

Research Article

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Phytocenotic Characteristics and Resources of *Ferula songarica* in Central Kazakhstan (within the Ulytau and Karaganda Regions)

The study of the biological characteristics and resource potential of medicinal plants is an important task in modern botany and pharmacognosy. One of the promising medicinal species in the flora of Kazakhstan is *Ferula songarica*, which is characterized by a high content of biologically active compounds and valuable pharmacological properties. The aim of this study was to identify populations of *F. songarica* in natural conditions in Central Kazakhstan and to assess plant raw material resources. Field studies were conducted in 2024–2025 using a route-reconnaissance method at eight key sites located in the Ulytau and Karaganda regions. During the study, plant density, morphometric parameters, yield, exploitable raw material reserves, and potential harvest volume were determined. It was established that natural populations containing *F. songarica* are characterized by a sparse spatial distribution of individuals. The density of reproductive plants ranges from 0.36 to 6.05 plants/10 m², and plant height is 83.06–133.2 cm. The yield of roots, calculated on an air-dry weight basis, was 3,580–7,010 kg/ha, and that of aboveground parts was 234–315 kg/ha. The total area of plots suitable for raw material harvesting was 281.5 ha. The exploitable stock of roots is estimated at 1,874.85 tons, and that of the herbaceous parts at 79.22 tons. The potential harvest volume of roots is estimated at 183.8 tons, and that of aboveground parts at 55.43 tons. The results obtained demonstrate the feasibility of harvesting *F. songarica* raw materials in natural conditions for the production of medicinal and parapharmaceutical products.

Keywords: *Ferula songarica*, population, yield, Central Kazakhstan, exploitable stock, potential harvest volume, roots, aboveground biomass, medicinal plant raw materials.

Introduction

The vegetation of Kazakhstan is characterized by a high level of biodiversity and significant resource potential for medicinal plants. According to current estimates, the flora of Kazakhstan includes more than 5,500 species of vascular plants [1], of which about 270 species are used in traditional and official medicine [2]. Many of them possess valuable pharmacological properties and are considered promising sources of biologically active compounds for the pharmaceutical industry [3–5].

A special place among medicinal plants is occupied by representatives of the genus *Ferula* L. (Apiaceae), which is one of the largest genera in the family and includes more than 180 species [6], distributed primarily in the arid and subarid regions of Central Asia, Iran, Afghanistan, and western China. The main centers of species diversity for the genus are also concentrated in Kazakhstan, where about 48 species of *Ferula* grow, many of which have medicinal, forage, and economic value [7].

Plants of the genus *Ferula* have long been widely used in practice, primarily in three capacities: as forage, medicinal, and essential oil plants [2, 6]. In recent years, interest in the pharmacological properties of ferulas has increased significantly, due to their high content of biologically active compounds, primarily terpenoid coumarins, terpene alcohols and their esters with aromatic acids, as well as sesquiterpene lactones [8–11]. These compounds are considered promising targets for further pharmacological research and the search for new drugs.

One of the promising representatives of the genus is *Ferula songarica* Pall. ex Spreng. The species inhabits the steppe and foothill regions of Kazakhstan [12]. The species is of economic interest as a medicinal plant possessing anti-inflammatory, antitumor, and antispasmodic properties, used in traditional medicine for the treatment of diseases of the joints, cardiovascular and digestive systems, as well as an antioxidant and immune stimulant [13, 14].

To understand the potential for practical use of *F. songarica*, research is needed to study natural populations and assess raw material reserves.

In light of the above, the aim of this study was to investigate the population characteristics and assess the raw material reserves of *F. songarica* under various ecological and phytocenotic conditions in Central Kazakhstan.

Experimental

Field studies were conducted in the first ten days of June 2024-2025, when *F. songarica* plants were in the mass flowering phase. A preliminary analysis of the species' distribution was performed based on an analysis of herbarium collections (QAR and NUR herbaria).

