

Comparative study on the performance of five lavender genotypes cultivated in the conditions of the west of the country, the perimeter of the Mănăştur locality, Arad County

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Abstract

The paper presents a comparative study on floral productivity, drying yield, and distillation process efficiency in five lavender cultivars belonging to the species *Lavandula angustifolia* Mill. and *Lavandula x intermedia*, cultivated in the locality of Mănăştur. The study was conducted to identify cultivars with the best agronomic and technological potential. The research aimed to evaluate the technological performance of the cultivars “Munstead”, “Miss Katherine”, “Silver Mist”, “Grosso”, and “Edelweiss” to identify the most productive and stable sources of raw material for obtaining essential oils. The experiment was carried out in the second year of vegetation (2024) using a randomized block design with three replications. Fresh and dry floral mass, drying yield, and distillation yield were determined, and the data were statistically analyzed using the ANOVA method. The results revealed significant differences between cultivars. *L. x intermedia* “Grosso” and “Edelweiss”, which are hybrids, recorded the highest floral productions (≈6.5–6.9 t/ha fresh and 1.9–2.1 t/ha dry), with a drying yield of about 30%, while the *L. angustifolia* cultivars had moderate values (≈3.1–4.6 t/ha fresh and 0.9–1.2 t/ha dry), but a superior quality of the inflorescences. In the distillation process, the essential oil yield ranged from 1.3% to 1.7% for fresh flowers and from 2.2% to 3.6% for dried flowers, with the highest value recorded for the “Edelweiss” cultivar (3.64%). The hybrids were distinguished by superior extraction efficiency, more intense oil color, and high aromatic stability.

The results confirm the technological potential of the *Lavandula x intermedia* cultivars “Grosso” and “Edelweiss” for commercial cultivation and the relevance of *L. angustifolia* cultivars for producing premium-quality essential oils, contributing to the strategic orientation of lavender cultivation in western Romania.

Keywords: essential oil, yield, drying ratio, cultivars, *Lavandula x intermedia*, agronomic characteristics

Introduction

Aromatic plants of the genus *Lavandula*, native to the Mediterranean basin, are now widely cultivated in many regions of the world [4], [5], [8], [14], [15]. This genus belongs to the family Lamiaceae and comprises approximately 39 species and nearly 400 cultivars, including both herbaceous and semi-shrub forms, as well as annual and perennial species [4], [5], [8], [14], [15]. Among the most representative species are *Lavandula angustifolia* Mill. (true lavender), *Lavandula latifolia* L. (spiked lavender), and the sterile hybrid *Lavandula x intermedia* “Grosso”, resulting from the cross between *L. angustifolia* and *L. latifolia* [4], [5], [8], [10], [11].

Lavender (*Lavandula* spp.) is one of the most valuable aromatic and medicinal plants cultivated worldwide, appreciated for its high ecological adaptability, rich essential oil content, and versatility in industrial applications [1], [2], [8], [9], [12]. The essential oil extracted from lavender flowers is a natural resource of great economic importance, widely used in cosmetics, perfumery, food, and pharmaceutical industries, due to its antimicrobial, antioxidant, anti-inflammatory, and soothing properties [1], [2], [4], [7], [11], [12], [13]. Multiple studies confirm the multifunctional properties of lavender essential oil, supporting its extensive use in cosmetics and therapeutics.

Romania has particularly favorable pedoclimatic conditions for lavender cultivation, especially in the plain and hill areas, where the thermal and precipitation regimes support the optimal accumulation of secondary metabolites [3] (Charbonneau, 2020) to support the part on optimal pedoclimatic conditions for lavender. Where the thermal and precipitation regimes support the optimal accumulation of secondary metabolites. In the last two decades, interest in developing lavender plantations has grown steadily [3], [6], [10], stimulated by the increasing demand for natural essential oils and the potential for processing flowers into artisanal, cosmetic, and phytotherapeutic products.

