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Gibberellic acid in vegetative and reproductive development of *Phalaenopsis* orchid hybrid genus

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ABSTRACT

The flower industry represents about one billion dollars in Brazil and the development of techniques aimed at flowering control is required. This study evaluated the influence of gibberellic acid (GA_3) on the vegetative and reproductive development of young plants of Phalaenopsis FSNT 'Dai-Itigo' hybrid pink color. The application of GA_3 was made by foliar sprays at concentrations of 0, 125, 250, 500 and 1,000 mg L^{-1}. The length of leaves increased significantly when using GA_3 at low concentrations, but leaf width decreased. The application of GA_3 at 125 mg L^{-1} showed the best results for the promotion of flowering and flower quality of this orchid hybrid. In this treatment, about 50% of plants treated with GA_3 flowered about 6-12 months before the plants that were non-treated with this plant growth regulator. The quality of flowering and flowers was best with 125 mg L^{-1} GA_3.

Keywords: *Phalenopsis*, young plants, leaf size, precocity, flowering, quality.

RESUMO

Desenvolvimento vegetativo e reprodutivo de orquídea híbrida do gênero *Phalaenopsis* tratadas com ácido giberélico

O setor de floricultura movimenta cerca de um bilhão de dólares no Brasil e o desenvolvimento de técnicas direcionadas ao controle do florescimento é necessário. O presente trabalho avaliou a influência do ácido giberélico (GA_3) no desenvolvimento vegetativo e reprodutivo de plantas jovens de *Phalaenopsis* FSNT 'Dai-Itigo', híbrido de coloração rósea. A aplicação do GA_3 foi feita via pulverização foliar nas concentrações de 0, 125, 250, 500 e 1.000 mg L^{-1}. O comprimento das folhas aumentou consideravelmente com o uso do GA_3 em baixas concentrações, porém houve diminuição da largura foliar das plantas tratadas com esse fitorregulador. A aplicação do GA_3 na concentração de 125 mg L^{-1} apresentou os melhores resultados para a promoção do florescimento e qualidade da floração deste híbrido de orquídea. Nesse tratamento, aproximadamente 50% das plantas pulverizadas apresentaram floração cerca de 6-12 meses antes da floração das plantas sem aplicação do fitorregulador. Em conclusão, a qualidade da floração e das flores foi melhor no tratamento com 125 mg L^{-1} de GA_3.

Palavras-chave: *Phalenopsis*, plantas jovens, tamanho da folha, precocidade, florescimento, qualidade.

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The Orchidaceae family comprises more than 25,000 species and thousands of hybrids with different sizes, shapes and colors of flowers. The export of floricultural products in Brazil totalized US$31.5 million in 2009, but the amount of imports in the sector (US$20 million) is still high (Kyiuna *et al*., 2010). Although the orchids have only a small share of this total, the annual increase of over 100% in exports represents a high potential for the export market (Junqueira & Peetz, 2008).

The increase in production and consumption of flowers has been stimulated by the reduction of production costs, with the development of research and technologies for ornamental and flower plants, like the work of determining nutritional requirements (Ludwig *et al*., 2008) and substrates (Ludwig *et al*., 2010). However, there are few papers with effects of plant growth regulators in species used in floriculture.

A climatic similarity between Brazil and some Asian countries contributes to the cultivation of highly commercial and ornamental species that has its center of origin in Asia (Suttleworth *et al*., 1994). As example, *Cymbidium*, *Dendrobium* and *Phalaenopsis* genera, growth in a large part of the world and with great commercial value, not just for the beauty of its flowers, but also for its easy hybridization and breeding, variety of colors and the flowers durability, enabling marketing and transportation over long distances.

Gibberellins are plant hormones biochemically characterized as tetracyclic diterpenoid acids. Gibberellins influence the stimulus to flowering in different ways, activating promoter genes in the meristem such as *LEAFY* (Blasquez *et al*., 1998), replacing the period of low temperatures required for the flowering of many species and increasing the C/N ratio in leaves through the activation of hydrolytic enzymes (Kerbauy, 2008). Gibberellins applied exogenously promote the flowering induction and flower development in plants that normally require long days under the conditions of short days, however, the reverse does not occur, although there are exceptions (Cid, 2000).

The objective of this study was to evaluate the plant development, early flowering and the quality of flowering of *Phalaenopsis* orchids using different concentrations of gibberellic acid (GA_3)

by foliar spraying.

