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THE MORPHOLOGY STUDY OF *Rosmarinus* L. SEEDLINGS

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ИЗУЧЕНИЕ МОРФОЛОГИИ САЖЕНЦЕВ *Rosmarinus* L.

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Abstract. In recent years, the interest in natural herbal medicines and essential oils obtained from them has increased significantly in medicine industry worldwide. Essential oils and products made from them are widely used in various fields of modern medicine, especially in aromatherapy, in traditional treatment methods. Therefore, the study of the composition of biologically active substances in essential plants is of special importance. From this point of view, the introduction of new types of medicinal plants, the study of their bioecological properties, and especially the expansion of research conducted for use in scientific medical practice regarding the pharmacological activity of essential oils obtained from them is very relevant. Among the mentioned prospective research objects, rosemary (*Rosmarinus* L.) species widely used in medicine and folk medicine in different regions of the world occupy a special place. Despite the great interest in this plant and the obtained essential oil in Azerbaijan, its biological properties, extraction and composition of the essential oil have not been thoroughly studied. Therefore, the introduction of new useful species belonging to the genus *Rosmarinus* L., the study of their bioecological characteristics, cultivation agrotechnics and biologically active substances on scientific grounds is in the spotlight with its relevance.

Аннотация. В последние годы интерес к натуральным растительным лекарственным средствам и полученным из них эфирным маслам значительно вырос в медицинской промышленности во всем мире. Эфирные масла и добываемые продукты из них находят широкое применение в различных областях современной медицины, особенно в ароматерапии, традиционных методах лечения. Поэтому изучение состава биологически активных веществ эфирных растений имеет особое значение. С этой точки зрения весьма актуальны интродукция новых видов лекарственных растений, изучение их биоэкологических свойств и особенно расширение проводимых для использования в научной медицинской практике исследований фармакологической активности получаемых из них эфирных масел. Среди перспективных объектов исследования особое место занимают виды розмарина (*Rosmarinus* L.), широко используемые в медицине, в т. ч. народной, в разных регионах мира. Несмотря на большой интерес к этому растению и полученному эфирному маслу в Азербайджане недостаточно изучены его биологические свойства, экстракция и состав эфирного масла. Поэтому интродукция новых полезных видов, принадлежащих к роду *Rosmarinus* L., изучение их биоэкологических особенностей, агротехники возделывания и

биологически активных веществ на научных основаниях находится в центре внимания и имеет свою актуальность.

Keywords: *Rosmarinus officinalis*, seedlings, petals, hypocotyls, epicotyls, biological development.

Ключевые слова: *Rosmarinus officinalis*, саженцев, лепестки, гипокотили, эпикотили, биологическое развитие.

Research Materials

The research was carried out in the Essential Oil Plants Laboratory of the Institute of Dendrology of Azerbaijan NAS during 2019–2020. *Rosmarinus officinalis* L. (medicinal rosemary) and *Rosmarinus prostratus* Mazziari species belonging to the genus *Rosmarinus* L. included in the family Lamiaceae (Labiatae) were taken as the research object. For the purpose of research, seeds collected from local conditions and from foreign botanical gardens were used.

Purpose and Methodology of the Research

The main purpose of our research is the study of the morphology and developmental stages of sprouts in *Rosmarinus officinalis* L. and *Rosmarinus prostratus* Mazziari species. The morphological characteristics of the sprouts were described according to the methodology of I. T. Vasilchenko, and the stages of development in plant species were characterized in sequence [1].

Discussion of the Study

Rosmarinus officinalis L. is an evergreen, densely branched, 0.8–1.0 m tall, sometimes 1.5–2.0 m tall, erect, transversely developing subshrub. Perennial barks are gray, and young barks are light gray in color, hairy, the bark of the trunk is peeling, four-lobed, and scaly. Since the plant is densely branched, the leaves are located in the form of a brush. The plant constantly renews itself; relatively old branches (branches) are stratified, the leaves take on a dark gray-green color. The leaves are evergreen, linear, opposite, narrow, turned or twisted, leathery, sessile or on a short stalk, relatively thick. Its length reaches 3.5–4.0 cm, width 0.2–0.4 cm, the upper surface is shiny, and the lower surface is gray-green or dark green, fragrant, and the lower layer is covered with dense hairs. whitish felt.

