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The Importance of Establishing Forest Plantations in the Aral Sea Region for Biodiversity Restoration, Food Security, and Improvement of the Ecological-Meliorative Condition of Soils

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Abstract

Since the 1960s and 1970s, the improper distribution and misuse of water resources in the region, the intensification of cotton monoculture, the large-scale development of deserts and the emphasis on extensive farming, the failure to plant crops that require less water and are resistant to salinity in these regions, as well as a global environmental problem, the tragedy of the century, the drying up of the Aral Sea, which once softened the climate of the region by softening the Arctic cold air masses in the winter and the hot and warm air masses coming from the Iranian regions in the summer, have had irreparable negative consequences, leading to the transformation of the region's soil cover, the loss of biodiversity, the transition of soil formation processes from hydromorphic to automorphic, and the intensification of degradation and desertification processes. The main direction and goal of the scientific research carried out in the region is to mitigate the consequences of the above-mentioned negative factors. At the same time, it is to convey to producers and farmers that planting phyto-ameliorative crops that are resistant to salinity and require less water in these regions is of great importance in ensuring the country's food security. This article examines the intense processes of drought, desertification, and degradation of soils and plants; the negative changes in the vegetation and soil cover of the Aral Sea region; plants suitable for cultivation in this region; their morphological structure, biology, and characteristics; agricultural technologies for growing these plants; the importance of these plants for improving the ecological reclamation of desert territories; as well as measures to reduce soil degradation; the acclimatization of crop species recommended for planting in these regions to obtain high-quality, environmentally friendly products, such as alfalfa, white sorghum, barley, and other crops; as well as the planting of tall shrub trees to reduce the amount of dust-salt mixture rising into the atmosphere from these regions, including white saxaul, black saxaul, kandim, cherkez, soap tree, and yulgun. Research on the cultivation of turangil and other trees is also considered. At the same time, given the large land areas in these regions, scientific research is being conducted on restoring biodiversity, rationally using plant and water resources, selecting saline and low-water crop species, planting them in these regions, and obtaining high yields from them.

Keywords

The Aral Sea, Soil Salinization, Fertility, Water Resources, Degradation Problems, Desertification, Saxaul Formation, Agriculture, Crop Rotation Systems, Meliorative, Agrotechnical, Biological, Forest-Meliorative Measures, Wind Erosion

1. Introduction

In general, in the research conducted by us in these regions, the leadership of our country planned to plant saxaul trees on large areas of the dried-up bottom of the Aral Sea, a plant that is resistant to desert zones and droughts, requires little water, and at the same time effectively uses groundwater. In 2018-2019, this figure was approximately 500 thousand hectares of saxaul and other desert plants. In 2021-2022, another 700 thousand hectares of land were greened. As of 2019, saxaul seeds were sown on 363 thousand hectares of land. In general, as a result of different years, saxaul planting was carried out on about several million hectares of land in Uzbekistan. We, scientific researchers, are also contributing to these processes. As a result of scientific research, it was found that saxaul has a strongly developed root system that penetrates deep into the soil. The ability of a 4 - 5-year-old saxaul tree to retain up to 4 - 5 tons of sand and salt mixture around its root system, and an 8 - 10-year-old saxaul tree to retain up to 10 tons of sand and salt mixture around its roots, depending on the age of the tree, has been confirmed once again in scientific research [1].

Today, more than 1 - 2 million hectares of land are planted with saxaul and desert plants, the main goal of which is to reduce sand and salt storms, improve the ecological situation in this region, stabilize the soil and plant cover of the Aral

Sea region, etc.

One of the greatest tragedies of the 20th century, the drying up of the Aral Sea, has led to the deterioration of the health of the population in the Aral Sea regions, the deterioration of the ecological situation, secondary salinization of the soil, the degradation of the lands in the agricultural working capital and their withdrawal from the agricultural working capital, the decrease in soil fertility, and the disruption of the ecological balance. Global climate change, drought, improper distribution and shortage of water resources, changes in the critical depth of the groundwater level, and frequent sandstorms in these regions have led to the deterioration of the ecological and reclamation state of the soils. As a result, it is of great importance to implement comprehensive measures to improve the soil and plant cover in the Aral Sea regions and to preserve biodiversity. To improve the level of soil salinity, it is recommended to apply phytoremediation measures in these regions, first of all [2].

These include the construction and reconstruction of collector-drainage systems to lower groundwater levels and prevent salts from rising to the soil surface. In addition, leaching irrigation practices are conducted to remove harmful salts from the root zone [3].

