

UDC 574.5;572.1/4

Biology**INNOVATIVE APPROACH FOR IMPROVEMENT OF MARGINAL RESOURCES
OF KUR-ARAZ LOWLAND OF AZERBAIJAN****Corresponding Member of NAS of Azerbaijan V.M.Ali-zade¹, T.S.Shirvani¹,
E.G.Alırzayeva¹, K.N.Toderich²**

Salinization and pollution of lands led to the degradation of soils in Kur-Araz lowland. Biological technology based on the introduction of salt-tolerant agricultural crops and wild halophytes in culture of rangelands is developed for phytorehabilitation of marginal resources of lowland.

Keywords: salinity, marginal resources, salt-tolerant plants, phytorehabilitation, Kur-Araz lowland

Conservation and rational utilization of the land being a constituent of ecosystem are one of the most important ecological problems of present day. Ever-increasing anthropogenic loading on the environment leads to the substantial disturbance in structure and the changes in the chemical composition of a soil cover in the extensive territories resulting in its degradation. In turn, a degradation of soils being the serious factor of the desertification of planet and one of the most powerful edaphic stresses limits growth and development of plants including native grasslands, reduces their quality and productivity. Thereby the possibilities of sustainable development of agriculture and preservation of natural resources are limited.

Salinization and heavy metal (HM) pollution of lands are considered as the main factors resulting in degradation of soils. This problem is especially acute for arid and semi-arid rangeland ecosystems of Azerbaijan. 70% of the territories of Kur-Araz lowland being a major and important agricultural region and main arid forage basis of the republic are seriously affected by different levels of salinity and heavy metal contamination [2; 13]. This lowland is characterized as arid-semiarid zone with an aridity coefficient of 3-3.5. For recent decades, these territories are one of the largest irrigated agricultural zones, where the poor management of irrigation system induced the secondary salinization of soils. This phenomenon turns huge territories of Kur-Araz lowland into marginal low productive, not suitable for agricultural use lands. Soil salinity and

alkalinity causes a serious problem for agriculture, because the productivity of almost all the crops shows a drastic decrease with increasing concentration of soluble salts in soils. Additionally, this lowland is intensively used as winter pastures. Growing on these lands salt-resistant grasses and shrubs are willingly eaten by cattle. The excessive grazing also contributes to the deterioration of quality and productivity of rangelands, and thus, induces further desertification and loss of some valuable native plant species. As a consequence, Kur-Araz plains (grasslands/winter pastures) face with the serious threat of soil water, loss of soil fertility and organic matter, increasing of soil salinization and waterlogging. As a result, the former highly productive livestock system has deteriorated and livelihoods of the people have dramatically declined.

To involve the saline soils of Kur-Araz lowland in agricultural circulation the realization of complex of reclamative actions is required as the meliorative state of arable lands in this region is extremely unsatisfactorily. Considering that the rehabilitation and exploitation of collector-drainage system providing the removal of salts and other pollutants from soils are costly and time-consuming, the alternative low-cost, environmental-friendly and socially accepted biological strategies on localized management were tested in the present study. Biological approaches by means of cultivation the salt-tolerant agricultural as well as natural plant species, in particular halophytes which could be involved to practical management to direct to

the decreasing of soil salinity, improving soil health and optimization of different arid and semiarid production systems [3; 14].

Fundamental and applied scientific investigations clearly show that there are some of agricultural crops and wild halophytic species, which not only safely survive under extreme edaphic conditions, but also possess a genetic potential for removal, degradation, metabolization and immobilization of wide spectrum of pollutants in the soils [6]. The resistance of plants to high levels of salts is defined by a totality of their biological properties in basis of which the specific mechanisms and strategies are developed [5; 9]. Plants evolved also subtle mechanisms for resistance to toxic metals in soil [4]. Salt-resistant plants like metal-resistant species try to avoid the absorption and accumulation of salts and HM, or to adapt to their high content due to mobilization of protective functions of metabolic processes and/or by means of the membrane functions to transport the toxicants to vacuoles [11]. Here the latter are isolated from metabolic processes concentrated in the great amounts and then by means of membrane system of the specialized salt glands and bladders are removed through vegetative organs [14]. Due to these peculiarities, these plants are considered to be a potentially ideal means for the cleaning up of soils in the phytoremediation process [7].

For a phytoimproving of the degraded semi-desert rangelands of Kur-Araz lowland there is a sharp necessity of introduction into ecosystems of pasture of the perspective native wild species of forage plants, possessing the high productivity and the great adaptive potential to stress factors, including drought, salinity and HM. Besides, these plant species must possess a high accumulative ability of salt and metal ions as well as their joint removal from the soils. An innovative strategy is based on the appropriate selection of plants which can successfully grow and produce seeds under dry and saline environments possessing a high rate of shoot and root biomass accumulation, deep root system and distinguishing by efficient nutrient uptake mechanism, re-

sistance to salinity and water deficiency which was the main goal of current work.