Hybrid lavender (*Lavandula* × *intermedia*) stands out for its vigorous growth, increased hardiness, and higher productivity than true lavender (*Lavandula angustifolia*). Due to these characteristics, intermediate hybrids are frequently recommended for large-scale commercial crops [5], [12], especially in areas with variable pedoclimatic conditions.

Although lavender is cultivated intensively in various regions of Europe, data on the agronomic performance and technological yield of cultivars grown in western Romania are limited [5], [6]. Recent comparative studies on the adaptability and essential oil content of different cultivars are relatively few, which justifies the need for an experimental evaluation under local pedoclimatic conditions. Among the cultivated cultivars, “Grosso” is considered one of the best performing, appreciated for its rich inflorescences, high essential oil content, and good adaptability to the moderate continental climate specific to Romania. In native crops, “Grosso” is grown with consistent results in hilly and lowland areas, offering high yields in both fresh and dried flowers. Another hybrid of *L. × intermedia*, “Edelweiss”, is distinguished by its delicate fragrance and balanced content of linalool and linalyl acetate [12], being suitable for cosmetic and aromatherapeutic uses. In contrast, *L. angustifolia* cultivars such as “Munstead”, “Miss Katherine”, and “Silver Mist” have a smoother, floral fragrance and a higher ester content [5], [12] but somewhat lower floral yields compared to intermediate hybrids. However, these cultivars are preferred in small-scale crops and ornamental gardens due to their compact habit, varied inflorescence colors, and good frost resistance. Thus, depending on the purpose of the crop—essential oil production, ornamental use, or artisanal processing—different cultivars can be recommended: “Grosso” and “Edelweiss” for intensive production, and “Munstead”, “Miss Katherine”, and “Silver Mist” for niche or decorative cultivation.

The present study aims to compare the floral yield, drying yield, and efficiency of the distillation process in five lavender cultivars belonging to *Lavandula angustifolia* and *Lavandula × intermedia*. The research aimed to identify the cultivars with the best agronomic and technological potential in the pedoclimatic conditions of the Western Plain of Romania. Due to their rich content in volatile compounds such as linalool, linalyl acetate, camphor, lavandulyl acetate, and lavandulol [4], [12], *Lavandula* species are among the most important aromatic plants cultivated in Europe. Essential oils and resins extracted from their flowers are widely used in perfume, cosmetics, the pharmaceutical industry, and products with antiseptic and insecticidal properties.

The results obtained contribute to substantiating recommendations on the choice of lavender cultivars with superior potential for commercial crops and for obtaining high-quality essential oils. At the same time, the study provides useful data for the valorization of local genetic resources and the expansion of aromatic crops in western Romania.

Materials and Methods

Experimental conditions. The study was conducted in Mănăştur, Arad County (46°00'37.3" N; 21°07'20.2" E), located in the Western Plain of Romania. The biological material originated from a crop of *Lavandula angustifolia* and *Lavandula × intermedia* (Figure 1).

The area is characterized by a moderate continental climate with warm summers and mild winters. The average annual temperature is around 10.5–11°C, and annual rainfall is between 500–600 mm. In 2024, the thermal regime was favorable, with hot summers (25–30°C) and moderate rainfall, the highest values being recorded in May–July. The prevailing winds were west-northwest, and the relative humidity varied between 40–85%. The soil in the experimental perimeter is a well-structured, clayey chernozeme with a clayey texture, good drainage, and moderate fertility. The experimental field is located on a slightly southern slope, which ensures excellent exposure to solar radiation, an important factor for the accumulation of aromatic compounds.



Figure 1. Lavender field (second year of vegetation) – the source of the plant material used in the experiment. (source)

The lavender crops were in the second year of vegetation, maintained by mechanical pruning works and without the application of chemical treatments. These climatic and agroecological conditions favored the optimal development of the inflorescences and the accumulation of volatile compounds specific to the genus *Lavandula*.

