Effect of growth regulators on flower and leaf yield of the calla lily (*Zantedeschia* Spreng.)

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Abstract

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To assess the effect of a mixture of benzyladenine and gibberellic acid on the quality and yield of flowers and leaves of cvs Albomaculata, Black Magic and Mango, their tubers were soaked before planting for 30 min in a water solution with 100–600 ppm BA and 150 ppm GA_3. The BA + GA_3 mixture application resulted in 2.5–3.5 times as many flowers in comparison to the control plants, which did not affect the quality of flowers and the yield of leaves. The leaves, however, showed higher greenness index and protein quantity.

Keywords: ornamental plants; benzyladenine; gibberellic acid; protein; index of leaves greenness

To promote the increase in flower yield, it is necessary to apply growth regulators to the calla lily cultivars of colourful spathe. In the light of the research done, gibberellic acid is proved to be an effective (Funnell, Tjia 1988; Corr, Widmer 1991; Funnell et al. 1992; Denis et al. 1994; Janowska, Krause 2001; Janowska, Schroeter 2002; Janowska, Zakrzewski 2006). Nonetheless, the increase in the yield depends on the cultivar and there are more than 120 recognized cultivars. Ready-made preparations of growth regulators are commonly in use in floriculture in Western Europe. Promalin (100 ppm GA_{4+7} + 100 ppm BA) belongs to the group (Ranwala, Miller 1998; Rodriquez-Pérez et al. 2009). Promalin is not only expensive as the synthesis of GA_{4+7} is costly but it is also not authorised in Poland. Hence, a study was focused on the effect of a mixture of BA + GA_3 on the yield and quality of flowers and leaves of three calla lily cultivars with colourful spathes.

MATERIAL AND METHODS

Research was conducted in the years 2008–2010. The cultivars used in the study were as follows: Albomaculata derived from *Zantedeschia albomaculata* /Hook./ Baill., Black Magic coming from interspecies hybrid of *Zantedeschia elliottiana* /Wats./ Engl. × *Z. macrocarpa* Engl. and Mango derived from *Zantedeschia* sp.

Tubers, that were bought in the Netherlands, 15–18 cm in circumference in cvs Black Magic and Mango and 20+ cm in Albomaculata were planted into 18-cm pots on 10 May 2008, 12 May 2009 and 15 May 2010 into a medium peat with a pH of 6.2, enriched with a slow-release fertiliser Osmocote Plus (3–4M) in the amount of 3 g/dm^3 and mixed with fresh, shredded pine bark at a rate of 3:1 (v:v). Before planting, the rhizomes were soaked for 30 min in water solutions of benzyladenine (BA) at concentrations of 0, 100, 350 and 600 ppm mixed

with gibberellic acid (GA_3) at a concentration of 150 ppm.

The experiment consisted of 12 treatments (BA concentration × cultivar). In each year of the study, one combination consists of 15 plants, five plants in three replications.

The plants, grown in a plastic tunnel, were fertilized starting in the fifth week of cultivation solutions of mixed fertilisers, Peters Professional and brown Superba at a concentration of 0.2%. At the beginning of vegetation indicated by full development of the foliage, lime saltpetre at a concentration of 0.2% was foliarily applied once.

The length of peduncles and spathes was measured. The yield of flowers developing from a single tuber and the fresh flower weight were determined. In calla lily a flower is a stipulated term, conventionally simplified to an inflorescence embedded on a peduncle called a spadix which is surrounded by a spathe.

The yield of leaves growing from a single tuber was calculated as well as their greenness index, in SPAD units, employing a SPAD-502 Chlorophyll Meter (Gregorczyk, Raczyńska 1997; Gregorczyk et al. 1998). In addition, protein content in the leaves was quantified applying Bradford's method (Bradford 1976). Two ml of the solution of Coomassie Brillant Blue G-250 (CBB) in 85% orthophosphoric acid was added to 100 µl of a diluted extract, with the extraction in a phosphorate-potassium buffer (pH 7.0). After 10 min the absorbance of light was measured at a wavelength of 595 nm. Protein content was determined form a curve plotted for albumin.

