf blade (cm). Additionally, 60 flowers and 60 leaves were measured in total during the same period, with 30 flowers and 30 leaves assessed per year. The characters measured included height of the inflorescence on the main shoot (cm), height of inflorescences on lateral shoots (cm), height of the corolla (cm), width of the lower lip of the flower (cm). Shoots were measured using a ruler, while leaves and flowers were measured with a digital calliper accurate to 0.02 mm.

During the field experiments, biological characteristics such as growth habits, flowering patterns, and overall adaptation to local climatic conditions were also investigated.

Statistical analysis

The basic descriptors of variability – mean, minimum value, maximum value, and coefficient of variation (%) – were utilized to characterize the data. The extent of variability was assessed through the coefficient of variation. The statistical calculations were done on separate data from each variety. The experimental data underwent statistical analysis using ANOVA, conducted in the STATISTICA 1.10 software.

Results and discussions

The information was gathered from national records and genebank databases, outlining the presence of Moldavian dragonhead accessions as of 2024. The national inventories shown in Figure 1 represent key regions where *D. moldavica* is preserved externally in seed collections.

Key insights from the figure reveal that, overall, there are few *D. moldavica* accessions held ex situ across the countries. A relatively large number of stored samples are documented in the databases of Ukraine, Bulgaria, Hungary, Romania, and Slovakia, where seed collection of aromatic and medicinal plants has significantly expanded during last two decades (FAO, 2008, a, b, c) indicating a notable presence of genetic diversity for this plant, including various varieties, promising lines, and wild forms. Conversely, other countries exhibit fewer accessions, which may suggest potential gaps in conservation efforts or research attention.

Since this study aimed to identify accessions with traits that align with the environmental conditions and agricultural needs of Armenia, an analysis of the origins of Moldavian dragonhead accessions was conducted. This analysis facilitated the selection of varieties with the greatest potential for adaptation to Armenia's diverse climates and soils (4th NCC Armenia, 2020). The analysis of accession origin data, as shown in Figure 2, reveals a significant gap in the information available in both global and national databases. This lack of comprehensive data impedes the effective selection of accessions based on their origin. Available information indicates that most accessions are of Romanian and Ukrainian origin; however, not all accessions with recorded origins have corresponding accession names.

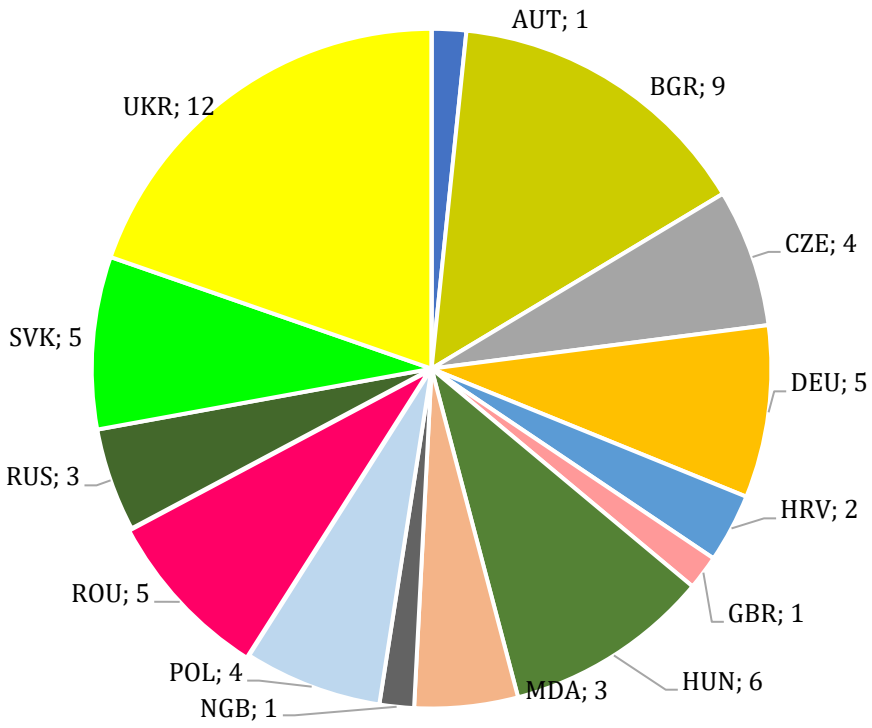

Figure 1 Distribution of *Dracocephalum moldavica* L. accessions across national inventories: NGB – Nordic Countries; AUT – Austria; BGR – Bulgaria; CZE – Czech Republic; DEU – Germany; HRV – Croatia; GBR – United Kingdom; HUN – Hungary; MDA – Moldova; POL – Poland; ROU – Romania; RUS – Russian Federation; SVK – Slovakia; UKR – Ukraine.

