EFFECTS OF BA AND GA_3 ON SPROUTING OF ACHIMENES RHIZOMES

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Abstract

Apical and basal halves of Achimenes rhizomes, cv English Waltz, were soaked in four different concentrations of benzyladenine solution for 8, 16 and 24 h. Kept at 25°C in a dark chamber for two weeks, the higher BA concentrations (50 and 100 mg l^{-1}) broke dormancy and enhanced sprouting in both rhizome halves.

In an other trial, rhizomes of cv Viola Michelssen were similarly treated in 50 mg l^{-1} GA_3 and placed at four different temperatures under continuous light and/or darkness for 3 weeks. Dormancy was broken by GA_3 at 21°C in the dark. In both experiments the apical halves sprouted earlier than the basal ones. GA_3 and temperature pretreatment significantly influenced height, number of leaf whorls and flowers in plants developed from treated rhizomes, growing at 21°C and 16 h light, for 22 weeks (5 months).

1. Introduction

Commercial production of Achimenes starts in late January by sowing rhizomes, produced from plants or leaf cuttings in the previous season. Starting in March, cuttings are taken at succesive intervals for plant production until August. The cultivation stops in September or October because plants do not grow in the winter, entering a period of senescence (Rohde, 1973). During the growing period, underground rhizomes are formed that must undergo a period of rest before they sprout for new plant production in the following season. Thus cultivation of Achimenes is limited to one crop per year.

Zimmer (1976) has investigated dormancy break and sprouting in several Achimenes cultivars. Results varied greatly depending on cultivar and environmental conditions under which rhizomes were formed and stored. It was concluded that the longer the rhizomes were stored the sooner they would sprout and that dormancy was broken at high temperatures (20 to 30°C) after dry storage for 10 to 15 weeks. This is a rather long period and it would be interesting to know if release from dormancy and sprouting can be controlled. This would allow not only a better timing in production but also it would make it possible to have 2 crops in a year, provided that the factors that cause senescence of plants would also be known.

Breaking dormancy of Achimenes rhizomes with growth regulators has not been investigated before. Gibberellin and benzyladenine were selected for these experiments because thay have been used with success in breaking dormancy in several bulbous and tuberous plants. Potato tubers have been induced to sprouting with GA_3 (Tsukamoto et al., 1960; Rappaport et al., 1965; Bruinsma and Swart, 1970). Also cytokinins and especially benzyladenine were most effective in releasing potato tubers from dormancy (Tsukamoto and Yazawa, 1972) and a combination of

BA and GA_3 has broken dormancy of gladiolus corms (Tsukamoto, 1974). Concentrations and method of application of substances used in these trials were based on previously reported research on other tuberous plants.

The purpose of the experiments reported here was to investigate the possibility of breaking dormancy and enhancing sprouting of Achimenes rhizomes and to observe if there is a carry-over effect on plants developed from treated rhizomes.

2. Material and methods

Rhizomes of cultivars English Waltz (EW) and Viola Michelssen (VM) were used because they were available at the required quantities for the trials. The rhizomes were collected from senescing plants of a cultivar assortment grown in the summer of 1983 at the Experiment station at Lent in the Netherlands. After harvesting, the rhizomes were cleaned, washed with tap water and those with a uniform size were selected and were broken by hand in two halves, the apical (A) and the basal (B). The rhizomes to be treated were soaked in freshly made growth regulator solutions while controls were soaked in water, at room temperature ($20 \pm 1^{o}C$). All rhizomes were sprayed with Preficure (2 ml/l) to prevent fungal infestation. Treatments contained 10 halves (A and B) and each lot was placed on moistened with water, double filter paper in a covered Petri dish, before being put under incubation conditions. The rhizomes were checked weekly and data were collected after 2 or 3 weeks. The length of emerging sprouts were recorded within 1 mm. If sprout length was 3 mm or more the rhizome was recorded as sprouted.

2.1. Experiment I

On September 26, 1983 freshly harvested rhizomes of 'EW' were treated in 1, 25, 50 and 100 mg l^{-1} BA solution for 8, 16 and 24 h and then placed at $25^{o}C$ in a dark chamber. Sprouting was recorded after 2 weeks.

