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A COMPARATIVE STUDY REGARDING THE MORPHOLOGY AND ANATOMY OF THE VEGETATIVE APPARATUS IN TWO *OCIMUM BASILICUM* L. BREEDS

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Abstract. This study compares the structure and morphology of the vegetative subterranean and aerial organs in two *Ocimum basilicum* L. breeds cultivated in Turkey. The object of this study is to emphasize the infraspecific variation of the plant morphology and anatomy of these two breeds, underlining the importance of the secretory hairs that produce the volatile oils and concede this species the virtue of medicinal herb and aromatic plant.
Key words: *Ocimum basilicum* L., morphology, anatomy, vegetative organs, secretory hairs

Introduction

Ocimum basilicum L. of the Family *Lamiaceae* is a herb grown as a perennial in warm, tropical climates. Basil is originally native to Iran, India and other tropical regions of Asia and it is cultivated in greenhouses or in the field in many other regions too.

Ocimum basilicum L. is an annual species with a vegetataive apparatus composed of a well ramified fibrous root, a strongly ramified, 60 cm long, four edged erect stem and many pointy ovate-lanceolate opposite leaves with atenuate serrate edges [1]. The flowers are quite big, white in colour and arranged in a terminal spike. The four stamens and the pistil are not pushed under the upper lip of the corolla, but lay over the inferior.

Materials and methods

The material of our investigations is represented by two *Ocimum basilicum* L. breeds cultivated in Turkey (to mark out the two species, they were noted with two numbers: 1 – nonflowering specimen and 2 – flowering specimen). The utilised methods are those currently used for vegatal anatomy investigations. Cross-sections through the vegetative organs using a botanical razor and a manual microtome have been executed. These sections have later been jewelised and tinted using iodine-green and ruthenium-red. The superficial lamina sections have been tinted using iodine-green. The sections were later analysed and photographed using a photonic microscope (NOVEX, Holland).

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Results and discussions

The morphology of the vegetative apparatus

Both basil breeds studied present a variable number (5 to 7 for the first breed and 8 to 9 for the second one) of strongly ramified aerial stems of various thickness (those of the first breed are thicker) that start out at the base of the root. There are leaves on the branches and the main stems, more numerous on the second breed plants and larger ones on the first breed plants (Pl. I: Fig. 1).

The structure of the vegetative apparatus

The structure of the subterrranean vegetative organs

The histo-anatomical analysis of the subterranean vegetative apparatus of the two basil breeds revealed the fact that the main axis which is in the scientific literature considered to be the main root, has a series of tipical subterranean stem (rhizom) structural features:

1. Lignified pith in the center of the organ, composed of polygonal cells without meatuses between them and 4 primary ligneous bundles surounded by few ligneous parenchyme cells also with lignified walls, between them (Pl. I: Fig. 3c);
2. The secondary xylem which is entirely lignified forms two annual clearly visible rings (Pl. I: Fig. 3d):

- the libriform fibers are prevalent in the first ring (the inner ring). These fibers have thick and slightly lignified walls. The radial range disposed, small diameter, scarce vessels are surrounded by few lignified ligneous parenchymatous cells.
- the second ring (the external ring) is thicker, composed of: numerous variable diameter vessels (bigger than the ones in the first ring); these radial range disposed vessels are surrounded by few lignified ligneous parenchyme cells, and libriform fibers; these fibers have strongly lignified thiner walls (compared to those of the first ring).

The felogene formation does not rely on the pericycle (which is the case of many dicotyledonous plants) but on the differentiation of different layers of the cortex, producing many layers of often stratified cork, composed of bigger cells than those of the pheloderme and those of the cortical parenchyme that is still unexfoliated or still persisting between the periderma successively formed (Pl. I: Fig. 3b). A genuine ritidoma that exfoliates along the organ is thus formed (Pl. I: Fig. 3a).

Therefore, considering this organ as being a rhizom, the roots that form on it are endogenous formed adventive roots (Pl. I: Fig. 3e). The structure of these roots is secondary, as a single result of the cambium activity. The diarche type stellum has a primary structure (Pl. I: Fig. 3f).

The structure of the aerial vegetative apparatus

The stem of both basil breeds has a primary structure only in the upper third part and a secondary structure, as a result of the cambium activity, in the other two.

