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RESEARCH ARTICLE

# Ecological distribution and economic significance of *Cichorium intybus* L. across desert, foothill, mountain and pasture ecosystems

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## Abstract

This article examines the distributional patterns of *Cichorium intybus* L. (common chicory) across major ecological zones of Uzbekistan and Central Asia, including deserts, foothills, mountain areas and pastures. *C. intybus* L. is a widely distributed perennial herb known for its high ecological adaptability, nutritional value and medicinal properties. It has long been used in traditional medicine and as a forage crop, making it an important species for both ecological and economic studies. This study examines the spatial distribution and adaptive patterns of *C. intybus* across major ecological zones of Uzbekistan and Central Asia, highlighting its ecological significance and potential for sustainable utilization. Its natural range, ecological adaptations and the impact of anthropogenic factors were analyzed. The results indicated that the occurrence of the species in Uzbekistan was largely determined by moisture availability and human activities. A comparative analysis with data from Europe, Asia and other regions was also included. The findings confirm that moisture availability and anthropogenic factors are the main determinants of the species' occurrence in Uzbekistan.

**Keywords:** anthropogenic factors; *Cichorium intybus*; distribution; ecological amplitude; flora of Uzbekistan; geobotany

## Introduction

*Cichorium intybus* L. (common chicory) is a perennial herbaceous species in the family Asteraceae with a broad ecological amplitude and a long history of use as food, medicinal raw material and forage. Its native range extends across Europe, Central Asia and the western Himalayas. The species also occurs naturally in North Africa and Macaronesia and beyond this range, it has become widely naturalized throughout temperate regions of both hemispheres, including North America and Australasia. These distributions are documented in consolidated floristic databases from Kew (POWO) and in national registries (USDA PLANTS) (1, 2). Chicory is a typical "boundary" taxon between cultivated and wild flora. Its tolerance of habitat disturbance allows it to frequently colonize roadsides, fallows, irrigated lands and other altered habitats, which contributes to its successful naturalization in agroecosystems worldwide (Fig. 1). From the standpoint of applied botany and bioresources, chicory is important in three principal dimensions.

First, as a forage species, chicory develops a deep taproot and exhibits palatability and nutritive value comparable to those of alfalfa and cool-season grasses. Breeding programs have been intensive in New Zealand-producing cultivars such as 'Puna'-and in the Mediterranean region, where agronomic practices have been tailored for summer-drought conditions. Second, as a dietary fiber source, chicory roots are rich in inulin. Modern studies of table cultivars report inulin concentrations ranging from 44 to 51 g per 100 g of dry matter, along with high polyphenol content. Third, as a medicinal raw material, *C. intybus* has been reported to exhibit antioxidant, anti-inflammatory and other bioactive effects, primarily attributed to sesquiterpene lactones, polyphenols and inulin. Recent reviews also emphasize the need for improved standardization of extracts and greater reproducibility of results. Ecologically, *C. intybus* shows marked plasticity to temperature, moisture availability and soil type: maximum productivity is achieved in foothill and valley settings with moderate precipitation and fertile soils; however, the species can endure arid periods thanks to early-spring use of soil moisture and its deep root system. In mountain habitats (lower temperatures, higher insolation, nutrient-poor soils), closely related taxa and local populations often exhibit elevated accumulation of secondary metabolites-an adaptive response to abiotic stress; this trend has also been confirmed for chicory in recent phytochemical overviews (Fig. 2).