One of the methods of rational use of water resources is the introduction of water-saving technologies such as drip, sprinkler, and subsurface-root irrigation, which not only saves water but also reduces secondary salinization of the soil. Full compliance with irrigation standards and water quality control helps stabilize the ecological and reclamation state of the soil. At the same time, another important direction is the improvement of agrotechnical measures.

The scientific and practical introduction of crop rotation systems, the cultivation of crops that are resistant to salinity and require less water, and the moderate use of organic and mineral fertilizers directly increase soil fertility. Fertilizers rich in organic matter improve soil structure and increase soil biological activity. In addition, the establishment of protective forest groves and the formation of green covers are of great importance. Planting water- and salinity-resistant plant species adapted to growing in the desert, such as saxaul, kandim, tamarisk, and Circassia, strengthens the soil and prevents the migration of salt and sand. Consequently, this process reduces wind erosion and prevents dust and salt storms, and in turn improves the ecological stability of the soil. Along with the above, another important measure is biological phytomelioration. In a natural way, increasing soil fertility is achieved by planting green manure or siderate crops and plants that fix nitrogen in the soil. Activation of microorganisms in the soil reduces the amount and negative effects of toxic salts. At the same time, constant observation and monitoring, as well as scientific research, are required. Continuous monitoring of the level of soil salinity, chemical composition, and moisture content of the soil allows the development of land reclamation measures appropriate to the area. The practical application of scientific research results requires the implementation of comprehensive measures to improve the ecological and reclamation status of soils in the Aral Sea region, as well as to improve the reclamation, agrotechnical, and biological status of soils and vegetation in these regions. These comprehensive measures ensure the sustainability of agriculture by restoring, preserving, and protecting soil fertility and play an important role in mitigating regional environmental problems. The significance of establishing forest plantations in the Aral Sea region for biodiversity restoration lies in the fact that the drying of the Aral Sea has caused one of the largest ecological crises in Central Asia. The drying up of the Aral Sea, secondary salinization of the soil, the rise of dust-salt mixtures into the atmosphere under the influence of strong winds, the recurrence of storms throughout the year, and sharp changes in the climate have led to a decrease in biodiversity and the extinction of plants in this region [3].

2. Materials and Methods

Today, the establishment of forest plantations has become a key tool for restoring ecological stability, protecting the environment, and meeting the population's food needs. In the Aral Sea region, forest plantations are mainly used with desert-adapted trees and shrubs, such as saxaul, kandim, cherkez, and yulgun. These species are adapted to saline and arid soils, reduce soil erosion, prevent sand and dust movement, and improve the microclimate. As a result, natural habitats for plants and animals gradually begin to recover. The establishment of forests, along with improving the ecological environment and restoring biodiversity, leads to an increase in plant cover, a source of food for birds and all mammals, the restoration of natural ecosystems, and the gradual stabilization of biological balance. At the same time, the green covers created in the Aral Sea region have a positive effect on the environment, human health, and socio-economic conditions. The reduction of dust and salt storms improves human health and creates new jobs in forestry. The establishment of forests in the Aral Sea regions ensures the preservation of ecological balance, restoration of biodiversity, and sustainable development. The Role of Forest Plantations in Ensuring National Food Security. The crisis caused by the drying up of the Aral Sea has not only caused environmental problems, but also had a serious negative impact on agriculture and food security. Soil salinization, water resource shortages, dust, salt, and sand storms reduce soil fertility and crop yields. The creation of forests on the dried-up bottom of the Aral Sea and its surroundings plays a strategically important role in ensuring national food security. Forest plantations consisting of trees and shrubs adapted to hanging in the desert zone, such as saxaul, kandim, yulgun, trurangil, and cherkez, prevent sand drifts under the influence of the wind. As a result, this prevents the degradation of agricultural land and, while creating favorable agroclimatic conditions for crops, preserves soil fertility and creates the basis for obtaining sustainable, environmentally friendly products. Moreover, forests enhance efficient use of water resources by increasing soil moisture retention, maintaining groundwater balance, and reducing salinization of irrigated lands. The above factors are very important for agricultural production, and the establishment of afforestation is of great importance for the development of livestock. Steppe plants serve as the main source of feed for livestock and reduce the degradation of pastures. It stabilizes the production of dairy and meat products. Afforestation provides employment for the rural population, creates wide opportunities for agriculture, and creates sources of income. Activities related to forestry, such as seed production and selection, and seedling cultivation, create additional economic opportunities [4].