The outline of the cross section (Pl. II: Fig. 4, 5) differs in each third of the stem (upper, middle and lower) and in the two breeds as well. In the upper third part, the outline of the cross section is rectangular-quadrangular shaped, with 4 generally attenuate costas, some of them more evident than others, with deeper and narrower valecules berween them in the second breed. The valecules progresivly grow wider and they become less deep with the thickening of the organ, so that in a cross-section they show an allmost circular outline.

The epidermis protects the entire surface of the stem (Pl. III: Fig. 6, 7) and it is composed of sligtly tangentially elongated isodiametrical cells (in the lower third) that have pericline walls, thicker than the others, a thin cuticle covering the external one. There are very few stomata present.

There are two types of hairs: 1. uniseriate pluricellular *trichomes* that are present on the entire outer surface of the stem; 2. *secretory hairs* composed of a unicellular or bicellular hinge, a unicellular pedicle and an unicellular or bicellular gland (Pl. V: Fig. 10a, b, c). The number of secretory and tectorial hairs per suface unit decreases from the top to the base of the stem. There are more hairs (tectotial and secretory also) on the first breed stems than on the second breed stems (Pl. II: Fig. 4, 5).

The parenchymatous-cellulosic cortex, meatus type in the upper third, is thin and slightly colenchymatic in a hypodermic position (in the first basil breed especially near the costas) and does not have a special type of endoderma on the exterior. The cortex cells tend to become tangentially elongated and the air spaces between them become larger as the stem grows thicker. The anticline division walls are visible inside the cortex inner cell layers in the lower third of the first basil breed stem.

The primary structure stellum (Pl. III: Fig. 6, 7) follows the general outline of the cross section and has four large collaterally open type bundles in the four costas and one very small bundle composed only of phloemic elements between them. The large bundles have radial ranges of ligneous vessels separated by uniseriate or pluriseriate areas of parenchymatous-cellulosic cells and the liberian tissue is composed of pierced tubes and annexe cells.

Belts of sclerenchyma fibers can be observed at the end of the large phloem vascular bundles in the second basil breed (Pl. III: Fig. 7a) that have in this developing state less thickened but still cellulosic walls. The fiber walls get progressively thicker and lignified from the base up to the top of the stem (Pl. III: Fig. 6, 7).

The thickening of the stem is based on the cambium activity that produces a thin phloem ring on the exterior and a thicker xylem one on the interior. The phelogen becomes differentiated based on an inner cortical layer at the base of the second breed stem, producing a single layer of cork (composed of very large cells that have thin walls and little cork) and 1-2 noncolenchymatous pheloderma layers.

The cambium activity is initialy unequal in the circumference of the organ, producing more secondary ellements (phloem and xylem) in the large bundles (near the costas); thus the secondary vascular tissue rings are sinuous during this developing stage (Pl. II: Fig. 4b, Fig.

5b). The cambium produces subsequently many vascular ellements between the costas so that both rings (secondary phloem and secondary xylem) become circular (Pl. II: Fig.4c, Fig. 5c).

The secondary xylem ring is almost entirely lignified at the base of the stem (composed of vessels, libriform fibers, lignified ligneous parenchymatous cells, horizontaly lignified parenchymatous cells) in the second breed or it has a thick tangential cellulose ligneous parenchymatous belt only on one side of the organ circumference so that the pith is not situated in the center anymore but on the side, in the first basil breed.

The pith is a meatus type cellulose-parenchymatous thick pith (Pl. II: Fig. 4a, b; Fig. 5a, b); the composing cell walls are lignified in the base of the stem (Pl. II: Fig. 4c, Fig. 5c).

The amphystomatic type **lamina** presents very small dyacitic stomata situated on top of the epidermis. Its structure is heterofacial bifacial and the mesophyll is differentiated as a very elongated cell unistratified palisadic tissue and a pluristratified lacunous tissue (4 to 5 layers).

The middle nervure (Pl. IV: Fig. 8a, Fig. 9a, b) is visibly prominent on the inferior side of the lamina and has a single vascular bundle inside the noncloroplastic noncolenchymatic fundamental parenchime, which is larger in the first basil breed.