Study of the contemporary status of vegetation cover of Kur-Araz lowland revealed more than 1.215 plant species (27% of the total flora of Azerbaijan numbering 4.500 species) [10], about 62 % species belonging to *Chenopodiaceae* family are identified as halophytes here [8]. Dominant halophyte species of genus *Salsola nodulosa* (Mog) Ilin, *Salsola dendroides* Pall, *Halostachys caspica* (Biob). S.A. Mey, *Suaeda dendroides* (C.A. Mey) Mog, *Artemisia fragrans* L., *Atriplex tatarica* L., *Tamarix ramosissima* Ldb. etc. occupy large areas of saline soils on the lowland with considerable project coverage in range of 13-19 % in dependence on different ecological edaphic conditions and landscape altitude [12]. A majority of these species are valuable fodder plants, distinguishing by the high contents of primary and secondary metabolites, which are tolerant to the various extreme factors and make them perspective for the restoration of pastures productivity [1]. In particular, a present study of caloric values of plant species, collected from the investigated areas, which is accepted as the energy allocation within individual organisms and measurements of ecological performance revealed the highest value for *Artemisia* shoots (4262 cal/g). This value for the shoots of *Salsola* spp., *Suaeda* spp. and *Halochneum* spp. distributed in these areas also was found to be high, ranging from 3644 cal/g to 3989 cal/g.

Among of the dominant plant species investigated *Suaeda dendroides* and *S. confusa* were found to distinguish by an exclusively accumulative capacity to Na^+ ions – 45mg/g DM and 50 mg/g DM, respectively, *Halochneum strobilaceum* – about 40 mg/g DM. However, the difference between these species was found in their selectivity to anions, while SO_4^{2-} ions were highly accumulated by *Suaeda dendroides* which is considered as an indicator of sulphate type of salinity (more than 75 mg/g DM) *S. confusa* mostly accumulated Cl^- ions (more than 80 mg/g DM). *Salsola* species possessed a less accumulation ability to the salt ions, but showing a high tolerance to them and no symp-

toms of toxicity vigorously occurred under these conditions. This halophyte accumulated in its assimilative organs the ions of metals including heavy metals in particular Al, Fe, Pb, Co, Zn, Cr more than other tested species growing in Kur-Araz lowland, *Suaeda* species was distinguished by accumulation capacity to Cd, Cu, Mn.

Analysis of the electric conductivity of soil samples collected from the investigated areas revealed the different salinity levels ranging from 0.5 to 17 mS/cm. The highest EC was found in Hajigabul on side close to intensive road (Fig. 1) which was estimated as a strong salinity. Other investigated sides in this region were revealed as the medium salinized. A study of one of these sides displayed that salinity degree increases proportionally to depth of soils profile which was also consistent with the results of analysis of soil layers in Kurdemir and Karrar regions, where EC value was higher in lower soils layers (Fig. 2). A

distinct situation was observed for Gobustan region where the soil surface was found to be more saline than the lower layers. EC values also were very different around plant species growing in different regions of lowland. The highest value was revealed for soil around *Suaeda confusa* from Sahil region (data not shown).

In the light of results of present work, *Salsola spp*, *Suaeda spp*, *Halochneum strobilaceum*, *Artemisia fragrans* could be proposed as the good candidates for the remediation of contaminated degraded soils of Kur-Araz lowland. These wild metal halophytes can be involved in practical management directed to the remediation of the root-zone area to enhance the economic productivities of agricultural and native fodder plant species and improve the livelihood of the local population in this target area.

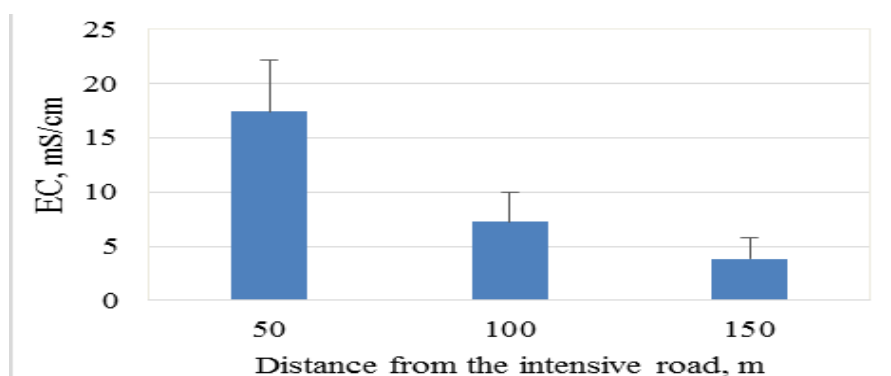


Fig. 1. Electric conductivity of soil samples collected in different distance from the intensive road in Hajigabul region of Kur-Araz lowland