2.2. Experiment II

Rhizomes of cv VM harvested on October 20, 1983 were stored dry in the dark, at room temperature, for 4 weeks. On November 17 they were treated in 50 mg l^{-1} GA_3 solution for 16 h and then placed in growth rooms at 13, 17, 21 and $25^{o}C$ under two light regimes; continuous dark (CD) and continuous light (CL) of 35 Wm^{-2} (phase 1). Sprouting was recorded after 3 weeks. The lots were then placed at $21^{o}C$ in CD, because sprouting was observed to be enhanced under these conditions (Phase 2). 3 Weeks later, on December 30, 1983, sprouting was recorded again and all rhizomes halves of CD regime were planted individually in 7½ pots in a standard potting soil and were kept at $21^{o}C$ and 16 h light in a growth room for 5 months. Data on plant growth and flowering were collected every 4 weeks. On June 5, 1984 the experiment was terminated and plants were checked for rhizomes. Data were processed with an analysis of variance test.

3. Results

3.1. Experiment I

The effect of benzyladenine on the sprouting percentage of both rhizome halves of 'English Waltz' is shown in Fig. 1. The highest sprouting percentage was achieved at 50 mg l^{-1} BA, while the highest mean sprout length of both A and B was observed at 100 mg l^{-1} BA (6mm).

It was also observed that mean sprout length of apical halves was significantly different from that of the basal ones (4.3 mm vs 1.5 mm). Data not shown here.

Fig. 2 shows that the mean sprout length was significantly influenced by a linear interaction of BA treatment and rhizome part. The 3 soaking time periods had no effect on sprouting, but at 16 h sprout length was slightly increased.

3.2. Experiment 2

Phase 1. Under CL none of the rhizome parts sprouted. Under CD, dormancy of controls (A) was broken only at 21°C, while GA_3 treated rhizomes sprouted in both 21° (A and B) and at 25°C (A). Sprouting percentages are shown on Table 1. Fig. 3 shows that the mean sprout length of both rhizome halves under CD exhibits a quadratic response to temperature levels with maximum at 19.8°C and no sprouting below 13.2°C.

Phase 2. Irradiance, temperature and GA_3 treatments during phase 1, influenced the responses of both rhizome halves, after 3 weeks under CD and 21°C. Table 1 (phase 1) indicates that apical halves of untreated rhizomes kept during phase 1 at 21 and 25°C in the light (CL) or in the dark (CD) sprouted for 20–40 percent. No basal halves sprouted. Apical halves of GA_3 treated rhizomes sprouted for 60-100 percent irrespective of CL or CD pretreatment, basal halves however, sprouted only if kept in CD and for a lower percentage. Fig. 4 shows that mean sprout length of rhizomes was influenced by an interaction between GA_3 treatment and temperature levels given during phase 1. Maximum mean sprout length was recorded at 21°C in GA_3 treated rhizomes.

Phase 3. Table 2 shows that plant height, number of leaf whorls and total number of flower per plant were significantly increased in plants whose rhizomes had been treated with gibberelic acid. Fig. 5 indicates the significant linear effect of the 4 temperature levels given at phase 1, on the number of flowers produced. It was also recorded that the first lot of plants to flower, 8 weeks after planting, were those produced from basal halves treated with GA at 21°C. Plants whose rhizomes had been treated with GA_3 flowered 2 to 3 weeks earlier than those not treated. When the experiment was terminated all plants were in fairly good condition with no signs of senescence. No rhizomes were formed by any of the plants.

4. Discussion

Benzyladenine promoted sprouting, expressed as a percentage or mean length of sprout, in both apical and basal halves of rhizomes of cv English Waltz (Fig. 6). Similar findings have been reported with gladiolus corms (Tsukamoto, 1974) and potato tubers (Tsukamoto and Yazawa, 1972). Masuda and Asahira (1978) have shown that high temperatures increase endogenous cytokinins and decrease inhibitor levels resulting in breaking of dormancy of Freesia corms. It is suggested that by soaking rhizomes in BA and storing at 25°C for 2 weeks a similar activity takes place (Fig. 6). In the trial with cv Viola Michelssen, the inhibitory role of light was clearly demonstrated which indicates that rhizomes seem to have a dark requirement for breaking dormancy (Fig. 7). It is known that seeds of several species do not germinate in light (Wareing and Phillips, 1975) and that sprouting of potato buds in the dark is highly promoted as compared with growth in the light (Burton, 1966).

