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BIOMORPHOLOGICAL CHANGES OF SOME TREE AND SHRUBS SPECIES IN THE SALINE SOILS OF THE ABSHERON PENINSULA

*©**Asadov H.,** Ph.D., Institute of Dendrology Azerbaijan NAS, Baku, Azerbaijan, asadovhuseynaga@mail.ru*
*©**Mammadov T.,** Dr. habil., Institute of Dendrology Azerbaijan NAS, Baku, Azerbaijan, denrary@mail.ru*
*©**Mirjalalli I.,** Institute of Dendrology Azerbaijan NAS, Baku, Azerbaijan, mirjalalli@mail.ru*
*©**Ataeva H.,** Institute of Dendrology Azerbaijan NAS, Baku, Azerbaijan*

БИОМОРФОЛОГИЧЕСКИЕ ИЗМЕНЕНИЯ НЕКОТОРЫХ ВИДОВ ДЕРЕВЬЕВ И КУСТАРНИКОВ НА ЗАСОЛЕННЫХ ПОЧВАХ АПШЕРОНСКОГО ПОЛУОСТРОВА

*©**Асадов Г. Г.,** канд. биол. наук, Институт дендрологии НАН Азербайджана, г. Баку, Азербайджан, asadovhuseynaga@mail.ru*
*©**Мамедов Т. С.,** д-р биол. наук, Институт дендрологии НАН Азербайджана, г. Баку, Азербайджан, denrary@mail.ru*
*©**Мирджалаллы И. Б.,** Институт дендрологии НАН Азербайджана, г. Баку, Азербайджан, mirjalalli@mail.ru*
*©**Атаева Х.,** Институт дендрологии НАН Азербайджана, г. Баку, Азербайджан*

Abstract. Although it is very difficult to study the biomorphological properties of plants according to their sensitivity to salt ions during introduction, the fact that species do not adapt to saline soils for a long time makes it necessary to conduct some experiments. The introduction of new trees and shrubs imported from abroad has become a priority in the Absheron Peninsula of the Republic of Azerbaijan, especially in the Khazar and Pirallahi regions. In this regard, chemical analyzes were carried out by analytical methods, the mechanism of action of salt ions (Cl^-, SO_4^{2-} and CO_3^{2-}) in plants was studied, intoxication of toxic salt ions and bio indicative properties of individual ions were studied. During the study, 44 species of trees and shrubs sensitive to Cl^-, SO_4^{2-} and CO_3^{2-} ions were selected and their salinization properties (weak, medium and high) were determined. It was found that the sensitivity of trees and shrubs to chlorine, sulfate and carbonate ions is significantly different, and the selectivity of plants to salt ions is correlated with bio indicative properties. The saline and re-salinized soils of the areas belong to the chloride-sulfate, sulfate-chloride and chloride-sulfate-carbonate types, in which high chlorine ion, medium carbonate ion and weak sulfate ions are found to cause intoxication. In saline soils, chlorine ions have been shown to form halo succulence in plants, and sulfate ions to have halo xerophytes, and trees' species are less resistant to salt ions than shrub species.

Аннотация. Хотя очень трудно изучать биоморфологические свойства растений по их чувствительности к ионам солей при интродукции, тот факт, что виды длительное время не адаптируются к засоленным почвам, вызывает необходимость проведения некоторых экспериментов. Интродукция новых деревьев и кустарников, завезенных из-за рубежа, стала приоритетной задачей на Апшеронском полуострове Азербайджанской Республики, особенно в Хазарском и Пираллахинском районах г. Баку. В связи с этим с помощью аналитических методов, изучены механизм действия ионов (Cl^-, SO_4^{2-} и CO_3^{2-}) на растения, токсическое воздействие и биоиндикаторные свойства отдельных ионов. В связи с этим с помощью аналитических методов, изучены механизм действия ионов (Cl^-, SO_4^{2-} и CO_3^{2-}) на растения, токсическое воздействие и биоиндикаторные свойства отдельных ионов. В ходе исследования были отобраны 44 вида деревьев и кустарников, чувствительных к ионам Cl^-, SO_4^{2-} и CO_3^{2-}, определена их способность к засолению (слабая, средняя и высокая). Установлено, что чувствительность деревьев и кустарников к хлоридам, сульфатам и карбонатам существенно различается, а селективность растений к ионам коррелирует с биоиндикационными свойствами. Засоленные и повторно засоленные почвы территорий относятся к хлоридно-сульфатному, сульфатно-хлоридному и хлоридно-сульфатно-карбонатному типам, для которых установлено, что интоксикацию вызывает высокое содержание хлорид-ионов, среднее карбонат-ионов и слабое сульфат-ионов. Показано, что засоленные ионами хлора почвы предпочитают галосуккуленты, а сульфат-ионами — галоксерофиты; древесные формы менее устойчивы к ионам солей, чем кустарниковые.