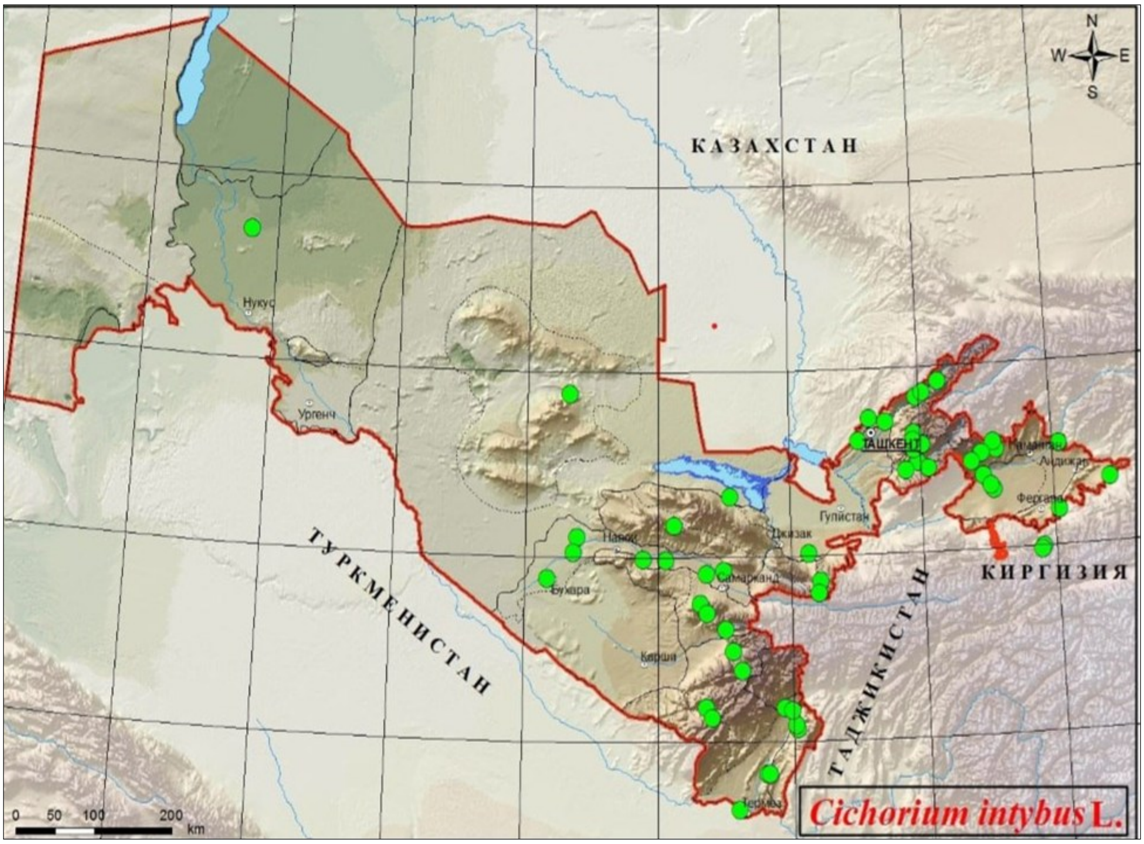


**Fig. 1.** *Cichorium intybus* L. the distribution of in the territory of Uzbekistan.

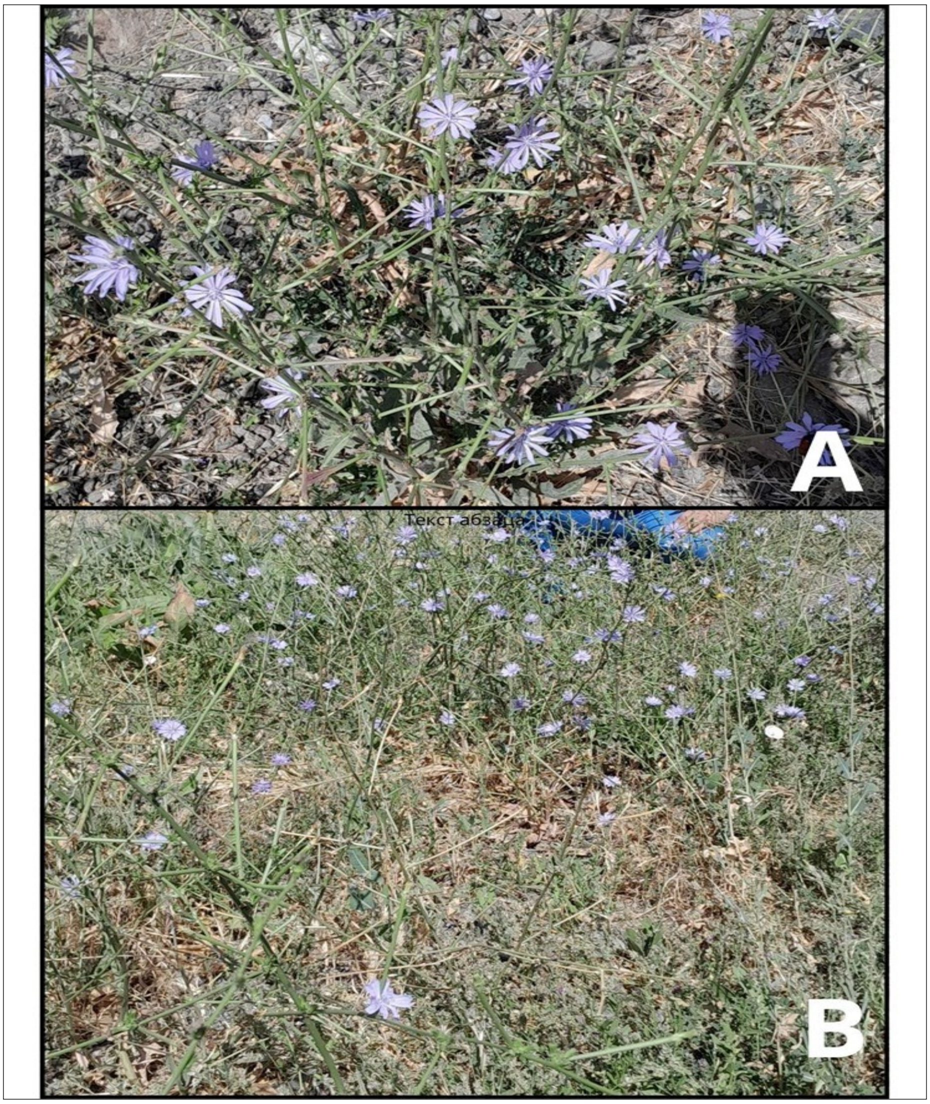


**Fig. 2.** Distribution in the A) desert area and B) mountain area.

For Uzbekistan and Central Asia, investigating the distribution of *C. intybus* is important for three reasons: the species serves as an indicator of anthropogenic transformation (road networks, irrigation, grazing), it can be a stable component of pasture communities and a source of summer forage and it is of interest as a local resource for dietary fiber and phytotherapeutics. Systematizing local observations with GIS support and comparing them with international data enables a more precise delineation of the species' ecological niche in the arid and semi-arid landscapes of the region (Fig. 3).

Finally, the historical trajectory of chicory agronomy makes it a convenient model for comparative studies: Europe remains the center of cultural cultivation (leafy and root forms), whereas selection of forage forms and pasture management technologies have been actively developed in New Zealand and several Mediterranean countries-providing a rich basis for benchmarking productivity, grazing tolerance and drought resilience.

## Materials and Methods

The study of the distribution of *C. intybus* was based on a combination of field surveys, laboratory analyses, herbarium material revisionand literature review. The study was structured to combine floristic, ecological and phytochemical information, providing a comprehensive characterization of the species' ecological amplitude and adaptation across the region.

### Data sources

#### Literature review

A systematic analysis of monographs, floristic checklists and scientific articles covering the flora of Uzbekistan, Central Asia and adjacent regions was conducted (1-4). International publications on the ecological and agronomic aspects of chicory were also considered to provide a comparative framework (5-7).