The importance of high temperature during storage of rhizomes has been demonstrated by Carow (1980) and Zimmer (1976). Burton (1966) has reported that increasing storage temperature increased sprout growth in the potato up to an optimum temperature above which growth was decreased. Similar results were observed in this experiment where sprout length showed a quadratic relationship to the 4 temperature treatments. The delay of sprouting at the lower temperatures was temporary as rhizomes kept at 13 and 17°C, when planted at 21°C eventually sprouted and produced plants (Fig. 8). Yamaguchi et al (1964) also reported delayed stem emergence when seed potato sprouted at lower temperatures and were then planted at higher ones.

Gibberellin treated rhizomes kept either in light or dark showed a marked increase in sprout growth 6 weeks after treatment. Numerous reports show that GA_3 can overcome dormancy in buds and shorten the rest period in underground organs (Vegis, 1964), while high endogenous gibberelin levels have been found in potatos towards the end of the dormant phase (Smith and Rappaport, 1961), but it has been questioned if GA_3 can actually break true dormancy or simply promotes elongation when dormancy has already largely disappeared (Doorenbos, 1958).

The observed mean sprout length and the increased sprouting percentage of rhizomes 100% at higher temperatures compared to 0% at lower temperatures agrees with Vegis (1964) suggestion that the effect of gibberelin maybe highly dependent on the temperature before and after treatment. Most interesting was the finding that GA_3-treated rhizomes produced plants with significant differences in growth and flowering in comparison to the controls (Fig. 8). The fact that gibberelins influence flowering in several plants by promoting earliness has been shown before (Wellensiek, 1972, Van Bragt and Van Gelder, 1979). The interaction between GA_3 and temperature in their effect on sprout growth is probably the result of an accelerated cell division and increased cell enlargement. The influence of temperature pretreatment on the number of flowers can be explained by assuming that the temperatures given before planting, influences the rate of sprout growth. Higher temperatures promote sprouting and subsequently affect flowering. Earlier sprouting, earlier flowering. Similar observations in iris bulbs have been reported by Le Nard (1980).

In both trials apical halves of treated or untreated rhizomes always sprouted first. Apical dominance could explain this as younger buds in the apex usually start growing first while buds in the basal end remain dormant (Burton, 1966). The injury caused by breaking the rhizome would have increased the rate of respiration, as reported for potato tuber by Timm et al (1965), and promoted sprouting in the basal half. Hemberg and Overlid (1967) have offered evidence that a difference in sprouting between apical and basal potato halves was the result of difference in the amount of an inhibitor, depending on the stage of the dormant period. This experiment does not allow such an explanation, but it would be interesting to investigate this possibility.

Total absence of rhizomes was not expected. It could be accounted for in the GA_3 treated plants, since it is a fact that gibberellin inhibits tuberization (Menzel, 1983). It can only be implied that conditions given during phase 2 (21°C and CD for 3 weeks) had some effect on the general metabolism of the plant in mobilizing assimilates to the above ground plant parts thus inhibiting tuberization. The influence of 21°C and 16 h photoperiod under which the plants grew has to be taken into account.

5. Conclusions .

The findings reported in this paper, although preliminary, establish significant relationships among storage temperature, growth regulators and light and give some information on how these factors may influence dormancy in Achimenes rhizomes. Further investigations on the role of both endogenous and exogenous factors that influence release from dormancy and subsequent plant growth are necessary.

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Table 1 - Effect of GA_3 on sprouting percentage of Achimenes rhizome halves cv Viola Michelssen , after 3 weeks at 4 temperatures in CL and CD (Phase I) followed by 3 weeks at 21°C and CD (Phase II).