3. Results

Recommended Tree and Shrub Species for the Aral Sea Region. White or Sand Saxaul (*Haloxylon persicum*). In recent years, large-scale efforts have been undertaken to establish green cover on the dried seabed of the Aral Sea, involving forestry enterprises across Karakalpakstan and other regions. Saxaul is a desert plant whose natural range covers desert and semi-desert zones. In Central Asia and Kazakhstan, saxaul forests cover approximately 20 million hectares, nearly half of which are located in Kazakhstan, while Turkmenistan and Uzbekistan each account for about one quarter. In Turkmenistan, saxaul forests occupy 94.1% of the forested area, while in Uzbekistan this figure reaches 64%. In terms of wood reserves, saxaul is second only to juniper forests. Due to its well-developed root system, the saxaul tree is considered the most convenient and useful plant for strengthening sands. This prevents the movement of sand and creates favorable conditions for the growth of other desert plants. White saxaul—Galoxylon persicum—is a shrubby tree, usually up to 2 - 3 m high, and in some cases up to 5 - 6 m high [5]. Saxaul does not form true leaves. Organic matter in the saxaul plant accumulates in newly formed shoots. The root system is not dependent on groundwater; the main root penetrates to a depth of up to 6 m. The wood is dense, heavy, brittle, and sinks in water, making it unsuitable for construction but highly valued as fuel and charcoal. White saxaul blooms for 5 - 7 days in March-April. Fruits mature in September-October and are dispersed by wind. Seed viability declines rapidly, and regeneration occurs both by seeds and vegetative root shoots (**Figure 1**).

Figure 1. A ship graveyard on the dried-up bottom of the Aral Sea.

Black Saxaul (*Haloxylon aphyllum*). Black saxaul is highly resistant to saline and sandy soils and requires minimal water. It is one of the most effective forest-forming species on the dried seabed of the Aral Sea. It grows on saline deserts, sour soils, and saline sandy and gray soils, performing critical functions such as soil protection, sand stabilization, and pasture conservation. Black saxaul Galoxylon aphyllum is one of the largest desert plants, growing up to 12 m tall, and its wood is dense and strong [3]. The plant has variegated leaves, and its buds open in February. Black saxaul produces small yellow flowers and winged fruits. The root system penetrates deep into the soil layer and spreads widely through the soil layers. Young saxaul plants grow very quickly. Growth Characteristics and Ecological Significance of Key. Seedlings of black saxaul in the first year reach a height of 25 - 30 cm (sometimes up to 120 cm), while stump shoots may grow up to 1 m. At the age of 6 - 10 years, black saxaul reaches a height of 5 - 7 m, with a trunk diameter of 25 - 30 cm. At 25 - 30 years of age, black saxaul can grow up to 8 - 11 m in height, and the trunk diameter reaches 40 - 50 cm [3].

Plant Species Recommended for the Aral Sea Region. Calligonum (Calligonum spp.) grows very quickly even on sandy and highly saline soils. It is very resistant to wind erosion, is very effective as a hedge tree, and partly serves as fodder for livestock. Calligonum belongs to the Polygonaceae family, which includes about 90 species in Central Asia. This plant is mainly distributed in desert ecosystems, and the height of the plant ranges from 50 cm to 3 m. The fruit is dry. The winged achene has 4 - 8 wings, and the number of stamens is 12 - 18. Leaves are arranged alternately and shed quickly. Leaves are considered reduced and inconspicuous, ribbon-shaped, 5 - 7 mm in length. Flowers are white, small, and fragrant, while the wood is hard. In Uzbekistan, kandym species are mainly found in the Kyzylkum Desert and Central Fergana sands, including black kandym (*Calligonum aphyllum*), gray kandym (*Calligonum eriopodum*), white kandym (*Calligonum junceum*), red kandym (*Calligonum caput-medusae*), and others [3]. Kandym species are primarily planted to stabilize shifting sands. Some species contain tannins and alkaloids. Kandym is grazed by livestock, used as an ornamental plant, and utilized as fuelwood. The average lifespan of kandym is about 25 years.

