Results of the introduction of the promising ethnomedicinal plant *Ferula tadshikorum* in the Tashkent Botanical Garden and technology of resin production under different conditions

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Research

Abstract

Background: The article presents the results of *F. tadshikorum* Pimenov introduction in Tashkent Botanical Garden and the technology of obtaining gum resin of roots from different growing conditions.

Methods: To study ontogenesis and to distinguish age states of *F. tadshikorum*, generally accepted methods were used. Field studies in natural conditions were carried out by route methods based on observation. The timing of resin collection, technical methods of root pruning and the weight of gum resin obtained from one plant were studied.

Results: According to the results of introduction in the Tashkent Botanical Garden the introduction evaluation of *F. tadshikorum* was carried out. Comparative data of conducted measures, time, technology of collection of gum resin from roots of *F. tadshikorum* were given. Climatic factors in natural populations and conditions of introduction were considered, the age of plants, time of collection, methods of root cutting were determined. The possibility of obtaining gum resin from virginile age specimens grown in the conditions of the Tashkent Botanical Garden in the sixth year of vegetation was established. In the conditions of Arnasay district of Jizzak region in the 10th year of vegetation, and in natural conditions plants of 12-16 years of life are mainly used. The yield of gum resin obtained from one plant was determined for plants from different locations, which makes it possible to calculate the economic efficiency of the plantations.

Conclusions: The results of 6-year work on introduction of *F. tadshikorum* in conditions of Tashkent botanical garden are summarized and introduction evaluation is given. On the plantations created in Tashkent region, it is recommended to collect gum resin from virginile plants on the sixth vegetation season.

Key words: Afghan knife, *Ferula tadshikorum*, gum resin, introduction assessment, plantations, root.

Background

Species of the genus *Ferula* Tourn. ex L. occurring in the flora of Uzbekistan are used by the local population for various purposes. For example, gum resin from roots of *Ferula foetida* (Bunge) Regel, *F. tadshikorum*, *Ferula foetidissima* Regel & Schmalh., *Ferula varia* (Schrenk) Trautv. and *Ferula kuhistanica* Korovin, from flowering shoot and leaves of *Ferula sumbul* (Kauffm.) Hook. F. and from the leaves of *Ferula tenuisecta* Korovin are used to treat various diseases (Khojimatov *et al.* 2019; Khojimatov *et al.* 2023). The chemical composition of species of the genus *Ferula* is quite complex. The roots of *Ferula* species accumulate substances such as resin, essential oil and a large number of carbohydrate and protein substances (Abd El-Razek *et al.* 2003). The chemical composition of more than 50 species of the genus growing in Central Asia has been studied and found to contain terpenoids, sesquiterpenoids, terpenoid coumarins, esters, lactones (Avalboev, 2020). A comprehensive study was conducted on the fruits of 49 *Ferula* species, mostly from Central Asia, to describe the fruit surface microstructure and understand the systematic significance of this character for infrageneric delimitation (Mustafina *et al.* 2021).

For use in medicine, gum resin is mainly obtained from the roots of *F. tadshikorum*. The chemical composition of the solidified milky juice of the roots is represented by resin (9.35-65.15%), gum (12-48%) and essential oil (5.8-20%). The following have been isolated from the resin: ferulic acid, asaresinotanol, asaresinol and their ferulic derivatives: farnesiferol C and umbelliferone. The essential oil consists mainly of organic sulfides, up to 65%: hexenyl sulfide, hexenyldisulfide, and fluorobutylpropenyl disulfide. The essential oil also contains pinene and p-oxycoumarin. The roots contain up to 9% resin, which yields 0.4% essential oil containing linolol, citronellol, and doremol acetates, as well as ferulene and sambulene. The terpenoid coumarins tadzhikorin and tadzheferin have been isolated from the roots and fruits (Rakhmonov, 2017).

As a result of uncontrolled exploitation of natural resources of *F. tadshikorum* during the last 25 years, the species, which was once the dominant species of the lower and middle mountain belt of Kashkadarya and Surkhandarya regions, was practically exterminated by nature users. This was the reason for including *F. tadshikorum* in the next edition of the Red Data Book of the Republic of Uzbekistan, with status 3 (Makhmudov, 2019).

