The Influence of Gibberellic Acid on Growth and Flowering of Some Zantedeschia Cultivars Grown Outdoors

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Abstract
The research was carried on rather small tubers (55-60 g) of four Zantedeschia cultivars: ‘Black Magic’, ‘Pink Persuasion’, ‘Cameo’ and ‘Florex Gold’. The aim of the experiment was the evaluation of gibberellic acid (GA₃) treatment, tuber dips in 0, 50 and 100 mg L⁻¹ GA₃ solutions before planting. Plants were grown outdoors, in containers during summer months, from June to October. The GA₃ application generally delayed Zantedeschia flowering, however, the reaction of cultivars were different. The earliest flowering was observed on the cultivar ‘Florex Gold’, 54 days, then ‘Black Magic’ and ‘Pink Persuasion’, 58 days. The latest flowering was ‘Cameo’, after 63 days. As expected GA₃ application increased flower yield in all varieties by 2-3 times. The highest yield was obtained on ‘Florex Gold’ and ‘Pink Persuasion’, 5-6 flowers/tuber. The cultivars ‘Cameo’ and ‘Black Magic’ gave 3-4 flowers/tuber. The GA₃ application did not affect the flower weight. Fresh weight of tubers, lifted after flowering, of cultivars with shorter flowers as ‘Florex Gold’ and ‘Pink Persuasion’ decreased, and increased in cultivars with long, big flowers (‘Black Magic’ and ‘Cameo’).

INTRODUCTION
Colored calla lilies are very attractive plants, grown for cut flowers and pot plants. The prices for tubers are still relatively high and growers are very interested in increasing yield and flower quality. Flower production is not very high and depends on cultivar, storage period, tuber size and growing conditions (Funnell, 1993). To increase flower yield the tubers are usually treated before planting with gibberellins, applied as gibberellic acid, GA₃ or GA₄+₇ and BA – Promalin™ (Corr and Widmer, 1990; Dennis et al., 1994; Funnell et al., 1992; Funnell and Go, 1993). Corr and Widmer (1987) showed that GA₃ treatment increased the total shoot number, flowering shoot number and number of shoots with more than one flower. Response of small tubers to gibberelin treatment depended on gibberellin dose, the concentration of treatment solution and treatment duration (Brooking and Cohen, 2002). However, the response to gibberellins depends on cultivar as well. Preplant tuber treatment with 25 to 500 mg L⁻¹ GA₃ could increase the flower yield by two to five times (Corr and Widmer, 1990; Dennis et al., 1994; Janowska and Krause, 2001; Treder, 2003). However, at higher GA₃ concentration some cultivars showed the symptoms of flower malformation (Dennis et al., 1994; Janowska and Krause, 2001).

To extend the growing season and protect the flowers, calla lilies are usually grown in greenhouses. In summer months plants grown in greenhouses should be protected against excessive temperature and light using screens or nets. Naor and Kigel (2002) showed in phytotron experiments that temperature affects flowering and tuber growth and also influenced flowering in the subsequent growing season. Zantedeschia reacted positively to high light levels (Corr and Widmer, 1990; Funnell, 1993). Funnell et al. (2002a, b) showed on cultivar ‘Best Gold’ that Zantedeschia is a shade tolerant plant, however increasing PPF and temperature increased leaf photosynthesis. Several cultivars of calla lilies grown under reduced PPF had lower yield and longer peduncles (Armitage, 1991). The results obtained on ‘Black Magic’ and ‘Mango’, showed that plants grown outdoors gave higher yield and had shorter peduncles and better flower coloration than greenhouse-grown plants (Treder, 2003).
The aim of the experiment was to evaluate the effect of different concentrations of GA₃ on flowering plant quality and tuber yield of four Zantedeschia cultivars grown outdoors.

MATERIAL AND METHODS
The research was carried out on four calla cultivars: ‘Cameo’, ‘Black Magic’, ‘Florex Gold’ and ‘Pink Persuasion’, grown in outdoor condition, from June till October. Tubers, approximately 50-60 g in weight, 15-18 cm in circumference, obtained from a commercial grower, were planted into containers (6 liters volume) and grown outdoors. Growing medium consisted of peat and sand (8:1 v/v) and was amended with 1 kg m⁻³ of a commercially available fertilizer (13.6 N-2.8 P-15.9 K-2.7 Mg plus microelements) and controlled release fertilizer Osmocote 3-4 M (15:11:13) at 2 kg m⁻³. The pH was adjusted to 6.5 with lime. Before planting tubers with 5 to 10 mm sprouts were immersed into GA₃ solutions (Tomatex Jaworzno, Poland) at 0, 50 and 100 mg L⁻¹ GA₃ for 20 min. After treatment tubers were left to dry for some hours and then planted. Liquid fertilization with complete fertilizer Peters 15:11:29 (Scotts, Poland) at concentration 1 g L⁻¹ and calcium nitrate 0.3 g L⁻¹ started 6 weeks after planting and was continued weekly up to the end of flowering. Plants were grown under plastic shade net to prevent against direct sunlight. During flowering period the following data were collected: number of days from planting to flowering, number of flowers on plant, scape and spathe length, and flower weight. At the end of growing season (in October) tubers were lifted and their fresh weight was determined.

