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Reintroduction of *Kok-saghyz* (*Taraxacum Kok-saghyz* L. Rodin)

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Abstract

For the first time in the Republic of Kazakhstan, the reintroduction of the kok-saghyz dandelion (Taraxacum kok-saghyz L. Rodin) has been carried out, a rare species included in the Red Book of Kazakhstan. Kok-saghyz is a valuable resource plant of world importance. It is used as an industrial crop, a source of high-quality rubber. During the works held in 2017-2018 the method of returning kok-saghyz to the limits of its natural growth zone, located on the intermountain valleys of the North-Eastern Tien Shan of Kazakhstan, has been tested. The survival rate of kok-saghyz seedlings decreased from 94% to 84% and then to 77% with an increase in the height of the seedlings above sea level (1795, 1842, 1900 meters, respectively). The tested method will be used in the practice of restoration, expansion and preservation of natural populations of Taraxacum kok-saghyz Rodin.

Keywords: Kok-saghyz, Reintroduction, *Ex Situ*, *In Situ*, *Taraxacum Kok-saghyz* Rodin, Rare Plant Species, Conservation.

1. Introduction

Kok-saghyz (*Taraxacum kok-saghyz* Rodin) is an herbaceous plant of the Dandelion genus, of the Asteraceae Cass., a natural rubber plant. Kok-saghyz is a valuable resource plant of world importance, it is used as an industrial crop, a source of high-quality rubber.

Natural rubber is widely used in rubber-technical industry for the production of tires for cars, aircraft, bicycles, as well as footwear, medical gloves, and other products. At the beginning of the twenty-first century, kok-saghyz was introduced from Kazakhstan to the USA and a number of countries of the European Union (A demonstration project "Dandelion Rubber and Inulin Valorization and Exploitation for Europe", PENRA). Kok-saghyz rubber has great prospects as an additive to bioplastics (Xiaoying Zhao et al. 2019).

Kok-saghyz was discovered by botanist L.Y. Rodin with the assistance of collective farmer V. Spivachenko in 1931 in the north-eastern spurs of the Tien Shan mountain system, in the Raiymbek district of the Almaty region of Kazakhstan, at an altitude of 1,850-2,100 m above sea level.

The area of kok-saghyz is characterized by rather diverse conditions. It covers partly mountain, partly mountain-steppe strip and includes the valleys of two mountain rivers - Tekes and Kegen, in a rather vast intermountain space, representing a kind of low-lying plains cut by mountain river beds.

Kok-saghyz prefers relatively open habitats. However, it is found among the closed vegetation cover, composing the understory of plant groupings. The rubber plant can be found:

1. In the bushes of chia (*Lasiagrostis splendens* Trin Kunth.).
2. In meadows with blady grass (*Elymus Regelii* Roshev.), or with iris (*Iris sogdiana* Bge.).
3. Together with sagebrush (*Artemisia Schrenkiana* L d b. or A. Rupestris L.).
4. Together with glasswort (*Salicornia herbacea* L.), or with ofaiston (*Ofaiston monandrum* (Pall.) Moq.), petrosimonia (*Petrosimonia sibirica* (Pall.) Bg e.), or with various types of seepweed (*Suaeda*).
5. Among tall-grass saline meadows with wheatgrass and barley (*Agropyrum sp., Hordeum brevisubulatum* (TrIn.) LInk, *Hordeum Bogdani* Wilensky) and blady grass (*Elymus Regelii* Roshev., *Elymus junceus*. FIsch).

The main indicators of kok-saghyz are aster (*Aster tripolium* L), plantain (*Plantago salsa* Pall.), potentilla (*Potentilla mutifida* L), barley (*Hordeum brevisubulatum* (TrIn.)), and from rare ones - saussurea (*Saussurea kaschgarica* Rupr.) and blady grass (*Elymus Regelii* Roshev.) (Lipshitz 1953).

In the last century, in the former USSR, kok-saghyz was cultivated on a large scale. For many years (from the 30s to the 50s of the last century), the harvesting of seeds and roots of kok-saghyz was carried out in the territory of its natural habitat. The first collection of seeds in natural brushwoods was organized in 1932. 1837 kg of seeds were collected and the next year 2410 kg. Points for retrieving kok-saghyz seeds were organized in the area of the Saryzhaskaya valley. The local population annually collected up to a ton of the wild-growing kok-saghyz seeds for the transfer and organization of rubber plantations. In the 1950s, in connection with the possibility of the USSR entering the world market of crude rubber, the cultivation of kok-saghyz was discontinued (Filippov 1953; Mynbaev 1946).

However, in subsequent years, the high sensitivity of kok-saghyz to anthropogenic impact, low rates and a long period of self-reproduction hampered the natural renewal of kok-saghyz populations, and in 1981 kok-saghyz was included in the Red Book of the Kazakh SSR, in the category II (rare species). It tends to decrease in number due to the violation of natural habitat conditions (Red Book of the Kazakh SSR).