To date, the number of individuals in the populations has sharply decreased. During the field surveys in 2020-2022, plants in generative phase were practically not found in natural populations, except for hard-to-reach places where collection is practically impossible (rock crevices, steep slopes and ravines). In order to preserve natural populations of *F. tadshikorum*, the Decree of the President of the Republic of Uzbekistan “On additional measures to protect and ensure the rational use of pastures”, No. PF-24, dated 16 February 2023, decided on a moratorium on the exploitation of natural populations of this species and long-term monitoring for the competent use of its natural reserves.

In recent years, the population of mountainous areas has actively started to establish industrial plantations of this valuable plant. In order to increase the production of *F. tadshikorum* gum resin and in the future to obtain a stable income, plantations are being established everywhere, both in the territories of natural habitats of Kashkadarya and Surkhandarya regions, and in regions not typical for this endemic species, such as Jizzak and Tashkent regions. These activities to a certain extent contribute to the conservation of the gene pool of the species in Uzbekistan.

To determine the current state of species in order to strengthen their subsequent protection and sustainable use, it is necessary to obtain annual information on the state of distribution, abundance, and the impact of negative factors on their populations. In such programs it is very relevant to use unified methods of scientific research, which would allow not only to record changes in dynamics, but also to identify the causes and predict the direction and nature of their further transformation. In addition, such an approach makes it possible to reveal the general state of populations, the natural state of medicinal plant thickets, in particular, including aspects of seasonal character, representative age composition of the population and those changes that are directly related to anthropogenic impact on the state of individuals.

In connection with the above, the study of methods of collection of raw materials of rare medicinal species of local flora and their further sustainable use, carrying out of introduction works and on the basis of these data creation of plantations, is the most actual requirement for today.

The aim of the present work was to reveal the regularities of adaptation during introduction in Tashkent Botanical Garden, to describe the technological parameters of obtaining gum resin roots in natural and introduced conditions.

Materials and Methods

F. tadshikorum is a perennial monocarpic plant, reaches 1.5-1.8 m height and sometimes up to 2 m, has a strongly pronounced garlic smell. The plant is an endemic of Southern Uzbekistan and is found in the middle belt of mountains of Surkhandarya and Kashkadarya regions, on loess and fine-grained rubble slopes, limestone, pestiferous, on dry river valleys and terraces, at an altitude of 1400-1800 m.

To study ontogenesis and identify age states of *F. tadshikorum*, we used generally accepted methods (Rabotnov, 1950 a, b; Ontogenetic Atlas of Medicinal Plants, 1997), observation of the rhythm of seasonal development and description of the small life cycle of individuals were carried out according to the method of I.G. Serebryakov (1947, 1961). Experiments on cultivation of *F. tadshikorum* at the site of the laboratory of Introduction and agroecology of raw plants of the Tashkent Botanical Garden at the Institute of Botany of the Academy of Sciences of the Republic of Uzbekistan were started in 2018 and phenological observations of experimental plants continue to this day (Khamraeva *et al.* 2019; Khamraeva *et al.* 2021).

We present data of observations on *F. tadshikorum* carried out directly with resin collectors in the territories of Babatag and Machai ridges in Surkhandarya region. In natural conditions, before resin harvesting, the age state of plants was determined and individuals of virginile age of 12-16 years of vegetation were selected, and for introduced plants it was determined according to our data on introduction in the Tashkent Botanical Garden (Khamraeva *et al.* 2019; Khamraeva *et al.* 2022). For resin collection, a special Afghan knife, a pick, a rounded blunt knife and cardboard paper to cover the plants are commonly used. Some resin collection activities were carried out according to (Khojimatov *et al.* 2021). Field studies were carried out on the basis of route methods. The time of resin collection, technological parameters of root incision and the mass of resin obtained from one *F. tadshikorum* plant were studied.

Surkhandarya province is located in the southernmost part of Uzbekistan. The region is surrounded on three sides by mountains, its border is open from the south, the border with Afghanistan, runs in the south along the extremely curved course of the Amu Darya River (Fig. 1). High mountains, in the western and north-western border of Surkhandarya, are the factors creating special climatic conditions of the region. Surkhandarya region is the only subtropical region of Uzbekistan, characterized by a dry, sharply continental climate, rich in sunshine. Daily and annual air temperature fluctuates sharply and is characterized by low precipitation. The dryness of the climate increases from the north-west to the south-east of the region. In this direction, the air temperature increases in summer and decreases in winter, this change occurring between seasons is due to the change in the structure of the relief of the place. The abrupt change of climatic conditions is observed especially in the mountainous areas. In the plain part of the region, air and soil surface temperatures are high (Ruziev, 1996).

