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Structural and adaptive features of the vegetative organs of *Lophanthus anisatus* Benth. in the conditions of the introduction of Uzbekistan

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ABSTRACT

In this study, we examined the morphoanatomical structure of the vegetative organs of *Lophanthus anisatus*, common in the conditions of introduction, the features of structural adaptation and localization of biologically active substances, i.e. pharmacological activity. Based on the study of the anatomical structure of assimilative and axial organs under the conditions of introduction (Tashkent and Jizzakh) of *L. anisatus*, species-specific diagnostic features were determined. According to a comparative analysis of the anatomical features of the vegetative organs, it was established that under the conditions of the introduction of the Tashkent Botanical Garden, mesomorphic signs predominate in the assimilation and axial organs, and in the conditions of the Jizzakh region - xeromorphic ones. The localization of biologically active substances in the assimilating and storage tissues of the main tissue was also determined. These identified diagnostic characters are considered permanent taxonomic characters and are used in taxonomy and in the process of identifying the raw material of the species.

Key words: Plant, Morphology, Anatomy, Vegetative organs, *Lophanthus anisatus*, Tashkent, Jizzakh.
Article type: Research Article.

INTRODUCTION

Nowadays, the demand for medicinal plants is increasing day by day and many medicinal preparations are successfully used in the treatment of various diseases (Khademian Amiri *et al.* 2022). However, the anthropogenic impact on nature and the complexity of the ecological situation lead to a sharp reduction of the natural reserves of many medicinal plants. The widespread and uncontrolled exploitation of essential oil plants leads to the depletion of many raw materials, so the study of introduced plants that can provide a stable raw material base is one of the recent urgent problems. Plants belonging to the Lamiaceae family are distinguished by the high concentration of essential oils in the treatment of many diseases, and are also widely used in the perfumery and cosmetics industry. One of the promising taxa in this regard is the Lamiaceae family, many species of which are now widely used in folk medicine in many countries as anti-inflammatory, wound-healing and soothing agents. At the same time, the morpho-anatomical structure of this plant in the conditions of introduction, adaptation features, localization of biologically active substances, i.e., pharmacological activity, as well as chemically, have not been sufficiently studied, and very little information is given in literature sources, therefore, a comprehensive study of this plant is very relevant (Gzyryan 1959; Gomenyuk & Danilenko 2001; Voronina & Godunov 2001; Autko 2003). It has been proven that essential oils stimulate the protective reactions of cells and tissues, activate

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their regeneration processes, and are potential radio-protective agents. This group of substances is universal preventive substances with immunomodulatory and antioxidant properties. The object of this study was *Lophantus annisatus*, a perennial herbaceous plant belonging to the Labiaceae family, common under the conditions of the introduction of the Tashkent Botanical Garden and the Jizzakh region. The height of *L. annisatus* reaches up to 180 cm. The leaves are heart-shaped, lanceolate, serrated, light green, with a purple-brown skin, opposite, simple, covered with essential oil glandular trichomes, the length of the leaf strip is 5-10 cm and its width 4-6 cm. In addition, *L. anisatus* is used in diseases of the gastrointestinal tract, colds, has bactericidal properties, normalizes blood pressure, cleanses the blood, and is widely used to remove heavy metals from the body (Chumakova & Popova 2013). The alteration in the structural and functional properties of plants along ecological gradients is the result of the influence of evolutionary and environmental factors and also reflects a change in the significance of adaptive mechanisms at different levels of plant organization (Diaz & Cabido 1997; Wright & Reich 2004). Quantitative changes occurring within the species, as well as the community as a whole, make it possible to assess the contribution of various parameters to the adaptation of individual plant species to environmental factors. As a result of our scientific research, species-specific diagnostic features were determined based on the study of the anatomical structure of the vegetative organs of *Hyssopus officinalis* L. in the conditions of Tashkent and Jizzakh. The localization of biologically active substances in assimilating organs, front garden and spongy cells, was also determined (Duschanova *et al.* 2022, Duschanova & Fakhriddinova 2022; Duschanova *et al.* 2022). Also in our studies, diagnostic signs and localization of biologically active substances were determined based on the study of the anatomical structure of the vegetative organs of *L. anisatus* species in the conditions of the Tashkent Botanical Garden (Ibragimova *et al.* 2022).

The above literature sources provide very little information about *L. anisatus*, under the conditions of introduction. It was also true for the morpho-anatomical structure of the vegetative organs and structural-adaptive features, the localization of biologically active substances with pharmacological activity. Therefore, the study of the morphoanatomical structure, adaptation features of the *L. anisatus* under the conditions of introduction is one of the most urgent tasks. The purpose of the study was to examine the diagnostic and adaptive features of *L. anisatus* based on the study of the anatomical structure of the assimilative and axial organs of the species under the conditions of the introduction of the Tashkent Botanical Garden and Jizzakh region, as well as to determine the localization of biologically active substances.

