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**MINISTRY OF HIGHER EDUCATION, SCIENCE AND INNOVATION**

**GULISTAN STATE UNIVERSITY**

**DEPARTMENT OF MEDICINAL PLANTS AND BOTANY**




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# "Biology and Ecology of Medicinal Plants of the Desert and Tugai Zones"

**(Electronic resource)**

**For 3rd-year students of the programme 60811100 – Technology of Cultivation and Processing of Medicinal Plants**

**Gulistan – 2026**

**Abdukholikov F.B. “Biology and Ecology of Medicinal Plants of the Desert and Tugai Zones” (electronic resource). – Gulistan, 2026. – 18 p.**

This electronic resource describes the climatic and soil conditions, main families and representatives, life forms, ecological groups, phenology and adaptations of medicinal plants distributed in the desert and tugai (riparian forest) zones of Uzbekistan, as well as issues of their conservation, illustrated with tables, charts and diagrams.

The resource is intended as a supplementary teaching material for the course “Biology and Ecology of Medicinal Plants” taught to 3rd-year students of the programme 60811100 - Technology of Cultivation and Processing of Medicinal Plants. It covers the lecture topics “Medicinal plants of the desert zone” and “Medicinal plants of the tugai” of the course syllabus, together with the related practical classes.

The electronic resource has been recommended as a supplementary teaching material by the Department of Medicinal Plants and Botany of Gulistan State University (minutes No. 3, 29.10 2026).

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**Topic: Biology and Ecology of Medicinal Plants of the Desert and Tugai Zones**

**Outline:**

1. Climatic and soil conditions of the desert zone. Desert areas of Uzbekistan. Main families and representatives of desert medicinal plants.

2. Biology and ecology of desert medicinal plants. Adaptation of medicinal plants to desert conditions.

3. Tugai forests: concept, distribution, climate and soil conditions. Structure and ecological profile of tugai vegetation.

4. Biology and ecology of the main medicinal plants of tugai forests. Life forms, family composition and conservation of tugai medicinal plants.

**Key words and phrases:** desert, sandy desert, gypsum desert, takyr, solonchak (salt flat), barchan, shifting sands, xerophyte, halophyte, psammophyte, phreatophyte, ephemeral, ephemeroid, succulent, $C_4$ photosynthesis, alkaloid, gum resin, tugai, floodplain, intrazonal vegetation, alluvial soil, groundwater, flooding, phreatophyte, mesophyte, hygrophyte, helophyte, Euphrates poplar, Russian olive, saltcedar, sea buckthorn, reed bed, nature reserve, biosphere reserve.

***Question 1:***

The altitudinal classification proposed by Academician K.Z. Zakirov is widely used to study the vegetation of Uzbekistan. According to it, the territory of the republic is divided into the **desert (chul)**, **foothill (adyr)**, **mountain (tau)** and **high-mountain pasture (yaylau)** belts. The desert belt occupies plains up to about 500 m above sea level and is the largest belt by area [1, 3].

The main desert areas of Uzbekistan include the **Kyzylkum** desert in the west, the **Ustyurt** plateau, the Amu Darya delta and the Aral Sea coast (Aralkum), the **Mirzachul** (Hungry Steppe), **Karshi** and **Sherabad (Surkhan)** deserts. The relief includes sand ridges, **barchans** and shifting sands, residual mountains, takyrs and saline depressions.

The desert climate is sharply continental: summers are long, hot and dry, winters are relatively cold. Annual precipitation is 80–200 mm and falls mainly in winter and spring. In summer the air temperature rises to 40–45 °C, while the sand

surface heats up to 60–70 °C. Potential evaporation exceeds precipitation several tens of times. This pattern is clearly seen in the long-term data of the Nukus weather station (Figure 1): the mean July temperature is 28.9 °C and the mean maximum is 36.4 °C, while only 10 mm of precipitation falls in June–September combined.

