Agricultural Science & Technology, 2013, 14(8): 1106–1108, 1131

Effects of Ethephon on Flowering of Ornamental Pineapple in *Guzmania*

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Abstract [**Objective**] This study aimed to establish the technical system for forcing ornamental pineapple in *Guzmania* to flower and further provide technical parameters for large-scale cultivation. [**Method**] The effect of different concentrations of ethephon solution on flowering in *Guzmania* ornamental pineapple was studied by using randomized block design. [**Results**] All the different concentrations of ethephon solution were capable to force the four mainly-cultivated ornamental pineapple varieties to flower to varying degrees. After the flower forcing, it took about 180 d for the pineapple to stay in the ornamentation period, and there were no significant differences in inflorescence shape, inflorescence height, inflorescence diameter and bract number among different treatment pineapples. [**Conclusion**] All the four varieties have shown high sensitivity to ethephon. The optimal ethephon concentration is 400 mg/L for treating *G. lingulata*, *G. remembrance* and *G. denise* and 500 mg/L for treating *G. conifera*. After treatment, their major ornamentation traits are were able to satisfy the requirements for commercial production of pineapple.
Key words *Guzmania*; Ethephonl; Flower forcing

Guzmania, as an important group of ornamental in the family *Bromeliaceae*, originated from the Andes region, South America, which is now mainly distributed in the tropical and subtropical regions of Central and South America[1]. Because of its bright color, peculiar and pretty flower shape, as well as an ornamentation period of up to six months, pineapples have become mainstream ornamental plants for Spring Festival. In recent years, the mainland China has started large-scale introduction of pineapples. However, since it is impossible to anticipate the natural flowering event in ornamental, artificial induction to flower becomes quite critical[2]. In China, flower forcing agents and their concentrations, flower bud differentiatition mechanism[4], and carbohydrate metabolism[5] in *Guzmania* 'Calypso', *Aechmea fasciate* cv. Vanriegata and *Guzmania* 'Denise' have been studied, but systematical research in flower forcing technique in several specified genera, especially the flowering process and flowering quality is seldom reported. Ehephon has a very obvious effect of on the induction of flowering in *Bromeliaceae* plants[2]. In this study, we explored the effects of different concentrations of ethephon on flowering, flowering process and flower quality in *Guzmania* plants, with the objective to provide technical bases for the mass- and standardization- production of ornamental pineapple.

Materials and Methods

Experimental materials

Experimental plant materials including *G. lingulata*, *G. remembrance*, *G. conifera* and *G. denise* in *Guzmania* were provided by the Deroose Plants Co., Ltd. at Shanghai Flower Port. The trials were carried out at the

Supported by the Department of Education of Sichuan Province(No.10zd1129); Sichuan Provincial Academic and Technical Leader Training Project (No. 11sd3105); Doctoral Program of Southwest University of Science and Technology (No.09zx7107); Collegiate Fund Program of Southwest University of Science and Technology(No.12xjjx90).
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Received: August 2, 2013 Accepted: August 16, 2013

乙烯利对果子蔓属观赏凤梨开花效应的影响

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摘 要 [目的]建立果子蔓属(*Guzmania*)观赏凤梨的催花技术体系,为规模化栽培提供技术参数。[方法]采用随机区组试验设计,研究了不同浓度乙烯利溶液对果子蔓属凤梨开花效应的影响。[结果]不同浓度的乙烯利对4个主栽观赏凤梨品种均有不同程度的催花效果,催花处理后从反应期到观赏期约180 d,花序形状、花序高低、花序直径和着花苞片数在不同处理间差异不显著。[结论] 4个品种均表现出对乙烯利的高度敏感,红星凤梨、黄苞果子蔓和丹尼斯最佳处理浓度为400 mg/L,圆锥擎天最佳处理浓度为500 mg/L,处理后其主要观赏性状满足凤梨商品化生产的要求。
关键词 果子蔓属;乙烯利;催花

基金项目 四川省教育厅重点项目(No. 10zd1129);四川省科学技术带头人培养项目(No. 11sd3105);西南科技大学博士基金项目(09zx7107);西南科技大学校基金项目(No. 12xjjx90)。
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收稿日期 2013-08-02
修回日期 2013-08-16

Agricultural Facilities Laboratory, Southwest University of Science and Technology. One-year-old plant tissue culture plantlets that are free of diseases and pests with robust growth and no significant growth differences were selected and grown in nutrition bowls (Φ=12 cm), and the soil was a compound substrate consisting of peat and perlite at 10:1.