Keywords: salinity, soil, introduction, trees, shrubs.

Ключевые слова: засоление, почва, интродукция, деревья, кустарники.

Introduction

In recent years, due to climate change, long periods of drought, changes in temperature, reduction of groundwater, re-salinization has occurred in the Khazar and Pirallahi regions of the Absheron Peninsula, weak and moderately saline soils have become highly saline. Changes in the species composition of natural vegetation, narrowing of the area and urbanization are observed in the soils of the areas. Although the natural vegetation in these areas is small in terms of species composition, the ephemerals and ephemeroids here have adapted to evolutionary salinization. In recent years, new parks, gardens and green areas have been laid in the areas under study using decorative trees and shrubs imported from abroad. Although tree and shrub species are variable in their bioindicator properties, they have been able to adapt to salt ions in the Absheron Peninsula. Annual landscaping has significantly changed the structure of saline soils. The threat of global warming and environmental crisis caused by climate change necessitates urgent, large-scale and effective measures to address the urgent needs of human society.

Materials and Methods

As an object of research in the Absheron Peninsula of the Republic of Azerbaijan, especially in the Caspian and Pirallahi regions have 39 types, *Limonium vulgare* Mill., *Taxus baccata* L., *Tamarix ramosissima* Ledeb., *Artemisia absinthium* L., *Vitex agnus-castus* L., *Alhagi pseudalhagi* (M. Bieb.) Desv. ex Wangerin and etc. are used. The salinity properties of selected trees and shrubs were determined as weak, medium and high [12]. The soils of these areas differ in the amount of salt ions. Lowland, steppe and desert soils are relatively saline, and forest and mountain slopes are characterized by humus content. From this point of view, the soil of the Absheron Peninsula is highly saline, and the humus layer is very low [1]. The coastal lands of the Caspian Sea are dominated by sandy and calcareous rocks in the lower layers. Here, the types of salinization are not separate, but mixed. Cl^-, $SO^{2-}{}_4$, CO_3^{2-}, which cause soil salinization during the study. ions and their degree of concentration were determined [5]. Since most of the trees and shrubs introduced in the saline soils mentioned above were brought from different areas, the degree of their adaptation to saline soils was studied. Physiological and biochemical processes in plant organs, salt ions collected in leaves and shoots Palintest (Soil test 10), irrigation water Palintest Photometer-7100, total amount of chlorophyll in leaves with chlorophylometer (SPAD), green pigments. The amount was determined by a device with a photometer AP-120.

Results and Discussion

Light radiation creates a photochemical effect in plants and provides the process of photosynthesis, thermal energy allows water to evaporate from the leaf organs of plants, creating conditions for chemical reactions. In recent years, in the Absheron Peninsula of the Republic of Azerbaijan, especially in the Khazar and Pirallahi regions, the decline of groundwater, mass irrigation in green areas and lawns has led to re-salinization, resulting in the predominance of chloride-sulfate, sulfate-chloride and chloride-sulfate-carbonate soils [2, 13].

