

凤梨叶缘变化规律及无性繁殖方式 对叶刺性状稳定性的影响

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摘要:【目的】分析不同凤梨品种叶缘变化规律, 探讨叶刺性状在无性繁殖过程中的稳定性。【方法】以4种凤梨属植物共计14个栽培品种为材料, 调查叶缘类型、叶刺形态, 并以2个不同叶缘类型的品种为材料比较吸芽繁殖和组培繁殖对叶缘性状稳定性的影响。【结果】根据叶刺着生的位置、密度和有刺叶片所占比例等差异, 可将凤梨植株的叶缘划分为完全无刺、仅叶尖有刺、偶尔有刺、偶尔无刺和全株有刺等5种类型; 进而将凤梨品种划分为全株有刺、完全无刺和中间类型3类。全株有刺、完全无刺类型品种无论以吸芽繁殖还是组培繁殖, 其后代叶缘类型稳定; 而中间类型品种的无性繁殖后代则叶缘性状不稳定, 即使以中间类型品种中完全无刺的吸芽进行繁殖, 后代中仍然会出现仅叶尖有刺、偶尔有刺、偶尔无刺等3种叶缘类型的植株。叶刺是由叶片细胞向外延伸而形成, 表面由一层较厚角质层所包裹, 向上弯曲呈钩状, 开张角度22°~55°, 间距1.99~9.72 mm, 长1.14~2.46 mm。将中间类型品种‘MD-2’中的全株无刺类型植株通过“以芽繁芽”方式增殖8~10代时, 所得组培植株的叶缘有刺率平均4.3%; 若不加选择地使用无刺或有刺的吸芽进行组培, 8~10代时有刺率达47.78%, 有刺率与田间吸芽繁殖情况没有显著差异。【结论】按叶缘状况可将凤梨属品种划分为全株有刺、完全无刺和中间类型3个种, 无性繁殖时中间类型品种的叶缘性状不稳定。

关键词:凤梨; 叶缘类型; 叶刺; 组培繁殖; 稳定性

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Leaf margin variation and the effect of asexual propagation on the stability of leaf thorn

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Abstract:【Objective】*Ananas comosus* is an important tropical fruit tree whose leaves have spines or no spines. The solid leaf spines are inconvenient for field management and are regarded as an important index to evaluate the economic characters of pineapple cultivars. In this paper, the characteristics of spines in pineapple leaves and variations in leaf margins were analyzed and the effect of asexual propagation on traits of leaf margins was observed in order to provide a reference for pineapple seedling cultivation.【Methods】The leaf margin types and leaf spine morphology were inspected in 14 cultivars from 4 species of *Bromeliades*. The structures of leaf spines of 5 cultivars including ‘Shenwan’ and ‘MD-2’ were observed with freehand sections. The stem tips from different leaf margin types of the cultivars ‘Shenwan’ and ‘MD-2’ were taken as explants, and young stems were obtained from the axillary buds on MS medium after about 30 days. The young stems were transferred to MS + 2.0 mg·L⁻¹ 6-BA + 0.1

