Assimilation dynamics of saline soil areas by cultivating biomeliorant herbal plant in the lower Amudarya region

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Abstract. 5 types of herbal plants (Herbal Chamomile, Herbal Clove, Dyed Royan, Peppermint, Liquorice) were developed for growth and development, productivity and primary agro-technics of their cultivation in the saline soils of Khorezm region. Bio-ecological and bio-melioration properties of salt-tolerant herbal plants as assimilators in the process of assimilation of saline soils were studied. The adaptor-genetic potential of the selected herbal plants as a plant that assimilates in moderately and strongly saline soils was determined. The agrochemical properties of the soil and its mechanism have been developed in the process of bio-melioration carried out using the cultivation of assimilating herbal plants.

1. Introduction
Growing salt-tolerant plants in saline soils is a key stage in the soil assimilation process [1, 2]. During the development of saline soils, plants grow and their productivity increases [3, 4]. The halophyte vegetation cover in the area is replaced by glycophyte vegetation. The microclimate in the area improves and evaporation-transpiration changes. The occurrence of these processes does not give a complete conclusion about the process of soil assimilation.

In most regions of Central Asia, agriculture is impossible without irrigation, since agricultural plants do not have enough water and they experience drought, that is, they are damaged from a lack of water in the soil and from too dry (containing little moisture) and hot air heated by the sun [5]. The air temperature in deserts often reaches 45 °C, and the soil heats up even more, over 75 °C.

At the same time, in the deserts there are many wild and bio-meliorated medicinal plants that have adapted to these harsh conditions, grow and develop well. A number of properties help them to endure severe drought and saline lands and successfully fight it. These properties did not arise for them immediately, but over a very long time. Many thousands of generations have changed; many of the species that have arisen have died. Only those species survived that, under the influence of environmental conditions, developed properties that helped plants in their fight against drought.

International research has been conducted in Cyprus, Mexico, Iran, China and Kazakhstan on the assimilation of this level of saline soils by plants. Some researchers studied salt-tolerant plants in the desert, desert sand, desert and tugai areas - saxophone — Haloxylon, right — Girgensohnia oppositiflora and liquorice [6] - Glycyrrhiza glabra-L [7].
The total irrigated area in Uzbekistan is 4303.0 thousand hectares, of which more than 60% is saline and requires 411.9 thousand hectares. Therefore, the development of saline soils, the selection of salt-tolerant plants and the widespread use of saline plants are among the issues that need to be addressed. 5 salt-tolerant species (Matricaria recutita L., Calendula officinalis L., Glycyrrhiza glabra L., Mentha piperita L. [8], Rubia tinctorum L.) bio-ecological and bio-melioration (improvement of soil reclamation, ie surface cover) properties, methods of cultivation and reproduction, as well as the development of initial agro-technical measures of cultivation are relevant and have important theoretical and practical significance [9]. In Uzbekistan, scientific research has been conducted on the biomelerative properties of agriculture and medicinal plants in saline soils. Abdurazzoqov (1973) [10] has conducted scientific experiments on the bioecological properties of alfalfa, corn, sunflower and other plants and as a biomelerant. Also, Tukhtaev conducted scientific research on the biomelerant properties of 112 species of medicinal plants in saline soils [11-17]. At present, our scientific research on the use of medicinal plants in the local pharmaceutical industry, along with the study of the biomelerant properties of medicinal plants in the climatic and soil conditions of Khorezm, continues.

2. Materials and Methods

2.1 Study area

![Figure 1. Geographical location of the Khorezm region (Soil salinity map)](image)

The area is a lowland plant located in the North-Western part of Uzbekistan, along the lower reaches of the Amu-darya River, between the longitude 60 °C-61 °C, the latitude 41 °C-42 °C and at 113-138m above the sea level. The vegetation period of plants is 200–210 days. The climate is extremely continental, with an average annual precipitation of 80-90 mm. Average temperature in January is -50C, in July + 300C. Meadow, meadow marshy, marsh-sandy a typical alkali soils prevail [18, 19]. The climate of the oasis is greatly influenced by the deserts of Kyzylkum and Karakum. The region is in the steppe zone, in the western part of the Khorezm oasis and in the southern part of the Aral Sea, 100 m above sea level. The relief consists of a low plain. It is the old Amudarya delta and consists of river sediments. The western and southwestern parts connecting with Karakum are covered with sand. Of the minerals, there are limestone, sand, clay and other building materials [18, 19]. The main part of agricultural crops is irrigated. Therefore, the annual water consumption of the region is very high. At the same time, wastewater from communal and agricultural enterprises is added to the irrigation water.
through concrete ditches and pipes. It has a negative impact on the ecological environment of the region [20]. In the Lower Amudarya region, the soil is saline to varying degrees, so the plant station has a unique appearance (Figure 1).

