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EFFECT OF BENZYLADENINE ON THE ABUNDANCE AND QUALITY OF THE LEAF YIELD IN THE CALLA LILY (*ZANTEDESCHIA* SPRENG.)

WPŁYW BENZYLOADENINY NA WIELKOŚĆ I JAKOŚĆ PLONU LIŚCI CANTEDESKII (*ZANTEDESCHIA* SPRENG.)

Summary. The soaking of rhizomes, 15-18 cm in circumference in the cultivars 'Black Magic' and 'Mango' and 20+ cm in cultivar 'Albomaculata', with leaf buds 0.5-2 cm in length, in solutions of benzyladenine at concentrations of 100, 350 and 600 mg·dm^{-3} lasted 30 and 60 min. After this practice, lightly dried rhizomes were planted into 20-cm pots. BA at concentrations of 100--600 mg·dm^{-3} reduces the yield of leaves in cultivar 'Mango', and at concentrations of 350-600 mg·dm^{-3} – in cultivar 'Albomaculata'. Leaves growing from rhizomes soaked in BA at concentrations of 100-600 mg·dm^{-3} have a higher greenness index and a higher protein and sugar content.

Key words: ornamental plants, leaves, yield, quality, growth regulators

Introduction

Florists' greens have become an indispensable element of special-occasion bouquets today. It is a very broad category which embraces leaves, leafy stems, and phylloclades that provide a background to, or fill in, floral arrangements. In Poland, the first additions to bouquets were the phylloclades *Asparagus densiflorus* and *A. setaceus.* They have been produced until today, their assortment having expanded to include *A. falcatus* and cultivars of *A. densiflorus* (SKUTNIK et AL. 2006). Also leaves of monsteras, philodendrons, fatsias, eucalyptuses and plantain lilies have recently started to feature prominently in floral arrangements (RABIZA-ŚWIDER and SKUTNIK 2008). New plant species keep appearing on the florist market as a result of the never-ending search for novelties. In the calla lily with colourful spathes, the leaf blades are lanceolate or narrowly to

broadly sagittate, medium- to dark-green, and covered or not with white, transparent spots (JANOWSKA 2006). They could be a valuable addition to bouquets obtained from plantations of those plants grown for cut flowers. In the calla lily, the yield of leaves depends on the cultivar. In the present article, an assessment is made of the effect of benzyladenine on the yield and quality of leaves of three calla lily cultivars with colourful spathes.

Material and methods

The research was conducted in the Department of Ornamental Plants of the Poznań University of Life Sciences from 12 May to 4 November 2007 and from 18 April to 30 October 2011. The cultivars employed were 'Albomaculata' deriving from *Zantedeschia albomaculata* (Hook.) Baill., 'Black Magic' coming from an inter-species hybrid of *Z. elliottiana* (Wats.) Engl. × *Z. macrocarpa* Engl., and 'Mango' deriving from *Zantedeschia* sp. The plants were grown in a plastic tunnel. Before planting, rhizomes of those cultivars were soaked in benzyladenine.

The soaking of rhizomes, 15-18 cm in circumference in the cultivars 'Black Magic' and 'Mango' and 20+ cm in cultivar 'Albomaculata', with leaf buds 0.5-2 cm in length, in solutions of benzyladenine at concentrations of 100, 350 and 600 mg·dm^{-3} lasted 30 and 60 min. After this practice, lightly dried rhizomes were planted into 20-cm pots into a medium consisting of peat with a pH of 6.2, enriched with a slow-release fertilizer 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). The plants, grown in a plastic tunnel, were fed starting with WRiL, Poznań: 33-43.
of benzyladenine and gibberellic acid on the growth and flowering of Anemone ce start vegetation, when the leaves were fully developed, lime saltpetre at a concentration of 0.2% was foliar applied once. One treatment (BA concentration × soaking time) involved five plants in three replications.

