Xerophytic and halophytic shrubs as the main biomaterials for phytomeliorational resource-saving technologies in arid lands

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Abstract. In recent years, the attention of scientists from the arid territories of the world, including countries from Central Asia, has been attracted by the problem of studying and developing halophytes and xerophytes in culture. Among the flora of the Gobi Desert, there are plant species that can function normally and reproduce on settled soils or irrigation with mineralized water. Currently, in the world practice, there are two directions in the use of halophytes and xerophytes in agriculture: the first is the ecological restoration of degraded arid pasturelands without the use of irrigation. The second is the selection of promising species of halophytes and xerophytes and the development of a technology for their cultivation for the production of high-protein energy-saturated feed. One of the main reasons for the low efficiency of forest nursery management is the insufficient supply of soils with mineral nutrition elements and, foremost, with humus. Our aim was to develop and study the technology of obtaining a peat-free substrate with optimal agro-chemical parameters for growing standard mycorrhizae planting biomaterial halophytes and xerophytes with a closed root system. For growing standard seedlings of halophyte and xerophyte plant species with a closed root system, the quality of the substrate is of great importance. Currently, almost all the substrates used are prepared on the basis of peat. The use of the proposed peat-free substrates for growing coniferous seedlings with a closed root system will help to increase the yield of mycorrhiza standard planting material by optimizing the physical-chemical properties of the substrate.

Keywords: xerophyte, halophyte, root systems, deflation, reclamation technology, arid land.

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1 Introduction

In arid areas, it is necessary to apply phytomelioration widely to create an organized, stable, and ecologically well-maintained forest–agrarian landscape in which agricultural lands can provide diverse and stable products, and to provide optimum ecology for the existence of a natural and anthropogenic system.

The aim of this work is to select shrub and woody plant species for the restoration of degraded lands in the arid zone of the Mongolia with the prospect of preserving and increasing the productivity of native biodiversity, and the structure and dynamics of pasture ecosystems [1].

The object of this study is the desert and desert-steppe zone in the southeast and southwest of the Gobi. The use of the adaptive and productive potential of ecologically specialized plant species for biocoenosis and landscapes is becoming an essential element of the new paradigm.

Halophytes and xerophytes - plants of saline habitats – for effective biotic reclamation of degraded pastures and saline soils, including deflationary landscapes.

The effect of salts on plants and their salt tolerance, the negative effect of salts on plants can be differentiated into three components: osmotic, toxic, and specific [2, 3].

According to most researchers, the main factor that has a negative effect on plants is the osmotic factor.

The most common effect of salinity is to stop plant growth. Salt-tolerant plants are combined into a group of halophytes, for which the limiting concentrations of salt content in the environment variable over a very wide range - from 10 to 300 g/l [4].

The main mass of salts absorbed by the plant accumulates in the aboveground organs, and in the leaves, it is noticeably more than in the stems [5].

Halophytes are heterogeneous in their bioecological, physiological and biochemical properties and economically useful characteristics. Ecologically different hyper-halophytes, euhalophytes, hemi-halophytes and haloglycophytes react differently to excessive salinity of the soil environment, and their salt tolerance is quite different.

1.1 Xerophytes and halophytes as a means of biotic reclamation of degraded agricultural lands

The critical state of agricultural lands in the arid regions of Central Asia and Mongolia, river pollution, soil salinization and degradation of pasture lands are indicators that determine the relevance of soil bioremediation as an integral part of integrated land reclamation.

Assessment of the environment-forming and environment-optimizing ability of plants and their systemic formations - the biocoenosis, the use of this biogeocenotic phenomenon for reclamation of degraded lands is an essential part of the new concept of sustainable development in agriculture science.

The optimization properties of plants – bio-reclamations are versatile and functionally indispensable and economically beneficial.

This gives grounds for identifying a special type of production activity and the corresponding special scientific activity – biotic reclamation of degraded agricultural landscapes [4, 6].

2 Materials and methods

After a 15-year study of expeditions into the arid territory and the southeastern and southwestern regions of Mongolia, a collection of xerophytes and halophytes was compiled, numbering more than 50 species [7].

These plants are common in the arid regions of Central Asia and in the south of Mongolia (Gobi Desert) where they are being tested for potential use as fodder and medical plants with increased environmental capacity [8].