Treatments		Phase I A	Phase I B	Phase II A	Phase II B
CL Control	13°C			0	0
	17			0	0
	21			20	0
	25			40	0
GA_3 50 mg l^{-1}	13°C	none		80	0
	17			60	0
	21			100	0
	25			100	0
CD Control	13°C	0	0	0	0
	17	0	0	0	0
	21	20	0	30	0
	25	0	0	40	0
GA_3 50 mg $-^{-1}$	13°C	0	0	60	20
	17	0	0	60	60
	21	100	30	100	80
	25	100	0	100	80

Table 2 - Influence of GA_3 treatment of rhizomes 'Viola Michelssen', during Phase I, on growth and flowering of produced plants. Numbers on same horizontal row are significant at P = 0.05.

	Control	50 mg l^{-1} GA_3
Height of plants (cm)	13.0	19.0
No. of leaf whorls	6.7	9.5
Total no. of flowers	32.5	43.5
No. of ax. shoots	3.1	4.8 NS

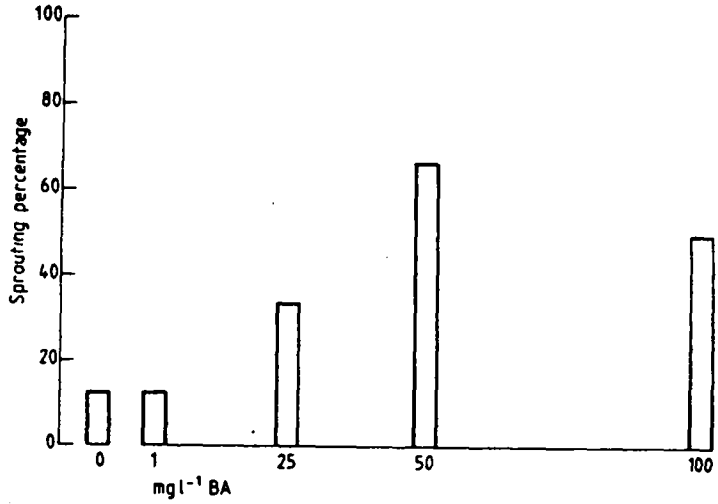

Figure 1 - Sprouting percentage of rhizomes cv English Waltz treated with 4 different concentrations of BA and kept at 25°C in the dark for 2 weeks.

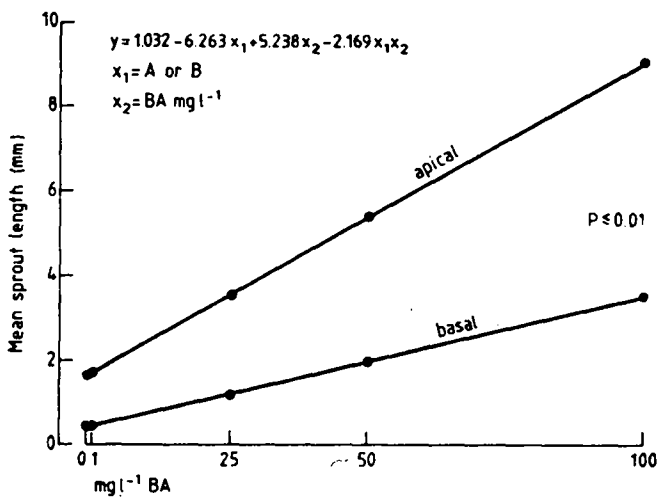

Figure 2 - Mean sprout length of apical (A) and basal (B) halves of rhizomes cv English Waltz treated with 4 different concentrations of BA and kept at 25°C in the dark.