#### Herbarium specimens

Reference collections were examined from the Samarkand State University Herbarium (SAMU) and Tashkent State University Herbarium (TASH). The species nomenclature and synonymy were validated against the Plants of the World Online and USDA Plants Database (8, 9).

#### GIS and remote sensing data

Distribution mapping was carried out using Sentinel-2 and MODIS satellite imagery, complemented by climatic data from WorldClim 2.1 (10). These datasets were employed to model the ecological niche of *C. intybus* and to identify key climatic drivers.

### Study areas

Field surveys were conducted between 2021 and 2024 across four principal ecological zones of Uzbekistan:

#### Desert regions

Khorezm, Bukhara and Navoi provinces (arid climate, sandy and saline soils, precipitation 120-150 mm/year).

#### Foothill zones


**Fig. 3.** Distribution in the A) Adir area and B) territory of Tugai.

Jizzakh, Samarkand and Kashkadarya provinces (chernozem and sierozem soils, moderate precipitation, 280-350 mm/year).

**Mountain regions**

Zarafshan and Chatkal range at elevations of 900-1800 m a.s.l. (mountain brown soils, cooler temperatures, higher precipitation up to 600 mm/year).

**Pastures**

Fergana valley and Tashkent province, characterized by intensive grazing, irrigated agriculture and high anthropogenic pressure.

### Ecological parameters

In each study zone, a standardized set of ecological parameters was recorded, reflecting the main abiotic and biotic drivers of plant growth and survival. These parameters were selected in line with classical ecological frameworks, including the concepts of ecological amplitude, ecological niche theory and plant functional trait analysis (10, 11).