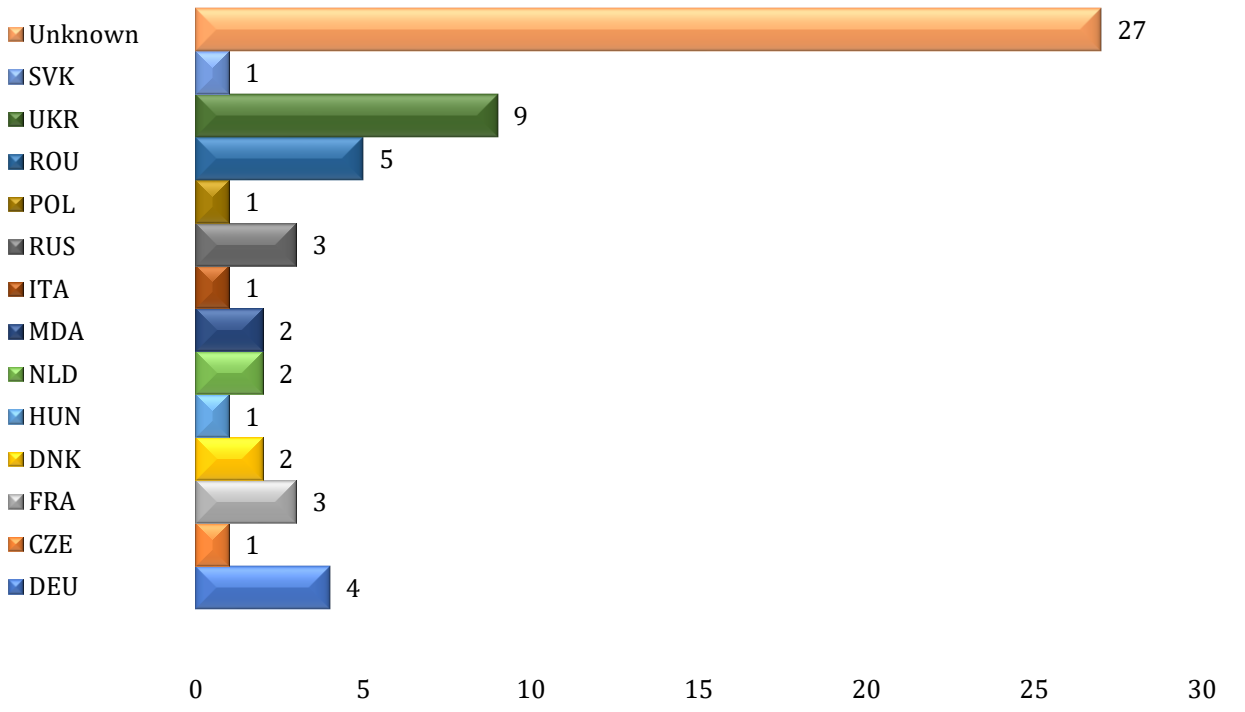

Figure 2 Distribution of *ex situ* stored Moldavian dragonhead accessions by origin: SVK – Slovakia; UKR – Ukraine; ROU – Romania; POL – Poland; RUS – Russian Federation; ITA – Italy; MDA – Moldova; NLD – The Netherlands; HUN – Hungary; DNK – Denmark; FRA – France; CZE – Czech Republic; DEU – Germany.

Since the research interest is focusing on the introduction of breeding cultivars of Moldavian dragonhead in the Republic, the availability of cultivars in genebanks was a key consideration and the recorded accession biological status was also considered. The results, as shown in the Figure 3, highlight the limited selection available for this study. Only 12 accessions were identified as 'advanced or improved cultivars,' while other accessions were classified under different biological statuses or marked as 'unknown.' This limited number of cultivars restricted our choices for selection, underscoring the challenges of sourcing suitable cultivars from global genebanks. As the study aimed to focus on breeding cultivars rather than wild forms or research material, these findings demonstrate the constraints on our ability to identify appropriate cultivars for introduction and cultivation in Armenia.