Tashkent is located in the foothill, slightly hilly part of the Tashkent oasis, near the spurs of the Western Tien Shan (at a distance of 80-90 km), directly adjacent to the Chirchik River from the north-east. The botanical garden is located in the north-eastern part of Tashkent at an altitude of 480 m above sea level. The climate of Tashkent is sharply continental and is characterized by high insolation (duration of sunshine 2871 hours/year), dryness, significant daily temperature fluctuations, hot summer, dry, warm autumn, and moderately cold winter. The absolute minimum temperature is ...-25.8°C, the absolute maximum is ...+44.6°C. The main amount of precipitation, according to long-term data 380-440 mm, which falls on autumn-winter-spring periods (Belolipov, 1989).

The city of Tashkent has a moderately warm climate. The city receives significantly more precipitation in winter than in summer. There is a small amount of precipitation throughout the year. The climate here is classified as Csa (hot summer Mediterranean climate by the Keppen-Geiger system). Temperatures here average +14.1°C. The average annual rainfall is 623 mm (https://ru.climate-data.org).

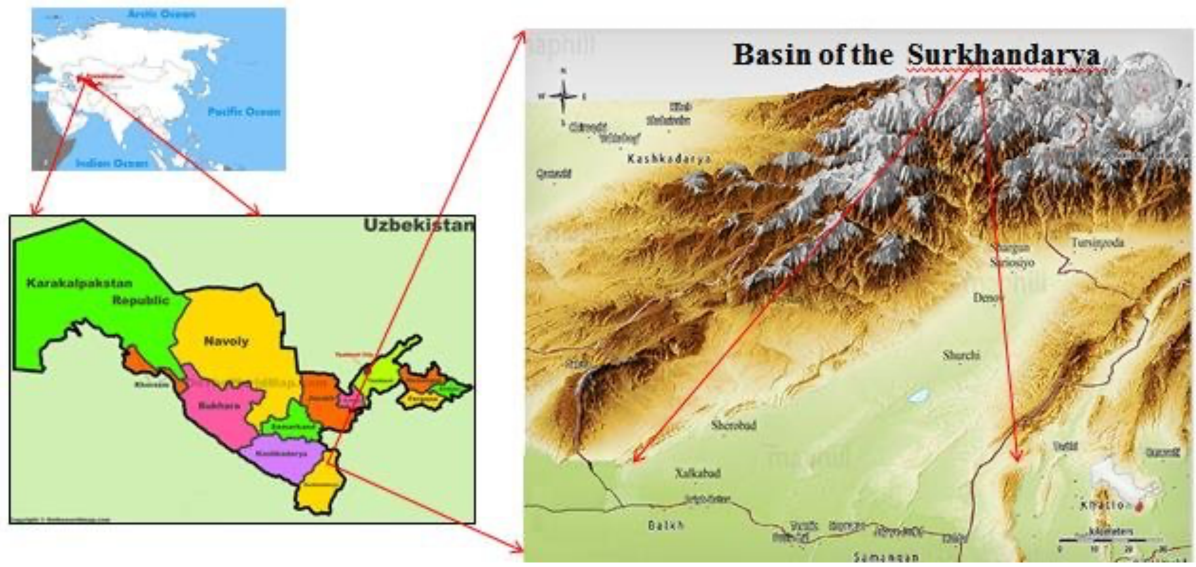

Figure 1. Surkhandarya region of Uzbekistan

Results and Discussion

Features of ontogenesis of the 6-vegetation year in the conditions of the Tashkent Botanical Garden

Compared to January 2023, January 2024 was warmer. The highest daytime temperature was 14°C. While the minimum night temperature dropped to 0°C. The average daytime and nighttime temperatures during January were +8.6°C and +5.6°C, respectively. Precipitation in Tashkent during January totaled 36.7 mm. In February, the highest daily temperature was 18°C. While the minimum temperature at night dropped to -3°C. The average day and night temperatures during February were +7.0°C and +3.7°C, respectively. Precipitation totaled 52.6 mm. Thus, February was one of the rainiest months of 2024. (http://uzbekistan.pogoda360.ru/955861/).