MATERIAL AND METHODS

The experiment was conducted in Pompeia, São Paulo state, Brazil (22°06'29'S, 50°10'36"W).

The plant material consisted of individual seedlings of a *Phalaenopsi*s hybrid, pinkish in color, and obtained by *in vitro* seeding. The *Phalaenopsis* plants used were 'FSNT Dai-Itigo' that were acclimatized and grown for eight months in greenhouse conditions. We selected for this experiment those plants presenting similar size and growth characteristics, to form a homogenized plant group to receive the application of different concentrations of gibberellic acid (GA_3).

Plants were grown in greenhouse conditions with 70% shading associated with a layer of 30% Aluminet®. Irrigation was performed four times a week using micro-sprinklers, irrigating about 150 mL of water per plant. The fertilization was made four times weekly with 1g L^{-1} of the formula 15-15-20 and 20-10-10, supplemented with 0.5% Mg, 0.02% B, 0.05% Cu, 0.10% Mn, 0.02% Mo and 0.10% Zn, applied by drip irrigation. For the cultivation of the plants, we used transparent plastic pots (1.3 L volume capacity) filled with coconut chips as substrate.

The treatments consisted of five concentrations of GA_3: 0, 125, 250, 500 and 1,000 mg L^{-1}, applied twice at intervals of 14 days under foliar spraying.

We used GA_3 with at least 95% purity. The product was diluted in 4 mL of 92.8° GL hydrated ethyl alcohol with the addition of 1 mL of Tween 20© per solution liter (0.1%) before completing the solution with water. Control plants were treated with water containing 0.1% Tween 20©.

The spraying was done between the dates of November 10 and December 10, 2006, in the morning (between 7 and 8 a.m.), when the air humidity is highest in the region, favouring the absorption of the product. For the spraying a 20 L costal sprayer (Jacto©) coupled with an X2 conical type nozzle was used. Upon application, the plants treated with the spray were separated from each other to prevent contamination with the product. Each plant was sprayed with about 40 mL of solution, directing the jet to the adaxial side of leaves, with runoff of the product to the roots.

The experimental design was of completely randomized blocks with six plants (replicates) for each treatment. The experiment lasted 12 months and was repeated twice.

The size of the plants was obtained through the width and the length of the leaves obtained after the treatment with different concentrations of GA_3. The reproductive phase was evaluated by the flowering quality, such as the time of the first flowering, flowering rate (%), the length of inflorescence, the number of flowers and the quality of the flowers obtained in each treatment. The quality of flowers was measured by the diameter of flowers and petals of flowering plants.

The flowering rates (%) were converted to $\arcsin\sqrt{x+0.5}$. All data were analyzed by ANOVA and the means were compared using the Duncan's multiple range test at 5% of probability. Linear regression was performed to establish the correlation between leaf length and the rate of flowering (%).

RESULTS AND DISCUSSION

Concerning the plant growth, there was influence of the GA_3 concentrations on the size of the leaves of *Phalaenopsis* 'FSNT Dai-Itigo'. The increase was from 10.9 cm (control) to 18.1 cm in a treatment using 125 mg/L (Table 1). In relation to the best treatment (125 mg L^{-1} of GA_3), the higher doses of GA_3 showed a slight decrease in the length of the leaves by increasing the concentrations used. The width of the leaves was reduced with the increased use of concentrations of GA_3, falling from 5.7 cm (control) to 4.4 cm with the use of 500 mg L^{-1} of GA_3 applied by foliar spray on the young plants of *Phalaenopsis* (Table 1).

The increase in length of the leaves of young *Phalaenopsis* plants, with age of 12 months, visually resembled plants with higher age, adult and ready to flowering (Figure 1). The results obtained for the leaf length and diameter for this species are consistent with those obtained by Vichiato *et al*. (2007) in *Dendrobium nobile* orchids. The cell growth promoted by the gibberellins, through the activation of hydrolytic enzymes, increases the length of the cells compared to their diameter, making tissues and organs such as leaves, stems and fruits, longer and thinner (Taiz & Zeiger, 2009).