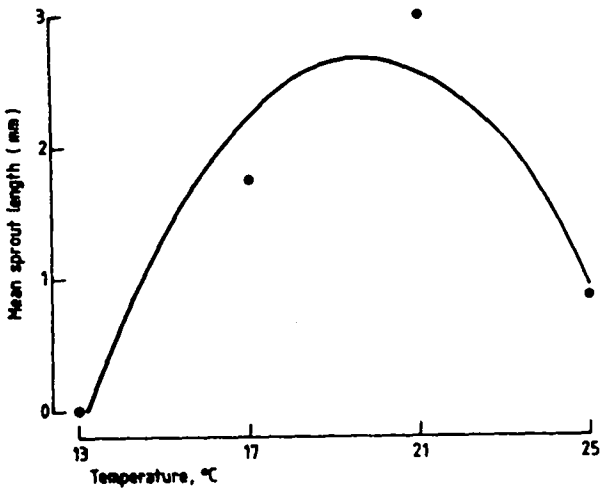

Figure 3 - Mean sprout length of both apical and basal halves of rhizomes cv Viola Michelssen treated with 50 mg l^{-1} GA_3 for 16 h and kept at 4 different temperatures in the dark for 3 weeks (phase 1).

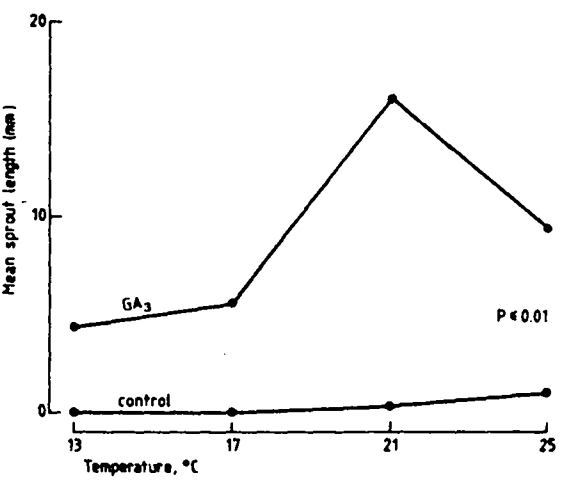

Figure 4 - Mean sprout length of rhizomes cv Viola Michelssen, after 3 weeks at 21°C in CD (phase 2) following treatment with GA_3 at 50 mg l^{-1} for 16 h and kept at 4 different temperatures either in CL or CD for 3 weeks (phase 1). Interaction of GA_3 and temperature treatment.

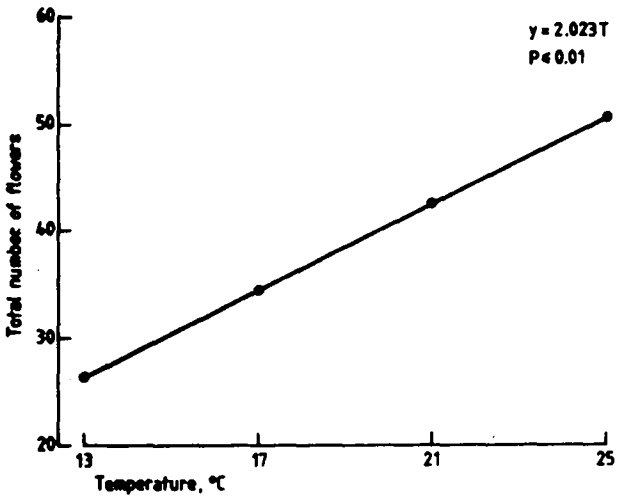

Figure 5 - Total number of flowers of Achimenes in Viola Michelssen grown at 21 and 16 h light for 22 weeks, in response to temperature pretreatment of rhizomes. Rhizomes were kept at 13, 17, 21 and 25°C for 3 weeks and then for another 3 weeks at 21°C in CD before planting.

