Cultivation of plants based on new technologies in the dry soil of the Aral Sea

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Abstract. The article presents the results of research aimed at growing plants on the basis of different technologies in the relic-swamp salt-sand desert soils of the Aral Sea. The amount of annual precipitation on the soils of this area formed in the conditions of the arid climate region is 180-200 mm. Many factors should be taken into account for growing plants in these areas. It is necessary to choose a suitable halophyte plant for marshy saline soils and to take into consideration sharp changes in temperature throughout the season. Planting in these soils is due to atmospheric precipitation and groundwater. Therefore, experiments were carried out on plant cultivation in the pipe method, and the efficiency was up to 1.5 times higher than in conventional conditions. The combined use of different technologies with the pipeline method has further increased efficiency.

1. Introduction

In recent years, the environmental problems in the Aral Sea regions have become more acute, which in itself has a negative impact on living organisms, in particular, humans, animals and plants. It is known that the area of these problems is expanding year by year, causing great losses in the territories of neighboring countries. It is important to carry out scientifically based researches, first of all greening of the Aral Sea territories in order to reduce the scale of negative situations arising as a result of the drying up of the Aral Sea.

Nowadays, the dry bottom of the Aral Sea does not have complete soil formation, because taking into consideration the participation of 6 factors in the formation of soil, if we assume that an average of 1 cm of soil is formed in 200 years, taking into account that it has been 60 years since the drying of the island until now, there is not even 1 cm of soil in the dry bottom of the island , the process of soil formation has started in some areas. From this point of view, it can be said that scientists and experts who plan to conduct scientific, practical and innovative research in the dry bottom of the Aral Sea should take into account the absence of soil cover. According to the opinion of scientists, it is correct to call it ground-soil.

The process of soil formation is underway [1, 2]. A lot of work has been done in greening the protected bottom of the Aral Sea, expanding the populations of wild and cultivated plants suitable for the area, improving the ecological environment, improving the lifestyle of the residents of Moynaq District, which is the Aral Sea region, bringing in industry and delivering agricultural products, especially the development of fisheries, livestock, and horticulture is increasing. However, there are enough ecological problems waiting to be solved in the territory of the island, which requires continuous scientific-based practical work on their solution.

The drying up of the Aral Sea was caused by global climate change and the irregular use of water resources since 1960, the poor functioning of drainage collectors and the expansion of irrigated farming activities in the region, resulting in a decrease in the water level and an increase in salt content [3–11], as well as the process of transition from hydromorphic to automorphic process accelerated, desertification became active. As a result of the drying up of the Aral Sea, the process of soil formation began in the open sand dunes. The drying up of the Aral Sea has led to an increase in salinity in the Khorezm region and an increase in water consumption in its washing [12].

