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Endo-Adaptive Component *Taraxacum Officinale L.* as a Determinant of the Adaptation Syndrome of Plant Organisms in the Background of Ecosystem Stability

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ABSTRACT

The research aim is to find out the specificity of the endo-adaptive component (Taraxacum Officinale L.) as a determinant of the adaptation syndrome of plant organisms against the background of ecosystem stability. The theoretical-methodological basis of the work was the synergistic use of scientific principles and a systematic approach, which determined a transparent approach to the choice of research methods: general scientific, general biological, mathematical statistics. It has been proven that in modern conditions, plants adapt to changes in the environment due to various adaptation mechanisms (xeromorphic features, etc.) which were formed in the process of phylogenetic development and which determine the existence of drought-resistant plants. It is shown that the reactions-responses of plants help to identify the main components of xeromorphism, to investigate the corresponding changes in the formation of the general adaptation syndrome of the plant organism.

KEYWORDS: Structural and functional rearrangements, xeromorphization, Taraxacum Officinale L., south of Ukraine.

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Componente Endo-Adaptativo de *Taraxacum Officinale L.* como determinante del síndrome de adaptación de los organismos vegetales en el fondo de la estabilidad del ecosistema

RESUMEN

El propósito del estudio es investigar la especificidad del componente endoadaptativo (agárico de miel) como determinante del síndrome de adaptación de los organismos vegetales en el contexto de la estabilidad del ecosistema. La base teórica y metodológica del trabajo fue el uso sinérgico de principios científicos y un enfoque sistemático, lo que determinó un enfoque transparente para la elección de métodos de investigación: estadística general científica, biológica general y matemática. Se ha demostrado que, en las condiciones modernas, las plantas se adaptan a los cambios en el ambiente externo debido a varios mecanismos de adaptación (características xeromórficas, etc.), que se formaron en el proceso de desarrollo filogenético y determinan la existencia de plantas resistentes a la sequía. Se muestra que las reacciones-respuestas de las plantas ayudan a identificar los componentes principales del xeromorfismo, para investigar los cambios correspondientes en la formación del síndrome adaptativo general del organismo vegetal.

PALABRAS CLAVE: Reordenamientos estructurales y funcionales, xeromorfización, Taraxacum Officinale L., Sur de Ucrania.

Introduction

Recently, the scientific community is increasingly aware of the need to integrate the knowledge obtained from the study of processes occurring at different levels of the organization of living systems, starting from the molecular to the cenotic. An important problem is the resistance of plant organisms to stress factors of the external environment: low and high temperatures, environmental pollutants, the consequences of man-made disasters (Box, 2006; Didukh et al., 2004; Golubets, 2017; Gulac, Oleksenko, Kaluha, Kravchenko & Yukhymenko, 2022). Plants have many mechanisms for responding to environmental changes, including various stressors. These mechanisms cover various aspects of plant anatomy, morphology, physiology and development (Gulac, Marchenko, Kapitanenko, Kuris & Oleksenko, 2022; Jones, 2012; Larcher, 2005; Preservation and monitoring of biological and landscape diversity in Ukraine, 2000; Pyurko, Velcheva & Arabadzhi-Tipenko, 2022). A wide range of adaptive processes are involved in the reaction-response of a plant to any adverse factor, which ensure a non-specific reaction of the plant and are responsible for increasing resistance to a specific factor. This allows plants to adapt

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to natural conditions, where the combined action of several stressors, such as drought and high temperature, often accompanied by salinity and increased insolation, is more common (Smirnoff, 2008; Zlobin, 2004).

The conditions of the external environment, characteristic of different geographical areas, determine the course of plant ontogenesis not only through the natural selection of appropriate forms, but also through a direct effect on the course of individual development of living organisms (Box, 2006; Crawley, 2000; Grozdynskyi, 2013; Khrystova & Pyurko, 2009). The stability of plant organisms is determined by adaptive reactions at the structural-physiological level; therefore anatomical-morphological and physiological-biochemical studies are relevant and attract more and more attention of scientists. The south of Ukraine forms a zone of risky agriculture, which is characterized by a temperate continental climate with hot summers, high solar insolation and a significant water deficit, and soil salinity determines the poverty and specificity of the natural flora (Didukh & Plyuta, 2004; Didukh & Shelyag-Sosonko, 2003; Kramer & Bayer, 2005).