Field surveys to determine the resources of the studied species were conducted using a route-reconnaissance method. In natural stands, we determined yield, stand density, and raw material reserves of aboveground and underground organs, and described the floristic composition of the sites [15, 16]. The studies were conducted in warm and dry weather; raw material collection for yield assessment was carried out in the morning, after the dew had dried.

The assessment of raw material reserves in the communities was conducted using the key plot method [17]. At each plot, the area, density of marketable specimens, yield, and reserves of underground and aboveground parts were assessed in terms of air-dry weight. The area of the stands was determined by mapping their configuration to geometric shapes. Control points were recorded using GPS, after which the dimensions and area of the stands were calculated. To assess yield, raw material was harvested from at least 8–10 plots, and underground organs from 4 plots. Young and middle-aged generative individuals served as marketable specimens.

The aboveground biomass was cut with pruning shears at a height of 10–12 cm from the soil surface to maximize the collection of leaves and inflorescences. *F. songarica* roots were dug up at a depth of 50–60 cm. The harvested biomass was dried in a room protected from sunlight [18]. The grass intended for drying was cut into smaller pieces (8–12 cm), the roots were washed to remove soil and also cut into smaller pieces (5–6 cm long and up to 2–3 cm wide). During drying, the raw material was regularly turned to prevent spoilage.

The air-dried raw material was weighed separately for each site. When selecting sites suitable for harvesting, the standards of Good Agricultural and Collection Practices (GACP) were taken into account [19].

The exploitable stock of raw material was calculated by multiplying the yield per unit area by the total area of the stands. The volume of the potential annual harvest of roots was set at 10 % of the exploitable stock, and that of aboveground parts at 70 % [20].

Species identification was performed based on the Flora of Kazakhstan [21], and Latin names were cited according to the Plants of the World Online (POWO) system.

Statistical analysis of the results was performed using the method of N.L. Udolskaya [22].

Results and Discussion

Field studies have shown that *F. songarica* is characterized by a sparse spatial distribution of individuals. The plants are found primarily as solitary specimens, in small groups of 6–8 individuals, or in thickets ranging in size from 10×20 to 20×70 m. This type of distribution is characteristic of many species of the genus *Ferula* growing in the steppe and semi-arid ecosystems of Central Asia, where the spatial structure of populations is determined by soil moisture conditions, microtopography, and competitive interactions with other plant species [21].

In the Karaganda and Ulytau regions (Central Kazakhstan), we surveyed sites containing natural stands of *F. songarica*, which cover the slopes of gentle, low hills and inter-hill depressions at elevations ranging from 250 to 540 m above sea level (Fig. 1). The flora of the surveyed areas consists of flowering plants of *Ferula songarica* and associated species: *Festuca valesiaca*, *Agropyron cristatum*, *Artemisia austriaca*, *Artemisia frigida*, *Artemisia dracunculus*, *Artemisia nitrosa*, *Artemisia pauciflora*, *Galatella villosa*, *Galatella tatarica*, *Astragalus danicus*, *Thymus marschallianus*, *Potentilla bifurca*, *Potentilla humifusa*, *Jurinea multiflora*, *Centaurea scabiosa*, *Phlomoides tuberosa*, *Atraphaxis spinosa*, *Androsace turkestanica*, *Carex* sp., *Ranunculus* sp., *Caragana frutex*, *Erysimum diffusum*, *Rosa spinosissima*, *Descurainia sophia*, *Spiraea hypericifolia*, *Achillea nobilis*, *Elytrigia repens*, and others. Vegetation aspect: yellow-green.



Figure 1. Typical habitats of *Ferula songarica* in Central Kazakhstan

Key site No. 1 is located in the vicinity of the village of Baikonyr, Ulytau District, Ulytau Region (N 47.83524, E 65.50149, elevation 250 m above sea level). The site covers an area of 225 ha. The soils consist of clayey saline meadows. The plant community belongs to the wormwood-grass-ferula type of phytocenoses. The dominant species is *F. songarica* (cop1, coverage about 80 %), the subdominants are species of the genus *Artemisia* (cop2, coverage about 80 %), and the herbaceous layer is arranged in two tiers. The density of generative individuals is 6.05 ± 0.52 individuals/10 m². The average height of reproductive plants is 133.2 ± 6.65 cm. The diameter of the aboveground part varies from 24 to 46 cm, and the length of the root system is 20–35 cm. The average plant density is 0.82 ± 0.06 plants/m². The raw material yield was 7,010 kg/ha on a dry weight basis (Tab. 1). The exploitable stock of root raw material is estimated at 1,577.25 tons; that of grass at 64.13 tons (Tab. 2). The potential harvest volume is estimated at 157.0 and 44.89 tons, respectively.

