海水灌溉对南盐 1号芦荟生长发育及产量结构的影响*

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摘 要　在经连续海水组培与大田海水胁迫栽培库拉索芦荟获得的 F6耐盐株系(暂定名南盐 1号)的基础上, 对南盐 1号芦荟与库拉索芦荟进行大田海水灌溉试验, 结果表明: (1)淡水灌溉下, 两品种芦荟生物产量(鲜重)没有显著差异, 而在 30%、60% 海水灌溉下, 南盐 1号芦荟生物产量(鲜重)均显著高于库拉索芦荟; (2)两种芦荟对海水胁迫的响应特征也不同, 在 30% 海水灌溉下, 南盐 1号芦荟生物产量(鲜重)与淡水灌溉没有差异, 而库拉索芦荟则显著低于淡水灌溉处理。(3)海水灌溉下两种芦荟形态特征也有明显的不同, 南盐 1号的株高显著高于库拉索芦荟, 而叶长、叶宽与叶厚两品种间没有显著差异; 南盐 1号根冠比随着海水浓度的增加呈上升趋势, 而库拉索芦荟在 30% 海水灌溉下根冠比略有下降; 南盐 1号 30% 海水灌溉下叶片表面细胞排列整齐, 小突起清晰可见, 60% 海水处理下, 表面细胞边际较清楚, 气孔轮廓较清楚。库拉索芦荟, 在 30% 海水灌溉下, 表面细胞边际开始模糊, 小突起明显减少, 60%海水灌溉下, 表面细胞边际已模糊不清, 气孔结构受到严重损害。(4)在各种不同比例海水灌溉下南盐 1号耐盐系数高于库拉索芦荟的耐盐系数。

关键词　芦荟品种; 海水灌溉; 生物产量; 形态特征

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为缓解我国淡水资源紧缺的矛盾, 从 1999年起, 进行了耐海水植物选育及海水灌溉的研究[1,2]。百合科多年生草本植物库拉索芦荟(*Aloe vera*), 是一种应用面十分广泛的野生植物[3], 具有一定的耐海水特性[4~6], 并可通过 N、P调控提高其耐海水能力[7,8]。为在沿海滩涂推广种植芦荟, 从 2000年开始, 用高浓度海水胁迫栽培选育生长较好的株系, 进行海水组织培养, 经轮番胁迫培育, 筛选出高耐海水株系 ——南盐 1号。并从 2003年 6月开始进行了南盐 1号与库拉索芦荟的海水灌溉平行对比试验, 就大田海水灌溉对南盐 1号芦荟生物产量、形态特征及其耐盐相关指标进行讨论, 分析其与库拉索芦荟的差异。

1 材料与方法

1.1 田间试验设计

于 2003年 6月至 2004年 6月, 在南京农业大学海南 863中试基地的砾质沙土、非耕地上进行了试验研究。种植地块基本性状: 砂粒(2.00~ 0.02 mm)占 69.35%, 粉粒(0.02~ 0.002 mm)占 30.45%, 黏粒(< 0.002 mm) 0.3%, 处于母质状态, 未测出有机质及其他营养元素。

试验小区面积 20 m^2 (5 m × 4 m), 以库拉索芦荟与选育的芦荟耐盐株系南盐 1号供试品种, 植苗期每小区施 250 kg牛粪 + 12.5 kg二级过磷酸钙作基肥, 每次灌溉时按 0.2% 浓度复合肥水混灌。选择四叶一心的芦荟苗按每小区 50株移栽, 15 d后每小区按对角线确定样点, 每点 3株, 即每个处理选取 9株作为观察测量对象, 然后进行海水灌溉处理。灌溉用水为南海北部湾海水与中试基地浅层地下水(井深8~ 10 m)混配, 设 3个海水配比处理: 0, 30%、60%。各处理 4次重复。小区之间用 12 mm厚聚乙烯农膜垂直埋入 70 cm土中, 以保证相邻小区间不侧渗。土壤中按不同深度同时埋设水分张力计与盐分传感器, 早上 8:00时当土层 10~ 30 cm水吸力达 29~ 31 kPa时, 每处理小区按用水量 1~ 1.5 t灌溉。

1.2 样品采集与数据分析

海水处理 1 a后测定其叶片数、叶长、叶宽、叶

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厚, 并收获中间一行计算产量并测定其生物量、根冠比及细胞形态等指标。