Test design

A randomized block design was adopted with the ethephon solution concentration gradient of A_0(water), A_1 (100 mg/L), A_2(200 mg/L), A_3(300 mg/L), A_4(400 mg/L) and A_5(500 mg/L), with A_0 (water) as the control. First, water in the cup consisting of central leaves was poured away. Then, ethephon solution at each concentration was poured into the cup of each plant three times, 40 ml every time, with time interval of 5 d, 100 plants for each concentration for each variety with three replications.

Observation of morphological characteristics

After flower forcing, the morphological characteristics during the flowering process in each variety were investigated. Trait description was accomplished with reference to the standard presented by Yu *et al*.[6], and the observation and record of traits was also achieved with reference to their method.

Results and Analysis

Effects of ethephon on flower forcing in different pineapple varieties

It can be seen from Table 1 that different concentrations of ethephon could force all the four pineapple varieties to flower to different degrees. *G. lingulata*, *G. lingulata* and *G. denise* exhibited similar physiological responses to different concentrations of ethephon, and their flowering rates increased with the increasing ethephon concentration within the concentration range of 100–400 mg/L, each peaking at 400 mg/L; while *G. conifera* required higher ethephon concentration than the other three varieties and obtained a flowering rate of 98.0% at 500 mg/L. During the process of transforming from vegetative growth into reproductive growth, all the four varieties exhibited high sensitivity to ethephon, with overall similarity.

Effect of ethephon on the flowering process in different pineapple varieties

It can be seen from Table 2 that different ethephon concentrations had different effects on the flowering process in different pineapple varieties. The concentration 100 mg/L could force *G. lingulata*, *G. remembrance* and *G. denise* to flower to varying degrees, while the concentration of 200 mg/L was required to force *G. remembrance* to flower. For all the four varieties, the response period shortened with the increasing concentration, but both the peak flowering period and ornamentation period prolonged with the decreasing concentration, which indicated that under the premise of guaranteed highest flowering rate, low ethephon concentration helped to maintain longer flowering and ornamentation periods. However, at the concentrations of either 300 or 400

Table 1 Effect of ethephon on the flowering rate in different pineapple varieties

Ethephon concentration // mg/L	*G. lingulata*			*G. lingulata*			*G. denise*			*G. remembrance*		
	Flowering rate // %	Significance		Significance	Significance		Flowering rate // %	Significance		Flowering rate // %	Significance	
		0.05	0.01		0.05	0.01		0.05	0.01		0.05	0.01
0	0	e	E	0	f	F	0	f	F	0	d	D
100	10.0	d	D	9.0	e	E	20.0	e	E	0	d	D
200	31.0	c	C	24.0	d	D	46.0	d	D	21.0	c	C
300	86.0	b	B	80.0	b	B	92.0	b	B	77.0	b	B
400	100.0	a	A	100.0	a	A	100.0	a	A	90.0	a	A
500	84.0	b	B	60.0	c	C	55.0	c	C	98.0	a	A

The significance test was conducted among different treatment plants in the same variety; the capital and lowercase letters represent the significant differences at the 0.01 and 0.05 levels, respectively.

