



Some aspects of morphobiology, conservation of resource potential, crop cultivation and harvesting of raw materials of promising *Ferula* species

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Abstract

Background: The purpose of this work was to increase scientific information against the background of increasing anthropogenic pressure on nature, which causes irreparable damage to the flora, especially the most sought-after raw materials (especially resins). An improvement of the situation would require cultivating wild species and establishing new plantations that combine the most effective method of cultivating and producing raw material (resins) from *Ferula tadshikorum* Pimenov and *Ferula foetida* (Bunge) Regel, in Uzbekistan.

Methods: In the present note we reviewed the existing literature for Uzbekistan and the surrounding areas to compile guidelines for the production of *Ferula*.

Results: In total, 5 different fractions of *Ferula* resin can be obtained, differing from each other in quality and organoleptic properties, which affects the grade and cost of the final product. The raw materials of both species of *Ferula* are marketed under the common commercial name "assafetida resin. After the collection of raw materials, the roots are again covered with soil. However, according to our observations, after such a long harvest and many cuts applied, the restoration of plants does not occur, the plants die. Therefore, we recommend stop collecting after receiving the Khalva-donak fraction, because this will result in better and more expensive raw materials for the market, and at the same time, will help to preserve and restore plants for subsequent years of harvesting.

Conclusion: When harvesting raw materials from underground parts of two species of *Ferula*, it is of paramount importance to leave a mandatory 20-25% of plants intact to produce seed material. Being monocarpics, both species produce seeds only once during their ontogenesis. The obtained seed material helps to maintain the population and will also serve for further expansion of plantations.

Keywords: *Ferula tadshikorum*, *Ferula foetida*, medicinal plant, resin, yield, plantations, Uzbekistan.

Background

Modern approaches to environmental protection should be based on the rational use of natural resources. An analysis of the dynamics of anthropogenic effects on the natural environment shows that the "prohibitive" approach is both ineffective and inhumane and cannot solve current and everyday environmental problems. The relationship between human activities and conservation policies should be built on the results of systematic scientific research on the state of biodiversity. Biological resources, including plants, and medicinal plants in particular, are an essential part of Uzbekistan's natural wealth. To determine the current conservation status of species, and to improve their protection and sustainable use, it is necessary to obtain comprehensive information on species distribution, number of individuals, and the impact of negative factors on their populations. In such programs, the use of standardized research methods is very relevant, to not only capture changes in population dynamics, but also to identify the causes and predict the direction and nature of their further transformation. In addition, this approach assesses the general state of the biota, and the natural state of the populations of medicinal plants, including aspects of seasonal nature, representative species composition and those changes that are directly related to anthropogenic effects on the state of populations.

Plant resources are an indispensable source of secondary metabolites which are responsible for possible curative and preventive properties. Useful substances are e.g., resins - a mixture of various high-molecular compounds formed in plants. Despite the long use of resinous species of the genus *Ferula* Tour. ex L., little is known about their conservation status, especially given that natural populations alone cannot guarantee the supply of sufficient raw materials. On the territory of the Republic of Uzbekistan grow about 60 species of the genus *Ferula*, many of which have medicinal properties, and are also a source of valuable plant raw materials for the pharmaceutical industry both in our country, and abroad (Flora Uzbekistana 1959). The economic value of these species is reflected in a wide range of uses, including medicinal, food and fodder. In connection with the above, the study of medicinal plants of the local flora and their further sustainable use, including the conservation of natural populations is the most pressing requirement today. The purpose of this work was to increase the scientific information against the background of increasing anthropogenic pressure on nature, which causes irreparable damage to the flora, especially the most sought-after raw materials (especially resins). An improvement of the situation would require cultivating natural species and establishing new plantations that combine the most effective method of cultivating and producing raw materials (resins) from *Ferula tadshikorum* Pimenov and *Ferula foetida* (Bunge) Regel, in Uzbekistan.