Table 1

**Yield and raw material reserves of *Ferula songarica* roots in Central Kazakhstan
(on an air-dry weight basis)**

| Region | Key site | Area of thickets, ha | Yield, kg/ha | Operational reserves, tons | Potential raw material harvest, tons |
|---------------|----------|----------------------|--------------|----------------------------|--------------------------------------|
| Ulytau | 1 | 225.0 | 7,010±212 | 1,577.25 | 157.0 |
| | 2 | 25.0 | 6970±340 | 174.25 | 14.4 |
| | 3 | 7.1 | 3688±256 | 26.18 | 2.6 |
| | 4 | 5.0 | 5152±302 | 25.76 | 2.6 |
| Karaganda | 5 | 5.3 | 5020±340 | 26.61 | 2.7 |
| | 6 | 4.8 | 4250±180 | 2.0 | 0.2 |
| | 7 | 3.2 | 3,580±190 | 11.45 | 1.2 |
| | 8 | 6.1 | 5,140±260 | 31.35 | 3.1 |
| Total: | | 281.5 | | 1,874.85 | 183.8 |

Table 2

**Yield and raw material reserves of *Ferula songarica* aboveground part in Central Kazakhstan
(in terms of air-dry weight)**

| Region | Key site | Area of the stand, ha | Yield, kg/ha | Operational reserves, tons | Potential raw material harvest, tons |
|--------|----------|-----------------------|--------------|----------------------------|--------------------------------------|
| Ulytau | 1 | 225.0 | 285±18 | 64.13 | 44.89 |
| | 2 | 25.0 | 260±31 | 6.5 | 4.55 |
| | 3 | 7.1 | 315±22 | 2.24 | 1.56 |
| | 4 | 5.0 | 220±30 | 1.1 | 0.77 |

| Region | Key site | Area of the stand, ha | Yield, kg/ha | Operational reserves, tons | Potential raw material harvest, tons |
|-----------|----------|-----------------------|--------------|----------------------------|--------------------------------------|
| Karaganda | 5 | 5.3 | 312±25 | 1.65 | 1.15 |
| | 6 | 4.8 | 250±19 | 1.2 | 0.84 |
| | 7 | 3.2 | 234±21 | 0.75 | 0.52 |
| | 8 | 6.1 | 270±34 | 1.65 | 1.15 |
| Total: | | 281.5 | | 79.22 | 55.43 |

Key site No. 2 is also located in the Ulytau Region, Ulytau District, 15 km north of the village of Baikonur (N 47.83442, E 65.93964, elevation 347 m above sea level). The area of the vegetation cover is 25 ha. The soils are clayey-saline. The phytocenosis belongs to the grass-wormwood-ferula type. The vegetation is two-tiered. The main dominants are *F. songarica* (cop1, coverage about 65 %), *Calamagrostis epigeios*, and *Poa bulbosa* (cop2, 10–15 %). The height of generative plants is 125.2±6.57 cm. The number of vegetative individuals is 18.3±1.52 individuals/100 m². The average height of generative plants is 125.2±6.65 cm. The density of generative plants is 0.82±0.06 plants/m². The number of vegetative plants reaches 18.3±1.52 plants/100 m². The diameter of the above-ground plant mass is 20–37 cm, and the root length is 15–25 cm. The raw material yield was 6,970 kg/ha on a dry weight basis (Tab. 1). The exploitable root stock is estimated at 174.25 tons on a dry weight basis, and the potential raw material harvest volume is 14.4 tons. For the aboveground parts, these figures are estimated at 6.5 and 4.55 tons, respectively.