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$\text{mg} \cdot \text{L}^{-1}$ NAA solid medium for proliferation, and then transferred to $\text{MS} + 0.5 \text{ mg} \cdot \text{L}^{-1}$ 6-BA + $0.1 \text{ mg} \cdot \text{L}^{-1}$ NAA solid medium. The effects on the stability of leaf edge characters between the sucker and tissue cultured seedlings were compared.【Results】According to the differences in the locations, densities and proportions of the leaf spines, the pineapple leaf margins could be divided into 5 types: ① completely spineless, ② spiny only at tip, ③ occasionally spiny, ④ occasionally spineless and ⑤ spiny. The cultivars were further divided into three categories: spiny, completely spineless and intermediate types. Most cultivars were intermediate type and only very few were completely spiny, but ‘Yellow Mauritius’ and ‘Shenwan’, which account for nearly 90% cultivated area in China, were both spiny. The observation of the freehand sections showed that pineapple leaf spines were formed by the outward extension of leaf cells, surrounded by a thick stratum corneum with smooth surface, curving upward like a hook with a sharp apex. The size, opening angle, color and density of spines varied with the germplasm materials, the spacing between spines ranged from 1.99 mm in ‘MD-2’ to 9.72 mm in *Ananas bracteatus* var. *Tricolor*; the length of spines ranged from 1.14 mm in ‘Shenwan’ *in vitro* plants to 2.46 mm in *Ananas bracteatus* var. *Tricolor*, and the opening angle from 22° in ‘Shenwan’ *in vitro* plants to 55° in *A. bracteatus* var. *Tricolor*. Compared with red bract (*A. bracteatus* ‘*Tricolor*’) and ‘Yulinglong’, *A. comosus* had smaller but higher density spines with lower open angles. The leaf margin characters in terms of spine traits were stable among the progenies obtained from suckers or *in vitro* propagation. The plants that belonged to ①-④ types could be found in the cultivars of the intermediate types, and different types could be found even in the same plant. The inner leaf margin characters of the cultivars were unstable and greatly affected by the environment. The proportion of spine ranged from 44.74% (‘HD’) to 80.00% (‘Caine’) in the progenies propagated from suckers with spines or not. The ②-④ type plants could also be found even in the offsprings propagated from plants without thorns. After the plant without spines of the intermediate type ‘MD-2’ was multiplied by bud propagation for 8 to 10 generations, the average proportion of plants with spines reached 4.3%. If particular selections for the spine characters were not performed, the proportion reached 47.78% after 8 to 10 generations of *in vitro* propagation, and exhibited no significant difference from those propagated in field. Except for the spines at the leaf margin, no significant abnormalities occurred in other agronomic traits like plant height, leaf number, leaf length and leaf width among the *in vitro* seedlings.【Conclusion】The *Bromeliadum* plants have 5 leaf types according proportion of spines and 3 types of varieties according to leaf margin types. The leaf edge characters for the cultivars with or without spines in whole plants are suitable to be propagated with suckers or *in vitro*, while those of the intermediate type were unstable. The density, size, opening angle and color of spines exhibite great variations among different varieties.

Key words: Pineapple; Leaf margin type; Nettle leaves; Tissue culture propagation; Stability

凤梨(*Ananas comosus*)俗称菠萝,为凤梨科凤梨属植物,是重要的热带果树。凤梨植株通常有30~60枚剑形片,莲座式排列,长40~90 cm,叶片有全缘或具锐齿(又称叶刺)两种类型^[1]。生产上根据叶缘状况可分为有刺品种和无刺品种两大类,约占我国栽培面积近90%凤梨的皇后类(Queen group)品种‘巴厘’‘神湾’等均为有刺品种;无刺品种主要是卡因无刺类(Smooth cayenne group)品种^[2]。凤梨叶刺坚硬,栽培管理极为不便,因此叶刺有无成为评

价凤梨品种经济性状的一个重要指标^[3],国内外凤梨品种改良都朝着无刺品种的方向推进^[4]。

凤梨生产中都是采用芽体(吸芽、冠芽等)繁殖^[5-6],因植株个体小,栽植密度稍高,为37 500~52 500株·hm⁻²,我国每年有超过4万hm²凤梨需更新,年需种苗18亿株左右,采用组织培养技术进行工厂化育苗成为一个发展方向^[7]。目前,菠萝组织培养技术已经比较成熟^[7-8],但是由于组培过程带来的变异是生产中的一大问题^[9],尤其是无刺品种中

的有刺变异一直为组培过程中的难题,因此研究叶刺性状及其在种苗繁殖过程中的稳定性对凤梨品种改良和良种繁育具有重要意义。

凤梨形态的重要特征是品种鉴别的依据之一。Collins^[10]最初描述了凤梨的6种叶缘类型:刺(spiny)、叶尖有刺(spiny tip)、光滑(smooth)、少刺(scallop)、反卷(piping)和粗糙(sandpaper)。Loison^[11]也将凤梨叶缘分成了6种类型,但考虑到红苞凤梨(*A. bracteatus*)的刺大,将其作为一个独特的类型,并取代了少刺(scallop)类型。Geo等^[12]则将其分为有刺(spiny)、部分有刺(partial spiny)、叶尖有刺(spiny tip)、光滑(smooth)、反卷(piping)和粗糙(sandpaper)6种类型。然而,对凤梨叶刺的形态特征及组培繁殖过程中的稳定性等问题一直缺少系统研究,迄今国内外也尚未见相关报道。笔者以4种凤梨属植物共计14个栽培品种为材料,研究了叶缘状况、叶刺形态,根据叶刺坐生状态进行了植株和品种的类型划分,同时以有刺品种‘神湾’和无刺优良品种‘MD-2’为材料,比较了吸芽繁殖和组培繁殖等对叶刺性状稳定性的影响,以期为凤梨组织培养育苗的产业化提供参考。