每处理选一株中等生长状况的芦荟为代表样株, 以倒三叶中间 2 mm ×2 mm 切片在 Tecnai 12型透射电镜下观察其表皮细胞形态并拍照。

数据采用 SPSS、EXCEL系统进行处理。

2 结果与分析

2.1 海水灌溉对库拉索与南盐 1号芦荟产量的影响

栽培 1 a后将所有处理的两品种芦荟分别收获, 统计其生物产量 (鲜重), 以讨论两品种在产量上的差异 (表 2)。可见各种灌溉处理后南盐 1号芦荟地上部与根部鲜重与库拉索芦荟均达显著差异, 表明南盐 1号芦荟在生物产量已较库拉索芦荟明显提高。

图 1和图 2为各种比例海水灌溉下的两种芦荟的地上部与地下部产量, 海水处理时, 南盐 1号的地上部与地下部产量与库拉索芦荟有显著差异, 而淡水灌溉, 两种芦荟地上部与地下部产量没有显著差异。

表 2为两种芦荟对海水的耐受能力。对于南盐 1号, 30% 海水处理无论地上部还是地下部的产量与淡水处理没有显著差异, 60% 海水灌溉下其地上部、地下部产量显著低于 30% 海水与淡水处理; 而库拉索芦荟地上部与地下部鲜重均为: 淡水灌溉 > 30% 海水灌溉 > 60% 海水灌溉, 但 30% 海水灌溉库拉索芦荟地上部产量与淡水灌溉处理的差异仍未达到极显著水平, 表明南盐 1号芦荟对海水的耐受能力明显增强。

表 1 大田海水灌溉 1 a后两种芦荟生物产量比较

Table 1 Comparison in biomass between two cultivars of aloe irrigated with seawater for one year

品种 Cultivar	地上部 Shoots(kg plant^{-1})	根部 Roots(kg plant^{-1})
南盐 1号 NanYan No. 1	2. 837±0. 032 a A	0. 126±0. 004 a A
库拉索 Conventional	2. 356±0. 027 b B	0. 106±0. 003 b B

注: 不同大写字母表示 *LSD* 检验 1%水平差异显著, 小写字母为 5% 水平 Note: Means followed by different letters in the same row indicate significance in difference at 1% and 5% level by *LSD* test

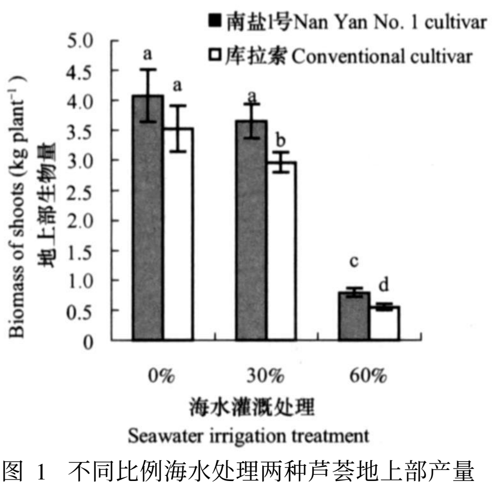

图 1 不同比例海水处理两种芦荟地上部产量

Fig. 1 Biomass of shoots of aloe irrigated with Seawaters different in concentration

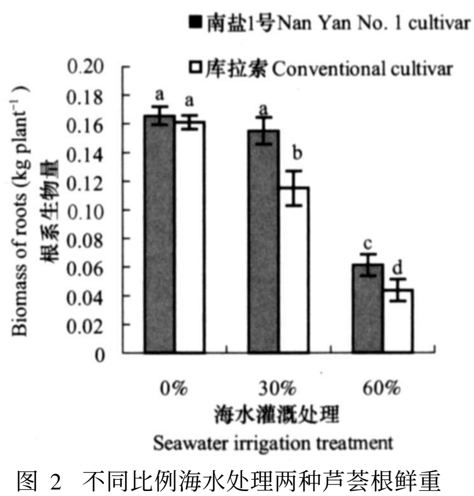

图 2 不同比例海水处理两种芦荟根鲜重

Fig. 2 Biomass of roots of aloe irrigated with seawaters different in concentration

表 2 不同比例海水处理 1 a后的两种芦荟产量

Table 2 Biomass yields of two cultivars of aloe irrigated with seawaters different in concentration for one year (kg plant^{-1})

处理 Treatment	南盐 1号 NanYan No. 1 cultivar		库拉索 Conventional cultivar	
	地上部鲜重 Biomass of shoots	根系鲜重 Biomass of roots	地上部鲜重 Biomass of shoots	根系鲜重 Biomass of roots
0%	4. 075 a A	0. 166 a A	3. 533 a A	0. 169 a A
30%	3. 650 a A	0. 155 a A	2. 964 b A	0. 115 b B
60%	0. 786 b B	0. 061 b B	0. 573 c B	0. 044 c C