Among the environmental factors that accompany the ontogenetic development of plant organisms, water supply occupies an important place. An insufficient level of moisture in the surrounding environment leads to the occurrence of a water deficit in plant organs, which affects all processes of their vital activity (Pyurko, Velcheva & Arabadzhi-Tipenko, 2022; Tyerman, Bohnert, Maurel et al., 2009; Weaver & Clements, 2008; Zlobin, 2004). This is due to the fact that water is not only the dominant component of cells in comparison with other substances, but also an active component, a regulator of the intensity of physiological processes and biochemical reactions (photosynthesis, respiration, etc.), which underlie the formation of cellular structures, the cells themselves and biomass in general (Jones, 2012; Musienko, 2005; Pyankov, Ivanovov & Lambers, 2008). Higher plants in natural conditions can survive a certain period of water deficit, which causes phenotypic structural and functional changes at the organ, tissue, cellular and subcellular levels (Didukh & Shelyag-Sosonko, 2001; Hajibagheri, 2003; Smirnoff, 2008; Wright & Westoby, 2001). It has been proven that the anatomical structure of plant organisms is largely caused by the conditions of their vital activity (Baczek, Kosakowska, Przybyl et al., 2015; Golubets, 2017; Grytsyk, Neiko & Melnyk, 2016; Nomani, Schuize & Ziegler, 2010; Sterk, Hommels, Jenniskens, Neuteboom, den Nijs, Oosterveld & Segal, 2007). Therefore, when studying the structural and adaptive changes of xerophytic plants, it is important to know: how they

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affect the anatomical structure of organs and tissues, especially the conducting system and stomatal apparatus, which are directly related to providing plants with nutrients and water (Khrystova & Pyurko, 2007; Spence, 2017; Vasylevska, 2014; Wilson, 2002). The level of vitality and productivity of plants will depend on how these vital processes will be carried out, in particular as an element of ecosystem stability in the conditions of southern Ukraine (Larcher, 2005; Malawska & Wilkomirski, 2001; Preservation and monitoring of biological and landscape diversity in Ukraine, 2000). The broad prospects for the use of *Taraxacum officinale L.* plants in medicine, pharmacology, cosmetics, veterinary medicine and landscaping necessitate a comprehensive study of endo-adaptive changes, particularly in the south of Ukraine.

The research aim is to find out the specificity of the endo-adaptive component (*Taraxacum officinale L.*) as determinants of the adaptation syndrome of plant organisms against the background of ecosystem stability.

1. Materials and methods

The theoretical and methodological basis of the work was the synergistic use of scientific principles and a systematic approach, which determined a transparent approach to the choice of research methods, in particular: general scientific (analysis, synthesis, systematization, generalization of literary sources); general biological (experimental method, quantitative-anatomical, physiological and system-structural analysis) (Carolin, Jacobs & Vesk, 2008; Kazakov, 2000; Pyurko, Musienko & Kazakov, 2002); methods of mathematical statistics. The digital material obtained in the research process was processed using Statistica version 10.0 general purpose data processing software package. The reliability of component differences (comparison of the average values of the indicator for each parameter) was determined using the Student's test (t) at a significance level of 5% ($p \leq 0,05$).

2. Results and discussion

A leaf is a vegetative organ in which the most important processes take place: gas exchange, transpiration, photosynthesis. The leaf is covered on both sides by a covering tissue - the epidermis. Epidermal cells tightly adhere to each other; form a cover that protects the plant from drying, mechanical damage, infections.

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The experimental plant *Taraxacum officinale L.* leaves, pinnately incised or whole, lanceolate or oblong-lanceolate, toothed, 10-25 cm long, 1.5-5 cm wide, collected in a basal rosette (Hajibagheri, 2003).