In history, in his medical practice, Abu Ali ibn Sina used *Ferula* to treat skin diseases (vitiligo), tuberculosis, joint pains, against parasites, inflammation of the stomach, intestines and as a means of cleansing the body from salts and food residues harmful to the body (Abu Ali ibn Sina 1954).

The use of *F. tadshikorum* in folk medicine has also a centuries-old history. Since ancient times, the species has been used as an analgesic agent for arthritis and joint pain. Pharmacological studies have shown that the plant exhibits expectorant and anticonvulsant properties in exudative diathesis, pulmonary tuberculosis, otitis, lymphadenitis. Some studies have shown an effective effect of the plant in malignant tumors and syphilis, for which the leaves of the plant are mixed with acidic milk (<https://planta-medica.uz/ferula-tadshikorum-pimenov-ferula-tadzhikov/>).

The communities of Central Asia use the resin of both species of *Ferula* as a remedy for nervous and viral diseases of the sexual system. The resin is also used as a galenic drug to alleviate symptoms such as flatulence and gut lethargy, and the species is used for the same purpose in homeopathy. In folk medicine in many countries of the east (e.g., India, Pakistan, Iran, and Afghanistan), *Ferula* gum-resins are used in food, to strengthen the body, get rid of pain, with ulcers of the stomach and intestine. Young leaves and generative organs also serve as medicinal raw materials (<https://planta-medica.uz/ferula-foetida-bunge-regel-ferula-vonyuchaya>).

In veterinary practice, a porridge obtained from roots, prepared with boiling water, is used as a wound healing agent in skin diseases of domestic animals. The population also eats young stems in spring in the form of salads and as a filling of green dolma. Leaves in dry form are used to feed cattle (<https://planta-medica.uz/ferula-tadshikorum-pimenov-ferula-tadzhikov/>).

In recent decades, the collection of resin of wild *Ferula* species growing in the southern regions of the Republic of Uzbekistan, in particular the Kashkadarya and Surkhandarya regions, has been especially popular, and become an entrepreneurial activity. *Ferula tadshikorum* has been the most exploited species leading to its inclusion in the 5th

edition of the Red Book of the Republic of Uzbekistan, with the status 3 (2Krasnayua kniga Respubliki Uzbekistan. 2019).

Because the natural reserves of both species are practically exhausted, resource specialists of the Institute of Botany of the Academy of Sciences of the Republic of Uzbekistan, and by entrepreneurs already suggested in 2015-2016 that plantations should be established within the ranges of their distribution. Following this advice, industrial plantations of *Ferula tadshikorum* were created in the Kashkadarya and Surkhandarya regions, and plantations of *Ferula foetida* - in the desert zone of Jizzakh and Navoi regions of Uzbekistan.

Ferula foetida - in the desert zone of Jizzakh and Navoi regions of Uzbekistan.

Material and Methods

In the present note we reviewed the existing literature for Uzbekistan and the surrounding areas to compile guidelines for the production of *Ferula* (Flora Uzbekistana 1959; 2017 Khalkuzieva & Rakhmonkulov 2020; Khalkuzieva & Rakhmonkulov (2020Khojimatov & Khamraeva 2018; Khojimatov *et al.* 2019; Khamraeva *et al.* 2019, 2021; Khalkuzieva & Rakhmonkulov 2020; Rakhmonov 2017). Because the natural reserves of both species are practically exhausted, resource specialists of the Institute of Botany of the Academy of Sciences of the Republic of Uzbekistan, and by entrepreneurs already suggested in 2015-2016 that plantations should be established within the ranges of their distribution. Following this advice, industrial plantations of *Ferula tadshikorum* were created in the Kashkadarya and Surkhandarya regions, and plantations of *Ferula foetida* - in the desert zone of Jizzakh and Navoi regions of Uzbekistan.

Results

***Ferula tadshikorum* Pimentov** (Figure 1).

Habitat and distribution. Abu Ali ibn Sina (1954) *Ferula tadshikorum* grows on mountain pastures and open slopes. Although this species is not included in the 6-volume fundamental work of Flora of Uzbekistan, the plant grows in the territories of the Kashkadarya and Surkhandarya regions of Uzbekistan.



