

Study of Morphogenesis and Anatomical Structure of *Arctium tomentosum* Mill. Native to Kazakhstan

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ABSTRACT

The article presents the biological features of *Arctium tomentosum* Mill. in natural and sowing conditions, the changes in morpho-anatomical structure of vegetative organs in ontogenesis. The growth rate of the germinal root was quite active, and the formation of many lateral roots was observed at the juvenile stage of life. There was an increase of the neck of the germinal root in the immature state, the formation of primary and secondary lateral roots in length, and an increase in the level of growth of the germinal root in the virginal age state. In the generative state, in the second year of life, the lateral roots form two distinct layers. The seed shell in the natural environment is lamellar, without protein, the seed is well ripened. In the next juvenile state, it was observed that the components of the xylem and phloem were not fully formed in the leaf-like cotyledon, with an underdeveloped mesophyll, of a homogeneous type. The first anatomical features in the root structure have been clarified. The size and shape of mesophyll cells are stable, columnar and loose parenchyma are determined, conductive tissues are formed. The anatomical structure of the root undergoes a period of over-development. In the generative state, the size of the central cylinder increased in the structure of the root, the layer of cutin thickened on the leaves, and the layer of columnar mesophyll containing chlorophyll grains increased. There was an accumulation of idiocytic cells and needle-like calcium oxalate druses in the root.

Keywords: medicinal plants, ontogenesis, association, morphology, anatomy.

INTRODUCTION

Asteraceae is one of the largest families of angiosperms, which has the highest evolutionary status among dicotyledons, is widespread in the world, and most species are of great economic importance as ornamental, food and medicinal plants. One of the most widespread medicinal plants of this family worldwide are the species of *Arctium* L., used as food and a rich source of secondary metabolites for the pharmaceutical industry. Arctiin and its aglucone, obtained from burdock roots, can interfere with the early stages of avian influenza virus replication, as well as prevent the release of the virus in offspring in mammalian cells (Bi

et al., 2012). Dicotyledons are the largest family in the class of dicotyledonous plants. Worldwide, this family includes 1150–1300 genera, 20,000 species (Baytenov, 2001), and in Kazakhstan it has about 140 genera and more than 700 species. *Arctium* L. plants have been widely used in traditional medicine since ancient times. Its powder is prescribed for the treatment of feverish conditions and gastrointestinal disorders resulting from heat and poisoning, it has a number of antitumor, anti-inflammatory, antidiabetic, antibacterial and antiviral properties. Burdock contains several chemical components, the main of which are lignans, volatile oils, fatty acids, terpenoids and phenolic acids (Strawa et al., 2020).

Arctium tomentosum Mill. – spider burdock, found in all regions of Kazakhstan, but not higher than 2000 m in absolute height and excluding the southern deserts. *Arctium tomentosum* is used to treat skin inflammation, relieves discomfort in the stomach, and has a diuretic effect. It was confirmed that arctiin and arctigenin were found in extracts of its fruits (Zhou et al., 2011). Few flavonoids (kaempferol, quercetin, luteolin and apigenin derivatives), chlorogenic acid, as well as luteolin-3-O-acetate and β -sitosterol-3-O-glucoside have been isolated from methanol extracts of leaves and inflorescences of *A. tomentosum*. In addition, the content of phytosterols, tocopherols and β -amyryn in lipophilic extracts was determined, and the composition of fatty acids was studied (Strawa et al., 2020). Water-soluble polysaccharides (glucofructans), pectin substances and hemicellulose were found in the roots of *Arctium tomentosum* (Turdumambetov et al., 2004). Since plants are rich in various biologically active compounds, extracts from them have antimicrobial, anti-inflammatory, antioxidant properties, etc. In the study, Aitynova A.E. et al. studied the antimicrobial effect of an extract of *Arctium tomentosum* Mill. obtained by supercritical extraction with carbon dioxide. The results showed that the extract of *Arctium tomentosum* Mill. it has antimicrobial activity, therefore it can serve as a basis for the creation of phytopreparations for the treatment of diseases of microbial origin (Aitynova et al., 2022).

Burdock roots, leaves and fruits are used in folk medicine. Extracts of roots and leaves improve metabolism and have a diuretic effect. They improve the functioning of the liver and pancreas, gastrointestinal tract. They are used to prevent diabetes by regulating the amount of glucose in the blood. In the treatment of cancer, burdock fruits, leaves and roots are used to reduce inflammation and irritation of acne, wounds and skin (Sederski et al., 2017). Many studies have been conducted on the activity and chemical composition of extracts of burdock roots, leaves and fruits. The extracts of burdock leaves contain arctiin and arctigenin, flavonoid luteolin, quercetin, quercitrin and rutin, phenolic acids, and phenolic and dicaffeoylquinic acids from the root extract (Carlotto et al., 2016; Ferracane et al., 2010).

Scientists have discovered a huge potential for using *Arctium tomentosum* in minimizing emerging environmental pollution problems. In simulated laboratory conditions, the growth and biochemical reactions of 14-day-old *Arctium*

tomentosum seedlings to the effects of polymetals on the body, including Pb, Cu, Ni and Zn (1.0 μm –10 mm) were studied in this work. The results showed a significant tolerance of *A. tomentosum* to multimetals, which may be related to its potential role in phytoremediation programs of metals (Waad et al., 2017). According to Bi et al. (2012) *A. tomentosum* completes its life cycle every two years. In the first year, it forms a rosette of leaves and a large fleshy taproot as a storage organ. In the second year, a rosette of large leaves is formed up to 45 cm long and 40 cm wide, with white hairs on the bottom. Subsequently, a green, woody, branched stem is formed up to 2 m high with flower heads at the ends of the branches. After flowering, plants die off, and seeds with a bristly-hooked structure spread, attaching to animal skin, fur, human clothing, etc. (Bi et al., 2012).