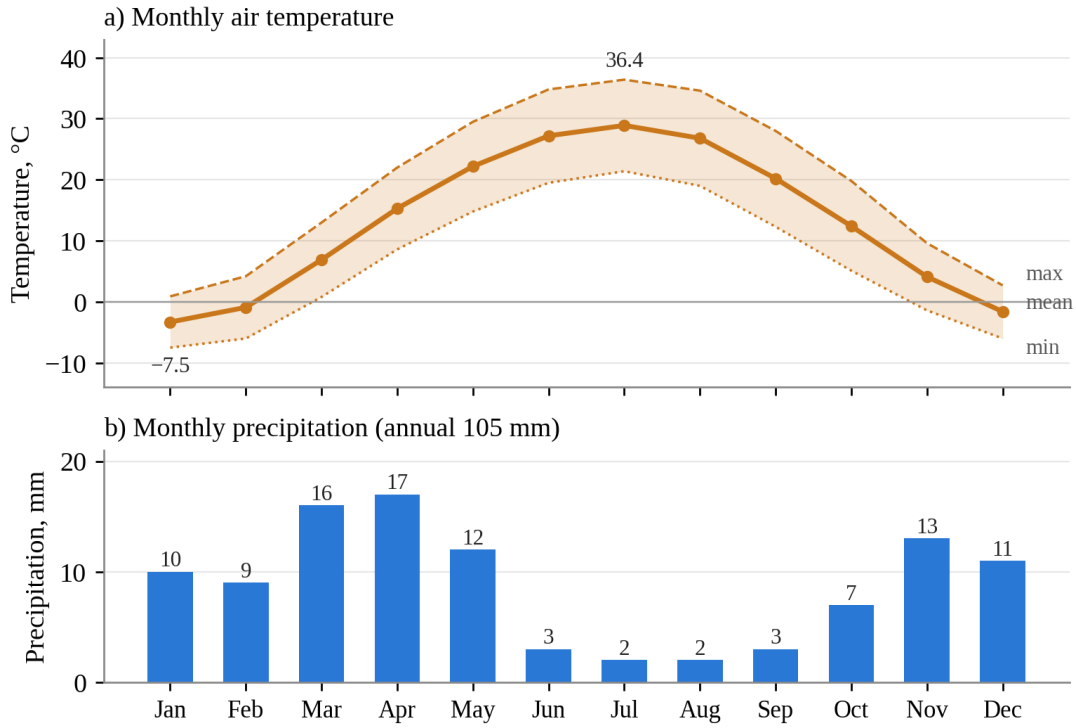



***Figure 1. Climate of Nukus (1991–2020 averages) [source: based on data from [17]]***

Depending on soil and substrate conditions, deserts are divided into several types. Each type has its own soils, water regime and vegetation (Table 1).

*Table 1*

**Main types of deserts in Uzbekistan and their characteristics**

| Desert type | Distribution | Soil conditions | Characteristic plants |
|---|---|---|---|
| Sandy deserts | Kyzylkum, Aralkum, Bukhara and Khorezm deserts | sandy and loamy sand, highly permeable, shifting sands present | white saxaul, calligonum, Richter's saltwort, *Stipagrostis pennata*, *Carex physodes* |
| Gypsum (stony) deserts | Ustyurt plateau, foothills of Kyzylkum residual mountains | grey-brown, gypsiferous, gravelly | *Salsola arbuscula*, *S. gemmascens*, *Anabasis salsa*, wormwoods |
| Clay deserts and takyrs | Karshi steppe, Mirzachul, lower Amu Darya | heavy-textured, takyr and takyr-like | *Carex pachystylis*, *Poa bulbosa*, wormwood, ephemerals |
| Saline deserts (solonchaks) | Mirzachul, Aral Sea coast, Kyzylkum depressions | solonchak, shallow groundwater, high salt content | *Halocnemum strobilaceum*, *Suaeda*, black saxaul, saltcedar |

***Source: compiled from [1, 3, 4].***

Although the desert flora is poorer in species than the mountain flora, it is rich in medicinal plants. According to field studies carried out by O.S. Abduraimov and co-authors in 2012–2022, **529 medicinal species** belonging to 70 families and 269 genera have been recorded in the arid regions of Uzbekistan [13]. The largest families are Amaranthaceae (73 species), Asteraceae (62) and Fabaceae (34); the 12 leading families account for 62.94% of all species (Figure 2).

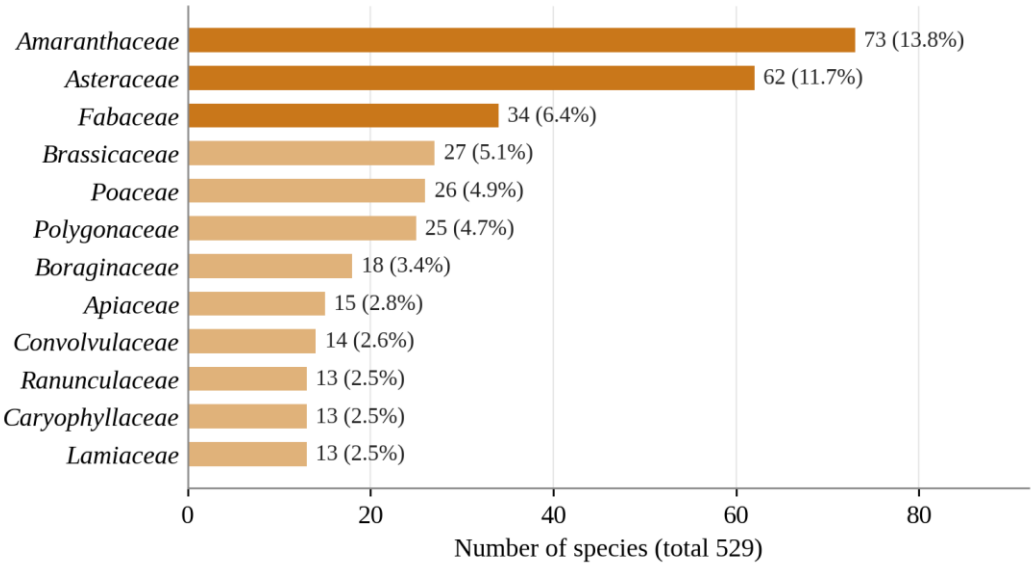



***Figure 2. Leading families of medicinal plants in the arid regions of Uzbekistan [source: based on data from [13]]***

Among the genera, *Artemisia* (16 species), *Tamarix* (9), *Anabasis*, *Astragalus*, *Atriplex* and *Calligonum* (8 each), *Ferula* and *Haplophyllum* (7 each) contain the most medicinal species [13]. The leading position of Amaranthaceae (the goosefoot family) reflects the halophytic and succulent character of the desert flora. The most important medicinal plants of the desert zone are described in Table 2.