Key site No. 3 is located in the Zhanaarkinsky District of the Ulytau Region, near the village of Aktubek (N 48.56255; E 70.90449, elevation 462 m above sea level). The site covers an area of 7.1 hectares. The plant community is a ferula-reed type. The main dominant species are: *F. songarica* (cop2), *Calamagrostis epigeios* (soc). The total projective cover reaches 70 %. The herbaceous layer is two-tiered and species-poor. The density of generative individuals is 0.36± 0.02 individuals/10 m², which is the lowest value among the studied plots. Plants are found singly or in small groups of 5–8 individuals. The average height of generative plants is 93.06±7.39 cm. Root yield is 3,688 kg/ha. The exploitable stock is estimated at 26.18 tons, and the potential harvest volume is 2.6 tons (Tab. 1). The exploitable stock of aboveground parts, with a yield of 315 kg/ha, amounted to 2.24 tons, and the potential harvest volume was 1.56 tons (Tab. 2).

Key site No. 4 is located in the Ulytau District, near the Krasnaya Zaimka wintering grounds, on a rocky, gravelly hill (N 48.73330; E 66.89036, elevation 539 m above sea level). The area covers 5 ha. The phytocenosis also belongs to the ferula-calamagrostis type. Main dominants: *F. songarica* (cop2), *Calamagrostis epigeios* (soc). Total cover is up to 65–75 %. The herbaceous layer is three-tiered, with a species composition of up to 15 taxa. The density of generative individuals is 0.41± 0.01 individuals/10 m², and the number of vegetative individuals is 21.3±1.92 individuals/100 m². The average height of generative plants is 135.1±6.52 cm. Root yield amounted to 5,152 kg/ha on a dry weight basis. The exploitable stock is estimated at 25.76 tons, and the potential harvest volume of underground organs is 2.6 tons (Tab. 1). For aboveground parts, the raw material yield was 220 kg/ha, the exploitable stock is estimated at 1.1 tons, and the potential harvest volume at 0.77 tons.

Key site No. 5 is located in the Karaganda Region, Karkaraly District, near the village of Matak (N 49.68053; E 74.70494, elevation 540 m above sea level). The study plot covers an area of 5 hectares. The community belongs to the ferula-calamagrostis type. The dominant species are *F. songarica* (cop2) and *Calamagrostis epigeios* (soc), with a total projective cover reaching 65 %. The herbaceous layer is two-tiered, and the species composition of the community consists of approximately 10–11 taxa. The density of generative individuals is 0.83± 0.05 individuals/10 m², and the number of vegetative individuals is 20.2±1.72 individuals/100 m². The average height of generative plants is 121.2±6.65 cm. Root yield was 5,020 kg/ha, and herb yield was 312 kg/ha. The exploitable root stock is estimated at 26.61 tons, with a potential harvest of 2.7 tons; for grass, these figures are estimated at 1.65 and 1.15 tons, respectively (Tab. 1, 2).

Key site No. 6 is located in the Karaganda Region, Karkaralinsky District, near the village of Koktas (N 49.61813; E 75.00541, elevation 522 m above sea level). The area of the study plot is 4.8 ha. The community belongs to the ferula-caragana type. The dominant species are *F. songarica* (cop2) and *Caragana frutex* (cop1); the species composition of the community comprises about 15 taxa. The total projective cover is estimated at 80–85 %. The herbaceous layer is three-tiered. The density of generative individuals is 0.54± 0.04 individuals/10 m², and the number of vegetative individuals is 5.9±0.07 individuals/100 m². The average height of generative plants is 126.8±8.2 cm. Root yield was 4,250 kg/ha, and grass yield was

250 kg/ha (Tab. 1, 2). The exploitable root stock is estimated at 2.0 tons, and the grass stock at 1.2 tons. The potential harvest volume of roots and grass was 0.2 and 0.84 tons, respectively.