Arctium tomentosum Mill. It is found everywhere except in the southern deserts of Kazakhstan and above 2000 m above sea level. Biologically active substances inulins, essential oils, organic acids, bile substances, bitter protein and fatty substances, vitamins C, glycosides in grains – arctin and up to 20% of oils, mineral salts, proteins, sugars, B vitamins, many ascorbic acids, carotenes were found.

The stem of *Arctium tomentosum* Mill. a well-developed, erect, branched, ribbed, perennial herbaceous plant 60–150 cm tall. The underground organ is somewhat thickened, thick, fleshy. The lateral branches are numerous, vertical or spreading, green when young, brown by autumn, pubescent. The inflorescence forms a spherical basket. His horse is thin, 17–20 mm long, 15–18 mm wide, strongly matted, pubescent, and in rare cases shiny. The flowers are bell-shaped, tubular, bisexual, there are two glandular outgrowths at the tip of the anther, the stigmas are long, ribbon-shaped. The fruit is inversely conical, slightly long-sided, horizontally folded, grayish-brown, shiny, the peduncle is 2–3 times shorter than the seed. It blooms from July to September. It grows like a weed in gardens, parks, along roadsides (Baytenov, 2001).

MATERIAL AND METHODS

In winter, in the first decade of December and in spring, in the first decade of May, the seeds were sown on a specially prepared plot. The distance between the planted plants was 20–25 cm,

during the growing season, appropriate agrotechnical measures were carried out on the sown field. Biological (David, 2018) and mathematical (William, 2010) methods were used to process the data obtained from the experiment. Phenological observations of plant growth and development were carried out every ten days. Methods were used to isolate the age-related conditions of plants in ontogenesis (Ontogenetic Atlas of Medicinal Plants, 2000). When describing shoots and studying the morphogenesis of underground organs of medicinal plants, methods were used to determine the depth of penetration and distribution of roots (Childibayeva et al., 2020, Mukhitdinov et al., 2001).

To study the anatomical structure of plants growing in natural conditions, alcohol, glycerin and water were fixed in a ratio of 1:1:1. Anatomical methods were used in the description of the anatomical structure of the objects of study, as well as in the preparation of drugs (Barykina and Veselova, 2004, Lotova, 2007).

Vegetative parts of the plant, leaves, stems and roots were taken for the study. When analyzing the anatomical structure of vegetative organs of plants, they are boiled in a 5% solution of sodium hydroxide, washed with clean water and the epidermis is removed in a thin format with a scalpel. A number of anatomical preparations are prepared on an OL-ZSO microtome with a freezing device (Inmedprom, Russia). For the purpose of quantitative analysis, morphometric indicators are measured using an eyepiece micrometer MOV-1-15 (lens x 10, magnification x 40, 10, 4). Micrographs of the prepared anatomical preparations were taken on an MS 300 microscope (Micros, Austria) using a CAM V400/1.3M video camera (JProbe, Japan).

The object of the study is Plants of *Arctium tomentosum* Mill., collected from a herbaceous plant community from the slopes of the Trans-Ili Alatau at an altitude of 1,680 m above sea level. The purpose of the study: To determine changes in morpho-ontogenesis and anatomical structure of the promising medicinal plant

Arctium tomentosum Mill. During the study, the features of morpho-ontogenesis of medicinal plants *Arctium tomentosum* Mill. were studied. *Asteraceae* family in natural conditions. Seeds adapted for cultivation in natural conditions were collected on the southern slope of the plateau in the Terisbutak gorge, from various herbaceous plant communities, at an altitude of 1630 m above sea level. Coordinates N 43° 5'27", From 76°47 '6"W.

The territory of Kazakhstan is rich in vegetation. This is evidenced by studies on the morphogenesis and structure of plants growing on mountain slopes, steppe plains and in desert regions (Akhtaeva et al., 2022, Nurmahanova et al., 2023), on physiological changes (Atabayeva et al., 2016, Atabayeva et al., 2018), on the accumulation of biologically active substances (Özek et al., 2022, Popova et al., 2023).

RESULTS AND DISCUSSION

In the latent period, the fruit of the medicinal plant *Arctium tomentosum* Mill., developed from the paracarpic guinea during the dormant period, is single-nesting, single-seeded. The seeds are pyramidal in shape, the tip is slightly wrinkled, slightly ribbed, gray or black in color, oily. The seeds are very small and were planted on the surface at a depth of 0.5–1 cm.

Control of seed germination and growth rate of *Arctium tomentosum* Mill. in its natural state, it was carried out in the open ground in a special nursery of the Aksai gorge. The formation of the first germinal root of the seed was observed on the 5–8th day after the rupture of the seed peel, and after 11 days the sprout appeared on the soil surface. In the pregenerative period, it was found that in the first year all stages of age-related conditions, germination, juvenile, imatural and virginal, pass (Table 1). In the age-related state of the seedling (p), the appearance of a light germinal root is observed, a slightly curved hypocotyl protrudes from the

Table 1. Biological characteristics of seeds of the studied medicinal plants

Types of plants	Seed		1000 seeds weight, g	Age of plants, years	Laboratory		In the conditions of sowing	
	Length	Width			Germination of seeds on certain days, %	Seed productivity, %	Germination of seeds on certain days, %	Seed productivity, %
<i>Arctium tomentosum</i> Mill.	4.61 ± 0.12	2.57 ± 0.41	8.42 ± 0.28	2	Day 3, 35%	80%	Day, 25%	49%

soil surface. The upper part of the hypocotyl is reddish-brown, the lower part is pale yellow. The formed shoot is flat, with smooth edges, with two cotyledons. The first real leaf is visible on day 24–27, bright green. The second true arrow-shaped leaf with a thin sawtooth edge appears on the 42–44 th day. The germinal root of the shoot is pale yellow, grows vertically and penetrates into the soil to a depth of 7–9 cm, has spreading 7–8 lateral roots of the first row about 1–2 cm long. The life cycle of a seedling is 42–45 days (Table 2, Figure 1).