*Table 2*

**Main medicinal plants of the desert zone**

| No | Species (Latin and common name) | Family | Life form; ecological group | Raw material | Main BAS | Uses |
|---|---|---|---|---|---|---|
| 1 | *Peganum harmala* L. Harmal (Syrian rue) | Nitrariaceae | perennial herb; xerophyte | aerial part, seeds | harmine, harmaline, peganine alkaloids | fumigant and antiseptic; peganine-based anticholinesterase drugs |
| 2 | *Capparis spinosa* L. Caper | Capparaceae | perennial herb; xerophyte | root bark, flower buds | rutin, glucocapparin, flavonoids | joint pain and rheumatism (folk medicine); spice |

| No | Species (Latin and common name) | Family | Life form; ecological group | Raw material | Main BAS | Uses |
|---|---|---|---|---|---|---|
| 3 | *Alhagi pseudalhagi* (M.Bieb.) Desv. Camelthorn | Fabaceae | perennial herb; phreatophyte | aerial part | flavonoids, tannins, vitamins | gastrointestinal disorders, haemorrhoids, wound healing |
| 4 | *Ferula foetida* (Bunge) Regel Asafoetida | Apiaceae | perennial herb; xerophyte | root (gum resin) | gum resin, sulphur compounds, ferulic acid | antispasmodic, spice; export raw material |
| 5 | *Anabasis aphylla* L. Leafless anabasis | Amaranthaceae | semi-shrub; halophyte | young shoots | anabasine alkaloid | anti-smoking preparations, insecticide |
| 6 | *Salsola richteri* (Moq.) Kar. ex Litv. Richter's saltwort | Amaranthaceae | shrub; psammophyte | young shoots | salsoline, salsolidine alkaloids | hypotensive (blood-pressure lowering) agent |
| 7 | *Rheum tataricum* L.f. Tatarian rhubarb | Polygonaceae | perennial herb; xerophyte | root | anthraglycosides, tannins | astringent in small doses, laxative in large doses |
| 8 | *Cistanche salsa* (C.A.Mey.) Beck Saline cistanche | Orobanchaceae | perennial herb; halophyte | fleshy stem | phenylethanoid glycosides (echinacoside, acteoside) | tonic, immunostimulant |
| 9 | *Artemisia diffusa* Krasch. ex Poljakov Spreading wormwood | Asteraceae | semi-shrub; xerophyte | aerial part | essential oil, sesquiterpene lactones | anthelmintic (folk medicine), fodder |
| 10 | *Calligonum aphyllum* (Pall.) Gürke Leafless calligonum | Polygonaceae | shrub; psammophyte | shoots, root | tannins, flavonoids | astringent; sand-fixing plant |

*Note: BAS – biologically active substances. Source: compiled from [1, 3, 6, 9, 13].*

**Harmal** (*Peganum harmala* L.) is a perennial herb 30–60 cm tall. The stem is erect and densely branched; the leaves are alternate and dissected into narrow lobes. The flowers are whitish-yellow and pentamerous; the fruit is a three-celled capsule. It is abundant on overgrazed pastures, roadsides and around settlements, and is therefore an indicator of pasture degradation. The seeds and aerial parts accumulate the alkaloids harmine, harmaline and peganine.

**Caper** (*Capparis spinosa* L.) is a perennial herb with prostrate stems 1–1.5 m long. The leaves are rounded-ovate, with hooked spines in their axils. The flowers are large, white or pale pink, with numerous stamens. The root penetrates several metres deep. The flower buds and fruits are pickled and used as a spice, and the root bark is used in folk medicine for joint pain.

**Camelthorn** (*Alhagi pseudalhagi* (M.Bieb.) Desv.) is a spiny perennial herb 40–100 cm tall. Its root system is very deep and reaches the groundwater, so the

plant stays green and flowers even in the hottest summer months. The flowers are reddish-pink; the fruit is a legume. It is a good honey plant, and its aerial part is used for gastrointestinal disorders.

**Asafoetida** (*Ferula foetida* (Bunge) Regel) is a monocarpic perennial herb: for several years it forms only basal leaves, then flowers once, sets seed and dies. The milky latex exuding from the cut thick root hardens in the air into a strong-smelling **gum resin**. This raw material is valued as an antispasmodic and a spice; improper harvesting leads to the decline of natural populations.

**Leafless anabasis** (*Anabasis aphylla* L.) is a semi-shrub 30–75 cm tall. Its leaves are almost undeveloped, and photosynthesis is performed by green jointed shoots. It grows on saline and clay soils. Its alkaloid **anabasine** is used to produce anti-smoking preparations and insecticides. **Richter's saltwort** (*Salsola richteri*) is a shrub of sandy deserts, important as a source of the alkaloids salsoline and salsolidine and as a sand-fixing plant.

***Question 2:***

The biology and ecology of desert medicinal plants depend primarily on **water shortage**, high temperature and soil salinity. By their relation to water and substrate they are divided into the following ecological groups:

1. **Xerophytes** – drought-tolerant plants (harmal, caper, asafoetida, wormwoods). They include sclerophytes (with hard, dry tissues) and succulents (with fleshy, water-storing tissues).

2. **Halophytes** – plants of saline soils (leafless anabasis, Halocnemum, *Suaeda*, saltcedar).

3. **Psammophytes** – plants adapted to sandy substrates (Richter's saltwort, calligonum, white saxaul, Stipagrostis).

4. **Phreatophytes** – plants whose roots reach the groundwater and are therefore constantly supplied with water (camelthorn, liquorice).

By life form, the desert is dominated by **shrubs** (saxaul, calligonum, Richter's saltwort), **semi-shrubs** (wormwoods, leafless anabasis, *Salsola arbuscula*), **perennial herbs** (harmal, caper, camelthorn, ferulas), **ephemerals** and

**ephemeroids**. Ephemerals (small annual herbs growing together with bulbous bluegrass) complete their whole life cycle within 1.5–2 months of the moist spring season. Ephemeroids (Carex pachystylis, Tatarian rhubarb, tulips) are perennials that survive the summer as underground organs – bulbs, tubers or thickened roots.

The phenological rhythms of desert plants also differ. Ephemeroids grow in March–May and flower in April, while xerophytic and phreatophytic perennial herbs and halophytic semi-shrubs grow from April to October and flower in summer or late summer (Figure 3).