Due to warmer temperatures in January and half of February 2024, the emergence of leaves accelerated compared to previous seasons, which contributed to their growth in early February. This season, no winter dieback was observed at the experimental sites. In previous years, we found the presence of scaly leaves in all different-aged plants, this year all age groups also had such leaves: juvenile individuals had 1, other individuals - 1-3 (Khamraeva *et al.* 2022).

In two experimental plots in 2024, as in the previous season, virginile plants were dominant, their number was almost 85-90% of plants. In this season, the number of juvenile plants sharply decreased, their number was no more than 3-5%, the share of immature individuals also decreased to 7-10% of the total number of experimental plants. Long-term observations have shown that juvenile plants usually form 1-2 rosette leaves on a rosette shoot (Fig. 2 c). The morphological structure of the leaf of these individuals does not differ from plants of previous seasons, but there were slightly differences in their size. The length of the leaf is 24-39 cm long, the plates were 14-23 cm long, the width of the plate is 4-8 cm wide, the length of the petiole is 10-16 cm (Fig. 2 c).

Immature individuals of this season were also characterized by the formation of species of leaves - triple-dissected or 5-6-lobed plate, very rarely in some 7-lobed individuals, in addition, these individuals, as in previous vegetation observations, were distinguished by the absence of simple leaves (Fig. 2 a, d). The presence of immature plants with two varieties of leaves was also noted. Triple-dissected leaf with ellipsoidal lobes, leaf lobes 20-30 cm long, 5.5-8.5 cm wide, petiole 10-22 long. Leaves were 5-6 (7) -bladed with ellipsoidal or broadly ellipsoidal segments, leaf length 30-55 cm, segments 15-26 cm long, 4-9 cm wide, most of all segments sessile, sometimes primary segments on short petioles, petiole 16-22 cm long.

The sixth growing season is characterized by the powerful development of aboveground mass in some virginile individuals. Observation results showed that virginile plants form from 1-2 to 6 leaves in a rosette. At this season, there is a complication in the structure of the leaves, therefore, in young individuals the leaves were once or twice pinnately dissected, and in virginile plants 3-4 years of life twice or thrice pinnately dissected up to 60-91 cm long (Fig. 2 b, e).

The leaves of virginile individuals below were pubescent, petiolate, the leaf blade is large, broadly triangular in shape, the leaf segments were elongated-oval, broadly ellipsoidal, 10-37 cm long, 3-12.5 cm wide, the final segments up to 26 cm long, up to 8.5 cm wide, lanceolate or ovate-lanceolate, pointed, citylike along the edge. Primary segments on short petioles, the rest were sessile, petiole up to 18-30 cm long.

The root system of virginile plants is deep-rooted, the main root is spindle-shaped, its basal part is shrouded in the remains of petioles of last year's leaves, the bark is dark brown. The thickened part of the root is in the upper middle layers of the soil, the root is elongated, penetrates to a depth of 50-70 cm. The diameter in the thickest part is 4-5 cm. The lateral roots were very small, formed one or two in the upper part of the root. Every year there is a thickening of the main root, there is an active accumulation of various organic substances. All individuals of the sixth season in the experimental areas also go to rest, starting from late May to mid-June.

According to the results of studies on the introduction of *F. tadshikorum* in the conditions of the Tashkent Botanical Garden, patterns in the morphological structure of leaves of individuals of different ages were established. Juvenile plants have only simple leaves, immature individuals have two varieties of leaves, ternary and 5-6-lobed or rarely 7-lobed, in virginile plants, depending on the year of life, once-twice or twice-thrice cirrus-dissected leaves in different quantities. Of course, there is a synchronous development of the aboveground and underground part of the plants.

In the conditions of the Tashkent Botanical Garden at *F. tadshikorum*, we have already noted (Khamraeva *et al.* 2019; Khamraeva *et al.* 2022), shortening the duration of ontogenetic state stages in a large mass of individuals. Based on our results, from the newly created resin plantations, you can collect from virginile plants for the sixth growing season. The bulk of the plants made up the virginile age group, which was used to obtain medicinal raw materials.