The relatively short uniseriated pluricellular trichomes can be found only on the lamina middle nervure (Pl. IV: Fig. 9b). There are two types of secretory hairs: a) located in a very small depression of the upper epidermis, having a bicellular gland (Pl. IV: Fig. 9c; Pl. V: Fig. 10d); b) located in a very large excavation of the lower epidrmis, having a four celled gland (Pl. IV: Fig. 8b; PL. V: Fig. 10e).

Conclusions

Investigating the vegetative apparatus of the two *Ocimum basilicum* L. breeds, an infraspecific variation regarding some morphological and anatomical features has been observed.

The two basil breeds studied are distinguished by the following morphological features: 1) the size and density of the aerial stem leaves; 2) the developing stage of the subterranean vegetative apparatus.

The presence of some subterranean stem (rhizom) specific features among the main subterranean axis indicates that the two basil breeds may be perennial, the species being considered annual according to the scientific literature.

The structure of the vegetative apparatus in the two basil breeds differes according to the following features: a. regarding *the stem*: 1) the outline of the croos-section in the upper third; 2) the number and density of the trichomes on organ surface unity; 3) the lignification stage of the secondary structure stellum; 4) the absence or the presence of the protecting secondary tissues; b. regarding *the lamina* – the developing stage of the vascular tissue in the middle nervure.

The number of secretory hairs on organ surface unit and the number of cells that compose their gland concede this species the virtue of aromatic and medicinal plant. Our research has shown that the number of secretory hairs on the vegetative apparatus in the first basil breed is greater compared to the second one. Both breeds show more numerous secretory hairs on the lamina and on the tip of the stems, most of the four celled gland hairs being situated on the lamina.

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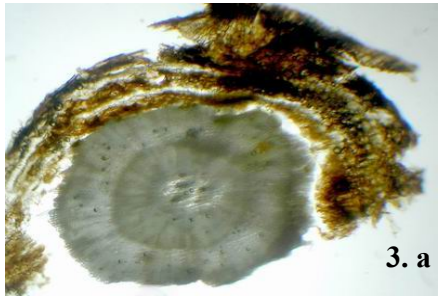
Explanation of figures:

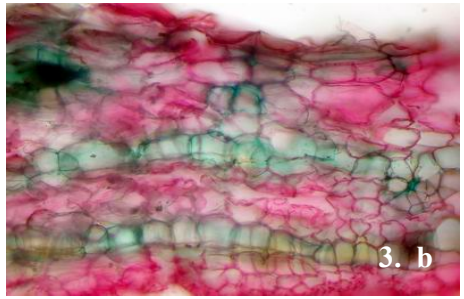
Fig. 1. The morphology of the aerial vegetative apparatus in *Ocimum basilicum* L.: first breed (on the left); second breed (on the right) (original macrophotographs). Fig. 2. The morphology of the subterranean vegetative apparatus in *Ocimum basilicum* L.: first breed (on the left); second breed (on the right) (original macrophotographs). Fig. 3. The structure of the subterranean vegetative apparatus in *Ocimum basilicum* L. second breed: a-e. rhizom cross sections: **a.** general view (unjewelised and untinted section) (x40); **b**. ritidoma detail (x200); **c.** pith and secondary xylem detail(x200); **d.** secondary xylem detail – the border between the two annual rings (x200); **e.** the formation of an adventive root (x100). **f.** adventive root cross section (general view) (unjewelised and untinted) (original microphotographs). **Fig. 4. The structure of the aerial stem on different levels in *Ocimum basilicum* L. first breed:** aerial stem upper third (a), middle third (b) and lower third (c) cross sections (x40) (original microphotographs). **Fig. 5. The structure of the aerial stem on different levels in *Ocimum basilicum* L. second breed:** aerial stem upper third (a), middle third (b) and lower third (c) cross sections (x40) (original microphotographs). **Fig. 6. The structure of the aerial stem on different levels in *Ocimum basilicum* L. first breed (details):** aerial stem upper third (a), middle third (b) and lower third (c) cross sections (x200) (original microphotographs). **Fig. 7. The structure of the aerial stem on different levels in *Ocimum basilicum* L. second breed (details):** aerial stem upper third (a), middle third (b) and lower third (c) cross sections (x200) (original microphotographs). **Fig. 8. The structure of the lamina in the *Ocimum basilicum* L. first breed:** - middle nervure cross sections **a)**- unjewelised and untinted (x100) and mesophillun **(b, c)** (x200) (original microphotographs). A secretory trichome and its four celled gland located inside a lower epidermis excavation **(b)** and a stomata in the superior epidermis **(c)** may be observed. **Fig. 9. The structure of the lamina in *Ocimum basilicum* L. second breed :** - middle nervure cross sections **a)**- unjewelised and untinted (x100) and mesophillun **(b)** (x200) (original microphotographs). A tectorial trichome on the adaxial side of the middle nervure **(b)** and a secretory trichome and its bicellular gland located inside a small excavation in the superior epidermis **(c)** may be observed. **Fig. 10. Secretory hairs in an aerial stem cross section in *Ocimum basilicum* L. (a, b, c) and in a lamina superficial section (d, e) a.** unicellular gland secretory trichome; **b.** bicellular gland secretory hairs; **c.** bicellular gland secretory trichome; the secretory product eliminated between the wall and the cuticle can also be observed; **d.** bicellular gland secretory trichome; **e.** four celled gland secretory trichome (x800) (original microphotographs).