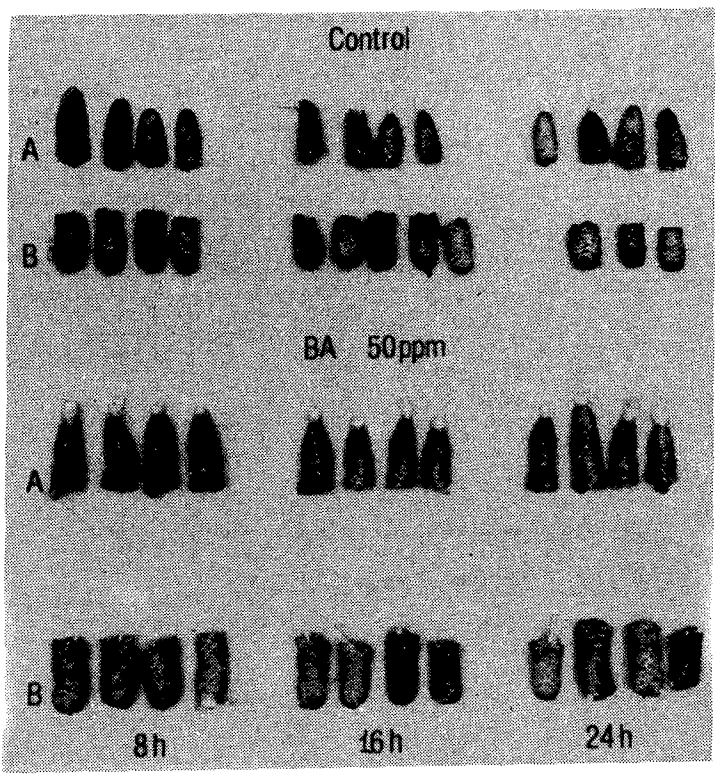

Figure 6 - Sprouting of Achimenes rhizomes cv English Waltz in response to treatment with BA at 50 mg l^{-1} for 8, 16 and 24 h, then kept at 25°C in the dark for 2 weeks. A = apical half, B = basal half.

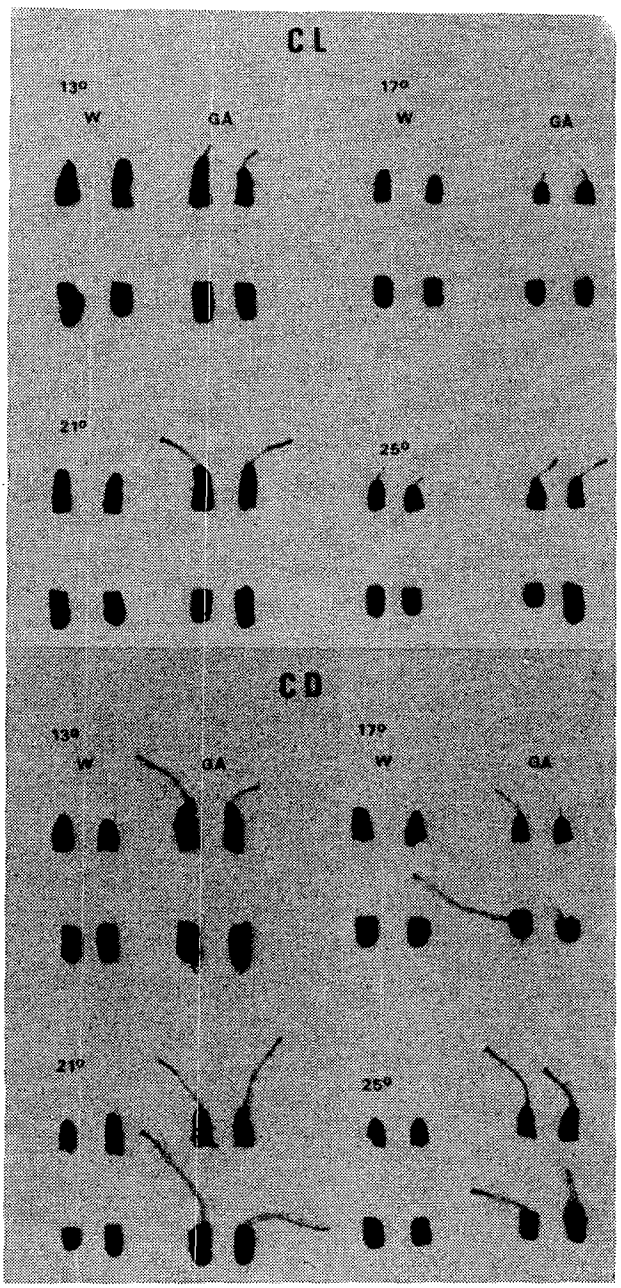

Figure 7 - Sprouting of Achimenes rhizomes cv Viola Michelssen treated with GA_3 at 50 mg l^{-1} for 16 h and then kept either in dark (CD) or in light (CL) at 13, 17, 21 and 25°C for 3 weeks. Controls labeled W (water).