MATERIALS AND METHODS

In 2019-2022, scientific study was carried out on *L. anisatus* in the introduction conditions of Tashkent Botanical Garden and Jizzakh region. The plant was fixed in 70% ethanol in the flowering phase of the generative period in order to study the anatomical structure of vegetative organs (leaf, petiole and stem). The processes of preparing cuttings from vegetative organs were carried out by hand. Paradermal and transverse sections were prepared to study the anatomical structure of the epidermis and stomata in the leaf. In studying the structural features of the vegetative organs of the plant, cross-sections were prepared from the middle of the leaf, the leaf band and the base of the stem. Sections were stained with methylene blue and safranin and sealed with glycerol-gelatin (Barykina *et al.* 2004). The main tissues and cells of assimilative and axis organs in plants were described by Esau (1969) and Kiseleva (1971), while epidermis by Zakharevich (1954), and the types of leaf mouth according to Baranova (1981). Photomicrographs were made using a computer photomicroscope, a *Canon* A123 digital camera, and a *Motic* B1-220A-3 microscope.

RESULTS AND DISCUSSION

The anatomical structure of vegetative organs in *Lophanthus anisatus* under the conditions of introduction in the Tashkent Botanical Garden and Jizzakh, as well as its structural diagnostic and adaptive features were established followed by the localization of biologically active substances in assimilating tissues and cells. *L. anisatus* leaves have a bifacial type in terms of their morphological structure. The leaves are heart-shaped, lanceolate, toothed, light green with purple-brown skin, covered with opposite, unicellular and multicellular simple trichomes, as well as a three-celled petiole and a two-celled round head covered with glandular trichomes and essential oil eight-celled trichomes (Fig. 1). In the paradermal sections of the leaf, the cell walls of the adaxial epidermis are relatively wavy, and the cell walls of the abaxial epidermis are strongly wavy and polygonal, which explains the origin of the plant from mesophytic conditions. Adaxial epidermal cells were found to be much larger than abaxial

epidermal cells. In the conditions of the Tashkent Botanical Garden, it was found that the adaxial and abaxial epidermal cells of the leaf are larger. Their rarity, simple unicellular and multicellular trichomes, glandular trichomes consisting of a three-celled foot and a two-celled round head, and the scarcity of eight-celled trichomes with essential oil dominate its mesophytic conditions. In Jizzax conditions, the abundance of adaxial and abaxial epidermal cells, composed of small cells, simple unicellular and multicellular trichomes, glandular trichomes consisting of a three-celled foot and a two-celled round head, and an abundance of eight-celled trichomes with essential oil are xeromorphic characters adapted to xerophytic, i.e., arid conditions of these species. it was found to prevail. Under the conditions of the Tashkent Botanical Garden and Jizzakh, the leaves of *L. anisatus* have a hypostomatic structure, which is explained by the fact that stomata are present in the abaxial epidermal cells of the leaf blade and absent in the adaxial epidermal cells sheet. The stoma belongs to the diasite type and has a round-oval shape. In the Tashkent Botanical Garden, a small number of stomata was revealed, while in Jizzakh region, a large number of stomata was found (Figs. 1-2).

In cross-sections of *L. anisatus* leaves, the anatomical structure of the leaf has a dorsiventral type [17], the palisade cells in the leaf mesophyll are located under the adaxial epidermal cells of the leaf, and the sponge cells are located in the abaxial part of the leaf. Epidermis consists of a series of round-oval cells. The cell wall is thin in the Botanic Garden, while relatively thick-walled in the Jizzakh. The leaf has a mesophyll of a non-cranz type; between the adaxial and abaxial cells of the epidermis, there is an assimilation tissue consisting of palisade and spongy cells. The cells of the palisade parenchyma are located between the adaxial cells of the epidermis and spongy cells. Palisade cells consist of one row of cells in the conditions of the Botanical Garden, while two rows of cells in the conditions of the Jizzakh region. The length of palisade cells in the conditions of the Jizzakh region is significantly greater (65.12 ± 0.61 μm) than in the conditions of the Botanical Garden (48.06 ± 0.38 μm; Figs. 2- 3).