Juvenile age condition (j). At this stage of development, the cotyledons dry up, and the size of these two pairs of leaves increases significantly (Fig. 1). The shape of the leaves increases, the veins become reticulated. In this state, the rhizome grows quite actively, penetrates into the soil to a depth of 15–20 cm

and gives the first row of many lateral roots. The length of the lateral roots of the first order is 2.5–5 cm. The petioles and rhizomes are slightly thickened. In June, the plant enters the stage of immature state. The juvenile age condition lasts 22–25 days (Table 2, Figure 1).

Immature age-related condition (im)

The plant has 3–4 leaves. The leaf blade is broadly ovate, with a solid edge. The diameter of the root reaches 0.5–0.7 cm. It retains its original shape and grows vertically, penetrating into the soil to a depth of 55–62 cm. The length of the lateral roots of the first order is 10–21 cm, the length of the second order is 7 cm. The duration of the immature age condition is about 33–35 days (Table 2, Figure 1).

Table 2. Morphological parameters of plants

Types of plants	Age-related condition	Plant height, cm	Leaves				Roots			
			Quantity	Length, cm	Width, cm	Penetration depth, cm	Length of the I-order, cm	Length II-order, cm	Length III-order, cm	Length IV-order, cm
<i>Arctium tomentosum</i> Mill.	The seedling (p)	3.8 ± 1.21	2	0.82 ± 0.21	0.42 ± 0.78	8.71 ± 0.72	1.17 ± 0.57	-	-	-
	Juvenile (j)	7.2 ± 0.57	2–3	5.17 ± 0.47	1.6 ± 0.41	17.1 ± 0.47	3.57 ± 1.24	-	-	-
	Immature (im)	17.23 ± 0.45	3–4	15.47 ± 0.47	6.91 ± 0.58	58.19 ± 1.28	19.21 ± 0.78	7.61 ± 1.24	-	-
	Virginian (v)	19.24 ± 1.29	5–6	25.69 ± 2.45	14.56 ± 1.21	137.4 ± 1.27	63.47 ± 1.39	44.85 ± 0.12	17.57 ± 0.87	-
	Generative (g)	140.2 ± 1.56	17–21	15.61 ± 2.0	11.24 ± 1.67	184.6 ± 0.96	93.54 ± 1.28	78.14 ± 0.62	9.49 ± 0.89	1.12 ± 0.51



Figure 1. Ontogenesis of *Arctium tomentosum* Mill. plants

Virginal age condition (v)

During this period, the leaves developed between the juvenile and immature stages wither, and the shoots remain. In this state, there are 5–6 large ovate leaves with a long petiole near the root neck, the edge is finely toothed, the lower part is deeply furrowed. The base of the leaves is flat, heart-shaped, with reticulated veins, 17–30 cm long, 10–16 cm wide. The stem length of the aboveground leaves is 11–15 cm. The upper surface of the leaf plate is mostly shiny, with a small number of small white hairs. The peri-dermal layer of the stem forms rollers along the axis.

The germinal root grows vertically and penetrates into the soil to a depth of 137–140 cm. Branching lateral roots 8–10.5 cm long extend from the germinal root, extending to a depth of 63 cm. In sowing conditions, the development of the plant in the first year ends with a virginal age condition. In this vital state, the plant has 5–6 well-developed long-stemmed leaves. The typical contour of the root system of *Arctium tomentosum* Mill. is fully formed in the first year, the germinal root, originating from the seed, is especially well developed. Branching in the first year is not very dense, which is typical for most biennial plants (Table 2, Figure 1).

Generative stage (g)

At this stage, the plant is divided into three life stages: young (g1), middle-aged (g2) and old (g3) generative states. In the first vital state (g1), inflorescences begin to form on the axial and lateral branches of the plant. In this state, it has all the characteristics of an adult plant. Generative shoots reach III–IV rows. The lower leaves along the stem are 20 cm long and 12–15 cm wide, and the upper leaves are 2–3 times smaller than the lower ones. It begins to bloom in June and July.

The diameter of the root neck is 2.5–3 cm, in the second vital state (g2) generative shoots increase 1–1.5 times. Full-fledged flowering occurs in the third decade of July, the first and second decades of August. The leaves on the root neck gradually turn yellow. The diameter of the root neck reaches 3.5–4 cm (Table 2, Figure 1).

Old generative stage (g3)

This state of life is characterized by the gradual withering of the lower leaves of the plant stem and the mass maturation of seeds. In some places, the

seeds remain immature. In this age-related state, the number of leaves of plants decreases, and their sizes increase slightly compared to the previous state. Generative activity is decreasing. Many dead branches, lateral roots and leaves can be observed. At this time, the height of the plant reaches 157 cm. The generative state of life lasts 65–75 days.

In the second year, the diameter of the neck of the germinal root reaches 4.5–5 cm. The thickening of the root is especially noticeable in the soil layer up to 50 cm deep. The germinal root grows vertically, making small turns, and by the end of the second year penetrates into the soil to a depth of 285 cm. At this time, the lateral roots form two separate tiers. The first tier forms the first and second rows of lateral roots from the germinal root at a depth of 45–55 cm. The roots of this tier appear from the germinal roots in the spring of the second year, reaching a length of 75–80 cm when there is enough moisture in the soil at this depth.