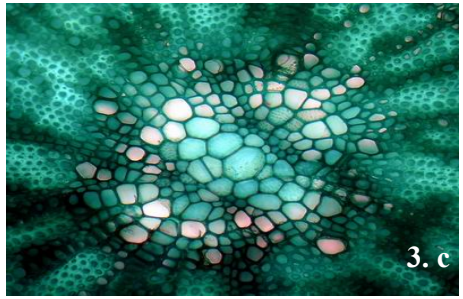
PLATE I

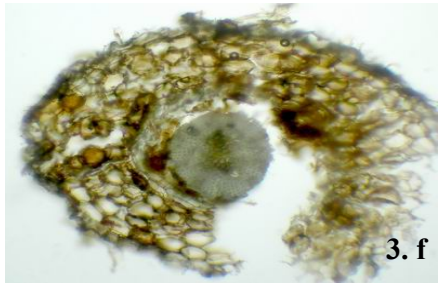
1

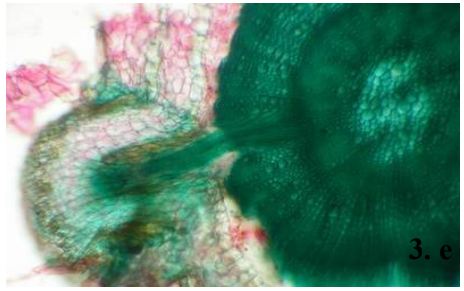
2

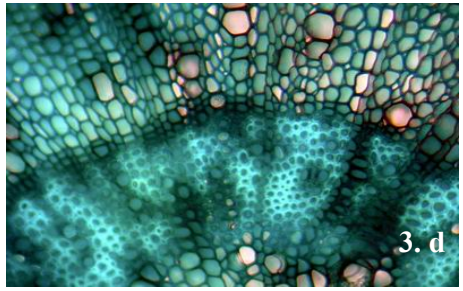












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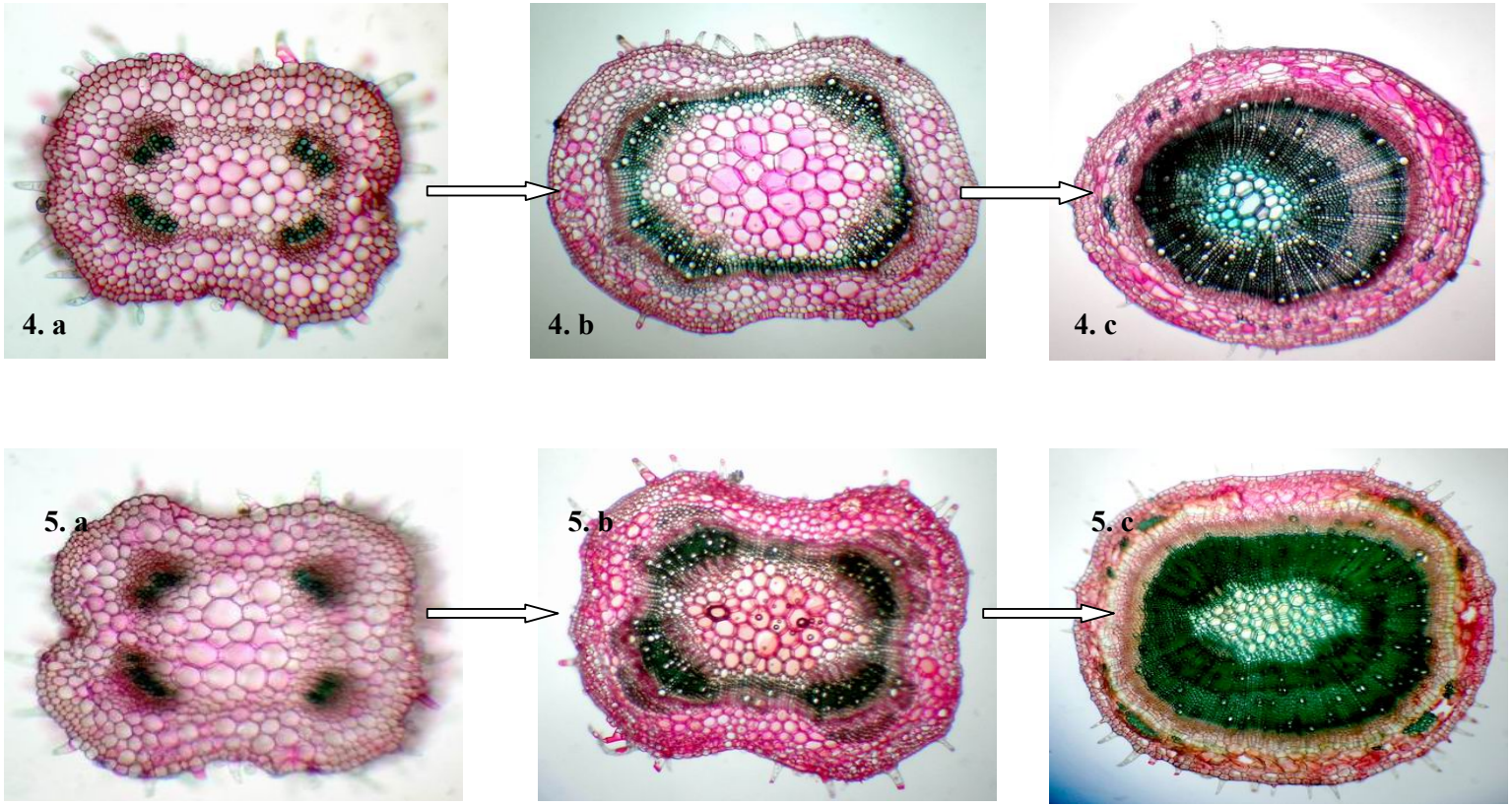