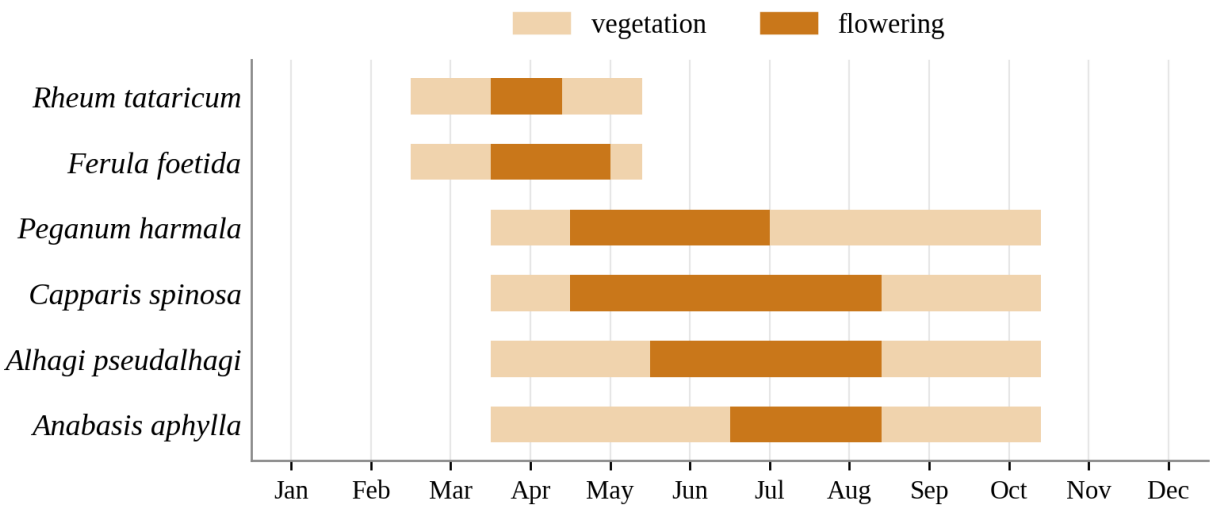



***Figure 3. Phenological spectrum of desert medicinal plants (generalised scheme) [source: compiled from [3, 6, 9]]***

Phenological knowledge is essential for timing the harvest of raw materials. For example, the roots of Tatarian rhubarb are collected after the aerial part has dried (late May – June), whereas the aerial part of camelthorn is harvested at flowering. The gum resin of monocarpic ferulas is tapped in the year before flowering, when the plant has accumulated the greatest reserves.

Over a long evolutionary history, desert plants have developed various **adaptations** to water shortage, heat and salinity. They can be grouped into four categories (Figure 4).

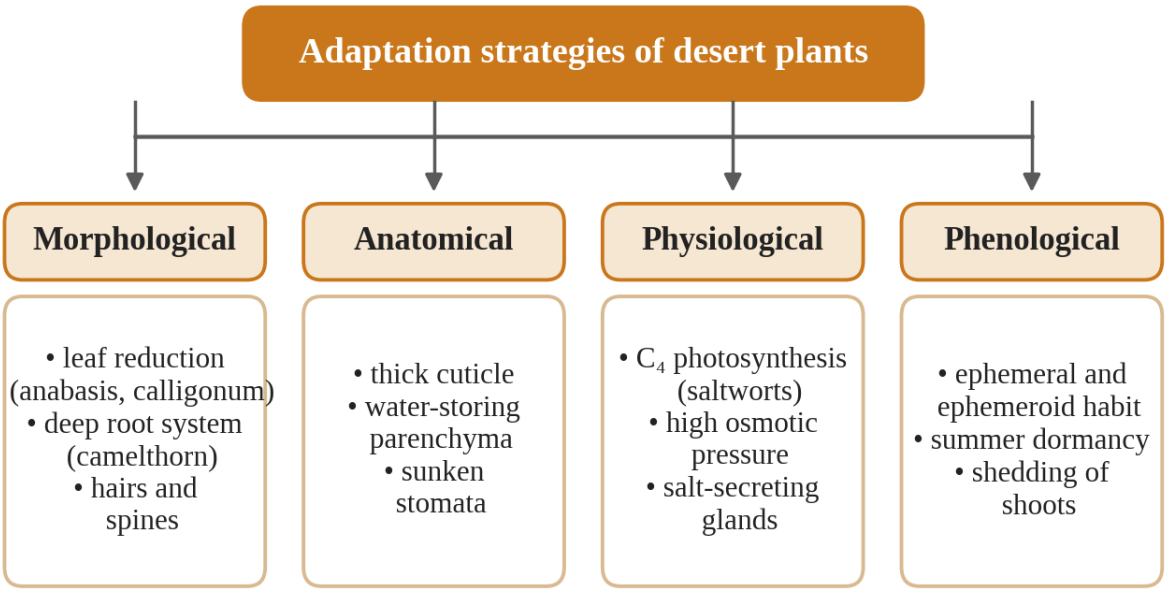



***Figure 4. Adaptation strategies of desert plants [source: compiled by the author from [1, 3, 4]]***

1. **Morphological adaptations.** Reduction or complete loss of leaves (leafless anabasis, calligonum, saxaul) with photosynthesis taken over by green shoots; a powerful and deep root system (camelthorn roots reach the groundwater); dense hairs on leaves and stems; formation of spines.

2. **Anatomical adaptations.** A thick cuticle and wax layer on the epidermis, stomata sunken in pits, water-storing parenchyma (in succulent goosefoots) and well-developed mechanical tissue.