The epidermis is a multifunctional tissue, the size and state of cells of which largely determine the plant's water balance, the intensity of CO_2 assimilation, respiration, which ultimately affects the nature of the production process. The histological features of the cells of the primary integumentary tissue are determined genetically, but their formation and functioning depend on many biological and environmental factors, therefore, in the qualitative and quantitative study of the epidermis, it is necessary to pay special attention to the influence of each of these factors not only separately, but also in their synergistic effect (Vasylevska, 2014; Weaver & Clements, 2008; Wilson, 2002; Wright & Westoby, 2001; Zlobin, 2004; Crawley, 2000; Didukh & Plyuta, 2004; Didukh & Shelyag-Sosonko, 2001; Didukh & Shelyag-Sosonko, 2003; Golubets, 2017; Grozdynskyi, 2013; Grytsyk, Neiko & Melnyk, 2016; Gulac, Marchenko, Kapitanenko, Kuris & Oleksenko, 2022; Gulac, Oleksenko, Kaluha, Kravchenko & Yukhymenko, 2022; Hajibagheri, 2003; Jones, 2012; Kazakov, 2000; Khrystova & Pyurko, 2007; Khrystova & Pyurko, 2009).

Our studies proved that the upper epidermis of *Taraxacum officinale L.* consists of a single layer of living, tightly closed cells that have an elongated shape. Along with the cells that make up the bulk, the epidermis also contains enclosing and surrounding stomatal cells. In the skin there are stomatal complexes - slits formed by two closing or stomatal cells. Stomatal cells are small, green, horseshoe-shaped. The membranes of these cells are unevenly thickened: the inner one facing the slits is thicker than the opposite one. Changes in the turgor of stomatal cells cause a change in their shape, as a result of which the stomatal gap is open, narrowed or completely closed, depending on environmental conditions. Stomata are usually located on the lower side of the leaf, but there are also on the upper side. During the study of the upper and lower epidermis, stomatal cells were observed, which belong to the diacytic type.

But the pericytic type of stomatal complexes is also observed on the upper epidermis, because the stomata is accompanied on each side by one or more side cells parallel to the length of the axis of the aperture and closing cells. On the lower epidermis there are stomatal complexes of the pericyte type - often elongated, finely tortuous (windy-wavy),

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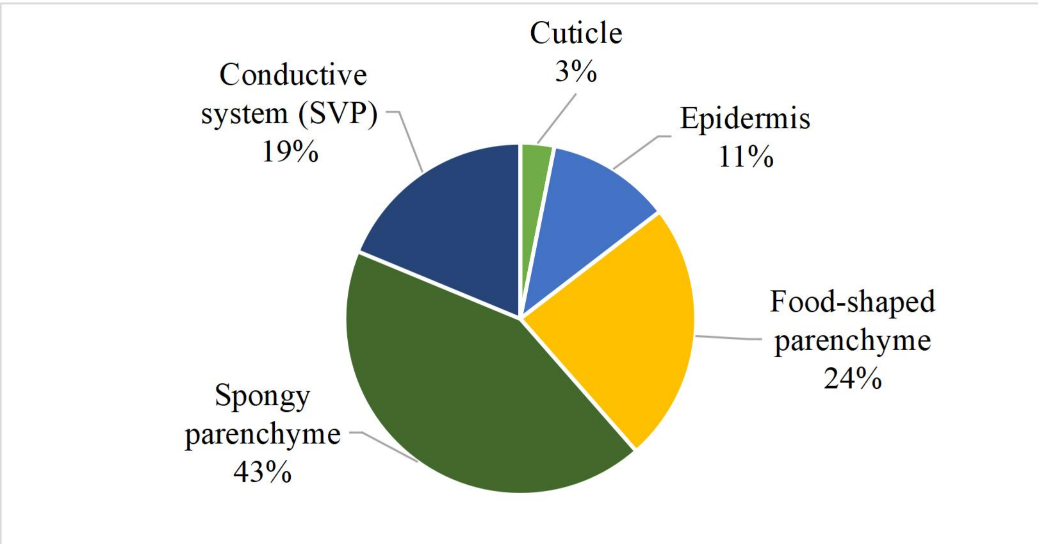
with a rectangular, elongated projection; the corners are sharp. We have shown that the leaves of *Taraxacum officinale L.* are amphistomatic, the type of stomatal apparatus is pericytic. The number of stomata in the epidermis ranges from 110 pcs. per 1 mm². Thus, the main cells of the upper epidermis of the studied xerophyte leaf differ from similar cells of the lower epidermis: projection, outline, number per 1 mm².

We proved that the internal structure of the leaf of *Taraxacum officinale L.* is characterized by the presence of cuticle (3%), epidermis (11%), columnar parenchyma (24%), spongy parenchyma (43%), conducting system (vascular-fibrous bundle-19%) (Fig. 1).

Fig. 1. Percentage histological ratio in the leaf of *Taraxacum officinale L.* (%).



