Bioresource potential of sea buckthorn phytocenes in the conditions of Southern Siberia

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Abstract. The work presents the results of a long-term analysis of the resource potential of sea buckthorn phytocenoses of Tuva growing in arid conditions of Southern Siberia. The biological potential of sea buckthorn, which has environmental, consumer and economic significance for the region, has been identified. Also, up to 95.0% of the area of sea buckthorn in the natural environment was identified in Tuva. Plants growing in natural and artificial conditions have different yield indicators. On the economic side, products are presented in the form of additional income for the population. The growing conditions that form fruits depend on the ecological state of the plants. We conducted our research within the Republic of Tyva, an economically underdeveloped territory of Southern Siberia. The growing conditions are not similar in characteristics. In total, sea buckthorn grows in its natural environment in 12 administrative divisions of the district. Options for artificial phytocenoses in the Botanical Garden of Tuva State University, grown in dry steppe conditions, require intensification and adherence to correct agricultural technology. When grown in agroecosystems, constant watering of the plants is required in the first half of the growing season. To increase, most fully realize and protect the bioresource potential of sea buckthorn in the conditions of Tyva, it is advisable to carry out work on growing sea buckthorn and recommendatory types of work have been proposed.

1 Introduction

The distribution area of *Hippophae rhamnoides L.* is considered huge, covering the sea cliff of England, the mountainous parts of Western Europe, the coast of the North and Baltic seas, further across Siberia and to the Far East [1, 8]. Sea buckthorn stretches across the Urals across Siberia, growing in the Tien Shan Mountains, and extends to the Far East [2]. In Siberia, the largest areas of natural sea buckthorn phytocenoses have been identified in Tuva, Buryatia, and Altai [4].

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A thorough study of the properties of the plant was carried out and satellite mapping of the area under sea buckthorn was carried out. The plant has enormous ecological value in addition to its economic utility [9].

Based on the introduction and selection of sea buckthorn in northern conditions, it was established that the successful introduction of sea buckthorn to the European North of Russia is possible only through breeding work aimed at obtaining local, resistant varieties of this valuable plant; 4 hybrid forms were also created, characterized by high winter hardiness and large-fruited and stability of fruiting [3].

The above speaks to the need to study them and assess the prospects of their products for use in a market economy. Growing conditions for sea buckthorn in the river valley. Kosh-Terek Tuva Autonomous Soviet Socialist Republic [7].

In the Tuva Autonomous Soviet Socialist Republic, an agricultural experimental station dealt with the issues of growing sea buckthorn. Research Institute of Horticulture of Siberia named after. M.A. Lisavenko had a business partnership with the Biysk forestry technical school and the Sibirsky state farm, where scientific proposals and forecasts of the institute's employees are tested on large areas under production conditions [6].

The most important indicator of the biological activity of the fruits of *Hippophae rhamnoides L.* is their high content of vitamin C, which is equivalent to the fruits of rose hips and black currants [10].

Typical habitats were classified as hilltops, sunny, shady, semi-shaded and semi-sunny hillslopes. In various habitats, the relationship between water and plant productivity is related to the value of transpiration. The average transpiration in the 5 habitats was ordered and the difference between diffusivity and transpiration was noticeable, and the same relationship was found between relative humidity and transpiration [15].

Temperature stress causing various physiological reactions in male and female bushes has been studied. The differences between dioecious plants according to physiological, ecological and biochemical characteristics under conditions of environmental stress associated with changes in temperature, respiration, water and habitat are also summarized. In different habitats, male and female individuals have different adaptive capabilities [14].

It was studied for its chemical components, pharmacological activity and use. To identify quality control and establish quality standards that would contribute to the rational exploitation of its resources and improve the healthy and sustainable development of the sea buckthorn industry [13].

H. rhamnoides L. has been scientifically analyzed and many of its traditional uses have been established through several biochemical and pharmacological studies [13].

In Siberia, the largest areas of sea buckthorn phytocenoses have been identified in Tuva, Buryatia, and Altai. It is a typical hygro-mesophyte. It reproduces abundantly by root suckers. The highest density is observed in young thickets. One trunk lives up to 25-30 years, which is considered a short life cycle. Fruiting and the ability to reproduce by root shoots decreases by the age of 18. The long life cycle of one individual clump is 60-70 years. In total, sea buckthorn in the arid conditions of Tuva grows in 12 of 17 administrative divisions adjacent to the territories of settlements in geographically remote areas [5].