The flowers are sessile, 5–10 small blue flowers are collected in the leaf sheath, in a small, dense broom-like group, located at the ends of the short spikes, the crown is blue-purple, drooping on the outside, the upper petal lips are pressed, the lower flowers are slightly elongated, the outer walls are toothed. Its flowering is massive. The fruit is a round-ovoid, grayish cone with a smooth surface. Although the flowering period is in early spring, in April-May, it lasts until August, and sometimes it lasts the whole year and completely covers the bush, and the fruits begin to ripen from September.

The seeds are brown and small. The root system is strongly developed. It is propagated by seed, pen and bush division.

It is light-loving, drought-, salinity-resistant, low-demanding plant. Young plants are sometimes destroyed in -7°C temperature conditions. It does not like too much moisture. When the bushes are shaped by pruning, they keep that shape for a long time. It is cultivated under cultural conditions in Absheron, Ganja, Gabala and Lankaran in Azerbaijan.

There are several varieties of *Rosmarinus officinalis* L. that differ by the color of the flowers: Fastigiatus, Miss Jessopp's Variety, Erectus, Tuscan Blue,

There are also varieties of *Rosmarinus prostratus* (they are short in growth with widely spreading shoots and are suitable for growing in the house): *Lavandulaceus* Hort, *Corsicus Prostratus*, *Venzano Prostrate*, *Corsica Prostratus* (Figure 1).



Figure 1. *Rosmarinus officinalis* L.

Rosmarinus prostratus — Spreading rosemary is an evergreen shrub up to 1.5 m tall, but also a spreading umbellate shrub that branches up to 1.5 m wide. When its 70 cm long branches begin to grow, they reach 1.5–2.0 m near the surface of the soil, and it got its name from here because of the way it spreads (Figure 2).



Figure 2. *Rosmarinus prostratus* Mazziari

The leaves are thick, bright green, with a white vein in the middle reminiscent of a fir needle. The characteristic of the species is that the color of the leaves varies from light green (in spring) to blue (in autumn). During flowering, the plant is covered with purple or blue small, dense flowers.

The plant is not demanding on soil, it can be cultivated in any type of soil. It grows and develops normally in sunny and well-lit areas. In cold and frosty climates, in strong winds, the plant needs to be covered. If grown in a pot, the plant should be placed on a balcony or terrace to protect it from the cold in winter.

It grows naturally in North Africa, Turkey, Cyprus and the southern parts of Europe. The plant is common in dry rocky and foothill areas. The plant is grown under cultural conditions in Russia.

This species is widely used in vertical greening works, mainly to cover the walls of rural houses, and in the construction of living fences because it grows densely and forms jungles. Also, since it is cultivated as a ground cover plant, the plant is not pruned, if it is pruned, the plant is not damaged and does not get any disease. A gardener can prune this plant and give it a certain shape. This ground cover species looks very beautiful during the flowering period, as the soil is covered with a purple covering. This species is also called “garden rosemary”, as the plant is used in decorative gardening in the design of picket fences. It is widely used in food because it has a high-quality spice taste.

There are several varieties of the species: Corsican rosemary, creeping rosemary, lavender rosemary, Venzano rosemary.

The use of medicinal rosemary in the treatment of various diseases and in the field of food has been known since ancient times. Young leaves are collected for the purpose of seasoning. It is used for dizziness and low blood pressure. It also has a positive effect on nerves, nervous tension, neurosis, general and sexual weakness.