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According to researches, as a result of the drying up of the Aral Sea, the amount of water-soluble salts in the soil increased from 0.4-0.5 g/l to 71.3 g/l, and the number of microorganisms decreased with increasing salts in the soil [13]. The increase of plants in the dry bottom of the island leads to the improvement of soil properties, according to the concentration of cations in the soil (Ca2+, K+, Mg2+ and Na+), cation exchange capacity, pH environment, enzyme activity (phosphotase, β-glucodase and N-acetylglucosaminidase) 0-10 cm When studied in the stratum, the planting of plants decreased the concentration of basic cations and electrical conductivity, the activity of enzymes and the amount of microorganisms increased [14], the extensive introduction of phytomelioration in Orolkum also prevents sand flying [15]. Intensification of salinization processes has caused the formation of different salinity levels and types in the regions, a sharp increase in the stock of toxic salts in soil covers, and as a result, the deterioration of soil fertility and land reclamation. Under the influence of desertification processes, 84.2 percent of the 677.6 thousand hectares of irrigated land in the Aral region (at the border of the Republic of Karakalpakstan and Khorezm region) are saline to varying degrees, of which 217.8 thousand hectares or 32.14 percent are weak, 188.8 thousand hectares or 27.86 percent are medium, 82.3 thousand hectares or 12.15 percent are strong and 81.7 thousand hectares or 12.06 percent are very strong saline soils (data of the Davyergeodezkadastr Committee of the Republic of Uzbekistan). Some studies have shown that the long-term depletion of water has led to the continuous deterioration of soil resources in the dry bottom of the Aral Sea. Salt, sand storms and reduction of water flow, increased desertification destroyed 40% of vegetation cover by 2019 [3,9,16–22].
The use of phytoremediation is one of the main methods to stabilize the ecological condition of the dry bottom of the Aral Sea. Studies have been conducted using perennial and annual halophytes: *Halocnemum strobilaceum*, *Haloxylon aphyllum*, *Halostachys caspica*, *Climacoptera aralensis*, *etc*. to identify promising plants for phytoremediation of saline soils [23]. In 1997, phytomeliorative studies were carried out in the flat saline soils of the dry seabed. The amount of salt in the layer 0-2 cm is 24.5% (CI- 10.4%, SO42-, 5.1%, Na+, K+ 7.8%). Due to the strong evaporation, the capillary moved upwards and brought a large amount of salt to the upper horizon of the soil. 2 to 50 cm deep silty layer, rather wet and moisture content increases downwards. At the beginning of the experiment, the groundwater level was 3 m, the mineral content was 48 g/l. Seeds of 17 types of halophytic plants are planted. Of these, 8 species (47%) have died. *Atriplex fominii*, *A. tatarica*, *Salsola nitraria*, *S. australis*, *Petrosimonia brachiata, Kalidium caspicum* and *Climacoptera* were grown. But after about 40-50 days, they died when the plants were 0.50-1.58 cm long (by the summer of the study). Only four species (23.5%) survived until the end of the growing season: *Halogeton glomeratus*, *Suaeda acuminata*, *Climacoptera* aralensis and *Atriplex fominii* [23]. The use of biochar, manure, preparations and rhizobacteria is highly effective in growing plants and improving soil properties under the influence of drought and salinity stress factors [1,24–27]. In other similar studies, the regression rate of the Aral Sea coastline was determined at 5-year intervals from 1965 to 2019, depending on the landform, lithology, depth and salinity of the groundwater. According to the TSAVI index, the dry bottom of the Aral Sea is classified as follows: water table, swamps, salt marshes, salt marshes, suitable areas for plants, areas of very low, low, medium, high and very high biomass land areas. Six salt-tolerant species were selected from the native flora of the dry bottom of the Aral Sea to anchor the shifting sands.
High sand tolerance has been found in *Salsola richterii* and *Calligonum* caput-medusae [28]. Processes such as the emergence and development of life in dried seabed soil can be observed only by studying the microbiological composition of the soil [1,2,10]. Changes in soil layer development and properties are primarily related to vegetation regeneration and vegetation persistence [27,29–31]. The regeneration of plants helps the development of the soil layer. As the depth of the soil increases, the changes in the properties of the upper layer of the soil decrease. Afforestation is one of the most successful measures to restore dry land and improve the ecological environment in the sandy desert region.
During the analysis of the references, we were convinced that it is necessary to help the soil in the bottom of the island to grow plants, that is, it is possible to achieve plant growth by providing support by controlling salinity stress, climatic conditions and humidity, and microbiological support. We aim to conduct research in this regard.

2. Methodology

The researches were conducted in the area of sand dunes in the dry bottom of the southern part of the Aral Sea. The dry bottom of the Aral Sea is a sandy desert-residue-swamp saline soil, sand dunes (59º 1′ 42″, 43º 46′ 40″) around the "Ship Cemetery" in Moynaq district. 2021-2022 was conducted in the 2nd educational-scientific landfill of the National University of Uzbekistan on an area of 0.13 hectares in this area. Researches have been carried out on the application of various technologies and increasing the level of growth and development of plants.
For this purpose, the tube method is used to protect young seedlings (1-year-old saplings) from soil moisture and adverse effects of the environment. For this, organic biopreparations in different variants were applied to the pipes. Haloxylon seedlings were planted with pipes buried 30 cm deep. 30 cm was put out on the surface of the earth. The experiments were carried out in 3 replicates, the scheme of the experiment is presented in Table 1.

Table 1. Scheme of the experiment

№	A-factor (tubular)	№	B-factor (pipeless)
1	Control	10	Control
2	Biochar (at the rate of 20 t/ha)	11	Biochar (at the rate of 20 t/ha)
3	Biochar (at the rate of 40 t/ha)	12	Biochar (at the rate of 40 t/ha)
4	Imbicom	13	Imbicom
5	Bist	14	Bist
6	Bionitrogen	15	Bionitrogen
7	Ground ointment	16	Ground ointment
8	Hydrogel	17	Hydrogel
9	Hydrogel (infused with nutrients)	18	Hydrogel (infused with nutrients)

Planting in field experiments, conducting phenological observations, and mathematical processing were performed according to B.A. Dospekhov's method.