And the second tier is formed by the first and second rows of very large lateral roots extending from the germinal root to a depth of 90–100 cm. The first row of lateral roots grows parallel to the germinal root in the vertical direction and penetrates to the same depth. In the second year, the length of the first row of lateral roots is 160–175 cm, the second row is 150 cm, the third row is 130 cm, the fourth row is 11 cm, the fifth row is no more than 1–3 cm (Table 2, Figure 1). The diameter of the root system of the plant reaches more than 2.5 m.

The post-generative period

Senile (s) and sub-senile (ss) age states represent transitions from an old generative state to a dying state due to the fact that the plant is biennial. After the seeds have fully matured, the underground and aboveground parts of *Arctium tomentosum* Mill. plants gradually wither and die (s). This is a regularly recurring phenomenon in biennial plants, plant ontogenesis lasts 198–215 days.

Anatomical features of the structure of the vegetative organs of *Arctium tomentosum* Mill. in ontogenesis

The latency period. On the transverse and longitudinal sections, the seed is covered from the outside with a black-brown completely decomposed exocarpic layer with dead cells. Below it is a layer of mesocarp, the cells of which are densely arranged,

fibrous structure, light color, extend inward. After the mesocarp, the cells of the inner endocarp are densely located, brownish-yellow in color. The endocarp layer and cotyledons are separated by the epidermis of cotyledons. The cotyledon covers the entire inner cavity of the seed, it consists of two flat oval-shaped plates, on which the hypocotyl and the germinal root are visible (Figure 2).

The stage of germination

The outer cells of the hypocotyl on the cross section are rounded, both lateral membranes are thin, and the upper one is slightly thickened, covered with a large-cell epidermis. The cells under the epidermis are rounded or polygonal, with a thin shell. The central cylinder has procambium, proto- and metaxylems and primary phloem, and the core radial parenchyma consists of multi-row collateral open conducting beams (Table 1, 2, 3, Figure 3).

Cotyledons of the dorsoventral-bifacial type. The mesophyll of the cotyledon is formed from a single homogeneous assimilating parenchyma. Stomata are located slightly above the level of the epidermis. Mesophyll cells are homogeneous, but the shape is not defined homogeneous, the intercellular space is extensive, the conductive bundles in the mesophyll are not fully formed, they are formed from individual elements of the xylem and phloem. The stomatal stripes are clearly defined.

The germinal root of the seedling is round in cross section. The germinal root has a primary anatomical structure. The outer cells of the root are covered with deformed, decayed epibleme cells. The cells under the epibleme are large, of different sizes, with 1–2 rows of exoderm. The shell is voluminous, with 9–12 rows of cells, the shell cells are thin-walled, rounded or polygonal in shape, with small

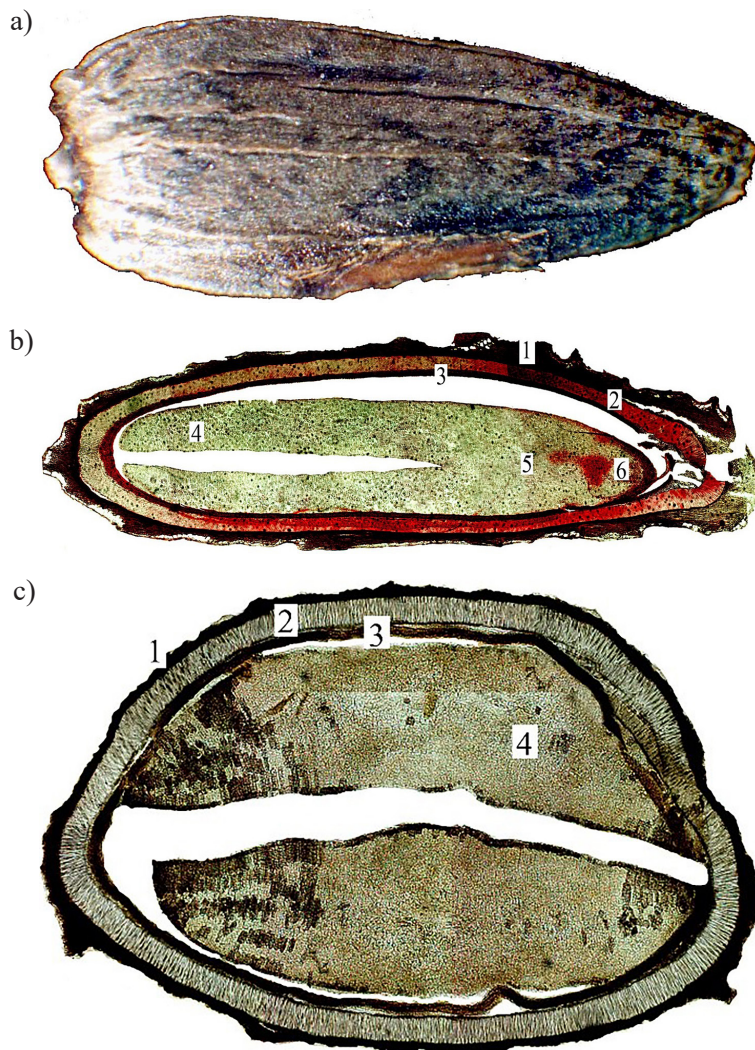
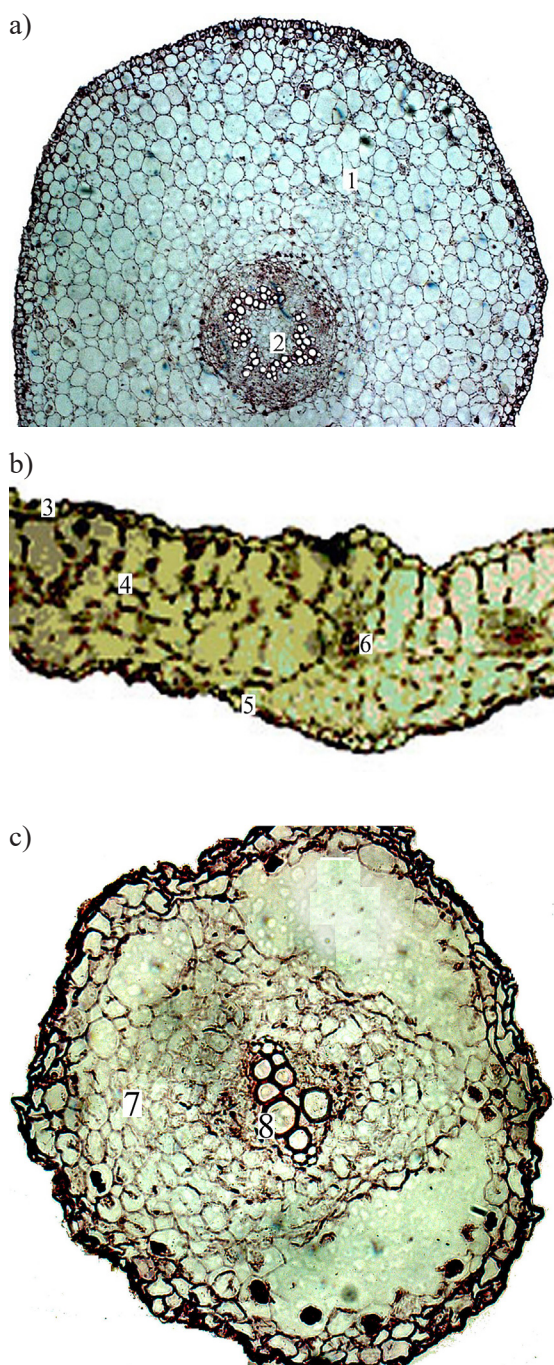


