EFFECTS OF GA_3 AND BA ON TWO CULTIVARS OF ACHIMENES LONGIFLORA UNDER TWO LEVELS OF IRRADIANCE

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Abstract

Two cultivars of A c h i m e n e s l o n g i f l o r a were placed at 21°C and 16 h of light of two irradiance levels, 22 and 35 W/m^2 for 12 weeks, after being sprayed with gibberellic acid (GA_3) and benzyladenine (BA). Number of axillary shoots, fresh weight, and number of rhizomes were higher in cultivar Flamenco than in Viola Michelssen. The higher irradiance level increased number of leaf whorls, number of flowers and number of leaf axils that developed more than one flower. Number and fresh weight of rhizomes were also increased at 35 $W m^{-2}$. The numbers of leaf whorls was increased by 100 $mg l^{-1}$ GA_3 alone and in combination with 25 $mg\ l^{-1}$ BA. Neither GA_3 nor BA influenced the total number of flowers while the number of atrophic flowers was increased by high GA_3 or BA concentrations. Growth regulator treatments had no carry-over effect on the dormancy and/or sprouting of produced rhizomes.

1. Introduction

Achimenes originates from Mexico, Brazil and Jamaica (Moore, 1975). Cultivated as a potted plant, it is propagated by rhizomes or stem cuttings in early spring and flowers until late fall before it becomes senescent, forming rhizomes in the soil which remain dormant until next spring (Jungbauer, 1977). Flower initiation of Achimenes cultivars usually occurs after the development of the 3rd or 4th leafwhorl in daylengths of 8 to 24 h and temperatures ranging from 15 to 25°C (Rhode, 1973). Leaf whorls are composed of 3 or 4 leaves and flowers are borne single or paired in the axils of the leaves (Broertjes, 1980). The lower 4 leaf whorls develop mainly axillary shoots from their axils. Research by Rohde (1974) with 2 Achimenes cultivars has indicated that plants are day neutral, and that best vegetative and generative growth is achieved at 20°C and 16 h light. Optimal light intensity for Achimenes is not known. The factors that cause senescence of the aerial parts and formation of dormant underground rhizomes have not been investigated, but it has been suggested that short days and low temperatures stimulate ABA synthesis which could be responsible for reduction of plant growth (Rohde, 1973).

The growth regulators gibberellic acid and benzyladenine were selected for this first investigation, to be applied to 2 cultivars of Achimenes to study their effects on flowering and rhizome formation. It is well established that both GA_3 and BA can influence the flowering process in many ornamental plants (Sachs and Hackett, 1977; Lyons and Meyer, 1983) and that cytokinins promote while gibberellins suppress tuberization (Smith and Palmer, 1970; Deutch, 1974; Melis and Van Staden, 1984). Two commercial cultivars, morphologically similar, were selected for this experiment in order to investigate if they would

respond differently to the given experimental conditions. They were cultivars Flamenco and Viola Michelssen both hybrids of Michelssen (Hannover), described as vigorous and well branched plants with large red flowers (Pouwer and Evers, 1983).

The aim of this work was to investigate if a difference in irradiance levels and/or application of growth regulators could influence growth, flowering and rhizome formation in two Achimenes cultivars.

2. Materials and methods

Achimenes plants of cultivars 'Flamenco' and 'Viola M.' propagated by stem cuttings originating from sprouted rhizomes were obtained from a commercial grower in September 1983. Plants were uniform in height (10 cm) and had 5 to 6 leaf whorls. 'Viola M.' had already formed visible flower buds in the upper two leaf axils.

On 21 September 1983, 80 plants from each cultivar were individually potted in 10 cm plastic pots with a standard potting medium and were sprayed to run off with the following concentrations of GA_3 and BA.