3. Results and Discussion

The experiments conducted on the basis of the pipe method gave more results than the experiments conducted under normal field conditions (Figure 1), in which the retention and growth of seedlings at 1% biochar was 57.14%, which was 4.0 times higher than the control. In the variant with 2% amount of biochar, the capture and growth of haloxylon seedlings was 42.86% and was 3.0 times higher than the control, but it was 14.28% less than the variant with 1% amount. This is explained by the damage to the roots of young seedlings as a result of the increase of organic matter in the pipe, the high temperature and "burning" of the roots (Table 2).

Table 2. Development and viability of haloxylon seedlings in the dry bottom of the Aral Sea, %

№	Options	Total number of seedlings planted	The number of grown seedlings	Survival rate, %
		A-factor (tubular)		
1	Control	6	1	16,7
2	Biochar (at the rate of 20 t/ha)	6	4	66,7
3	Biochar (at the rate of 40 t/ha)	6	3	50,0
4	Imbicom	6	2	33,3
5	Bist	6	4	66,7
6	Bionitrogen	6	5	83,3
7	Ground ointment	6	5	83,3
8	Hydrogel	6	4	66,7
9	Hydrogel (infused with nutrients)	6	3	50,0
		B-factor (pipeless)		
10	Control	6	1	16,7
11	Biochar (at the rate of 20 t/ha)	6	2	33,3
12	Biochar (at the rate of 40 t/ha)	6	2	33,3
13	Imbicom	6	2	33,3
14	Bist	6	3	50,0
15	Bionitrogen	6	3	50,0
16	Ground ointment	6	4	66,7
17	Hydrogel	6	3	50,0
18	Hydrogel (infused with nutrients)	6	2	33,3

The experiments conducted under the pipe method gave more results than those conducted under conventional conditions, in which the retention and growth and development of seedlings were 66.7% when biochar was applied at the rate of 20 t/ha, which was 4.0 times higher than the control. In the variant applied at the rate of 40 t/ha of biochar, the capture, growth and development of haloxylon seedlings was 50.00% and was 3.0 times higher than the control, but it was 16.67% less than the variant applied at the rate of 20 t/ha. This is explained by a sharp increase in organic matter in the pipe.

Fig. 1. Growth and development of haloxylon seedlings in the pipe method

In the variant of the next study, where the biopreparation "Imbikom" was used, this indicator was 33.3%, which is 2.0 times higher than the control. And in the variant where "Bist" was used, the results were 66.7%. In option 6, where "Bionitrogen" was applied, the catch and growth and development of seedlings was 83.33%, which is 5 times higher than the control. In option 7, where "Ground ointment" was used, the growth and development of haloxylon seedlings was 83.33%, which is 5 times higher than the control. In the following 8 options, where hydrogel nutrients were applied, the rate of growth and development of haloxylon seedlings was 50.0%, in the 7th option, where hydrogel was used, the result was 66.7%. For the purpose of comparison, this option was also implemented without a pipe (B-factor). In this case, in the control variant, the viability rate was 16.7% when applied without any technology, and it varied from 33.3 to 66.7% in technology-dependent development. The highest rate was observed when planting treated with biopreparation "ground ointment". After that, the indicators reached 50.0% in the variants using Bist, Bionitrogen and hydrogel. In the remaining options, 33.3% of the results were recorded.