2.2 Methods

In our study, assimilated plants are selected based on salinity levels. Plants such as alfalfa, corn, white oats, sunflower, cotton, raygrass were selected in areas with low or moderate salinity, water-soluble salts with a density of 1.40-1.60% and chlorine (Cl) anions 0.005-0.015% [10, 11, 12]; In areas with moderate or strong salinity, density of water-soluble salts in the soil 1.6-2.0% and chlorine (Cl) anions 0.040-0.100%, smooth licorice, peppermint and dyed rhubarb, herbal chamomile and herbal cloves [11-17]. In areas with high or very high salinity, water-soluble salts with a residual density of 2.0–2.5% or more, and chlorine (Cl) anions of 0.300–0.400%, a smooth licorice plant was selected.

Development of saline soils is investigated in 2 stages. 

Step 1. Engineering land reclamation: land leveling (planning); opening of ditches (open and closed) and ditches (trays); plowing the land, etc.

Step 2. Selecting and planting salt-tolerant cultivating plants (Figure 2).

![Figure 2. Stages of development of saline soils](image-url)
3. Results

In order to determine the change of halophyte vegetation cover to glycophyte vegetation, improvement of microclimate and evapotranspiration changes during the development of saline soils, we observed changes in the agrochemical composition of the soil in the areas where plants are grown. In our view, the analysis of the results of agrochemical analyses gives clear conclusions. Based on the results of the introduction of herbal plants in moderately saline soils, attention was paid to changes in the amount of water-soluble salts in the soil in areas where 3 types of root crops (smooth licorice, peppermint, dye) were selected.

The soils of the experimental area are 3-4 points according to the classification of soil salinity by Feodorov and are characteristic of moderate or strongly saline soils [21]. Prior to planting, the density of water-soluble salts in the 0-50 cm layer of soil was 1.534% and chlorine (Cl) anions were 0.061%. According to the results of agrochemical analysis, the density of water-soluble salts in the soil decreased by 0.167% in the 0-50 cm layer and chlorine (Cl) anions by 0.016% in 2 years and the density by 0.496% in 3 years (Table 1).

| Experiment, years | Horizontal, cm | HCO₃⁻ | CO₃²⁻ | Cl | SO₄²⁻ | Mg⁺ | Ca | Na⁺+K | Residue Density |
|-------------------|----------------|-------|-------|----|-------|-----|----|-------|-----------------|
| 2                 | 0-10           | 0.022 | NA    | 0.075 | 1.015 | 0.055 | 0.220 | 0.050 | 1.520          |
|                   | 10-20          | 0.022 | -     | 0.051 | 0.660 | 0.037 | 0.210 | 0.045 | 1.435          |
|                   | 20-30          | 0.019 | -     | 0.038 | 0.520 | 0.028 | 0.190 | 0.015 | 1.380          |
|                   | 30-50          | 0.020 | -     | 0.031 | 0.380 | 0.022 | 0.185 | 0.028 | 1.250          |
|                   | 0-50           | 0.021 | -     | 0.045 | 0.591 | 0.029 | 0.198 | 0.033 | 1.367          |
| 3                 | 0-10           | 0.020 | NA    | 0.020 | 0.815 | 0.050 | 0.170 | 0.020 | 1.115          |
|                   | 10-20          | 0.018 | -     | 0.005 | 0.480 | 0.030 | 0.165 | 0.013 | 1.080          |
|                   | 20-30          | 0.022 | -     | 0.002 | 0.340 | 0.025 | 0.150 | 0.009 | 1.015          |
|                   | 30-50          | 0.022 | -     | 0.004 | 0.210 | 0.020 | 0.145 | 0.012 | 0.990          |
|                   | 0-50           | 0.021 | -     | 0.007 | 0.411 | 0.029 | 0.155 | 0.013 | 1.038          |

