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HISTO-ANATOMICAL AND MICROMORPHOLOGICAL MODIFICATIONS OF THE STEM AND LEAVES IN FOUR CULTIVARS OF *LAVANDULA ANGUSTIFOLIA* MILL. SUPPLEMENTED WITH HOAGLAND NUTRIENT SOLUTION

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Abstract: This paper presents the histo-anatomical and micromorphological characteristics of the stem and leaves of four cultivars of *Lavandula angustifolia* Mill. (`Codreanca`, `Provence Blue`, `Vera` and `Sevtopolis`) that were supplemented with Hoagland nutrient solution. This study aimed to assess the structural differences between the cultivars and the experimental variant using color photographs acquired from optical microscopy and scanning electron microscopy (SEM) observations. The stem investigations showed that there is contour variation among the cultivars and the epidermis and bark tend to exfoliate, due to the formation of a suber in the depth of the bark. The cross-sections through the leaf blade highlights a midrib vein that contains a singular vascular bundle of collateral type formed from xylem and phloem, and numerous smaller lateral vascular bundles, that vary among the cultivars. The SEM micrographs on the surface of the leaf blade, showed differential densities and types of the protective and secretory hairs.

Keywords: *Lavandula angustifolia*, histo-anatomy, optical microscopy, scanning electronic microscopy (SEM), trichome density, Hoagland nutrient solution.

INTRODUCTION

Lavandula angustifolia Mill. species belongs to the *Lamiaceae* family of the *Lamiales* order (Upson, 2002; Upson *et al*., 2004). Lavender is a valuable cultivated medicinal plant native to the Mediterranean Basin, but also grows spontaneously in France, Italy, Spain and North Africa (Zhao *et al*., 2015).

Lavandula angustifolia is a plant cultivated at industrial scale used in agriculture (Tomescu *et al*., 2015) for products, such as honey (Estevinho *et al*., 2016), and has various uses: medicinal (Firoozeei *et al*., 2021; Shahdadi *et al*., 2017), aromatic (Cavanagh *et al*., 2002; Zuzarte *et al*., 2010; Hassanpouraghdam *et al*., 2011; Woronuk *et al*., 2011; Prusinowska *et al*., 2014; Lesage-Meessen *et al*., 2015), cosmetic industry and ornamental (Dragovic, 2015; van Oost *et al*., 2021). As products used in industries, we have the flowers (*Lavandulae flos*), represented by the dried flowers of *Lavandula angustifolia* Mill. as well as volatile oil (*Lavandulae atheroleum*), defined as the essential oil obtained by steam distillation from the flowering tops of *L. angustifolia* (European pharmacopoeia 10th, 2019).

Species of the *Lavandula* genus have been extensively studied from a histo-anatomic perspective (Toma *et al*., 1982; Nikolakaki *et al*., 2006; Robu *et al*., 2011; do Rocio Duarte *et al*., 2014; Lungu *et al*., 2014; Riva *et al*., 2014; Brailko *et al*., 2017; Fakhriddinova *et al*., 2020; Tanase *et al*., 2020; Ștefan *et al*., 2021) and from a micromorphological point of view by characterization of the glandular and protective trichomes (Huang *et al*., 2005; Iriti *et al*., 2006; Huang *et al*., 2008; Zuzarte *et al*., 2010; Giuliani *et al*., 2020; Ștefan *et al*., 2021), giving some specific taxonomic features for identification.

There have been made cultivation (Economakis *et al*., 2002; Chrysargyris *et al*., 2016) and utility studies (Salehi *et al*., 2018; Zhao *et al*., 2015; Ciocarlan *et al*., 2021; Mushtaq *et al*., 2021), as well as investigations on the chemical composition of the essential oil (EO) and methods to improve the oil production (Mulder-Krieger *et al*., 1988; Lis-Balchin, 2002; Urwin *et al*., 2008; Prins *et al*., 2010; Zuzarte *et al*., 2010; Hassanpouraghdam *et al*., 2011; Woronuk *et al*., 2011; Herraiz-Peñalver *et al*., 2013; Lesage-Meessen *et al*., 2015; Tomescu *et al*., 2015; Erland *et al*., 2016; el Hamdaoui *et al*., 2018; Segura *et al*., 2019; Ciocarlan *et al*., 2021).

Due to the favorable pedo-climatic conditions in Romania, *Lavandula angustifolia* cultivars have the advantage of being very suitable for the production of lavender oil, one of the main products that can be obtained and used. The oil extracted from this species is very well evaluated and highly appreciated by perfume manufacturers and pharmaceutical companies due to the essential elements that make it up (Jianu *et al*., 2013; Mihalașcu *et al*., 2020; Oroian *et al*., 2019; Robu *et al*., 2012).

The average production is between 3.5 - 4.5 tons/ ha, sometimes even more, which makes it possible to obtain 15 - 50 liters of essential oil per acre due to the high percentage of oil.

Considering the above-mentioned aspects, the study aims to assess by comparison the histo-anatomical and micromorphological differences between the four cultivars of *Lavandula angustifolia* and the experimental variants by optical microscope and SEM analysis of the stem and leaves.

MATERIALS AND METHODS

Plant material and experimental protocol

The plant material was provided by local producers in Vorona, Botoșani county, Satu Nou, Vrancea county and Sânpaul, Cluj county. from specimens grown in

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cultures from Romania for oil production as seen in Table 1 and identified in the Laboratory of Plant Morphology and Anatomy of the Faculty of Biology, Alexandru Ioan Cuza University of Iași.

The plant material consists of four varieties of *Lavandula angustifolia* Mill. (`Codreanca`, `Provence Blue`, `Vera` and `Sevtopolis`), grown in an unheated greenhouse in Romania, Vrancea county (coordinates 45°43′22″N 27°15′16″E). Voucher specimens are being kept at the Laboratory of Plant Morphology and Anatomy of the Faculty of Biology, Alexandru Ioan Cuza University of Iași.

To achieve the objectives proposed in this study, seedling of four varieties of *Lavandula angustifolia* and two experimental variants were used. Plants were planted in 5 L production pots in April 2018, containing a mixture of peat with perlite, in a ratio of 3: 1, and irrigated with water (v1) and for the experimental variant individuals were watered with Hoagland nutrient solution (v2) twice a month (Table 2) (Hoagland *et al*., 1950).

Table 1.

