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互花米草对红树植物化感作用的初步研究

Preliminary Studies on Allelopathic Potentials of *Spartina alterniflora* on Mangrove plants

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摘　要

本文研究了不同质量浓度互花米草水浸液(**SAAE**)对白菜、黄瓜和萝卜种子萌发和幼苗生长的影响，系统评价其化感潜力；同时研究了不同质量浓度SAAE对桐花树、白骨壤和木榄幼苗生长的影响以及不同密度互花米草与秋茄混种对秋茄幼苗生长、光合特性、渗透调节物质和氧化抗氧化系统变化的规律。结果表明：

1. 不同浓度SAAE对白菜、黄瓜和萝卜种子萌发的速度均有影响；除了部分低浓度SAAE对受体植物的苗高生长具有促进作用外，其余各浓度对受体植物苗高和根系的生长均产生抑制作用，且随着浓度的升高抑制作用增强；其中0.4 g·ml^{-1}地上部分水浸液和0.5 g·ml^{-1}地下部分水浸液对受体植物的苗高和根系的生长抑制作用最强。

2. 高浓度SAAE显著抑制受体植物的生长，随着浓度降低，抑制作用减弱甚至转而促进。

3. 高浓度SAAE影响下，桐花树幼叶光合速率降低，气孔导度减小，蒸腾速率降低，且抑制了超氧化物歧化酶(SOD)和过氧化物酶(POD)活性，促进了膜脂过氧化作用及丙二醛含量上升，破坏抗氧化酶类与膜脂过氧化之间的正常平衡，导致桐花树生长受到抑制。

4. 随着 SAAE 的增大，白骨壤幼苗叶片光合色素和可溶性糖含量均下降，根中的 SOD 和 POD 活性降低，根中的游离脯氨酸和丙二醛含量却上升。

5. 浓度为 0.05 g·ml^{-1}SAAE 显著提高了木榄幼叶色素含量、同时也促进了可溶性糖和淀粉含量的积累，但其它浓度的水浸液对木榄的生长影响并不显著。

6. 低密度互花米草混种促进了秋茄的茎长以及各部分生物量，高密度则起抑制作用。随着互花米草密度的增大，秋茄幼苗叶片光合速率、气孔导度、蒸腾速率、水分利用率、叶片色素含量、蛋白含量、SOD 和 POD 活性均下降；相反，胞间 CO_2 浓度、可溶性糖、淀粉、脯氨酸、游离氨基酸含量和丙二醛含量却上升，这些变化有利于对抗互花米草带来的不利影响。

关键词：互花米草；红树植物；化感作用

Abstract

This paper evaluated systematically the potential of allelopathy for *Spartina alterniflora* by treating with different concentrations of *S. alterniflora* aqueous extracts (**SAAE**) on cabbage, cucumber, and radish. The effects of different concentration of SAAE on *Aegiceras corniculatum*, *Avicennia marina* and *Bruguiera gymnorrhiza*; and the mix-cultured effects of different densities of *S. alterniflora* with *Kandelia candel* seedlings were studied. In these experiments, the germination of propagule, the growth and physiological characteristics of seedlings were measured. The results are described as follow:

1. Compared to the control, the germination speed of cabbage, cucumber, and radish seeds were affected by the different concentration of SAAE. The seedlings height and roots length for cucumber seedlings were increased under treatments with low concentration of SAAE, while other concentrations of SAAE inhibited the roots length of receptor plants. And the inhibition were promoted with high concentration of SAAE. The most serious inhibition appeared in the 0.4 g •ml^{-1} SAAE treatment for the above-ground biomasses, and 0.3 g • ml^{-1} SAAE treatment for the underground respectively.

2. The growth of receptor plants were significantly inhibited by the treatment with high concentration of SAAE, however, the inhibition effect was weakened and even because a promotion effect as the SAAE concentration decreased.