3. **Physiological adaptations.** $C_4$ photosynthesis in many goosefoots (water-efficient carbon fixation), high osmotic pressure of cell sap, excretion of salts through special glands (saltcedar) or their accumulation in vacuoles (Halocnemum).

4. **Phenological adaptations.** Ephemeral and ephemeroid habits – timing the life cycle to the moist spring; summer dormancy; shedding of part of the leaves and shoots during drought.

These adaptations also affect the quality of medicinal raw materials. Drought, intense solar radiation and salinity stress enhance the synthesis of secondary metabolites – alkaloids, phenolic compounds, essential oils and resins – in many species. This is why desert plants such as harmal, leafless anabasis, Richter's

saltwort and asafoetida are valuable sources of alkaloids and resins for the pharmaceutical industry [9, 13].

At the same time, desert ecosystems are very fragile. Overgrazing, felling of saxaul stands and uncontrolled harvesting of roots and resin reduce the stocks of medicinal plants. Therefore, part of each population should be left for regeneration during harvesting, and root raw material should be collected from the same site only at intervals of several years [1, 5].

***Question 3:***

**Tugai** is a plant community of trees, shrubs and herbs that develops on the floodplains of rivers in the desert and semi-desert zones, where the groundwater lies close to the surface and the land is periodically flooded. Because tugai forests exist thanks to river water rather than the surrounding desert climate, they are regarded as **intrazonal** vegetation.

The main tugai forests of Uzbekistan are located along the **Amu Darya**, **Syr Darya**, **Zarafshan**, **Chirchiq**, Kashkadarya and Surkhandarya rivers. The largest tugai massifs survive in the lower reaches and delta of the Amu Darya. In Syrdarya region, tugai forests occur as a narrow strip along the Syr Darya floodplain.

The climate of the tugai hardly differs from that of the surrounding desert: summers are hot and dry and annual precipitation is low. However, plants obtain moisture not from precipitation but from **groundwater** and river **floods**. The discharge of the Amu Darya peaks in summer (June–July) due to glacier melt. Soils are alluvial-meadow and tugai-meadow soils, and salinity increases with distance from the river.

In the second half of the 20th century, increasing water withdrawal for irrigation, river flow regulation and the Aral Sea crisis sharply reduced the area of tugai forests. Today, protected areas play an important role in conserving the remaining tugai (Table 3).

*Table 3*

**Selected protected areas conserving tugai ecosystems in Uzbekistan**

| Name | Location | Year established | Area, ha |
|---|---|---|---|
| Lower Amu Darya State Biosphere Reserve | Karakalpakstan, Amu Darya delta | 2011 (Badai-Tugai Reserve since 1971) | 68,717.8 |
| Kyzylkum Nature Reserve | banks of the middle Amu Darya | 1971 | 3,985 |
| Aral-Paygambar Nature Reserve | Surkhandarya region, Amu Darya | 1971 | 3,043 |
| Zarafshan Nature Reserve | Samarkand region, right bank of the Zarafshan River (46 km) | 1975 | 2,518 |

*Source: based on uzbekistan.travel and turkestantravel.com [15, 16]. Note: area figures may differ slightly between sources.*

Tugai vegetation consists of belts that replace one another from the river channel towards the desert in accordance with changes in **groundwater depth** and soil salinity. This sequence is called the **ecological profile** of the tugai (Figure 5).

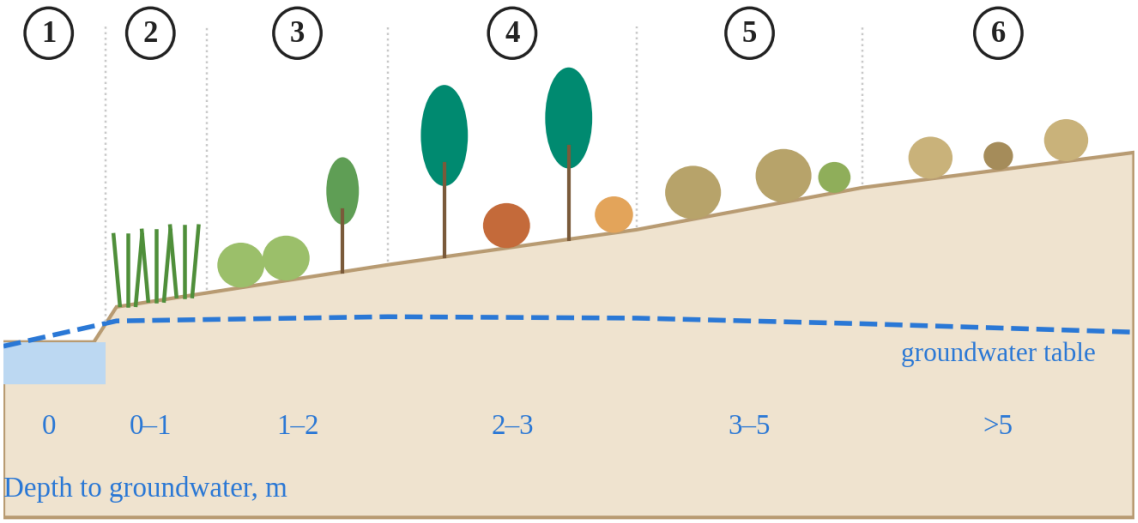



***Figure 5. Schematic ecological profile of a tugai ecosystem: 1 – river channel; 2 – bank reed belt (reed, cattail); 3 – young tugai (saltcedar, young poplar); 4 – mature tugai (Euphrates poplar, Russian olive, dogbane, liquorice); 5 – degrading tugai (saltcedar, camelthorn, liquorice); 6 – desert (saxaul, saltwort, calligonum) [source: compiled by the author from [3, 4]]***

1. **Bank reed belt** – permanently supplied with water, groundwater at 0–1 m. Hygrophytes and helophytes – common reed, cattail and sedges – dominate.