Species and cultivars used in the study

Species	Cultivars	Morphological description
Lavandula angustifolia Mill.	`Codreanca`	Is a Romanian variety of lavender, from the English varieties Hidcote, acclimatized by INCDA Fundulea, approved in 1992. The plants are of medium size, with dark purple inflorescence and have a high content of volatile oil. It's considered one of the best varieties for Romania's climatic conditions and is resistant to low temperatures and frost.
	`Provence Blue`	This cultivar has beautiful spikes of fragrant deep purple flowers with blue overtones rising above the foliage from early to late summer, extremely fragrant.
	`Vera`	This is a variety of English Lavender known for its sweetly fragrant oil, dark lavender-blue flower spikes, and compact growth habit. It's grown commercially for its essential oil.
	`Sevtopolis`	This cultivar is native to Bulgaria. It reaches a height of 40-60 cm and a width of 50-60 cm. It has long green-gray leaves and blue flowers and has a great commercial interest due to its high content in essential oils.

Table 2.

Hoagland nutrient solution (Hoagland *et al*., 1950)

Component	Stock solution [g/L]	Stock solution [ml/L]
Macronutrients		
2M KNO_3	202 g/L	2.5
2M $Ca(NO_3)_2 \cdot 4H_2O$	236 g/0.5 L	2.5
2M $MgSO_4 \cdot 7H_2O$	493 g/L	1
1M KH_2PO_4	136 g/L	1
Micronutrients		
H_3BO_3	2.86 g/L	1
$MnCl_2 \cdot 4H_2O$	1.81 g/L	1
$ZnSO_4 \cdot 7H_2O$	0.22 g/L	1
$CuSO_4 \cdot 5H_2O$	0.08 g/L	1
$H_2MoO_4 \cdot H_2O$	0.09 g/L	1
Iron		
Sprint 138 iron chelate	15 g/L	1.5

Optical microscopy

Plant material was collected from specimens while in bloom in June 2019 and the vegetative organs (leaf and stem) were fixed in 70% ethanol for anatomical studies. Cross sections of the material used for the study were carried out manually using a microtome and a botanical razor and double stained with iodine green and ruthenium red.

The sections were fixed in glycerol-gelatin and photographed using an Olympus BX51 photonic microscope using a Canon digital camera.

Scanning Electron Microscopy

The material used for this study consisted of fresh leaves prepared according to SEM techniques adapted to the standard techniques described by Bozzola *et al*., 1999. The leaves were dried to eliminate excess water. Small fragments were fixed on a carbon band and the fragments were then covered with a thin layer of gold particles. Samples were observed and photographed on a Tescan VEGA II SBH Scanning Electron Microscope, at the Electron Microscopy Laboratory of the Faculty of Biology, Alexandru Ioan Cuza University of Iași.

Trichome density

In this investigation, the type and frequency of glandular and non-glandular trichomes were examined on both leaf sides. The areas of leaves were measured from digital images and were analyzed by ImageJ software using Cell Counter plugin (Abràmoff *et al*., 2004). Trichome density was calculated by dividing the hair number by the leaf area (Gonzáles *et al*., 2008).

RESULTS AND DISCUSSIONS

Histo-Anatomical aspects of the lavender stem

At the stem level (Table 3 and Table 4), there are present all the layers and structures described in other anatomical studies of the *Lavandula angustifolia* (do Rocio Duarte *et al*., 2014; Fakhriddinova *et al*., 2020; Ștefan *et al*., 2021). In its upper third, the stem has a square contour in cross-section, with four very prominent ribs. Towards the base of the stem, the ribs attenuate, the epidermal cells in the ribs become much elongated tangentially, the elements of the collenchyma cords flatten much, the last layer of the bark dedifferentiates and gives a phellogen, which produces a thick suber and a few layers of small phelloderm cells; the cambium becomes inelar, so that from its activity results a thin ring of secondary phloem (with sieved tubes, attachment cells and parenchymal cells) and another sinuous ring composed of secondary xylem, thicker along the ribs (consisting of vessels, few parenchymal cells and a lot of libriform); the medullary rays at the level of the wood are sclerified and lignified, forming with it a continuous ring.

Table 3.

Histo-Anatomical aspects of the lavender stem on plants irrigated with water (v1)

Criteria	`Codreanca` (Fig. 1 - 1)	`Provence Blue` (Fig. 1 - 2)	`Vera` (Fig. 1 - 3)	`Sevtopolis` (Fig. 1 - 4)
Epidermis	- unilayered, with the tendency to exfoliate due to the formation of a subler in the depth of the bark due to the internal dedifferentiation of the phellogen, except for `Vera`, where although the suber is formed similarly to the other varieties, the epidermis has a longer persistence;			
Bark	- multilayered (4-6 layers) mainly parenchymal, in some places there are small islands of angular collenchyma; - the phellogen is deeply differentiated, which will immediately generate a multilayered suber that will cause the exfoliation of the tissues from its exterior; - the suber contains tannin;			
Central cylinder	- secondary wood has a lot of libriform and relatively few vessels; - all components are lignified; - the large amount of existing libriform is responsible for supporting the inflorescence, which can be rich and well supported up to the period of anthesis; - the elements from the periphery of the secondary phloem are colenchymatized (seeved tubes and adjacent cells);			
	- the pericycle is missing, with the consequence that the stems are more flexible;	- begins with a multi-layered pericycle grouped in islands with elements with uniformly thickened and lignified walls; - this pericycle will be exfoliated because it is outside the suber;		- the pericycle is missing, with the consequence that the stems are more flexible;
Pith	- for `Codreanca`, `Provence Blue` and `Sevtopolis` the pith has a square contour, persistent, parenchymal; - for the `Vera` cultivar, the pith has a hexagonal contour;			
Cross section outline	- square - rectangular, with slightly rounded corners;		- square, with angles of approximately 90 °;	- rounded (ovoid); - has few secretory and protective trichomes;