Figure 2. Morphology and anatomical section of the seed of *Arctium tomentosum* Mill. (x 63)

Table 3. Anatomical parameters of plant leaves

Types of plants	Age-related condition	The size of the epidermis cells, microns		The thickness of mesophyll cells, microns	Columnar mesophyll				Spongy mesophyll	
		The upper one	Lower		Number of rows	Layer thickness, microns	Cell, microns		Number of rows	Layer thickness, microns
							Length	Width		
<i>Arctium tomentosum</i> Mill.	The seedling (p)	49.75 ± 0.42	26.18 ± 0.35	324.16 ± 0.74	-	-	-	-	-	-
	Juvenile (j)	38.21 ± 0.90	22.54 ± 0.38	239.96 ± 0.57	-	-	-	-	-	-
	Virginian (v)	40.26 ± 0.18	23.74 ± 0.18	-	1	53.64 ± 0.23	47.34 ± 0.88	12.31 ± 0.21	4–5	93.52 ± 0.21
	Generative (g)	25.49 ± 0.16	14.64 ± 0.29	-	1	44.48 ± 0.18	38.41 ± 0.96	9.24 ± 0.62	3–4	44.46 ± 0.24

**Figure 3.** *Arctium tomentosum* Mill. at the germination stage (x 63)

intercellular spaces, the sizes decrease towards the endoderm, are densely arranged (Tables 1, 2, 3, Figure 3). The central cylinder is tetrachic, the row of the pericycle is clearly pronounced. Metaxylemic tubes of primary xylem 10–12, protoxylemic tubes 8–10. Parenchymal cells are thin-walled, rounded, fill the spaces between conductive elements or are located between them.

Juvenile age condition (j)

The leaf blade is dorsoventral in cross section, the upper epidermis is clearly cuticulated. The cells of the upper epidermis are large, oval in shape, of different volumes, the two lateral and upper shells are thickened, the inner one is thin.

Columnar mesophyll is single-layered, cells of irregular square and oval shape, arranged in 3–4 rows, with intercellular cells. Stomata are clearly expressed. Conductive bundles of leaf plates are formed from 2–3 elements of underdeveloped xylem and phloem. The conducting bundles are collateral closed. The xylem of the conductive bundle consists of 5–7 vessels arranged in a straight chain, the total number is 25–27, and the elements of the sieve-like tubes of the phloem form 3–5 rows, the cells of the lower epidermis are large, thick-walled, oval-shaped, cuticulated. The row of the pericycle is not clearly defined. The parenchyma of the central cylinder, especially in the layers adjacent to the endoderm, are aerenchymal (Table 3, Figure 4).

The vascular system of the root is tetraachal, wide-brimmed, formed on average by 15–24 secondary xylem vessels. The cambium is located in a circle between the xylem and the phloem. The walls of parenchymal cells are thin-walled, rounded or polygonal in shape, with small intercellular spaces (Table 4, Figure 4).

Table 4. Anatomical parameters of plant roots

Types of plants	Age-related condition	The germinal root			Wood thickness, microns		The area of xylem vessels x 10–3 mm ²
		Diameter, mm	Diameter of the central cylinder, mm	Thickness of the bark, microns	The thickness of the secondary phloem	The thickness of the secondary xylem	
<i>Arctium tomentosum</i> Mill	The seedling (p)	768.14 ± 1.38	235.59 ± 0.43	264.15 ± 0.77	-	-	21.18 ± 2.15
	Juvenile (j)	1214.60 ± 1.21	993.56 ± 0.37	258.14 ± 1.54	-	-	47.24 ± 0.43
	Virginian (v)	-	-	244.51 ± 0.26	416.47 ± 0.82	367.12 ± 0.48	88.32 ± 0.29
	Generative (g)	-	-	160.53 ± 0.25	457.43 ± 0.89	987.63 ± 0.87	159.15 ± 0.94