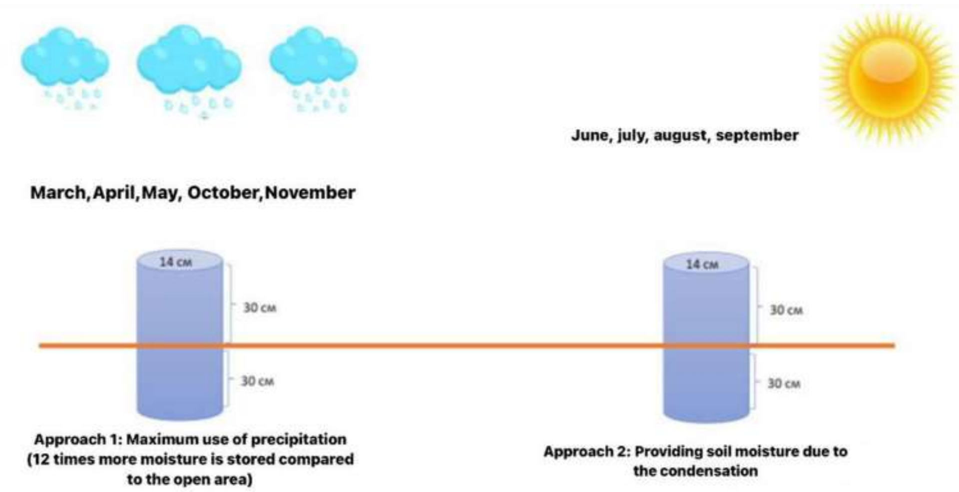

Fig. 2. Effect of pipe method on soil moisture conservation

Comparing the effects of factors A and B, there is no difference in plant viability in the control option. It was observed that the A-factor is 1 times higher than the B-factor in the variant using biochar (at the rate of 20 t/ha).
1.5 times the A-factor advantage was achieved in the variant where biochar was used (at the rate of 40 t/ha).
Effect of A-factor and B-factor was found to be equal when using Imbikom.
A 1.25 times higher index was recorded in the variants using ground ointment compared to A-factor and B-factor.
In the cases where hydrogels were used, it was found to be 1.33-1.5 times higher than factor A and B.
In our opinion, we will discuss the reason for the differences in the effect of factor A and B.
The pipe method works on the basis of mechanism shown in Figure 2.
The high performance of the pipe method is based on the following mechanisms:

- the amount of natural rain is 12 times slower compared to the soil in open field conditions;
- protects young seedlings from temperature and sunlight when planted;

- favorable conditions for the adaptation of microorganisms contained in the used biopreparations will be created due to greater preservation of moisture in the soil;
- the effectiveness of organic fertilizers such as biopreparation, manure, biochar will be high;
- in the pipe method, due to the sharp difference in temperature during the day and night, water condensation occurs and additional moisture is created.

Moisture condensation is a very important process, and due to partial temperature control, less water evaporates inside the pipe than in the open field. The annual amount of water vapor reaches 400 mm in Central Europe, 420 mm in Moscow, and up to 1800 mm in Central Asia, including summer months. Repeated moisture occurs due to condensation of water in the pipe and its walls. This, in turn, has a positive effect on the effectiveness of microorganisms and plant growth.

According to Aleksandr Andrevich Rode (2009), 0.1-0.2 mm of water condenses in one night, 0.27 mm if dew is added. When we calculate together with dew, about 100.0 mm of water falls on the soil during 1 year. This is important for the region where water falls due to various precipitations in the arid climate region, about 180-200 mm per year. Most of the moisture that falls due to condensation is suffocated in open conditions, and in the pipe method it returns completely to the soil.

4. Conclusion

Among these technologies, the basis for maintaining moisture, to further support this process, various organic treatments of the soil (manure, siderate, planting of various types of plants), in a word, by improving the organic part of the soil and its agrochemical properties, was created. The most important situation in the research was scientifically based on the indicator of increased use of the moisture created on the basis of condensation and the mechanism of improving the physical and agrochemical properties of the soil due to the maximum use of natural precipitation. The soils of the dry bottom of the Aral Sea are unconsolidated sandy soils with varying degrees of salinity, these soils do not retain much moisture, and the efficiency of using moisture is not high, so the basis for the maximum use of existing moisture for germination, growth and development of plants has been created.

The research conducted in the experimental fields in the dry bottom of the Aral Sea showed that in the options where "Ground ointment" and "Bionitrogen" biopreparations were used in haloxylon, good growth and development of plants was found. It was found that the planting and growing of haloxylon seedlings in the dry bottom of the Aral Sea by the pipe method is more effective than the method in the open field. According to the results, the moisture in the soil in the pipe method is 12 times slower, direct sunlight is 6-7.3 times less in the high temperature days of the summer season, and microorganisms live, the emergence of favorable conditions for, due to the sharp difference in temperature during the day and night in the summer season, the condensation process appeared, which gave the opportunity for the appearance of additional moisture.