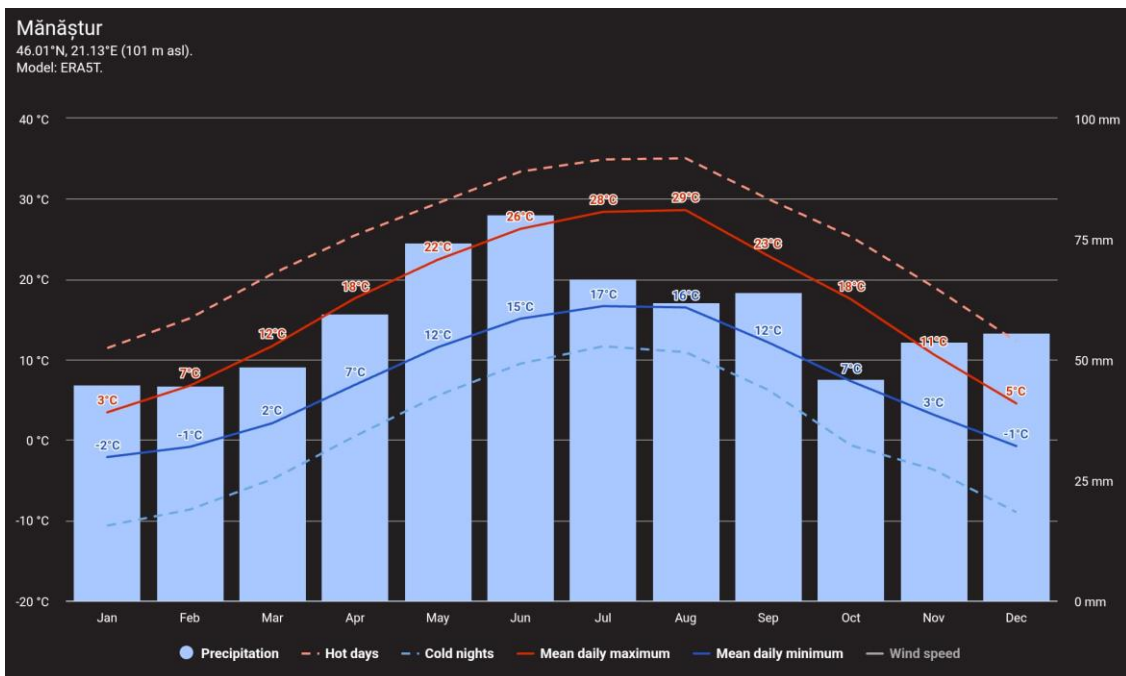


Figure 2. Climate data for the experimental year 2024 (minimum temperatures, maximums, and average monthly rainfall)

Agrochemical characterization of soil. The agrochemical analyses were performed on a representative soil sample taken from the 0–30 cm horizon within the experimental area where the lavender crop was established. The soil was identified as a weakly acidic clay chernozem with a loamy-clay texture, moderate

fertility, and high macroelement content, typical of the Western Plain of Romania. The determined agrochemical parameters are presented in Table 1.

Table 1. Agrochemical characterization of the soil – (0–30 cm)

Indicator	Determined value	Reference range	Classification
pH (H ₂ O)	5.49	5.01–5.80 = moderately acid	moderately acid
Mineral nitrogen (NO ₃ ⁻ + NH ₄ ⁺ , mg/kg)	19.94	<20 = very low	very low
Available phosphorus (P ₂ O ₅ , mg/kg)	216.79	>144 = excessive	excessive
Exchangeable potassium (K ₂ O, mg/kg)	260.99	200–265 = good	good (upper level)
Exchangeable calcium (CaO, mg/kg)	3917.7	>2500 = high	high
Exchangeable magnesium (MgO, mg/kg)	1513.5	>600 = high	high
Exchangeable sodium (Na ₂ O, mg/kg)	18.94	<50 = normal	normal
Available sulfur (S, mg/kg)	13.29	>10 = good	good

The soil in the experimental area was identified as a moderately acidic argic chernozem, characterized by a loamy texture and good structural stability. The nutrient analysis indicates a very low nitrogen content, but high to excessive levels of phosphorus, potassium, calcium, and magnesium, which reflect a naturally fertile soil well suited for aromatic and medicinal plants. The moderate acidity and balanced nutrient supply create favorable conditions for lavender growth and essential oil biosynthesis.