The extract obtained by infusing medicinal rosemary regulates the activity of the stomach and intestine, ensures the flow of bile from the bile ducts, and reduces foam in the intestines. Its aqueous solution is used in thrombophlebitis, neuritis and rheumatism. It is used in heart muscle infarction, vascular diseases, diabetic nutrition.

Medicinal rosemary leaves contain up to 2% essential oil. During the 3-year period of the plant, the essential oils reach the maximum amount, and during this period, the collection of leaves is more effective. Rosemary essential oil contains alkaloids: rosmarinicin, rosmarinic acid, vaccine compounds, α -pinene (30%), camphene (20%), cineole (10%), borneol, cineole, L-camphor, sesquiterpene hydrocarbons: caryophyllene, bornyl acetate, limonene, resins and the bitterness is close to 1% [2, 3].

Rosemary essential oil has an antiviral, antiseptic, antispasmodic, heterogenous, regulatory effect, it is a treatment tool that has a direct effect on various types of colds, the flu virus, or it is an indispensable substance for increasing the activity of the immune system and destroying infections in general [4, 5].

Taking all this into account, important species of the genus were cultivated in Absheron conditions and monitoring was carried out on the developmental stages of ontogenesis.

In the course of our research, initially, the researched species of the genus were germinated with seeds and observations were made on the development stages of ontogenesis, and the differences and general aspects of the age and height development of the species cultivated under cultural conditions were studied. The main purpose of the research is to study the growth and development cycle in the ontogeny of the species, to determine the dynamics of the essential oil in the introduced species by phases, to investigate the chemical changes occurring in the essential oils obtained from the plants cultivated under natural and cultural conditions.

The study of ontogeny refers to the study of periods and stages from seed germination to natural death due to aging. During the research, we observed the following periods and stages in the ontogeny of the rosemary species: 1. Latent period — the time of seed rest; 2. Four stages in the pregenerative period: sprouts, juvenile, immature and virginal stage; 3. Young and old stage in the generative period; 4. Subsenile and senile age periods were recorded after the generative period.

Latent period: Medicinal rosemary seeds are small, brown, with an average length of 0.2 cm and an average width of 0.1 cm. The mass of 1000 fully ripe seeds are 0.6–1.4 g. Germination of seeds is observed within 18–22 days in laboratory conditions and 25–28 days in the field. The optimum temperature for seed germination was 18–22 °C. The percentage of seed germination in the open field (70.0%) is lower than in laboratory conditions (86.0%). After 1–3 years, the percentage of seed germination decreases to half. The seeds of the studied species germinate well in humid conditions, it should be noted that the role of light for seed germination is not so important, however, after the cotyledons emerge on the ground, the need for light increases significantly, especially during the developmental stages of the seedlings.

Pregenerative period: Germination of seeds is above ground. First, a white rhizome is formed, and then the bent hypocotyl erects and raises the cotyledon leaves to the top layer of the soil. Sprout consists of cotyledons and cotyledon leaves. Hypocotyl is greenish in color, 1.5–1.8 cm long, 0.2–0.3 mm in diameter. The rhizome is 0.5–1.0 cm long and 0.2–0.3 mm wide and covered with tufts. Petals are ellipsoidal, full-margined, 1.1–1.5 cm long, 0.2–0.3 cm wide, the upper surface is smooth, light green, covered with short, sparse hairs, the lower surface is grayish green. The vasculature is reticulate, the main vein is clearly visible. The stems are short and sparsely hairy. The length of the epicotyl is 1.0–1.5 cm. The life of the petals is 30–35 days (Table 1).

