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Clone Selection of Kok-Saghyz (*Taraxacum kok-saghyz*), A Source of Natural Rubber

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ABSTRACT

In the temperate zone, the kok-saghyz dandelion (*Taraxacum kok-saghyz* Rodin) is considered a promising source of natural rubber (NR). NR cannot be replaced by synthetic rubber in the manufacture of a wide range of rubber products. **The purpose of this** study was to develop regulations for obtaining the seeds of the early-ripening kok-saghyz for cultivation as an annual crop in the South-East Kazakhstan. **The methods of the study** include propagation by root cuttings and individual and family selection of the early-ripening kok-saghyz plants that reach a high root mass in the first year of cultivation. **The results of the study** are the stages of the regulations for obtaining the seeds of the early-ripening kok-saghyz: selection of five large early-ripening forms of kok-saghyz → cloning of selected plants on isolated plots → repeated selection of the best plants → combining elite plants from five families on one plot of an elite plant nursery → cross-pollination of elite plants → seeds of the early-ripening kok-saghyz for plantation growth. **Conclusions.** Kok-saghyz is recommended for plantation cultivation in the South-East Kazakhstan as an annual crop.

KEYWORDS

Kok-saghyz, Early-ripening, Selection, Cloning, Productivity, South-East Kazakhstan.

Introduction

Natural rubber (1,4 – polyisoprene) is one of the most important biopolymers used in industry and medicine. Natural rubber (NR) is irreplaceable by synthetic rubber in the manufacture of a wide range of products: tires for cars, planes and bicycles; belts; adhesives; gloves and many more [**1**]. Technologies for producing bioplastics using natural rubber are being developed [**2, 3**].

The main source of NR are plantations of the rubber tree (*Hevea Brasiliensis*) located in the tropical humid climate of Southeast Asia. However, there is a real threat of destruction of the rubber tree plantations by the fungal parasite (*Microcyclus ulei*) which causes mass infection and death of rubber trees. which has happened in South America. It used to be the world's natural rubber production center but lost this status completely due to *Microcyclus ulei* [**4**].

In this regard, technologies for the cultivation of alternative supplementary plant species are being developed, which can be a source of NR in temperate zones where the rubber tree does not grow. Dandelion kok-saghyz (*Tagahasim kok-saghyz* Rodin) is considered the best source of the NR in the temperate zone. NR produced from kok-saghyz is equal in quality to NR produced from the rubber tree, and, unlike the latter, does not cause allergies in humans and has prospects for the manufacture of medical devices [**5**].

Kok-saghyz (*Taraxacum kok-saghyz* Rodin) is a perennial herb of the *Taraxacum* genus,

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Asteraceae family, and a source of rubber. The center of origin of kok-saghyz is the Kazakhstan intermountain valleys of the South-East Tien Shan of Kazakhstan [**6**].

The complex and peculiar soil and climatic conditions of the natural habitat of kok-saghyz caused the existence of a large variety of inherited forms of kok-saghyz. In natural populations of kok-saghyz, there are forms with the highest content of rubber in the roots (16–27%), but it must be noted that in other environmental conditions, the content of rubber decreases [7].

Until the mid-1950s, kok-saghyz was grown in the Soviet Union, however after the discovery of synthetic rubber and the lifting of the blockade of the industrial plantations of the rubber tree in Southeast Asia, kok-saghyz stopped to be used.

Since the beginning of the 21st century, due to threats to the rubber tree plantations and the global NR market, kok-saghyz research has been resumed, aimed at its industrial cultivation in the United States [8–11] and the European Union [**12–14].**
In Kazakhstan, kok-saghyz research has been carried out since 2008 at the Institute of Plant Biology and Biotechnology, Almaty [**15**].

Kok-saghyz is mainly used as a biennial crop. It is important to create an early-ripening variety of kok-saghyz. Indeed, in the climate of the South-East Kazakhstan, individual kok-saghyz plants complete their biological maturation, having high biomass as early as in the first year of cultivation, before the onset of the drought period in mid-July and August. The combination of the following conditions makes it possible to use kok-saghyz as an annual crop in the South-East Kazakhstan: the use of seedlings, sufficient moisture (rain, irrigation), higher optimal temperatures in the spring months for accelerated plant development [1**6**]. In the second year, the yield of root, rubber and inulin does not increase, which eliminates the need to cultivate the early-ripening kok-saghyz according to the traditional biennial crop procedure. The cost of growing early-ripening varieties of kok-saghyz is greatly reduced in comparison to the biennial variety.