2. **Young tugai** – on fresh sand and silt deposits (groundwater at 1–2 m), young saltcedar, willow and Euphrates poplar grow.

3. **Mature tugai** – groundwater at 2–3 m; Euphrates poplar and Russian olive trees, sea buckthorn and salt tree shrubs, with dogbane, liquorice, Bermuda grass,

horse mint and madder in the lower layer. The diversity of medicinal plants is highest here.

4. **Degrading tugai** – groundwater drops to 3–5 m and the soil becomes saline; trees thin out, and saltcedar, camelthorn and liquorice increase.

5. **Desert** – groundwater deeper than 5 m; tugai is replaced by desert plants – saxaul, saltwort, calligonum.

The profile shows that most tugai plants are groundwater-dependent **phreatophytes** and **mesophytes**. A fall in the groundwater table therefore turns the tugai into desert.

***Question 4:***

Many medicinal plants in the form of trees, shrubs and herbs occur in tugai forests. The main ones are listed in Table 4.

*Table 4*

**Main medicinal plants of tugai forests**

| No | Species (Latin and common name) | Family | Life form; ecological group | Raw material | Main BAS | Uses |
|---|---|---|---|---|---|---|
| 1 | *Populus euphratica* Olivier Euphrates poplar | Salicaceae | tree; phreatophyte | buds, bark | phenolic glycosides (salicin), flavonoids, resin | anti-inflammatory, antipyretic |
| 2 | *Elaeagnus angustifolia* L. Russian olive | Elaeagnaceae | tree; phreatophyte | fruit, flowers | tannins, sugars, flavonoids | antidiarrhoeal, astringent; honey plant |
| 3 | *Tamarix ramosissima* Ledeb. Saltcedar | Tamaricaceae | shrub; halophyte | shoots, leaves | tannins, flavonoids | astringent, wound healing |
| 4 | *Hippophae rhamnoides* L. Sea buckthorn | Elaeagnaceae | shrub; mesophyte | fruit | carotenoids, tocopherols, ascorbic acid, oil | burns, wounds, gastric ulcer (sea-buckthorn oil) |
| 5 | *Glycyrrhiza glabra* L. Liquorice | Fabaceae | perennial herb; mesophyte | root, rhizome | glycyrrhizic acid, flavonoids | expectorant, anti-inflammatory |
| 6 | *Apocynum lancifolium* Russanov Dogbane | Apocynaceae | perennial herb; mesophyte | leaves | cardiac glycosides (cymarin) | cardiotonic; technical fibre |
| 7 | *Phragmites australis* (Cav.) Trin. ex Steud. Common reed | Poaceae | perennial herb; hygrophyte | rhizome | polysaccharides, ascorbic acid | diuretic, antipyretic |
| 8 | *Typha angustifolia* L. Narrow-leaved cattail | Typhaceae | perennial herb; hygrophyte | pollen, rhizome | flavonoids, starch | pollen is haemostatic |

| No | Species (Latin and common name) | Family | Life form; ecological group | Raw material | Main BAS | Uses |
|---|---|---|---|---|---|---|
| 9 | *Mentha longifolia* (L.) L. Horse mint | Lamiaceae | perennial herb; mesophyte | aerial part | essential oil (pulegone, piperitone) | digestive, antispasmodic |
| 10 | *Cynodon dactylon* (L.) Pers. Bermuda grass | Poaceae | perennial herb; mesophyte | rhizome | flavonoids, saponins | diuretic |
| 11 | *Urtica dioica* L. Stinging nettle | Urticaceae | perennial herb; mesophyte | leaves | vitamin K, chlorophyll, flavonoids | haemostatic, vitamin source |
| 12 | *Rubia tinctorum* L. Madder | Rubiaceae | perennial herb; mesophyte | root | anthraglycosides (ruberythric acid) | aids dissolution of kidney stones; dye |

***Source: compiled from [1, 3, 6, 9, 14].***

**Euphrates poplar** (*Populus euphratica* Olivier) is the main tree of the tugai, reaching 10–15 m. Its distinctive feature is **heterophylly**: leaves on young shoots and root suckers are narrow and willow-like, while on mature trees they are rhombic or kidney-shaped and toothed. It is dioecious; its hairy seeds are dispersed by wind and water, and it reproduces vegetatively by root suckers. It is a salt-tolerant phreatophyte; its buds and bark are used in folk medicine as an anti-inflammatory remedy.

**Russian olive** (*Elaeagnus angustifolia* L.) is a tree or large shrub 3–7 m tall. Its shoots and leaves are covered with silvery stellate hairs, and the branches bear spines. The flowers are small, yellow and very fragrant, making it a good honey plant. Its roots form a symbiosis with nitrogen-fixing actinomycetes, so it grows even on poor soils. The mealy-sweet drupe-like fruit is used as an astringent.

**Sea buckthorn** (*Hippophae rhamnoides* L.) is a spiny dioecious shrub 1–4 m tall, found mainly on the floodplains of mountain and foothill rivers. Its leaves are narrow and silvery beneath. The orange fruits are densely crowded on the branches and are rich in carotenoids, tocopherols and ascorbic acid. **Sea-buckthorn oil** obtained from the fruit is used to treat burns, wounds and gastric ulcers.

**Liquorice** (*Glycyrrhiza glabra* L.) is a perennial herb 0.5–1.5 m tall. Its roots and rhizomes are strongly developed and penetrate several metres deep. The leaves are odd-pinnate, the violet flowers are collected in racemes, and the fruit is a legume. The root contains **glycyrrhizic acid** and flavonoids and is used to produce

expectorant and anti-inflammatory preparations. It is also valued as a plant that improves saline soils [14].