The uncontrolled collection of plants led to the complete disappearance of a number of Taraxacum kok-saghyz cenopopulations in natural ecosystems. It is important to note that since many years of intensive and unsystematic harvesting of seeds and roots of kok-saghyz in the last century, no measures have been taken to restore and preserve the populations of kok-saghyz. In the 21st century, there remains a need to restore and preserve the natural populations of kok-saghyz in Kazakhstan (Uteulin and Baitulin 2017).

Natural renewal of the kok-saghyz populations is difficult due to the following factors.

Factors Impeding the Natural Regeneration of the Kok-saghyz Natural Populations

- Low seed production of kok-saghyz in natural habitat conditions.
- Lack of anemophilia in kok-saghyz (the adaptability of plants to pollination by the transfer of pollen by wind). Seed formation occurs as a result of normal fertilization through cross-pollination.
- The kok-saghyz pollen retains its viability only for five days. For hybridization, the limited duration of this period is a negative point, especially in relation to species that are geographically isolated from each other or blooming in different months of the year.
- Field germination of seeds varies considerably from growing conditions and often does not exceed 18 - 27% (Lipshitz 1953).
- It should be noted that there is a high sensitivity of kok-saghyz to anthropogenic impact, like road construction, construction of facilities, cattle grazing and others (Uteulin and Baitulin 2017).
- In the twenty-first century, expeditions of foreign scientists were organized to the zone of natural growth of kok-saghyz in Kazakhstan (Kirschner et al. 2013; Volis et al. 2009). Separate populations of kok-saghyz with an extremely small size from 10 to 100 plants were found (Peter van Dijk et al. 2010).
- It is known that a decrease in the size of a population increases its vulnerability (Gilpin and Soulé 1986), in this case the measures are needed to preserve the rare species of kok-saghyz

(*Taraxacum kok-saghyz*), for example the method of reintroduction (Uteulin and Baitulin 2017).

- *In situ* conservation of selected species is preferred over *ex situ* conservation. Reintroduction, as a way to restore plant species, is a promising measure to save endangered plants (Gorbunov et al. 2008).

The purpose of this research is to preserve natural populations of the rare species of Kok-saghyz plants, to test the method of reintroduction, return kok-saghyz to the zone of its natural growth according to the following scheme: introduction of kok-saghyz → seed reproduction → selection and reproduction of species with the highest rubber content in the roots → reintroduction, returning kok-saghyz into the zone of natural growth with the provision of survival, flowering and fruiting for the reintroduced plants.

2. Materials and Methods

For the collection the kok-saghyz seeds of and the organization of experimental plots in the zone of its natural growth, we obtained permission from the Forestry Committee of the Kegen district, Almaty region, the Republic of Kazakhstan. The collection of seeds was carried out in accordance with the "Rules for the collection of seeds of rare and endangered plant species (for botanical gardens)" (1981). In the greenhouse of the Institute of Plant Biology and Biotechnology (Almaty) seedlings were obtained from the seeds of kok-saghyz wild populations (seedlings on peat tablets).

Cultivation, selection of plants for a high content of rubber (at least 6%) in the roots, reproduction of the best forms of kok-saghyz was carried out in isolated introductory plots at the Institute of Plant Biology and Biotechnology (Almaty, 43°15′24.1″N, 76°55′43″E).

In early June 2017, reintroduction sites were organized in the coastal zones of the Kegen River and Salt Lake with sufficient moisture supply. Kok-saghyz seedlings were planted manually in planting pits. The processing of field materials was carried out using data analysis of the Microsoft Excel application program. The rubber content in the roots was determined according to Koloyavich using the method of alkaline extraction (Koyalovich and Alpatieva 1939).

According to the well-known methodological approaches, the kok-saghyz plants were reintroduced not inside the preserved populations, but on the borders with its natural populations (Tikhonova 1987).

3. Results and Discussion

Samples of kok-saghyz populations Zhalauly, Kegen, Saryzhaz, Salt Lake (Figure 1) were introduced and propagated by seed regeneration method *ex situ* in isolated areas of the Institute of Plant Biology and Biotechnology (Almaty). During 2013-2016, the selection of kok-saghyz forms with a high content of rubber in roots (6-10%) was carried out for subsequent reproduction (Figure 1) (Uteulin et al. 2020). Other species of the genus *Taraxacum brevicorniculatum* and *Taraxacum officinale* had significantly lower rubber content. Self-seeding of kok-saghyz took place during the introduction.

Figure 1- Natural Habitats of Kok-saghyz: Zhalauly (a), Kegen (b), Saryzhaz (c), Salt Lake (d)

a b

c d

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For reintroduction, kok-saghyz seedlings were being prepared in a greenhouse during two months (April-May). Seedlings were planted *in situ* in areas of natural growth in early June. The climate of the kok-saghyz natural growth zone is mountainous and sharply continental. The warmest months are June, July, August. The average temperature ranges from 12 to 17°C.