The yield of leaves developing from a single rhizome was determined as well as their greenness index, in SPAD units, using a SPAD-502 Chlorophyll Meter (GREGORCZYK and RACZYŃSKA 1997, GREGORCZYK et AL. 1998). In addition, protein and sugar content in the leaves was calculated.

The determination of protein content was made with the help of BRADFORD's (1976) method. 2 ml of a solution of Coomassie Brilliant 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 absorbance was measured at a wavelength of 595 nm. Protein content was determined from a curve plotted for albumin.

Total saccharides were determined using the antron reagent (BJÖRNESJÖ 1955). The method consists in the fact that under the influence of sulphuric acid, all saccharides transform into derivatives of furfural, which, together with antron, yield blue-green products. The intensity of the colour is proportional to their content. Weighted portions (0.5 g) were crushed in a mortar with 5 cm^3 of distilled water and the homogenate was centrifuged for 20 min. 1 cm^3 of the supernatant thus obtained was added to 2 cm^3 of a cooled antron reagent (0.02% in concentrated H_2SO_4), and then the content of the test tubes was heated, slowly mixed, on a water bath at 90°C for 14 min. After the tubes

were cooled, the absorbance of the solutions was measured in a spectrophotometer at a wavelength of 620 nm. The content of saccharides was read from a standard curve prepared for glucose. The final results, which were means of four replications, were expressed in milligrams of glucose per 1 g of fresh weight.

The results, given as means from the two years of study, were processed with the help of a two-factor analysis of variance. The means were grouped using Duncan's test at the $\alpha = 0.05$ significance level.

Results

It was found that, with the exception of cultivar 'Black Magic', the yield of leaves depended significantly only on the concentration of benzyladenine (Table 1). Irrespec-

Table 1. Yield of leaves of calla lily depending on concentration of benzyladenine and time of rhizomes soaking (number of leaves from 1 rhizome)
Tabela 1. Plon liści cantedeskii w zależności od stężenia benzyloadeniny i czasu moczenia kłączy (liczba liści z 1 kłącza)

Concentration of BA Stężenie BA ($mg \cdot dm^{-3}$)	Time of rhizomes soaking Czas moczenia kłączy		Mean Średnia
	30 min	60 min	
'Black Magic'			
0	9.0 a	9.0 a	9.0 a
100	9.0 a	8.0 a	8.5 a
350	9.6 a	10.2 a	9.9 a
600	8.8 a	10.1 a	9.4 a
Mean – Średnia	9.1 a	9.3 a	
'Mango'			
0	12.0 b	12.0 b	12.0 b
100	10.9 a	10.3 a	10.6 a
350	10.0 a	10.0 a	10.0 a
600	10.4 a	9.6 a	10.0 a
Mean – Średnia	10.8 a	10.5 a	
'Albomaculata'			
0	28.5 b	28.5 b	28.5 b
100	30.1 b	29.7 b	29.9 b
350	20.5 a	20.7 a	20.6 a
600	20.4 a	10.9 a	20.1 a
Mean – Średnia	24.9 a	24.1 a	

Means followed by the same letter do not differ significantly at the level of $\alpha = 0.05$.
Średnie oznaczone tą samą literą nie różnią się istotnie na poziomie $\alpha = 0,05$.

tive of the duration of rhizome soaking, in cultivar 'Mango' benzyladenine at the concentrations studied inhibited the formation of leaves, while in cultivar 'Albomaculata' the same result was observed when benzyladenine applied to rhizome soaking was at concentrations of 350 and 600 mg·dm^{-3}.

When comparing the index of leaf greenness, it was found that it depended significantly on BA concentration only (Table 2). Irrespective of the duration of rhizome soaking, the application of BA at concentrations of 100-600 mg·dm^{-3} caused the cultivars under study to develop leaves with a higher greenness index.