Additionally, it should be noted that out of the 12 cultivars, only two are registered with MLS (Multilateral System of the International Treaty on Plant Genetic Resources for Food and Agriculture) status. This status is essential for the sharing and sustainable use of genetic resources within the framework of the Treaty (Marden, et al., 2023; Morrison et al., 2021). Overall, these figures highlight the challenges in selecting appropriate cultivars due to inadequate passport data for accessions maintained in *ex situ* collections worldwide.

The absence of characterization and evaluation data on *D. moldavica* in online databases also hindered the selection of cultivars for introduction in Armenia.

Based on an analysis of data from information systems, national genebanks, as well as literature sources (Ovechko et al., 2001; Egorova, 2017; Gryaznov and Tockaya, 2019;), two cultivars of Moldavian dragonhead – Gorynych and Moldavia – were selected for study and potential introduction.

During the field experiments, the biological characteristics that include studying the growth habits, flowering patterns, duration of the main developmental stages, morphometric indicators, and overall adaptation to local agro-climatic conditions were investigated throughout the growing season.

The analysis of the morphological data presented in Table 1 shows that, under the local conditions of the Ararat Valley, the morphological differences between the two plant cultivars, Gorynych and Moldavia, are minimal. Both cultivars have branched stems that are either erect or ascending. The leaves are basal. In both cultivars, the flowers are arranged in pseudo-whorls that grow in the leaf axils. The calyx and corolla are bilabiate. The corolla of cv. Gorynych is dark purple, while that of cv. Moldavia is white, or light purple. At the base, the corollas form a long tube accessible to insects. Cv. Gorynych has a relatively tart lemon aroma, while cv. Moldavia has a minty-lemon aroma. Both varieties exhibit similar overall growth habits and characteristics. Both cultivars have comparable shoot heights, with cv. Gorynych being slightly taller.

Both cultivars produce a similar number of lateral shoots, with cv. Moldavia having slightly taller lateral shoots. Compared to plants cultivated in other climatic zones, the average number of lateral shoots is higher in the Ararat Valley, where plants tend to be shorter but have more lateral shoots. Cultivar Moldavia's leaves are slightly longer and wider than those of cv. Gorynych.

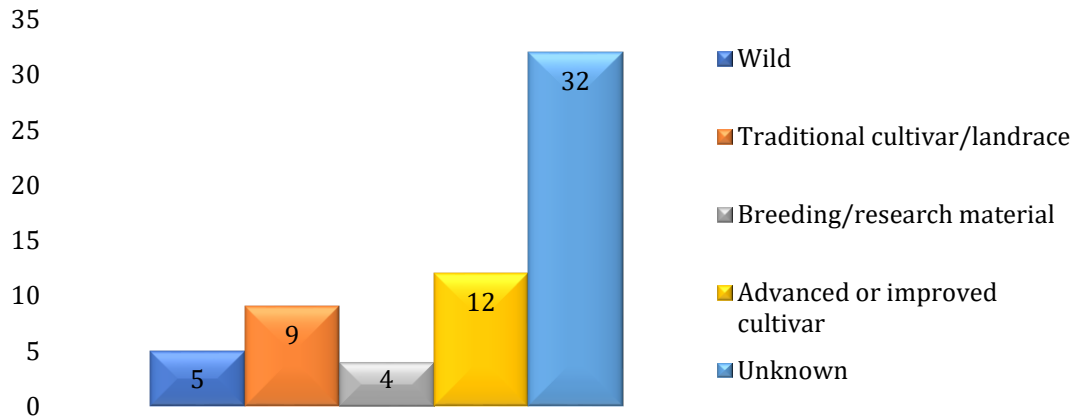

Figure 3 The biological status of recorded *ex situ* accessions of *Dracocephalum moldavica* L

Table 1. Morphometric indicators of *Dracocephalum moldavica* L. cultivars plants at the flower-bud formation stage

Cultivar	Variables	DF	Plant morphological parameters				
			Shoot height, cm	Number of lateral shoots, pcs	Height of lateral shoots, cm	Length of the leaf blade, cm	Width of the leaf blade, cm
Gorynych	Samples	30	73.41*	11.2*	62.81*	3.81*	4.51
	Errors	86	0.96	0.22	0.12	0.12	0.11
	CV%**	–	2.46	6.43	6.8	3.22	3.14
Moldavia	Samples	30	71.3*	11.4*	63.22*	4.01*	5.11
	Errors	82	0.91	0.35	0,14	0.14	0.12
	CV%**	–	2.51	6.03	7.2	3.68	2.69

Note: * Correlation is significant at the 0.01 level (2-tailed); **ratio of the standard deviation to the mean; DF – degrees of freedom, representing the number of independent pieces of information, associated with the comparison of samples.