1. Control (only water)
2. GA_3 1 mg l^{-1}
3. GA_3 10 mg l^{-1}
4. GA_3 100 mg l^{-1}
5. GA_3 100 mg l^{-1} + BA 25 mg l^{-1}
6. BA 25 mg l^{-1}
7. BA 50 mg l^{-1}
8. BA 100 mg l^{-1}

Two weeks later the same applications were repeated. The solutions were made on the day of application and for GA_3, Berelex 90% tablets were used. The pH of the solution was brought to 7 and Tween 20 was added as a surfactant at the rate of 0.1 ml l^{-1}. Each plant was sprayed with approximately 15 ml of solution. The treated plants were placed in a growth room at 21°C day and night temperature and 16 h light. Plant density was 60 plants/m^2. Sodium (SON/T) and Mercury (HPI/T) lamps of 250 and 400 W provided illumination. The higher irradiance (hI) consisted of 35 W m^{-2} while the lower irradiance (lI) of 22 W m^{-2} at plant level. This 35% reduction of light intensity was achieved by covering the plants with a single layer of white cheese cloth. The experimental lay out was a randomized complete block design with 2 cultivars, 2 levels of irradiance and 8 treatments in 5 blocks, with a total of 160 plants. All plants received fertilization twice and were sprayed 3 times for spider mites with the insecticide Vydate L. Height of the main stem was recorded every two weeks and at the end of the 10th week (30 November, 1983) the following data were taken: Number of leaf whorls, number of leaf axils with more than one flower (MFLA for Multiple Flower Leaf Axils) and their position on the stem, number of atrophic flowers, number of open and dead flowers on both the main and the axillary shoots and number of axillary shoots developed from the lower 4 leaf whorls. In Achimenes only the corolla is shed while the pedicel with the lobed calyx and the pistil remain intact. It was therefore possible to estimate the total number of flowers produced during the 10 week period by counting seperately the old (dead) flowers and the open ones on both main and axillary shoots. Atrophic flowers were also observed and counted similarly.

The plants were left in the growth room for another 2 weeks before they were destroyed and the rhizomes in the soil were removed, counted, weighed and then stored dry at room temperature in the dark for 10 weeks (from 15 December to 10 February, 1984). The rhizomes from each treatment were then planted (sown) in a mixture of peat and sand, covered with a layer of 1.5 - 2 cm, and were placed in the greenhouse at tem-

peratures of 18-20°C. On April 6, (8 weeks later) they were checked for sprouting).

3. Results

3.1. Effects of cultivar

Table 1 indicates that both cultivars developed an equal number of axillary shoots from the first leaf whorl while 'Flamenco' formed more side shoots from the 2nd to the 4th leaf whorl than 'Viola M.'. It should be mentioned that both in 'Flamenco' and in 'Viola M.' the leaf whorls are composed of 3 leaves. Only the basal whorl usually has 2 leaves. From the leaf axils of the lower leaf whorls axillary shoots develop while flowers begin to appear mostly after the 4th whorl. The present results are in agreement with observations by Rohde (1974) that the number of side shoots in each whorl is influenced by the number of shoots developed in the previous lower whorls and by the onset of flower initiation. Although the number of flowers is not different between the two cultivars, the number of old (dead) flowers on the main stem is higher in 'Viola M.' because as it forms less side shoots, flower formation started earlier on the main stem. The number of open and dead flowers on side shoots was greater in 'Flamenco' as it develops more side shoots. The number and percentage of atrophic flowers on both main and side shoots were higher in 'Flamenco'. Total number of flowers was not different between the two cultivars. Number and fresh weight of rhizomes were greater in 'Flamenco'.

3.2. Effects of Irradiance levels

The effects of two irradiance levels are given in Table 2. An irradiation of 35 W m^{-2} for 16 h significantly increased the number of leaf whorls and the total number of flowers as compared to 22 W m^{-2}. The number of leaf axils that formed more than one flower (MFLA) was also increased under hI. These MFLA developed usually 2 or 3 flowers buds that were brought to anthesis at successive stages (Fig. 3). The number of atrophic flowers was higher in the hI regime but when expressed as a percentage of the total number of flowers there was no difference. Number and total fresh weight of rhizomes as well as fresh weight of each rhizome were significantly increased under hI. The rhizomes produced under lI were also of a smaller size than those under hI.