Cherkez (Salsola spp.) is adapted to grow in very saline soils, is drought-tolerant, is used to strengthen the soil cover, and slows down desertification processes. Salsola richteri belongs to the Chenopodiaceae family and is found as a large shrub or small tree in the sandy deserts of Iran, Afghanistan, and Central Asia. It grows up to 4 m in height and is distinguished from other desert plants by its thin, almost fibrous leaves, 4 - 8 cm long. Bracts are equal to or shorter than the flowers; flowers are inconspicuous, with a simple, five-lobed perianth. Flowering and fruiting occur from June to September. This species is widely distributed in sandy areas of Uzbekistan. Cherkez is considered a valuable fodder and medicinal plant. It is used to stabilize mobile sands. Its forage is nutritious; medicinal substances are obtained from the fruits, dyes from fresh leaves, and soap is produced from its branches. It reproduces by seeds [6].

Tamarisk (Tamarix spp.) grows well in saline soils and areas with shallow groundwater levels. It effectively traps wind and dust and is widely used in the establishment of protective forest belts. The genus Tamarix (family Tamaricaceae) includes shrub-like or small tree species. More than 60 species of tamarisk are known worldwide, mainly distributed in Africa and Eurasia. In the Republic of Uzbekistan, there are more than 10 species, the most common of which are *Tamarix elongata*, *Tamarix ramosissima*, and *Tamarix hispida*. These species are widely distributed in river valleys, saline lands, deserts, as well as in natural landscapes and semi-deserts. Tamarix is distinguished from other desert plants by its high resistance to salinity, soil purification, and ecological significance. Morphologically, yulgun is a deciduous shrub or small tree reaching 2 - 10 m in height. The stem is thin and has many branches and spreading branches, and the leaves are needle-like, small, coin-shaped, and densely arranged along the branches. There are salt-secreting glands on the surface of the leaf, which secrete excess salts and increase its resistance to salinity and water shortage. The flowers are small, pale pink, white, or purple, and are located in panicle-shaped inflorescences. The flowering period usually begins in May and continues throughout the summer. The fruits are capsules, with hairy seeds that are dispersed by the wind.

The olive tree (*Elaeagnus angustifolia*) is a shrubby tree with fragrant yellow flowers and silvery leaves, valued for its sour and sweet fruits. The fruits of the olive tree are widely used in traditional medicine. The leaves are widely used to treat gastrointestinal diseases and wounds. Due to the antique color of its seeds and fruits, this olive tree also has decorative properties. The olive tree is a low, thorny tree with silvery branches and small, narrow leaves, sometimes reaching a height of 3 - 7 m. It blooms in small, fragrant, yellow flowers in May-June. The fruits are oval, reddish-yellow, edible, starchy, and sweet-sour in taste, and ripen in autumn. The fruits are eaten and are widely used in pharmaceuticals. In medicine, decoctions of the fruits and leaves are used against diarrhea and gastrointestinal diseases, and fresh leaves are used to treat wounds. The fruits are rich in vitamins and sugars, especially ascorbic acid.

Olive oil contains important nectar, which attracts bees and serves as a source of valuable honey, and grows very well on saline, low-fertility, dry, sandy soils and along river banks. The plant is important for its frost resistance to −29˚C, resistance to salinity, waterlogging, and drought, the presence of nodular bacteria in its roots, which increases soil fertility as a result of the absorption of atmospheric nitrogen, and its use in the food industry has medicinal properties.

Planting alfalfa in the Aral Sea region improves the soil-reclamation condition. Alfalfa (Medicago spp.) belongs to the Fabaceae family and includes annual and perennial grasses. Alfalfa is a phytoamelioration plant, characterized by its salt tolerance and its importance as a major forage crop for livestock. Approximately 100 species exist, with blue alfalfa being the most widespread in Central Asia. Alfalfa has been cultivated in Central Asia for 3000 - 5000 years. Its origin is Iran, from where it spread approximately 2000 - 2500 years ago to Greece, Ancient

Rome, and North Africa. Alfalfa is a cultivated and nutritious crop widely distributed in North and South America, Australia, and Europe. In the Caucasus region and Central Asia, alfalfa is the main crop in crop rotation systems. Alfalfa has a highly branched stem, and the height of the plant reaches 70 - 150 cm. The leaves are trifoliate and have a complex structure, with small petioles at the base of the stem. The color of the leaves ranges from light green to dark green, with almost round leaflets. Blue alfalfa flowers have yellow, blue, and hybrid forms that are blue-yellow. The fruit is a legume, sickle-shaped or spiral-shaped, with 2 - 3 twisted seeds. Seeds are yellow or yellow-brown, oval to kidney-shaped, small in size, with 5 - 7 seeds per pod [1]. The weight of 1000 seeds of alfalfa is from 1.8 to 2.7 g. The root system is strongly formed, highly developed, and penetrates deep into the soil layer. It penetrates to a depth of 4 - 5 m or more. The roots contain nodules of bacteria that absorb atmospheric nitrogen or nitrogen fixation, converting molecular nitrogen from the air into free nitrogen in the soil. Due to its well-developed root system, alfalfa forms 80 - 120 cm of root biomass within the plough layer during 2 - 3 years, which is equivalent to 30 - 40 tons of manure per hectare.