1 材料和方法

1.1 材料

供试材料为11个凤梨(*A. comosus*)栽培品种(‘神湾’‘巴厘’‘台农11’‘卡因’‘HD’‘MD-2’‘台农17’‘台农16’‘台农21’‘西瓜凤梨’和‘波多黎各’)、1个红苞凤梨品种(‘三色凤梨’*A. bracteatus* ‘Tricolor’)、1个矮凤梨品种(‘玉玲珑’*A. nanus* ‘Yulinlong’)和1个立叶凤梨品种(*A. erectifolius* ‘Curaua’)。

1.2 方法

1.2.1 叶刺着生类型的划分 根据上述14个品种叶缘情况田间调查统计结果,按叶刺着生的位置、密度和特征等划分类型。

1.2.2 叶刺形状、开张角度、密度、大小和色泽的测定 对6个种质材料(‘MD-2’有刺、‘巴厘’、‘神湾’、‘神湾’组培株、‘三色凤梨’和‘玉玲珑’)分别用Leica立体显微镜和测量工具等观察测定其开张角度、密度、大小和色泽。

1.2.3 叶刺的切片观察 以‘MD-2’‘玉玲珑’‘HD’‘台农17’和‘神湾’等5个品种为材料进行徒手切

片。切片时,用自来水清洗叶片,沿叶缘取1.5 cm×1.5 cm的块条,把块条放在锡箔纸上;用新的双面刀片,对准叶片从一端慢慢切向另一端,切下叶片的厚度约50 μm;将样品置于载玻片上,用胶头滴管滴一滴清水,迅速盖上盖玻片,用Zeiss正置荧光显微镜拍照。石蜡切片参照何业华等^[13]的方法进行。

1.2.4 吸芽繁殖植株叶缘情况调查 在已开花结实的生产园中,对吸芽繁殖的8个凤梨品种(‘MD-2’‘卡因’‘台农11’‘台农17’‘HD’‘西瓜凤梨’‘神湾’和‘巴厘’)进行叶缘的变化情况调查,统计有刺率。调查采用随机抽样,30株为1个小区,3次重复。

1.2.5 组培繁殖育苗及其组培植株叶缘情况调查 从2015年开始,在位于广州市华南农业大学果园采取有刺品种‘神湾’、无刺品种‘MD-2’和‘台农21’吸芽为外植体,参照本课题组方法^[14-15]获得无菌的茎尖(长约1 cm)进行组织培养。在晴天采下生长健壮的‘MD-2’吸芽,从基部剥除衰老叶片后,用自来水将吸芽冲洗干净,在吸芽生长点的上方约5 cm处短截,并去除根部,用自来水冲洗干净并放在培养皿中备用。在超净工作台内把洗净后的吸芽用0.1% HgCl消毒8 min,无菌水冲洗3次;再于10% NaClO消毒7 min,无菌水冲洗3次;用无菌手术刀将外植体纵切成2~4个小块。接种于MS固体培养基上进行初始诱导,约30 d腋芽萌发出幼茎。将幼茎转入MS+2.0 mg·L⁻¹6-BA+0.1 mg·L⁻¹NAA固体培养基上进行增殖培养后,再转入MS+0.5 mg·L⁻¹6-BA+0.1 mg·L⁻¹NAA固体培养基上进行壮苗培养,最后转入1/2 MS+0.2 mg·L⁻¹NAA+0.2 mg·L⁻¹IBA固体培养基上生根。培养周期为30 d,培养基均添加30 g·L⁻¹蔗糖,以7.0 g·L⁻¹琼脂固化,pH 5.8,培养温度26~28 °C,光照强度2 000 lx,光照时间12 h·d⁻¹。炼苗5 d后于2018年9月20日移栽于盛在V_{泥土}:V_{椰糠}=1:1基质的营养杯中,待苗高达25 cm时,按随机区组方式对5个小区(每个小区1 050株组培苗,共计5 250株)组培苗的叶缘类型、植株高度、叶片数、叶片长度、叶片宽度等性状进行调查分析。