Virginal age condition (v)

The mesophyll of the leaf blade is clearly dorsoventral. Columnar mesophyll is single-row, with vertically arranged cells, irregular or regular square shape. The conductive bundles are collaterally closed, the xylem of the conductive bundle is arranged in the form of a chain of 5–7 tubes, the lower one is surrounded by 1–2 rows of collenchyma, 3–5 rows of tissue fibers (Table 3, Figure 5). The outside of the root is covered with deformed parenchymal cells and endoderm cells. Between the cycles there are elements of the parenchyma of the central cylinder and

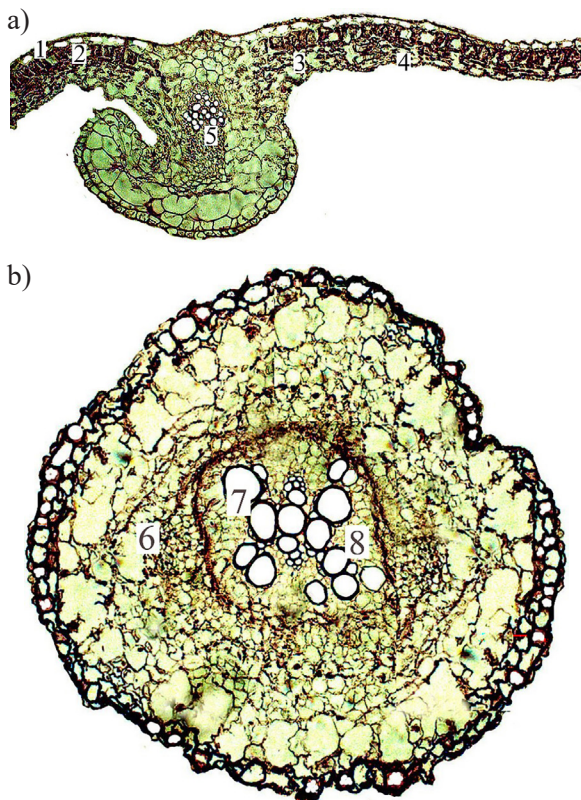


Figure 4. Juvenile age status of *Arctium tomentosum* Mill. (x 10)

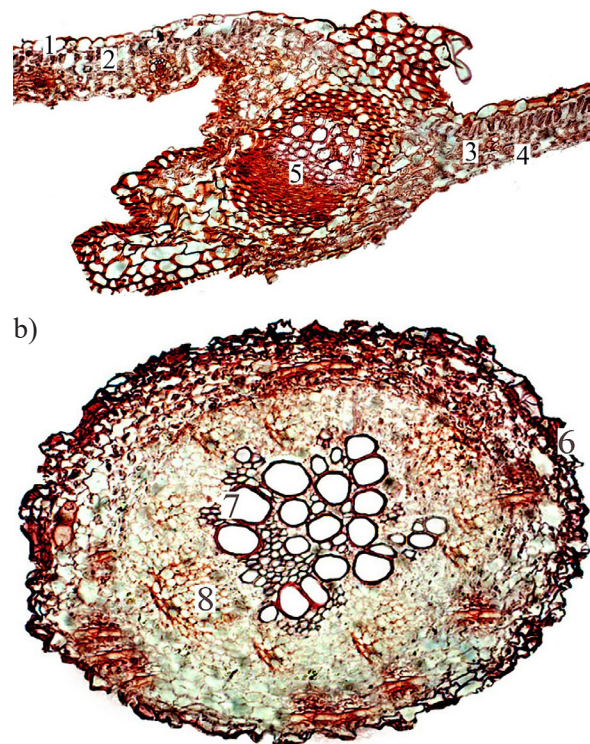


Figure 5. Virginal age state of *Arctium tomentosum* Mill. (x 10)

elements of the secondary phloem. The cambial row is clearly defined. Between the secondary elements of the phloem and the endoderm there are large intercellular spaces and resin passages, inulins. The function of the integumentary tissue is performed by partially preserved cells of the parenchyma membrane and cells of the endoderm (Table 4, Figure 5).

Generative age condition (g)

The stem has a primary anatomical structure with an intermittent conductive bundle. The outside of the epidermis is covered with a wavy cuticle and bristly hairs, along the edges there are 1–2 rows of lamellar collenchymal cells. The cortical parenchyma

Table 5. Anatomical parameters of plant stems

Types of plants	Age-related condition	The thickness of the primary crust, microns	Wood, мкм	Thickness of the core parenchyma, microns	Number of conducting beams	The area of xylem vessels, x 10–3 mm ²
<i>Arctium tomentosum</i> Mill.	Generative (g3)	296.68 ± 0.75	519.46 ± 1.91	1418.7 ± 2.47	39-48	79.84 ± 0.42

in the protruding lateral areas forms 5–7 rows, in 3–5 rows, the cells are rounded or polygonal, thin-walled, with weakly developed intercellular cells. The starch membranes of the cells are thin-walled, oval in shape, and form a chain. The central cylinder has conductive collateral open beams, separately located on two levels. The conducting bundles are large and small, small ones are located closer to the endoderm, and somewhat larger ones are closer to the center, surrounded by a 10–12 – row sclerenchymal cap. The

core parenchyma is usually voluminous, the cells are thin-walled, homogeneous intercellular, rounded or polygonal in shape, completely preserved.

The cells of the upper epidermis of the leaf are rounded, protruding and slightly square, with a cuticle. Rare, slightly raised stomata are located in the epidermis. The columnar mesophyll is single-row. The lower epidermis consists of oval, thin-walled cells with many stomata. The conducting beams are collaterally closed (Tables 3, 4, 5, Figure 6). In the second year, the germinal root becomes much thicker than in the first year, reaching a diameter of up to 5 cm. The last layer of wood occupies 51.6% of the volume of the roots.