Based on its biological characteristics, alfalfa is a long-day plant, has a high demand for light, and is drought-resistant due to its strong root system that penetrates deep into the soil. Yellow and hybrid alfalfa varieties are significantly more cold-resistant than blue alfalfa. Alfalfa is a moisture-loving plant, and under irrigated conditions in warm climatic zones, high yields can be obtained. Alfalfa grows well in sandy and loamy soils with good air exchange and good water and air permeability, and produces high yields. Alfalfa is a perennial plant, producing high yields for 4 - 5 years. In crop rotation systems, it is usually grown for up to 3 years, and for fodder production, up to 5 years. Alfalfa is sown either as a sole crop or together with cereals such as barley and wheat in early spring using a broadcast or row sowing method [1]. The seeding rate ranges from 12 to 22 kg per hectare. Seeds germinate within 15 - 20 days and retain their germination capacity for 5 - 7 years, and in some cases up to 10 years. When sown separately in spring, alfalfa grows rapidly, forming highly branched and leafy stems in the first year, during which it flowers and produces seeds. Under irrigated conditions, alfalfa is harvested 2 - 3 times in the first year when 40% - 50% of plants are in bloom. In the second and third years, it is harvested 5 - 6 times or more at intervals of 40 - 45 days. Between harvests, irrigation is applied 1 - 2 times. Once harvested, alfalfa grows much faster than other crops and outperforms other perennial forage crops in terms of regrowth rate. Alfalfa is a highly nutritious forage crop rich in vitamins and proteins. One hundred kilograms of green biomass contain 21.7 feed units and 4.1 kg of digestible protein, while 100 kg of hay contain 45.3 feed units and 10.3 kg of digestible protein. Alfalfa hay contains 0.35% - 0.40% phosphorus, 0.25% - 0.30% calcium, and various microelements. The nutrient absorption rate of alfalfa is 70% - 80%, making it one of the most useful and productive crops in alfalfa crop rotation systems under irrigated farming conditions. For 2 - 3 years, alfalfa accumulates up to 300 - 400 kg of nitrogen per hectare in the soil, enriches the soil with organic matter, acts as a biological drainage and phyto-ameliorant, improves soil structure, and is a good predecessor crop for agricultural crops. During the growing season, it evaporates 12,000 - 15,000 m^3 of water per hectare, maintaining the critical depth of groundwater.

Licorice (*Glycyrrhiza glabra* L.) is a perennial plant belonging to the Fabaceae family and is widely distributed in the study areas. In ancient writings, Theophrastus referred to this plant as "sweet root," "Scythian herb," and "Pontic herb." In Russian, it is known as solodka golaya, in Uzbek as shirinmiya, chuchukmiya, or qizilmiya, and in the Karakalpak Autonomous Republic as buyan. Licorice has a wide distribution range, including Crimea, the Caucasus, Siberia, Asia Minor, Iran, Afghanistan, and North Africa. In Uzbekistan, licorice is considered a typical tugai (riparian forest) plant and is mainly found in the lower reaches of the Syr Darya and Amu Darya rivers. Licorice is a polycarpic perennial herb with well-developed cylindrical stems that are partially woody. The plant grows to a height of 150 to 160 cm and can grow to over 200 meters in groves. It grows to a height of 50 - 70 cm in saline soils. The leaves have an extremely complex structure, consisting of 4 - 8 pairs of leaves arranged in a row on the stem. Leaf length ranges from 11 to 18 cm; leaflets are ovate to elliptical, entire-margined, pubescent, about 5 cm long and 2.5 cm wide. Flowers are pale violet to whitish, with large, heavy stamens. The licorice plant attracts bees and other pollinating insects due to its very strong nectar production. After drying, the aboveground biomass is used as a nutritious feed for livestock; licorice contains 11% - 18% protein, 10% - 15% crude protein, 3.3% - 9.1% fat, and other useful substances. The rhizomes contain 3% - 24% glycyrrhizic acid, 11% sucrose, 34% starch, and 24% fiber, 8% glucose [1].