Table 2. Morphological parameters of flower of *Dracocephalum moldavica* L. cultivars

Cultivar	Variables	DF	Flower and leaf morphological parameters			
			Height of the inflorescence of the main shoot, cm	Height of inflorescences of lateral shoots, cm	Height of the corolla of the flower, cm	Width of the lower lip of the flower, cm
Gorynych	Samples	30	24.21*	19.22*	1.44*	0.68*
	Errors	75	0.68	0.48	0.19	0.39
	CV%**	–	5.04	5.04	4.81	2.68
Moldavia	Samples	30	19.07*	21.71*	1.52*	0.71*
	Errors	69	0.45	0.21	0.45	0.35
	CV%**	–	4.98	4.28	4.98	3.01

Note: * Correlation is significant at the 0.01 level (2-tailed); **ratio of the standard deviation to the mean.

In terms of flower dimensions, cv. Gorynych generally has taller inflorescences (both main and lateral shoots) compared to cv. Moldavia. Specifically, the main shoot inflorescence of cv. Gorynych is 1.14 cm taller than that of cv. Moldavia, while the lateral shoot inflorescences are 0.51 cm taller, a relatively minor difference (Figure 4).

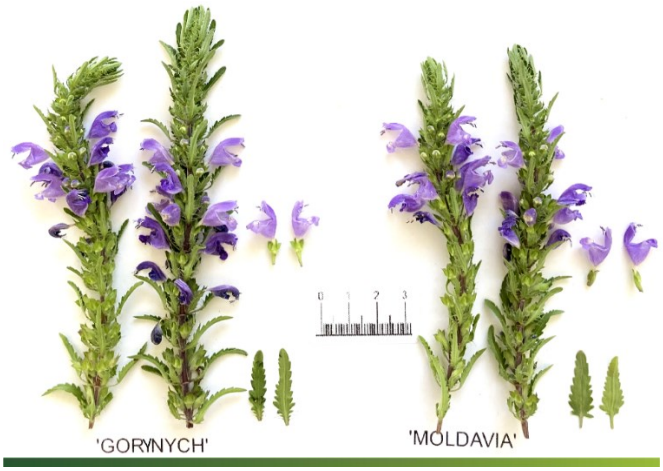

Figure 4: Inflorescences of two cultivars of *Dracocephalum moldavica* L.

Table 3. Duration of phenological stages of two cultivars of *Dracocephalum moldavica* L.

Phenological stages	Duration of phenological stages, days			
	Cv. Gorynych		Cv. Modavia	
	Year 1	**Year 2**	**Year 1**	**Year 2**
From sowing seeds in seedling boxes to sprouts emergence under greenhouse conditions	4	5	5	6
From sprout emergence to the beginning of flower-bud formation	88	90	88	91
From the beginning of flower-bud formation to mass flower-bud formation	11	13	12	14
From mass flower-bud formation to the beginning of flowering	7	8	7	8
From the beginning of flowering to mass flowering	8	9	8	9
From mass flowering to seeds maturing	36	38	37	38

On the other hand, Moldavia has slightly larger floral dimensions. The corolla height of cv. Moldavia is 0.08 cm greater than that of cv. Gorynych, and the width of the lower lip of the flower is 0.03 cm wider (Table 2). This suggests that cv. Gorynych might be preferred for its taller inflorescences, whereas Moldavia could be favoured for its slightly larger floral features.

In the conditions of Armenia, dragonhead plants develop significantly shorter stems compared to those grown on the chernozem soils of southern Ukraine, where stems can reach up to 1 meter in length. This difference can be attributed to the higher soil fertility in Ukraine and the elevated temperatures in the Ararat Valley (Schubert et al., 2021), which partially inhibit stem elongation. However, no significant differences were observed in leaf blade size compared to data from other cultivation zones (Ovechko et al., 2001). It's reasonable that leaf blade size might remain consistent across regions, as it's often less sensitive to environmental variations than stem height (Hirokazu, 2005). Leaf size is more genetically stable, so minor environmental changes might not create notable differences. In comparison to data on dragonhead varieties cultivated in Belarus on sod-medium podzolic, heavy loamy soils, as well as in experiments conducted in the Czech Republic (Aćimović et al., 2019), the stem height in Armenia was 10–12 cm greater. A similar trend was observed in the number of lateral shoots, which reached 11 in the Ararat Valley of Armenia, compared to 8 in Belarus (Grjaznov and Totskaya, 2019), where the harsher climate likely influenced the results (Loginov, 2002). This highlights the significant role of soil conditions in influencing plant growth (Nortcliff and Gregory, 2013). A similar trend was observed in the number of lateral shoots, which reached 11 in the conditions of the Ararat Valley in Armenia, compared to 8 in Belarus.