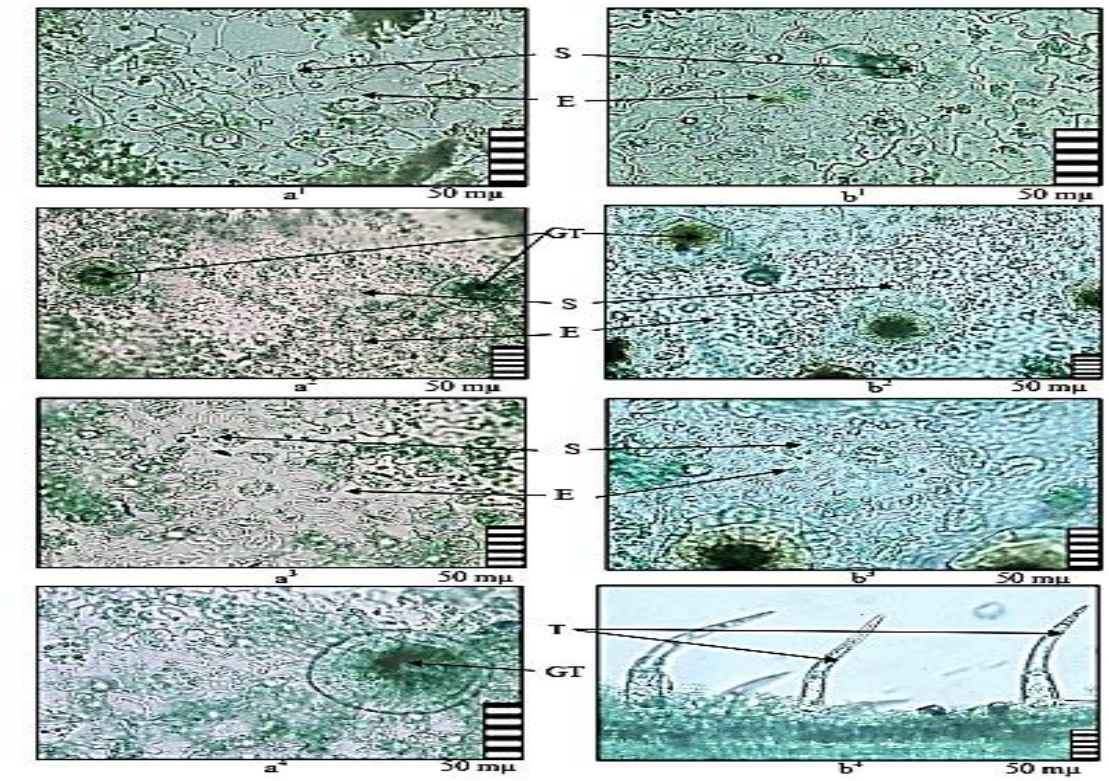

Fig. 1. Anatomical structure of the leaf epidermis of *Lophanthus anisatus* in Tashkent (a^1-a^4) and Jizzakh (b^1-b^4) conditions: a^1-a^4 – adaxial epidermis (Tashkent Botanical Garden); b^1-b^4– adaxial epidermis. Legend: GT - glandular trichomes, T - trichomes, S - stomata, E - epidermis.

In the conditions of the Botanical Garden, the palisade has intercellular spaces between the cells of the parenchyma, while in the conditions of Jizzakh, the palisade cells are densely located to each other, and there are no intercellular spaces. Between the abaxial epidermis and the palisade cells are cells of the chlorophyll-bearing spongy parenchyma. In the conditions of the Botanical Garden, spongy cells consist of large, sparse 3-4 rows of

isodermal, round-oval cells, between which there are many large intercellular spaces compared to the conditions of the Jizzakh region. Under the conditions of Jizzakh, the cells are spongy, small, relatively numerous, consisting of 4-5 rows of round-oval cells. Under both conditions, the presence of drops of essential oil in the palisade and spongy cells of the leaf mesophyll was determined. The abaxial leaf epidermis also contains multicellular rounded glandular trichomes. Among the assimilation tissues there are numerous lateral vascular bundles, consisting of 3-4 xylems of small diameter and phloem (Figs. 2-3). The main vein of the leaf bulges towards the abaxial epidermis, and its main part consists of thin-walled round-oval parenchyma cells.