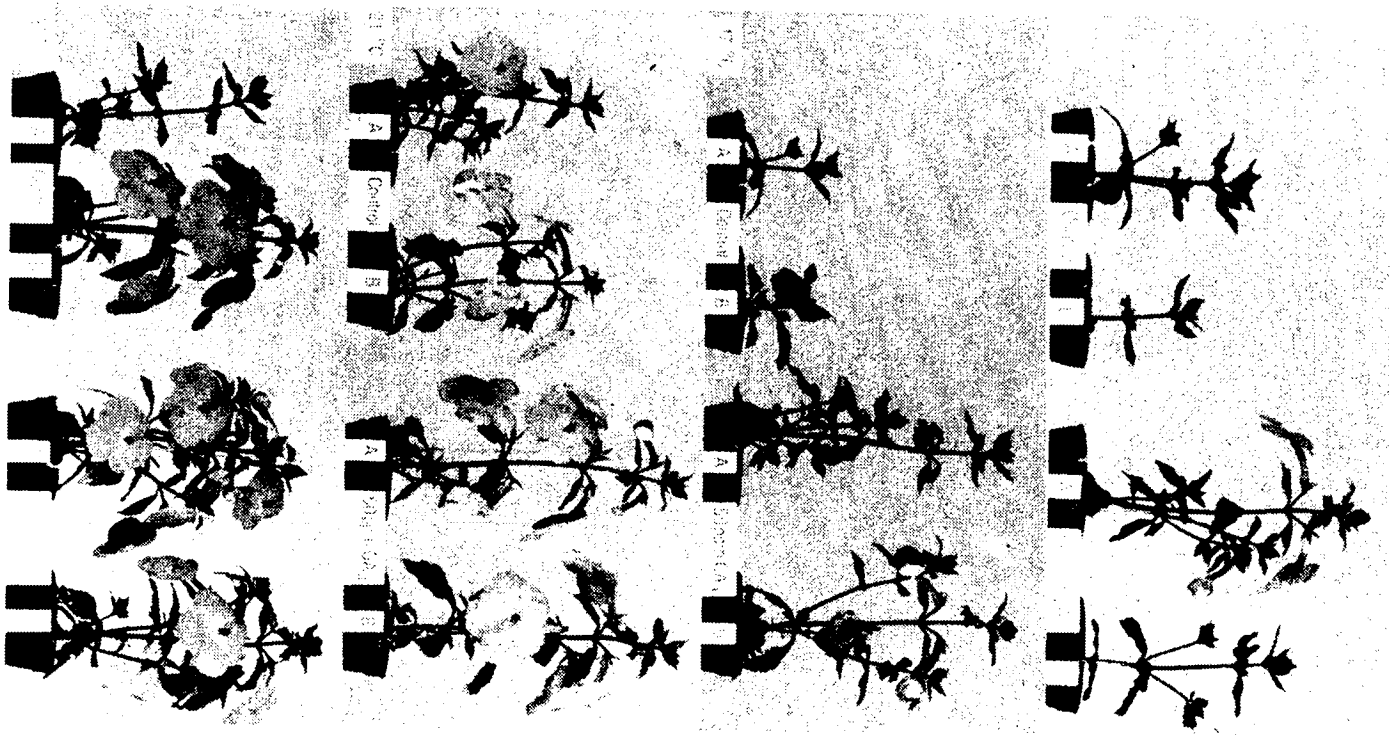

Figure 8 - Growth and flowering of Achimenes cv Viola Michelssen, at 21°C and 16 h light, after pretreatment of rhizomes. Rhizomes were treated with GA_3 at 50 mg l^{-1} for 16 h and then kept in the dark at 13, 17, 21 and 25°C for 3 weeks. They were then kept for another 3 weeks at 21°C in darkness, before planting. Photo taken 10 weeks after planting.