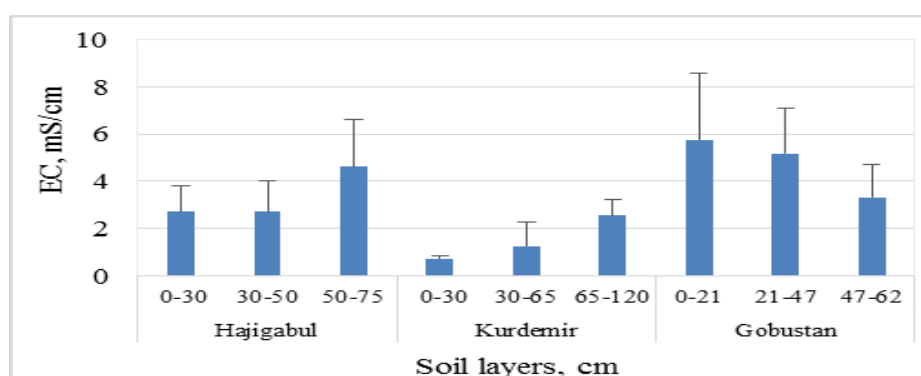


Fig. 2. Electric conductivity of different layers of soils collected in various regions of Kur-Araz lowland



Fig.3. Demonstration pilot site of Karrar
Experimental Station of the Institute of Botany of ANAS

Based on the comparative study of multiple soil and plant parameters from different regions of Kur-Araz lowland Karrar Experimental Station of the Institute of Botany of ANAS was selected as the demonstration pilot site for agriculture development of marginal lands ensuring an improving their productivity and of soil quality (Fig.3.). An integrated biosaline agriculture program for sustainable use of marginal mineralized water and salt affected soils for trees/shrubs, food-feed crops and forage perennial grasses, chenopods and legumes has been developed by the scientists of the Institute of Botany of ANAS and the International Center for Biosaline Agriculture (ICBA). Seeds of salt tolerant germplasm from ICBA along with local crops were planted on the Karrar Experimental Station. All crops achieved good production at salinity levels where traditional crops production is commercially non-profitable. Sorghum, pearl millet, quinoa, amaranth, soya bean, cow pea, mung bean, indigofera, sunflower and others in pure or mixed farming based systems are suggested as alternative crops for biosaline agriculture. Perennial shrubs, especially *Atriplex canescens* could be suggested as a potential agroforestry option for restoration of degraded winter pastures of Kur-Araz lowland. The results showed the insignificant differences between local and ICBA varieties in seed germination rate, plant height, and accumulation of green biomass when cultivated on soils with light clay texture and low level of soil salinity.

Management strategies to be developed for these resources should be dependent on local and

regional environmental conditions, especially on the availability and quality of water resources and on the properties of soils, which strongly affect the agricultural conception for each particular site. Integrated and holistic approaches should reflect local and regional ecosystems' relationships, addresses the long-term sustainability of saline agriculture and aims at (1) developing models, predictions and decision-support systems for dry land salinity management and utilization and (2) providing flexible and efficient means for evaluating alternative options in saline agricultural production. However lack of contact with the international scientific community has caused a technology lag and prevented scientists from keeping abreast of scientific advances, while links between research and producers have been lost with the breakdown of the central planning system. Researchers now have no formal channels through which to disseminate information, knowledge and new technologies.

Institute of Botany of ANAS jointly with ICBA will further promote biosaline technologies based on utilization of halophytes as well as water and land management in Kur-Araz area. This will help to define improved strategies and carry out field experiments, the result of which will be recommended for local farmers and pastoralists.

This work was supported by the Science Development Foundation under the President of the Republic of Azerbaijan- Grant No EIF-2012-2(6)-39/18/3 and partially by financial support of ICBA Funds during 2013-2015 years.