3.3. Effects of GA_3 and BA treatments

Effects of treatment with 3 different concentrations of GA_3 and BA, one combination of 100 mg l^{-1} GA_3 + 25 mg l^{-1} BA are presented in Table 3. Concentrations of 10, 100 mg l^{-1} GA_3 alone and in combination with 25 mg l^{-1} BA increased the number of leaf whorls. Height of the main stem was significantly increased by 100 mg l^{-1} GA_3 alone and in combination with 25 mg l^{-1} BA. The number of atrophic flowers was increased by the highest concentrations of both GA_3 and BA and the combination 100 mg l GA_3 + 25 mg l BA (atrophic flowers are shown in Fig. 4). The fresh weight of rhizomes was highest after 100 mg l BA_3 and lowest after 100 mg l^{-1} GA_3, but the difference with the control was not significant.

3.4. Interaction effects

Fig. 1. shows the interaction between GA_3 treatments and irradiance on the height increase of plants. Under hI control plants and those treated with 1 mg l^{-1} GA_3 and all concentrations of BA showed a higher

increase of height, than those under lI, while those treated with 10 mg l^{-1} GA_3 and 100 mg l^{-1} GA_3 + 25 mg l^{-1} BA had a higher height increase under lI than those treated under hI.

Fig. 2. shows there was an interaction effect between BA treatment, and cultivar on the number of leaf axils that produced more than one flower (MFLA). Increasing concentrations of BA increased the number of MFLA in 'Flamenco' from 2.4 (control) to 6.2 while GA_3 was stimulating only at 10 mg l^{-1} (4.7) and at 100 mg l^{-1} there was a sharp decrease (0.08). 'Viola M.' responded differently. The lowest concentrations of BA and GA_3 increased MFLA while increasing concentrations decreased MFLA. Collected data also showed that 80% of the observed MFLA were located between the 5th and the 10th leaf whorl in both cultivars. There was no effect of the BA and/or GA_3 treatments on the plants on dormancy or sprouting of rhizomes (data not shown).

4. Discussion

Results from this experiment show that irradiance levels are very important for growth, flowering and rhizome development in Achimenes. Low irradiance (lI) might have promoted height of the main stem as reported in an other Gesneriad, gloxinia, by Sydnor et al (1972). Instead, only the number of leaf whorls was decreased in comparison to hI which indicates that internode length was increased since there was no difference in the overall height of the plants under the two irradiances. The greater number of flowers under hI can be partially attributed to the increase in leaf whorls since flowers develop in the axils of leaves. The occurence of more flowers per leaf axil (Fig. 3) in a greater number of cases under hI can be explained by assuming that higher energy levels activated already existing dormant buds to develop into flowers. Similar results were reported by Berghoef (1979) in begonia where hI also increased the number of flowers in the inflorescences. The greater number and fresh weight of rhizomes produced under hI may also be explained by higher assimilate levels, as it has also been mentioned in studies on tuberization (Park, 1984).

Gibberellin (GA_3) did not influence the total number of flowers but increased the number of atrophic flowers (Fig. 4). These results can be related to findings where GA_3 caused poor quality flowers in cyclamen (Thomas et al, 1983) and retarded normal flower development in Cosmos (Molder and Owens, 1974). Increased plant height and number of leaf whorls by treating plants with GA_3 can be explained by assuming that GA_3 influences assimilate distribution, diverting movement of assimilates away from flowers to shoot apices. The decrease of fresh weight of rhizomes by gibberellin is in accordance with results reported by Okazawa (1960) and Menzel (1983) where gibberellins inhibited tuberization in potatos.