The analysis of the phenological stages for the two plant cultivars, Gorynych and Moldavia (Table 3) reveals minimal differences in their growth patterns. In particular, cv. Gorynych has a slightly faster emergence from sowing compared to cv. Moldavia and reaches flower-bud formation slightly earlier and progresses faster to mass flowering. As for flowering duration, the transition from flower-bud formation to mass flowering is quicker in cv. Gorynych, and it also matures seeds slightly sooner than cv. Moldavia. Both cultivars show similar durations for mass flower-bud formation and flower development, with only marginal differences in timing throughout their growth stages. In both varieties flowering continued until mid-August which is a good indicator of the melliferous potential (Ion et al., 2018) of *Dracocephalum moldavica* when cultivated in valley conditions of Armenia.

In general, the duration of the growing season with seedling cultivation in two cultivars was 155–160 days. The longer growing season observed in the local conditions compared to regions with shorter summers (Egorova, 2017; Ovechko et al., 2001) is justified by the extended favourable environmental conditions in the Ararat Valley. The local climate likely supports a longer

growth period, allowing plants to fully develop from seedlings to maturity (Sripathy and Groot, 2023). This extended period is beneficial for optimizing plant growth and yield (Hazrati et al, 2024; Brukhin and Morozova, 2011) in specific conditions of the Republic.

The study demonstrates that both cultivars, Gorynych and Moldavia, can be successfully cultivated in Armenia, passing all phenological stages and forming fully developed, mature seeds. The long growing season enhances their development and melliferous potential, providing a strong foundation for maximizing productivity (Yadav et al., 2023).

Conclusions

The analysis of national records and genebank data reveals a significant presence of genetic diversity for *Dracocephalum moldavica*, particularly in Ukraine, Bulgaria, Hungary, Romania, and Slovakia, while other regions show fewer accessions, suggesting gaps in conservation efforts. Notably, only 12 accessions were classified as 'advanced or improved cultivars,' limiting options for cultivar introduction to Armenia. Overall, the analysis of germplasm availability, accession origin data, MLS status, as well as characterization and evaluation data, highlights significant gaps in conservation and research attention for this plant. Experimental trials indicate that both Gorynych and Moldavia cultivars are well-suited to the climatic conditions of Armenia's Ararat Valley. Both cultivars demonstrated similar growth patterns, with only minor differences in growth stages, plant height, inflorescence size, and leaf dimensions. Cv. Gorynych exhibited slightly taller plants and larger inflorescences, while Moldavia had slightly larger floral dimensions. The growing season for both cultivars lasted 155–160 days, which is longer than observed in regions with shorter summers, likely due to the favourable local climate. Overall, both cultivars show strong potential for introduction to Armenia, with their minimal differences offering flexibility in selection based on specific local conditions. Further research will focus on evaluating their melliferous potential and their content of essential oils and biologically active substances, which are crucial for their broader application.

Conflict of interest

The authors have no conflicts of interest to declare.

Ethical statement

This article doesn't contain any studies that would require an ethical statement.

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References

Aćimović, M., Sikora, V., Brdar-Jokanović, M., Kiprovski, B., Popović, V., Koren, A., & Puvača, N. 2019. *Dracocephalum moldavica*: Cultivation, chemical composition and biological activity. In *Journal of Agronomy, Technology and Engineering Management*, 2(1), 153–167.

Aprotosoaie, A.C., Mihai, C.T., Vochita, G., Rotinberg, P., Trifan, A., Luca, S.V., Petreus, T., Gille, E., & Miron, A. 2016. Antigentoxic and antioxidant activities of polyphenolic extract from European *Dracocephalum moldavica* L. In *Industrial Crops and Products*, 79, 248–257.