Table 2. Index of leaf greenness (SPAD) of calla lily depending on concentration of benzyladenine and time of rhizomes soaking
Tabela 2. Indeks zazielenienia liści (SPAD) cantedeskii w zależności od stężenia benzyloadeniny i czasu moczenia kłączy

Concentration of BA Stężenie BA (mg·dm^{-3})	Time of rhizomes soaking Czas moczenia kłączy		Mean Średnia
	30 min	60 min	
'Black Magic'			
0	46.8 a	46.8 a	46.8 a
100	61.0 b	60.8 b	60.9 b
350	59.0 b	58.6 b	58.8 b
600	57.4 b	56.6 b	57.0 b
Mean – Średnia	56.0 a	55.7 a	
'Mango'			
0	51.4 a	51.4 a	51.4 a
100	66.4 c	66.4 c	66.4 c
350	58.8 b	61.7 bc	60.2 b
600	65.6 c	70.3 d	67.9 c
Mean – Średnia	60.6 a	62.4 a	
'Albomaculata'			
0	45.3 a	45.3 a	45.3 a
100	56.4 c	59.9 d	58.1 d
350	50.5 b	50.6 b	50.6 b
600	57.1 c	54.3 c	55.7 c
Mean – Średnia	52.3 a	52.5 a	

Means followed by the same letter do not differ significantly at the level of $\alpha = 0.05$.
Średnie oznaczone tą samą literą nie różnią się istotnie na poziomie $\alpha = 0,05$.

It was shown that protein content in the leaves of cultivar 'Mango' depended significantly on both, the duration of rhizome soaking and the concentration of benzyladenine, while in the cultivars 'Black Magic' and 'Albomaculata' this feature only depended on BA concentration (Table 3). Irrespective of the duration of rhizome soaking, in all the cultivars the application of BA at 100-600 mg·dm^{-3} boosted protein content in the leaves. In cultivar 'Mango' protein content in the leaves was significantly higher when rhizomes underwent a prolonged soaking in a solution of this cytokinin irrespective of its concentration.

Table 3. Protein content in leaves of calla lily depending on concentration of benzyladenine and time of rhizomes soaking (mg·g^{-1} f.w.)
Tabela 3. Zawartość białka w liściach cantedeskii w zależności od stężenia benzyloadeniny i czasu moczenia kłączy (mg·g^{-1} ś.m.)

Concentration of BA Stężenie BA (mg·dm^{-3})	Time of rhizomes soaking Czas moczenia kłączy		Mean Średnia
	30 min	60 min	
'Black Magic'			
0	18.2 a	18.2 a	18.2 a
100	22.8 b	31.4 c	27.1 b
350	22.0 c	33.0 c	27.5 b
600	21.3 b	34.5 c	28.3 b
Mean – Średnia	21.1 a	29.3 a	
'Mango'			
0	14.2 a	14.2 a	14.2 a
100	20.3 b	22.5 b	21.4 b
350	18.2 b	27.8 c	23.0 b
600	18.7 b	32.7 d	25.7 bc
Mean – Średnia	17.8 a	24.3 b	
'Albomaculata'			
0	14.2 a	14.2 a	14.2 a
100	18.9 b	17.9 b	18.4 b
350	18.6 b	19.1 b	18.8 b
600	19.2 b	18.7 b	18.9 b
Mean – Średnia	17.7 a	17.5 a	

Means followed by the same letter do not differ significantly at the level of $\alpha = 0.05$.
Średnie oznaczone tą samą literą nie różnią się istotnie na poziomie $\alpha = 0,05$.

When comparing sugars content in the leaves, in the cultivars 'Black Magic' and 'Albomaculata' this feature was found to depend significantly only on the concentration of benzyladenine, while in cultivar 'Mango' on both, BA concentration and the duration of rhizome soaking (Table 4). Irrespective of rhizome soaking time, in all the cultivars a significantly higher sugar content was noted after the application of benzyladenine at concentrations of 100-600 mg·dm^{-3}. In cultivar 'Mango', irrespective of BA concentration, sugar content was found to be significantly higher in leaves growing from rhizomes soaked in its solutions for 60 min.

Table 4. Sugars content in leaves of calla lily depending on concentration of benzyladenine and time of rhizomes soaking (mg·g^{-1} f.w.)
Tabela 4. Zawartość cukrów w liściach cantedeskii w zależności od stężenia benzyloadeniny i czasu moczenia kłączy (mg·g^{-1} ś.m.)

