

Preservation of *ex-situ* gene pool of rare medicinal plant species in Kazakhstan

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Abstract. The approved "List of Medicinal Plants" consists of 278 medicinal plants used in official or traditional medicine. At the same time, 65 species have been listed in the Red Book of Kazakhstan. In the experimental medicinal plant collections located in the foothills of Zailiyskiy Alatau (in the Main Botanical Garden, Almaty), a total of 48 (74%) are indigenous medicinal herbs of Kazakhstan's flora were grown over different years. A significant number of rare medicinal plant species of Kazakhstan (37 species), which is more than half of all tested ones, can be successfully grown. Eight of them are blooming and bearing fruit regularly and tree crops give real yields. Thirteen species of trees and shrubs have high adaptive abilities and were introduced at the expositions of the botanical garden. Sixteen species could bloom but not all of them produced seeds consistently. Introduction of 13 species are very difficult or unsuccessful, 17 species (26%) of the medicinal flora have not been tested in culture, mainly due to the known futility of cultivation in the open ground.

1 Introduction

Botanical gardens have a significant role in achieving the Global Strategy for Plant Conservation (GSPC) goals by preserving and expanding the *ex-situ* collections of living plants, particularly the rare and economically valuable relict species [1].

The distribution and current status of Kazakhstan's rare and endemic plant species have been considered high attention. *In-situ* studies of rare species in their natural habitats as part of wild populations and individual specimens is widely discussed in foreign literature on various regions of the world [2] and in Kazakhstan where rather active works are conducted by Kotukhov (2009) [3].

Valuable medicinal plants that are rare are better studied through *ex-situ* species. By replicating these plants in culture and artificial conditions over large areas, we can produce the necessary raw materials without harming the natural populations. However, this process is not always successful due to the conservative nature of most rare species, especially relict ones, which make them poorly adapted to new conditions.

Biotechnological methods of reproducing rare plants hold more promise in this matter. An example of such a method is developing a technique for reproducing and *Allochrusa*

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gypsophiloides - a precious rare species [4]. The newly developed method has successfully ensured this species preservation but challenging to grow in open plantations are unsuccessful and unstable [5, 6].

Since the mid-1960s, a collection of medicinal plants has been studying some of Kazakhstan's rare but highly valuable raw plants as *Convallaria majalis* L., *Eminium lehmannii* (Bunge) Kuntze, *Crocus alatavicus* Regel et Semen, *Rhaponticum carthamoides* (Willd.) Iljin and etc. (Table 1). The 70s-80s witnessed some of the most extensive and dynamic experiments aimed at developing techniques for cultivating Kazakhstan's rare plants [4, 7]. A collection site for rare plants of Kazakhstan was established during this time, leading to the successful introduction of relicts like *Incarvillea semiretschenskia* (B. Fedtsch.) Grierson (*Niedzwedzkia semiretschenskia* B. Fedtsch.), *Spiraeanthus schrenkianus* Maxim, *Jurinea robusta* Schrenk, *Tanacetum kelleri* (Krylov et Plotn.) Takht. (*Pyrethrum kelleri* (Kryl. et Plotn.) Krasch.), виды *Eremurus*, *Juno*, *Tulipa* and others in the foothill zone of ZailiyskyAlatau.

Over the following years, extensive tests were conducted to study the propagation of bulbous and tuberous plants indigenous to Kazakhstan [8, 9]. The exploration of the characteristics of rare plant species from Kazakhstan is ongoing. These include studying the overall generic complexes such as *Allium* genus and individual species [10].

The List of Medicinal Plants approved by Article 9 of the Law of the Republic of Kazakhstan "On the Plant World" (dated March 7, 2023, No. 77) [11] there are 278 medicinal plant species of Kazakhstan. Most 212 species (76%) are widespread throughout the Republic and can be harvested for medicinal purposes from natural populations to varying degrees. Less of them 65 species (23%) are rare, relicts or endemic species which strictly ban for harvesting from nature. Table 1 provides a list of rare (65) medicinal herb of Kazakhstan, out of which 20 species (31%) are used in official medicine, while 45 species (69%) are traditionally in folk medicine.

2 Materials and Methods

The research object focused on a group of rare medicinal herbs studied at different times in the experimental medicinal plant collection plot. The research aimed to analyze the physical and biological features of a particular group of species to understand their growth patterns, reproductive capacity, and ability to withstand environmental factors in the cultivation setting. The study followed the methodology outlined in the reference [12]. The species in the collection were evaluated by the introduction success index (ISI), which ranges from 1 to 6 [13]. This assessment involved examining each species' introduction features and current life state.