The data, given as means from the three years of research, were processed applying a two-factor analysis of variance. The means were grouped employing the Duncan's test at the $\alpha = 0.05$ significance level.

RESULTS

The flower yield in the cultivars depended significantly on both, the concentration of the growth regulators and the cultivar (Table 1). The least number of flowers, irrespective of the BA + GA_3 concentration, was harvested from the tubers of cvs Black Magic and Mango. Cv. Albomaculata was marked by the best flower production giving 6.2 flowers per tuber on average. The result was not attributed to any specific BA + GA_3 concentration. Irrespective of the cultivar, the examined concentrations of the growth regulators had a similar effect on the intensity of flowering of the three cultivars, with 2.5–3.5 times as many of flowers per rhizome comparing to the control plants. When comparing interactions, it was found that in cv. Black Magic all the concentrations of the growth regulators employed improved its flowering in a similar way, in cv. Mango significantly the highest flower yield was obtained when benzyladenine in the mixture had a concentration of 600 ppm, and in cv. Albomaculata – 100 and 600 ppm.

The quality of flowers depended significantly only on the cultivar (Table 1). The smallest spathes and the lowest weight of flowers were attributed to the tubers of cv. Albomaculata. Nonetheless, the length of peduncles in this cultivar was similar comparing to cvs Black Magic and Mango.

When analysing the leaf yield, it was found to depend significantly only on the cultivar. Albomaculata was the cultivar with the most abundant leaves (Table 2).

The leaf greenness index depended significantly on both, the cultivar and the concentration of the growth regulators (Table 2). Irrespective of the BA + GA_3 concentration, the lowest greenness index characterized cv. Albomaculata, whereas the highest – cv. Mango. The concentrations of the growth regulators applied stimulated the development of leaves with a significantly higher greenness index. When comparing interactions, it was found that in cvs Black Magic and Mango leaves with the highest greenness index grew from tubers soaked in a solution in which gibberellic acid was mixed with benzyladenine at a concentration of 600 ppm.

The protein content in leaves was proved to depend significantly only on the BA + GA_3 concentration (Table 2). Irrespective of the cultivar, the application of a mixture of BA + GA_3 increased the protein content.

DISCUSSION

The flowering of calla lily cultivars with colourful spathes depended on the cultivar and the size of tubers, therefore healthy and large tubers were chosen to research. Planting even large tubers does not ensure a high flower yield, as proved by the current research of cvs Black Magic, Mango and Albomaculata in which merely 0.8 to 1.9 flowers per tuber were obtained from the control. What the experiment proved, however, was that a mixture of BA + GA_3 affected positively the flowering of the cultivars involved. It is worth marking that similar results were received in next years. The results obtained corroborate those of

Table 1. Yield and quality of flowers of *Zantedeschia* depending on concentration of growth regulators and cultivar

Concentration of BA + GA_3 (ppm)	Cultivar			Mean
	Black Magic	Mango	Albomaculata	
Yield of flowers				
0 + 0	0.8	1.9	1.9	1.5
100 + 150	2.7	2.9	9.3	5.0
350 + 150	3.1	3.1	5.8	4.0
600 + 150	2.7	4.0	8.1	4.9
$LSD_{D, 0.05}$ for interaction		0.78		
Mean	2.3	2.9	6.2	
$LSD_{D, 0.05}$ for means		2.73		1.19
Length of inflorescence peduncle (cm)				
0 + 0	24.6	26.3	32.9	27.9
100 + 150	24.0	23.1	26.7	24.6
350 + 150	25.0	24.1	24.1	24.4
600 + 150	29.8	24.1	29.1	27.7
$LSD_{D, 0.05}$ for interaction		6.78		
Mean	25.9	24.4	28.2	
$LSD_{D, 0.05}$ for means		–		–
Length of spathe (cm)				
0 + 0	9.3	9.8	8.6	9.2
100 + 150	9.7	9.5	8.8	9.3
350 + 150	10.1	9.4	8.9	9.3
600 + 150	10.5	9.0	7.8	9.1
$LSD_{N-K, 0.05}$ for interaction		0.28		
Mean	9.9	9.4	8.5	
$LSD_{D, 0.05}$ for means		1.54		–
Weight of flower (g)				
0 + 0	14.9	16.5	10.9	14.1
100 + 150	13.6	14.3	8.7	12.2
350 + 150	15.4	14.7	7.9	12.7
600 + 150	16.9	15.6	7.9	13
$LSD_{D, 0.05}$ for interaction		2.18		
Mean	15.2	15.2	8.8	
$LSD_{D, 0.05}$ for means		5.88		–