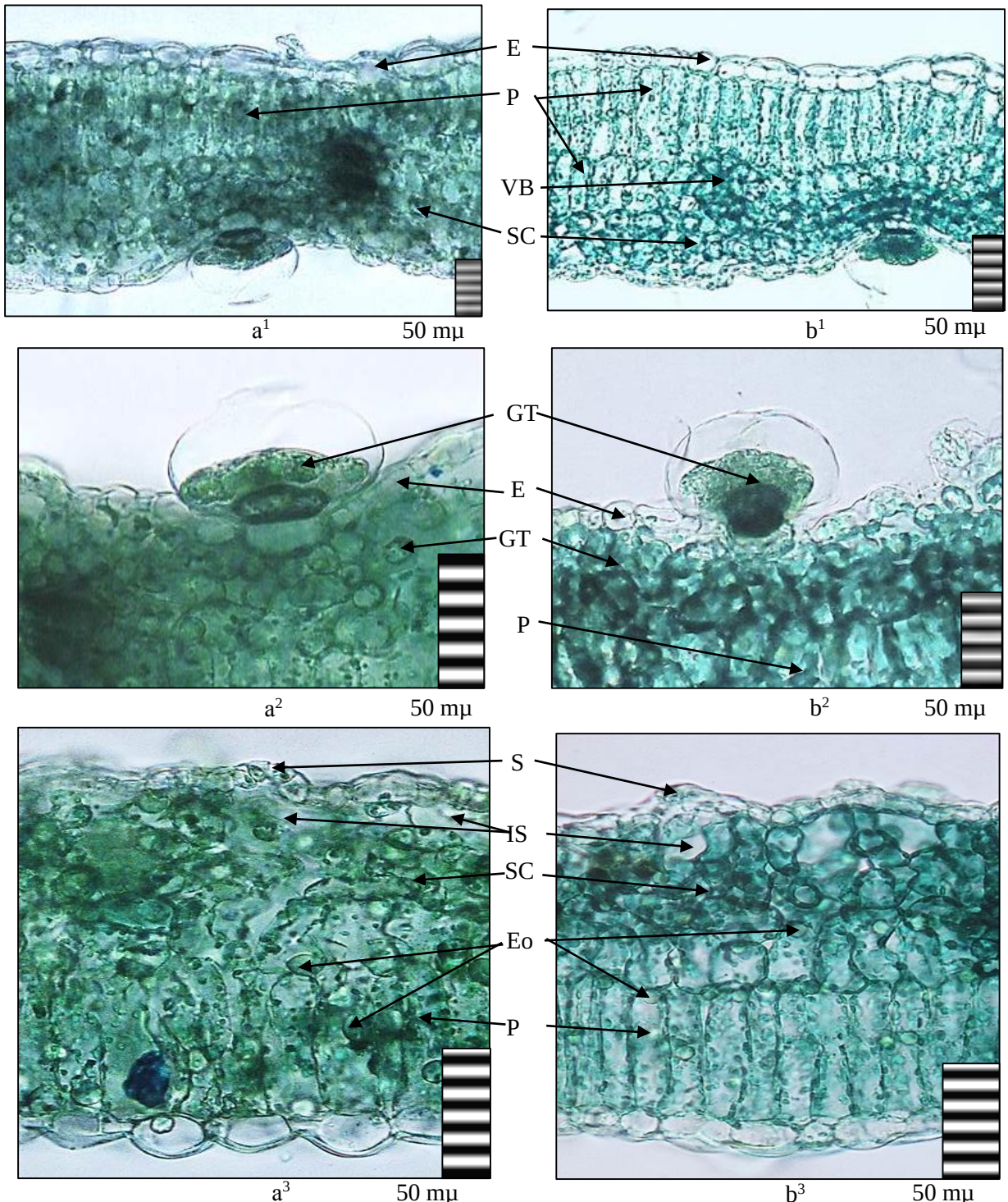

Fig. 2. Anatomical structure of leaf mesophyll of Lophanthus anisatus species in Tashkent (a^1-a^3) and Jizzakh (b^1-b^3) conditions: a^1- b^1– palisade and sponge cells in the leaf; a^2-b^2 - spongy cells and round glandular trichomes on the leaf; a^3-b^3 – stomata and assimilating tissue that is not deeply located. Legend: GT – glandular trichomes, S – stomata, P – palisade cell, E – epidermis, Eo – drops of essential oil, VB - vascular bundles, SC – sponge cell, IS – intercellular spaces.

In its central part, there is one vascular bundle, which is of the closed collateral type and consists of phloem and xylem. Xylem cells are thin and thick-walled, elongated, and their tubes have a spiral shape. In Botanical Garden conditions, xylem cells are large, thin-walled cells, while in Jizzakh conditions, xylem cells are small, thick-walled cells. In the main vein of the leaf, epidermal cells consist of a row of oval cells, under which there are 2-3 rows of plate-like collenchyma cells. Beneath the collenchyma cells are numerous parenchyma cells. In the conditions of the Botanical Garden, the parenchyma cells are large, thin-walled, while in the conditions of Jizzakh, the parenchyma cells are small, thick-walled, round-oval in shape, among which there are many hydrocytic cells (Fig. 3). The petiole has a reniform parenchymal-bundle type in cross section and consists of the epidermis, collenchyma, parenchyma and vascular ligaments.

The petiole is swollen to the abaxial side of the leaf, externally covered with unicellular and multicellular simple trichomes, glandular trichomes consisting of a three-celled pedicel and a two-celled rounded head, as well as eight-celled trichomes with essential oil (Fig. 4). In the conditions of the Tashkent Botanical Garden, the paucity of different types of trichomes was determined, while in Jizzakh, the abundance of trichomes was determined. Epidermis cells consist of a number of round-oval cells, which in the Botanic Garden, the cell is thin-walled, while in Jizzakh, relatively thick-walled. In both conditions, there are 3-4 rows of plate-like collenchyma cells under the epidermal cells, and 7-8 rows of angular collenchyma cells at the edge of the petiole. It was found that the mechanical tissue, collenchyma, was better developed in the petiole in Jizzakh than in Botanic Garden (Fig. 4). The main part of the petiole consists of parenchyma cells, and these cells contain biologically active substances. In Botanical Garden, parenchyma cells are large and thin-walled, while in Jizzakh, are small, thick-walled, round-oval in shape, and among them there are many hydrocytic cells. Between the parenchyma cells of the petiole there are 1 large and 2 small vascular bundles. Vascular bundles consist of phloem and xylem and are of closed collateral type. Xylem cells are thin and thick-walled, elongated, and their tubes have a spiral shape. In the conditions of the Botanical Garden, the xylem cells are large, thin-walled, while in Jizzakh, they differ in that the xylem cells are small, thick-walled (Figs. 4-5). Based on the study of the anatomical structure of the assimilation organs of the *L. anisatus* in Tashkent and Jizzakh, diagnostic signs specific to the species were determined. Also, on the basis of the comparative analysis of the anatomical features of leaves and petiole, the structural and adaptive features specific to the conditions of Tashkent and Jizzakh were determined. Leaf- dorsiventral type of leaf mesophyll; the presence of a large intercellular space in the leaf mesophyll; strong undulation and multifacetedness of the epidermal cell wall; leaf hypostomatic type; diacid type stomata are not deeply located; presence of chlorophyll grains in the palisade parenchyma cell; closed collateral type of vascular bundles; It was found that in adaxial and abaxial epidermal cells, single and multicellular simple trichomes, globular three-celled and two-celled glandular trichomes, as well as eight-celled essential oil glandular trichomes are located. Petiole - parenchyma-ligamentous type in the anatomical structure of the petiole; thin-walled circular-oval shape of parenchyma cells and the presence of hydrocytic cells and biologically active substances in them; closed collateral type of vascular bundles. It was found that plate-like and angular collenchyma cells consist of a dense, strongly thickened cell shell (Figs. 1-5). It has been established that the basal frequent stem of *L. anisatus* has a square-ribbed shape in cross section and a non-bundle type structure. The anatomical structure of the stem is divided into three main zones - the epidermal-cortical parenchyma, the central cylinder and the heart zone. The stem diameter is larger in Botanical Garden and relatively thinner in Jizzakh condition (Fig. 6). The epidermis consists of a series of round-oval cells. It was found that simple unicellular and multicellular trichomes, globular glandular trichomes with essential oil are located in the cells of the epidermis. Under the epidermal cells, there are one row of round-oval thin-walled hypoderm cells in Botanic Garden, while two rows in Jizzakh. In *L. anisatus,* species growing in the botanical garden, the bark parenchyma consists of 7-8 rows of cells, and 3 rows of cells under the hypoderm have chlorophyll grains. In the conditions of Jizzakh, the bark parenchyma consists of 6-7 rows of cells, and it was found that 2 rows of cells under the hypoderm have chlorophyll granules. Mechanical tissue and conductive tissue are well developed in the bark parenchyma of the stem. In the rib-like parts of the stem, in both conditions, angular-type collenchyma cells were well developed under the hypoderm cell, In addition, in the Botanic Garden, the number of cells was 7-8 rows, while in the Jizzakh, the number was 11-12 rows (Figs. 6-7). Where the border of the central cylinder joins with the primary bark, there are lignified, thick-walled cells separated by parenchyma - primary lub fibers. In the conditions of the Botanical Garden, hard lube fibers are not well developed in the parenchyma of the bark compared to Jizzakh, which are adapted to arid conditions, protect and support the tissues and cells of the stem from various environmental influences (Figs. 6-7).

