SUMMARY

of the doctoral thesis entitled:

RESEARCH ON THE BEHAVIOR OF SOME HALOPHITE SPECIES ON SALNY SOILS/ SUBSTRATES

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The process of soil salinization represents a significant ecological and agricultural issue, exacerbated by global climate change. Salinization, which involves the excessive accumulation of soluble salts in soils, is driven by both natural and anthropogenic factors. The dynamics of salts in soils are complex, encompassing processes such as increased evaporation, improper irrigation, and changes in hydrological regimes caused by climate change. These changes can lead to increased salt concentrations, negatively affecting soil structure and fertility.

Climate change amplifies salinization problems by altering precipitation and temperature patterns, which intensify evaporation and salt accumulation, particularly in semi-arid and arid regions. Additionally, extreme climate events, such as droughts, contribute to the accumulation and concentration of salts in soils.

The ecosystem services provided by soils are essential for maintaining environmental health and agricultural productivity. Saline soils reduce agricultural production capacity and affect biodiversity, leading to significant economic and ecological consequences. In this context, halophytic plants, which are adapted to saline conditions, play a crucial role in ameliorating affected soils. They not only contribute to soil stabilization and salinity reduction but also provide sources of food, fodder, and biofuels.

The focus of the research was on finding nature-inspired models that mimic ecological processes and mechanisms for the restoration and sustainable management of soils. These solutions, known as "nature-based solutions," included elements that imitate natural processes, such as the use of halophytic plants for potential ecosystem restoration, aimed at restoring the functions of degraded ecosystems and mitigating the negative impact of salinization.

Thus, the research conducted had the following main objectives:

Objective 1	Comparative study of the influence of different salt concentrations on seed germination in vitro and in vivo;
Objective 2	Comparative analysis of growth and development characteristics of the plant species used (number of leaves, plant height, number of inflorescences) *in vivo* and *in situ*;
Objective 3	Comparative study of the translocation and accumulation of mineral elements from saline soils in plant parts;
Objective 4	Obtaining an experimental model applicable for soil improvement as well as for obtaining cut flowers and/or halophyte biomass.

The research and analyses were conducted between 2016 and 2021 and took place at the Faculty of Horticulture and the Research Center for Studies of Food Quality and Agricultural Products, USAMV Bucharest:

1. Agrochemistry Laboratory;
2. Laboratory of Physical-Chemical Analysis;

3. Research Block Greenhouse.

The thesis consists of 171 pages, structured into seven chapters and organized into two main sections: the first includes a bibliographic review, and the second is dedicated to original research.

The bibliographic study is structured into two chapters that provide an overview of the situation of salinized soils at both international and national levels, the stages of the salinization process in nature, factors influencing the dynamics of salts in soil, the effects of certain salts on the soil-plant system, and the regulatory mechanisms of plants under saline stress, as well as classical and modern remediation methods, and perspectives on utilizing salinized soils and halophyte biomass.

Chapter I, "**Current state of research on the influence of sodium on the soil-plant system**" addresses the issue of saline soils and their impact on agriculture in the context of the growing global population and limited natural resources. This chapter includes relevant information on the rapid increase in the world population and the heightened demand for resources, which places significant pressure on agricultural lands that are already affected by soil degradation and climate change. It also presents information on the salinization process and its impact on arable lands and crop productivity, as well as the need for identifying adaptive management solutions. Additionally, this chapter discusses the classification of salt-affected soils, highlighting the differences between saline and sodic soils, both of which negatively impact plant growth. At the same time, it addresses plant tolerance mechanisms, which can employ various strategies to cope with salinity, including salt exclusion, accumulation of osmotic-active substances, and activation of antioxidant systems. The chapter concludes with information about halophyte species, particularly ornamental ones, as a sustainable alternative for the effective management of saline soils in the context of global challenges.

Chapter II, "**Management of salt-affected soils**" highlights the importance of managing salt-affected soils through the use of appropriate amendments and halophyte plants, promoting sustainable solutions for salinization issues. This management approach can not only improve soil health but also contribute to enhancing ecosystem services, circular economy, and adaptation to climate change. In this context, the chapter includes information on both conventional and modern amelioration techniques, which involve various types of amendments for saline soils, organized into three categories: organic, inorganic, and their combinations. Organic amendments, such as biochar and compost, are valued for their ability to improve soil stability and water retention. Among inorganic amendments, gypsum is effective in ameliorating sodic soils by providing calcium and reducing sodium levels. The chapter also covers applications of these amendments where promising results have been achieved, improving the physical, chemical, and biological properties of the soil. Additionally, it provides information on the use of halophyte species for ameliorating saline soils, emphasizing the need to understand salinization sources and adapt techniques to specific soil conditions, as well as the potential for utilizing biomass obtained from cultivation.

The section on original research begins with a general overview of the materials and analytical methods used, followed by additional details in the chapters dedicated to each experiment. Each experiment is described in separate chapters, offering a detailed account of the procedures used.