The increased number of atrophic flowers and increased fresh weight of rhizomes caused by the highest concentration of BA can be explained by assuming that flowers and rhizomes compete for assimilates when the supply is limited. Cytokinins have been regarded as an important stimulus for rhizome development (Smith and Palmer, 1970). BA could have triggered a flow of assimilates to the active meristematic areas of the stolon tips where high endogenous cytokinin levels already exist (Melvin and Van Staden, 1984) establishing a storage "sink" attracting metabolites. This does not mean that BA alone is responsible for rhizome formation as tuberization processes involve an intergrated action of several hormones in the plant. BA had no effect on growth of the

aerial parts, except that many leaves showed wilting and became curly after application of BA.

Interaction effects between cultivar and treatment on the number of MFLA indicated that cultivars react very differently when treated with the same concentrations of growth substances exhibiting an optimal and suboptimal reaction. Treatment and irradiance also interact on the expression of height increase and it is evident that GA_3 is promoting cell division and elongation more under lI than under hI. Controls and BA treated plants are slightly taller under hI.

Investigations on the effect of gibberellins and benzyladenine on Achimenes rhizomes showed that both substances can break dormancy and promote sprouting (Vlahos, 1984). It could therefore be expected that treatment of mother plants with these substances should affect sprouting of the rhizomes produced as reported in a similar study with potato tubers by Tsukamoto et al (1960). However, such a carry-over effect was not found. It is possible though that storage temperature or incubation conditions were not optimal for expression of such an influence. Further studies will investigate this possibility. It was also observed that irradiance levels, under which the plants were kept, had a profound effect on sprouting and subsequent formation of secondary rhizomes (puppation). These results are not discussed here as they would be further investigated and reported in a future publication.

5. Conclusion

The present study and the results obtained indicate the complexity of interplay among various environmental factors and growth regulators involved in growth, flowering and tuberization processes in Achimenes. Only a few of these factors have been studied in this experiment and the need arises to extend the investigations into several other areas involving photoperiod, temperature, nutrition and a greater spectrum of growth regulators in several combinations.

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Table 1 - Main characteristics of two cultivars of Achimenes grown under two levels of irradiance at 21°C and 16 h light. All values are means of 80 plants. Numbers on the same horizontal row are different at p = 0.001. Those marked with * are not significant.

	cv. Flamenco	cv. Viola Michelssen
No. of axillary shoots on		
1st leaf whorl	1.6*	1.6*
2nd leaf whorl	2.0	1.4
3rd leaf whorl	2.0	0.5
4th leaf whorl	0.9	0
Total number of ax. shoots	6.6	3.7
No. of atrophic flowers on		
a. main stem	2.3	1.5
b. ax. shoots	3.2	1.2
No. of atrophic flowers	5.3	2.9
Percentage of atrophic flowers	18.6	11.2
No. of open flowers on		
a. main stem	3.5*	4.0*
b. ax. shoots	6.0	2.9
No. of dead flowers on		
a. main stem	7.7	12.8
b. ax. shoots	6.9	3.1
Total No. of flowers	29.7*	25.7*
No. of rhizomes (g)	7.8	5.1
Fresh weight of rhizomes (g)	2.3	1.6

Table 2 - Main effects of two irradiance levels on two cultivars of Achimenes grown for 12 weeks at 21°C and 16 h light. All values are means of 80 plants. Numbers on the same horizontal row are different at P = 0.001. Those marked with * are not significant.

	Level of irradiance	
	22 W m^{-2}	35 W m^{-2}
No. of leaf whorls	12.8	13.8
No. of MFLA	1.6	6.9
No. of atrophic flowers	2.8*	5.6*
Percentage of atrophic flowers	14.5*	15.5*
Total No. of flowers	19.5	35.8
No. of rhizomes	5.7	7.2
Fresh weight of rhizomes (g)	1.3	2.5
Fresh weight per rhizome (g)	0.2	0.4

Table 3 - Main effects of foliar spray with GA_3 and BA on two Achimenes cultivars at 21°C and 16 h light. All values are menas of 20 plants. Numbers in one column followed by the same letter are not different at P = 0.05.