- 1 – the plants fall during the first growing season;
- 2 – grows, sometimes blooms, but does not produce full-fledged seeds;
- 3 – fruit bearing at creation of specific conditions;
- 4 – fruits in open ground, but not regularly;
- 5 – successfully grows and bears fruit;
- 6 – a naturalized species.

3 Results and Discussion

We referred to the approved list of medicinal herbs [11] and [4] to determine the status of the studied species. The systematics of the species are given according to the Online resources [14, 15]. Currently, the researchers examined the fundamental traits of medicinal plant species, particularly those native or ancient, present at the experimental collection site.

Moreover, the archival notes were analyzed to understand the features of introduced tree and shrub species, including their life status [16, 17].

Within the MP collection 48 (74%) rare species of Kazakhstan flora were grown in different years and with different success. Out of these species, there are 7 plants: *Arum korolkovii* Regel, *Convallaria majalis* L., *Lilium martagon* L., *Paeonia anomala* L., *Rhaponticum carthamoides* (Willd.) Iljin, *Rheum wittrockii* C.K. Lindstr., *Taraxacum kok-saghyz* L.E. Rodin. that have been introduced successfully, with an ISI score of 5.

There are 16 rare herbaceous species including *Corylus avellana* L., *Eminium lehmannii* (Bunge) Kuntze, *Gymnospermium altaicum* (Pall.) Spach, *Lonicera iliensis* Pojark., *Pulsatilla patens*, (L.) Mill., *Paeonia hybrida* Pall., *Iris alberti* Regel, *Paris quadrifolia* L., *Rheum compactum* L., *Tulipa greigii* Regel, *Tulipa kaufmanniana* Regel. are fairly stable in flowering, but not always producing matured seeds (ISI score of 4).

Thirteen species of trees and shrubs introduced at the expositions of the botanical garden in the 60s of the last century have high adaptive abilities (ISI = 4–5). Out of all the rare medicinal plant species of Kazakhstan that were tested, over half of them (37 species, 56.9%) have been successfully grown at the foothills of the Zailiyskiy Alatau. Additionally, 8 of these species have the ability to produce complete raw materials and seeds in the current conditions, including *Allium microdictyon* Prokh., *Arum korolkovii* Regel, *Astragalus glycyphyllos* L., *Chelidonium majus* L., *Convallaria majalis* L., *Lilium martagon* L., *Rhaponticum carthamoides* (Willd.) Iljin, *Rheum wittrockii* Lindstr. Полноценное сырье и реальные урожаи в предгорной зоне Зайлийского Алатау дают такие культуры как: *Armeniaca vulgaris* Lam., *Berberis iliensis* Popov, *Celtis caucasica* Willd., *Corylus avellana* L., *Fraxinus sogdiana* Bunge, *Malus niedzwetzkyana* Dieck., *Malus sieversii* (Ledeb.) M. Roem, *Quercus robur* L., *Sibiraea laevigata* (L.) Maxim., *Vitis vinifera* L. It is a challenging task to introduce 13 species of plants which also includes raw material plants like *Aconitum talassicum*, *Adonis* (3 species), *Artemisia cina*, *Bupleurum longifolium*, *Cypripedium* (3 species), *Malacocarpus crithmifolius* (Retz.) C. A. Mey., *Mediasia macrophylla* (Regel et Schmalh.) V.Pimen., *Rhodiola rosea*, *Tulipa korolkowii* Regel. in the foothill zone of Zailiyskiy Alatau.

From the total number of rare medicinal Kazakhstan's species (65 species), approximately 17 species (26%) of them have not tested yet in the culture at the foothills of the Trans-Ili Alatau in Kazakhstan. These lack of the unavailability of experimental materials (*Adonis chrysocyathus*, *Crataegus ambigua* C.A. Mey., *Ribes janczewskii* and etc.) and/or the introduction experience has proven futile in some species like (*Adiantum capillus-veneris*, *Drosera rotundifolia*, *Huperzia selago*, *Ledum palustre* and etc.).

The lifespan of a species or introduced population in culture under our conditions is determined by the life form of the species, its adaptive and ontogenetic features. For most herbaceous species, life expectancy in cultivation varies from 3-5 years (*Colchicum luteum* Baker, *Rhaponticum carthamoides* (Willd.) Iljin, *Ungernia severzowii* (Regel) B.Fedtsch.), up to 9-10 years for *Allium*, *Crambe tatarica* Sebeok, *Ferula iliensis* Krasn., *Lilium martagon* L., *Paris quadrifolia* L). Most of the tested tree species have been growing successfully in the botanical garden for 60 years or more. In our conditions, introduced populations of *Convallaria majalis* L. and *Corydalis sewerzowii* Regel self-renew (weed).