Table 1

MORPHOLOGICAL INDICATORS OF SPROUTS IN ROSEMARY SPECIES

<i>Species</i>	<i>Length (cm)</i>		<i>Seed-lobe length (cm)</i>		
	<i>hypocotyl</i>	<i>epicotyl</i>	<i>min</i>	<i>max</i>	<i>medium</i>
<i>Rosmarinus officinalis</i> L.	1.5–1.8	1.0–1.5	1.1	1.5	1.3
<i>Rosmarinus prostratus</i> Mazziari	1.6	1.5–1.7	1.3	1.6	1.4

The first true leaves appear 25–27 days after the seeds germinate. Within 10–15 days, the first pair of true leaves takes its full form. The first pair of true leaves are linear, entire-margined, opposite, leathery, shiny, smooth on the upper surface, sessile, 1.0–1.2 cm long and 0.2–0.3 cm wide, grayish green or light green.

The lower surface is silvery-white and covered with whitish hairs. At this stage of development, the main root extends up to 4–5 cm. This age stage lasts up to 30 days.

Juvenile age stage (y): petioles fade, 2–3-cut true leaves are fully formed. Fully formed leaves are 1.3±0.1 cm long and 0.3±0.03 cm wide. The main root extends to a depth of 5–7 cm into the soil. Root throat is 2.0±0.02 mm. Lateral roots of the first degree are formed on the main root. The juvenile state lasts 25–27 days.

Immature age stage (m): In this age stage, 2–3 pairs of true leaves are formed and finally the main stem grows. The length of the main gills is 4.5±0.3 cm, and the width is 2.5±0.2 cm. The immature stage lasts 24–27 days. At the end of this period, the height of the sprouts reaches 6–8 cm.

Virginal stage (v): This stage covers the second year. Active growth of the main and side branches takes place. At the end of this stage, the plants reach a height of 20–25 cm, and the diameter of the umbel is 12–15 cm. The main root develops intensively and extends to a depth of 12–15 cm and branches into II–III grade lateral roots.

Generative period (g): it occurs mainly in the 3rd year. At the young stage, during the development of side shoots, a group of flowers is formed, and its development continues. The intensive growth of the plant and the complete formation of the bush are observed. During this period, the average height of the bush reaches 30–40 cm, and the diameter of the umbrella reaches 20–30 cm. Rosemary stems rise in an orthotropic (straight) position, are grayish-green in color, slightly hairy, surrounded by dense leaves. Both vegetative and generative branches are observed on the plant. A group of flowers begins to develop first at the tip of the growing bush, first at the main stem, and then at the tip of the alternately formed side branches. The opening of the flower group goes from the base of the plant to the top in the acropetal direction, and finally the flowers at the top of the flower bud open. The height of flowering branches is up to 23–28 cm. In the third year, 55–65% of the plants enter the generative state.

After the generative period, subsenile and senile age periods were recorded. When the plant gets old, the leaves at the bottom of the bush turn yellow, dry and fall off.

From our observations, it became clear that the sprouts grow better under conditions of favorable temperature and humidity, the cotyledons are shed after the true leaves are formed and fully formed, and the main stem begins to grow normally. Petals play the role of an assimilative organ during the time the sprout is on it, protecting the sprout from unfavorable conditions. From the morphological study of the sprouts, it was found that the life span of the petals depends on the conditions under which the sprout is cultivated and the biological characteristics of each species. In the studied species of *Rosmarinus officinalis*, petals remain on the sprout for 33±3 days (Table 2).

In *Rosmarinus prostratus* Mazziari, the seeds are small and dark brown. The length of the seed is 1.7–2.0 mm, and the width is 0.8–1.0 mm. The weight of 1000 seeds are 1.5 g. Mass germination is observed in 24–25 days in laboratory conditions, and in 30–32 days in open conditions. Seed germination in laboratory conditions is 75.0%, and in the open field is 62.0%. Germination decreases to 50–60% after the seeds have been left for several years.