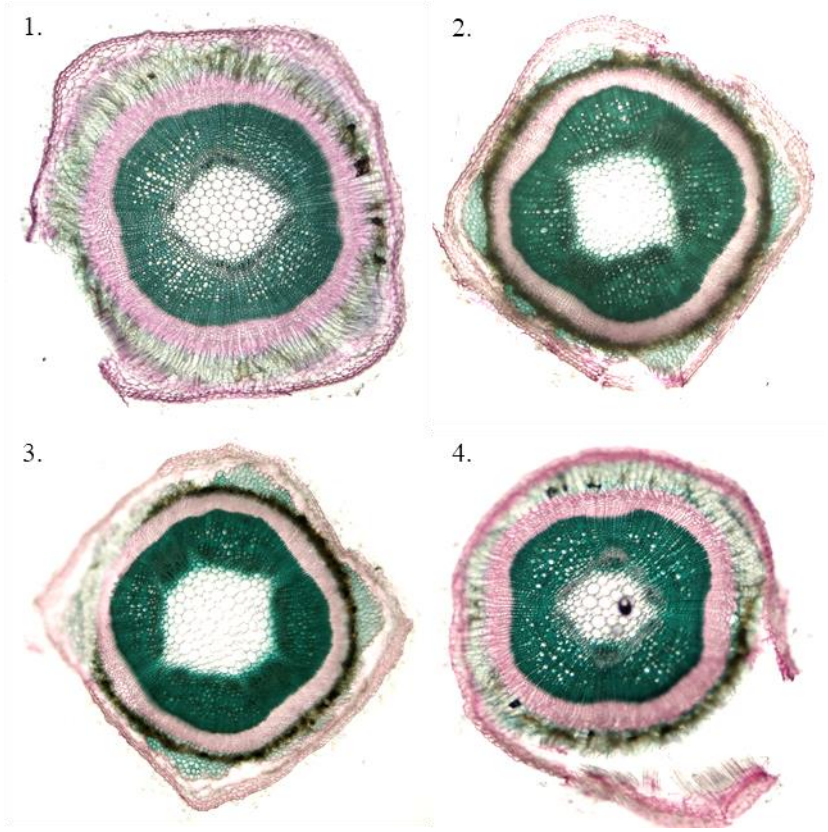

Fig. 1. Cross section through the stem of *L. angustifolia* irrigated with water (v1) (x40); 1. `Codreanca`, 2. `Provence Blue`, 3. `Vera`, 4. `Sevtopolis`.

Table 4.

Histo-Anatomical Aspects of the Lavender Stem on plants irrigated with Hoagland nutrient solution (v2)

Criteria	`Codreanca` (Fig.2 – 1)	`Provence Blue` (Fig. 2 - 2)	`Vera` (Fig. 2 - 3)	`Sevtopolis` (Fig. 2 - 4)
Epidermis and bark	- the tendency to exfoliate due to deep suber in all varieties;			
Central cylinder - the presence of islands of sclerenchymal pericycle;	- xylem vessels and libriform predominate in almost equal quantities; - the phloem ring (primary and secondary) is very small in quantity; - reduced pericycle, almost absent; - iodine green staining indicates the presence of lignin in the walls of the sclerenchyma;	- the libriform predominates to the detriment of wooden vessels; - iodine green staining indicates the presence of lignin in the walls of the sclerenchyma;	- wooden vessels and libriform predominate in almost equal quantities; - iodine green staining indicates the presence of lignin in the walls of the sclerenchyma;	- the libriform predominates to the detriment of wooden vessels; - the pericycle has elements with thin and non-lignified walls;
Pith	- rhomboidal contour;	- elliptical contour;	- elliptical contour, elongated radial;	

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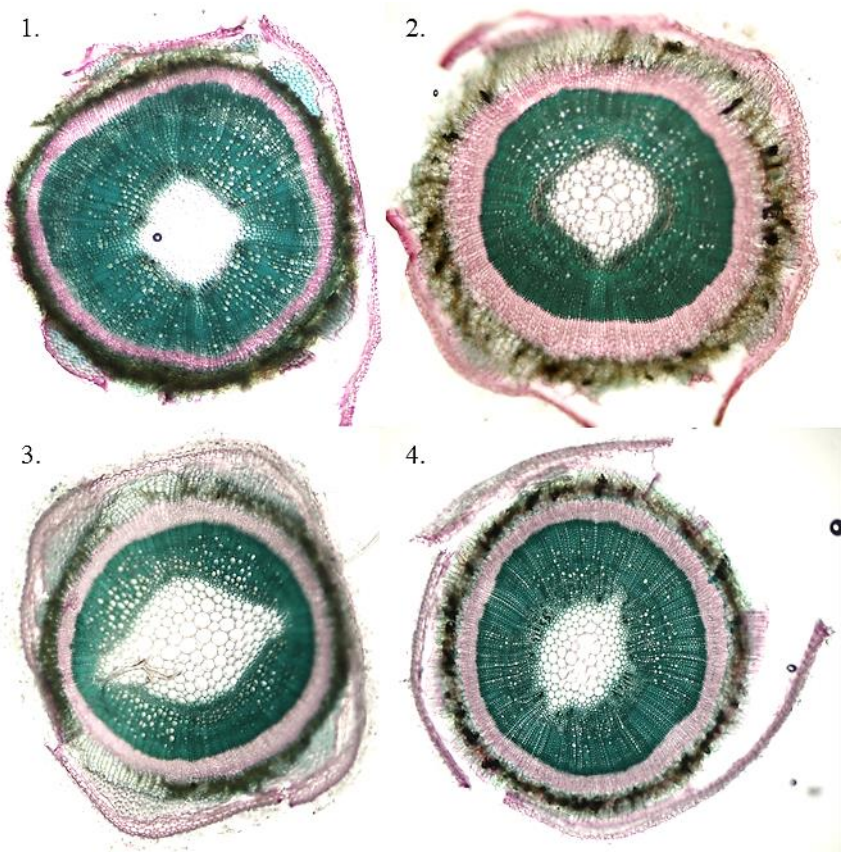

Fig. 2. Cross section through the stem of *L. angustifolia* irrigated with Hoagland nutrient solution (v2) (x40); 1. `Codreanca`, 2. `Provence Blue`, 3. `Vera`, 4. `Sevtopolis`.

At the stem level, the structural organization follows the *Lavandula* genus type (Toma *et al*., 1982; Robu *et al*., 2011; Fakhriddinova *et al*., 2020; Ștefan *et al*., 2021), but there are also some differences regarding the presence and absence of the pericycle, the degree of lignification of the central cylinder and the libriform quantity. There were seen also differences in the shape of the pith, which varied from a square contour for the watered plants to elliptical and rhomboidal shape for the individuals irrigated with Hoagland solution.