In such soils, the natural vegetation is also significantly thinned, naturally no tree species are recorded, the main species composition is monocotyledonous grasses-ephemerals, and perennials are ephemeroids. For this reason, planting greenery, planting salt-resistant trees and shrubs in the Absheron Peninsula is urgent. Although the dry subtropical nature of the Absheron Peninsula is very effective for the introduction of trees and shrubs, the intoxication of introducers with salt ions in the soil is very complicated, resulting in long-term adaptation. The presence of ions in the soil ($NaCl$, $CaCl_2$, $MgCl_2$, $MnCl_2$, $CaSO_4$, $CaCO_3$, $NaCO_3$, $MgSO_4$, KCl, K_2SO_4, K_2CO_3), as well as the presence of complex salts, makes a difference in the adaptation mechanism of intoxicated trees and shrubs [3, 4]. As a result of our long-term research, it has been found that the root system of plants shows a stress response against salt ions. There are plants that are sensitive to sulfate (SO_4^{2-}) ions in the soil in which they grow but are highly intoxicated when exposed to chlorine ions (Cl^-) in the Absheron region, and the cells of the root system are severely toxic. In this case, the leaves of plants show signs of chlorosis, and after a short time the leaves dry up [6, 8, 9]. As the concentration of salt ions accumulated in the cytoplasm of the cell increases, protein molecules are hydrolyzed, and intermediates such as cadaverine, ammonia, putretsin, etc. Toxic compounds have an adverse effect on the adaptation mechanism of plants. In analyzing these mechanisms, we have divided plants into groups that use salt ions in the exchange process, remove ions from the vegetative organs, and remain indifferent to salt ions, and have proposed certain measures. Halophyte or facultative halophyte plant species belong to the 1st group, *Limonium vulgare* Mill., *Salsola rigida* Pall., *Taxus baccata* L., *Tamarix ramosissima* L. and so on. Species that are indifferent to salt ions (*Artemisia absinthium* L., *Vitex agnus-castus* L., *Alhagi pseudalhagi* L.) are included in the 2nd group. In trees and shrubs, the chloride ion was distinguished by its halosucculence and the sulfate ion by its haloxerophytic properties [7, 10, 11].

Adaptation of plant species to environmental conditions is a long-term process, because in a short period of time plants cannot create a mechanism of adaptation to the effects of environmental factors. On the other hand, because each species has an individual metabolism, they react differently to salt ions in the soil. They form an adaptation mechanism using chlorine, sulfate, carbonate ions in the exchange process [14–16]. The development of trees and shrubs in accordance with soil conditions is shaped by evolutionary bioindicators. The characteristic salinization type of the soils of the regions we studied (Khazar and Pirallahi) did not exist separately as chloride-sulphate, sulphate-chloride, chloride-sulphate-carbonate and differ in dominant salt ions. Research has been conducted in this direction, the degree of adaptation of plants to chlorine, sulfate and carbonate salinity, the ability to accumulate salt ions and biomorphological characteristics, the growth dynamics of leaves and green (single) shoots, deformation, etc. symptoms were studied and reflected in the tables [11, 14].

As can be seen from Table 1, the formation of biomorphological characteristics of tree and shrub species planted in saline soils (number of leaves, area, length of annual shoots, flower formation, flowering period) is relatively weak and different compared to the control option. While the development of species under study in the experimental field began early, the development of leaves and shoots from shoots in the field was observed much later. The formation of biomorphological characteristics of the species in saline soils occurs 10–15 days late. For example, in the experimental field of Khazar region, the length of newly formed shoots of *Ligustrum japonicum* Thunb. in May was 13.2 cm, the number of leaves in the shore was 6, the width of the leaf was 2.3 cm, the length of the leaf was 5.3 cm and the area was 12.2 cm^2. the length of the stem of this species is 11.0 cm; The number of leaves in the stalk was 4, the area was 7.6 cm^2 when the leaf was 1.9 cm wide and 3.4 cm long. Similarly, in the conditions of carbonate salinization in Buzovna settlement *Callistemon rigidus* R.Br. The length of the newly formed shoots is 20.0 cm, the number of leaves is 13, the width of the leaves is 0.5, the length is 4.0 cm, and the area is 6.0 cm^2. Leaves were 2.0 cm wide, 7.4 cm long and 13.0 cm^2 in area (Table 1).