The main goal was to find out the bioresources and potential of *Hippophae rhamnoides L.* in natural and artificial phytocenoses of Tuva, which has bioeconomic significance. Determine the functional role of species diversity of forest stands and their condition, systematize and analyze representative data.

2 Materials and methods

Objects and materials include natural and artificial sea buckthorn phytocenoses of Tuva growing in arid conditions of southern Siberia. The study of natural sea buckthorn phytocenoses on the territory of the Republic of Tyva was carried out using the method of expeditionary route surveys using generally accepted methods of geobotany. The basis of research methods and geobotanical description of the area were carried out based on materials from Tropova (2014) [6].

Bioresources, potential and bioeconomic significance of *Hippopha erhamnoides L.* were carried out according to Chuikina (2012) [6].

Data processing was carried out using tabular methods. The results were processed using statistical methods of analysis of variance. The experimental data were statistically processed using the methods of dispersion and correlation analysis using the Excel and SNEDECOR application package according to Sorokin (2004), and the indicators of variation statistics for the data array were also determined [12].

A complex of field and laboratory surveys was carried out using forestry methods [8].

Analysis of cenoflora syntaxa was carried out using traditional floristry methods. Sea buckthorn phytocenoses were conventionally divided into three areas according to their place of growth. The size of test plots to identify the floristic composition of phytocenoses was determined experimentally, using a mini-area with natural boundaries on an area of 25 m^2 in three test plots in the natural environment and in artificial phytocenoses.

3 Results

Studies of sea buckthorn phytocenoses were carried out at the mouths of rivers in the Tuva Basin on wing-feather grass zonal steppes, occupying an intermediate position between extremely arid desert steppes and more humid large-turf grasslands. In total, sea buckthorn grows in the natural environment in 12 administrative divisions of the district.

The work was carried out within the Republic of Tyva, an economically underdeveloped territory of Southern Siberia. The areas of work carried out differed in natural and anthropogenic features. In them, priority forms of economic development of territories are associated primarily with cattle breeding, which is considered a type of agro-industrial development. Variants of artificial phytocenoses are located in the Botanical Garden of Tuva State University, an educational experimental field and an agrobiological station. The growing conditions are not similar in characteristics. Correlation analysis revealed a significant moderate inverse relationship between the number of sea buckthorn shoots and the number of perennial herbaceous vegetation competing with it.

The total area of natural phytocenoses was more than 4000 hectares. The largest phytocenoses were identified in the Tes-Khem, Ulug-Khem and Duzun-Khemchik regions. Sea buckthorn grows in large dense thickets, clumps, stripes, groups and individual bushes with a ratio of female to male forms of 3:1 in floodplains and on river terraces together with *Salix glauca L., Betula microphylla Bunge and Betula pendula Roth. (Betula verrucose Ehrh.), Populus caprifolia (Ledeb.), Caragana frutex L., Rosa canina L.* Mature bushes and their shoots grow in association with grass-legumes and horsetail perennial plants. The growing season of sea buckthorn lasts 166-168 days: the period of bud bursting is noted in the third ten days of April, the beginning of flowering is in the third ten days of May, the ripening of fruits is in the first ten days of September, the leaf fall is in the second ten days of October, i.e. somewhat later than in Western Siberia.

Generalized long-term data on the morphological and production characteristics of sea buckthorn on the territory of the Republic of Tyva and analyzes showed that sea buckthorn phytocenoses are characterized by significant diversity according to a set of characteristics:

- According to plant height records, sea buckthorn similar to the Altai ecotype grows in Tyva: the limit of variation was 1.8-2.1 m versus 1.8-3.0 m in Altai. Tall specimens 6-7 m, especially among male forms, are recorded both in Tyva and Altai. In general, these parameters correspond to standard sizes and do not differ from the new ecotype.
- Analysis of the morphological parameters of sea buckthorn shoots and leaves in Tyva indicates that their parameters are also close to the Altai ecotype. Thus, the size of sea buckthorn leaves in Tyva is characterized by limits of 4-7 × 0.4-0.6 cm versus 5.5-8 × 0.8 in Altai and 3.3 × 0.5 cm of the ecotype growing in these conditions (we I wanted to name and name the Khemchik ecotype). The shape of the leaves in Tyva is lanceolate, the color is light and dark green above, silver below, as in other regions.
- Comparison of the length of sea buckthorn spines (2.8-4.3 cm) in the conditions of Tyva and the Altai Territory (2-4 cm) also indicates the similarity of their average size. The thorniness of sea buckthorn and the new ecotype is not significantly different - the size is 3.5-4.5 cm.