As the plant grows and develops, the stem undergoes a lignification process, specific to subshrubs such as lavender, and the stem loses its epidermis and bark, as well as secretory and protective trichomes along with them, these structures remaining visible only on new green-grown portions in each new year of cultivation.

Histo-anatomical structure of the leaf blade

Table 5.

Comparative characterization of the experimental variant with water (v1)

Criteria	`Codreanca` (Fig. 3 - 1)	`Provence Blue` (Fig. 3 - 2)	`Vera` (Fig. 3 - 3)	`Sevtopolis` (Fig. 3 - 4)
The contour of the cross-section through the leaf blade - adaxial face (upper); - the abaxial (lower) face is prominent, identifiable in all varieties;	- very slightly deepened, almost imperceptible; - concave;	- straight (flattened); - slightly concave, strongly flattened;	- visible (arc of a circle) visible; - concave, slightly flattened;	

Section width	- variable;	- variable; - has a particularly general shape, with the lateral extremities of the adaxial face reflected (facing the abaxial face);	- variable, but visibly larger than the other varieties;	- variable;
Mesophyll thickness	- in descending order `Codreanca`, `Provence Blue`, `Vera`, `Sevtopolis`;			
Protective formations (protective hairs and secretory hairs)	- the varieties `Codreanca` (Fig. 4 - 1), `Vera` (Fig. 4 - 3) and `Sevtopolis` (Fig. 4 - 4) have numerous trichomes, present along the entire length of the adaxial and abaxial faces; - for `Provence Blue` (Fig. 4 - 2): the trichomes are missing at the adaxial face near the median rib;			
Median rib	- has a bundle of xylem and phloem of collateral type, large in size for all varieties; - phloem and xylem are in relatively equal proportions; the phloem consists of sieve tubes and companion cells, to the outside all the elements being colenchymatized angularly; the xylem has protoxylem and metaxylem vessels arranged in radial rows separated by wood parenchyma cells with thin, cellulose-pectic walls;			
	- at the periphery of the collateral bundle there is a parenchymal sheath formed by rounded cells, of larger dimensions;			
Composition of leaf blade according to mesophyll differentiation	- bifacial heterofacial; - compact palisade tissue, occupying almost half the thickness of the leaf surface;	- bifacial heterofacial; - loose palisade tissue, with cells leaving air spaces between them, in some places a second layer of palisade cells can be seen;	- bifacial heterofacial; - compact palisade tissue, occupying almost half the thickness of the leaf blade;	- bifacial heterofacial; - compact palisade tissue, occupying almost 1/3 of the thickness of the leaf blade
Number of vascular bundles corresponding to the lateral ribs	- fewer, but larger;	- numerous, smaller in size;		
Stomata position	- present only in the abaxial (lower) surface, so the leaf blade is hypostomatic; - the stomata are located far outside the external level of the epidermis, a characteristic that indicates the presence of excess water in the soil; this position is also favored by the tomentum of tree-branched protective trichomes, which has the role of creating an atmosphere of normal humidity that prevents the leaf from opening.			

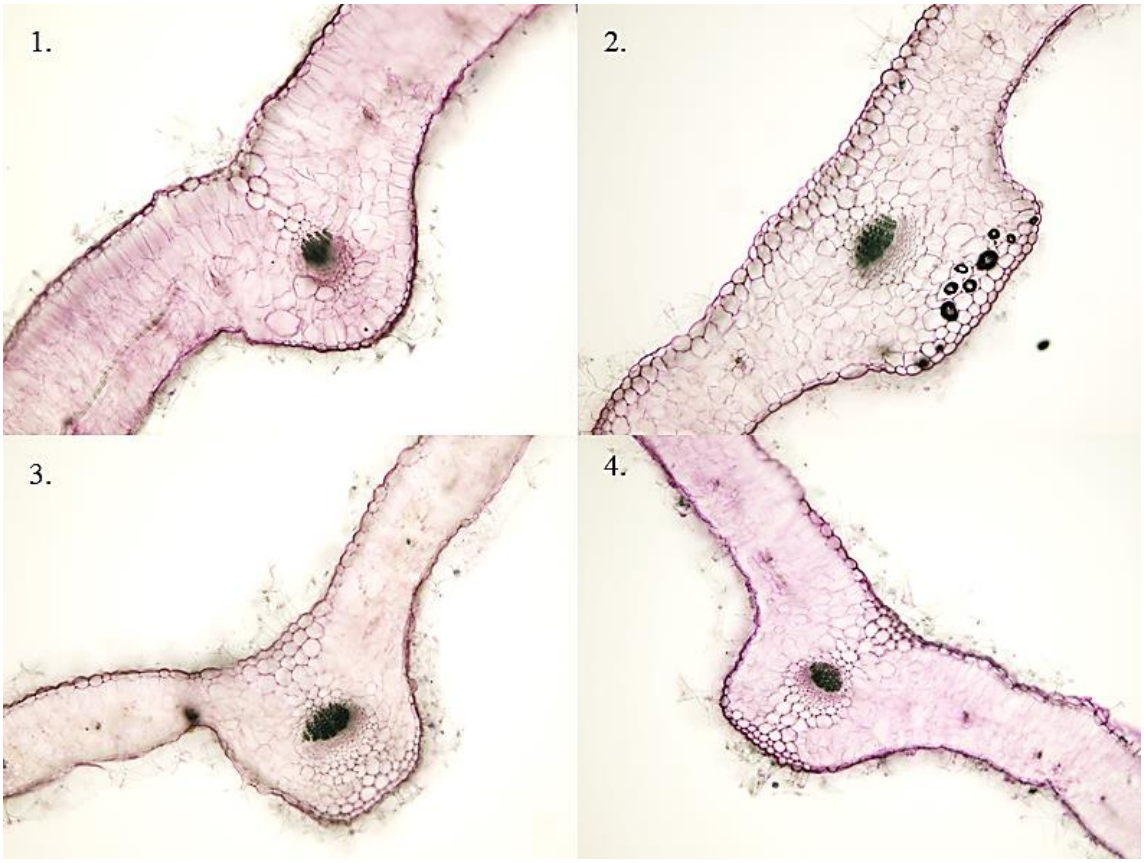

Fig. 3. Cross-section through the leaf blade of *L. angustifolia* irrigated with water (v1) (x100); 1. `Codreanca`, 2. `Provence Blue`, 3. `Vera`, 4. `Sevtopolis`.

