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BIOLOGICAL AND ECOLOGICAL CHARACTERISTICS OF MEDICINAL PLANTS

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Abstract. This paper analyses, on the basis of the literature, the biological characteristics of medicinal plants (life forms, reproduction, developmental stages, and the synthesis of secondary metabolites) and the influence of environmental factors on them. The ecological adaptation and practical significance of endemic species are discussed using examples of medicinal plants in the flora of Uzbekistan, including Ungernia victoris, Lagochilus inebrians, Dracocephalum komarovii, and Codonopsis clematidea. The main directions for protecting natural resources and cultivating medicinal plants under cultivated conditions are outlined.

Keywords: medicinal plants, biological characteristics, environmental factors, secondary metabolites, flora of Uzbekistan, endemic species, conservation.

Introduction

Medicinal plants have been used by humankind for therapeutic purposes since ancient times. The second volume of Ibn Sina's "The Canon of Medicine" describes approximately 1,500 medicinal substances and about 800 species of medicinal plants [1]. Today, they remain an important source of raw materials for the pharmaceutical, perfumery, and food industries. More than 4,500 species of higher plants have been recorded in the flora of Uzbekistan; approximately 600 of them have been documented as medicinal, although only about 200 have been studied phytochemically [1]. Official documents indicate that 750 of the more than 4,300 plant species in the local flora are considered medicinal [2]. The difference between these figures is related to the varying definitions of medicinal species and counting methods used in different sources.

The medicinal properties of a plant are determined by the biologically active substances contained in it. The accumulation of these substances depends on the plant's hereditary characteristics, developmental stage, and growing conditions. Therefore, knowledge of the biological and ecological characteristics of medicinal plants constitutes a scientific basis for managing raw material quality and conserving natural resources.

Relevance of the Study

As demand for medicinal plants increases, natural populations are coming under pressure. Globally, the collection of medicinal plants from their natural habitats is recognised as one of the factors affecting biological diversity [5]. Ensuring the quality of raw materials requires compliance with international requirements in their collection and cultivation [6]. In Uzbekistan, this area has a special place in state policy: Resolution No. PQ-4670 of 10 April 2020 established measures for the protection, cultivation, and processing of wild medicinal plants; it was also reported that processed medicinal plant products worth USD 48 million were exported in 2019 [2]. In accordance with the resolution, clusters for the cultivation, storage, and processing of medicinal plants, as well as regional specialisation, were introduced [2]. These processes require in-depth knowledge of the biological and ecological characteristics of the species.

Aim and Objectives of the Study

Aim: to analyse the main biological characteristics of medicinal plants and the effects of environmental factors on their growth and the accumulation of active substances, using examples from

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Uzbekistan. Objectives: (1) to summarise the biological characteristics of medicinal plants; (2) to examine the effects of environmental factors; (3) to describe ecological adaptation using examples of medicinal and endemic species of Uzbekistan; and (4) to identify approaches to conservation and cultivation.

Research Methods

The study was based on an examination of scientific articles, monographs, regulatory legal documents, and open electronic sources. Information on Uzbekistan was obtained from an ethnobotanical study by researchers of the Institute of Botany of the Academy of Sciences of the Republic of Uzbekistan [1] and from official documents [2]. The methods of comparison, analysis, and generalisation were applied.

Results and Discussion

In terms of life form, medicinal plants include herbs, subshrubs, shrubs, and trees. They reproduce by seeds, while some species also reproduce vegetatively (through rhizomes, tubers, and bulbs). Their medicinal properties are determined by secondary metabolites (alkaloids, flavonoids, glycosides, essential oils, saponins, tannins, and coumarins). These compounds are distributed unevenly among plant organs: in some species, they accumulate mainly in the above-ground parts, while in others they accumulate in the roots, bulbs, flowers, or fruits. Therefore, the plant organ used as raw material and the collection period are determined separately for each species.

The content of active substances also changes over the course of the season. For example, the highest concentration of alkaloids in Ungernia victoris is observed in early spring; this plant is currently an industrial source of the alkaloid galantamine [1]. In an ethnobotanical study conducted in the Kashkadarya, Samarkand, and Tashkent regions in 2014–2019, the 117 medicinal species recorded belonged to 45 families and 94 genera. The most represented families were Asteraceae (18 species), Lamiaceae and Rosaceae (10 species each), and Fabaceae (8 species) [1].

Light, temperature, moisture, soil composition, and altitude above sea level affect plant growth and the rate of secondary metabolite synthesis [3, 4]. Reviews have shown that adverse factors such as drought, salinity, temperature fluctuations, and ultraviolet radiation alter the synthesis of secondary metabolites that perform protective functions in many species [3, 4]. However, this effect varies depending on the species and the group of metabolites; therefore, the balance between yield and quality must be assessed separately for each species.

Central Asia has a broad ecological gradient extending from deserts to high-mountain plateaus, which increases the diversity of medicinal plants [1]. The flora of Uzbekistan occupies a central position in the region and is distinguished by a high level of local endemism [1]. Dracocephalum komarovii is a perennial spiny subshrub growing in the alpine zone of the Western Tian Shan at elevations of 3,000–3,600 m and is an endemic species adapted to mountain conditions [1]. Species such as Ungernia victoris and Codonopsis clematidea, distributed in the Gissar Range of the Pamir-Alay, are also significant because of their association with specific territories [1].

Table 1 presents some examples of medicinal plants of Uzbekistan.

Table 1. Selected medicinal plants of Uzbekistan [1]

Species	Local name	Biological and ecological characteristics	Significance
Ungernia victoris Vved.	Omonqora	Endemic to the Pamir-Alay (Gissar Range); alkaloid content is highest in early spring	Industrial source of the alkaloid galantamine

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Lagochilus inebrians Bunge	Bozulbang	Endemic species; all parts contain lagoxilin, alkaloids, essential oil, and tannins	Haemostatic and sedative agent
Dracocephalum komarovii Lipsky	Buzbosh	Perennial spiny subshrub growing in the alpine zone of the Western Tian Shan (3,000–3,600 m)	Above-ground parts used as tea (for inflammation and blood pressure)
Codonopsis clematidea (Schrenk) C.B. Clarke	Dugboy	Widely distributed in the Western Pamir-Alay	Used for liver diseases; a preparation based on it has been used since 2002
Glycyrrhiza glabra L.	Shirinmiya	The root is used as medicinal raw material	Used in folk medicine for heart and respiratory tract diseases; an export-oriented species

The main ways to reduce pressure on natural resources are compliance with collection limits, protection of rare and endemic species, and propagation of promising species under cultivated conditions. In Uzbekistan, the population status of the most widely used and export-oriented species–Ungernia victoris, Ferula foetida, Helichrysum maracandicum, Capparis spinosa, Ephedra equisetina, and Glycyrrhiza glabra–has been assessed; the annual potential for using wild resources has been determined, GIS maps have been developed, and measures for sustainable use have been proposed [1]. In cultivation, the biological characteristics of each species (method of reproduction and developmental rhythm) and its ecological requirements (soil, moisture, and light) must be taken into account, while collection and cultivation processes should comply with international recommendations [6].

Conclusion

The biological characteristics of medicinal plants (life form, reproduction, developmental stages, and accumulation of active substances) and their ecological requirements determine their growth and the quality of raw materials. The flora of Uzbekistan is rich in medicinal and endemic species, among which Ungernia victoris, Lagochilus inebrians, Dracocephalum komarovii, and Codonopsis clematidea are distinguished by their adaptation to specific environmental conditions. To preserve natural resources, it is necessary to regulate collection, protect rare species, and cultivate promising species under scientifically grounded conditions.

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