There were 12 plants in each treatment, each plant was treated as a replicate. Statistical analysis was performed using Statistica for Windows and the results were presented graphically with SE between the replicates.

RESULTS AND DISCUSSION
Gibberellin application before planting significantly influenced growth and flowering of all investigated Zantedeschia cultivars. The GA₃ application generally delayed Zantedeschia flowering, but the reaction of cultivars were different (Fig. 1A). The earliest flowering was observed on the cultivar ‘Florex Gold’ – 54 days, then ‘Black Magic’ and ‘Pink Persuasion’ – 58 days. The latest-flowering cultivar was ‘Cameo’, after 63 days. The GA₃ application resulted in delay in flowering compared to control plants. The highest delay in flowering was observed in the late-flowering cultivar ‘Cameo’ – 12 days, then ‘Pink Persuasion’ – 5 days, ‘Black Magic’ – 4 days and ‘Florex Gold’ – 4 days. There were only small differences in flowering time between 50 and 100 mg L⁻¹ GA₃. The delay of calla flowering after GA₃ treatment was also observed by Janowska and Krause (2001) on ‘Pink Persuasion’ and ‘Sensation’ and by Treder (2003) on ‘Black Magic’ and ‘Mango’. However, Funnell et al. (1992) working with ‘Galaxy’ did not observe this delay in flowering. On the contrary, Brooking and Cohen (2002) showed that small tubers of ‘Black Magic’ flowered earlier after gibberellin (GA₃ and GA₄⁺₇) treatment than control plants.

GA₃ application significantly increased flower yield (Fig. 1B). The highest yield was obtained when GA₃ was applied at 100 mg L⁻¹. ‘Florex Gold’ and ‘Pink Persuasion’ gave 5-6 flowers/tuber and ‘Cameo’ and ‘Black Magic’ gave 3-4 flowers/tuber. In the case of ‘Pink Persuasion’ and ‘Black Magic’ the differences in yield between 50 and 100 mg L⁻¹ GA₃ were not significant. The yield after GA₃ treatment was 1.6, 1.7, 2.4 and 2.8 times higher than on control plants in ‘Black Magic’, ‘Florex Gold’, ‘Pink Persuasion’ and ‘Cameo’, respectively. These data confirm previous observations on Zantedeschia (Corr and Widmer, 1987, 1990; Dennis et al., 1994; Janowska and Krause, 2001).

The length of flower peduncles was increased by 4 to 10 cm after tuber treatment with 50 mg L⁻¹ GA₃ in case of ‘Cameo’, ‘Pink Persuasion’ and ‘Black Magic’ (Fig. 2A). ‘Cameo’ had the longest peduncles – 84 cm, then ‘Black Magic’ – 77 cm and ‘Pink Persuasion’ – 69 cm. Increased peduncle length after GA₃ treatment was also observed by Dennis et al. (1994) and Janowska and Krause (2001). ‘Florex Gold’ had the shortest...
peduncles, around 63 cm, and their length was not affected by gibberellin treatment. Gibberellin increased spathe length in ‘Pink Persuasion’ but decreased it in ‘Black Magic’ (Fig. 2B) and had no influence in ‘Cameo’ and ‘Florex Gold’.

For all cultivars, GA3 application had no effect on flower weight (Fig. 3A). The average fresh weight of flowers was 72, 57, 38 and 23 g in ‘Cameo’, ‘Black Magic’, ‘Pink Persuasion’ and ‘Florex Gold’, respectively. There was no effect of GA3 application on flower malformation during the experiment (data not presented).

Tuber weight increased at the end of experiment an average of 5 to 3 times compared with initial weight in the long stemmed cultivars ‘Black Magic’ and ‘Cameo’ and short stemmed cultivars ‘Pink Persuasion’ and ‘Florex Gold’, respectively. Corr and Widmer (1987) reported that GA3 treatment that promoted floral performance also reduced tuber growth. In the present study it was observed that GA3 application reduced tuber growth in the case of short cultivars as ‘Pink Persuasion’ and ‘Florex Gold’ but increased it with long stemmed cultivars (Fig. 3B). One of possible explanations is that short flowered cultivars had greater flower yields and the growing flowers acted as a sink for assimilates and nutrients. As in the case with other geophytes there is a competition between developing flowers and storage organs to attract the assimilates. Dennis et al. (1994) did not observe the influence of GA3 treatment on tuber size after flowering.

Growing *Zantedeschia* during summer months outdoors seems to be a very good method to obtain high flower yield, good tuber growth and excellent flower quality expressed as sturdy stems and good flower color.

ACKNOWLEDGEMENTS

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Literature Cited


Figures

Fig. 1. The influence of GA₃ treatments on number of days to flower (A) and flower yield (B).
Fig. 2. The influence of GA₃ treatments on scape (A) and spathe (B) length.

Fig. 3. The influence of GA₃ treatments on flower (A) and tuber (B) weight.