Plant material (Cultivars). The selection of lavender cultivars was based on their frequency in commercial crops and on the representative morphological and technological differences between *L. angustifolia* and *L. x intermedia*.

For this study, five representative cultivars were selected:

Lavandula angustifolia “Munstead”

Lavandula angustifolia “Silver Mist”

Lavandula angustifolia “Miss Katherine” (pink)

Lavandula x intermedia “Grosso” (lavandin)

Lavandula x intermedia “Edelweiss” (white)

The experiment was carried out in an experimental lavender field arranged in an orderly system, with rows covered by agrotexile film (Agril type) for weed control and moisture conservation. Each cultivar was represented by 16 plants, forming an experimental unit, with three replicates arranged in parallel blocks.

The plants were individually labeled for cultivar identification. Planting distances were 0.5 m between plants and 1.2 m between rows (0.6 m for hybrids). The experiment took place in 2024, corresponding to the second year of vegetation, when the plants entered the active production phase. Maintenance was done manually, and no pests or diseases were recorded.

These cultivars were selected to compare adaptability and flower yield under the pedoclimatic conditions of the Western Plain of Romania.

Determination of quantitative and qualitative indicators. The inflorescences were harvested manually during full flowering (July), in the morning hours after dew evaporation, to ensure optimal volatile oil content. For each cultivar, flowers were harvested from 16 bushes (one experimental unit), with three replications. The fresh flower mass was determined immediately after harvesting, and the dried flower mass was established after drying in a well-ventilated space at a constant temperature of 25–28°C, until a stable weight was reached. Drying was considered complete when successive weight differences were below 0.1 g. The drying yield (Ru, %) was calculated to express the ratio between the mass of dried flowers and the mass of fresh flowers, according to the following formula:

$$Ru(\%) = \frac{M_u}{M_p} \times 100$$

where:

M_u – represents the mass of dried flowers (kg),

M_p – represents the mass of fresh flowers (kg).

Thus, the drying yield indicates the percentage of dry material remaining after the complete removal of moisture from the harvested flowers.

The essential oil yield was determined by steam distillation using an 80 L still. Each cultivar was distilled for 4 hours, both fresh and dried flowers (10–12% residual humidity). The oil was separated using a separation funnel, measured volumetrically, and reported to the average flower yield (L/ha).

These determinations allowed the comparison of technological efficiency among cultivars and highlighted their potential as sources of high-quality raw material for essential oil extraction.

Results and discussion

Floral productivity - Fresh flowers

The determinations carried out in the second year of vegetation allowed the evaluation of the floral productivity of five lavender cultivars under the pedoclimatic conditions of western Romania.

In the first year of vegetation, the plants allocate resources to root system development, with flower production accounting for only 10–30% of the potential (about 50–100 g of flowers per plant). In the second year, lavender enters the active production phase, reaching 150–300 g of flowers per plant, and in years 3–5, the maximum yields of 400–800 g per plant are achieved, depending on the cultivar and cultivation technology.