The following 15 species of xerophytic and halophytic plants turned out to be promising for use in the system of this technology: *Haloxylon ammodendron, Tamarix ramosissima, Zygophyllum xanthoxylon, Caragana korshinskii, Caragana leucophloea, Ephedra equisetina, Nitraria sibirica, Reamuria soongorica, Kochia prostrata, Eurotia ceratoides, Artemisia xerophytica, Kalidium foliatum, Ulmus pumila, Glycyrrhiza uralensis, Anabasis brevifolia* and others.

3 Results and discussion

3.1 Reclamation of degraded pasture lands

In conditions with a disturbed structure of plant communities and a destabilized ecological environment, restoring and increasing the productivity of pasture ecosystems is an important task for biological and agricultural sciences. This dictates the need for an adaptive approach to the development of biotic principles and methods for the ecological restoration of degraded pasture ecosystems in the arid regions of Mongolia [9].

The development of biotic principles and methods for the ecological restoration of degraded pasture lands involves the comprehensive use of the biological potential of life forms, species and ecotypes of plants of the natural flora, on the one hand, and on the other hand the ecological resources and reserves of the environment of the arid biome to ensure the stability, high productivity and sustainability of the constructed pasture ecosystems against the effects of adverse abiotic and anthropogenic factors that are constantly prevalent in the arid regions of Mongolia.

The main idea behind the development of biotic principles for the ecological restoration of degraded lands based on the creation of pasture ecosystems is based on:

1) More complete stimulation of the biological resources of arid zones, more complete and rational use of the ecological and biological potential of life forms, species and ecotypes of fodder plants of natural flora;

2) An ecologically reasonable, rational investment and use of additional anthropogenic energy in the technology of ecological restoration of disturbed pasture ecosystems.

Based on the use of these principles, biotic principles and methods for the ecological restoration of degraded pasture ecosystems using xerophytes and halophytes in arid regions have been developed.

3.2 Xerophytes and halophytes as resource-saving plants

Xerophytes and halophytes are used as wood fuel. The possibility of using halophytes, such as mangroves, to produce combustible material has been exploited for more than a century. There are many other halophytes. Plantations of xerophytic and halophytic plantations are energy-producing renewable biological means and at the same time energy storage.

The sustainable functioning of pasture ecosystems created on the site of degraded lands with the participation of halophytes, mesohalophytes and xerophytes is ensured by the following ecological and biological mechanisms:

• Experimentally proven benefits of polycomponent pasture ecosystems created from a mixture of species and ecotypes of different plant life forms.

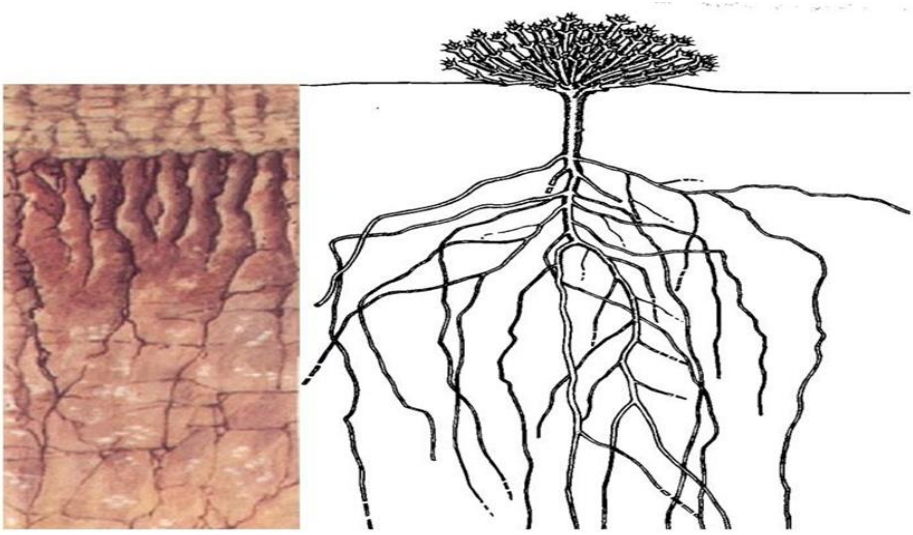

Fig. 1. Morphological structure of the halophytic semi-shrub *Anabasis brevifolia* C.A.Mey.

