盐碱地生态修复原理与技术

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中国林业出版社

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图书在版编目（CIP）数据

盐碱地生态修复原理与技术/张建锋著. -北京：中国林业出版社，2007.12
ISBN 978-7-5038-5127-8

Ⅰ.盐… Ⅱ.张… Ⅲ.盐碱地-生物土壤改良 Ⅳ.S156.4

中国版本图书馆 CIP 数据核字（2007）第 182578 号

出　版：中国林业出版社（100009　北京西城区德内大街刘海胡同 7 号）
网　址：http://www.cfph.com.cn　电话：（010）66184477-2028
E-mail：cfphz@public.bta.net.cn
发　行：新华书店北京发行所
印　刷：北京地质印刷厂
版　次：2008 年 1 月第 1 版
印　次：2008 年 1 月第 1 次
开　本：889mm×1194mm　1/32
印　张：5.75
字　数：155 千字
印　数：1～1500 册
定　价：20.00 元

前　言

土地盐碱化是一个全球性的难题，在发展中国家尤为严重，因为随着人口不断增长和城市化进程的逐步加快，人类对粮食、蔬菜等生活必需品的需求不断增长，环境问题更加突出，现有耕地承载的压力越来越大，导致土地盐碱化、荒漠化等现象愈演愈烈。同时，基础设施建设用地、工矿企业开发用地、社会发展城市用地、生态建设绿化用地等对土地的需求日益增长，导致耕地面积逐年减少。如何促进人口—资源—环境和谐发展是一个世界范围内需要迫切解决的问题。

全世界盐碱地面积约 9.5 亿 hm^2。我国的盐碱地面积约 $3.47 \times 10^7 hm^2$，主要集中在华北的黄淮海地区、东北的三江平原和西北地区的大部等干旱、半干旱地区，大致在沿淮河—颍河—秦岭—积石山—巴颜喀拉山—唐古拉山—喜马拉雅山一线以北的广袤地带，以及东部沿海地区的滩涂、近海土地。盐碱地作为我国的一项重要的土地资源，应当在社会经济发展中发挥重要作用，关键是如何认识，如何对待。在 2007 年的全国十届人大五次会议上，温家宝总理郑重承诺，一定要确保全国 18 亿亩（1 亩 = 1/15hm^2）耕地的“红线”不能突破，这是一个事关 13 亿人吃饭的大问题。在这种情况下，改良利用盐碱地具有十分重要的意义。

鉴于上述状况，作为科研工作者，有责任将一些认识和研究简况成册，以期为盐碱地改良利用垫一脚石。本书是站在前辈的肩上，借鉴以往的盐碱地改良利用经验，结合新兴的生态学理论与方

法，从资源利用、植被恢复的角度考虑，着重阐述生物改良的技术，而不是采取工程措施、物理改良的方法。基于此，本书总论部分介绍了盐碱地的特点和成因、资源状况与分布、改良利用研究进展、生态修复的原理与技术、植物耐盐机理与耐盐植物选育、盐碱地造林技术，在后面的几章中，分别从树木种子、苗木、林木等不同生长阶段分析测定了其在盐分胁迫条件下的生理特性，这是进行植被恢复植物材料选择的基础性工作。最后，以白刺为例介绍了滨海重盐碱地造林技术及其土壤改良效果。

著 者

2007 年 10 月

Preface

Soil salinization is a serious environmental problem in the world, especially in developing countries, as population is growing and urbanization is speeding in these lands, so that the demand on living goods such as grain, vegetables is increasing which leads to environment worsening, loads on the farmland rising, soil degrading, e. g. salinization and desertification. Meanwhile the demand on lands for infrastructure construction, industrial development, social progress & urban area enlarging, ecological construction and so on is gradually expanding, which causes farmland area to decrease. Thus it is vital that how to realize harmonious development among population, resources and environment on the earth.

There is 0. 95 billion ha salt-affected soils on the earth, of which nearly one tenth of it is in China, distributed mainly in Huang-huai-hai region, three-river plain area and northwestern semi-arid and arid area, eastern coastal beach lands as well. In view of the environmental situation the country faced currently, no doubt, saline soils are important land resources and should play crucial role to speed up socioeconomic development. The key is how to understand and recognize soil salinization, how to cope with it as well. In this year national tenth session of National People's Congress fifth conferences, Premier Wen Jiabao seriously pledged that, must guarantee the national 1. 8 billion Mu (Chinese

acres 1/15 ha) cultivated land "the red line" not to be able to break through, this was the critical issue concerned with the food of 1.3 billion people. In this kind of situation, the improvement, amelioration and exploitation of salt alkaloid has the extremely vital significance.

In view of the fact that the above mentioned conditions, I drafted the book based on some personal superficial understanding on soil salinization and the coarse researches in this field, hoped to be helpful to promote the study as a foot stone. This book in fact is the author standing on senior's shoulder, summing up experiences from formerly salt alkaloid improvement, by the help of currently emerging ecology theory and methods, to approach that saline soil how to utilize and exploit as the resources. Hence it emphases on ecological amelioration from the angle of vegetation restoration instead of physical methods. Based on this consideration, the part of general remarks in this book partially introduced the salt alkaloid characteristics and formation, the resources condition and distribution, the improvement progress, the ecology rehabilitation principle and the technology, the mechanism of plant salinity-tolerance and the salt-resistant plants selecting & breeding, as well as afforestation techniques. In the behind several chapters, salinity tolerance features of trees in different growing stages were separately discussed based on the experiments of seed germination and pot trial of seedlings under salt stress, in addition to some parameters concerned with salt resistance of forest stocks. Finally, as the example, the planting techniques of *Nitraria sibirica* in worst salt-affected soil and its effect on soil amelioration were introduced.