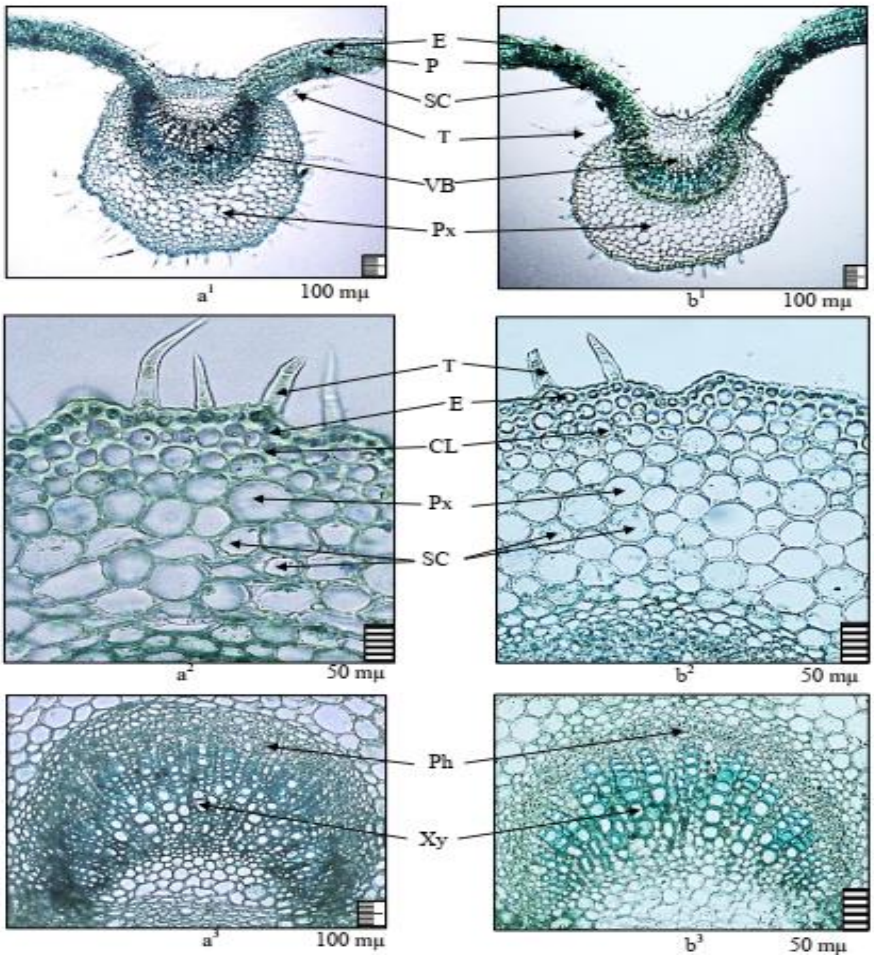

Fig. 3. The anatomical structure of the main leaf vein of *Lophanthus anisatus* species in Tashkent (a^1-a^3) and Jizzakh (b^1-b^3) conditions: a^1, b^1 – general view of the leaf; a^2, b^2 – single and multicellular simple trichomes and parenchyma cells; a^3, b^3 – main conductive links. Legend: HC - hydrocyte cell, CL - collenchyma, Xy - xylem, Px - parenchyma, T - trichome, P - palisade cell, Ph - phloem, E - epidermis, VB - vascular bundles, Sc - sponge cell.