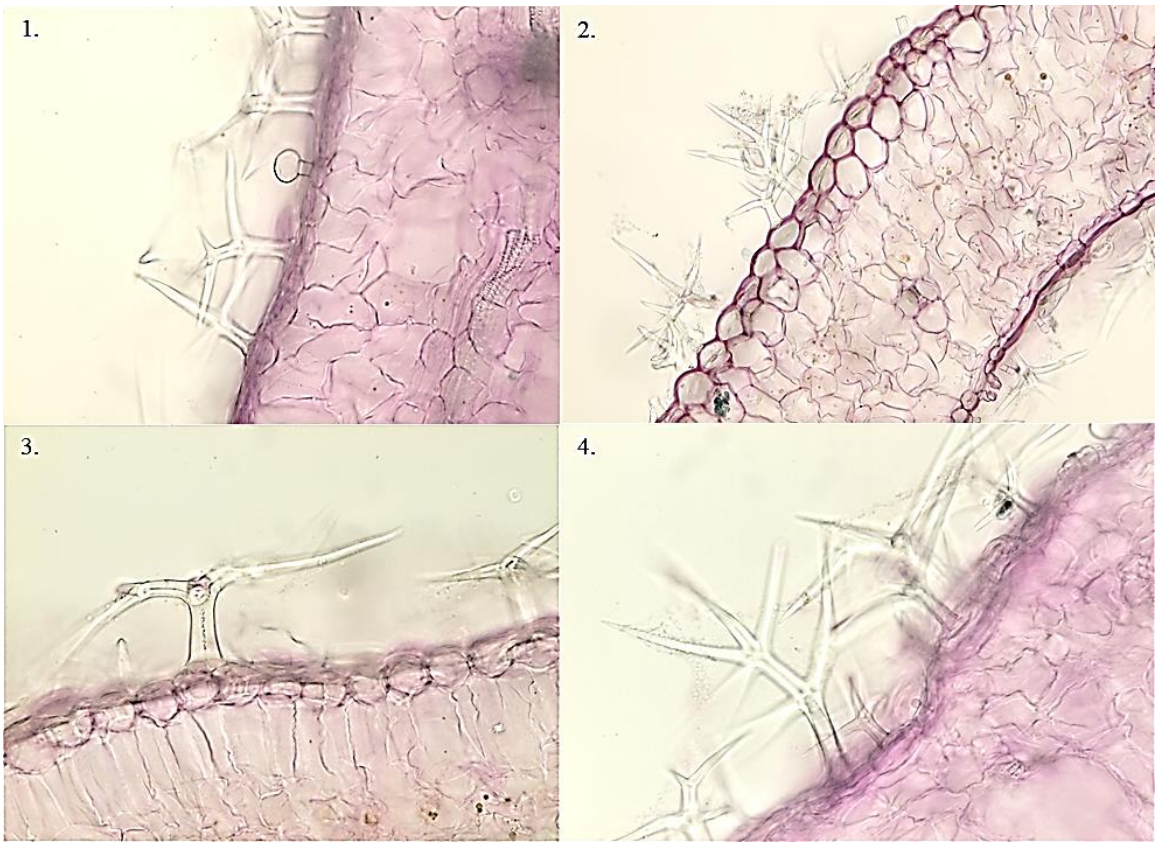

Fig. 4. Protective and secretory trichomes of *L. angustifolia* irrigated with water (v1) 1, 3, 4 - (x400); 2 – (x200); 1. `Codreanca`, 2. `Provence Blue`, 3. `Vera`, 4. `Sevtopolis`.

Table 6.

Comparative characterization on plants irrigated with Hoagland nutrient solution (v2)

Criteria	`Codreanca` (Fig. 5 - 1)	`Provence Blue` (Fig. 5 - 2)	`Vera` (Fig. 5 - 3)	`Sevtopolis` (Fig. 5 - 4)
Section width	- has the largest width;	- variable;	- the two halves of the leaf blade have a reflective position;	- variable;
Mesophyll thickness	- in descending order: `Sevtopolis`, `Provence Blue`, `Vera`, `Codreanca`			
	- few ribs, relatively equal in size;		- numerous lateral ribs in the thickness of the mesophyll;	
Protective formations (protective hairs and secretory hairs)	-numerous on the lower face and relatively rare on the upper face;		- extremely numerous on both sides;	- very rare on both sides;
Median rib	- has a vascular bundle of collateral type, large in size for all varieties;			
			- slight disproportion between phloem and xylem, to the detriment of the wood;	
Composition of leaf blade according to mesophyll differentiation	- bifacial-heterofacial structure; - unilayered palisade tissue, occupying almost 1/3 of the thickness of the leaf;	- bifacial-heterofacial structure; - bilayered palisade tissue, which occupies 2/3 of the thickness of the leaf blade;		- ecvifacial bifacial structure (isofacial) homogeneous centric; - mesophyll with 5-6 layered palisade tissue, the cell size decreasing from the upper face to the lower face of the leaf;
Stomata position	- stomata located above the external level of the epidermal cells in the adaxial face;			