Chapter III, "**Materials and Methods**," provides a detailed description of the materials and methods used in the doctoral thesis that investigates the adaptation capacity of halophyte plants to different types of soils. The chapter begins with an overview of the soils/substrates used in the experiments testing the adaptability of various halophyte species and presents the main characteristics of these soils/substrates. The soil used in the experiments was sampled from the upper horizon to a depth of up to 20 cm. Samples were taken from three representative areas: natural saline soil (Lacu Sărat, Brăila), anthropogenic saline soil (Bucşani, Dâmboviţa), and floodplain soil (Balaciu, Dâmboviţa). The soils were analyzed from physical and chemical perspectives, with some of the evaluated properties having a significant impact on the conduct of the experiments. The chapter also describes the types of substrates used. Additionally, it details the methods employed for analyzing the soils/substrates and the plants grown under experimental conditions. The experimental designs and preparation procedures are presented separately in each respective chapter.

Chapter IV, "**Research on the impact of sodium concentration on the germination capacity of halophyte species seeds**" highlights the importance of salinity as an environmental factor affecting agricultural production, with negative effects on plants such as ionic toxicity and osmotic stress. The biological material used included seeds of *Portulaca sativa* L. (Purslane common green), *Gypsophila elegans* Crimson, *Festuca arundinacea* L., *Limonium sinuatum* L., *Celosia plumosa* Fresh Look Mix, *Amaranthus cruentus*, *Amaranthus cruentus* Oeschberg, *Amaranthus cruentus* Red Garnet, as well as the in vitro testing conditions with sodium chloride concentrations of 0.2%, 0.6%, 1.2%, and 2.4%. The experiments were conducted in a climate chamber for 8 days, with parameters such as germination percentage, hypocotyl length, and radicle length being monitored. The results indicated that *Celosia plumosa* Fresh Look Mix seeds were suitable for a concentration of 0.2%, seeds of *Festuca* sp. and *Gypsophila* sp. could germinate at concentrations up to 0.6% NaCl, seeds of *Portulaca* sp. could tolerate up to 1.2%, while those of *Limonium sinuatum* L. could tolerate up to 2.4%, but at a very low percentage (4%).

Chapter V, "**Research on the behavior of halophyte species cultivated on saline substrates – under controlled conditions**" presents experimental research on the behavior of ornamental species grown on saline substrates in greenhouse conditions, with the aim of assessing their adaptability to saline soils and selecting them for real-world testing. The research in this chapter is divided into two sections as follows. The first experiment involved evaluating the germination percentage of several ornamental plant species (*Celosia plumosa* 'Fresh Look Mix', *Celosia plumosa* 'Bombay Cherry', *Celosia plumosa* 'Ice Cream (Mix)', *Celosia plumosa* 'Glorious Red', *Limonium sinuatum* 'QIS Mix', *Amaranthus* 'Autumn Palette', *Amaranthus caudatus*, and *Gypsophila elegans* 'Crimson', *Festuca arundinacea* L., *Portulaca sativa* L.) on different substrates (mixtures of garden soil with saline soil in various proportions). Parameters such as germination percentages, germination dynamics, plant height, number of leaves, and inflorescences were monitored. In the second experiment, plants were cultivated on soils with different salinity levels (S1-S6) to observe their growth and adaptability over a period of four months. Parameters such as plant height, pH value, and electrical conductivity of the soil were monitored before and after cultivation.

Chapter VI, "**Research on the behavior and dynamics of certain salts in halophyte plants – in real environment**" presents experimental research on the behavior of species selected in the previous chapter under real conditions. The species used in the experiment are *Limonium sinuatum* L., *Festuca arundinacea* L., and *Portulaca sativa* L., cultivated in two experimental plots: one in Dâmboviţa (saline soil) and the other in Tulcea (reference soil). The chapter includes data on the growth and development parameters of the plants (plant height, number of leaves, number of floral stalks, and inflorescences) as well as results regarding the dynamics of mineral elements in the soil and plants. The results indicate that sodium plays a dominant role in the dynamics of minerals in plants grown in the experimental plot in Dâmboviţa, with soil salinity being higher compared to the Tulcea plot. Plant behavior varies depending on species and stress conditions, highlighting the adaptability of these plants to saline environments. Among the three cultivated species, *Limonium* sp. showed the most promising results. Regarding the dynamics of salts, the analysis results showed that the translocation of sodium, potassium, and calcium occurred at the leaf level, while magnesium was stored in the roots. The findings suggest that halophyte species can contribute to the restoration of salt-affected lands, having a positive impact on soil quality and biodiversity.

Chapter VII, "**General conclusions and recommendations**" provides a synthesis of all the experiments regarding the influence of salt concentration on seed germination and plant growth, correlated with sodium levels in the soil, soil type, and the cultivated plant. Several recommendations have been formulated, which can serve as a basis for future studies. These recommendations aim to continue observations on the effects of soil salt concentration on crop plants and to find alternative solutions that mimic natural conditions impacted by climate change.