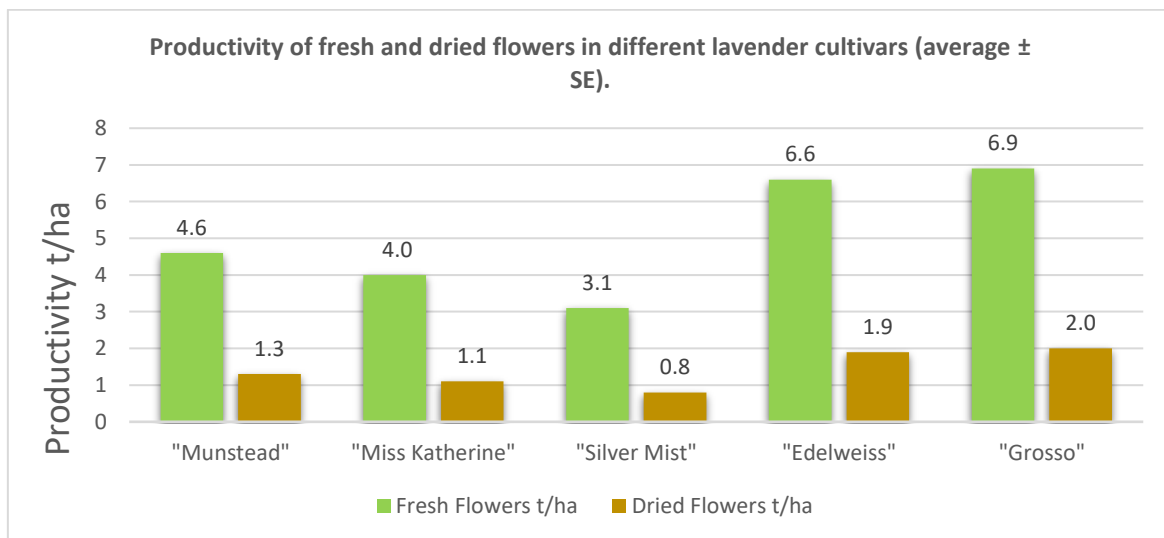
The number of flowers harvested from lavender plants in the second year of vegetation depends on several factors — cultivar, planting density, fertilization, irrigation, climatic conditions, and maintenance. In year two, the plants enter the active production phase — flower production increases significantly, reaching 60–80% of the maximum potential. These observations provided the foundation for assessing the floral productivity of the analyzed cultivars.

Determination of fresh floral productivity

Floral productivity was determined for each lavender cultivar by weighing the fresh flowers harvested from 16 plants constituting an experimental unit. For each cultivar, three replications were performed, allowing the calculation of representative mean values and the estimation of variability among repetitions.

The data obtained were statistically analyzed using the ANOVA method, and the differences between cultivars were considered significant at a confidence level of $p < 0.05$. The mass of fresh flowers was measured immediately after harvesting using a precision scale.

The results were expressed in kilograms per plot (16 plants) and related to the average mass per plant (g) and the estimated production per hectare (t/ha), considering a planting density of 13,900–16,600 plants/ha, depending on the cultivar. The determinations were performed under uniform harvesting conditions (phenological stage 70–75% open inflorescences, 11:00–13:00, sunny weather) to ensure comparable volatile oil content. The results are shown in Figures 3 and 4, highlighting differences in floral productivity between lavender cultivars.