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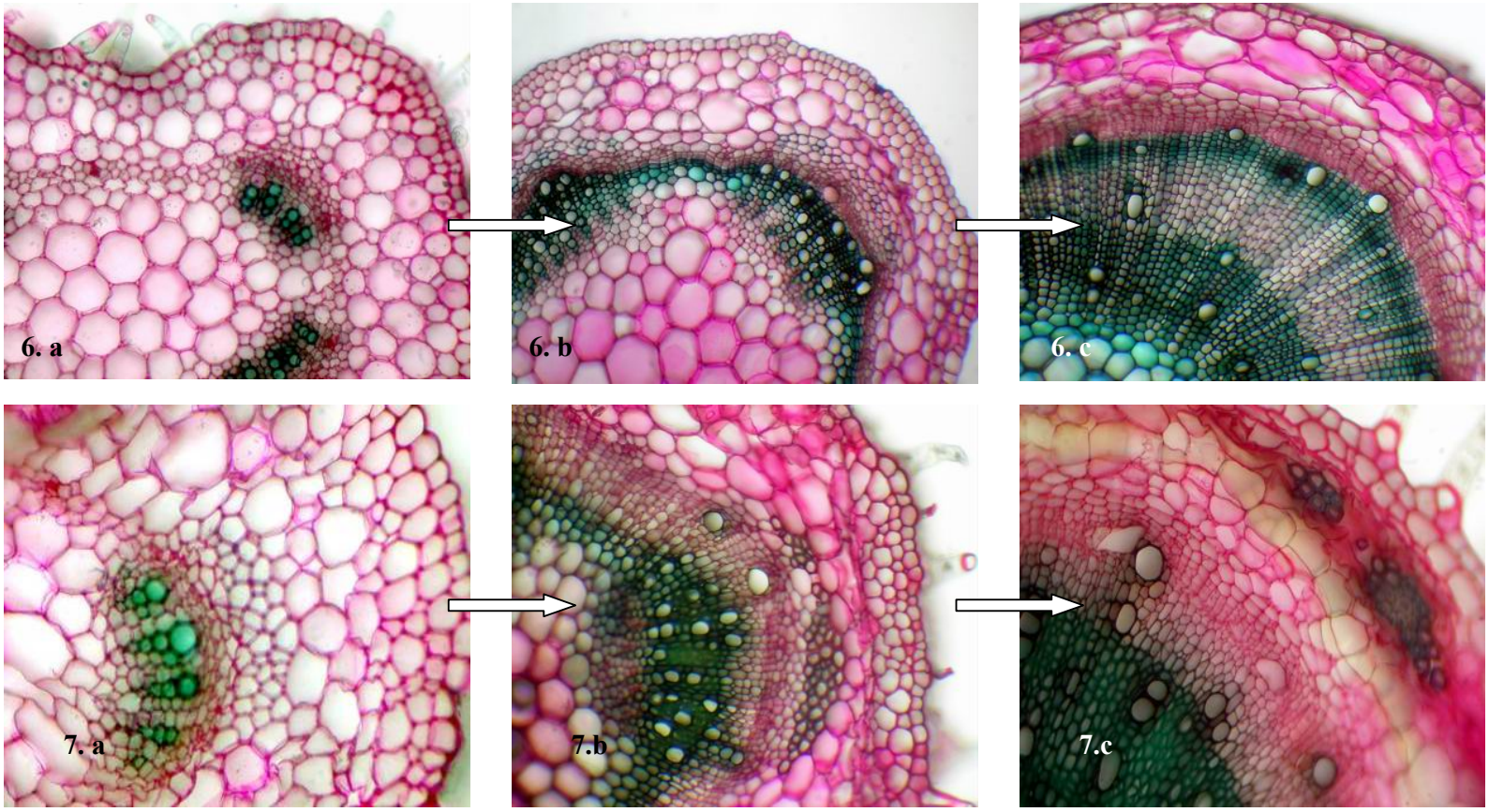

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