Borghei, S.F., Azizi, A., Hadian, J., & Abdosi, V. 2015. Broad variation in herbage yield and essential oil content among Iranian landraces of *Dracocephalum moldavica*. In *Biological Forum - an International Journal*, 7, 1568–1574.

Bijani, F., & Madandoust, M. 2023. Comparison of chemical composition and biological activities of *Dracocephalum moldavica* L. shoots in different regions of Fars (Southern Iran). In *Journal of Essential Oil Bearing Plants*, 26(2), 378–385. http://dx.doi.org/10.1080/0972060X.2023.2187263

Brukhin, V., Morozova, N. 2011. Plant Growth and Development Basic Knowledge and Current Views. In *Math. Model. Nat. Phenom.* Vol. 6 (2), pp. 1-53. https://doi.org/10.1051/mmnp/20116201

Dmitruk, M., Weryszko-Chmielewska, E., & Sulborska, A. 2018. Flowering and nectar secretion in two forms of the Moldavian dragonhead (*Dracocephalum moldavica* L.) – a plant with extraordinary apicultural potential. In *Journal of Apicultural Science*, 62, 97–109. https://doi.org/10.2478/JAS-2018-0010

Dziki, D., Cacak-Pietrzak, G., Gawlik-Dziki, U., Sułek, A., Kocira, S., & Biernacka, B. 2019. Effect of Moldavian dragonhead (*Dracocephalum moldavica* L.) leaves on the baking properties of wheat flour and quality of bread. In CyTA – *Journal of Food*, 17(1), 536–543. https://doi.org/10.1080/19476337.2019.1609587

Egorova, P.S. 2017. To the introduction of *Dracocephalum moldavica* l. (Moldavian draconhead) in the Yakut botanical garden. In *Bulletin of KrasSAU*, 5, 117–122. [In Russian]

Eong, K.S., Jang, C.S., Park, S.H., Lee, J.S., Yoon, S.M., Kim, T.H., Shin, C.H., & Choi, K. 2016. Two unrecorded naturalized plants in Korea: *Stachys agraria* and *Dracocephalum moldavica* (Lamiaceae). In *Korean Journal of* Plant Taxonomy, 46, 413–419.

FAO. 2008. a. State of Plant Genetic Resources for Food and Agriculture in Slovak Republic [online]. https://www.fao.org/4/i1500e/Slovakia.pdf

FAO. 2008.c. State of Plant Genetic Resources for Food and Agriculture in Ukraine [online]. https://www.fao.org/4/i1500e/Ukraine.pdf

FAO. 2008. b. State of Plant Genetic Resources for Food and Agriculture in Hungary [online]. https://www.fao.org/4/i1500e/Hungary.pdf

Flora of Armenia. 1987. Institute of Botany, Yerevan, 8, 419. [In Russian]

Fourth National Communication on Climate Change (4th NCC Armenia). 2020. Yerevan. UNDP Armenia, 213p.

Grjaznov, M.Yu., & Totskaya, S.A. 2019. *Dracocephalum moldavica* L. new variety of breeding of VILAR. In *Vegetable crops of Russia*, 3, 65–67. https://doi.org/10.18619/2072-9146-2019-3-65-67[In Russian]

Hazrati, S., Mousavi, Z., Nicola, S., 2024. Harvest time optimization for medicinal and aromatic plant secondary metabolites. In *Plant Physiology and Biochemistry*, v. 212, https://doi.org/10.1016/j.plaphy.2024.108735

Hegazy, M.H., Alzuaibr, F.M.A., Mahmoud, A.A., Mohamed, H.F.Y., & Ahl, H.A.S.A. 2016. The effects of zinc application and cutting on growth, herb, essential oil and flavonoids in three medicinal Lamiaceae plants. In *European Journal of Medicinal Plants*, 12(3), 1–12. http://dx.doi.org/10.9734/EJMP/2016/23589

Hirokazu T. 2005. Leaf shape: genetic controls and environmental factors. In Int. J. Dev. Biol. 49: 547-555 https://doi.org/10.1387/ijdb.041921ht

Ion N., Odoux J.F., Vaissière B. 2018. Melliferous potential of weedy herbaceous plants in crop fields of Romania from 1949 to 2012. In *Journal of Apicultural Science*, 62 (2), pp.149-165. https://doi.org/10.2478/jas-2018-0017

Kotyuk, L.A., & Rakhmetov, D.B. 2017. Component composition of essential oil from *Dracocephalum moldavica* L. grown in the Ukrainian polissya. In *Proceedings of International Scientific Symposium "Conservation of Plant Diversity"*, Chisinau.