2 结果与分析

2.1 叶缘类型划分

根据14个品种的叶缘类型情况的田间调查统计结果,按照叶刺着生的位置、密度和有刺叶片所占

比例等差异,可将植株的叶缘划分为5种类型(表1)。①完全无刺:整株整片叶缘无刺;②仅叶尖有刺:整株仅叶先端2 cm左右有细锯齿,叶身无刺;③偶尔有刺:叶尖有刺,叶身通常无刺,部分叶片叶身

边缘偶尔出现一段有刺(叶缘有刺率<50%);④偶尔无刺:叶尖有刺,叶身通常有刺,部分叶片叶身偶尔出现一段无刺(叶缘有刺率>50%);⑤全株有刺:全株所有叶片的叶缘都布满刺状锯齿。若叶尖无刺

表1 凤梨属植株的叶缘类型

Table 1 Types of leaf margins of *Bromeliad* plants

| 级别 Level | 类型 Type | 特征 Characteristic | 代表品种 Representative cultivars |
|----------|-----------------------------|---|--|
| 1 | 无刺品种 Spineless cultivars | | |
| ① | 完全无刺 Completely spineless | 全株所有叶片的缘都均匀无刺(锯齿) The margin of all leaves of the whole plant was uniformly free from spineless(serration) | 立叶凤梨,波多黎各 Curaua, Puerto Rico |
| ② | 仅叶尖有刺 Spiny only at tip | 仅叶尖(约2 cm)部有细锯齿 Only the blade tip (about 2 cm) has fine serrations | HD,卡因类品种中的个别叶片 HD, individual leaves in a cayenne group cultivars |
| ③ | 偶尔有刺 Occasionally spiny | 叶尖有刺;叶缘通常无刺,部分叶片叶缘偶尔出现一段有刺 Spiny tip,leaf margins usually spineless,some blades have occasionally a spiny | 卡因类品种中的个别叶片 Individual leaves in a cayenne group cultivars |
| ④ | 偶尔无刺 Occasionally spineless | 叶尖有刺;叶缘通常有刺,部分叶片叶缘偶尔出现一段无刺 Spiny tip, leaf margins usually spiny,some blades have occasionally a spineless | 卡因类品种中的个别叶片 Individual leaves in a cayenne group cultivars |
| 2 | 有刺品种 Spiny cultivars | | |
| ⑤ | 全株有刺 Spiny | 全株所有叶片的边缘都均匀布满刺(锯齿) The margins of all leaves of the whole plant are evenly covered with spiny (serration) | 皇后类品种 Queen group cultivars |

时,通常就属于全株无刺类型;而只要叶身边缘出现叶刺时,叶尖必定是有刺的。

红苞凤梨(‘三色凤梨’)、矮凤梨(‘玉玲珑’)及凤梨中的‘神湾’‘巴厘’等皇后类品种,它们的叶尖、叶身边缘均布满刺状锯齿,属于全株有刺类型品种;全株无刺类型品种仅‘Curaua’和‘波多黎

各’,其叶尖叶身均无刺;而生产中通常认为无刺凤梨品种的‘无刺卡因类’(Smooth cayenne group)、‘MD-2’等中,绝大部分植株都或多或少有刺,它们的植株包括可分为完全无刺、仅叶尖有刺、偶尔有刺和偶尔无刺等4种类型,属于中间类型的品种(图1,表2)。



A. 叶尖无刺(立叶凤梨 Curaua);B. 仅叶尖有刺(MD-2);C. 叶身无刺(立叶凤梨 Curaua);D、E. 偶尔有刺(MD-2);F. 偶尔无刺(MD-2);G. 全株有刺(巴厘);H. 全株有刺(神湾);I. 全株有刺(神湾组培株);J. 全株有刺(红苞凤梨三色凤梨);K. 全株有刺(矮凤梨玉玲珑)。

A. Spineless tip (Curaua); B. Spiny only at tip (MD-2); C. Spineless (Curaua); D, E. Occasionally spiny (MD-2); F. Occasionally spineless (MD-2); G. Spiny (Yellow Mauritius); H. Spiny (Shenwan); I. Spiny (Shenwan Tissue Culture seed); J. Spiny (Tricolor); K. Spiny (Yulinglong).