注: 同列中不同大写字母表示 LSD检验 1% 水平差异显著, 小写字母为 5% 水平 Note: Means followed by different letters in the same list indicate significance in difference at 1% and 5% level by LSD test

2.2　海水灌溉对库拉索与南盐 1号芦荟生长发育的影响

图 3为两种芦荟海水灌溉前的长势长相, 从芦荟的株高、叶长、叶宽与叶厚的指标来看, 两种芦荟没有显著的差异。经 1 a海水灌溉处理, 南盐 1号随着海水比例的增加, 株高显著高于库拉索芦荟, 而叶长差异不显著 (图 4), 库拉索芦荟叶宽、叶厚海水灌溉显著大于淡水灌溉, 而海水处理南盐 1号叶宽与叶厚同淡水处理没有显著差异 (图 5)。从图 5发现, 两种芦荟在相同比例海水灌溉下的叶宽与叶厚没有明显的差异。海水胁迫能显著提高南盐 1号芦荟的根冠比 (图 6), 根冠比在 30% 海水灌溉下较淡水灌溉略有增加, 但未达到显著水平, 而 60% 海水灌溉下南盐 1号根冠比极显著地高于淡水与 30% 海水灌溉处理; 而库拉索芦荟在 30% 海水灌溉下根冠略有下降, 但差异不显著, 60% 海水灌溉下根冠比变化趋势同南盐 1号。

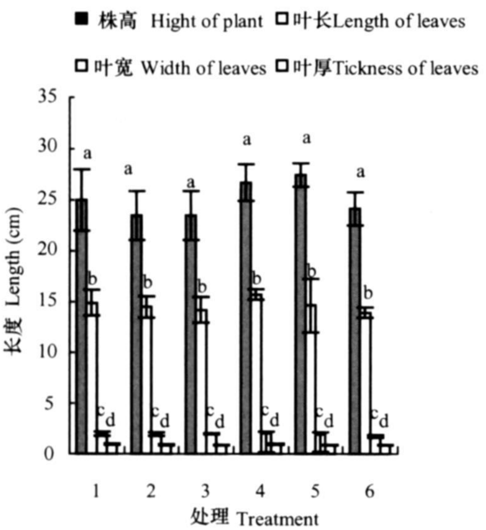

图 3　灌溉处理前两种芦荟的形态

Fig. 3　Shapes of two cultivars of aloe plants before irrigation with seawater

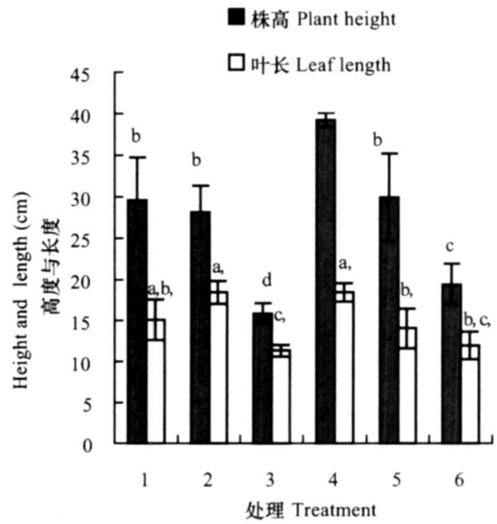

图 4　海水灌溉处理 1 a 两种芦荟株高与叶长

Fig. 4　Plant height and leaf length of two cultivars of aloe irrigated with seawater for one year

注: 横坐标的 1、2、3 表示库拉索芦荟的淡水、30%、60% 的海水灌溉处理, 4、5、6 表示南盐 1 号的淡水、30%、60% 的海水灌溉处理

Note: Columns 1, 2 and 3 represents Conventional cultivar irrigated with freshwater, 30% seawater and 60% seawater, respectively and Column 4, 5 and 6 does Nan Yan No. 1 cultivar irrigated in the same way, respectively

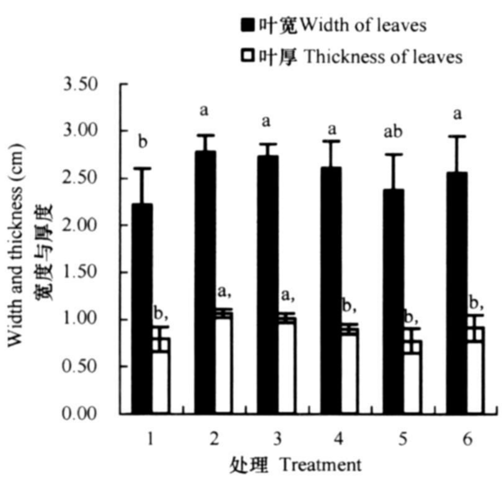

图 5　海水灌溉处理 1 a 两种芦荟叶宽与叶厚

Fig. 5　Width and thickness of leaves of two cultivars of aloe irrigated with seawater for one year