Key site No. 7 is located in the Abai District of the Karaganda Region, on the slopes of the Spassky Hills (N 49.50934; E 73.25108, elevation 605 m above sea level). The site covers an area of 3.2 ha and is dominated by a rose-spirea-ferula community, with a total projective cover of 90 %. The dominant species is *Rosa spinosissima* (cop2), with *Spiraea hypericifolia* (cop1) and *F. songarica* (cop — sp) as co-dominants. The overall species composition is quite rich—up to 18–20 taxa. The herbaceous layer is three-tiered. The density of generative individuals is 0.81 ± 0.06 individuals/10 m², and the number of vegetative individuals is 10.5 ± 0.04 individuals/100 m². The average height of generative plants is 112.6 ± 8.3 cm. Root yield was 3,580 kg/ha, and above-ground yield was 234 kg/ha (Tab. 1, 2). The exploitable root stock is estimated at 11.45 tons, and the potential root harvest at 1.2 tons. For aboveground parts, these figures are estimated at 0.75 and 0.52 tons, respectively.

Key site No. 8 is located in the Bukhar-Zhyrau District of the Karaganda Region, in the floodplain of the Nura River near the village of Rostovka (N 50.07045; E 72.73544, elevation 385 m above sea level). The area is 6.1 ha, with a community of *Calamagrostis*, *Ferula*, and *Spiraea*. The dominant species is *Calamagrostis epigeios* (cop2); co-dominants are *F. songarica* and *Spiraea hypericifolia*—both with cop1. The total number of species in the community is 18–19. The herbaceous layer is three-tiered. The density of generative individuals is 0.71 ± 0.05 individuals/10 m², and the number of vegetative individuals is 9.4 ± 0.03 individuals/100 m². The average height of generative plants is 126.4 ± 9.4 cm. Root yield was 5,140 kg/ha, and above-ground yield was 270 kg/ha (Tab. 1, 2). The exploitable root stock is estimated at 31.35 tons, with a potential raw material harvest of 3.1 tons. For aboveground parts, these figures are estimated at 1.65 and 1.15 tons, respectively.

Analysis of the data revealed significant variability in the population parameters of *F. songarica* across different habitats. The highest density of reproductive individuals was observed in Plot 1, where it reached 6.05 individuals/10 m², while the lowest was recorded in Key site No. 3. The highest root yield indices were recorded for key site No. 1 — 7,010 kg/ha, and the lowest for plot No. 7 (3,580 kg/ha). However, the highest grass yield was recorded in key site No. 3 — 315 kg/ha — while the lowest was in site No. 7 — 234 kg/ha. Differences in the yield and growth density of *F. songarica* are likely related to soil and climatic conditions.

Conclusion

The study of natural populations of *F. songarica* in Central Kazakhstan within the Karaganda and Ulytau regions revealed their widespread distribution and the presence of stands suitable for harvesting raw materials, including both above-ground and underground parts.

Eight key sites were identified, with a total stand area of 281.5 ha. Root yields ranged from 3,688 to 7,010 kg/ha on an air-dry weight basis, while above-ground organ yields ranged from 234 to 315 kg/ha. The potential harvest volumes of roots and grass amounted to 183.8 and 55.43 tons, respectively.

The results obtained expand our understanding of the population structure and resource potential of *F. songarica*. The practical significance of the study lies in the possibility of using the obtained data to develop scientifically sound recommendations for the rational use of the species' natural resources and its conservation.

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Author Contributions

The manuscript was written through contributions of all authors. All authors have given approval to the final version of the manuscript. CRediT: **Mukhtubayeva S.K.** — research, field study, species identification; **Ramazanov A.K.** — raw material collection, draft writing; **Ageev D.V.** — data analysis; **Takirova M.B.** — data curation, data collection, draft writing; **Myrzagaliyeva A.B.** — statistical analysis.

Conflict of Interest

The authors declare no conflict of interest.