图1 凤梨植株的叶缘类型
Fig. 1 Leaf margin types of pineapple plants

表2 无刺品种中各种叶缘类型所占的比例

Table 2 Proportion of various leaf margin types in spineless cultivars

| 品种 Cultivar | 各类型所占比例 The proportion of each type/% | | | | |
|----------------------|---------------------------------------|-------------------------|-------------------------|-----------------------------|------------|
| | 完全无刺 Completely spineless | 仅叶尖有刺 Spiny only at tip | 偶尔有刺 Occasionally spiny | 偶尔无刺 Occasionally spineless | 全株有刺 Spiny |
| MD-2 | 20 | 14 | 14 | 3 | 50 |
| 台农 21 Tainung No. 21 | 50 | 10 | 3 | 6 | 33 |

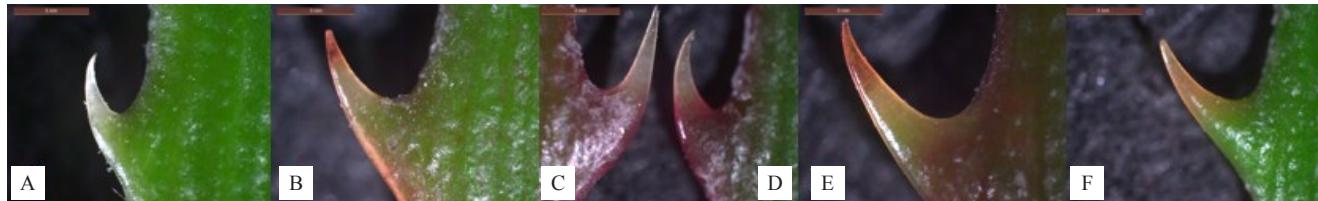
注:每品种调查 30 株。 Note: 30 plants per cultivars were investigated.

2.2 不同种质材料的叶刺形状、大小和密度

用体视镜对6个种质材料锯齿观察结果显示,锯齿均呈刺状,先端尖锐,表面光滑,并向上弯曲呈钩状,其大小、开张角度、色泽及密度因种质材料而异(图2)。有刺品种的叶刺开张角度大小依次是‘三色凤梨’(55°)、‘玉玲珑’(45°)、‘巴厘’(40°)、

‘神湾’(30°)、‘MD-2’有刺(25°)、‘神湾’组培株(22°)。不同种质材料叶刺的颜色也不一样,‘MD-2’叶刺基部1/3呈绿色,其上部2/3呈乳白色;其他品种则在此基础上呈现不同程度的红色,尤其是‘神湾’红色更为显著(图2)。