Table 2 Effect of ethrel on the process of blossom in different pineapple varieties

Ethephon concentration // mg/L	*G. lingulata*			*G. lingulata*			*G. denise*			*G. remembrance*		
	Response period // d	Peak flowering period // d	Ornamentation period // d	Response period // d	Peak flowering period // d	Ornamentation period // d	Response period // d	Peak flowering period // d	Ornamentation period // d	Response period // d	Peak flowering period // d	Ornamentation period // d
0	0 fF	0 eE	0 eE	0 fF	0 eE	0 eE	0 fF	0 eE	0 eE	0 eE	0 eE	0 eE
100	123 aA	148 aA	221 aA	119 aA	146 aA	213 aA	117 aA	143 aA	197 aA	0 eE	0 eE	0 eE
200	115 bB	137 bB	201 bB	110 bB	132 bB	198 bB	109 bB	131 bB	182 bB	155 aA	179 aA	225 aA
300	98 cC	119 cC	199 cC	101 cC	125 cC	193 cC	92 cC	113 cC	175 cC	141 bB	171 bB	202 bB
400	90 dD	115 cC	194 cC	95 dD	120 cC	186 cC	85 dD	110 cC	174 cC	132 cC	149 cC	193 cC
500	82 eE	98 dD	181 dD	84 eE	100 dD	179 dD	79 eE	94 dD	154 dD	126 dD	142 dD	185 dD

The response period was defined as the number of days from the first time of flower forcing to the inflorescence growing to 1/2 of the total length; the peak flowering period was defined as the number of days from the first time when flowers opened on the inflorescence increased to 50% to the second time when flowers opened on the inflorescence dropped to 50%; the ornamentation period was defined as the number of days from the inflorescence growing to 1/2 of the total length to flowers noticeably fading and lossing their ornamentation value.

Table 3 Effect of ethephon on flower traits during the peak flowering period in different varieties

Pineapple variety	Ethephon concentration mg/L	Crown diameter cm	Leaf number	Inflorescence shape	Inflorescence height	Inflorescence length // cm	Length of inflorescence inserted with flowers // cm	Inflorescence diameter // cm	Bract number
G. lingulata	0	87.7 aA	36 aA	/	/	/	/	/	/
	100	73.6 bB	32 bB	Star-shaped	Tall	56.2 aA	25.6 aA	19.7 aA	18 aA
	200	72.2 bB	32 bB	Star-shaped	Tall	54.8 aA	25.3 aA	19.3 aA	17 aA
	300	71.6 bB	31 bB	Star-shaped	Tall	55.1 aA	25.0 aA	19.3 aA	17 aA
	400	71.3 bB	31 bB	Star-shaped	Tall	54.6 aA	24.9 aA	19.0 aA	17 aA
	500	66.6 cC	27 cC	Star-shaped	Tall	50.0 bB	20.9 bB	18.9 aA	16 aA
G. lingulata	0	84.9 aA	35 aA	/	/	/	/	/	/
	100	71.1 bB	31 bB	Star-shaped	Tall	53.1 aA	26.1 aA	20.2 aA	12 aA
	200	70.2 bB	31 bB	Star-shaped	Tall	52.7 aA	25.8 aA	19.9 aA	12 aA
	300	68.6 bB	32 bB	Star-shaped	Tall	52.0 aA	25.1 aA	19.5 aA	10 aA
	400	68.1 bB	30 bB	Star-shaped	Tall	52.1 aA	24.9 aA	19.0 aA	11 aA
	500	64.3 cC	25 cC	Star-shaped	Tall	47.9 bB	21.1 bB	18.8 aA	10 aA
G. denise	0	79.3 aA	34 aA	/	/	/	/	/	/
	100	69.1 bB	30 bB	Star-shaped	Equally high	40.1 aA	13.3 aA	26.2 aA	20 aA
	200	68.2 bB	30 bB	Star-shaped	Equally high	39.9 aA	13.1 aA	26.1 aA	20 aA
	300	67.7 bB	29 bB	Star-shaped	Equally high	39.2 aA	12.9 aA	25.9 aA	19 aA
	400	66.9 bB	29 bB	Star-shaped	Equally high	38.8 aA	12.2 aA	26.0 aA	18 aA
	500	63.3 cC	24 cC	Star-shaped	Equally high	33.1 bB	9.6 bB	25.6 aA	19 aA
G. remembrance	0	114.4 aAA	48 aA	/	/	/	/	/	/
	100	98.8 bB	43 bB	/	/	/	/	/	/
	200	98.2 bB	43 bB	Torch-shaped	Tall	47.8 aA	17.6 aA	16.6 aA	75 aA
	300	98.7 bB	42 bB	Torch-shaped	Tall	47.3 aA	17.0 aA	16.1 aA	73 aA
	400	97.4 bB	41 bB	Torch-shaped	Tall	46.7 aA	16.8 aA	15.9 aA	74 aA
	500	95.9 bB	40 bB	Torch-shaped	Tall	46.1 aA	16.6 aA	15.6 aA	72 aA