Thus, during the introduction of *F. tadshikorum* in the Tashkent Botanical Garden, an acceleration in the ontogenetic development of most plants was noted. This fact indicates that the production of plant raw materials is possible in the shortest possible time compared to natural individuals, which once again proves the success of the introduction of this plant in the Tashkent oasis.

Patterns of adaptation and success of *F. tadshikorum* introduction in the Tashkent oasis

The first scales for assessing the success of acclimatization belong to E.L. Wolf (1929), who considered the winter hardiness of plants. But this is only one of the factors (frost resistance), which is considered during acclimatization. In the literature there are works on the introduction assessment of herbaceous plants of many scientists, for example N. Andreev (1975), B.A. Golovkin (1973), N.A. Bazilevskaya (1964), etc.

I.V. Belolipov (1989) analyzed the results of the complex introduction of more than 2,000 Central Asian species from 41 families of dicotyledonous plants, mainly grassy, shrubs and, rarely, shrubs, to new conditions of existence in the conditions of the Tashkent Botanical Garden.

The result of the assessment of acclimatization and adaptation of plants was the distribution of the species based on the sum of points, according to the prospects for introduction. As can be seen from Table 1, the stability criterion of *F. tadshikorum* phenorhythm had a more stable result. The deep adaptation of the species to the harsh conditions of mountainous territories is evidenced by the specific rhythm of plant development, expressed in the reduction of the growing season. The monocarpic *F. tadshikorum* grows in nature from February to the end of May or early June and then goes to rest. In introduced conditions, the beginning and end of vegetation from year to year remained in the same rhythm, however, a positive air temperature above + 50C in the winter season may affect a slight transfer of the beginning of vegetation from February to the end of January.

The survival rate and laboratory germination of seeds was distinguished by a high score. Freshly harvested seeds sown in open ground had a high germination rate of up to 85-90%. The same seeds did not lose their germination during the storage period, and according to the results of laboratory germination carried out in 2022, a high germination rate of 70 to 100% was noted.

Morphological and anatomical as well as phytochemical parameters showed the same results as in natural individuals (Khamraeva *et al.* 2024; Khamraeva *et al.* 2025). This indicates the genetic attachment of these traits and preservation under introduction conditions.

Figure 2. Different-aged plants of *F. tadshikorum* under culture conditions. a, d – 5th year immature plant (15.02.2024; 02.05.2024), b, e – virginile plant of the 4th year (15.02.2024; 02.05.2024), c – juvenile plants of year 6 (02.05.2024). Scale bar 1 mm.

To assess the introduction of *F. tadshikorum* in the conditions of the Tashkent Botanical Garden, a 100-point scale by B.E. Tukhtaev (2009) was used in our research work. For the organization of industrial plantations *F. tadshikorum*, the main criteria were focused on the adaptability and endurance of plants in the new conditions. For the introduction assessment, we identified 10 criteria: according to the characteristics of the phenorhythm, reproduction and viability in culture (Table 1).

When assessing the phenorhythm, we noted the duration of vegetation (the beginning of vegetation and the care of plants in peace). Plant survival and laboratory seed germination were determined to characterize the propagation score. To characterize the viability of the species, we identified morphological and anatomical and phytochemical parameters, resistance to diseases and pests, drought resistance, frost resistance and winter hardiness. Each criterion was reasonably evaluated according to 3 degrees and a 100-point system.

Table 1. *F. tadshikorum* Introductory Evaluation Summary (2018-2023)

Criteria	Grade and scores						Introductory evaluation	
Phenorhythmic stability	стабилен	10	slightly varies by year	7	not stable by years	3	slightly varies by year	7
Plant survival	it is stable	10	middle	7	low	3	high	10
Laboratory germination	it is stable	10	middle	7	low	3	high	10
Leaf shape and size	rates are greater than in vivo	10	indicators are the same as in natural conditions	7	less than natural	3	indicators are the same as in natural conditions	7
Mesophyll type preservation	rates are greater than in vivo	10	indicators are the same as in natural conditions	7	less than natural	3	indicators are the same as in natural conditions	7
Thickening of the upper part of the main root	rates are greater than in vivo	10	indicators are the same as in natural conditions	7	less than natural	3	indicators are the same as in natural condition	7
Presence of sulfide containing substances in the root	are present	10	there are traces of substances	7	are absent	3	are present	10
Disease and pest resistance	not damaged	10	damage not massive	7	damage annual mass	3	damage not massive	7
Drought resistance	watering optional	10	watering is desirable	7	watering is mandatory	3	watering is mandatory	3
Frost resistance and winter resistance	frost-resistant, winter-hardy	10	damage not massive	7	damage annually massive, shelter required	3	frost-resistant, winter-hardy	10
In total							78	