Table 1. Total list of rare medicinal plant of Kazakhstan.

Species	Family	App licat ion	ISI	Flowering / fruit bearing	Life cycle in cult.	Introd. year
<i>Aconitum talassicum</i> Popov	Ranunculaceae	FM	1	–	–	1993
<i>Adonis tianschanica</i> (Adolf) Lipsch.	Ranunculaceae	OM	0	–	–	1993
<i>Adonis vernalis</i> L.	Ranunculaceae	OM	1	–	–	1995
<i>Adonis wolgensis</i> Stev.	Ranunculaceae	FM	2	–	–	1985
<i>Allium microdictyon</i> Prokh.	Amaryllidaceae	FM	4	+/+	> 10	2013
<i>Allium pskemense</i> B.Fedtsch.	Amaryllidaceae	FM	5	+/+	9-12	1986
<i>Allochrysa gypsophiloides</i> (Regel) Schischk. (Acanthophyllum gypsophiloides Regel)	Caryophyllaceae	OM	4	+/-	3-5	1981
<i>Alnus glutinosa</i> (L.) Gaertn.	Betulaceae	OM	2	–	5-6	1970
<i>Armeniaca vulgaris</i> Lam.(= <i>Prunus armeniaca</i> L.)	Rosaceae	OM	5	+/+	> 60	1955
<i>Artemisia cina</i> O. Berg	Asteraceae	OM	1	–	–	1991
<i>Arum korolkovii</i> Regel	Araceae	FM	5	+/+	> 30	1990
<i>Astragalus glycyphyllos</i> L.	Fabaceae	FM	5	+/+	> 20	1985
<i>Berberis iliensis</i> Popov	Berberidaceae	FM	5	+/+	> 60	1965
<i>Celtis caucasica</i> Willd.	Cannabaceae	FM	4	+/-	22	1990
<i>Colchicum kesselringii</i> Regel	Colchicaceae	FM	4	+/-	2-3	2002
<i>Colchicum luteum</i> Baker	Colchicaceae	FM	4	+/-	2-4	2002
<i>Convallaria majalis</i> L.	Asparagaceae	OM	5	+/+	self-renewal	1965
<i>Corydalis sewerzowii</i> Regel	Papaveraceae	FM		+/-		
<i>Corylus avellana</i> L.	Betulaceae	FM	4	+/+	> 30	1995
<i>Crambe tatarica</i> Sebeok	Brassicaceae	FM	4	+/-	10-15	1990
<i>Daphne altaica</i> Pall.	Thymeliaceae	FM	4	+/-	> 10	1986
<i>Drosera rotundifolia</i> L.	Droseraceae	FM	–	–	–	
<i>Eminium lehmannii</i> (Bunge) O.Kuntze	Araceae	FM	4	+/-	2-3	1992
<i>Erythronium sibiricum</i> (Fisch. & C.A. Mey.) Krylov	Liliaceae	FM	4	+/-	5-7	1964
<i>Ferula iliensis</i> Krasn.	Apiaceae	FM	4	+/-	5-7	1989
<i>Fraxinus sogdiana</i> Bunge (<i>F. potamophila</i> Herder)	Oleaceae	FM	5	+/+	> 60	1963
<i>Gymnospermium altaicum</i> (Pall.) Spach	Berberidaceae	OM		+/-	2-3	
<i>Iris alberti</i> Regel	Iridaceae	FM	–	+/-	> 5	2018
<i>Ledum palustre</i> L.	Ericaceae	OM	–	–	–	
<i>Lilium martagon</i> L.	Liliaceae	FM	5	+/+	9-10	2002
<i>Malacocarpus crithmifolius</i> (Retz.) C. A. Mey.	Nitrariaceae	FM	2	–	3-4	
<i>Malus niedzwetzkyana</i> Dieck.	Rosaceae	FM	4	+/-	> 60	