Soft lub fibers (phloem) are located in the bark part of the stem in a ring shape. The cambial zone in the stem consists of several rows of cells extending in a tangential direction. The cells formed by the division of the cambium zone change the anatomical structure of the stem over time. Secondary xylem (wood) is formed from it every year. The woody parenchyma of the stem was found to be scattered-tubular. Primary conductive tissue is preserved in the stem and is located in the primordial zone of the core of the stem. It was found that tracheids (sclerenchyma) and sclerified parenchyma cells are located between secondary xylem and tracheae. The secondary conducting tissues in the stem are tracheas scattered., In the Botanic Garden, tracheae and tracheids were larger, smaller and thin-walled, while in the Jizzakh, tracheae and tracheids were smaller in diameter, more numerous and thick-walled. It was found that the cells of the radial rays were elongated, heterogeneous in Botanical Garden, while homogeneous in Jizzakh, and filled with tannin (Figs. 6-7). In the core part of the stem, thin-walled parenchyma cells have round-oval shapes, including hydrocytic cells. In both conditions, the core occupied the most part of the stem., It was also found that a cavity was formed as a result of the erosion of the wall of parenchyma cells in the central part of the core. The diameter of the stem, its ratio to the diameter of the stem, and the size of the cells vary from top to bottom depending on the plant's habitus and water storage function. In our species growing in the Tashkent Botanical Garden, the diameter of the core part of the stem is wider due to the size of the plant habitat, while in those growing in Jizzakh, the diameter of the core part of the stem is relatively narrow due to the relatively small habitat of the plant (Figs. 6-7).

Also, the parenchyma cells in the core have a round-oval and isodermic shape., The cell diameter is larger in the conditions of the Tashkent Botanical Garden, while smaller in Jizzakh, and there are water-retaining (hydrocyte) cells between these cells (Figs. 5-6).

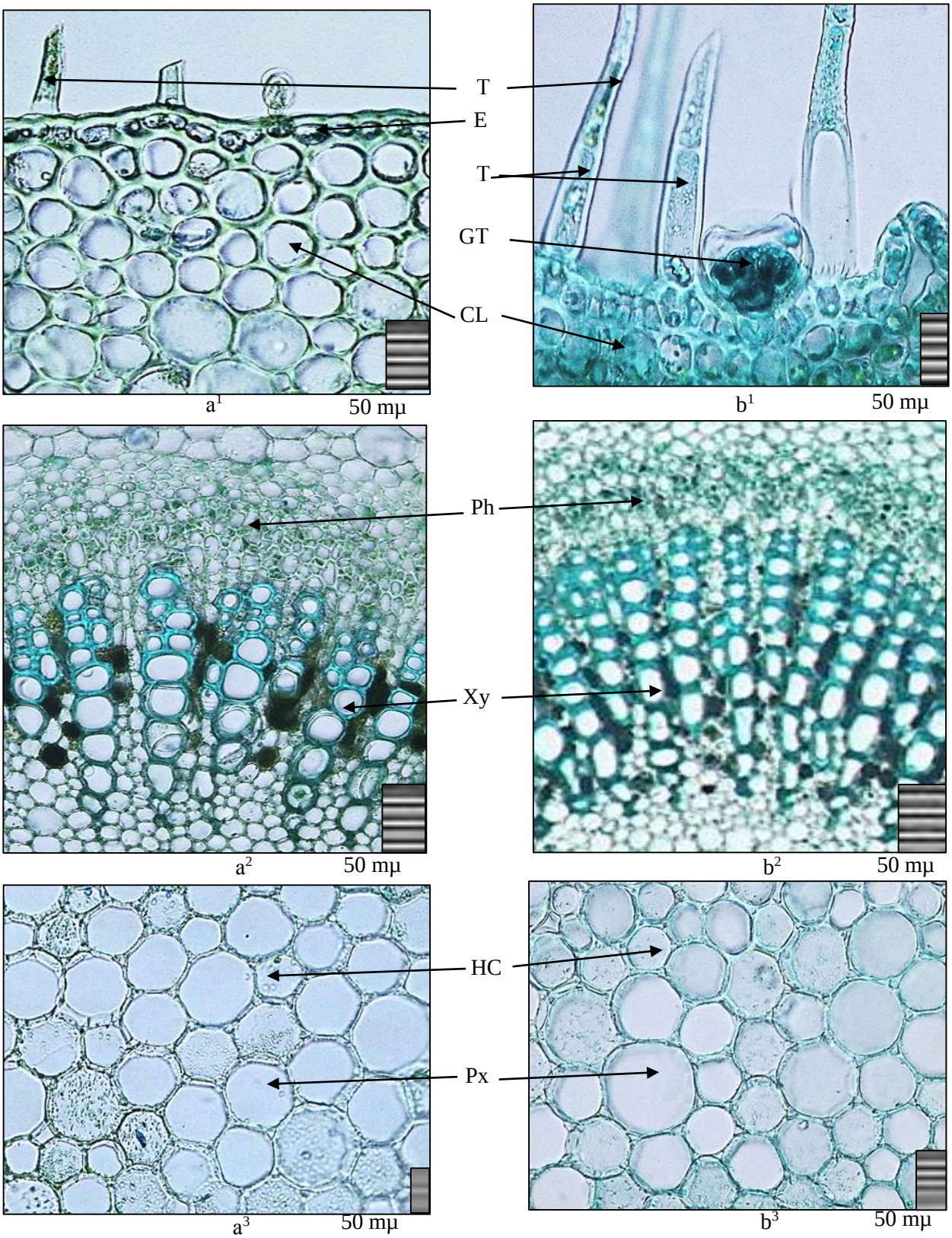

Fig. 5. The anatomical structure of the leaf band of Lophanthus anisatus species in Tashkent (a^1-a^3) and Jizzakh (b^1-b^3) conditions: a^1, b^1 – simple and glandular trichomes in the leaf band; a^2, b^2 – vascular bundles: phloem and xylem; a^3, b^3 – parenchyma and hydrocytic cells. Legend: GT - glandular trichome, CL - collenchyma, Xy - xylem, Px - parenchyma, T - trichome, Ph - phloem, E - epidermis.