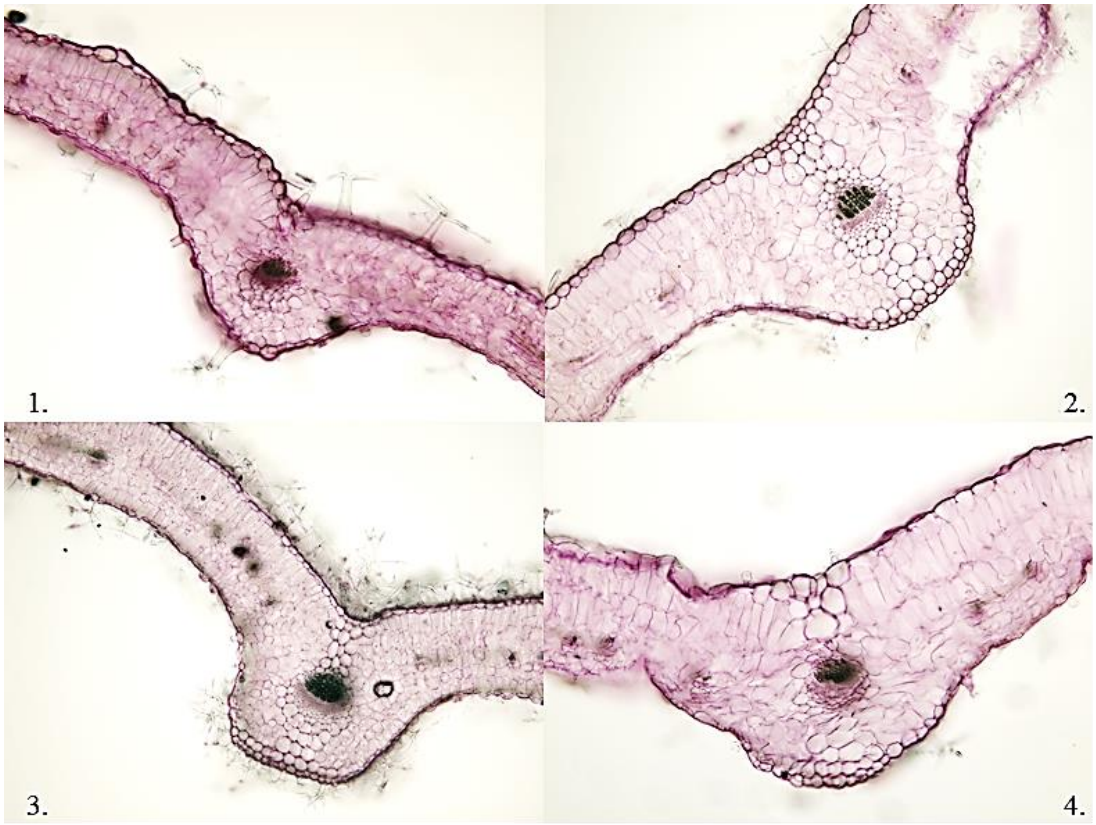

Fig. 5. Cross-section through the leaf blade of *L. angustifolia* irrigated with Hoagland nutrient solution (v2) (x100); 1. `Codreanca`, 2. `Provence Blue`, 3. `Vera`, 4. `Sevtopolis`.

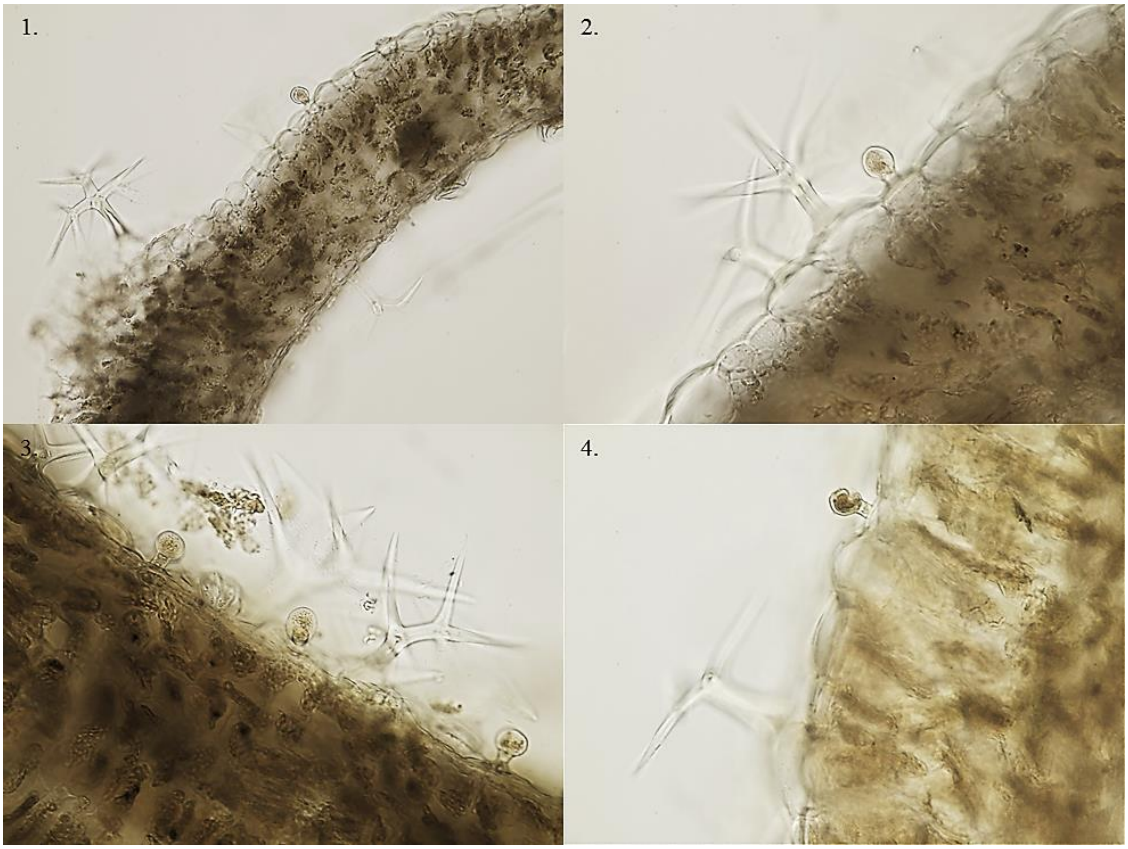

Fig. 6. Protective and secretory trichomes of *L. angustifolia* irrigated with Hoagland nutrient solution (v2); 1 – (x200); 2, 3, 4 - (x400); 1. `Codreanca`, 2. `Provence Blue`, 3. `Vera`, 4. `Sevtopolis`.

The histo-anatomical characteristics of the leaf blade can be seen in Table 5 and Table 6. The cross-sections through the leaf blade showed that all varieties presented in this study have a unilayered epidermis with rounded, elliptical or rectangular cells (slightly elongated tangentially), with the outer wall slightly thicker than the others and covered by a thin cuticle. The midrib vein contains a singular vascular bundle of collateral type formed from xylem and phloem, and there are also numerous smaller lateral vascular bundles, that vary among the cultivars.

The leaf blade has polygonal cells, with straight or slightly wavy side walls on the upper side of the leaf and visibly wavy on the lower side. The stomata, of the diacitic type, are present only in the lower epidermis, so the blade is hypostomatic. The mesophyll is made up of palisade tissue and meats.

