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Analysis of Important Ecological Factors Affecting Representatives of the Genus Helichrysum Occurring in Uzbekistan

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Abstract

This study analyzes the distribution areas and main climatic factors — annual average temperature and annual precipitation — of selected species belonging to the genus Helichrysum (H. arenarium, H. maracandicum, H. mussae, H. nuratavicum, H. thianschanicum) in Uzbekistan. Climatic indicators obtained from the WorldClim database were compared with plant coordinates using ArcGIS software. The results showed that each species is adapted to specific ecological and climatic conditions. Differences in temperature and moisture requirements among the species influence their natural distribution and sensitivity to climate change. These findings provide important insights into the ecological requirements of Helichrysum species and serve as a foundation for their conservation and preparation for future environmental changes.

Keywords: Helichrysum, climatic factors, ecological analysis, flora of Uzbekistan, WorldClim, ArcGIS, distribution area, precipitation, temperature.

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1. Introduction

At present, studying the relationships between plants and ecological factors is of great scientific and practical importance in ecological monitoring, biodiversity conservation, and plant introduction studies [1]. The flora of Uzbekistan is rich and diverse, comprising more than 4,500 plant species, approximately 20% of which are endemic [2]. Among these valuable plant groups, representatives of the genus Helichrysum belonging to the Asteraceae family occupy a special place.

Species of the genus Helichrysum are mainly distributed in semi-desert and mountainous regions, particularly on rocky and sandy soils [3]. Although representatives of this genus are adapted to various environmental conditions, they exhibit a certain degree of sensitivity to factors such as temperature, moisture, soil mechanical composition, and mineral content [4]. Therefore, determining the ecological requirements of these plants is important for assessing their natural habitats, evaluating introduction possibilities, and developing appropriate cultivation and management practices [5]. Although the number of Helichrysum species in Uzbekistan is relatively limited, some species possess narrow distribution ranges and are

considered rare and ecologically vulnerable. In particular, Helichrysum nuratavicum is distinguished by its occurrence within specific territories and possesses significant scientific value [6]. Consequently, detailed investigation of the distribution characteristics of these species and the major ecological factors affecting their growth and development is considered an important research task.Five species of the genus Helichrysum are distributed within the territory of Uzbekistan, including H. arenarium (L.) Moench, H. maracandicum Popov ex Kirp., H. mussae Nevski, H. nuratavicum Krasch, and H. thianschanicum Regel [11,12]. This article analyzes the distribution ranges and major ecological factors (light, moisture, soil, temperature, and others) influencing representatives of the genus Helichrysum in Uzbekistan. In addition, their ecological adaptation strategies, sensitivity to environmental factors, and the necessity of conservation are discussed on a scientific basis.

Materials And Methods

The present study investigated the relationship between ecological factors and plant species belonging to the genus Helichrysum distributed within the territory of Uzbekistan. GPS coordinates of the species were collected from natural distribution areas and the GBIF database and subsequently imported into ArcGIS Pro software [13]. Based on these occurrence points, the following bioclimatic variables were extracted from the WorldClim 2.1 database (WorldClim): Bio1 – annual mean temperature (°C), and Bio12 – annual precipitation (mm) [7].WorldClim is a global climate database providing climatic information collected worldwide for the period from 1970 to 2000 and is widely used for developing ecological models of species and ecosystems [8]. These data were downloaded in raster format with a spatial resolution of 30 arc-seconds (~1 km²) and overlaid with species occurrence coordinates in ArcGIS Pro. The “Extract Values to Points” tool was used to obtain climatic values corresponding to each occurrence point [9].As a result, annual mean temperature and precipitation data for the habitats of each species were exported in CSV format and analyzed statistically and graphically using MS Excel software. This approach proved effective for identifying ecological niches and assessing the bioclimatic characteristics of species distribution ranges [10].

Results

A comprehensive analysis of the ecological and climatic characteristics of endemic and rare medicinal plant species is essential for their effective conservation and for developing adaptation strategies in response to global climate change. The complex geological history, diverse relief, and ecological heterogeneity of Uzbekistan have created favorable conditions for the natural distribution of numerous endemic species. In particular, the unique climate and geostructure of the Nurata botanical-geographical region serve as a natural refuge for many plant species.Within the framework of this study, the natural distribution areas of Helichrysum species occurring in Uzbekistan and the bioclimatic factors characteristic of their habitats — annual mean air temperature and annual precipitation — were investigated. The analysis included important species such as H. maracandicum, H. nuratavicum, H. mussae, H. thianschanicum, and H. arenarium (Figures 1–2).Based on the occurrence points of each species, temperature (°C) and precipitation (mm) values characteristic of their habitats were calculated. Figure 1 presents temperature values, while Figure 2 illustrates precipitation levels together with standard deviation indicators.

The results demonstrated that the annual mean temperature of the habitats ranged from 10°C to 17°C. The highest temperature values were recorded in the distribution areas of H. thianschanicum and H. arenarium, indicating that these species are well adapted to warm and low-precipitation climatic conditions (Figure 1). In contrast, H. mussae was distributed in relatively cooler regions with average temperatures ranging between 5°C and 6°C, suggesting a high tolerance of this species to cold environmental conditions.