**Dogbane** (*Apocynum lancifolium* Russanov) is a perennial herb with milky latex. Its leaves are opposite, and the small pink flowers are bell-shaped. The leaves contain cardiac glycosides (cymarin) with a cardiotonic effect, and the stems yield a strong technical fibre. **Saltcedar** (*Tamarix ramosissima*) is a shrub with small scale-like leaves bearing salt-secreting glands, while **common reed** (*Phragmites australis*) and **cattail** (*Typha angustifolia*) are long-rhizome helophytes that form the bank belt.

The 12 tugai medicinal species in Table 4 belong to 10 families: Elaeagnaceae and Poaceae have 2 species each, and the other families (Salicaceae, Tamaricaceae, Fabaceae, Apocynaceae, Typhaceae, Lamiaceae, Urticaceae, Rubiaceae) are represented by one species each. By life form, there are 2 trees, 2 shrubs and 8 perennial herbs. Ecologically, mesophytes predominate (7 species), with 2 phreatophytes, 2 hygrophytes and 1 halophyte. Among desert medicinal plants, by contrast, xerophytes predominate and trees are absent (Figure 6).

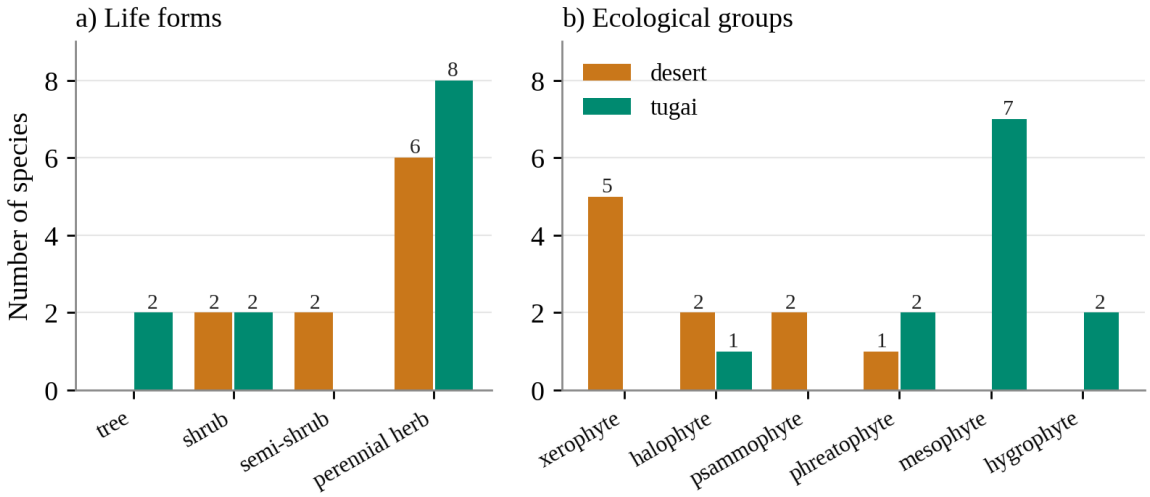



***Figure 6. Comparative distribution of desert (n = 10) and tugai (n = 12) medicinal plants by life form (a) and ecological group (b) [source: based on Tables 2 and 4]***

The 22 medicinal species of both zones provide 27 raw-material records in total. Aerial parts and roots (rhizomes) are used equally often – 33.3% each; fruits and seeds, and flowers and pollen account for 11.1% each, leaves for 7.4%, and bark

and buds for 3.7% (Figure 7). The high share of root raw materials shows that harvesting norms must be strictly followed to preserve populations.

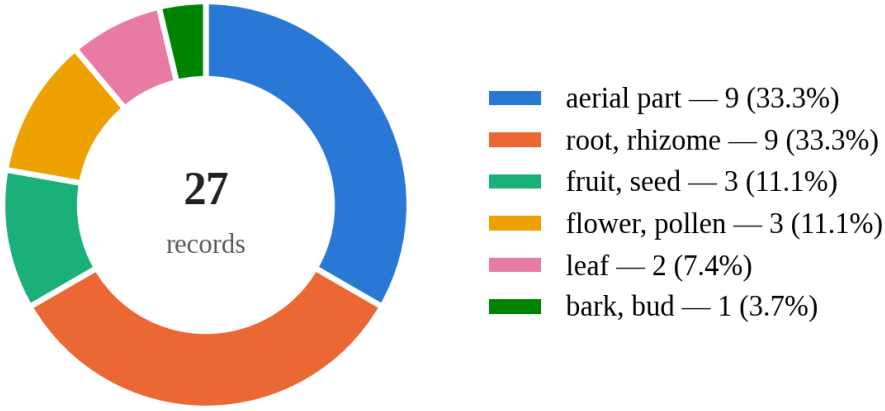



***Figure 7. Share of plant parts used as raw material in desert and tugai medicinal plants [source: based on Tables 2 and 4]***

The main bioecological differences between desert and tugai medicinal plants are summarised in Table 5.