Figure 1. Habitat and vegetative parts of *Ferula tadshikorum*

Harvest and quality of *Ferula tadshikorum* seeds.

To obtain full or completed seeds, it is recommended to collect complete umbels from the central umbel and side axes of the first order. In addition, in a small amount, it is possible to collect high-quality seeds from the side axes of the second order. After collecting the seed material, it is necessary to sort the seeds, separating damaged ones and. Seeds are 1.9-2.7 cm long and 0.9-1.2 cm wide.

When describing *Ferula tadshikorum* as a new species and identifying features that distinguish it from *Ferula foetidissima* Regel et Schmalh. and *F. conocaula* Korovin, M.G. Pimenov used the structure of their mericarps (Khojimatov & Khamraeva 2018; Khojimatov *et al.* 2019).) We also further investigated the structure of the pericarp of the fetus and identified several species-specific features that will serve to accurately determine the species affiliation (Khojimatov & Khamraeva 2018; Khojimatov *et al.* 2019).

Sowing technology of *Ferula tadshikorum*

To create large-scale plantations, based on the experience of growing the species in the Tashkent Botanical Garden (Khamraeva *et al.* 2019, 2021), we recommend using standard agricultural care - two-fold watering and weeding in

the first growing season, and then, if possible, once in the second and third growing years. Special agricultural measures, for example the use of mineral fertilizers should be avoided, but it is desirable to use agricultural equipment for plowing the soil, improving aeration as shown by Khalkuzieva & Rakhmonkulov (2020) in the plantations created in the Arnasai district of the Jizzak region. It should also be borne in mind that the admission of farm animals and the use of these lands for pasture at certain times are not desirable. It is desirable to sow plant material in areas of natural phytocenoses of *Ferula tadshikorum* or in places with similar ecological-cenotic factors, such as soil cover, height above sea level, exposition, etc.

The sowing of seeds in natural phytocenoses of *F. tadshikorum* should be carried out in the autumn-winter period, from early November to the first decade of December (Figure 3), because spring comes much earlier in these southern regions of the Republic. This is necessary so that the seeds can undergo natural stratification which needs 80-90 days. *F. tadshikorum* seeds are covered with a thin pericarp, which during autumn-winter precipitation is impregnated with moisture which induces the processes that precede germination. According to our data, under Tashkent conditions, once air temperature reached + 5 °C, the seedlings, depending on the timing of sowing, begin to appear at the end of the first decade of February or at the end of February and the beginning of March (Khamraeva et al. 2019). According to Rakhmonov (2017), the optimal rate of sowing per hectare is 5-6 kg/ha of seeds (with a norm of 16-17 per 1m²) or according to Khalkuzieva & Rakhmonkulov (2020) 8-10 kg/ha.



Figure 2. Sowing of *Ferula tadshikorum* in rocky and crushed soils (Surkhandarya region, 2017)

According to the literature (Rakhmonov 2017), survival is stabilized because in these areas the root system, even on rocky slopes, penetrates quite deeply, which provides favorable environmental conditions for plant conservation on the plantations created for the third-fourth growing season. According to the results of our observations in the plantations created by farmers in the Kashkadarya and Surkhandarya regions plants of 5-6 years of vegetation have a strong root system, which favorably contributes to the further stable preservation of individuals in the cultivated areas. Therefore, to preserve and restore populations in the territory of southern Uzbekistan to allow the sustainable use of *F. tadshikorum*, it is recommended to use the following options for sowing seeds in conditions of natural growth with different ecological characteristics:

- 1 - with seeding in the soil to a depth of 2-3 cm in areas with different grass cover.
- 2 - with seeding in the soil to a depth of 1.0-2 cm on eroded crushed and rocky slopes.

To date, the area of plantations of both species in Uzbekistan, can be estimated at about 4000 ha.