Table 1

BIOMORPHOLOGICAL INDICATORS
OF TREES AND SHRUBS IN KHAZAR AND PIRALLAHI DISTRICTS IN 2020

Types	*Stalk Length (cm)*	*Number of leaves in 1 stalk (pieces)*	*The width of the leaf (cm)*	*The length of the leaf (cm)*	*The area of the leaf (cm^2)*
Ligustrum japonicum Thunb.	13.2	6.0	2.3	5.3	12.2
	11.0	4.0	1.9	3.4	7.6
Callistemon rigidus R. Br.	32.4	27.0	2.0	7.4	13.0
	20.0	13.0	0.5	4.0	2.0
Pittosporum heterophyllum Franch.	12.1	14.0	3.7	3.2	10.8
	8.0	10.0	1.5	2.3	3.4
Magnolia grandiflora L.	28.6	6.0	6.0	7.0	42.0
	24.0	4.0	5.2	7.5	39.0
Euonymus japonicus Thunb.	16.0	13.0	4.1	4.7	19.27
	14.0	11.0	3.0	3.5	10.5
Morus alba L.	12.3	8.0	4.7	6.8	31.6
	9.0	5.0	4.5	6.0	27.0
Ilex aquifolium L.	16.0	8.0	5.2	7.7	37.9
	14.2	7.0	4.1	7.3	29.9
Camellia japonica L.	14.3	8.1	5.0	8.0	40.0
	12.0	5.0	4.0	7.3	36.5
Laurocerasus officinalis M. Roem.	15.4	8.2	4.1	5.0	20.5
	13.0	7.0	3.3	4.6	15.2
Ficus microcarpa L. fil.	24.3	18.0	4.0	4.2	16.1
	20.5	16.0	3.2	3.4	10.9
Buxus sempervirens L.	14.3	12.0	3.7	4.7	17.3
	11.0	9.0	2.5	5.0	12.5

Since the toxic effect of chloride ions is higher than that of sulfate and carbonate ions, signs of chlorosis are observed in plant organs, especially in leaves. Under such conditions, the height of plants was relatively weak. If cracks form in the leaf axils as a result of carbonate salinization, in soils dominated by sulfate ions, there are signs of yellowing or twisting at the edges of the leaves of plants. During the research, about 40 trees and shrubs were used in greening the soils of Khazar and Pirallahi regions salted with chlorine, sulfate and carbonate ions. The rate of use of chlorine, sulfate and carbonate ions in the soil by plants varies considerably, and some species have been observed to die prematurely. In order to investigate the solution of this process, the bioindicative properties of trees and shrubs in salt soils for their sensitivity to salt ions were studied (Table 2).

Table 2

BIOINDICATIVE PROPERTIES OF 44 SPECIES
OF TREES AND SHRUBS INTRODUCED TO KHAZAR AND PIRALLAHI REGIONS

Those who collect chlorine ions	*Those who collect sulfate ions*	*Collecting carbonate ions*
Magnolia grandiflora L.	*Sophora japonica* L.	*Amygdalus communis* L.
Cupressus macrocarpa Hartw. ex Gordon	*Laurus nobilis* L.	*Olea europaea* L.
Ligustrum lucidum W. T. Aiton	*Eucalyptus camaldulensis* Dehnh.	*Ephedra equisetina* Bunge
Cotoneaster franchetii Boiss.	*Pinus eldarica* Medw.	*Ficus carica* L.
Chamaerops humilis L.	*Cupressus sempervirens* L.	*Elaeagnus angustifolia* L.
Robinia pseudoacacia L.	*Pinus pinea* L.	*Hibiscus syriacus* L.
Punica granatum L.	*Pinus halepensis* Mill.	*Caesalpinia gilliesii* (Hook.) Wall., 1830
Phragmites communis Trin.	*Juniperus chinensis* L.	*Nerium oleander* L.
Bambos arundinacea Retz.	*Ligustrum japonica* L.	*Ziziphus jujuba* Mill.
Quercus castaneifolia C. A. Mey.	*Callistemon speciosus* (Sims) Sweet	*Ailanthus altissima* (Mill.) Swingle
Pyracantha coccinea M. Roem.	*Morus alba* L., *M. nigra* L.	*Ficus carica* L.
Pistacia terebinthus L.	*Melia azedarach* L.	*Ulmus densa* Litv.
	Pistacia vera L.	*Salix alba* L.
	Elaeagnus angustifolia L.	*Vitis acerifolia* Raf.
		Cupressus macrocarpa L.