叶刺密度因种质材料而异。除‘MD-2’中的全



A. MD-2; B. 巴厘; C. 神湾; D. 神湾组培株; E. 三色凤梨; F. 玉玲珑。Bar=3 mm。

A. MD-2; B. Yellow Mauritius; C. Shenwan; D. Shenwan tissue culture seed; E. Tricolor; F. Yulinglong. Bar=3 mm.

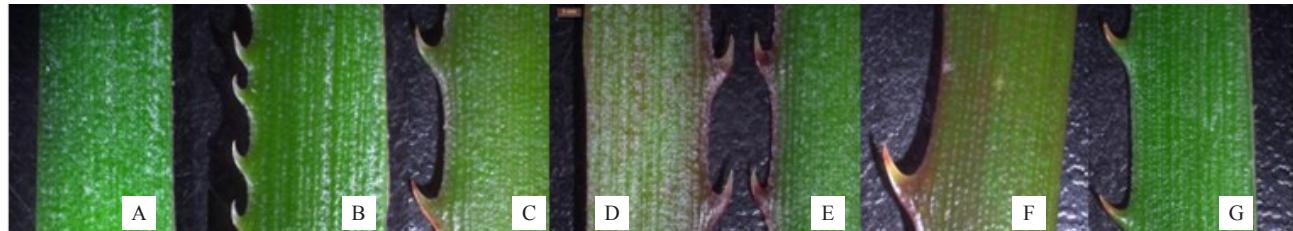
图2 不同种质叶刺形状和大小的比较

Fig. 2 Comparison of the size and shape of leaf spines among different varieties

株无刺类型和仅叶尖有刺类型植株外,其他类型叶身边缘的叶刺间距大小依次是:‘三色凤梨’(9.72 mm)、‘玉玲珑’(7.18 mm)、‘神湾’(6.14 mm)、‘巴

厘’(5.21 mm)、‘神湾’组培株(4.63 mm)、‘MD-2’有刺(1.99 mm)(图3)。

不同种质材料的叶刺长度也不一样。除‘MD-



A. MD-2 无刺; B. MD-2 有刺; C. 巴厘; D. 神湾; E. 神湾组培株; F. 三色凤梨; G. 玉玲珑。Bar=1 mm。

A. MD-2 spineless; B. MD-2 spiny; C. Yellow Mauritius; D. Shenwan; E. Shenwan tissue culture seed; F. Tricolor; G. Yulinglong. Bar=1 mm.

图3 不同种质叶刺密度的比较

Fig. 3 Comparison of spines density among different varieties

2’中的全株无刺类型和仅叶尖有刺类型外,其他类型叶身边缘的叶刺长度大小依次是:‘三色凤梨’(2.46 mm)、‘玉玲珑’(1.91 mm)、‘巴厘’(1.63 mm)、‘神湾’(1.35 mm)、‘MD-2有刺’(1.18 mm)、‘神湾’组培株(1.14 mm)。

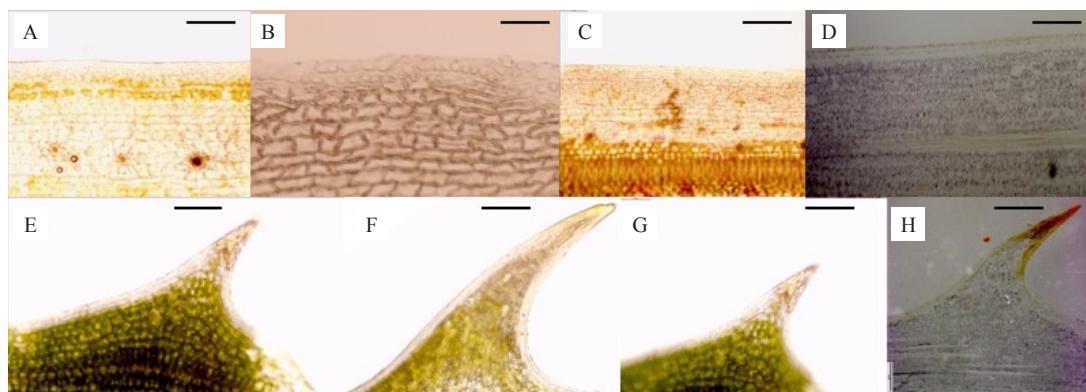
相对红苞凤梨(*A. bracteatus* ‘Tricolor’)和矮凤梨(*A. nanus* ‘Yulinglong’),凤梨(*A. comosus*)栽培品种的叶刺较小、密度较大、开张角度较小。

2.3 不同种质材料叶刺的切片观察

对叶缘纵向徒手切片和石蜡切片观察的结果显示,无刺叶片叶缘细胞平行排列(图4-A~D),而叶刺是由叶片细胞向外延伸而形成,外面为一层较厚角质层所包裹(图4-E~H)。