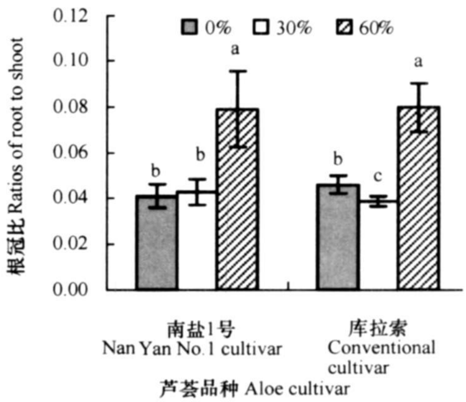

图 6　海水灌溉 1 a 两种芦荟的根冠比

Fig. 6　Roots/shoots ratios of two cultivars of aloe irrigated with seawater for one year

注: 图 5 横坐标的 1、2、3 表示库拉索芦荟的淡水、30%、60% 的海水灌溉处理, 4、5、6 表示南盐 1 号的淡水、30%、60% 的海水灌溉处理

Note: Columns 1, 2 and 3 represents Conventional cultivar irrigated with freshwater, 30% seawater and 60% seawater, respectively and Column 4, 5 and 6 does Nan Yan No. 1 cultivar irrigated in the same way, respectively in Fig. 5

2.3　大田海水灌溉对库拉索与南盐 1号芦荟形态结构的影响

库拉索芦荟淡水灌溉处理下细胞壁厚约为 0.6 μm, 60% 海水灌溉下约为 1.0 μm。南盐 1号淡水处理细胞壁厚为 0.9 μm, 60% 海水处理下为 1.3 μm左右。可见, 增加细胞壁的厚度是南盐 1号芦荟对盐胁迫环境适应性的一种表现。

海水灌溉下两种芦荟叶片表面微形态产生了显著不同的变化 (图 7)。海水灌溉对两种芦荟叶片表面细胞的损害程度南盐 1号显著小于库拉索芦荟, 30% 海水灌溉对南盐 1号叶片表面细胞基本没有影响, 而库拉索芦荟表面细胞出现一些伤害特征, 其细胞边际开始模糊, 细胞表面小突起数目减少, 清晰度降低; 60% 海水灌溉处理, 两种芦荟叶片表面细胞形态差异更加显著。