Treatments	Height increase (cm)	No. of leaf whorls	No. of atrophic flowers	Percentage of atrophic flowers	Fresh weight of rhizomes (g)
1. Control	14.5a	12.3a	1.4a	4.9a	2.2ab
2. GA_3 1 mg l^{-1}	14.4a	12.7ab	2.3ab	7.7ab	1.9ab
3. GA_3 10 mg l^{-1}	18.1a	13.9bc	3.6ab	11.6ab	2.0ab
4. GA_3 100 mg l^{-1}	30.8b	14.6cd	5.3bc	19.3bc	1.6a
5. GA_3 100 mg l^{-1} + BA 25 mg l^{-1}	28.6b	14.6cd	7.1c	25.7c	1.3a
6. BA 25 mg l^{-1}	15.4a	12.4a	2.1ab	8.3ab	1.9ab
7. BA 50 mg l^{-1}	14.6a	12.5a	4.6abc	17.5abc	1.9ab
8. BA 100 mg l^{-1}	15.8a	12.9a	7.1c	27.6c	2.6b

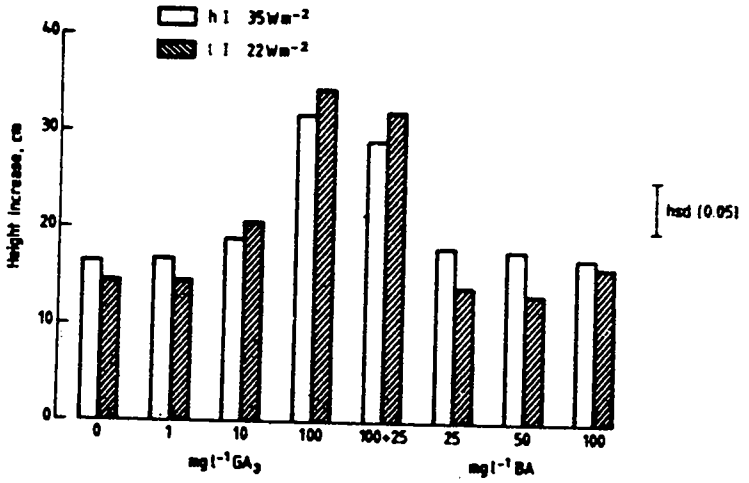

Figure 1 - Height increase (cm) of main stem in Achimenes cultivars. Interaction of irradiance levels and treatment with GA_3 and BA.

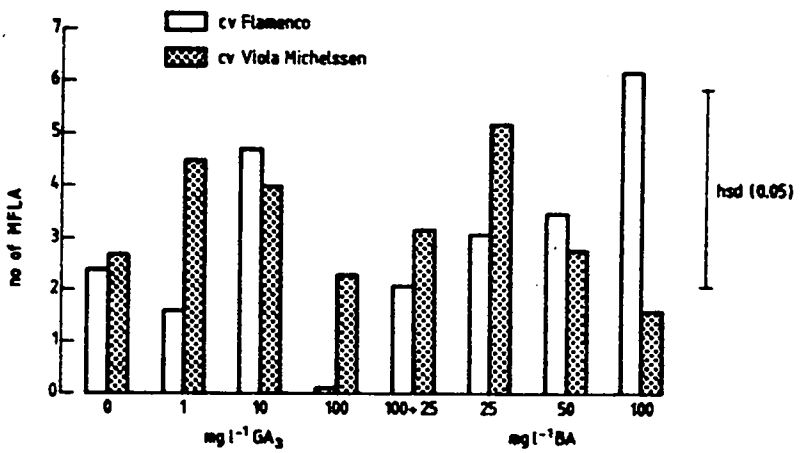

Figure 2 - Number of leaf axils with more than one flower (MFLA). Interaction of Achimenes cultivar and treatment with GA_3 and BA.