The process of soil desalination is initially somewhat slow in the experimental field where pepper and mint are grown. During the first 2 years, the density of water-soluble salts in the soil decreases by 0.083% and chlorine (Cl) anions by 0.002%, and this process is accelerated with the onset of the 3rd vegetation. During the growing season, the density of water-soluble salts in the soil decreased by 0.167% in the 0-50 cm layer and chlorine (Cl) anions by 0.016% in 2 years and the density by 0.496% in 3 years (Table 2).

| Experiment, years | Horizontal, cm | HCO₃⁻ | CO₃²⁻ | Cl | SO₄²⁻ | Mg⁺ | Ca | Na⁺+K | Residue Density |
|-------------------|----------------|-------|-------|----|-------|-----|----|-------|-----------------|
| 2                 | 0-10           | 0.024 | NA    | 0.090 | 1.042 | 0.072 | 0.236 | 0.065 | 1.665          |
|                   | 10-20          | 0.022 | -     | 0.070 | 0.920 | 0.065 | 0.228 | 0.050 | 1.510          |
|                   | 20-30          | 0.022 | -     | 0.055 | 0.870 | 0.047 | 0.205 | 0.032 | 1.420          |
|                   | 30-50          | 0.022 | -     | 0.042 | 0.650 | 0.038 | 0.202 | 0.030 | 1.330          |
|                   | 0-50           | 0.021 | -     | 0.059 | 0.826 | 0.052 | 0.215 | 0.042 | 1.451          |
| 3                 | 0-10           | 0.021 | NA    | 0.048 | 0.980 | 0.058 | 0.205 | 0.038 | 1.480          |
|                   | 10-20          | 0.021 | -     | 0.025 | 0.850 | 0.042 | 0.190 | 0.025 | 1.310          |
|                   | 20-30          | 0.022 | -     | 0.020 | 0.690 | 0.033 | 0.182 | 0.015 | 1.200          |
|                   | 30-50          | 0.020 | -     | 0.020 | 0.510 | 0.028 | 0.165 | 0.016 | 0.180          |
|                   | 0-50           | 0.021 | -     | 0.027 | 0.708 | 0.038 | 0.181 | 0.022 | 1.270          |
Also, the salinity index changes very little in the area where the dyed rye is grown. During the first 2 years, it was noted that the density of water-soluble salts in the soil remained the same, and even the amount of chlorine (Cl) anions increased slightly. After three years, the process of soil assimilation accelerated slightly, and the density of water-soluble salts decreased by 0.183% and chlorine (Cl) anions by 0.020% (Table 3).

### Table 3. Changes in water-soluble salts in the soil in the area where the dye is grown

| Experiment? years | Horizontal, cm | HCO₃⁻ | CO₃²⁻ | Cl⁻ | SO₄²⁻ | Mg²⁺ | Ca²⁺ | Na⁺+K⁺ | Residue density |
|-------------------|----------------|-------|-------|-----|-------|------|------|--------|--------------|
| 2                 | 0-10           | 0.024 | NA    | 0.115 | 1.065 | 0.068 | 0.252 | 0.120   | 1.880        |
|                   | 10-20          | 0.024 | -     | 0.085 | 0.980 | 0.052 | 0.250 | 0.088   | 1.612        |
|                   | 20-30          | 0.025 | -     | 0.060 | 0.880 | 0.046 | 0.238 | 0.058   | 1.460        |
|                   | 30-50          | 0.026 | -     | 0.048 | 0.620 | 0.042 | 0.222 | 0.036   | 1.370        |
| 3                 | 0-10           | 0.024 | NA    | 0.065 | 1.010 | 0.062 | 0.220 | 0.076   | 1.520        |
|                   | 10-20          | 0.022 | -     | 0.047 | 0.870 | 0.048 | 0.210 | 0.047   | 1.435        |
|                   | 20-30          | 0.023 | -     | 0.030 | 0.720 | 0.041 | 0.190 | 0.037   | 1.380        |
|                   | 30-50          | 0.024 | -     | 0.028 | 0.580 | 0.033 | 0.178 | 0.022   | 0.210        |
|                   | 0-50           | 0.023 | -     | 0.039 | 0.752 | 0.043 | 0.163 | 0.041   | 1.351        |

We have also paid attention to changes in the amount of nutrients N, P, K, and humus in the soil. According to the results of agrochemical analyzes, the nutrient content of the soil before the experiments was N-0.042%, P-0.113%, K-1.108% and the amount of humus -0.41%.