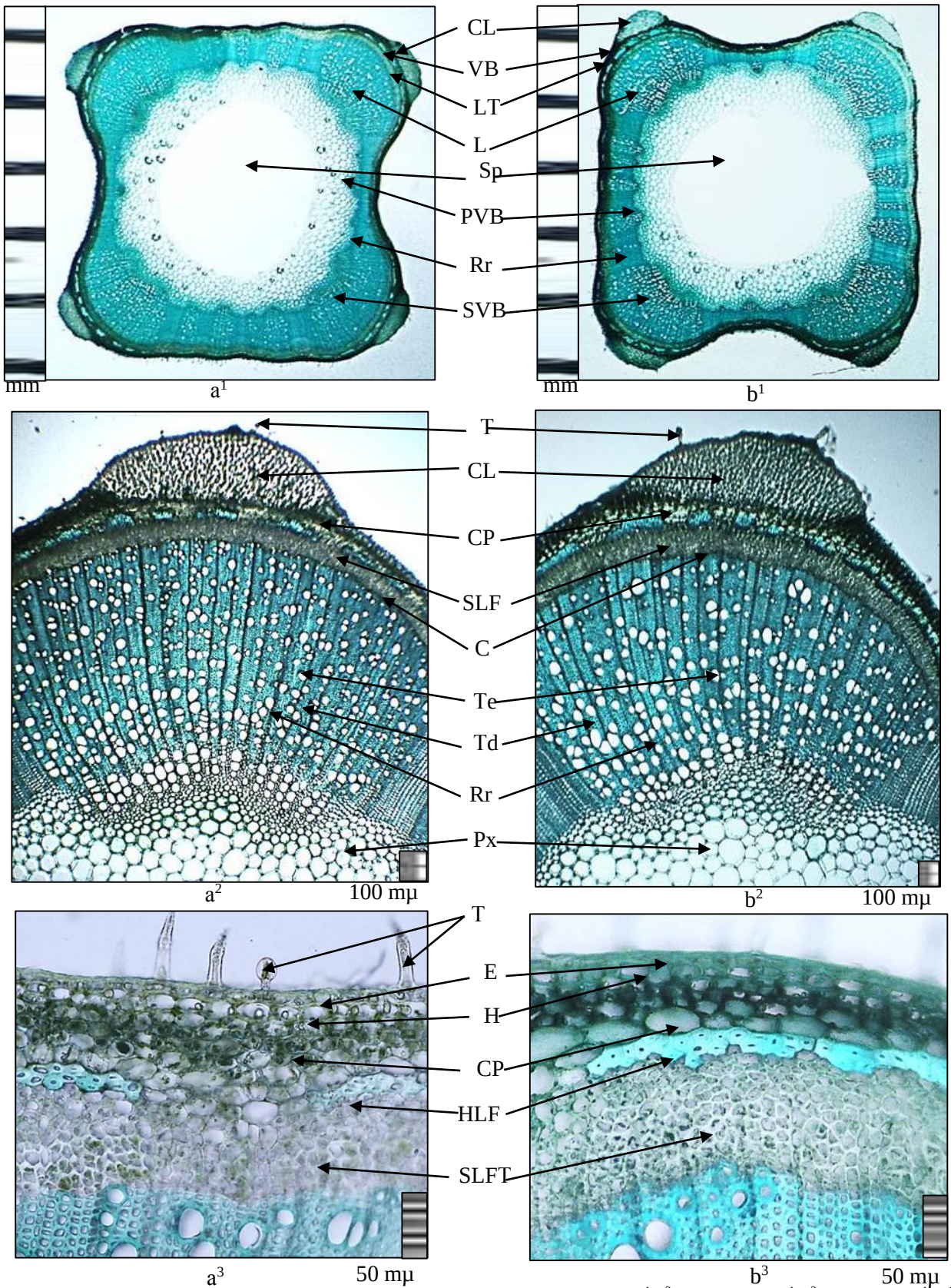

Fig. 6. Anatomical structure of the stem of Lophanthus anisatus species in Tashkent (a^1-a^3) and Jizzakh (b^1-b^3) conditions: a^1- b^1– general view of the stem; a^2-b^2 – stem detail; a^3- b^3 – cortex parenchyma. Legend: Sp – space, PVB – primary vascular bundles, H – hypoderm, SVB - secondary vascular bundles, C - cambium, CL - collenchyma, CP - cortex parenchyma, Px - parenchyma, Rr - radial ray, Te - trichome, Td - tracheid, Te - trachea, E - epidermis, SLF - soft lub fiber, HLF - hard lub fiber.