The root is characterized by an anatomical structure. Intensive root growth is directly related to the active development of sieve tubes. The outer part of the root section is dead, the secondary rows are preserved, are in the stage of rotting, has a thin shell, of various shapes, and are easily crushed. The cells of the endoderm are oval, square, thin-walled, arranged in a chain (Table 3, 4, 5, Figure 6).

During the flowering period, the roots of *Arctium tomentosum* Mill are characterized by the most pronounced anatomical restructuring. The outer surface of the root is covered with parenchymal cells, completely decomposed, wrinkled, and similar to wear. The endodermal cells of the inner layer of the shell are also deformed (Tables 3, 4, 5, Figure 6).

CONCLUSIONS

Based on the results of studying the morpho-ontogenesis and anatomical structure of the vegetative organs of *Arctium tomentosum* Mill. The following conclusions were drawn in various age-related conditions of life.

At the juvenile stage of life, there was a fairly active development of the germinal root, lateral roots appear. At the initial stage of life, the diameter of the root neck was about 0.5–0.7 cm, with a depth of penetration into the soil of 55–62 cm.

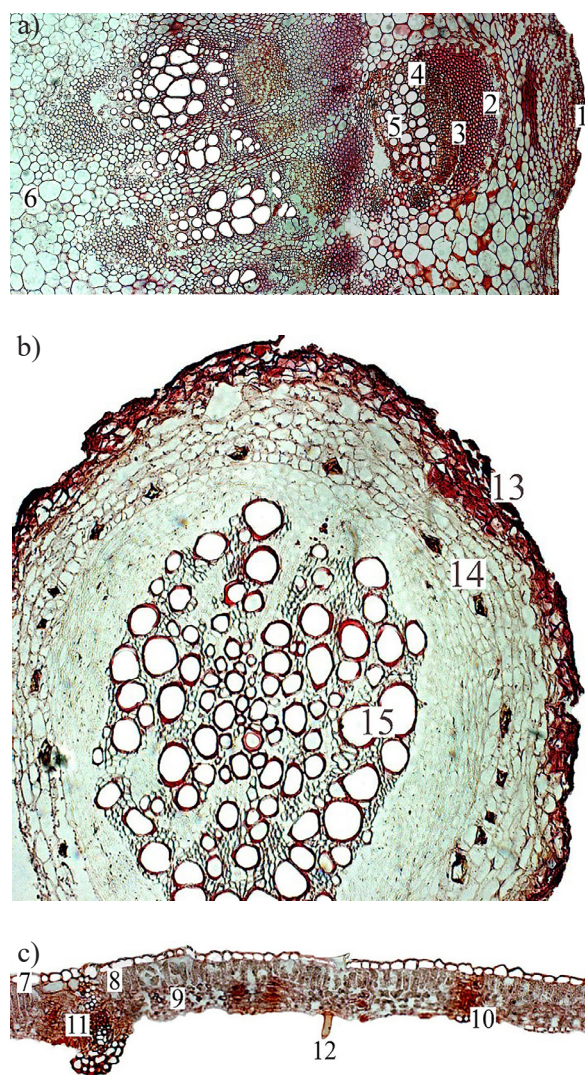


Figure 6. The generative age state of *Arctium tomentosum* Mill. (x 10)

The length of the primary lateral roots was 10–21 cm, and the length of the secondary lateral roots reached up to 7 cm. In the virginal age state, the germinal root has sunk into the soil to a depth of 140 cm. In the generative period, all the signs characteristic of the plant are formed. After the seeds have fully matured, the underground and aboveground parts of the plant gradually wither and die off.

On the cut of the seed of the plant, it can be seen that only the exocarp (pericarp) matures, and the mesocarp and endocarp develop as much as possible. The seed shell is lamellar, large, without protein, the seed is well ripened. The structure of the hypocotyl of the shoot has an intermediate structure between the stem and the root. The cotyledons is leaf-shaped, the mesophyll is not fully developed, of a homogeneous type. In the hypocotyl section, a uniformly formed parenchymal cover is visible, the elements of conductive tissues in the central cylinder are in the stage of neoplasm. Cotyledons of the leaf-like type, mesophyll of the dorsoventral type, the components of the xylem and phloem are not fully formed in it;

Leaf blades in the juvenile age state have a dorsoventral type, mesomorphic structure. The main root of the plant is characterise by primary anatomical development. The secondary parenchyma of the phloem in the central cylinder is quite voluminous, well-developed, the function of the integumentary tissue at the root is performed by the remnants of the parenchyma of the cortex. In the virginal age state, the size and shape of the mesophyll on the leaf blade section are stabilized, columnar and spongy parenchyma are determined, conductive tissues fully mature. The root ends with a limited anatomical reconstruction at the end of the first year of life. The anatomical restructuring of the root is determined by the activity of the secondary parenchyma of the phloem. The central cylinder is radically increased in the generative state of life. The integumentary tissue is preserved as remnants of the endoderm and cortical parenchyma.

In natural conditions, the cut of the leaf in this age-related state has a thickened cuticle layer, and the row of columnar mesophyll is enlarged. The dimensions of the conductive bundles of the stem are small, the xylem vessels have a narrow cavity, the interstitial radial parenchyma is multi-rowed. Scattered idioblasts are formed in the core parenchyma. In secondary anatomical development, most of the central cylinder of the root is formed by the

secondary xylem and parenchyma of the stem. The number of needle-like calcium oxalate druzes in the central cylinder of the root has increased.