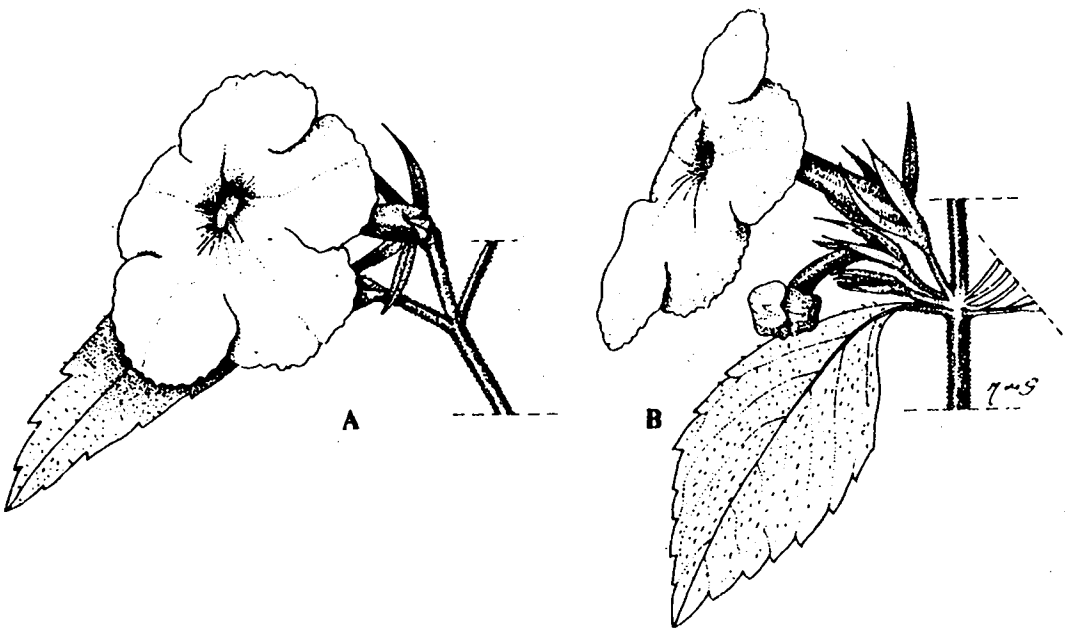

Figure 3 - A. One flower per leaf axil.
B. More than one flower per leaf axil (MFLA).

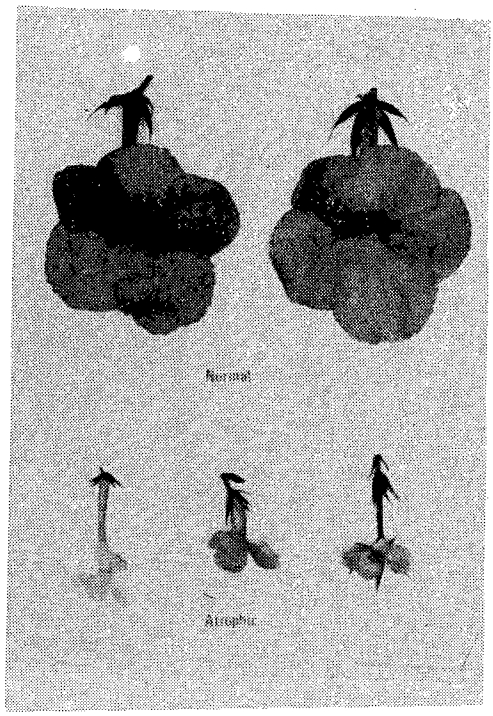

Figure 4 - Normal and atrophic flowers of Achimenes.