Due to the large number of irrigation measures in the 1st growing year, the fertility of the soil surface area decreased to a certain extent (-0.16%). In the 2nd growing season, the content of N, P, K and humus in the soil increased slightly. The reason for the increase in these indicators:
- 4 times decrease in the number of irrigations;
- Leaf rot of plants for 2 years;
- the growth of weeds in the area and their drying out and the formation of humus on the soil surface.

From year 3 of the experiments, it was found that the process of soil assimilation in the area or the decrease in the amount of water-soluble salts in the soil composition varied to a certain extent. Now, it has been observed that the same normative constant changes are also characteristic of the increase in the amount of nutrients in the soil - N, P, K and humus, during the 3-5 growing years. Agrochemical analyzes showed that in the 3rd growing year, the total N-0.058%, R-0.141% and K-1.232% in the 0-50 cm soil layer, while in the 4th growing year N-0.054%, P-0.117% and K were present –1.114%. These figures increase by 0.013%, 0.016%, and 0.056%, respectively, in the 5th growing year. The amount of humus, on the other hand, varies from 0.46% to 0.51% in 3-5 growing years.

The above-mentioned process of assimilation (desalination) and the orderly structure of the factors influencing it are shown in the following diagram. It can be seen from the diagram that the planting and cultivation of assimilating plants is the basis of the assimilation process and depends on it. Once the cultivating plants are planted, the agronomic measures applied to their growth first affect the soil conditions in the field and then directly to the plant.

During the 1st growing season, the high amount of water in young plants and their constant storage increases their resistance to salt. By the end of the growing season, an average of 5-6 new stems is formed per plant. Rapid growth of surface and underground organs of plants is observed, as well as the density of stems in the area. The surface part of the soil in the area is first covered by 50-60% and then by 80-90%. In the 3rd growing year, it is estimated that the leaves of plants occupying 1 m² cover 16 m². This situation leads to a positive change in the microclimate in the area. Changes in the microclimate of the area, in turn, lead to an increase in water evaporation from plants and a decrease in water evaporation from the soil surface. In other words, in the first year after planting, the main part of the water evaporation index (evapotranspiration) in the field is water
evaporation from the soil surface, in subsequent years, the main part of this indicator is water evaporation from the plants in the field. Water evaporation is reduced as a result of the rapid growth of ground organs of plants and the covering of the soil surface part of surface organs. The roots of plants act as an "absorber" to evaporate water. Hence, field evapotranspiration changes at the expense of transpiration. The rise in moisture on the soil surface decreases and the salinity naturally decreases. Once the saline water stops rising from the bottom layer of the soil, it begins to seep into the surrounding ditches. This process ensures the migration of a certain amount of water-soluble salts.

4. Conclusions
Thus, the cultivation of salt-tolerant plants in saline soils is a key stage in the process of soil assimilation, and its chemical composition changes. Experiments on moderately and strongly saline soils have shown that smooth sweetener covers 80-100% of the soil surface for 2 years, pepper mint and dyed rye for 3 years. The process of soil assimilation occurs in 2-3 - vegetation years, and in the areas where smooth licorice is grown, it is accelerated, and in the areas where peppermint and dyed rye are grown, it is slightly slower. In strongly saline soils, however, the assimilation properties of the plants are manifested during the 3rd growing season, and at the end of the growing season this process is fully realized. In the 4th-5th years of vegetation, the process of assimilation changes in a positive way. During the year in which the intermediate plants are grown, the amount of nutrients and fertility in the soil almost doubles. This is due to: - until the intermediate plants are planted, the underground parts of the assimilating (smooth licorice) plants are dug up and humus increases as a result of the average 20% of the roots remaining in the ground during harvesting; - In areas where smooth licorice is grown, as a result of many years of shedding of plant leaves and drying of the surface parts of weeds, 5-10 cm layer of hay is formed on the soil surface. Phytomass residues are mixed with soil plowing (plowing) and turned into humus. Hence, the cultivation and cultivation of smooth licorice in strong or very strongly saline soils, smooth licorice in moderate or strongly saline soils, pepper mint and dyed rye as salt-tolerant absorbing plants is one of the important factors in saline soils assimilation.

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