REFERENCES

1. Aitynova A.E., Ibragimova N.A., Kenesheva S.T., 2022. Antimicrobial effect of extract from root of *Arctium tomentosum* Mill. (woolly burdock) against several reference strains. International journal of biology and chemistry 15(2).
2. Akhtaeva N., Boribay E., Nurmakanova A., Tynybekov B., Moldagazyeva Zh., 2022. Adaptive characteristics of plants in the conditions of technogenic pollution. Journal of water and land development 55 (X–XII), 251–258.
3. Atabayeva S., Lee T., Nurmahanova A., Akhmetova A., Narmuratova M., Asrandina M., Beisenova A., Alybayeva R., Lee T., 2016. Anatomical peculiarities in wheat (*Triticum aestivum* L.) varieties under copper stress. Pak. J. Bot., 48(4), 1399–1405.
4. Atabayeva S.D., Nurmahanova A., Yernazarova G.E., Asrandina S.Sh., Aybayeva R.A., Turasheva S.K., Ablaihanova N.T., Tynybekov B., Turasheva S., Fei L., 2018. Effect of cadmium on mineral composition of rice grain. Research on Crops. 19(4) Research on Crops, 569–575.
5. Baytenov M.S. Flora of Kazakhstan. In 2 Vol. Almaty: Gylym, 2001. (in Russian).
6. Barykina R.P., Veselova T.A., 2004. Reference book on botanical microtechnology. Moscow, PH MSU: 322. (in Russian)
7. Barykina R.P., Veselova T.D., Devyatov A.G., 2004. Handbook of botanical microtechnics. – Moscow. MSU: 313. (in Russian).
8. Bi Yaqi, Tugume A.K., Valkonen J.P.T., 2012. Small-RNA Deep Sequencing Reveals *Arctium tomentosum* as a Natural Host of *Alstroemeria virus X* and a New Putative Emaravirus. Plos one 7(8).
9. Carlotto J., de Souza L.M., Baggio C.H., Werner M.F.D.P., Maria-Ferreira D. Sasaki G.L., Iacomini, M., Cipriani T.R., 2016. Polysaccharides from *Arctium lappa* L.: Chemical structure and biological activity. Int. J. Biol. Macromol. 91, 954–960.
10. Childibaeva A.J., Ametov A.A., 2020. Experiments on the introduction of a rare, endangered, narrowly endemic plant *Rosa iliensis* Chrshan in the conditions of the steppe belt of the Trans-Ili Alatau. Bulletin of the Treasury. The series is biological. 3(84), 26–36 (in Russian).
11. David C., 2018. Statistical Methods for Psychology, Howell - Wadsworth, Cengage Learning, 178.
12. Ferracane R., Graziani G., Gallo M., Fogliano V., Ritieni A., 2010. Metabolic profile of the bioactive

- compounds of burdock (*Arctium lappa*) seeds, roots and leaves. J. Pharm. Biomed. Anal., 51, 399–404.
13. Lotova L.I., 2007. Botany. Morphology and anatomy of higher plants: Textbook. 3rd ed. Moscow: 510 (in Russian).
 14. Mathematical statistics with examples in Excel by William M. Bolstad, 2010.
 15. Mukhitdinov N.M., Parshina G.N., Aidosova S.S., 2001. To the methodology of studying the features of ontogenesis of herbaceous medicinal plants. Bulletin of KazGU. Ser. biologicheskaya. 7(14), 3–6.
 16. Nurmahanova A., Ibisheva N., Kurbatova N., Atabayeva S., Seilkhan A., Tynybekov B., Abidkulova K., Childibaeva A., Akhmetova A., Sadyrova G., 2023. Comparative Anatomical and Morphological Study of Three Populations of *Salvia aethiopis* L. Growing in the Southern Balkhash Region. Journal of Ecological Engineering, 24(9), 27–38.
 17. Ontogenetic atlas of medicinal plants. Yoshkar-Ola: Mari State University, 2000. 268.
 18. Özek G., Chidibayeva A., Ametov A., Nurmahanova A., Özek T., 2022. Chemical Composition of Flower Volatiles and Seeds Fatty Acids of *Rosa iliensis* Chrshan, an Endemic Species from Kazakhstan Records of Natural Products. 16(3), 225–235.
 19. Popova E., Titova M., Tynykulov M., Zakirova R., Kulichenko I., Prudnikova O., Nosov A., 2023. Sustainable Production of Ajuga Bioactive Metabolites Using Cell Culture Technologies: A Review. *Nutrients*, 15(5), 1246. DOI 10.3390/nu15051246.
 20. Sederski M.E., 2017. Prawie Wszystko o Ziołach i Ziołolecznictwie, 3rd ed. Mateusz E: Podkowa Leśna, Poland. (In Polish).
 21. Statistical Methods for Psychology. David C. Howell - 2018 r.
 22. Strawa, J., Wajs-Bonikowska A., Jakimiuk, K., Waluk, M., Poslednik, M., Nazaruk, J., Tomczyk, M., 2020. Phytochemical examination of woolly burdock *Arctium tomentosum* leaves and flower heads. Chem. Nat. Compd., 56, 345–347.
 23. Turdumambetov K., Bakirov G.A., Rakhimov D.A., 2004. Glucofructans from *Arctium tomentosum* roots. May-jun. Chemistry of Natural Compounds, 40 (3), 211–214.
 24. Waad E.Q. AL Harbawee, Alina N. Kluchagina, Nasser A. Anjum, Dmitry I. Bashmakov, Alexander S. Lukatkin, Eduarda Pereira, 2017. Evaluation of cotton burdock (*Arctium tomentosum* Mill.) responses to multi-metal exposure. Environmental Science and Pollution Research. 24(6), 5431–5438.
 25. Zhou X., Zhang H., Ge L., Gong H., Tian S., 2011. Determination of arctiin and arctigenin contents in *Arctium tomentosum* Mill. by HPLC method. J. Chem., 8, 372–377.