So, all these features of leaf tissues are determinants of such important plant functions as photosynthesis, gas exchange and transpiration. A green leaf performs an important function in the life of a plant - organic substances are formed here. O_2 and CO_2 enter the leaf with amphoteric air through the stomatal complexes. Oxygen is used for respiration; CO_2 is needed by the plant for the formation of organic substances. O_2, which is formed in the process of photosynthesis, is released into the air through the stomata. CO_2, which appeared in the plant during respiration, is also released. Photosynthesis is carried out only in the light, and respiration - in the light and in the dark, that is, constantly (Kazakov, 2000; Nomani, Schuize & Ziegler, 2010; Preservation and monitoring of biological and landscape diversity in Ukraine, 2000; Pyankov, Ivanovov & Lambers, 2008; Pyurko, Musienko &

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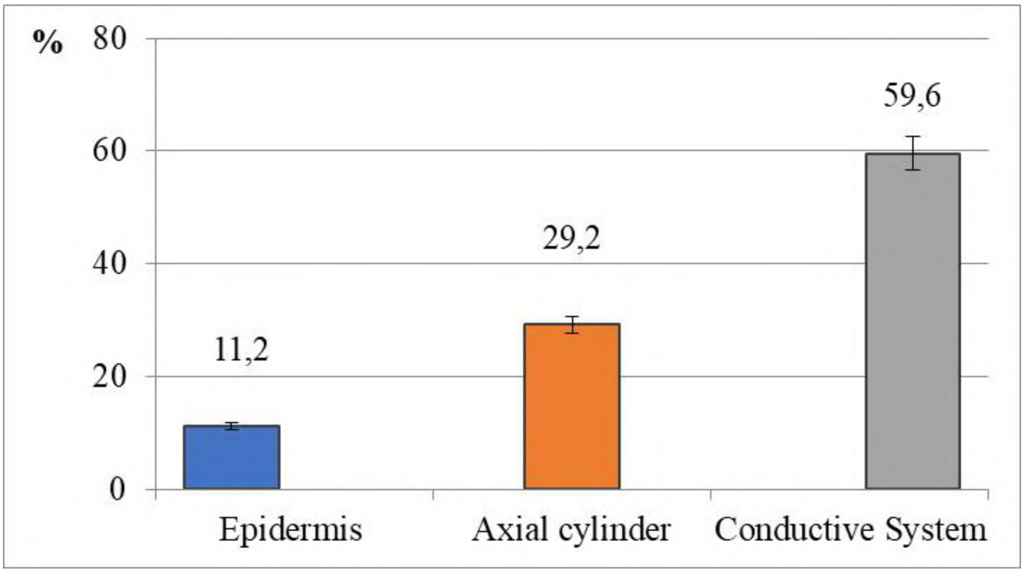
Kazakov, 2002; Pyurko, Velcheva & Arabadzhi-Tipenko, 2022; Smirnoff, 2008; Spence, 2017; Sterk, Hommels, Jenniskens, Neuteboom, den Nijs, Oosterveld & Segal, 2007).

Our studies have shown that the characteristic features of the anatomical structure of the plant are the presence of a basal rosette and the absence of a core in the stem. The stem is simple, leafless, hollow, slightly webbed, 15-30 cm tall. The stem has a bundle structure, collenchyma is not found. Conductive bundles are densely intertwined in the internodes and are located along the entire cross-section of the stem, they are collateral. The endoderm is weakly developed, core rays and core are absent. The main stem parenchyma is important. At the periphery, it forms chlorophyll-bearing or assimilating tissue. The parenchyma of the stem is very developed, because the stem is almost leafless. Mechanical tissue is represented by sclerenchymal fibers. Peripheral layering of sclerenchyma gives strength to stems, they do not break when bent and resist wind and other deforming influences (Wilson, 2002; Wright & Westoby, 2001; Zlobin, 2004). During the research, it was established that the epidermis of Taraxacum officinale L. is 11.2%, the axial cylinder is 29.2%, and the conducting system is 59.6% (Fig. 2). Based on the structural and logical analysis of the measurement results, we proved that there is a close relationship between the structure of the stem and the physiological features of the xerophytic plant.

Fig. 2. The stem histological features of *Taraxacum officinale L.* (%).