Glycyrrhizin is widely used in medicine, pharmaceuticals, cosmetology, and the food industry due to its anti-inflammatory, immune-supporting, and soothing effects. Licorice raw materials produced in Uzbekistan are exported to developed countries such as the United States, the United Kingdom, Germany, Japan, and Korea. The plant is undemanding to soil conditions and is particularly valuable for improving the meliorative condition of lands with shallow groundwater and secondary salinization that have been excluded from agricultural rotation. Licorice is propagated by three main methods: seeds, rhizomes, and seedlings. Seed propagation: seeds are sown on well-prepared, ploughed, leveled, and weed-free fields. Furrows are made at 70 cm spacing, and seeds are sown at a depth of 1 - 3 cm in autumn or early spring using mechanized methods. The sowing rate per hectare is 4 - 5 kg per hectare. After sowing in the field, it is watered and the soil moisture is maintained until germination. Licorice seedlings germinate at a soil temperature of 10˚C. During the growing season, the rows are cultivated and watered 8 - 10 times. The germination rate is low in saline soils, 1.5% - 2.0%. It can also be propagated from rhizomes. The rhizomes are dug up, 10 - 15 cm cuttings are prepared and planted in rows 90 cm apart to a depth of 5 - 8 cm. Seedlings are first grown on non-saline soils and then transplanted to saline areas. Survival rates reach 70% - 80%. From the 4th-5th year, industrial raw material yield is obtained. The underground biomass yield reaches 8 - 10 tons per hectare (dry matter), while fresh forage yield reaches 20 - 25 tons per hectare [7]. The harvested licorice roots are cleaned, dried, tied, and stored in warehouses for up to three years. The most effective method of propagation for economically valuable licorice plantations in the national economy is the use of rootstock and seedling propagation methods. Ferula cultivation in the Aral Sea region is of great practical importance. The Aral Sea regions are characterized by an arid climate, a large area of saline soils, and a shortage of water resources. In such extremely difficult conditions, the cultivation of environmentally friendly and economically important medicinal plants brings a lot of income to the country's economy. Ferula (Ferula spp.) is a plant that is naturally adapted to grow in desert regions and sandy areas [3].

Biological characteristics of the plant-Ferula is a perennial plant belonging to the umbrella family (Apiaceae). Since the roots of the fern are very well developed, they absorb moisture and nutrients from the deep layers of the soil. The fern plant is resistant to drought, high temperatures, and soil salinity, and grows well in hot and dry climates [2]. The fern plant grows well on sandy and sandy soils with a light mechanical composition. At the same time, it also grows well on very saline soils. Ferula reproduces primarily by seed. Seeds are sown in the fall or early spring. Natural seed stratification before sowing (exposure to cold) improves germination. Sowing is done in the fall, October-November, or early spring. Ferula plants should be planted 2 - 3 cm deep, with row spacing of 60 - 70 cm and plant spacing of 40 - 50 cm. The seeding rate is 3 - 5 kg per hectare. Care and watering: light watering is required in the first year, and practically no watering is required in subsequent years. Weed control in the first years is carried out mechanically. When fertilizing, organic fertilizers, rotted manure, and phosphorus fertilizers improve the development of the root system. Ferula uses chemicals to combat pests and diseases of the plant, and this plant is relatively resistant to diseases and pests, rarely suffering from serious diseases. Preventive agricultural practices are sufficient. Ferula (asafoetida) root resin is collected from 4 - 5-year-old plants. In order to extract the sap from the plant, the root of the ferula plant is carefully cut and the released resin is collected. When cutting the roots of the plant, it should be done with minimal damage to the plant. The ferula plant brings great economic benefits in restoring degraded lands, reducing wind erosion, and due to its medicinal properties. Ferula cultivation in the Aral Sea regions is one of the most economical and sustainable agricultural areas that is suitable for agro-ecological conditions [2].