Funnell et al. (1992), who had achieved a substantial increase in the flower yield of cv. Galaxy on application of Promalin. According to the research conducted by Ngamau (2001), an increase in the flower yield is also possible to obtain in *Zantedeschia aethiopica* on application of a mixture of BA + GA_3.

The quality flowers, assessed in the experiment in terms of the length of peduncles and spathes and the weight of flowers, was not affected by the growth regulators at the concentrations studied. The results do not show any influence of the growth regulators at the concentrations analysed. Benzyladenine is likely to react as an anty-gibberellic acid. The results of the little research done in the world indicate the differentiation of the effect of the growth regulators mentioned on different ornamental species. Ngamau (2001) achieved slightly longer peduncles at application of BA + GA_3 to *Zantedeschia aethiopica* cv. Green Goddess, while Suh (1997) obtained shorter flower stems at application of Promalin to tulips.

Table 2. Yield and quality of leaves of *Zantedeschia* depending on concentration of growth regulators and cultivar

Concentration of BA + GA_3 (ppm)	Cultivar			Mean
	Black Magic	Mango	Albomaculata	
Yield of leaves				
0 + 0	5.8	4.2	22.8	10.9
100 + 150	6.0	3.8	23.5	11.1
350 + 150	5.3	3.9	21.5	10.2
600 + 150	4.8	3.6	20.7	9.7
$LSD_{D, 0.05}$ for interaction		5.75		
Mean	5.5	3.9	22.1	
$LSD_{D, 0.05}$ for means		1.97		–
Index of leaf greenness (SPAD)				
0 + 0	53.2	55.1	48.0	52.1
100 + 150	57.1	61.7	56.6	58.5
350 + 150	56.8	63.3	55.9	58.7
600 + 150	59.5	70.1	54.9	61.5
$LSD_{D, 0.05}$ for interaction		2.33		
Mean	56.6	62.5	53.8	
$LSD_{D, 0.05}$ for means		2.47		2.21
Protein content (mg/g FW)				
0 + 0	15.2	15.4	14.4	15.0
100 + 150	25.3	22.2	24.1	23.9
350 + 150	31.5	19.8	30.5	30.6
600 + 150	40.0	41.0	39.2	40.1
$LSD_{D, 0.05}$ for interaction		4.49		
Mean	28.0	27.1	27.2	
$LSD_{D, 0.05}$ for means		–		5.12

In the present research the growth regulators did not affect the yield of leaves, but they represented a higher greenness index and a higher protein content. The available literature does not offer a response to the question of how a mixture of BA + GA_3 influences the yield and quality of leaves in ornamental plants. What is acknowledged, however, is that in calla lily cultivars with colourful spathes gibberellic acid does not have effect on the leaf yield (Jerzy, Janowska 2003; Janowska, Zakrzewski 2006). On the other hand, Janowska (2010) reports that in cv. Pink Pimpernel benzyladenine stimulates the development of leaves while it inhibits it in cv. Mango. Additionally, both benzyladenine and gibberellic acid boost the index of leaf greenness (Janowska, Zakrzewski 2006; Janowska 2010).

Not only do proteins regulate life processes of plants but they are also a part of building components of cells and tissues. They are responsible for the majority of biochemical reactions in living organisms. The higher level of proteins after BA + GA_3 treatment corresponded with the expectations and proved the results of the studies on florists' green (Rabiza-Świder et al 2004; Rabiza-Świder, Skutnik 2008; Janowska et al. 2012).

CONCLUSIONS

In conclusions, after the tubers of cvs Black Magic, Mango and Albomaculata were dipped in a water solution with 100–600 ppm BA and 150 ppm GA_3, 2.5 to 3.5 more flowers were harvested from them than from those of control plants. It did not affect the quality of flowers, the yield of leaves, but the leaves represented a higher greenness index and a higher protein content.

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