The stem of the plant serves as a connecting link between the root, through which water and minerals enter the plant, and the assimilating surface, where nutrients are synthesized. Conductive tissues of the stem form a single whole with similar tissues of the root and leaf - these are the ways of substances movement. The basal rosette supports the leaves in such a position that they receive as much sunlight as possible, as a result of which nutrients move along the stem. Reserve organic substances are deposited in the stem (Khrystova & Pyurko, 2007; Khrystova & Pyurko, 2009; Kramer & Bayer, 2005; Larcher, 2005; Malawska & Wilkomirski, 2001; Musienko, 2005; Nomani, Schuize & Ziegler, 2010; Preservation and monitoring of biological and landscape diversity in Ukraine, 2000; Pyankov, Ivanovov & Lambers, 2008; Pyurko, Musienko & Kazakov, 2002; Pyurko, Velcheva & Arabadzhi-Tipenko, 2022).

A root is a vegetative organ with unlimited growth, which ensures anchoring of plants in the substrate, absorption and transport of water and dissolved minerals and products of life of soil microorganisms and roots of other plants, primary synthesis of organic substances, release of metabolic products into the soil, and vegetative reproduction.

The root of *Taraxacum officinale L.* is spindle-shaped, sparsely branched, fleshy, 20-60 cm long, 1-2 cm in diameter, bitter in taste. Our research proved that the cells of the root hair have an elongated shape. A certain zonal sequence of the placement of histological elements is observed. The young root is divided into zones: conducting, absorption, growth, division, root cap, group of initial cells. The growth point of the root consists of a group of initial cells arranged in three layers. The initial cells of the lower layer give rise to the rhizoderm and all the cells of the cap. The middle layer of the initial forms a transitional tissue - the periblem, from which the primary cortex is formed. From the upper layer of the initial comes the pleroma, which gives rise to the axial cylinder (Didukh & Shelyag-Sosonko, 2003; Golubets, 2017; Grozdynskyi, 2013; Grytsyk, Neiko & Melnyk, 2016; Gulac, Marchenko, Kapitanenko, Kuris & Oleksenko, 2022; Gulac, Oleksenko, Kaluha, Kravchenko & Yukhymenko, 2022; Hajibagheri, 2003).

On the surface of the root there is a rhinoderm, root hairs develop from trichoblasts. During the research, it was found that the exoderm is differentiated, it is multi-layered. In the mesoderm, the intercellular spaces are small. The endoderm consists of one layer of cells, the cells are thickened, there are no intercellular spaces. No narrowing was observed,

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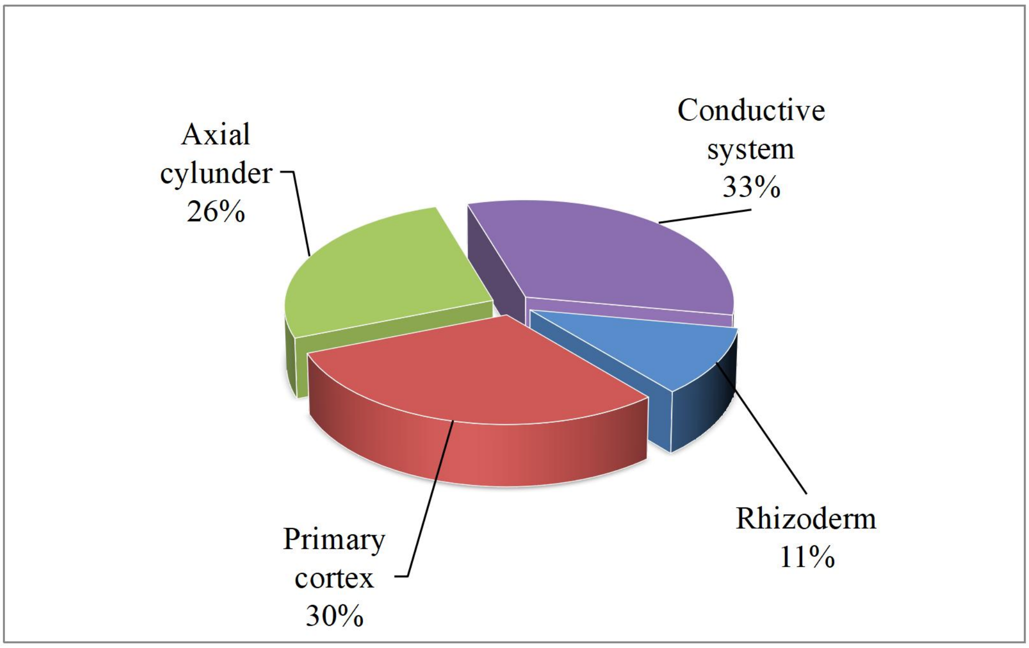
accordingly, there were no Caspari bands. The pericycle looks like a continuous ring of living cells, it is the axial cylinder of the root. Phloem and xylem alternate with each other, arranged in radial groups, which cause the absence of concentric zones in the root. Phloem is located between xylem rays. The mechanical tissue of the root is represented by sclerenchyma fibers (Grozdynskyi, 2013; Grytsyk, Neiko & Melnyk, 2016; Hajibagheri, 2003; Jones, 2012; Kazakov, 2000; Khrystova & Pyurko, 2007; Khrystova & Pyurko, 2009; Kramer & Bayer, 2005).