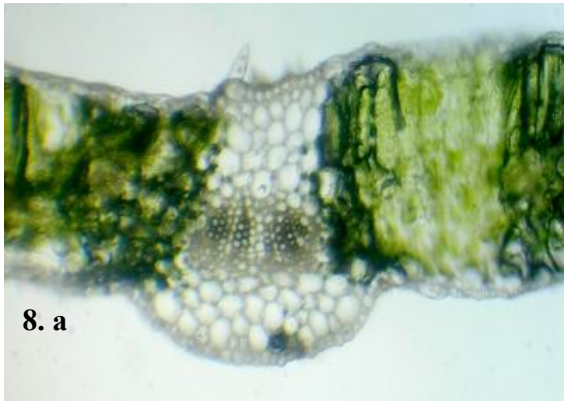
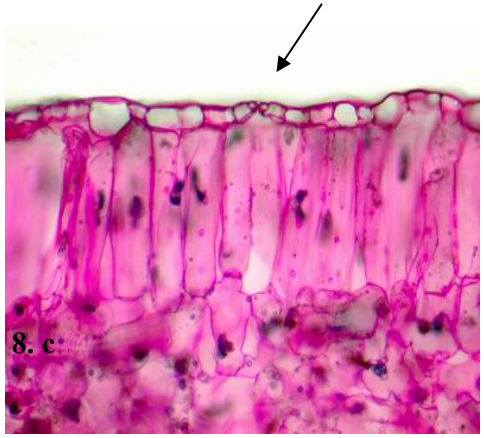
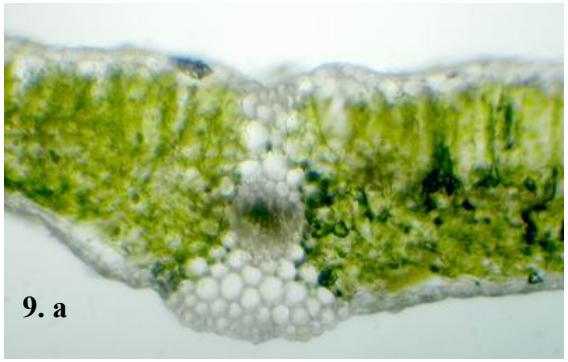