***Ferula foetida* St. Lag.** (Figure 3).

Habitats and distribution. *Ferula foetida* grows in sandy deserts, adyr and foothill plains, in the Jizzak, Navoi and Bukhara regions and the Republic of Karakalpakstan (Flora Uzbekistana 1959).

F. foetida has extensive drug potential and nutritional use. Being a perennial monocarp (can reach the age of up to 26 years), the plant is able to produce resin only after reaching the virginal age state, i.e. from 7-9 years old, when roots become well developed, i.e. the formation of a massive turnip shaped-thickened root, in which a perennial supply of substances creates prerequisites for the formation of a stem 3 meters high. After having formed a powerful peduncle, the plant dies, i.e. the ontogenesis cycle ends with fruiting.



Figure 3. Habitat and vegetative parts of *Ferula foetida*

F. foetida is a plant of xeromorphic habitat, having developed a protective function in the form of a specific metabolism - the formation of resins, localized mainly in the roots and seeds, although secretory cells containing them are dispersed throughout organs of the plant. Resins are insoluble in water, in contrast to gums (water-soluble polysaccharides). The combination of both (gum-resin) increases the resistance to xeromorphic conditions - high temperatures and moisture deficiency and, at the same time, forms a unique medical source.

Resin production process

From wild plant, resin can be harvested from *Ferula tadshikorum* starting with an age of 10-13 years, and from *F. foetida* starting with plants 7-9 years old, when the plants enter the virginal phase of development. In plantations the preparation of resin from the roots of plants can begin after 6 years of vegetative growth, when the plant is sufficiently

strong and yields a commercial product. The collection process is identical for both species.

The process of collecting gum begins with digging and opening the root pin of the plant (Figure 4), then, with a special sharp knife, a small incision is made on the side along the line of the remains of the petioles of last year's rosette leaves (in the basal part of the root). Next, the plant is covered with cardboard (Figure 5), this is necessary for steaming and better release of gum resin, and also protects the resin from wind and mechanical contaminants (dust, plant residues, etc.).

The collected adhesive liquid mass with a pronounced garlic smell is concentrated in the form of resinous products (peculiar waxy globules), hardens in the air after collecting for about 2 days. These then are dried on cardboard paper, in well-ventilated rooms. On average, about 5-7 grams of gum are isolated from one root section (Figures 6-7). After the release of gum resin is stopped, the next incision is made nearby or slightly lower. Thus, in the process of producing gum resin, the number of incisions can reach 20 units, the total amount of the obtained raw material can range from 70 to 120 grams. The collection of raw materials begins after drying of the aboveground parts of the plant and continues from May to October.

In total, 5 different fractions are obtained, differing from each other in quality and organoleptic properties, which affects the grade and cost of the final product. The raw materials of both species of *Ferula* are marketed under the common commercial name "assafetida resin. However, vernacular names vary and are given in table 1. The fractions, their names and characteristics are shown in Table 1.



Figure 4. Rhizome harvest of *Ferula foetida*



Figure 5. *Ferula foetida* steaming process



Figure 6. *Ferula tadshikorum* resin release



Fig. 7. *Ferula foetida* resin release

Fraction	Number of notches	Physical state	Color	Smell
Donak	up to 5	crystals	golden-yellow	sharp garlic
Khalva-donak	+2	crystals	yellowish	sharp garlic
Khalva	+3	solid-liquid mass	yellowish-gray	sharp garlic
Silt	+5	liquid, gravitational resin	gray	sharp garlic
Shira	+5	liquid	beige	sharp garlic

After the collection of raw materials, the roots are again covered with soil. However, according to our observations, after such a long harvest and many cuts applied, the restoration of plants does not occur, the plants die. Therefore, we recommend stop collecting after receiving the Khalva-donak fraction, because this will result in better and more expensive raw materials for the market, and at the same time, will help to preserve and restore plants for subsequent years of harvesting.