Loginov V.F. 2000. Reasons and consequences of climate changes in Belarus. Acta Agroph. 26, 255-274

Marden, E., Hamilton R., Halewood M., McCouch S. 2023. International agreements and the plant genetics research community: A guide to practice. In *Proc Nat Acad Sci USA.* 120 (14) https://doi.org/10.1073/pnas.220577311

Moldovan, C., Nițu, S., Hermeziu, M., Vidican, R., Sandor, M., Gâdea, Ș., David, A., Stoian, V.A., Vâtcă, S.D., & Stoian, V. 2022. Growth characteristics of *Dracocephalum moldavica* L. in relation to density for sustainable cropping technology development. In *Agriculture*, 12(6), 789. https://doi.org/10.3390/agriculture12060789

Morrison, C., Humphries, F., Lawson, Ch. 2021. A Regional Review of Genetic Resource Access and Benefit Sharing: Key Issues and Research Gaps. In *Environmental Policy and Law,* 51(5), pp. 273-296. https://doi.org/10.3233/EPL-201028

Nortcliff, S., Gregory P.J. 2013. The historical development of studies on soil–plant interactions. In *Soil Conditions and Plant Growth,* Blackwell Publishing Ltd. https://doi.org/10.1002/9781118337295.ch1

Ovechko, S.V., Svidenko, L.V., & Rabotyagov, V.D. 2001. Biology of growth and development *Dracocephalum moldavica L.* in conditions of steppe zone on the south of Ukraine. In *Introduction of Plants*, 3–4, 71–73.

Popova, O.I., Nikitina, A.S., & Markova, O.M. 2008. Studies of iridoids from *Dracocephalum moldavica* cultivated in the Stavropol Region. In *Pharmaceutical Chemistry Journal*, 42, 351–353. https://doi.org/0091-150X/08/4206-0351

Simea, Ș., Ielciu, I., Hanganu, D., Niculae, M., Pall, E., Burtescu, R.F., Olah, N.K., Cenariu, M., Oniga, I., Benedec, D., & Duda, M. 2023. Evaluation of the cytotoxic, antioxidative and antimicrobial effects of *Dracocephalum moldavica* L. cultivars. In *Molecules*, 28(4), 1604. https://doi.org/10.3390/molecules28041604

Sripathy, K.V., Groot, S.P.C. 2023. Seed Development and Maturation. In: *Seed Science and Technology.* Springer, https://doi.org/10.1007/978-981-19-5888-5_2

Schubert, M., Michelsen, N., Schmidt, A. *et al.* 2021. Age and origin of groundwater resources in the Ararat Valley, Armenia: a baseline study applying hydrogeochemistry and environmental tracers. In *Hydrogeol J* 29, 2517–2527 https://doi.org/10.1007/s10040-021-02390-4

Weremczuk-Jeżyna, I., Gonciarz, W., & Grzegorczyk-Karolak, I. 2023. Antioxidant and anti-inflammatory activities of phenolic acid-rich extract from hairy roots of *Dracocephalum moldavica*. In *Molecules*, 28(19), 6759. https://doi.org/10.3390/molecules28196759

Wojtowicz, A., Oniszczuk, A., Oniszczuk, T., Kocira, S., Wojtunik, K., Mitrus, M., Kocira, A., Widelski, J., & Skalicka-Wozniak, K. 2017. Application of Moldavian dragonhead (*Dracocephalum moldavica* L.) leaves addition as a functional component of nutritionally valuable corn snacks. In *Journal of Food Science and Technology*, 54, 3218–3229. https://doi.org/10.1007%2Fs13197-017-2765-7

Yadav, D., Yadav, A., Singh, M. et al. 2023. Cultivation of aromatic plant for nature-based sustainable solutions for the management of degraded/marginal lands: techno-economics and carbon dynamic. In *Carbon Res.* 2, 27 https://doi.org/10.1007/s44246-023-00055-3

Zhan, M., Ma, M., Mo, X., Zhang, Y., Li T., Yang, Y., & Dong, L. 2024. *Dracocephalum moldavica* L.: An updated comprehensive review of its botany, traditional uses, phytochemistry, pharmacology, and application aspects, In *Fitoterapia*, 172. https://doi.org/10.1016/j.fitote.2023.105732.