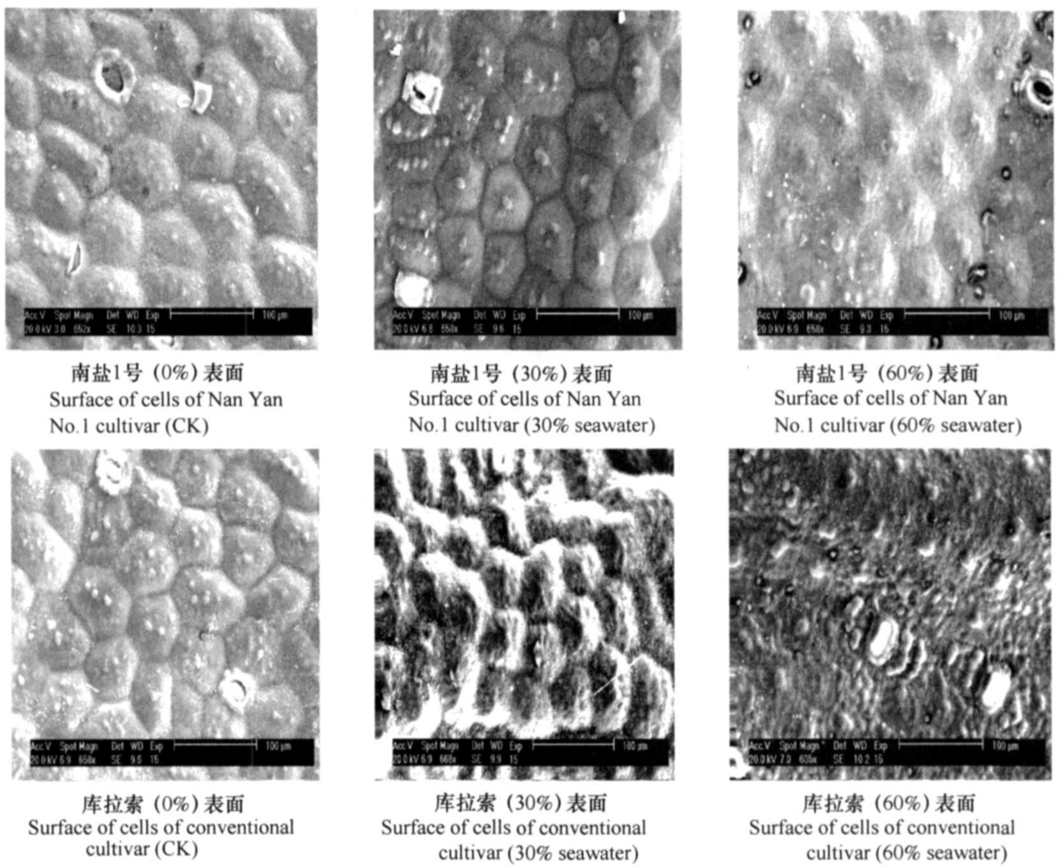

图 7　海水灌溉下两种芦荟叶片表面微形态特征

Fig. 7　Micromorphological characteristics of surface cells of the leaves of aloe irrigated with seawater

2.4　库拉索与南盐 1号芦荟耐盐系数的比较

品种耐盐系数是植物抗盐的重要指标之一。品种耐盐系数 = 盐渍土上的经济产量 /非盐土上的经济产量[9]。从图 8看出, 在 30% 海水灌溉 1a的情况下, 南盐 1号芦荟与库拉索芦荟的耐盐系数相差不显著, 而在 60% 海水长期灌溉下, 南盐 1号的耐盐系数显著高于库拉索芦荟。

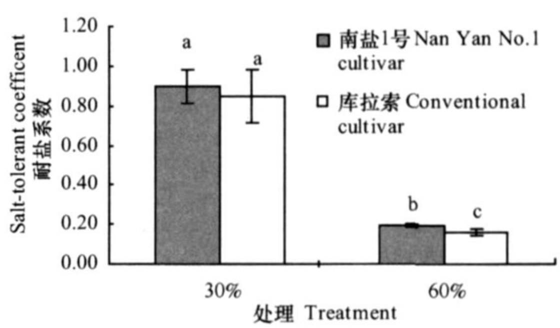

图 8　大田海水灌溉 1 a后两种芦荟的耐盐系数

Fig. 8　Salt-tolerant coefficients of two cultivars of aloe irrigated with seawater for one year

3　结　论

南盐 1号是利用其遗传基础经海水组培反复筛

选的高耐盐株系,从其大田海水灌溉下产量结构、耐盐系数以及植株形态特征、叶肉与表皮的微结构等诸方面分析,南盐 1号芦荟与库拉索芦荟发生了明显的变化,耐海水能力有了显著的增强。

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MORPHOLOGICAL CHARACTERISTICS AND YIELD OF ALOE (NAN YAN No. 1) IRRIGATED WITH SEAWATER

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Abstract Aloe Nan Yan No. 1 is a new cultivar of aloe cultured out of the cultivar of *aloe barbadensis Mill* after sequential hydroponic cultivation in seawater and field cultivation under seawater stress. During the year from June 2003 to June 2004, a field experiment was conducted to make comparison in growth between Nan Yan No. 1 and *aloe barbadensis Mill* irrigated with seawater in Yuedong, Hainan Province. Results show that 1) the two cultivars were more or less the same in yield when irrigated with freshwater, but Nan Yan No. 1 was significantly higher than the other when irrigated with 30% and 60% seawater; 2) their responses to seawater stress varied between cultivars, i.e. Nan Yan No. 1 cultivar did not change much in yield whether irrigated with 30% seawater or fresh water, but the other dropped significantly when fresh water was replaced with 30% seawater in irrigation; 3) irrigated with seawater the two cultivars were also significantly different in morphology or growth characteristics, e. g. Nan Yan No. 1 was much taller than the other, but they were more or less the same in length, width and thickness of leaves; its root/shoot ratio increased with concentration of seawater in irrigation, while that of the other decreased a little bit when it was irrigated with 30% seawater; when seawater concentration in irrigation was 30%, Nan Yan No. 1 still showed orderly arrayed cells on the surface of leaves and distinct teats on the surface of cells, while the other began to lose its clear cell boundary and teats; when seawater concentration in irrigation was 60%; cell boundaries and stomatal structure were still quite clear with Nan Yan No. 1, whereas only blurred cell boundary and damaged stomatal structure were found with the other; and 4) the two cultivar of aloe varied significantly in salt-tolerant coefficient, and Nan Yan No. 1 was always higher than the other when irrigated with seawater, regardless seawater concentration.

Key words Aloe cultivar; Seawater irrigation; Biomass yield; Morphological characteristic