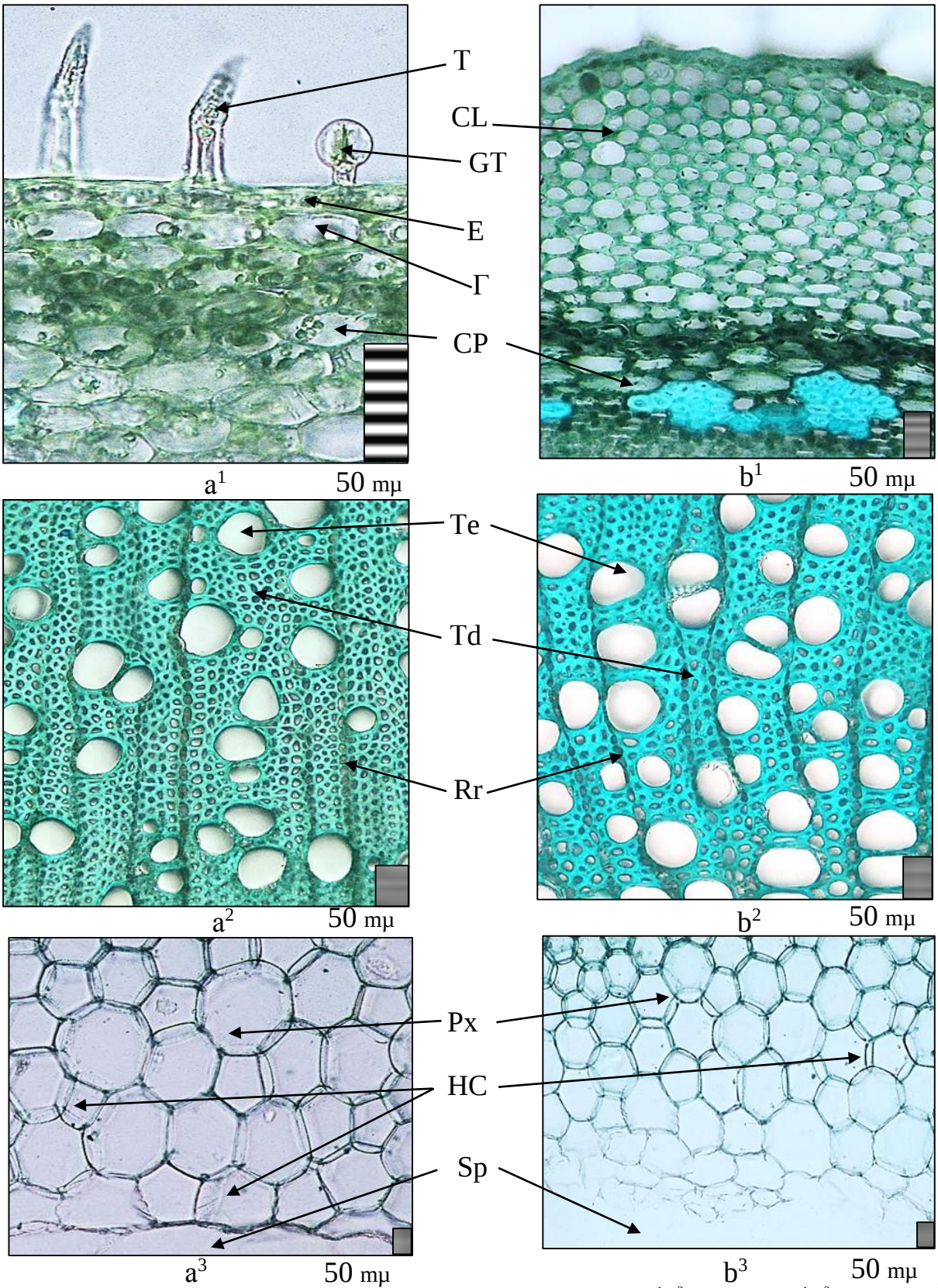

Fig. 7. Anatomical structure of the stem of Lophanthus anisatus species in Tashkent (a^1-a^3) and Jizzakh (b^1-b^3) conditions: a^1-b^1– epidermis, cortex parenchyma and collenchyma; a^2-b^2 – secondary vascular bundles; a^3- b^3 – core – parenchyma and hydrocyte cell. Legend: Sp – space, GT – glandular trichome, G – hypodermis, GH – hydrocyte cell, CL – collenchyma, CP – cortex parenchyma, Px – parenchyma, Rr – radial ray, T - trichome, Td - tracheid, Te - trachea, E - epidermis.

CONCLUSION

To sum up, for the first time, diagnostic signs specific to *Lophanthus anisatus* were determined based on the study of the anatomical structure of the assimilative and its shoot organs in the conditions of Tashkent and Jizzakh. Also, on the basis of the comparative analysis of the anatomical signs in the vegetative organs, the structural and adaptive signs characteristic of the conditions of Tashkent and Jizzakh were determined. It was found that in Tashkent Botanical Garden, mesomorphic characters predominate in the assimilative and axis organs, while in Jizzakh, xeromorphic characters predominate. This indicates that this species is well adapted to both conditions. Also, the localization of biologically active substances was determined in the columnar and porous cells of the leaf mesophyll, parenchyma of the bark of the stem, and parenchyma cells of the core. In *L. anisatus* species, there is no internal separating tissue. However, unicellular and multicellular simple trichomes on the leaf, leaf band and stem, as well as glandular trichomes consist of a three-celled foot and a two-celled round head, as well as eight-celled trichomes with essential oil, assimilating and biologically active in the shoot organs. separation of substances was determined. These identified diagnostic signs are considered permanent taxonomic signs and are used in systematics and in the process of identification of raw materials of the species.

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