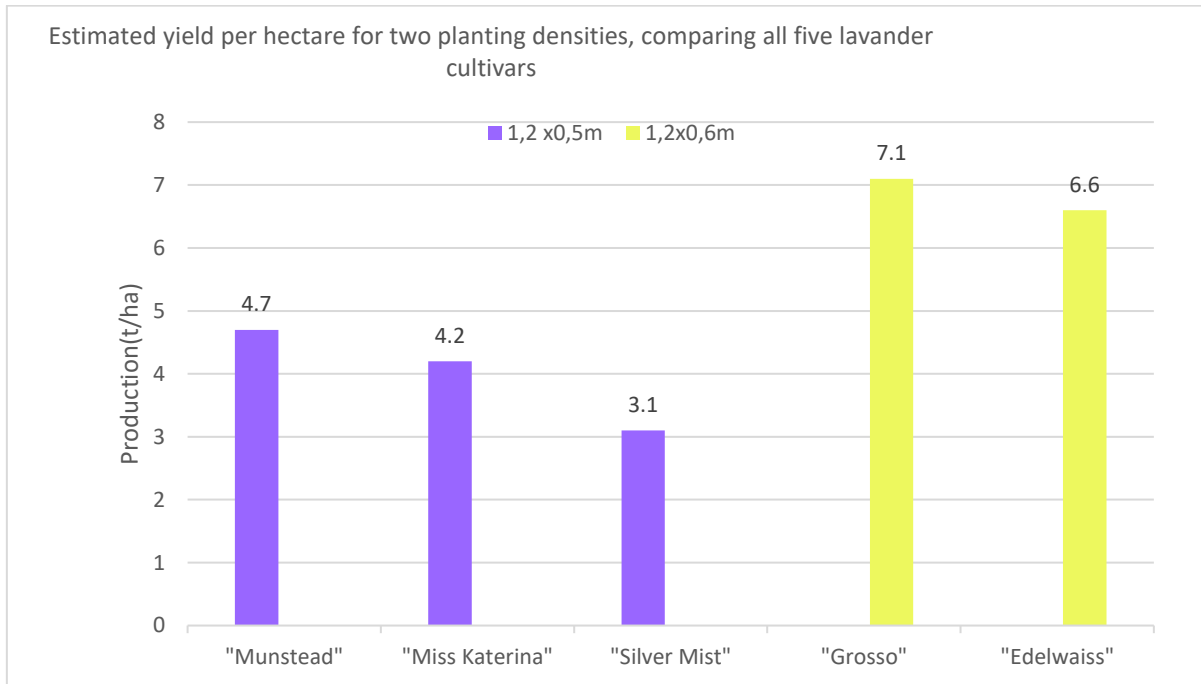


Type of flower	"Munstead"	"Miss Katerina"	"Silver Mist"	"Grosso"	"Edelwaiss"
Fresh t/ha	4,6 ± 0,3	4,0 ± 0,2	3,1 ± 0,6	6,6 ± 0,55	6,9 ± 0,4
Dried t/ha	1,3 ± 0,20	1,1 ± 0,4	0,8 ± 0,31	1,9 ± 0,8	2,0 ± 0,6

Figure 3. Productivity of fresh and dried flowers in different lavender cultivars (average ± SE).

The hybrid cultivars (“Grosso” and “Edelweiss”) recorded the highest values for both fresh and dried flower production, confirming their superior agronomic potential. On the other hand, the *L. angustifolia* cultivars (“Munstead”, “Miss Katherine”, and “Silver Mist”) had lower yields but comparable drying ratios (26–30%), indicating good adaptation for producing high-quality raw material.

It is observed that *Lavandula x intermedia* cultivars (“Grosso” and “Edelweiss”) recorded significantly higher yields compared to the *L. angustifolia* cultivars, with estimated values between 6.5–7.1 t/ha for fresh flowers and 1.9–2.0 t/ha for dried flowers (Figure 4).



crop density	"Munstead"	"Miss Katerina"	"Silver Mist"	"Grosso"	"Edelwaiss"
1,2 x 0,5	4,7 ± 1.15	4,2 ± 1.20	3,1 ± 0.81	-	-
1,2 x 0,6	-	-	-	7,1 ± 2.35	6,6 ± 2.10

Figure 4. Estimated yield per hectare for two planting densities, comparing all five lavender cultivars.

Comparative analysis of fresh flower productivity shows significant differences among the cultivars studied. The *Lavandula x intermedia* hybrids (“Grosso” and “Edelweiss”) recorded the highest yields, exceeding 6 t/ha, while *L. angustifolia* cultivars (“Munstead”, “Miss Katherine”, and “Silver Mist”) showed lower values, between 3.1 and 4.7 t/ha. Planting density also influenced production, as higher density ensured increased yields. These results confirm the agronomic superiority of *Lavandula x intermedia* hybrids and highlight the variability of productivity depending on cultivar, an essential criterion for selecting genotypes adapted to western Romania’s conditions.

Determining the Distillation Yield of Essential Oil

Essential oil yield was determined by steam distillation using a still-type apparatus with an 80 L capacity. Each distillation lasted 4 hours for the total floral mass of each cultivar. The distillation process and the experimental equipment used are illustrated in Figure 5.