Construction of multi-tiered and multi-component pasture ecosystems from trees, shrubs, semi-shrubs with deep root systems (see Fig. 1), as well as grasses (ephemera and ephemerides) with different periods of development over time, based on the differentiation of ecological niches by tiered, seasonal, succession, fluctuation and

functional complementarity of species , ensures the intensification of the use of environmental resources and the formation of stable and relatively highly productive pastures in arid regions [10].

• Technological processes that ensure the success of reclamation systems for degraded pasture lands in arid areas of other countries are based on the use of transformative agro-technical practices aimed at improving the ecological conditions for seed germination, plant growth and mitigating the negative effect of limiting factors on arid lands.

An environmentally sound technology will give a sufficiently high agronomic, ecological and economic effect even in extremely arid areas, radically changing and creating comfortable environmental conditions for seed germination, normal growth, development and formation of fodder and phytomass on arid pasture lands.

Conclusion

The critical state of pasture ecosystems in Mongolia requires the need to search for potential plant resources that can restore the biological productivity of degraded lands (disturbed pasture ecosystems, saline soils, etc.). The use of the adaptive and productive potential of ecologically specialized plant species and their systemic formations - agro and biocoenosis is becoming an essential element of a new paradigm of agricultural science and practice – the concept of sustainable development of viable agriculture.

The system of sustainable agriculture is considered as an ecological complex: soil - plant - wildlife protection - use.

The mobilization of ecologically specialized plant species, in particular, xerophytes and halophytes – plants of saline habitats - for effective biotic amelioration of degraded pasture and saline lands is recognized as a priority direction of the system of sustainable development of agricultural production.

The resources of xerophytes and halophytes of the natural flora are enormous and are of great importance for development in culture as fodder and energy carriers and biomeliorant plants.

A preliminary analysis of the available flora, pasture-plant ecological and ecological literary sources shows that there are more than 15 halophyte species of potential interest for their involvement in the orbit of introduction and breeding work for the purposes of xerophyte and halophyte crop production.

In this regard, it is necessary to systematically collect seeds of xerophytes and halophytes in the arid regions of Mongolia and adjacent territories and create collection nurseries. Study their ecological and biological properties and select highly productive, salt-tolerant species and forms of wild-growing populations for plant growing.

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References

1. Rachkovskaya E. I.: Vegetation of Gobi deserts of Mongolia. Nauka, St. Petersburg: Russia (1993)
2. Viktor P. D., Elena V. D., Sergey N. T., Khadbaatar S., Ariunbold E., and Peter D. G., Sergey N. B.: The Influence of vegetation on reflected solar radiation in arid and extra-arid zone of Mongolian Gobi. Geography environment sustainability 13(4): 72-80 (2020). https://doi.org/10.24057/2071-9388-2020-91
3. Zolotokrylin A. N., Gunin P. D., Titkova T. V., Bazha S. N., Danzhalova E. V., Kazantseva T. I.: Diagnosis of the desertification dynamics of arid pastures in Mongolia from observation in key areas and MODIS data. Arid Ecosystems 6, 149-157 (2016). https://doi.org/10.1134/S207909611603010
4. Shamsutdinov Z. S.: Biological reclamation of degraded agricultural lands. Moscow (1996).
5. Shamsutdinov Z. S.: Principles and methods of biological melioration of degraded lands. Astrakhan (1994).
6. Gunin P. D., Dedkov V. P., Danzhalova E. V., Bazha S. N., Zolotokrylin A. N., Kazantseva T. I.: NDVI for monitoring of the state of steppe and desert ecosystems of the Gobi. Arid ecosystems 9, 179-186 (2019). https://doi.org/10.1134/S207909611903003X
7. Ariunbold E.: Dynamic structure of plant communities in the dry steppes of the Central Mongolia. St. Petersburg, Russia (2014).
8. Danzhalova E.V., Ariunbold E., Dorofeyuka N. I., Myagmarsuren D., Baja S. N.: The edibility of plant communities as one of the criteria for the qualitative assessment of pastures in Mongolia. Arid Ecosystems 13(2), 208–216 (2023). https://doi.org/10.1134/S207909612302004X
9. Kazantseva T. I.: Productivity of zonal plant communities of steppes and deserts of the Gobi part of Mongolia. Nauka, Moscow, Russia (2009).
10. Slemnev N. N., Gunin P. D., Tsooj Sh., Ariunbold E.: The life state of undergrowth of dominant plants in the ecosystems of extra arid line in the desert zones Mongolia. Botanical Journal 95(6), 834–849 (2010).