Consequently, the purpose of the studies of kok-saghyz was the following: using clone selection, develop and test regulations for obtaining seeds of early-ripening kok-saghyz for cultivation as an annual crop.
The following goals were set:

1. Select early-ripening forms of kok-saghyz.
2. Clone the best, elite forms of kok-saghyz having a large root and a high content of rubber and inulin.
3. Obtain the seeds of the early-ripening kok-saghyz.

It must be noted that clonal lineage are the best object of research for other *Taraxacum* species: the common dandelion (*Taraxacum officinale*; Asteraceae) [**17**].

Materials and Methods

The research methodology included the use of agronomic, chemical, biotechnological and selection method.
Selection methods were used as follows: individual, family selection, cloning of the best plants to

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reduce the period of creating an early-ripening kok-saghyz variety.

To create an early-ripening kok-saghyz variety, the previously created Kazakh Saryzhaz variety, a source of economically useful traits, was used. The Saryzhaz variety has a high intravarietal polymorphism in terms of the time of flowering (includes early-, mid- and late-ripening genotypes) and other biological characteristics [**18**].

Kok-saghyz research was carried in open-ground conditions of Mirnoye horticultural society: Ostemir Village: Talgar District, Almaty Region, Kazakhstan (N43^{o}37´49´, E77^{o}.15´41´). The presence of artesian wells ensures low-cost water supply – irrigation of Ostemir farm plots.

The soil of the nursery plots is sandy loam fertilized (400 kg of manure per 200 m2 plot) to a depth of 15 cm.

Kok-saghyz was cultivated using seedlings [**19**]. In a greenhouse, seeds were sown on peat tablets. Seedlings developed for two months (February, March) at a temperature of +25^{o}C.

Seedlings of kok-saghyz were planted into the open ground of Ostemir experimental plots. Care for the plantings included fertilization (manure), watering, soil loosening between rows, weeding [**16**].

The climate of Ostemir is typical for a steppe — continental with hot summers and cold winters. Spring and early summer periods are rainy, with the average air temperature in April being +18.2°C, in May — +23.9°C, which is optimal for the development of kok-saghyz plants. The average temperature in June is +27.2^{o}C. The hottest months are July and August. Temperatures close to +30°C are observed on average for 36 days a year [**20**].
According to well-known methods, root cutting of kok-saghyz [21, 22] was performed and the content of rubber [23] and inulin [24] in plant roots was determined.

The results were processed statistically [**25**].

Results

In this paper, we have developed **a technology regulation for obtaining "improved" seeds of the early-ripening kok-saghyz for cultivation as an annual crop in the South-East Kazakhstan. The stages of the technology regulation are presented below.**

Stage 1. Selection of the best (elite) plants that combine early maturation (fruiting in the first year, before the onset of heat and drought in July–August) with the root mass of 27–35 grams, rubber content of 8± 2% and inulin content of 28±5% in the roots of kok-saghyz plants for further reproduction and organization of a nursery of the parent material.

Stage implementation and results: Preparation of kok-saghyz seedlings in greenhouse conditions (February–March) → Planting of seedlings on an open-ground plot (April), organization of a nursery of the parent material as a source of genetic diversity → Selection of early-ripening plants that have reached high root mass and fruiting in the first year over a short growing season before the onset of heat and drought in July–August → Selection of five elite

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plants with the largest root, high content of rubber and inulin from the group of early-ripening plants. Elite plants are used for cloning by root cuttings.

As is well-known, cuttings are clones of the parent plant. A clone is the offspring of a single vegetatively propagated plant.