Studies have shown that there are species (calciphobes) that accumulate chloride ions in the root system, add sulfate ions to the metabolism, and are sensitive to carbonate ions. In some species (*Magnolia grandiflora* L., *Robinia pseudoacacia* L., *Cotoneaster franchetii* L.), Chlorine ions have acidic properties, so chlorophyll grains break down, resulting in the destruction of the chromoplast stroma in the leaf. The chlorophyll-protein bond is broken, phytol alcohol is formed, sulfate ions form theosulfide bonds, sulfur amino acids accumulate, and carbonate hardens the leaves, and the leaf dries quickly. When the concentration of chloride ions is high, proteins are also hydrolyzed, intermediates: cadeverine, putrecine, ammonia, etc. accumulates. These toxic compounds cause chlorosis, premature drying or burns of various sizes on the leaves.

Studies have shown that *Cupressus macrocarpa* L., *Ligustrum lucidum* W. T. Aiton, *Chamaerops humilis* L., *Punica granatum* L., *Phragmites communis* Trin., *Pyracantha coccinea* M. Roem. and so on. The species thrives normally in chlorinated saline soils (Table 2). *Juniperus chinensis* L., *Melia azedarach* L., *Pistacia vera* L. Grow satisfactorily in saline soils with sulfate ions. They are used in the synthesis of amino acids, easily adding sulfate ions to the metabolism. Calciphobic trees and shrubs growing in saline soils (sandy, clayey-sandy) with carbonate ions can be considered as characteristic species in the Absheron Peninsula. In such soils *Amygdalus communis* L., *Olea europaea* L., *Elaeagnus angustifolia* L., *Amygdalus communis* L., *Ailanthus* *altissima* L., *Nerium oleander* L., *Ulmus densa* L., *Salix alba* L., *Ficus carica* L., *Vitis acerifolia* L., *Punica granatum* L. and so on. The species is widely used in landscaping gardens and parks. The leaves of species that use carbonate ions are hard, sliced and sometimes small.

Olea europaea L., *Platanus orientalis* L., *Elaeagnus angustifolia* L. They are distinguished by their resistance to salt ions in the saline soils of the Absheron Peninsula. As shown in Table 2, the relationship of species to salt ions is relative Magnolia grandiflora L. It is not recommended to be introduced in these areas as it is not resistant to soils with high chlorine ion and is prematurely destroyed. *Populus* L. It is not advisable to plant species of this genus in soils with high sulfate ions, as the wood is not dense, dries early in drought conditions and is less resistant to pathogens. It is not expedient to plant tall trees in windy weather in Absheron. There are also species that are indifferent to salt ions under natural conditions and exchange iodine, sulfate and arsenium ions for amino acids. Research is underway in this direction.

The phytomeliorative properties of halophytes, which remove salt ions from the leaf surface using salt ions, are much weaker in trees and shrubs.

Although it is very difficult to detect the bioindicative properties of trees and shrubs growing in saline soils, it is very effective. Thus, by determining the properties of saline soils in advance, it is also economically advantageous to know in advance in which areas the species is suitable for planting.

Conclusions

Determining the bioindicative properties of species according to their sensitivity to salt ions, their selection according to the regions and the differentiation of plants according to the nature of the accumulation of salt ions provide a reliable basis for introduction.

The saline and re-salinized soils of the Khazar and Pirallahi regions of the Absheron Peninsula of the Republic of Azerbaijan belong to the chloride-sulphate, sulphate-chloride and chloride-sulphate-carbonate types, in which chlorine ions are high, carbonate-medium and sulphate ions are weakly intoxicated. Experimental experiments show that the sensitivity of trees and shrubs to chlorine, sulfate and carbonate ions is quite different, as the resistance of tree species to salt ions is weaker than that of shrub species. It was found that the selectivity of plants against salt ions is correlated with their bioindicative properties. In saline soils, chlorine ions have been found to form halosucculence in plants, and sulfate ions to form haloxerophytes.

Before starting landscaping works, salt ions in saline soils, type of salinization, chemical components of irrigated water, bioecological properties of cultivated plants, degree of adaptation to salinization should be studied, species should be selected according to soil conditions.

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