mg/L, the differences in the peak flowering period and ornamentation period among *G. lingulata*, *G. lingulata* and *G. denise* were not significant. Among the four varieties, *G. remembrance* exhibited longer response period and peak flowering period compared to the other three varieties at the same concentration conditions.

Effects of ethephon on flower traits during the peak flowering period in different pineapple varieties

After flower forcing with ethephon, the central leaves in the four varieties spiraled into sword-shape, and the upper part coloured to form an inflorescence that specialized into star-shape or torch-type according to their own variety properties. It could be seen from Table 3 that the control plants didn't bloom, and revealed significant differences in the crown diameter and leaf number with the treatment plants. After treated with different concentrations of ethephon, there were significant differences in inflorescence length and the length of inflorescence inserted with flowers among treatments with higher concentration and those with lower concentration, while there were no significant differences in inflorescence diameter and bract number.

Conclusion and Discussion

This study revealed that different concentrations of ethephon has different effects on the flower forcing in the four major ornamental pineapple varieties. The flowering rate in *G. lingulata*, *G. lingulata* and *G. denise* all reached 100% at the concentration of 400 mg/L and that in *G. remembrance* reached 98% at 500 mg/L, which all meet the requirement of large-scale cultivation. Under the concentration conditions with the highest flowering rate, it took *G. lingulata*, *G. lingulata* and *G. denise* about 90 d to undergo the response period, about 120 d to stay in the peak flowering period, and about 180 d to stay in the ornamentation period, and it took *G. remembrance* 130 d to undergo the response period, 150 d to stay in the peak flowering period, and about 190 d to stay in the ornamentation period, based on which the best time for flowering period regulation can be determined according to market demand. Although after treatment with different concentrations of ethephon, there were differences in the crown diameter and leaf number among the control plants and the treatment plants in the four pineapple varieties, and there were also difference in the the inflorescence length and the length of inflorescence inserted with flowers among pineapples treated with higher concentrations and those treated with lower concentrations, but the major ornamentation traits like inflorescence shape, inflorescence height, inflorescence diameter and bract number did not vary with ethephon concentration, which satisfy the requirements for or-

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Responsible editor: Fujuan QI **Responsible proofreader: Xiaoyan WU**

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namentation properties in pineapple commercialization.

Xia[7] proposed that saturated aqueous solution of acetylene gas had a good effect on flower forcing, but the acetylene is easy to volatilize, thus it is hard to accurately control its concentration, bringing great difficulty in operation in actual production. This study shows that the four pineapple varieties are highly sensitive to ethephon and suitable to be applied to the large-scale in-season cultivation taking account of the flowering rate, flowering process and flower trait indexes at the peak flowering period. In this study, we also found that different concentrations of ethephon solution had certain inhibitive effects on the growth of ornamental pineapples compared to the control, which are mainly displayed in plant appearance characteristics like the crown diameter and leaf number, and the inhibition was improved with the increasing concentration. Whether it is feasible to reduce the effect on pineapple growth through lowering the increasing concentration as low as possible and increasing the treatment times properly, requires further rigorous tests.

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