3. The high concentration of SAAE reduced the *Pn*, *Gs* and *Tr* in *A. corniculatum* leaf, and significantly inhibited the activities of SOD and POD, while promoted the MDA content; these led to the abnormal balance between the activity of anti-oxidant enzymes and peroxidation of membrane lipids, and then decreased biomass for *A. corniculatum* seedlings.

4. The chlorophyll and sugar content of *A. marina* leaf decreased with the increasing of SAAE concentration, and so did the activities of SOD and POD; however, the free proline and MDA content increased as the SAAE increased.

5. The 0.05 g • ml^{-1} SAAE treatment increased the chlorophyll content in *B.*

gymnorrhiza leaf, and promoted the content of sugar and starch too. But the growth of *B. gymnorrhiza* seedling didn't change obviously in other treatments.

6. The stem height and biomass of *K. candel* seedlings were promoted at mix-cultured with low density of *S. alterniflora*, while those mix-cultured with high density were inhabited. As the density of *S. alterniflora* increased, the Pn, Gs, Tr, WUE, contents of chlorophyll and protein, activities of SOD and POD in *K. candel* seedlings all decreased. On the contrary, *Ci*, *t*he content of sugar, starch, proline, free amino acids and MDA content increased with the increasing of density of *S. alterniflora*. These physiological changes promoted the anti-stress abilities in *K. candel* seedlings to counteract the adverse effects from *S. alterniflora*.

Key words: *Spartina alterniflora*；mangroves；allelopathy

第一章 前 言

互花米草（*Spartina alterniflora* Loisel.），英文名smooth cordgrass、Atlantic cordgrass或saltmarsh cordgrass，禾本科米草属（*Spartina* Schreb.）（又名绳草属）多年生草本植物。互花米草原产于北美洲与南美洲的大西洋沿岸[1]，近200 年来，由于有意或无意的人类活动，互花米草的分布区域已经从其原产地扩展到欧洲、北美西海岸、新西兰与中国沿海[2]。1979 年被初次引进中国，次年10 月在福建沿海等地试种成功，之后陆续扩种和扩散到山东、江苏、浙江、上海、广东、广西等地[3]。中国东南沿海各省的互花米草大规模蔓延已成为近年来我国在生物入侵方面的关注焦点[4]，在2003年被列入国家环保总局公布的首批外来入侵物种名单，被看作是研究生物入侵生态学和遗传学特征的模式植物[5]。

1.1 互花米草生态学研究

1.1.1 互花米草的形态学特征

互花米草地下部分通常由短而细的须根和长而粗的地下茎（根状茎）组成。根系发达，常密布于地下30 cm深的土层内，有时可深达50–100 cm。植株茎秆坚韧、直立，高可达1–3 m，直径在1 cm以上。茎节具叶鞘，叶腋有腋芽。叶互生，呈长披针形，长可达90 cm，宽1.5–2 cm，具盐腺，根吸收的盐分大都由盐腺排出体外，因而叶表面往往有白色粉状的盐霜出现。圆锥花序长20–45 cm，具10–20 个穗形总状花序，有16–24 个小穗，小穗侧扁，长约1 cm；两性花；子房平滑，两柱头很长，呈白色羽毛状；雄蕊3 个，花药成熟时纵向开裂，花粉黄色。种子通常8–12 月成熟，颖果长0.8–1.5 cm，胚呈浅绿色或蜡黄色[6]。

1.1.2 互花米草入侵的生态后果

互花米草具有耐盐、耐潮汐淹没、繁殖力强、根系发达等特点，当初引种的目的为了保滩护堤、改良土壤、绿化海滩以及改善海滩生态环境[7]。然而由于其特殊的生物学特性，其生长的速度远超过人们的控制能力，致使大片适宜养殖的滩涂底质被侵占固化，而且使海水营养盐含量下降，浮游生物减少，原有生态环境被破坏，给自然环境、生物多样性和生态系统产生了很大的影响（表 1-1）。