REFERENCES

1. Alirzayeva E.H., Ali-zade V.M., Shirvani T.S. (2013) Evaluation of wild halophytes for the soil restoration in Kur-Araz lowland. In: Proc. Book of XVII Intern. Plant Nutr. Colloq. Istanbul, Turkey, 1176-1177.
2. Ali-zade V.M., Shirvani T.S., Alirzayeva E.H. (2011) Plant resistance to toxicity of metals and petroleum hydrocarbons. Approaches to phytoremediation. Baku: Elm: 280 p. (in Russian)
3. Dikilitas M., Karakas S (2010) Salt as potential environmental pollutants, their types, effects on plants and approaches for their phytoremediation. In: Ashraf M., Ozturk M., Ahmad M.S.A. (eds) Plant Adaptation and Phytoremediation. Springer Science+Business Media B.V.: 357-383
4. Ernst W.H.O. (2006) Evolution of metal tolerance in higher plants. Forest Snow Landscape Research 80: 251-274
5. Hameed M., Ashraf M., Ahmad M.S.A., Naz N. (2010) Structural and functional adaptations in plants for salinity tolerance. In: Ashraf M., Ozturk M., Ahmad M.S.A. (eds.) Plant Adaptation and Phytoremediation. Springer Science Business Media B.V.: 151-170
6. Kramer U. (2010) Metal hyperaccumulation in plants. Ann Rev Plant Biol. 61:517-534
7. Manousaki E., Kalogerakis N. (2011) Halophytes present new opportunities in phytoremediation. IndEngChem Res 50: 656-660
8. Movsumova F.G. (2011) Distribution, ecological-phytocoenotic peculiarities and useful features of species of *Chenopodiaceae* family in Azerbaijan. Proc. of the "Man and Biosphere" (MAB, UNESCO) Azerb. Nat. Com., Ann. edition 7: 311-318
9. Munns R., Tester M. (2008) Mechanisms of salinity tolerance. Ann Rev Plant Biol 59: 651-681
10. Musayev S.G., Fataliyev R.A. (2004) Flora of Azerbaijan: new data. Transact. of Bot. Inst. of ANAS XXV: 16-22 (in Russian)
11. Seregin I. V., Kozhevnikova A.D. (2008) Role of root and shoot tissues in transport and accumulation of cadmium, lead and strontium. Plant Physiol. 55: (1): 1-26 (in Russian).
12. Shukurov E., Jafarova A., Abduyeva R., Shirvani T. (2013) Current status of the arid and semiarid winter pastures in Azerbaijan// Proc. Inst. of Bot. of ANAS, XXXIII: 121-124 (in Azerbaijani).
13. Soil Atlas of Azerbaijan Republic (2007) Mammadov G.Sh. et al. (Eds.) The State Committee of Land and Cartography of Azerbaijan Republic and Institute of Soil and Agrochemistry ANAS. Baku Cartography Factory.
14. Toderich K.N., Shuyskaya E.V., Khujanazarov T.M., Ismail Sh., Kawabata Y. (2010) The structural and functional characteristics of Asiatic desert halophytes for phyto-stabilization of polluted sites. In: Ashraf M., Ozturk M., Ahmad M.S.A. (eds.) Plant Adaptation and Phytoremediation. Springer Science Business Media B.V.: 245-274

¹Institute of Botany of ANAS²International Center for Biosaline Agriculture for Central Asia and Caucasus (ICBA-CAC), Tashkent, Uzbekistan

vm_alizade@yahoo

AZƏRBAYCANIN KÜR-ARAZ OVALIĞININ AZMƏHSULDAR RESURSLARININ BƏRPASI ÜÇÜN İNNOVATİV YANAŞMA

V.M.Əli-zadə, T.S.Şirvani, E.H.Əlirzayeva, K.N.Toderiç

Duzluluq və müxtəlif toksikantlarla çirklənmə Kür-Araz ovalığında torpaqların degradasiyasına səbəb olmuşdur. Ovalığın azməhsuldar resurslarının fitobərpası üçün duzadavamlı kənd təsərrüfatı bitkiləri və yabanı halofitlərin otlaq kulturalarına introduksiya edilməsinə əsaslanan bioloji texnologiya işlənilib hazırlanmışdır.

Açar sözlər: duzluluq, azməhsuldar resurslar, duzadavamlı bitkilər, fitobərpa, Kür-Araz ovalığı

ИННОВАЦИОННЫЙ ПОДХОД ДЛЯ РЕАБИЛИТАЦИИ МАЛОПРОДУКТИВНЫХ РЕСУРСОВ КУРА-АРАЗСКОЙ НИЗМЕННОСТИ АЗЕРБАЙДЖАНА

В.М. Али-заде, Т.С. Ширвани, Э.Г. Алирзаева, К.Н. Тодерич

Засоление и загрязнение почв различными токсикантами привело к деградации земель Кура-Аразской низменности. Разработана биотехнология, основанная на введении в культуру пастбищ солеустойчивых сельскохозяйственных растений и диких галофитов для фитореабилитации малопродуктивных ресурсов низменности.

Ключевые слова: засоление, малопродуктивные ресурсы, солеустойчивые растения, фитореабилитация, Кура-Аразская низменность