Stage 2. Cloning of elite plants by roots cuttings on isolated plots. The organization of cloning nurseries of elite plants**.**

Stage implementation and results: Cutting the root of each elite plant, obtaining roots cuttings (cuttings of one elite plant form a family) → Planting of cuttings (clones) into the soil by families in isolated compartments of the greenhouse → Obtaining of a vegetative offspring of elite plants → Selection of the best forms within each family: early-ripening, with a large root and a high content of rubber and inulin. Rejection of forms that do not meet the selection requirements → Repeated isolated cloning of the best plants of each family on isolated open-ground plots with the same ecological background → Testing of plants in comparative tests with the control to confirm the selective advantages of the clone → Transfer of large plants with the high content of rubber and inulin to the nursery of elite plants.

Theoretically, there are no genetic differences between plants of the same clone. However, in the nursery, there are differences in the rate of the development of plants of the same clone, which depend on the weight of the cuttings, the supply of nutrients, as well as the root segment of the parent plant which the cuttings were taken from: basal, middle, lower part of the main root, the branching segment.

Plants from seeds grow very slowly in the first 1.5 months, whereas the root cuttings grow 4–5 times faster in the soil than plants from seeds.

Stage 3. Organization of a nursery of elite plants – a source of elite seeds.

Stage implementation and results: Combining of the vegetative offspring of all families on one open-ground plot → Cross-pollination of plants and obtaining of elite, "conditionally varietal" seeds → Transfer of elite seeds to the selection program for creating an early-ripening variety, as well as to the farms of kok-saghyz industrial cultivation → Conclusion of an agreement and act of acceptance of the seeds.

Cross-pollination of vegetative offsprings of different genotypes (different families) of kok-saghyz was carried out to preclude possible genetic erosion — loss of genetic diversity.

Discussion

In this study, the principles of clone selection of the rubber tree *Hevea brasiliensis* for plantations in tropical countries of Southeast Asia were applied for the first time to clone selection of the early-ripening kok-saghyz for use in the temperate zone of the South-East Kazakhstan.

As is well-known, the rubber tree plantations are created using material of a seed origin (seedlings and saplings). However, the seeds used for the production of planting material have a

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selective origin. To obtain it at the first stage, the best plants are selected from natural populations by their phenotype, which is adequate for the selection of select trees. In order to identify genetically best plants, the selected samples are propagated vegetatively, and the resulting vegetative offsprings are tested in comparative trials. The best of the tested samples (whose selective advantages have been confirmed) are used to create a seed plantation which serves as a source of seeds for the production of planting material for industrial plantations [**26**].

Using the technology regulation for obtaining the rubber tree seed plantations as a model, regulations for obtaining seed material of the early-ripening kok-saghyz for cultivation as an annual crop in the South-East Kazakhstan were developed.

Clone selection is successfully used for breeding new varieties based on both hybrid material and existing varieties. The offspring of the single best clone, provided it meets all the requirements during trials and reproduction, becomes an agricultural variety [**27**].

In this paper, a clone selection of the early-ripening kok-saghyz was carried out. The seeds of the cloned elite kok-saghyz plants were assigned to the "conditionally varietal" selection category. Varietal seeds can be obtained at experimental plots after the state variety testing.

Conclusion

In the climate conditions of the South-East Kazakhstan, individual plants of introduced kok-saghyz complete their biological maturation, having high biomass as early as in the first year of cultivation. In the second year, the yield of root, rubber and inulin of early-ripening plants does not increase, which eliminates the need to cultivate the early-ripening kok-saghyz according to the traditional biennial crop procedure.

Clone selection of early-ripening forms of kok-saghyz was carried out, the regulations for obtaining "improved" seeds of the early-ripening kok-saghyz for cultivation as an annual crop in the South-East Kazakhstan were developed, tested and recommended for use.

Introduction of the early-ripening kok-saghyz into crop production reduces production costs for its plantation cultivation.

Declarations

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Conflicts of interest: The author has no conflicts of interest to declare.

Availability of data and material (data transparency): Data are available from the author on reasonable request.

Code availability (software application or custom code): No code or software application has

been used in this study.

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[2] Author's certificate No. 641 is certified by Uteulin KR, Zhambakin KZh, Rakhimbaev I on the variety of "Saryzhaz" kok-saghyz of the Institute of Plant Biology and Biotechnology of the Science Committee, Ministry of Education and Science of the Republic of Kazakhstan. September 13, 2017.

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