Based on the morphological characteristics, the sea buckthorn of natural phytocenoses of Tyva should be classified as an ecotype (subspecies) *mongolica*.

The weight of 100 sea buckthorn fruits showed a significant variation in the average indicators across survey sites - from 9 g (floodplain of the Torgalyg River) to 20.9 g (floodplain of the Tes-Khem River), or 2.3 times. Absolute indicators for individual cenoses varied by 33 times in terms of the weight of 100 fruits, indicating significant biological diversity. The fruits of sea buckthorn in the phytocenoses of Tyva were predominantly ovoid and spherical in shape, orange and orange-yellow or orange-red in color; there are elongated fruits of orange-red color.

The obtained indicators indicate the characterizing diversity of the complex of characteristics: plant height up to 6-7 m, morphological parameters of shoots - elongated twisted and leaves within 3.3x0.5 cm, and sometimes up to 6.7x0.7 cm, length of sea buckthorn spines up to 3.5-4.5 cm. The identified and distinctive features from other ecotypes are significant and we wanted to name the sea buckthorn growing in the Tuvan basin Khemchik ecotype.

The influence of natural and anthropogenic environmental factors on the state of natural sea buckthorn phytocenoses indicates a different influence of the degree of impact. Negative environmental anthropogenic factors have a weak impact in the form of fruit collection by breaking off branches on the sea buckthorn forests of the Chedi-Kholsky region. The total effect of three negative factors has not been identified; they are presented in the form of livestock grazing, growth near a highway, and the impact of spring fires. The influence of anthropogenic and natural factors leads to a decrease in the degree of self-healing of plants. Weak and strong degrees of influence of anthropogenic factors were identified on the sea buckthorn forests of the Ulug-Khem region. A strong degree of influence of anthropogenic and natural factors has mostly been identified in the sea buckthorn forests of the Dzun-Khemchik and Tes-Khem regions. The degree of impact of environmental factors: natural fire, anthropogenic factors, grazing, Chedi-Kholsky highway.

The most intensively natural phytocenoses of sea buckthorn are subject to the negative influence of the anthropogenic factor (trampling, breaking off branches when collecting fruits) in the floodplains of the Chata River in the Ulug-Khem region, Chyrgaki - Dzun-Khemchik region and Tes-Khem in the Tes-Khem region. Cattle grazing, and therefore severe trampling of sea buckthorn, has been recorded in the floodplains of the Chyrgaki rivers in the Dzun-Khemchik region. The total negative impact from visits to sea buckthorn by humans and animals was approximately equal.

The negative technogenic impact on the realization of the bioresource potential of sea buckthorn was most significant in the floodplains of the Chata and Tes-Khem rivers of the Ust-Khem and Tes-Khem districts, respectively, and was due to

a highway lined with sea buckthorn trees.

When assessing the total of 90 possible indicators under the strong influence of anthropogenic and natural factors, the total effect of negative factors reached 52, which amounted to 57% of the actually possible indicators. Natural factors of biotic (diseases, pests) and abiotic (fires) origin had a significant negative impact on the ecological state of sea buckthorn.

Diseases and pests caused significant damage in the floodplains of the Chyrgaky and Tes-Khem rivers, respectively, in the Dzun-Khemchik and Tes-Khem districts, and fires - in the floodplain and along the banks of the Torgalyg rivers in the Ust-Khem district and Tes-Khem in the Tes-Khem district, where the most significant tracts of sea buckthorn.

Sea buckthorn self-healing processes have been identified in all areas, but especially intensively, with the formation of up to 70 shoots/m^2, they occur in the floodplain of the Chyrgaki River in the Khemchik region, despite the negative effects of a number of natural and anthropogenic factors.

Analysis of soil samples from sea buckthorn plots with different restoration intensities showed that these processes were better on relatively fertile chestnut soils with a humus content of 3.5%, total nitrogen NO_3 0.42%, mobile forms of P_2O_5 20 mg/kg, K_2O - 181 mg/kg at pH 7.2.

Slow self-regeneration of sea buckthorn (no more than 20 shoots/m^2) was noted in the floodplains of the Elegest River in the Chedi-Khol region and the Shagonar River in the Ulug-Khem region. Observations have shown that this is largely due to the competitive ability of perennial cereal-legume grasses, which suppressed the development of sea buckthorn shoots, with reduced soil fertility and the unfavorable effect of a complex of natural and anthropogenic factors.