Ulmus pumila L. is one of the promising tree species growing in the desert zone. If we pay attention to the bioecological characteristics of Ulmus pumila, Ulmus pumila is a deciduous tree belonging to the Ulmakaceae family; its height usually reaches 10 - 15 meters. The crown is wide and well-developed, and the shape of the leaves is oval, with serrated edges and a smooth surface, which distinguishes it from other desert plants. Ulmus pumila is well adapted to the sharply continental climate, withstands hot summer temperatures, withstands severe winter frosts, and is adapted to prolonged drought and water shortage. It is relatively resistant to strong winds and dust, which are widespread in the central region of Karakalpakstan [3]. Dwarf willow is undemanding of soil conditions but thrives in the following: loamy and sandy soils; soil with low to moderate salinity; and soil with good drainage. It also grows well in saline and heavy soils. Its ecological importance lies in the fact that it helps prevent wind erosion, acts as a cover for green spaces, and helps purify the air from dust and harmful gases. Vegetative propagation (by cuttings) is used. Seed preparation and storage: Seeds ripen in May-June. Collected seeds quickly lose their viability, so it is recommended to sow them fresh. Long-term storage of seeds is carried out in a dry and cool place. Sowing is recommended in early spring. The sowing depth is 1 - 2 cm, the row spacing is 20 - 25 cm, and the seed sowing rate is 6 - 8 g/m^2. The seedlings are regularly cared for and watered. Weed control is carried out mechanically. When fertilizing, a small amount of nitrogen fertilizer can be applied after 2 - 3 leaves appear [8] [9]. Transplanting: Seedlings are transplanted to a permanent location at the age of 1 - 2 years. Planting pattern: 3 × 3 m and 2 × 4 m for green areas. After planting the plant, watering and mulching are recommended. Agrotechnical and sanitary measures are the main protection measures. Growing and planting seedlings using appropriate agricultural technologies improves the ecological balance in the region, expands green spaces, and reduces soil erosion [2].

If we focus on the bioecology and propagation technology of the soap tree (*Koelreuteria paniculata* L.), the soap tree, *Koelreuteria paniculata* L., which belongs to the Sapindaceae family, is an ornamental and economically important tree species. Its homeland is East Asia (China, Korea, Japan), and it has now been widely introduced in Central Asia, including Uzbekistan [1]. If we pay attention to the bioecological characteristics of the soap tree, we will find that the soap tree is a heat- and light-loving plant, drought-resistant and soil-selective, but grows well on light, fertile, and well-drained soils. Growth slows down in saline and excessively wet soils. The height of the tree usually reaches 8 - 15 m, the branches are widely spread, and in the summer months it gives a scenic view with its pale yellow flowers. The flowering period corresponds to June-July. The fruit is a three-lobed capsule; the seeds are hard-shelled and stored for a long time. Soapwood is important for urban ecology, and due to its resistance to dust and gases, it is widely used in landscaping, parks, and avenues [10]. Its leaves have phytoncide properties and play an important role in environmental health. The soap tree is mainly propagated by seeds. In order to ensure physiological maturation and good growth and development, the seeds are treated before planting, that is, stored in moist sand at 3˚C - 5˚C for 2 - 3 months. Sometimes freezing or soaking in hot water (60˚C - 70˚C) also increases seed germination. Seeds are sown in early spring at a depth of 3 - 4 cm. Seedlings germinate in 10 - 20 days [3].

The relevance of the scientific problem is that the Aral Sea region is a zone of ecological crisis resulting from the drying up of the Aral Sea. This process is associated with the drying up of the Aral Sea and has caused the following problems:

1) Soil salinization and degradation;

2) A sharp decrease in biodiversity;

3) Intensification of dust-salt storms;

4) Changes in the microclimate.

Therefore, the creation of afforestation is scientifically and practically relevant. As a result of afforestation, trophic chains are also restored in these areas, in areas where vegetation cover is restored, according to laws proven in ecology. At the same time, as a result of the reproduction of plants such as saxaul (Saxovul), kandim, and Circassia, habitats for birds and insects are created and the population of small mammals is restored. With the creation of afforestation, phytocenosis → zoocenosis → biocenosis is formed, and the ecological balance is restored.

This process is fully consistent with the Law of Ecological Succession. The impact of forests on soil cover is one of the main factors in the process. As a result:

1) The soil is strengthened, and this was determined during the research. The root system of plants retains sand and dust, that is, it reduces deflation (wind erosion).

2) The rate of humus formation is accelerated, leaves and plant residues rot, and organic matter is formed. This, in turn, leads to an increase in soil fertility.

3) Primary and secondary salinization of soils decreases, plants absorb salts, and the critical depth or level of groundwater stabilizes.

The creation of forests softens the climate. That is, air humidity increases, temperature amplitude decreases, wind speed decreases, and as a result, biodiversity is restored and favorable environmental conditions are formed for plants and animals. As a result of planting saxaul on millions of hectares of the dried-up bottom of the Aral Sea, it is observed that dust and salt storms have partially decreased, new plant and animal species have appeared, and the mechanical composition of the soil has improved [11].