Continuation of Table 1

<i>Malus sieversii</i> (Ledeb.) M. Roem	Rosaceae	OM	5	+/-	> 60	
<i>Mediasia macrophylla</i> (Regel et Schmalh.) V.Pimen. (= <i>Athamantha macrophylla</i>)	Apiaceae	FM	2	-	2-3	1992
<i>Paeonia anomala</i> L.	Paeoniaceae	OM	4	+/-	> 20	1990
<i>Paeonia hybrida</i> Pall.	Paeoniaceae	OM	4	+/-	up to 7	1985
<i>Paris quadrifolia</i> L.	Melanthiaceae	FM	3	+/-	> 14	2009
<i>Pistacia vera</i> L.	Anacardiaceae	FM	4	+/-	> 7	
<i>Quercus robur</i> L.	Fagaceae	OM	5	+/+	> 70	1950
<i>Rhaponticum carthamoides</i> (Willd.) Iljin (<i>Stemmacantha carthamoides</i> (Willd.) Dittrich)	Asteraceae	OM	4	+/+	3-5	1985
<i>Rheum wittrockii</i> Lindstr.	Polygonaceae	FM	5	+/+	> 40	1985
<i>Rhodiola rosea</i> L.	Crassulaceae	OM	2	-	до 7	1993
<i>Sibiraea laevigata</i> (L.) Maxim. (<i>S. altaiensis</i> Laxm.)	Rosaceae	FM	5	+/+	> 60	1960
<i>Tulipa greigii</i> Regel	Liliaceae	FM	5	+/-		1980
<i>Tulipa kaufmanniana</i> Regel	Liliaceae	FM	5	+/-		
<i>Tulipa korolkowii</i> Regel	Liliaceae	FM	2	+/-		
<i>Ungernia severzowii</i> (Regel) B.Fedtsch.	Amarylidaceae	OM	4	+/-	2-3	1985
<i>Vitis vinifera</i> L.	Vitaceae	OM	5	+/+	> 30	

4 Conclusion

The approved "List of Medicinal Plants" contains 278 medicinal plants used in official or traditional medicine. Most of these plants can be collected from natural populations; at the same time, 65 of them have been listed in the Red Book of Kazakhstan that are strictly prohibited from being harvested in their natural populations.

In the experimental plot of medicinal plant collections which located in the foothills of Zailiyskiy Alatau, a total of 48 (74%) rare indigenous medicinal plants species of the Kazakhstan's flora were grown in different years (Table 1). A significant number of rare medicinal plant (37) species of Kazakhstan, which is more than half of all tested ones can be successfully grown. Eight of them (*Arum korolkowii*, *Convallaria majalis*, *Rhaponticum carthamoides* and etc.). Sixteen species could bloom but not all of them produced seeds consistently (*Colchicum kesselringii*, *Ferula iliensis*, *Iris alberti*, *Paeonia hybrida*, *Pulsatilla patens* (L.) Mill. and etc.). Thirteen species of trees and shrubs have high adaptive abilities and were introduced at the expositions of the botanical garden. Such species as *Allium microdictyon*, *Astragalus glycyphyllos*, *Rhaponticum carthamoides*, *Convallaria majalis*, *Rheum wittrockii* provides a complete medicinal raw material and seeds. Tree crops obtained real yields, as an example *Armeniaca vulgaris*, *Berberis iliensis*, *Fraxinus sogdiana*, *Corylus avellana*, *Malus niedzwezykyana*, *M. sieversii*, *Sibiraea laevigata* *Quercus robur*.

It is challenging to introduce 13 species of plants, including *Aconitum talassicum*, *Adonis* (3 species), *Artemisia cina*, *Mediasia macrophylla*, *Rhodiola rosea* and others, that are used for raw material, to the foothill zone of Zailiyskiy Alatau. These plants do not grow well in this region.

Moreover, around 26% (17 species: *Adiantum capillus-veneris* L., *Adonis chrysocyathus* Hook. fil. et Thoms., *Arctostaphylos uva-ursi* (L.) Spreng., *Bryonia melanocarpa* Nabiev, *Crataegus ambigua* C.A. Mey., *Cymbaria daurica* L., *Cypripedium calceolus* L., *C. guttatum* Sw., *C. macranthon* Sw., *Erysimum croceum* M. Pop., *Huperzia selago* (L.) Bernh. ex Schrank et C. Mart., *Orchis militaris* L., *Oxycoccus microcarpus* Turcz. ex Rupr., *Ribes janczewskii* Pojark., *Sanicula europaea* L., *Saussurea involucrata* (Kar. et Kir.) Sch. Bip., *Thesium minkwitzianum* B. Fedtsch.) of medicinal plants could not be tested in cultivation due to their impracticality of growing in open ground.

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Authors' contribution

Conceptualization and design of the study was made by L.G.; R.A., M.R., K.Sh. and Zh.K. carried out the collection field data, preparation plant samples and data collection; L.G. took the lead in writing the manuscript. The presented data was conceptualized, interpreted, and translated by L.G. and Zh.K. The authors of this article agree to be accountable for all stage of the research.

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