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Орталық Қазақстандағы *Ferula songarica* фитоценодикалық сипаттамасы мен ресурстары (Ұлытау және Қарағанды облыстары шегінде)

Дәрілік өсімдіктердің биологиялық ерекшеліктері мен ресурстық әлеуетін зерттеу қазіргі заманғы ботаника мен фармакогнозияның маңызды міндеті. Қазақстан флорасының перспективалы дәрілік түрлерінің бірі құрамында биологиялық белсенді қосылыстардың жоғары болуымен және бағалы фармакологиялық қасиеттерімен сипатталатын *Ferula songarica*. Осы зерттеудің мақсаты Орталық Қазақстанның табиғи жағдайларында *F. songarica* популяциясын және өсімдік шикізатының ресурстарын анықтау. Далалық зерттеулер 2024-2025 жылдары маршруттық-барлау әдісімен Ұлытау және Қарағанды облыстарының аумағында орналасқан сегіз негізгі учаскеде жүргізілді. Жұмыс барысында өсімдіктердің өсу тығыздығы, морфометриялық көрсеткіштері, өнімділігі, шикізаттың пайдалану қорлары және ықтимал жинау көлемі айқындалды. *F. songarica* қатысатын табиғи популяциялар дарактардың сирек кеңістікте орналасуымен сипатталатыны айқындалды. Генеративтік өсімдіктердің тығыздығы 0,36-дан 6,05 данадан /10 м², ал өсімдіктердің биіктігі 83,06-133,2 см құрайды, Тамыр өнімділігі ауа-құрғақ салмаққа есептегенде 3580-7010 кг/га, жерүсті органдары — 234-315 кг/га құрады. Шикізат дайындау үшін жарамды учаскелердің жиынтық ауданы 281,5 га болды. Түбірлердің пайдалану қоры 1874,85 тоннаға, шөптер 79,22 тоннаға бағаланды. Ықтимал тамыр жинау көлемі 183,8 тонна, жерүсті органдары — 55,43 тонна деңгейінде есептелген. Алынған нәтижелер дәрілік және парафармацевтикалық заттарды өндіру үшін табиғи жағдайларда *F. songarica* шикізатын жинау мүмкіндігін көрсетеді.

Кілт сөздер: *Ferula songarica*, популяциясы, өнімділігі, Орталық Қазақстан, пайдалану қоры, ықтимал жинау көлемі, тамыры, биомассасы, дәрілік өсімдік шикізаты.

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Фитоценодикалық характеристика и ресурсы *Ferula songarica* в Центральном Казахстане (в пределах Улытауской и Карагандинской областей)

Изучение биологических особенностей и ресурсного потенциала лекарственных растений является важной задачей современной ботаники и фармакогнозии. Одним из перспективных лекарственных видов флоры Казахстана является *Ferula songarica*, характеризующаяся высоким содержанием биологически активных соединений и ценными фармакологическими свойствами. Целью настоящего исследования являлось выявление популяций *F. songarica* в природных условиях Центрального Казахстана и оценка ресурсов растительного сырья. Полевые исследования проводились в 2024-2025 гг. маршрутно-рекогносцировочным методом на восьми ключевых участках, расположенных на территории Улытауской и Карагандинской областей. В ходе работы определялись плотность произрастания, морфометрические показатели растений, урожайность, эксплуатационные запасы сырья и объем возможного сбора. Установлено, что природные популяции с участием *F. songarica* характеризуются разреженным пространственным размещением особей. Плотность генеративных растений варьирует от 0,36 до 6,05 экз./10 м², а высота растений составляет 83,06–133,2 см. Урожайность корней в пересчете на воздушно-сухой вес составила 3580–7010 кг/га, надземных органов — 234–315 кг/га. Совокупная площадь участков, пригодных для заготовки сырья, составила 281,5 га. Эксплуатационный запас корней оценен в 1874,85 тонн, травы — 79,22 тонн. Объем возможного сбора корней рассчитан на уровне 183,8 тонн, надземных органов — 55,43 тонн. Полученные результаты показывают возможность сбора сырья *F. songarica* в природных условиях для производства лекарственных и парафармацевтических средств.

Ключевые слова: *Ferula songarica*, популяция, урожайность, Центральный Казахстан, эксплуатационный запас, объем возможного сбора, корни, надземная биомасса, лекарственное растительное сырье.

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