An increase in the percentage of flowering plants and the quality of blooming with the use of GA_3 was also observed and this could be used to accelerate the flowering of *Phalaenopsis*. With the application of 125 mg L^{-1} of GA_3, 50% of the plants of *Phalaenopsis*, at 12 months of age, flourished in their flowering season (May/June), about 4-6 months before the plants not treated with this plant growth regulator and 6 to 12 months before the commercial flowering of this orchid, demonstrating the effect of GA_3 in early flowering and shortening the juvenility of this genus of orchids. The use of concentrations higher than 125 mg L^{-1} of GA_3 did not increase the percentage of flowering, and under these conditions only 33% of plants flowered in the same period. In the control, the percentage of flowering plants was 16.7%. This may be due to the fact that these concentrations may be above those required for the flowering of this hybrid of *Phalaenopsis* (Table 1).

The physiological effects of some gibberellins in flowering were observed and depend on the plant species or cultivar. The responses could be positive, neutral or negative in the induction of flowering; generally the response of the induction of flowering by GAs occur more frequently in long-day plants (LDP) and plants which require a period of low temperature (vernalization) to blooming (Kerbauy, 2008). The latter seems to be the case for most of the *Phalaenopsis* species, since the use of low temperatures, regardless of photoperiod, appears to be a limiting factor for the flowering of these plants, a technique used in commercial productions.

According to Wang (2000), species

Table 1. Vegetative and reproductive development of *Phalaenopsis* 'Dai-Itigo' sprayed with gibberellic acid (desenvolvimento vegetativo e reprodutivo de *Phalaenopsis* 'Dai-Itigo' pulverizados com diferentes concentrações de ácido giberélico). Pompéia. FSNT. 2006.

Development		Concentrations of GA_3 (mg L^{-1})					CV (%)
		Control	125	250	500	1.000	
Vegetative parts							
Leaves (cm)	Lenght	10.9 c	18.1 a	17.0 a	14.3 b	16.2 ab	9.72
	Width	5.7 a	5.8 a	4.9 ab	4.4 b	4.9 ab	14.33
Reproductive parts							
Flowering rate (%)		16.7 b	50.0 a	33.3 ab	33.3 ab	33.3 ab	27.38
Inflorescence	Lenght (cm)	20.1	45.5	47.0	38.8	45.0	ns
	Number of flowers	3.0	6.6	6.5	5.0	6.0	ns
Diameter (cm)	Flowers	8.5	9.4	8.7	7.7	8.6	ns
	Petals	5.5	5.8	5.4	5.2	5.5	ns

*Means followed by the same letter in the line do not differ by Duncan's multiple range test at 5% of probability; Ns= non-significant (medias seguidas pela mesma letra não diferem entre si pelo teste de Duncan a 5% de probabilidade; ns= não significativo).