Diseases and pests of *F. tadshikorum* in the introduced conditions of the Tashkent Botanical Garden

In Uzbekistan, phytopathogenic fungi, such as pathogens of rust, powdery mildew, septoriosis and phyllostictose, are widespread on representatives of the genus *Ferula.* Species in the genus *Ferula* are affected by rust caused by the fungi *Puccinia sogdiana* Kom. and *Puccinia libani* Magnus. *P. sogdiana* is mainly found on species such as *Ferula tenuisecta* Korovin, *F. angreni* Korovin, *F. kokanica* Regel & Schmalh., *F. moschata* (H. Reinsch) Koso-Pol., while *P. libani* found on *Ferula karatavica* Regel & Schmalh. и *F. ovina* Boiss. The disease causes damage to the stems, leaves and flowers of plants, as a result of which the affected parts dry out over time. Powdery mildew caused by the fungus *Erysiphe umbelliferarum* f. *ferulae* Golovin, affects leaves, young stems and immature plant seeds. This disease is most common on *Ferula penninervis* Regel & Schmalh species. и *Ferula angreni*. Phyllostictosis, caused by the fungus *Phyllosticta kenimaechia* Golovin, is widespread on almost all species of the genus *Ferula* in Uzbekistan, causing significant damage to plants. Affected leaves dry up completely over time (Panfilova T. S., Gaponenko N. I., 1963; Mustafaev *et al.* 2019; Islomiddinov *et al.* 2022; Mustafaev *et al.* 2023).

However, it should be noted that *F. tadshikorum* is affected less frequently by phyllostictosis than other species, and the plant is not significantly harmed by this disease. When growing *F. tadshikorum* under introduction conditions, no mass cases of infection with rust, powdery mildew and septoriosis were recorded. Symptoms of phyllostictosis have been observed extremely rarely, suggesting high resistance of *F. tadshikorum* to fungal diseases.

It should be emphasized that in addition to pathogenic fungi that cause various diseases, fungi that live in endophytic and symbiotic states have also been found on species of the genus *Ferula*. Scientific studies conducted in Iran have shown that a number of species of mushrooms are in symbiosis with species of *Ferula* spp. All 1348 isolates were morphologically and molecularly classified into 77 species, most of which belong to the Ascomycota division. *Ferula ovina*, *F. gummosa* Boiss. and *F. persica* Willd. demonstrated a diversity of endophytic fungal species, suggesting that endophytic fungi are specific to different hosts (Safaie *et al.* 2024). This exclusive distribution of endophytic fungal species among different host plants may indicate specific ecological niches required for these species, as well as their specific functional roles in host plants, including promoting growth and development, increasing tolerance to environmental stresses, and protection against herbivores and phytopathogens (Nourian *et al.* 2024; Ranjbar *et al.* 2024). Studies in China have examined the mycorrhizal associations of *Ferula sinkiangensis* K.M. Shen. As a result, 10 «operational taxonomic units» (OTUs) from the genus *Glomus* Tul. & C. Tul and 2 from *Diversispora* C. Walker & A. Schüßler were identified, which were present at all soil depths and at various positions on the slope. Given their versatility among the specimens collected, it is assumed that these fungi have a close relationship with the growth of *Ferula sinkiangensis*. This may suggest that further investigation of these fungi will provide important soil microbiology data that may contribute to the successful artificial cultivation of *F. sinkiangensis* (Luo *et al.* 2020).

Thus, in the future, the study of endophytic fungi and mycorrhizal associations of *F. tadshikorum* may provide opportunities to use these fungi to support plants when grown in a variety of climatic and soil conditions. *F. tadshikorum* is minimally affected by pests. Under introduction conditions in the spring, damage to the terrestrial mollusk *Xeropicta candaharica* is observed. This mollusk feeds on young leaves of plants, leaving holes and notches of various shapes on them.