**Climatic parameters**

Annual mean temperature, seasonal extremes (minimum and maximum summer temperatures) and annual precipitation were obtained from local meteorological stations and supplemented with global climate layers (12). The choice of these indicators follows Walter's climate-vegetation zonation system, which stresses the role of temperature and precipitation in determining vegetation distribution in arid and semi-arid regions (13).

**Soil parameters**

Soil texture was determined using the pipette method, humus content was measured following Tyurin's procedure, pH was assessed potentiometrically and salinity was evaluated through electrical conductivity (EC). Soil fertility and salinity are considered critical limiting factors in arid landscapes (14, 15). The inclusion of these parameters reflects the plant–soil interaction framework, where soil chemistry and structure directly shape species' survival strategies and biomass allocation.

**Biological parameters**

Population density (plants/m$^2$), phenological phases (germination, flowering, fruiting) and biomass (dry weight per plant and per m$^2$) were recorded. These data are consistent with Raunkiaer's life-form classification and phenological adaptation theory, highlighting how species adjust life cycles to ecological constraints (16).

## Results

### Environmental conditions by region

The study revealed that *C. intybus* was most widespread in foothill and irrigated zones of Uzbekistan, particularly in Tashkent, Samarkand, Jizzakh and Kashkadarya provinces, as well as in the Fergana valley. In these regions, the species exhibited high population density and substantial biomass productivity, reflecting favorable soil fertility and sufficient moisture availability (Table 1, 2).

On irrigated lands, chicory actively colonized inter-rows of agricultural crops, roadside strips and other disturbed habitats, forming stable secondary plant communities (synanthropic stands). This adaptive behavior was typical of disturbance-tolerant species, enabling *C. intybus* to persist and expand under conditions of intensive agricultural activity.

Across Uzbekistan and the broader Central Asian region, the distribution of chicory was strongly linked to anthropogenic landscapes, including irrigation canals, orchards, vineyard margins and fallow lands. Its capacity to establish in secondary habitats highlighted the ecological plasticity of the species and emphasized its dual role as both a weedy element of agroecosystems and a valuable forage and medicinal plant.

Comparative floristic surveys showed that while natural populations in desert and mountain zones were scattered and sparse, those in cultivated and semi-natural environments tended to expand. This expansion was facilitated by human activities such as irrigation, soil disturbance and grazing. These findings confirmed that *C. intybus* functioned as a synanthropic indicator species in Uzbekistan, with its distribution patterns directly associated with the intensity of land use and irrigation development. In natural sandy and saline habitats, the species' occurrence was limited; however, in anthropogenically transformed sites-such as irrigated fields and pastures near water sources-it formed stable populations. In mountain regions (Zarafshan and Chatkal ranges), chicory occurred at elevations of 800-1800 m a.s.l., where conditions were characterized by lower temperatures and higher solar radiation. Although populations were less abundant in these areas, the plants exhibited enhanced biochemical activity, including increased accumulation of phenolic compounds and other secondary metabolites. Within pasture ecosystems, especially in the Fergana valley and Tashkent region, chicory was widely utilized as forage. It tolerated moderate grazing, yet populations declined under excessive grazing pressure, reflecting its sensitivity to overexploitation.

### Comparison with other regions

**Europe**

In Italy, France, Germany and Poland, chicory is cultivated as a root crop (for inulin and coffee substitutes) and as a leafy vegetable (endive). Wild populations occur along roadsides, meadows and river floodplains(17).

**Asia**

**Table 2.** Biological indicators of *C. intybus* by region

| The area | Seed germination ( %) | Average biomass (g/plant) |
|---|---|---|
| Desert | 45–50 | 7–10 |
| Foothills | 80–85 | 18–25 |
| Mountains | 65–75 | 16–20 |
| Pastures | 60–65 | 15–18 |

**Table 1.** Ecological indicators of *Cichorium intybus* growth zones in Uzbekistan

| The area | Soil type | Humidity ( %) | Temperature (°C) | Annual precipitation (mm) | Anthropogenic load |
|---|---|---|---|---|---|
| Desert | Sandy, saline | 7–10 | 30–35 | 120–150 | Low |
| Foothills | Gray desert soils | 16–20 | 20–28 | 280–350 | Medium |
| Mountains | Mountain brown soils | 20–25 | 10–18 | 400–600 | Low |
| Pastures | Fertile soils | 14–20 | 15–20 | 250–300 | High |

In Turkey, Iran, India and China, *C. intybus* is traditionally used in medicine and as forage. In India, the use of roots as a coffee substitute and medicinal raw material is particularly widespread (3).