*Table 5*

**Comparative bioecological characteristics of desert and tugai medicinal plants**

| Parameter | Desert zone | Tugai zone |
|---|---|---|
| Source of moisture | precipitation (80–200 mm), mainly in winter and spring | groundwater (0–3 m) and river floods |
| Soils | sandy, gypsiferous, takyr, solonchak | alluvial-meadow, tugai-meadow, partly saline |
| Dominant life forms | shrubs, semi-shrubs, ephemerals and ephemeroids | trees, shrubs, rhizomatous perennial herbs |
| Dominant ecological groups | xerophytes, halophytes, psammophytes | mesophytes, phreatophytes, hygrophytes |
| Key adaptations | leaf reduction, deep roots, $C_4$ photosynthesis, ephemeral habit | heterophylly, root suckers, hairy seeds, salt glands |
| Important BAS | alkaloids, gum resins, essential oils | glycosides, flavonoids, carotenoids, tannins |
| Main threats | overgrazing, uncontrolled harvesting of roots and resin | falling groundwater table, felling, fires |

*Source: compiled by the author from [1, 3, 4, 13].*

Conserving tugai medicinal plants requires ensuring ecological river flows, limiting felling and grazing in tugai forests, expanding the network of protected areas, and cultivating valuable species such as liquorice, sea buckthorn and Russian olive on plantations. These tasks should be implemented in line with the Red Data

Book of the Republic of Uzbekistan and the national biodiversity conservation strategy [12].

**Independent study assignments.**

1. Compile a list of 10 medicinal plant species occurring in desert or desert-like areas near your home and classify them into ecological groups (xerophyte, halophyte, psammophyte, phreatophyte).

2. Using data from a nearby weather station, draw a climate chart similar to Figure 1 and compare it with Nukus.

3. Choose harmal, caper or camelthorn and write an essay on its morphology, BAS composition and harvesting rules.

4. Compile a list of tugai medicinal plants found on the floodplain of the Syr Darya or another river near you and place them in the profile belts shown in Figure 5.

5. Prepare a presentation on the biology, ecology and harvesting rules of Euphrates poplar, Russian olive, sea buckthorn or liquorice.

6. Add two more parameters (e.g. reproduction methods, phenology) to Table 5 and compare desert and tugai plants.

**Review questions.**

1. What altitude range does the desert belt occupy according to K.Z. Zakirov’s classification?

2. Which desert areas of Uzbekistan do you know?

3. How do sandy, gypsum, clay and saline deserts differ from each other?

4. Which families dominate the medicinal flora of arid regions?

5. What is the difference between ephemerals and ephemeroids?

6. Give examples of morphological, anatomical, physiological and phenological adaptations of desert plants.

7. What plant community is called tugai, and why is it considered intrazonal?

8. Along which rivers of Uzbekistan are tugai forests distributed?

9. How do the belts of the tugai ecological profile change with groundwater depth?

10. What is the heterophylly of Euphrates poplar?

11. Explain the medicinal importance of sea buckthorn and Russian olive.

12. What are the main directions for conserving tugai medicinal plants?

## References


1. Karshibayev X.K., Makhkamov T.X. Biology and Ecology of Medicinal Plants (Dorivor o‘simliklar biologiyasi va ekologiyasi). – Gulistan: Ziyo Nashr-matbaa, 2022. – 244 p. (in Uzbek)

2. Isagaliyev M., Meliboyev S., Isomiddinov S., Obidov M. Biology and Ecology of Medicinal Plants. – Fergana, 2021. – 167 p. (in Uzbek)

3. Qaysarov V.T. Biology and Ecology of Medicinal Plants. – Tashkent: Fan ziyosi, 2023. – 220 p. (in Uzbek)

4. Rakhimova T.U., Allaberdiyev R.X., Atanbayeva N.K., Kuchkarov N.K. Bioecology (Plant Ecology). – Tashkent: Innovatsiya-Ziyo, 2020. (in Uzbek)

5. Karshibayev X.K., Jumanov J.A. Practical Classes in Biology and Ecology of Medicinal Plants. – Tashkent: Metodist, 2025. – 184 p. (in Uzbek)

6. Jurayeva M.A. Atlas of Medicinal Plants. Textbook. – Tashkent: Noshir, 2019. – 264 p. (in Uzbek)

7. Karshibayev X.K. Reproductive Biology and Life Strategy of Plants. – Tashkent: Metodist, 2023. – 180 p. (in Uzbek)

8. Berdiev E.T., Khakimova M.Kh., Makhmudova G.B. Forest Medicinal Plants. Textbook. – Tashkent, 2016. – 252 p. (in Uzbek)

9. Khojimatov O.K., Haydarov X.Q., Khamraeva D.T., Imomova D.A., Khujanov A.N. Atlas of Medicinal Plants of Uzbekistan. – Samarkand, 2021. – 224 p. (in Uzbek)

10. Karshibayev X.K., Abduraimov A.S. Structural Botany. Textbook. – Tashkent: Metodist, 2024. – 156 p. (in Uzbek)

11. Karshibayev J.Kh. Biology and Ecology of Medicinal Plants (Astragali). – Gulistan, 2019. – 96 p. (in Uzbek)

12. Red Data Book of the Republic of Uzbekistan. Vol. 1. Plants. – Tashkent: Chinor ENK, 2019. – 356 p.

13. Abduraimov O.S., Li W., Shomurodov H.F., Feng Y. The main medicinal plants in arid regions of Uzbekistan and their traditional use in folk medicine // Plants. – 2023. – Vol. 12, No. 16. – Art. 2950.

14. Kushiev H., Noble A.D., Abdullaev I., Toshbekov U. Remediation of abandoned saline soils using Glycyrrhiza glabra: a study from the Hungry Steppes of Central Asia // International Journal of Agricultural Sustainability. – 2005. – Vol. 3, No. 2. – P. 102–113.

15. Amudarya State Biosphere Reserve // https://uzbekistan.travel/en/o/amudarya-state-biosphere-reserve/

16. Nature reserves and national parks in Uzbekistan // https://www.turkestantravel.com/en/useful/nature-reserves-and-national-parks-in-uzbekistan/

17. Nukus climate // https://www.climatestotravel.com/climate/uzbekistan/nukus