4. Discussion and Conclusions

The Aral Sea soils are saline, dry, and windy, and the climate is harsh; only hardy tree and shrub species are planted here. The most suitable species and their benefits are listed below. Trees and shrubs suitable for planting in the Aral Sea region include: saxaul (white and black saxaul), which is highly drought-resistant, grows even in saline soils, and has deep roots that stop sand and dust storms, strengthen the soil, slow desertification, and provide refuge for wildlife. Kandim is a shrub and tree suitable for desert conditions; it reduces sand drift, quickly establishes roots, and reduces wind erosion. Cherkes and calligonum are suitable for saline and sandy soils, strengthen sandy areas, grow quickly, and are important for ecosystem restoration. Yulgun and tamarisk are very suitable for saline soils; they soften saline soils, reduce wind, and somewhat moderate the climate [3]. Poplar is a relatively hardy fruit tree that improves soil fertility, its fruit is nutritious, and provides economic benefits to the population. Poplar, especially hardy varieties, grows rapidly in areas near water bodies, purifying the air and creating green spaces. The main goal of planting this tree is to reduce dust and salt storms, slow down the desertification process and mitigate its negative consequences, improve public health, restore biodiversity and mitigate the climate, while creating new jobs and green spaces [1].

Planting desert-resistant plants, mainly saxaul, in the Aral Sea regions is the most effective and beneficial. This not only restores nature but also creates a healthy environment for future generations [12]. Due to the dominance of the arid climate in the Aral Sea region, scarcity of water resources, and strong salinity of the soil, it is recommended to plant intensive crops that are resistant to salt and drought and consume less water. The recommended crops include barley, one of the most suitable grain crops, tolerant of saline soils, requiring little water, maturing quickly, and serving as the basis for livestock feed. Millet is highly drought- and heat-resistant, requires minimal watering, and is used as a food and forage crop. Sorghum (a variety of sorghum), or white sorghum, is suitable for hot and saline soils, requires little water, conserves water, and serves as the basis for grain and forage, being resistant to wind erosion. Mung bean enriches the soil with nitrogen, requires little water, and is edible. Planting bean varieties that are suitable for these areas and are resistant or adapted to local conditions will increase soil fertility and serve as a source of protein for the population [12]. Planting salt-tolerant sugar beet varieties, melons, watermelons, and alfalfa will help reduce salinity, bring economic benefits, and are very important for ensuring the country's food security. Forage crops, including alfalfa, salt-tolerant varieties, and Sudan grass, will develop livestock and strengthen the soil. Medicinal plants, such as wormwood, which have medicinal properties and are highly drought-resistant, are recommended for planting. Isirik, a plant suitable for saline and dry soils, is both medicinal and technically important. Finally, barley, millet, sorghum, mung bean, and forage crops are the most effective in the Aral Sea region [1]. These crops are distinguished from other crop types and are considered useful due to their low direct water requirement, water-saving, salinity-tolerant, and economically efficient production [3].

The practical importance of creating forests in these regions is that they are mainly a fodder base for livestock; plants such as saxaul, kandim, and Circassia are considered food for livestock, especially camels, sheep, and goats. As a result of creating forests, pastures in this region are restored, and meat and dairy production increase. Biodiversity is restored. Flora and fauna are restored. Ecotourism is developed. Water resources are saved. The need for irrigation of agricultural crops is relatively reduced [5].

It is advisable to plant the following crops on saline soils. Among salt-tolerant agricultural crops, cereals such as barley are the most resistant to salinity. Crops such as triticale, sorghum, rice, melon, watermelon, and legumes—peas (some varieties), beans (suitable varieties); forage crops such as Sudan grass, sorghum (for fodder), perennial alfalfa—salinity-resistant varieties; and from amelioration and agroforestry crops—tree-shrub plants such as saxaul (white and black varieties), kandim, Circassian tamarix (yulgun) play a key role in improving soil properties. Planting the above-mentioned crops is of great importance in ensuring the country's food security [13].

Based on the above, it can be concluded that the scientific and practical significance of the ongoing scientific and research work is proven by the following: Ecological laws are improved. Succession and biocenosis are formed.

- Soil cover is restored;
- Biodiversity is restored;
- Soil degradation is reduced.
- Ecological stability is ensured. These are clearly visible in the ongoing research.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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