On the surface of both epidermises there are numerous protective and secretory trichomes specific for this species (Iriti *et al*., 2006; Nikolakaki *et al*., 2006; Huang *et al*., 2008; Zuzarte *et al*., 2010; Lungu *et al*., 2014; Giuliani *et al*., 2020).

Micromorphological aspects of the leaf surfaces

Following the analysis of the leaf surfaces under the scanning electron microscope (SEM), aspects regarding the density and the structure of the protective and secretory hairs were observed.

All studied cultivars and experimental variants have numerous protective trichomes, branched with a one-celled stalk and three or more branches at the top and many glandular trichomes (Fig. 7) of different types, most common with a one-celled stalk and one, two or eight-celled gland on the surface of the leaf, specific to the genus *Lavandula* (Huang *et al*., 2005; Lungu *et al*., 2014; Nikolakaki *et al*., 2006; Ștefan *et al*., 2021).

Secretory formations (peltate and capitate trichomes) found on the surface of the leaves of the studied cultivars showed a similar structure to glandular trichomes reported for other species and varieties of the *Lavandula* genus. Peltate trichomes were constituted by a cell at the base, a short stalk, and a large secretory head and capitate trichomes were constituted by a rounded head, smaller in size than peltate hairs and a stalk with variable length, as reported for other cultivars of *Lavandula angustifolia*, *Lavandula hybrida* and *Lavandula dentata* (Brailko *et al*., 2017; do Rocio Duarte *et al*., 2014; Martínez-Natarén *et al*., 2011; Ștefan *et al*., 2021).

After analyzing the density of secretory and protective hairs among the studied cultivars and experimental variants (Table 7), non-glandular trichomes were widely observed on both surfaces of the leaves and their number was higher than glandular ones.

Based on the morphology and cell number, the non-glandular trichomes were divided into four types: simple unicellular or multicellular, branched unicellular or multicellular (Fig. 8).

Regarding the density of secretory and protective trichomes, there were seen significant improvement in the varieties `Codreanca` and `Sevtopolis` watered with Hoagland nutrient solution (v2), but for `Provence Blue` and `Vera` the number of glandular and non-glandular formations were greater for the individuals irrigated with water (v1).

The highest density of protective hairs, on both leaf surfaces were seen for `Provence Blue` and `Vera` irrigated with water.

The highest density of secretory trichomes was seen for the `Provence Blue` cultivar with water and `Sevtopolis` with Hoagland solution, on both leaf surfaces.

Table 7.

Density per mm^2 of glandular and protective trichomes in *Lavandula angustifolia* cultivars

Species		Adaxial (sup)				Abaxial (inf)			
		Capitate	Peltate	Secretory	Protective	Capitate	Peltate	Secretory	Protective
L. angustifolia `Codreanca` (v1)	**Mean**	**13.41**	**3.72**	**17.14**	**42.01**	**29.71**	**10.20**	**39.91**	**45.94**
	Std. dev.	**4.63**	**1.56**	**6.19**	**3.53**	**11.26**	**1.55**	**12.75**	**8.21**
L. angustifolia `Codreanca` (v2)	**Mean**	**36.27**	**4.62**	**40.89**	**52.41**	**44.49**	**19.06**	**63.56**	**69.70**
	Std. dev.	**9.46**	**1.96**	**7.72**	**6.71**	**5.38**	**2.36**	**6.33**	**10.53**
L. angustifolia `Provence Blue` (v1)	**Mean**	**35.23**	**18.27**	**53.50**	**148.77**	**16.70**	**25.51**	**42.22**	**212.60**
	Std. dev.	**17.78**	**5.08**	**19.64**	**19.18**	**9.04**	**2.39**	**10.79**	**14.54**
L. angustifolia `Provence Blue` (v2)	**Mean**	**23.55**	**6.89**	**30.44**	**80.54**	**24.53**	**14.87**	**39.40**	**143.17**
	Std. dev.	**8.47**	**2.01**	**10.10**	**12.13**	**2.26**	**3.12**	**5.33**	**15.13**
L. angustifolia `Vera` (v1)	**Mean**	**32.78**	**3.95**	**36.72**	**110.19**	**38.13**	**28.10**	**66.24**	**228.26**
	Std. dev.	**13.03**	**0.92**	**13.21**	**4.05**	**11.67**	**10.21**	**17.79**	**17.38**
L. angustifolia `Vera` (v2)	**Mean**	**34.75**	**9.43**	**44.19**	**96.47**	**35.05**	**16.64**	**51.68**	**166.55**
	Std. dev.	**3.25**	**1.02**	**3.90**	**0.51**	**6.46**	**1.82**	**8.18**	**6.65**
L. angustifolia `Sevtopolis` (v1)	**Mean**	**35.42**	**7.97**	**43.38**	**76.20**	**23.38**	**12.17**	**35.55**	**143.67**
	Std. dev.	**13.26**	**2.63**	**15.80**	**14.92**	**1.70**	**2.55**	**1.08**	**10.53**
L. angustifolia `Sevtopolis` (v2)	**Mean**	**44.58**	**5.95**	**50.54**	**76.84**	**55.75**	**12.40**	**68.15**	**167.70**
	Std. dev.	**7.63**	**1.59**	**8.95**	**2.42**	**5.40**	**0.18**	**5.22**	**21.62**