Zhang Jianfeng
October, 2007

Abstract

With socio-economic development and population growth in the world, it is increasing that concerns of the effects of global climate change on food and fiber production, new questions and challenges have arisen. In recent years, prolonged drought and frequent flooding have been attributed to global climate change and the deterioration of the environment. Meanwhile environmental problems are more and more critical, of which soil salinization is one of the types of human-induced degradation in all over the world. For example, before extensive land clearing occurred, native vegetation used most of the water in the soil and unused water leaked into the groundwater. However, the replacement of native plants with shallow-rooted crops and pasture grasses has led to more water leaking into the groundwater, causing watertables to rise. As the watertable nears the ground surface, waterlogging begins and salt stored in the soil is mobilised, creating saline seeps. Water and salt emerge in the floors and sides of valleys, forming salt crusts, killing plants, aiding erosion as plants die, and increasing the salinity of streams.

How to balance and harmonize economic development and environmental protection in resource-limited areas is becoming a world-wide concern.

The effective way to reclaim and utilize saline soil is by ecological rehabilitation which focusing on planting trees. The key for forestation in

these areas is tree species selection and breeding salt-tolerant plants. In view of this it is a fundamental step for tree species selection to probe salinity tolerance features of trees in different growing stages.

In this study the experiments of seed germination and pot trial of seedlings under salt stress were conducted, through these trials characteristics of salinity tolerance of trees in stages of seed germination and seedling establishment were approached. Meanwhile some parameters concerned with salt resistance were measured for trees growing in saline soils to describe the effects of salinity on tree growth. Besides of these contents the experiment of *Nitraria sibirica* planting in worst salt-affected soil was included as well, capability of salt tolerance and planting techniques of the tree were concluded based on the test as well as the effect of the plantation on plant community coverage and soil conditions were studied.

From the experiment of seed germination the results were given that *Cedrela sinensis*, *Chionanthus retusa* and *Rhus chinensis* were salt tolerant to some extent. When salinity was 0.4%, their germination percentage all were over 80%; with salinity increasing the percentage fell, sapling growth too. Additionally the inhibition of single Na^+ to seed germination was stronger than compound salts $Na^+ + K^+$, which suggested that K^+ could alleviate jeopardizing of Na^+. By regression analysis the regression equations between salinity and germination rate were built, which shown that the relation all were negative linear for the three species, and correlation coefficients were high.

The concept of Index of Salinity Tolerance was defined based on the experiment, which covered more information on seed germination under salt stress. Thus using the parameter could compare salinity tolerance among various species as well as among different salts.

The pot culture experiment with 4 clones of poplars and willows was

performed to study salinity tolerance merits of trees in seedling stage. The results indicated that salts inhibited establishment and growth of seedlings. With salt concentration rising survival rate, seedling height & weight, root weight and leaves weight all declined; shoots newly sprouted decreased as well. However proline content in leaves increased while chlorophyll content reduced. The regression equations between salts and proline contents were binomial, while for chlorophyll were linear.

Addition of NaCl into soil not only had adverse influence on plants, also on soil itself. In the test two soil enzymes, i. e. β - glucosidase and L-asparaginase, both belonging to amidohydrolase, were analyzed. The results shew that the activity of two enzymes fell with salinity increasing.

As above mentioned, the concept of Index of Salinity Tolerance for seedling growing under salt stress also here defined to modify the parameter of survival rate and to compare effects of different salts on tree growth and development.

Some physiological parameters involved were measured such as proline content, bound-water percentage and relative electrical conductivity for totally 13 species such as *Nitraria sibirica*, *Ulmus pumila* and so forth. The results indicated that the stronger for trees to salt tolerant, the higher the values of these parameters. Also the content of some elements such as Cu^{2+}, Mn^{2+}, Fe^{2+}, Mg^{2+}, K^{+}, Na^{+}, Ca^{2+} was analyzed, which indicated that the contents were different among various tree species. Moreover the values changed when they grew in saline soils. It was argued that extra Na^{+} was harmful to plants. Its absorption was related with the levels of other ions in addition to the general nutrition condition of the tree. By the analysis it was concluded that the ratios of Na^{+}/K^{+}, Na^{+}/Ca^{2+} and Na^{+}/Mg^{2+} were quite different in leaves and in roots among different species. Generally spoken the ratios change reflected that the state of trees uptaking salt ions and nutrients.

The trial of *Nitraria sibirica* planting in worst salt-affected land in Yellow River delta region was initiated during the study. Seedling planting and direct seeding both were available for plantation establishment. The survival percentage could reach 90% even when growing the tree in soil with salinity 0.6% ~ 1.5% and it grew fast. In the 3rd year after planting plant community coverage reached 85% when initial plantation density was 4995/ha; and the coverage could be 80% when density was 2505/ha. In forested land salinity was reduced and soil quality as well as soil nutrition were improved. For *Nitraria sibirica* forestation in this region, site preparation is a key to success.

Key words: Tree; Salinity tolerance; Growing stage

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