2.4 不同品种在吸芽繁殖时叶缘变化规律

对生产中被认为无刺的凤梨品种‘MD-2’‘卡因’‘台农11’‘台农17’‘HD’和‘西瓜凤梨’等吸芽繁殖植株叶缘状况调查的结果显示,它们都存在不同比例的有刺变异植株(类型②、③、④)。植株有刺率分别为‘卡因’80.00%、‘西瓜凤梨’68.97%、‘台农11’57.27%、‘台农17’64.44%、‘MD-2’46.56%、‘HD’44.74%(图5)。说明这些中间类型品种叶缘性状不稳定,有刺变异叶片普遍存在,只是不会出现像‘巴厘’等皇后类品种那种全株布满叶刺的植株。因此,中间类型品种的无刺性状在吸芽繁殖中通常不是很稳定的性状;而全株有刺类型品种‘神湾’‘巴厘’吸芽繁殖植株中均未发现无刺植株或部分无刺



A. MD-2 无刺;B. MD-2 有刺;C. 巴厘;D. 神湾;E. 神湾组培株;F. 三色凤梨;G, H. 玉玲珑。

A. MD-2 spineless; B. MD-2 spiny; C. Yellow Mauritius; D. Shenwan; E. Shenwan tissue culture seed; F. Tricolor; G, H. Yulinglong.

图 4 叶缘及叶刺纵向切片

Fig. 4 Longitudinal section of leaf margin and spines

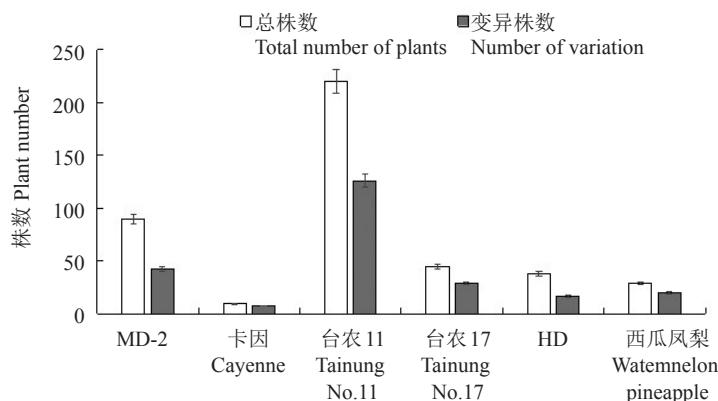


图 5 吸芽繁殖时不同品种叶缘变化情况

Fig. 5 Leaf margin changes in different varieties during sucker propagation

的植株。

2.5 组培繁殖时叶缘变异规律

以中间类型品种‘MD-2’的全株无刺类型植株的吸芽为材料,通过“以芽繁芽”方式繁殖8~10代后所获得的组培植株,其叶缘仍然出现不同程度的叶刺,有刺率为0.8%~12.0%,平均4.3%;若不加选择地使用无刺或有刺的吸芽作外植体,8~10代后所获

得的组培植株有刺率达47.78%,有刺率基本与吸芽繁殖没有显著差异。对‘MD-2’和‘台农21’组培繁殖植株表型数据分析的结果表明:变异株与正常株相比,除叶缘变异有刺外,组培苗之间在植株高度、叶片数、叶片长度、叶片宽度等其他性状均无显著影响(表3)。而全株有刺品种‘神湾’组培植株只是叶刺比吸芽繁殖时小(图2),叶刺密度并未减少,也未

表 3 ‘MD-2’‘台农 21’全株无刺类型组培繁殖植株生长情况比较

Table 3 Comparison of the growth of *in vitro* plants generated from the spine-free plants of ‘MD-2’ and ‘Tainung No.21’

| 品种 Cultivar | 植株类型 Plant type | 植株高度 Plant height/cm | 每株叶片数 Number of leaves per plant | 叶片长度 Leaf length/cm | 叶片宽度 Blade width/mm |
|------------------------|-------------------------------------|-------------------------|-------------------------------------|------------------------|------------------------|
| MD-2 | 正常植株 Normal plants | 35.13±2.13 a | 17.77±0.57 a | 37.89±2.08 a | 19.28±0.62 a |
| | 有刺变异植株 Spiny variation in plants | 38.38±2.35 a | 15.99±0.51 a | 39.14±2.33 a | 21.89±0.94 a |
| 台农 21 Tainung No.21 | 正常植株 Normal plants | 96.85±8.14 a | 98.37±16.58 a | 79.82±4.41 a | 45.96±2.72 a |
| | 有刺变异植株 Spiny variation in plants | 105.73±7.26 a | 73.64±7.54 a | 85.08±9.11 a | 63.33±8.13 a |
| | | | | | |

注:不同小写字母表示正常植株与有刺变异植株 Tukey 法多重比较差异显著($p < 0.05$)。

Note: Different small letters followed the means in the same row indicate significant difference ($p < 0.05$) between varieties and types according to Tukey multiple range test.