Figure 5. Experimental process of lavender essential oil extraction, showing the distillation equipment, oil separation, and final oil samples obtained from different cultivars.

Distillations were performed on both fresh and dried flowers under the same technological conditions to assess the effect of moisture content on oil yield. Dried plant material was brought to a residual humidity of about 10–12%. The resulting essential oil was separated from the aqueous phase using a separatory funnel, collected, measured volumetrically, and expressed as liters of oil per hectare.

Table 2. Essential oil yield (L/ha) obtained from fresh flowers of five lavender cultivars

Crt. no.	Cultivar	Material condition	Plant weight (kg)	Oil volume (ml)	Yield per 1kg flower (ml)	Oil quantity(L/ha)
1	„Munstead”	Fresh	4,5	66	14,666	68,8
2	„Miss Katerina”	Fresh	2,9	45	15,517	64,6
3	„Grosso”	Fresh	4,0	59	14,750	102,9
4	„Edelwaiss”	Fresh	3,2	55	17,187	112,4
5	„Silver Mist”	Fresh	2,5	33	13,200	41,1

Table 3. Essential oil yield (L/ha) obtained from dried flowers of five lavender cultivars

Crt. no.	Cultivar	Material condition	Plant weight (kg)	Oil volume (ml)	Yield per 1 kg flower (ml)	Oil quantity(L/ha)
1	„Munstead”	Dry	2,6	62	23,846	29,8
2	„Miss Katerina”	Dry	2,0	45	22,500	26,3
3	„Grosso”	Dry	2,1	51	24,285	50,1
4	„Edelwaiss”	Dry	1,1	40	36,363	60,7
5	„Silver Mist”	Dry	1,2	25	20,833	32,5

The values represent the average of three repetitions \pm the standard error.

The flowers were dried to a residual humidity of 10–12%, then distilled under the same technological conditions (still 80 L, duration 4 hours).

Differences between genotypes are significant at $p < 0.05$ (ANOVA test).

The essential oil yield varied significantly between cultivars, both for fresh and dried flowers, confirming the genetic influence on extraction efficiency. The hybrids “Edelwaiss” and “Grosso” recorded the highest oil yields, exceeding 100 L/ha for fresh flowers and 50–60 L/ha for dried flowers. *L. angustifolia* cultivars had lower yields (25–70 L/ha) but are appreciated for the purity and fine fragrance of the oil obtained. These differences highlight the economic advantage of *Lavandula x intermedia* hybrids for large-scale crops, while

L. Angustifolia cultivars remain valuable sources of premium-quality essential oils for cosmetic and pharmaceutical applications.

Conclusions

The comparative analysis of the five lavender cultivars (*Lavandula angustifolia* and *Lavandula × intermedia*) cultivated under the pedoclimatic conditions of western Romania revealed significant differences in floral productivity, drying yield, and essential oil extraction efficiency (present study).

The hybrid cultivars ‘Grosso’ and ‘Edelweiss’ stood out with the highest yields, exceeding 6 t/ha of fresh flowers and over 100 L/ha of essential oil, confirming their technological potential for large-scale commercial crops [5], [12].

The *L. angustifolia* cultivars “Munstead”, “Miss Katherine”, and “Silver Mist” recorded lower floral yields but produced essential oils of superior quality, with a fine fragrance and balanced volatile composition [4],[11], [12], [13], suitable for premium cosmetic and aromatherapeutic applications.

These findings confirm that both hybrid and true lavender cultivars have distinct production advantages that can be strategically exploited according to cultivation goals — productivity for industrial crops versus quality for high-value essential oils.

From an applied perspective, the results provide practical recommendations for lavender growers in western Romania, indicating that hybrid cultivars ensure better yields under variable climatic conditions [5], [12], while *L. angustifolia* cultivars remain valuable for specialized, high-quality production systems.

Future studies should focus on the chemical profiling of essential oils and the long-term stability of yield and composition under climate variability, to optimize cultivar selection and technological processes for sustainable lavender cultivation [4],[11], [12], [13].

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