References

1. Jabborova D, Abdrakhmanov T, Jabbarov Z, Abdullaev S, Azimov A, Mohamed I, AlHarbi M, Abu-Elsaoud A, Elkelish A, *PeerJ* **11**, e15684 (2023)
2. Jabborova D, Sayyed RZ, Azimov A, Jabbarov Z, Matchanov A, Enakiev Y, Baazeem A, El Sabagh A, Danish S, Datta R, *Saudi Journal of Biological Sciences* **28**, 5268 (2021)
3. Xu H, Wang X, Yang T, *Science of The Total Environment* **579**, 1658 (2017)
4. Micklin P, *Lakes & Reservoirs* **15**, 193 (2010)
5. Nihoul JCJ, Zavialov PO, Micklin PP, editors, *Dying and Dead Seas Climatic Versus Anthropic Causes,* Springer Netherlands, Dordrecht (2004)
6. Conrad C, Usman M, Morper-Busch L, Schönbrodt-Stitt S, *Water Security* **11**, 100078 (2020)
7. Sattarov D, Mahammadiev S, Makhkamova D, *BIO Web of Conferences* **78**, 02012 (2023)
8. Makhkamova D, Nabiyeva G, Abdushukurova Z, Iskhakova S, Abdujabbarovna A, *E3S Web of Conf.* **413**, 03033 (2023)
9. Aslanov I, Kholdorov S, Ochilov S, Jumanov A, Jabbarov Z, Jumaniyazov I, Namozov N, *E3S Web Conf.* **258**, 03012 (2021)
10. Egamberdieva D, Jabbarov Z, Arora NK, Wirth S, Bellingrath-Kimura SD, *Environmental Sustainability* **4**, 335 (2021)
11. Kholdorov S, Jabbarov Z, Yamaguchi T, YamashiTa M, ShamsiDdiNov T, Katsura K, *EJSS* **13**, 26 (2023)
12. Forkutsa I, Sommer R, Shirokova YI, Lamers JPA, Kienzler K, Tischbein B, Martius C, Vlek PLG, *Irrig Sci* **27**, 319 (2009)
13. Jiang H, Huang J, Li L, Huang L, Manzoor M, Yang J, Wu G, Sun X, Wang B, Egamberdieva D, Panosyan H, Birkeland N-K, Zhu Z, Li W, *Science of The Total Environment* **765**, 142675 (2021)

14. An J, Chang H, Han SH, Khamzina A, Son Y, *Forest Science and Technology* **16**, 26 (2020)
15. Issanova G, Abuduwaili J, Galayeva O, Semenov O, Bazarbayeva T, *Int. J. Environ. Sci. Technol*. **12**, 3213 (2015)
16. Indoitu R, Kozhoridze G, Batyrbaeva M, Vitkovskaya I, Orlovsky N, Blumberg D, Orlovsky L, *Aeolian Research* **17**, 101 (2015)
17. Xu H, Wang X, Zhang X, *International Journal of Applied Earth Observation and Geoinformation* **52**, 390 (2016)
18. Kochkarova S, *LEPI* **51**, 764 (2020)
19. Haag I, Jones PD, Samimi C, *Climate* **7**, 123 (2019)
20. Egamberdieva D, Alaylar B, Alimov J, Jabbarov Z, Kimura SB, *Turkish Journal of Agriculture and Forestry* **47**, 357 (2023)
21. Kholdorov Sh, Lakshmi G, Jabbarov Z, Yamaguchi T, Yamashita M, Samatov N, Katsura K, *Eurasian Soil Sc.* **56**, 1178 (2023)
22. Jabbarov ZA, Imomov ON, Nomozov UM, *International Journal of Biological Engineering and Agriculture* (2023)
23. Meirman GT, Dimeyeva L, Dzhamantykov K, Wucherer W, Breckle S-W, in *Sustainable Land Use in Deserts*, edited by Breckle S-W, Veste M, Wucherer W, Springer Berlin Heidelberg, Berlin, Heidelberg, pp. 318–322 (2001)
24. Jabbarov Z, Abdrakhmanov T, Pulatov A, Kováčik P, Pirmatov K, *Agriculture* (Pol'nohospodárstvo) **65**, 88 (2019)
25. Jabborova D, Ziyadullaeva N, Enakiev Y, Narimanov A, Dave A, Sulaymanov K, Jabbarov Z, Singh S, Datta R, *PAK. J. BOT*. **55** (2023)
26. Kholdorov S, Jabbarov Z, Shamsiddinov T, *Soil Security* **13**, 100105 (2023)
27. Atoev B, Kaypnazorov J, Egamberdieva M, Makhammadiev S, Karimov M, Makhkamova D, *E3S Web Conf.* **244**, 02040 (2021)
28. Shomurodov K, Rakhimova T, Adilov B, Beshko N, Karimov F, Polvonov F, *IOP Conf. Ser.: Earth Environ. Sci.* **629**, 012085 (2021)
29. Makhkamova D, Gafurova L, Nabieva G, Makhammadiev S, Kasimov U, Juliev M, *IOP Conf. Ser.: Earth Environ. Sci.* **1068**, 012019 (2022)
30. Jabborova D, Choudhary R, Azimov A, Jabbarov Z, Selim S, Abu-Elghait M, Desouky SE, Azab IHE, Alsuhaibani AM, Khattab A, ElSaied A, *Horticulturae* **8**, 43 (2022)
31. Kholdorov S, Gopakumar L, Katsura K, Jabbarov Z, Jobborov O, Shamsiddinov T, Khakimov A, *IOP Conf. Ser.: Earth Environ. Sci.* **1068**, 012037 (2022)