A comparative analysis of Taraxacum officinale L. root tissues showed that the rhizoderm is 11%, the primary bark is 30% (exoderm, differentiated into long and short cells, mesoderm, endoderm), the axial cylinder is 26%, and the conducting system is 33% (Fig. 3).

Fig. 3. Ratio of *Taraxacum officinale L.* root tissues (%).



Considering the research results, it can be concluded that the structure of the root affects the physiological features of the studied xerophyte. In addition to the clearly expressed protective role, with the help of root tissues, ions, nutrients, and water are absorbed and delivered to other parts of the plant. The root of *Taraxacum officinale L.* is negatively phototropic, this is manifested in the fact that its elements avoid the rays of sunlight in the opposite direction, and it is also positively hydrotropic, that is, it orients its growth in the soil in the direction of higher humidity. According to certain features,

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Taraxacum officinale L. belongs to the following ecogroups: in relation to moisture - it is a mesophyte, in relation to soil salinity - it is a glycophyte, i.e. it tolerates slight salinity, and in relation to acidity - it is a neutrophyte.

Conclusions

As a result of the experimental study, the specificity of the endo-adaptive component (*Taraxacum officinale L.*) was determined as determinants of the adaptation syndrome of plant organisms against the background of ecosystem stability. The study of the histological and functional characteristics of the vegetative organs of *Taraxacum officinale L.* showed that the leaves of the plant are amphistomatic, the type of stomatal apparatus is diacytic and pericytic. The main cells of the upper epidermis of a leaf of a plant organism differ from similar cells of the lower epidermis in projection, outline, and number per 1 mm^2. It is proved that the internal structure of *Taraxacum officinale L.* leaf is characterized by the presence of cuticle (3%), epidermis (11%), columnar parenchyma (24%), spongy parenchyma (43%), conducting system (vascular-fibrous bundle - 19%). The proportions of *Taraxacum officinale L.* stem tissues are equal to the following values: epidermis – 11,2%, axial cylinder – 29,2%, conductive system – 59,6%. Studies have shown that the characteristic features of the anatomical structure of the plant are the presence of a basal rosette and the absence of a core in the stem. The endoderm is weakly developed; core rays and core are absent. Mechanical tissue is represented by sclerenchymal fibers. A comparative analysis of *Taraxacum officinale L.* root tissues showed that the rhizoderm is 11%, the primary bark is 30% (exoderm differentiated into long and short cells, mesoderm, endoderm), the axial cylinder is 26%, and the conducting system is 33%. A rhizoderm is located on the surface of the root, root hairs develop. The exoderm differentiates into long and short cells, it is multi-layered.

So, on the basis of a generalized structural and logical analysis of experimental data, it is shown that in modern conditions plants adapt to changes in the surrounding environment due to various adaptation mechanisms that were formed in the process of phylogenetic development, in particular, the acquisition of xeromorphic features under conditions of insufficient moisture, which determine the existence of drought-resistant plants with stressful changes in the environment against the background of ecosystem stability. Moreover, the greater the number of adaptation mechanisms used by the plant at the same time at different levels of organization, the greater is the resistance of the organism. The obtained results showed that the reactions of plants to changes in climatic conditions, in particular in the south of Ukraine, help to identify the main components of the adaptation syndrome of xeromorphism, to investigate the corresponding changes in the general chain of adaptation of the plant organism, and to determine the prospects for further use.

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