Resin production process under introduced conditions

The first work on the production of resin was carried out in the Tashkent Botanical Garden at the Institute of Botany of the Academy of Sciences of the Republic of Uzbekistan. According to the results of 6-year studies, it was found that with the introduction of *F. tadshikorum* in the conditions of the Tashkent oasis, it is possible to collect resin from this year of vegetation.

Resin production process under introduced conditions

The first work on the production of resin was carried out in the Tashkent Botanical Garden at the Institute of Botany of the Academy of Sciences of the Republic of Uzbekistan. According to the results of 6-year studies, it was found that with the introduction of *F. tadshikorum* in the conditions of the Tashkent oasis, it is possible to collect resin from this year of vegetation.

Collection of resin from the roots of *F. tadshikorum* must be started before the individuals enter a resting state. In mid-June (14.06.2024) first from selected virginile individuals, dry leaves were cut, and pits were dug up to 20-30 cm in diameter and 15-20 cm deep around the top of the root with an open cone of growth. Then these leaves neatly covered the top of the root and covered the dug hole with cardboard paper. All this is done to stimulate the resin to rise from the deep tissues of the taproot to the thickened part of the root. In this state, the plant is left for 15-20 days. Then, with a sharp knife to a shallow depth (so as not to damage the growing cone), cuts are made, and the plant is again left covered with cardboard paper for 2-

5 days (Fig. 3 a-c). In some individuals, the leaked resin hardens in air until the next incision, and in some it remains a slightly solid-liquid mass, popularly this state of juice is called "halva" (Fig. 3 d, e). Collection and subsequent incisions can be carried out before the beginning of the first frosts of autumn. From one virginile plant in one growing season, you can get 20-30 g of resin. After the end of the collection, you should bury the pit and sprinkle the root with soil to prevent freezing. Under introduced conditions, we did not collect resin on cloudy days, or during precipitation, or when dust winds intensified, as well as when the experimental site was flooded due to watering of plants in neighboring areas, since all these circumstances lead to fungal damage to the root.

We also carried out technological work to collect resin from the roots of *F. tadshikorum* in the Arnasai district of Jizzakh region. During 2014-2021, *F. tadshikorum* seeds were planted and plantations were laid out on 20 hectares on the territory of the Shifo Kovrak farm. From the roots of *F. tadshikorum* plants planted in November 2014, resin was first produced in 2024. The 10-year-old roots of *F. tadshikorum* in diameter reach 6-11 cm, and the length reaches 50-90 cm. Larger virginile representatives of *F.tadshikorum* growing on this plantation were chosen to collect gum resin. These works began in the third decade of May 2024, when the plant had 5-7 leaves that were almost dry. The leaves were then removed, the root circumference was excavated, and the dried leaf residue above the root was cleaned with a brush. Next, the root was covered with cardboard paper and a stone was placed on top of the cardboard (Fig. 4 a-d).

Root cutting was carried out in stages, and in about 35-40% of the upper part of the root, cut horizontally with respect to the ground. The resin that flowed out of the root began to turn into a hard glue after 2-3 days. Local people refer to the condition as "Danak." Further, slices 0.2-0.3 cm thick were cut from the root, at the place where it was cut. From the place of the new pruning of the root, the resin also hardened after 3 days. Since August, instead of "Danak" gum, resins began to receive non-solid semi-liquid, that is, not quite dry juice called "Halva." It was more liquid, creamy. Such a "halva" was filmed only 2-3 times. The rest of the time, from about August 15 to early October, only liquid juice was received. The root of each *F. tadshikorum* plant yielded up to 25-30 grams of gum resin.

Process for producing resin from natural conditions. As a result of observations of the process of obtaining resin from *F. tadshikorum* under natural conditions, it was found that in practice there are several different cutting methods. People talk about notching methods in different ways.

There are techniques such as radial cross-cut, full-diameter cross-cut, notched cut, and others. Subject to the rules during the cutting process, the plant will retain its viability and will be able to continue growing next year. According to Kh.S. Rakhmonov (2017) and the authors' own data, the collection of *F. tadshikorum* resin in natural conditions is carried out from virginile plants, 12-16 years old, when they have the ability to give from 50-100 to 150-250 g of resin (Fig. 3). However, collectors collect resin from 7-8-year-old individuals, sometimes from 5-6-year-olds, there have been cases of resin collection from individuals 2-3 years of age.