Within 23-29 days, the seedlings underwent adaptation to the reintroduction conditions, the leaves dried out and then a new plant with morphological characteristics of wild kok-saghyz regenerated. The reintroduced, regenerated, and adapted plants returned to the morphological characteristics of the wild kok-saghyz. That means that the size of the plants decreased significantly.

So, under the conditions of the introduction in Almaty, the leaf length was up to 15 cm, the leaf width was up to 1.5 cm, the height of the aboveground part with the peduncle was up to 22 cm, the average root weight of the kok-saghyz plant was 16 grams (Uteulin et al. 2020).

In plants of wild kok-saghyz, the leaf length was up to 2 cm, the width was up to 0.8 cm, the height of the aboveground part with the peduncle was from to 2 to 5 cm, the root weight was from 2 to 6 grams.

The general morphological features of the kok-saghyz species (*Taraxacum kok-saghyz*) under conditions of introduction and wild populations are as follows: the leaves of the kok-saghyz do not have sharp spines at the edges, the leaves of the basket wrap surrounding the inflorescence have horn-shaped appendages, the roots contain 6-10% rubber.

Samples of introduced, wild and reintroduced kok-saghyz are presented in Figures 2, 3 and 4.

Figure 2- Plant Samples of Introduced Kok-saghyz at the Experimental Plots of the Institute of Plant Biology and Biotechnology, Almaty

Figure 3- Plant Samples of Wild, Non-reintroduced Kok-saghyz

Figure 4- Plant Samples of Reintroduced Kok-saghyz

As it is known, wild kok-saghyz in natural populations reproduces its-self by seeds, it does not bloom in the first year, while the flowering and fruiting is observed in the second year (Lipshitz 1953).

The kok-saghyz reintroduced by us is similar to the wild one. In the first year it did not bloom, flowering and fruiting occurred only in the second year. Observations of the third year showed self-seeding of the reintroduced kok-saghyz.

At the time of monitoring (end of June, 2018) the survival rate of kok-saghyz plants in the natural growth zone depended on the height of the reintroduction site above sea level. With an increase in height from 1795 meters to 1900 meters above sea level the survival rate of kok-saghyz seedlings decreased and at an altitude of 1972 meters the planting material did not take roots (Table 1).

Table 1- The Survival Rate of Kok-saghyz Seedlings in the Zone of its Natural Growth

No	Place of reintroduction	Survival of planting material
1	The outskirts of the Zhalauly village (altitude 1795 meters above sea level, N 43°03'45,8', E 79°07'09,7').	93%
2	The outskirts of the Kegen village (altitude 1842 meters above sea level, N 42°59'50,4", E 79°16'00.3")	84%
3	The outskirts of the Saryzhaz village (altitude 1900 meters above sea level, N 42°55'31,9", E 79°40'17,5")	77 %
4	Coastal zone of the Salt Lake (altitude 1972 meters above sea level, N 43°01'556", E 79°59'404")	0 %, seedlings did not take roots

Note. Planting material of a virginal state represented seedlings with 5-8 leaves. The amount of planting material is 100 seedlings per plot. Time of introduction - June 2-10, 2017. Planting sites with sufficient natural moisture supply were located in the coastal areas of the Kegen River and the Salt Lake.

4. Conclusion

For the first time, the method of the kok-saghyz reintroduction has been tested in Kazakhstan. Local populations have been created, capable of self-supporting. Artificial populations are formed *in situ* with a normal ontogenetic structure from seedlings to adult generative individuals, producing viable seeds.

In the future, the method of the kok-saghyz reintroduction will be used more widely for the restoration, expansion and preservation of this rare plant species.

With the use of the reintroduction method, it is possible to organize *in situ* a nursery of elite plants, a source of elite seeds for international exchange, to regulate access to genetic resources of kok-saghyz and joint usage by states of the Nagoya Protocol (2010).

The conservation of biological diversity in terms of control and management of natural resources is one of the most important areas of the sustainable development strategy. For the implementation of scientifically grounded programs for the conservation of biodiversity, it is necessary to apply various methods of its assessment on different spatial scales, both for the entire

population of plants and for individual rare and vulnerable biological species. It is necessary to use the experience of modern systems for assessing the conservation state of rare plant populations, which combine population trends with criteria for assessing the vulnerability of habitats (Gauthier et al. 2017; Walsh et al. 2015), as well as methods for mapping rare plants (Carli et al. 2018).

As the most valuable and vulnerable component of biodiversity, rare and endangered species are of the greatest interest for study and the assessment of the state of their populations is a priority.

Conflicts of Interest

The authors declare that they have no conflict of interest.

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