In addition, no significant temperature differences were observed between H. maracandicum and H. nuratavicum, which occur in geographically close regions. Both species develop under temperature conditions ranging from 10°C to 12°C, indicating similarities in their ecological requirements.

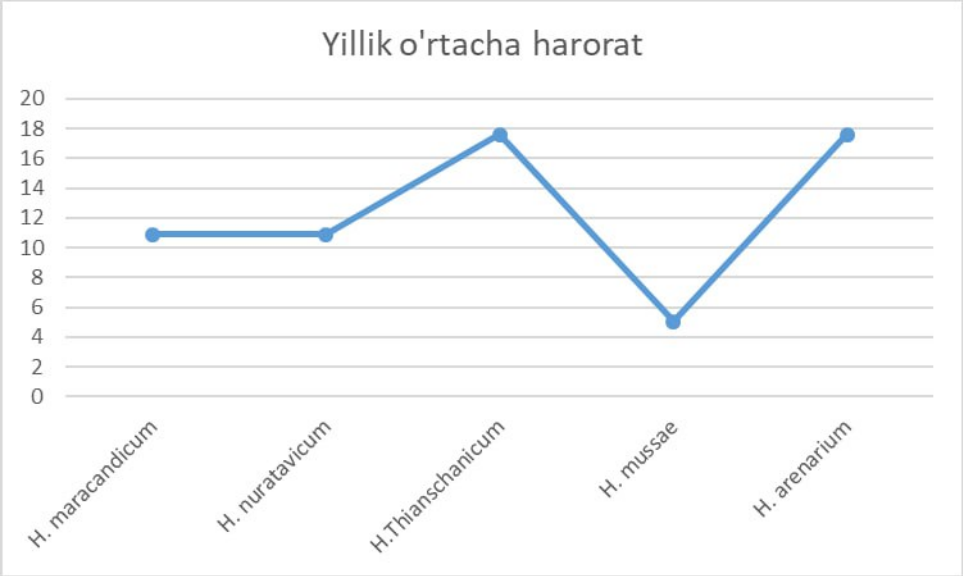

Figure 1. Annual mean precipitation characteristics of habitats of Helichrysum species distributed in Uzbekistan.

Annual precipitation values varied within a broad range from 100 mm to 1000 mm. The study revealed that H. arenarium and H. thianschanicum were distributed in areas with the lowest precipitation levels, ranging from 100 to 350 mm annually. This indicates that these species are highly adapted to dry and semi-desert climatic conditions. In contrast, H. maracandicum and H. nuratavicum occur in relatively moderate and relatively humid environments receiving approximately 550–600 mm of annual precipitation (Figure 2).

It is assumed that all representatives of this genus may possess adaptive characteristics related to water-deficiency tolerance. In particular, rhizomes or vegetative structures may have water-retention properties. Such characteristics are important for evaluating the ecological adaptation potential of these species.

Furthermore, some species, including H. mussae, were found in regions with relatively higher precipitation levels. The habitats of this species receive comparatively greater annual rainfall, indicating its stronger adaptation to moist environmental conditions and relatively lower tolerance to drought conditions. These findings provide important information for understanding the ecological plasticity of the genus Helichrysum.

4.10B

Figure 2. Annual mean air temperature characteristics of habitats of Helichrysum species distributed in Uzbekistan.

Based on the collected ecological data, representatives of the genus Helichrysum can be classified into the following groups according to their ecological requirements and habitat characteristics:

1. Species adapted to warm and dry climatic conditions (thermophilic and xerophytic species):

Helichrysum thianschanicum and Helichrysum arenarium belong to this group. These species mainly occur in semi-desert and desert landscapes. They are characterized by the ability to tolerate high temperatures and low moisture conditions, possess relatively short vegetation periods, and exhibit morphophysiological adaptations associated with water deficiency tolerance.

2. Species preferring moderate temperature and precipitation conditions (mesophytic or mesoxerophytic species):

Helichrysum maracandicum and Helichrysum nuratavicum belong to this group and are distributed in regions characterized by moderate climatic conditions. Stable temperatures and moderate annual precipitation are important for the growth and development of these species. Under such conditions, these species may exhibit sensitivity to climatic fluctuations and environmental changes.

3. Species requiring cool and relatively humid climatic conditions:

Helichrysum mussae belongs to this group. It mainly grows under microclimatic conditions in mountainous regions, characterized by lower temperatures and higher moisture levels. Due to its relatively narrow ecological range, this species may respond sensitively even to minor climatic changes.

Conclusion

The five species of the genus Helichrysum distributed in Uzbekistan (H. arenarium, H. maracandicum, H. mussae, H. nuratavicum, and H. thianschanicum) are adapted to diverse ecological and climatic conditions. According to the results of this study, these species can be classified into specific ecological groups based on the annual mean temperature and precipitation characteristics of their habitats.

For example, H. thianschanicum and H. arenarium are distributed in warm and dry regions, whereas H. mussae is adapted to cool and humid environments. In contrast, H. maracandicum and H. nuratavicum occur in areas characterized by moderate climatic conditions. These findings are important for understanding species distribution patterns, evaluating their responses to climate change, and developing effective conservation strategies for these species.

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