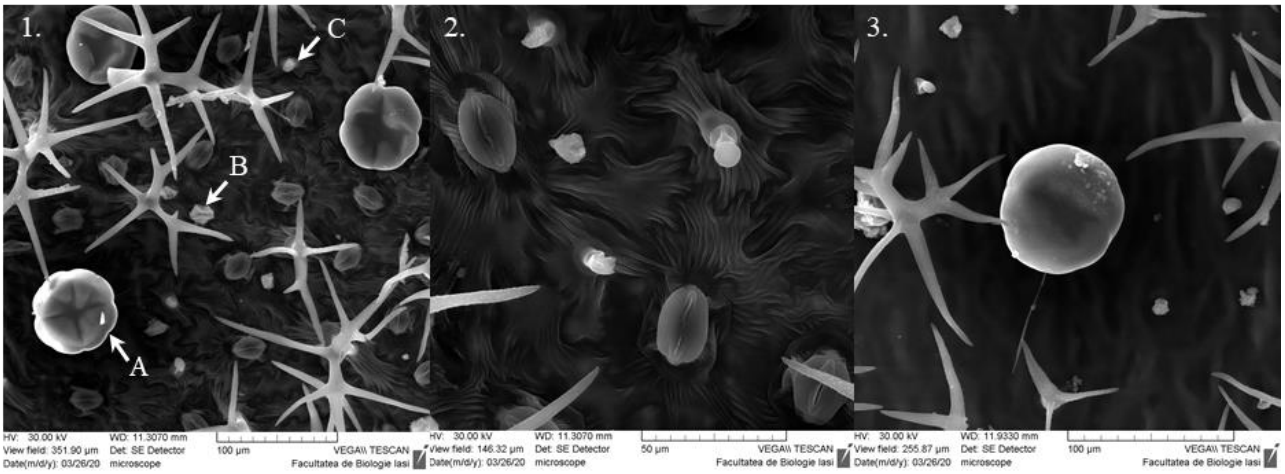

Fig. 7. Scanning electron micrographs of secretory trichomes on the leaf surface of *Lavandula angustifolia* cultivars; 1. `Codreanca` (v1) (A - peltate trichome with eight secretory cells, B, C - post-secretory uni- and two-celled glandular trichomes); 2. `Codreanca` (v2) – unicellular capitate trichomes; 3. `Sevtopolis` (v2) - peltate trichome with tetracellular head and unicellular capitate trichomes.

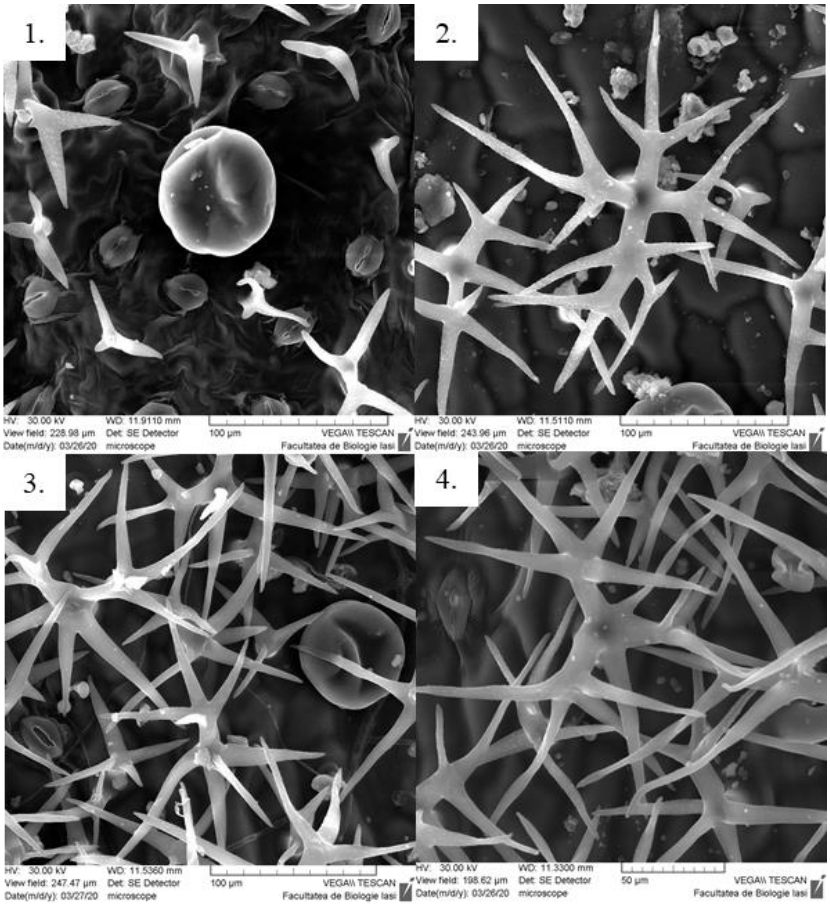

Fig. 8. Scanning electron micrographs of protective trichomes on the leaf surface of *Lavandula angustifolia* cultivars; 1. `Codreanca` (v1); 2. `Codreanca` (v2); 3. `Provence Blue` (v2); 4. `Vera` (v1).

CONCLUSIONS

This study was based on the histo-anatomical and micromorphological analysis of four cultivars and two experimental variants of the genus *Lavandula*. In comparison with other works on the species of the genus (Robu *et al*., 2011; do Rocio Duarte *et al*., 2014; Lungu *et al*., 2014; Riva *et al*., 2014; Brailko *et al*., 2017; Tanase *et al*., 2020), all histological structures in investigated cultivars are generally circumscribed in the typical structural plan of the *Lavandula* genus.

Following the histo-anatomical analysis of the vegetative organs (stem and leaves) and the microscopic observations, the 4 varieties (`Codreanca`, `Provence Blue`, `Vera` and `Sevtopolis`) of the species *L. angustifolia*, have the following differences: at the level of the stem, there are variations in the contour of the cross-section, the epidermis and bark tend to exfoliate

and the pith presents different shapes in all varieties and experimental variants analyzed so far; for the watered plants (v1), at `Codreanca` and `Sevtopolis` cultivars the pericycle is missing.

At the level of the leaf blade, there are obvious variations of the anatomical characteristics, related to the contour of the section, the thickness of the mesophyll, the number of protective formations (protective and secretory trichomes) and the number of vascular bundles corresponding to the lateral veins.

Both epidermises of the leaf blade of the studied cultivars and experimental variants have indumentum consisting of glandular and non-glandular hairs. The density of trichomes varied between these taxa and two types of secretory trichomes were observed: capitate and peltate. The protective hairs were divided into branched and unbranched, with higher density than the secretory trichomes for all analyzed taxa, as confirmed by other studies on the *Lavandula* genus (Giuliani *et al*., 2020; Martínez-Natarén *et al*., 2011; Ștefan *et al*., 2021).

Improvements regarding the number and distribution of trichomes were seen for the plants supplemented with Hoagland nutrient solution, especially for the `Codreanca` and `Sevtopolis` cultivars, where the density of protective and secretory trichomes was greater than the cultivars irrigated with water.

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AUTHORS CONTRIBUTIONS

Conceptualization: S.G.A., Z.M.M. and I.L.C.; methodology, S.G.A., data collection S.G.A.; data validation, S.G.A. and I.L.C.; data processing S.G.A. and I.L.C.; writing—original draft preparation, S.G.A.; writing—review and editing S.G.A., Z.M.M. and I.L.C.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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