Figure 8. Donak of *Ferula foetida*



Figure 10. Silt of *Ferula tadshikorum*



Figure 9. Donak of *Ferula tadshikorum*

Discussion

When harvesting raw materials from underground parts of two species of *Ferula*, it is of paramount importance to leave a mandatory 20-25% of plants intact to produce seed material. Being monocarpic, both species produce seeds only once during their ontogenesis. The obtained seed material helps to maintain the population and will serve for further expansion of artificial planting. As a result, the sustainable exploitation of plantations will allow to relieve the pressure on the natural populations of these species, which will serve their complete restoration in nature. In addition, it will be possible to obtain raw materials, without incurring extra costs for obtaining quotas, etc., and allow farms and other entities to earn consistently high income over a long period of time.

Declarations

Ethics approval and consent to participate: All participants involved in the interview process gave their prior informed oral consent.

Consent for publication: Not applicable.

Competing interests: The authors declare that they have no competing interests.

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Availability of data and materials: The data was not deposited in public repositories but is available from the corresponding author upon request.

Authors' contributions: O.K. Khojimatov collected and analyzed the data, drafted, and developed the manuscript. D.T. Khamraeva searched literature, cooperated in data collection, and adjusted the manuscript to the journal submission guidelines. R.W. Bussmann critically revised the manuscript. All authors contributed in the research, data collection, and approved the final manuscript.

Literature cited

Flora Uzbekistana 1959. Volume 4:1-509. Tashkent, FAN. (In Russian).

<https://planta-medica.uz/ferula-foetida-bunge-regel-ferula-vonyuchaya/> (accessed 10.6. 2021).

<https://planta-medica.uz/ferula-tadshikorom-pimenov-ferula-tadzhikov/> (accessed 10.6. 2021).

Ibn Sina AA. (Avicenna) 1954. Kanon vrachevnoi nauki Volume 1:1-548. Tashkent: Izd-vo AN UzSSR. (In Russian).

Khalkuzieva MA, Rakhmankulov U. 2020. Sokhranenie sajencev na plantaciyakh *Ferula tadshikorom* Pimenov po godam vegetacii. Vestnik Gulistanskogo gosudarstvennogo universiteta. Seriya estestvennikh I Selskokhozyastvennikh Nauk Gulistan 4:19-24. (In Russian).

Khamraeva DT, Grabovec NV, Bussmann RW, Khojimatov OK. 2021. Leaf morphological and anatomical structure of pregenerative individuals of *Ferula tadshikorom* in ex situ conditions. Acta Biologica Sibirica 7:193-210. doi: 10.3897/abs.7.e 63714.

Khamraeva DT, Khojimatov OK, Uralov AI. 2019. Rost i razvitie *Ferula tadshikorom* Pimenov v usloviyakh introdukcii. Acta Biologica Sibirica 5(3):172-177. doi: 10.14258/abs.v5.i3.6588. (In Russian).

Khojimatov OK, Khamraeva DT 2018. Izuchenie stroeniya perikarpia ploda cennogo lekarstvennogo rasteniya *Ferula tadshikorom* i perspektivi eyo kultivirovaniya v Uzbekistane. UBJ, Tashkent 45-48. (In Russian).

Khojimatov OK, Khamraeva DT, Makhmudov AV, Khujanov AN 2019. Instrukciya po semennomu virashivaniyu *Ferula tadshikorom* Pimenov v usloviyakh yujnogo Uzbekistana. Tashkent, MUXR press, 44 p. (In Russian).

Krasnayua kniga Respubliki Uzbekistan. 2019. Volume 1:1-359. Tashkent: Chinor ENK. (In Uzbek).

Pimenov MG. 1974. Novii vid feruli iz podroda *Narthex* (Falcon.) Drude. Bulletin Gkavnogo Botanicheskogo sada. M.: Nauka 94:54-58. (In Russian).

Rakhmonov KhS. 2017. Biologiya i resursi *Ferula tadshikorom* M. Pimen. & B. Yujnom Tadjikistane. Dissertaciya na soiskanie uchenoi stepeni kanddata selskokhozyaistvennikh nauk. Dushanbe, 179 p. (In Russian).