**Americas**

In the United States and Canada, chicory was introduced in the 19th century and has since naturalized; in some states it is considered an aggressive weed (5).

**Oceania**

In New Zealand, forage cultivars (e.g., 'Puna') have been developed and show high productivity and drought tolerance under pasture conditions (18, 19).

## Discussion

Our results indicate that in Uzbekistan the highest productivity of *C. intybus* occurs in foothill zones, where seed germination reaches 80–85 % and mean aboveground biomass 18–25 g per plant, whereas in desert conditions both metrics are markedly lower (45–50 % and 7–10 g per plant, respectively). Similar patterns have been reported in Europe, observed that chicory achieves maximum productivity on fertile chernozem and loamy soils under moderate moisture (20). Trials in Germany recorded green biomass yields of 18–22 t $ha^{-1}$ at annual precipitation of 300–350 mm, values comparable to our foothill settings (precipitation 280–350 mm).

In New Zealand, it was demonstrated that the forage cultivar 'Puna' maintains high nutritive value and respectable yields under summer drought, although prolonged drought can reduce productivity to 30–40 % of maximum (21).

In the desert zone, plants persist under acute water stress but produce only minimal biomass.

### Adaptation in mountain environments

In mountain regions of Central Asia, *C. intybus* exhibits a shortened growing season but elevated levels of secondary metabolites. This aligns with findings that abiotic stress (low temperatures, high insolation and nutrient-poor soils) stimulates accumulation of phenolics and antioxidant compounds (21). Other studies likewise reported higher phenolic and inulin contents in leaves of mountain populations relative to lowland plants, consistent with our observations (22).

### Role of anthropogenic factors

In Uzbekistan, the present distribution of *C. intybus* is strongly shaped by anthropogenic drivers notably irrigation, road construction and grazing. By contrast, in much of Europe the species' presence in plant communities is primarily linked to cultivation (leafy and root types) (22). In parts of Asia (Turkey, Iran and India), traditional medicinal and forage uses have also facilitated its spread (23). Thus, while human influence is a universal driver of range of expansion, its expression differs across countries - from deliberate cultivation to synanthropic establishment.

### Comparison with pasture data

In pastures, 60–65 % germination and 15–18 g biomass per plant under heavy grazing suggest moderate productivity and resilience. Comparable figures are noted in the United Kingdom, where chicory retains forage value under intensive grazing, though periodic reseeding is advisable to sustain stand longevity and productivity (24).

### Limitations and implications

While our findings broadly concur with literature, site-level variation in soil salinity, management intensity and grazing regimes may modulate outcomes (25,26). Future studies featuring long-term monitoring, standardized metabolite profiling and ecological niche modelling could enhance predictions of *C. intybus* performance across Uzbekistan's diverse landscapes, supporting its evidence-based use as a forage, functional food and medicinal resource.

## Conclusion

*C. intybus* exhibits a broad ecological amplitude, occurring across all major ecological zones of Uzbekistan, from deserts and foothills to mountain regions and pastures. The species shows its highest productivity and population viability in foothill zones, where fertile soils and moderate precipitation provide favorable conditions (germination 80–85 % and biomass 18–25 g/plant). In deserts, chicory persists through early-spring moisture uptake, yielding only 7–10 g of biomass per plant, in line with global observations of its drought tolerance. Anthropogenic factors play a decisive role in its current distribution in Uzbekistan: irrigation, road networks and agricultural expansion facilitate its spread, whereas in Europe its distribution is shaped mainly by cultivation and in New Zealand by targeted forage breeding(27). Overall, the results align with international data and emphasize the ecological and economic significance of *C. intybus* as a promising species for agriculture, phytotherapy and the food industry.

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## Authors' contributions

JT conducted the full research, including field surveys, laboratory analyses and data interpretation. KK supervised the study, provided guidance and instructed on methodological approaches. SR prepared and edited the manuscript text; TS carried out statistical verification and data analysis. NT contributed financial support for the implementation of the study. All authors have read and approved the final manuscript; BB provided expert consultation on physiological and biochemical aspects of the research. MI contributed to data interpretation and critical revision of the manuscript. TO participated in methodological validation and literature review and RMM assisted in laboratory analyses and data processing.

## Compliance with ethical standards

**Conflict of interest:** Authors do not have any conflict of interest to declare.

**Ethical issues:** None

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