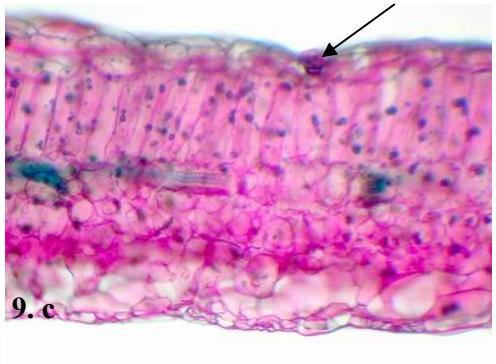
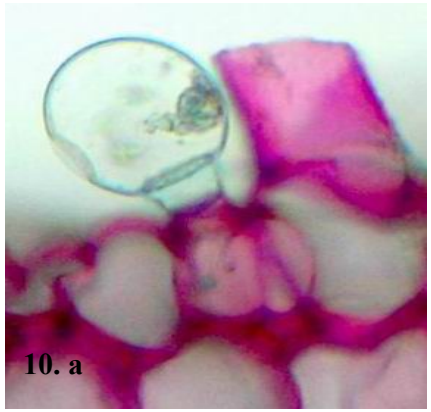


PLATE V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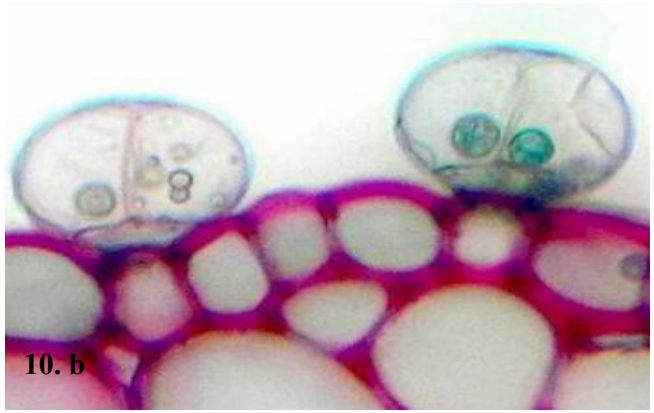
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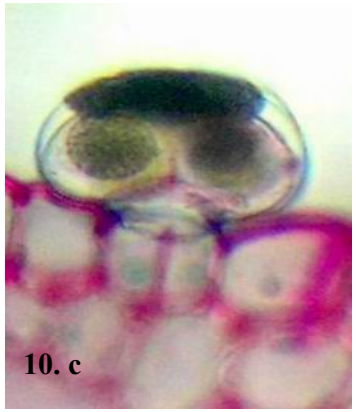
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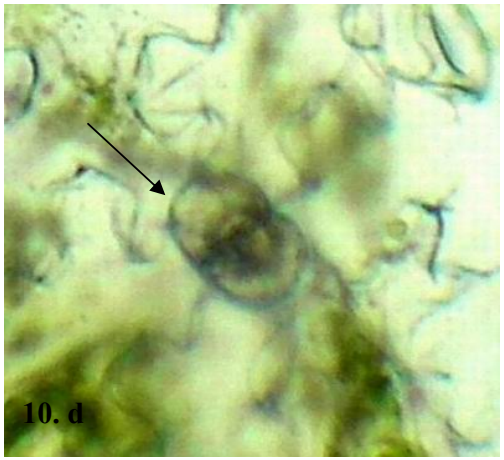
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10. e