产生少刺或无刺现象。

3 讨 论

凤梨叶占营养器官总质量的 $3/4^{[16]}$,由坚硬而密集叶片组成强大叶幕本来就不方便凤梨园的栽培管理;若有叶刺,将会更加不便于栽培管理。凤梨属野生种类及原始的凤梨品种都是有刺的。1819年由Perrotet在法属圭亚那(French Guiana)的Cayenne一带首次发现无刺的凤梨类型(即卡因无刺,Smooth cayenne),育种工作者以它为材料培育出了一系列的无刺新品种,并逐渐发展成为国际上主要的商业品种,世界上70%的凤梨产品及95%罐头凤梨品种来自无刺卡因类。

凤梨属植物叶片有全缘和有锐齿两种状况^[1],生产上也据此将凤梨品种分成有刺和无刺两类。但本实验通过对凤梨属4种(共14个品种)叶缘类型仔细调查后发现,植株叶片全部有刺或全部无刺之间有许多过渡类型,绝对无刺的品种很少。按叶缘状况,可将凤梨植株划分为①完全无刺、②仅叶尖有刺、③偶尔有刺、④偶尔无刺、⑤全株有刺等5个类型。除类型②之外,③~⑤类型的叶尖也均有刺。

就品种而言,可分为全株有刺品种、完全无刺品种和中间类型品种,完全无刺品种和中间类型品种在生产中习称无刺品种,而全株有刺品种即为生产上所称的有刺品种。完全无刺品种的所有植株均为类型①,这类品种数量较少,14个品种中仅‘波多黎各’(*A. comosus*)和立叶凤梨‘Curaua’(*A. erectifolius*);全株有刺品种的所有植株均为类型⑤,叶刺性状稳定性、一致性强,未发现完全无刺和中间类型的植株;中间类型品种叶缘性状不稳定,同一品种中①~④类型植株同时兼有,且常常是同一植株上①~④类型叶片并存。与全株有刺品种相比,中间类型品种的叶刺较短(1.1~1.2 mm)而细;相对于红苞凤梨品种(*A. bracteatus* ‘tricolor’)和矮凤梨品种(*A. nanus* ‘Yulinglong’),凤梨(*A. comosus*)栽培品种的叶刺较小、密度较大、开张角度较小。

有刺凤梨品种叶刺性状稳定。笔者课题组长期对广东徐闻、中山等我国凤梨核心产区长期调查,均未发现占我国生产面积近90%的有刺品种‘巴厘’和‘神湾’等出现无刺变异植株^[7];但是,培养时继代过多会出现叶缘刺减少现象,以全株有刺类型品种‘神湾’愈伤组织在MS + 3.0 mg · L⁻¹ BA + 2 mg · L⁻¹

NAA上培养增殖继代8年96代后所获得的再生植株中,30%的再生植株叶刺减少^[9]。但在本实验中,采用的低代(继代不超过15次)培养中未发现少刺或完全无刺类型的植株,仅仅是部分再生植株的叶刺稍微变小。

中间类型品种叶缘性状不太稳定。以‘MD-2’全株无刺类型的吸芽为材料,通过以芽繁芽的方式繁殖8~10代后所获得组培植株,其叶缘仍然出现不同程度的叶刺,有刺率达平均4.3%;若不加选择地使用无刺或少刺的‘MD-2’吸芽作外植体,8~10代后所获得组培植株有刺率达47.78%。除叶刺性状不稳定外,组培苗之间在植株高度、叶片数、叶片长度、叶片宽度等其他性状均无显著差异。

4 结 论

按叶缘状况,凤梨的品种则可划分为3个类型:全株有刺、完全无刺和中间类型。以吸芽或组培繁殖时,前2个类型叶缘性状稳定,而中间类型品种的叶缘性状则受环境因素影响出现波动。叶刺的密度、大小、开张角度和色泽因种质材料而异。

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