Table 2

LIFESPAN OF COTYLEDONS IN ROSEMARY SEEDLINGS

<i>Species</i>	<i>The seed-lobe</i>		
	<i>the emergence of petals on the surface of the soil</i>	<i>falling of petals</i>	<i>life duration (days)</i>
<i>Rosmarinus officinalis</i> L.	15.IV±3	20.V±3	33±3
<i>Rosmarinus prostratus</i> Mazziari	20. IV±2	28.V±4	40±2

Pregenerative period: Seeds produce aerial sprouts. As the white rhizome develops, the hypocotyl stretches and raises its petals to the upper layer of the soil. Seeds grown under favorable conditions produce two opposite cotyledons. Sprout consists of cotyledons and cotyledon leaves. Petals are ellipse-shaped, the edge is entire, the tip is sharp, sparsely hairy on both sides, the upper part is green, and the lower part is light green, the veins are net-like. The stems are short and sparsely hairy. It is 0.4–0.5 cm long and 0.1–0.2 cm wide. The hypocotyl is light green, 1.6–1.9 cm long, and the epicotyl is 1.5–1.7 cm long, relatively green with weak hairs. The lifespan of a leaf is 38–42 days (Figure 3). The rhizome of the sprout is thin, the first row of delicate lateral rhizomes develops on it, the length is 1.0–1.4 cm, it is gray-white in color. Due to the formation of true leaves, the length of the root reaches 2.5–4.0 cm. 28–30 days after the formation of the cotyledon, the first pair of true leaves appear, they look like conifers, linear, leathery, sessile, arranged opposite, with a blunt tip. Its length is 1.3–1.6 cm, its width is 0.2–0.3 cm. The edges of the leaf are folded inwards. The lower surface is slightly convex, light green, the upper surface is dark, shiny. At the end of vegetation, a thin root is gradually formed, its length is 7–9 cm, its diameter is 0.4–0.5 cm, it has several first-order lateral roots.



Figure 3. Appearance of the first sprouts in *Rosmarinus officinalis* species

Juvenile age stage (y): In this stage, petioles fade. 2-3 pairs of true leaves are formed gradually. The development of the main root and its extension into the depth of the soil is noted. The length of the main root reaches 10.5–13.0 cm, and its spread to the sides reaches 5.0–7.5 cm, on which the gradual formation of second-grade lateral roots is observed.

Immature age stage (m): In this age stage, the formation and formation of true leaves is observed in sequence, the main shoot grows. True leaves are 6.5 ± 0.5 cm long and 3.0 ± 0.4 cm wide. At the end of the 1st vegetation year, the length of the main root is 14.5 ± 0.6 cm. At the end of this period, the height of the sprouts reaches 9–11 cm. The immature stage lasts 30–37 days.

Virginal stage (v): This stage covers the second year. Active growth of the main and side branches takes place. At the end of this stage, the plants reach a height of 24–28 cm, and the diameter of the umbel is 15–17 cm. The main root develops intensively and extends to a depth of 18.0 ± 0.5 cm, and the development of II–III level side roots is observed. The formation of side nodules of the first degree on the main stem is noted.

Generative period (g): As in other species, this stage is mainly observed in the third year in the type of rosemary. During this period, an increase in the height of the plant and the formation of side branches are observed. The number of main side branches is 3–5, and the height reaches 17–25 cm. The height of the bush is 42–46 cm.

During this period, the plant enters the flowering stage. The flower group is first observed at the tip of the main stem and then alternately formed side branches. The flower group is in the form of a false brush, on which there are 3–5 sessile flowers. 60–67% of the plants enter the flowering stage. Since flowering is observed sequentially, seed ripening also continues sequentially from February to May. After the generative period, subsenile and senile age periods were recorded. When the plant gets old, the leaves at the bottom of the bush turn yellow, dry and fall off.

Conclusion

The following results were obtained during our research:

1. The seeds of the rosemary species produce aerial sprouts.
2. The following periods and stages were observed in ontogeny: 1. Latent period (calm); 2. Pregenerative (germinal, juvenile, immature and virginal); 3. Generative period; 4. Subsenile and senile age.
3. Rosemary species have different morphological indicators of sprouts. The life of petals lasts 33 ± 3 days in *Rosmarinus officinalis* and 40 ± 2 days in *R. prostratus*.

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