Notching methods. There is not enough information in the literature on the extraction (cutting methods) of resin from the roots of the plant. In the work of H. S. Rakhmonov (2017), data on this process are summarized. According to information obtained during field studies, there are 2 main methods of notching among the local population:

1. Cross section in radial direction (Fig. 5 a).
It is carved in the upper part of the root, in the shape of a crescent in a thin layer (comparable to slices) using a sharp tool (Afghan knife).

2. Cross section along the entire diameter (Fig. 5 b).
Straight incision across the root. Popularly, the transverse incision is compared with sausage cutting. The advantage of this method is the large amount of resin produced, but the consequence is death of the plant.

Fig. 3. Resin collection technology in Tashkent Botanical Garden. a, b – root steaming process, c, d – radial shear process, e – general view of the resin “Danak”.

Figure. 4. Technology for collecting resin in rainfields on the territory of the "Shifo Kovrak" farm. a – general view of the plantation, b – general view of the virginile plant, c, d – preparation of the root for resin collection.

Technology of resin production under natural conditions. Resin collection in the Surkhandarya region begins in the third decade of May, after the leaves dry out. The method of preparing for resin collection does not differ from the above methods used in the introduction conditions. Depending on the size of the root of the virginile plant, a shallow hole is dug, opening the root neck of the plant, and then covered with cardboard paper. In this state, they are left for 15-25 days, sometimes this process can last up to 30-40 days. A prerequisite is to consider the climatic factors of the weather at the time of cutting, if the sky is cloudy, dusty or precipitation falls, incisions cannot be made, since the root is affected by fungi, which leads to the death of the plant. With the help of an Afghan knife, a very thin incision of the root is made, after the first cut, the plant is covered with cardboard paper for another 3-5 days. The flowing milky juice of the root's freezes in the air. It is popularly called "Danak" (Fig. 5 c, d).

According to the literature, after competent collection of resin, the plant can fully recover in 2-3 years and continue growing (Sharipov, Turginov, 2022).

Figure. 5. Technology of resin collection in natural conditions. a - resin section along the radius, b - section along the entire diameter, c - leaked resin, d - resin weight from one plant.

Resin yield. In 2019-2022 studies conducted under natural conditions, it was found that when using the transverse radial notching method, an average of 60-80 grams of resin were extracted from one plant (12-16 years old), while up to 90-100 grams of resin were obtained when notching along the entire diameter. Depending on the size and age of the root of the virginile plant, cuts can be made from 5-6 to 15 times per season. The process of collecting resin from the root lasts from June to October-November.

Conclusion. At the newly created *F. tadshikorum* plantations in the Tashkent region, resin collection is recommended from virginile plants of the sixth growing season, since the bulk of the plants fall at this stage of ontogenesis development. Based on the results of 6 years of work on the introduction of *F. tadshikorum* in the Tashkent Botanical Garden, an introduction assessment was carried out, morphological, anatomical and phytochemical indicators, resistance to diseases and pests, drought resistance, frost resistance and winter resistance were analyzed. Each criterion was evaluated according to the 3rd degree and 100-point system, as a result, the sum of the points of the introduction assessment of *F.tadshikorum* was 78.

In November 2014, plantations on 20 hectares were laid on the territory of the «Shifo Kovrak» farm in the Jizzakh region. In 2024, resin was first obtained from the roots of plants.

The study revealed some features of resin collection in the rare and endemic medicinal plant *F. tadshikorum*. Abiotic environmental factors (cloudy weather, dust or precipitation) have a direct effect on the resin yield, which must be considered when carrying out procurement work. The biological age of plants is also important, that is, virginile plants 5-6 years old are suitable for collection in the conditions of the Tashkent Botanical Garden, 10 years old in the Arnasai district of the Jizzakh region, and 12-16 years old plants in natural conditions. The most optimal root incision method is considered to be a transverse incision in the radial direction, which is recommended for use in resin mining on industrial plantations.

Declarations

List of abbreviations: Not applicable.
Ethics approval and consent to participate: All participants provided oral prior informed consent.
Consent for publication: All participants shown in images agreed to have their image taken and published.
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Authors' contributions: DK, OK, IM, MK, ShA, NR collected, analyzed the data and drafted the manuscript. DK, OK, RB and advised, reviewed, and approved the final manuscript.

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