The main (about 70%) areas of sea buckthorn phytocenoses in Tyva are at the age of 5-15 years - the period of stable maximum fruiting, and therefore natural sea buckthorn can be considered as the main source of raw materials for the developing processing industry and consumer needs of the population.

Generalized data from regional forestry enterprises and the results of our own surveys on long-term dynamics of sea buckthorn yields show the variation in sea buckthorn yields in individual areas during the years of research ranged from 0.5 to 6.8 kg/bush, or almost 14 times. At the same time, the average range of variation across sites over the years was within 2.6 times, and on average over the years of research across sites - 3.5 times. The variation was due to weather conditions, which for months VI-X changed in average air temperature by 2.7 times (from 5.6ºC to 14.5ºC), and in average monthly precipitation by 6.6 times (from 8.7 to 57.0 mm). The warmest years were 1998 and 2000, and the wettest were 1996 and 1997.

The average sea buckthorn fruit yield over 30 years in four areas was 3 kg/bush with a plant density of 500-1000 ind./ha. Consequently, the biopotential of sea buckthorn in the natural phytocenoses of Tyva is realized at a level of 1.5 to 3 t/ha. The maximum realization of potential at the level of 6-7 t/ha was observed only in 5.5% of dense phytocenoses.

4 Discussion

In natural phytocenoses at river mouths, the impact of floods is detected in the form of spring floods, which reduce growing conditions, despite self-recovery observed annually. Types of anthropogenic impact on forest plantations as a result of livestock breeding have been identified in sea buckthorn phytocenoses. Domestic livestock activities lead to degradation of the grass cover, destroying sandy loam soil and trampling undergrowth. Correlation analysis revealed a reliable moderate inverse relationship between the number of its shoots and the number of perennial herbaceous vegetation competing with it: $r = -0.435 \pm 0.137$. The maximum height of sea buckthorn bushes on site 1 coincided with the highest content of humus in the soil here - 1.4-1.6 times higher compared to other sites and especially the second site.

On plantings created in dry steppe conditions, intensification and adherence to technological methods of agricultural technology are required. The growing season in the risky farming zone of Tuva had a very dramatic impact on the formation of the yield of varieties, drought and short-term dust storms, requiring constant irrigation or watering in the first half of the growing season.

Since 2023, they began to create plantings based on Altai, Minusinsk, and Biysk varieties in several administrative divisions of the district. An increase in the area of artificial sea buckthorn phytocenoses will contribute to the formation and creation of sustainable development and production of sea buckthorn in conditions more similar to natural phytocenoses.

5 Conclusion

Thus, the results obtained show that in this area, in natural and artificial phytocenoses at the mouth of rivers, in dry steppes, the variation in the species diversity of plants growing in sea buckthorn contributed to the variation.

Use the identified sea buckthorn gene pool of natural phytocenoses to create varieties with a high content of oil and vitamins, harvesting fruits for the production of sea buckthorn oil in the ripening phase, vitamin C in the fruit growth phase, carotenoids in the ripening phase in areas without flooding.

To increase, most fully realize and protect the bioresource potential of sea buckthorn in the conditions of Tyva, it is advisable to work in the following directions:

- Expansion and compaction of the areas of natural sea buckthorn phytocenoses by sowing seeds on an area of about 4 thousand hectares to increase the density of bushes from 1.0-1.25 to 2.5 thousand ind./ha. The organization of a seed farm is first necessary. In addition to significantly increasing the bioresource potential of sea buckthorn, this will contribute to the ecological well-being of forest fauna, reproduction and increased activity of insectivorous birds and entomophages to reduce the number of pests, limiting and eliminating the use of insecticides.
- Organization of institutions and farms for growing planting material of modern, adapted to the conditions of Tyva, varieties of sea buckthorn for various purposes, depending on the direction and purpose (dietary and baby food, production of sea buckthorn oil, herbal teas, additives for animal feeding), as well as the use of fruits in fresh form, the use of sea buckthorn in the design and arrangement of dachas, landscapes, reclamation of erosion-hazardous lands.
- Preservation and protection of phytocenoses from a complex of unfavorable environmental factors: natural (pests, diseases, fires), anthropogenic (violation of fruit harvesting technology, trampling of sea buckthorn by people and during grazing, location of highways near large tracts of sea buckthorn).

Statistical processing of data indicates a significant variation in characteristics, characterizing the biological diversity of *Hippophae rhamnoides L.*, which is a bioresource.

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