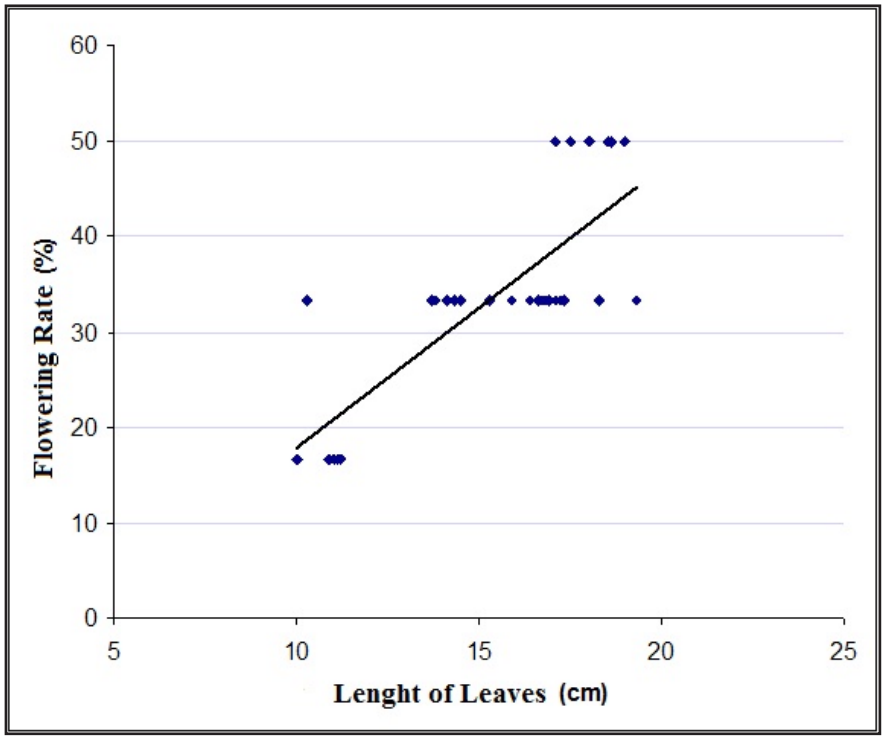

Figure 1. Correlation between the leaf length (cm) and the flowering rate (%) of plants of *Phalaenopsis* 'Dai-Itigo' with 12 months of age and sprayed with different concentrations of GA_3 (correlação entre o comprimento das folhas (cm) e a taxa de florescimento (%) de plantas de *Phalaenopsis* 'Dai-Itigo' com 12 meses de idade e pulverizadas com concentrações de GA_3). Pompéia, FSNT, 2006. $Y = 2.92x - 11.31$, $R^2 = 0.64$*

and hybrids of *Phalaenopsis* require a period of 3-5 weeks of exposure to a reduction of temperature from 25 to 15°C to initiate the induction of flowering.

Kataoka *et al*. (2004) observed a significant increase in the amount of sucrose in the leaves of pre-flowering *Phalaenopsis* when these were grown in a temperature of 20°C. The use of high temperature (27°C) reduced the levels of sucrose and the percentage of plants that flower of this orchid genus.

Chen *et al*. (1997) reported that it is possible to induce flowering in *Phalaenopsis* in high temperature conditions (non-inductive conditions) with GA_3 application, obtaining positive results on the induction of flowering of *Phalaenopsis* 'Leda'.

A positive correlation (r = 0.64*) between the length of the leaves and the rate of flowering of *Phalaenopsis* 'FSNT Dai-Itigo' (Figure 1) was observed. This result and the fact that plants thrive in their normal flowering season led to the proposal of an indirect effect of GA_3 on flowering induction, caused by increasing the size of *Phalaenopsis* leaves with GA_3. High quantities of energy are necessary for flowering induction and development of the flowers. The number and size of leaves increase the photosynthetic area, ledding to high energy production, and that sustain the development of inflorescences and flowers (Bustan & Goldschmidt, 1998; Taiz & Zeiger, 2009).

The number of inflorescences was the same in all plants observed, one inflorescence per plant. However, an increase in the length of the flower stalks, from 20 to 45.3 cm, was observed using the treatment with 125 mg L^{-1} GA_3 compared to control plants sprayed with water. The number of flowers per plant also increased to 6.6 at a concentration of 125 mg L^{-1} GA_3, compared to 3.0 flowers per plant in those treated with water (Table 1). The length of the inflorescence and the number of flowers have been used as parameters to evaluate the quality of classification of *Phalaenopsis* plants in flower markets, where long inflorescences

and a high number of flowers get the best classifications and prices (Veilling, 2009).

The flower quality was also affected by the application of different concentrations of GA_3 (Table 1). The best result on the diameter of the flowers also was obtained using 125 mg L^{-1} GA_3. The application of this plant growth regulator in this concentration allowed the flowers obtained to a diameter about 0.9 cm larger than the flowers obtained in control plants. Still, the increase in the diameter of the petals creates a visual appearance having good impact, increasing the quality of the flowers. The fact that higher concentrations of GA_3 promoted reduction in the size of the flowers and the diameter of the petals may be explained due to the phytotoxicity of GA_3 applied in high concentrations. The absence of statistical differences on these data is mainly due to the great number of zero values, attributed to the failure of flowering of some plants.

The results obtained in this experiment were according with Chen *et al*. (2003) that also observed an increase in the quality of the flowering plants of *Philodendron* 'Black Cardinal' by applying GA_3 compared to those treated with water.

The experiment achieved good results for the use of GA_3 in the commercial production of *Phalaenopsis*, reducing the time for the first flowering to 6-12 months and increasing the quality of first flowering, which in normal cultivation conditions and without the application of this plant growth regulator, is generally of poor quality, with few flowers and short inflorescence, that results in non-commercial plants. It was possible to obtain approximately 50% of flowering induction of *Phalaenopsis* plants at 12 months of age, averaging 6.6 flowers per plant, with a GA_3 application at 125 mg L^{-1} reducing the time of the first flowering for fast marketing of the product. At this concentration, the GA_3 also promoted an increase in inflorescence length and diameter of flowers and petals, improving the quality of flowering.

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