Concentration of BA Stężenie BA (mg·dm^{-3})	Time of rhizomes soaking Czas moczenia kłączy		Mean Średnia
	30 min	60 min	
'Black Magic'			
0	12.3 a	12.3 a	12.3 a
100	25.9 b	24.1 b	25.0 b
350	26.6 b	25.4 b	26.0 b
600	28.5 b	26.5 b	27.5 b
Mean – Średnia	23.3 a	22.1 a	
'Mango'			
0	16.5 a	16.5 a	16.5 a
100	22.1 b	29.5 c	25.8 b
350	25.7 b	31.3 cd	28.5 b
600	28.5 c	33.8 d	31.5 c
Mean – Średnia	23.2 a	27.8 b	
'Albomaculata'			
0	10.9 a	10.9 a	10.9 a
100	19.6 b	18.2 b	18.9 b
350	21.6 b	19.1 b	20.3 b
600	17.8 b	18.4 b	20.3 b
Mean – Średnia	17.5 a	16.6 a	

Means followed by the same letter do not differ significantly at the level of $\alpha = 0.05$.
Średnie oznaczone tą samą literą nie różnią się istotnie na poziomie $\alpha = 0,05$.

Janowska B., Stanecki M., 2013. Effect of benzyladenine on the abundance and quality of the leaf yield in the calla lily (*Zantedeschia* Spreng.). Nauka Przyr. Technol. 7, 1, #6.

Discussion

In the present research, an assessment was made of the effect of benzyladenine on the yield and quality of leaves of calla lily cultivars with colourful spathes. It was found that at concentrations of 100-600 mg·dm^{-3} in cultivar 'Mango' and 350-600 mg·dm^{-3} in cultivar 'Albomaculata' benzyladenine reduced the yield of leaves. From the practical point of view, this is an undesirable development because calla lilies with colourful spathes provide not only beautiful flowers for special-occasion bouquets, but are also a valuable source of florists' greens, indispensable in modern floral arrangements. The few studies of the effect of benzyladenine on the development of leaves in ornamental plants published so far indicate that the response largely depends on the species. In the research by JANOWSKA et AL. (2009), as in the one reported here, the application of benzyladenine inhibited the growth of leaves in *Anemone coronaria* 'Sylphide'. In comparison with the control, the number of leaves developing from tubers soaked in benzyladenine only amounted to one-third or one-fourth. Besides, after the application of benzyladenine the leaves growing from tubers had shorter petioles and blades. Similarly in *Syngonium*, benzyladenine not only inhibited the growth of leaves, but also halved their number (WANG and BOOGHER 1987). However, MARCINEK and HETMAN (2006) did not observe this in *Hedera helix* 'Brokamp'. Those authors obtained the poorest-leaved plants after the application of benzyladenine at a concentration of 8 mg·dm^{-3}, but the difference was not statistically significant. In turn, at concentrations of 750 and 1000 mg·dm^{-3}, benzyladenine had a good effect on the number of leaves in *Spathiphyllum* 'Petite' (POGROSZEWSKA 2002).

Benzyladenine had a good effect on the quality of leaves in the calla lily cultivars studied. When it was added at concentrations of 100-600 mg·dm^{-3} to the rhizome soaking solution, the leaves that developed from them had a higher greenness index and a higher protein and sugar content, with the highest level of saccharides in cultivar 'Mango' recorded in the leaves growing from rhizomes soaked for 60 min. Owing to the higher index of leaf greenness, they had a more intensive green colour. This can suggest a connection with a higher chlorophyll content. There is little information in the available literature about the effect of cytokinins on the content of chlorophyll in the leaves of ornamental plants cultivated under cover. What is known is that benzyladenine inhibits chlorophyll degradation in inflorescences of broccoli (CLARKE et AL. 1994, DOWNS et AL. 1997) and leaves of brussels sprouts (ZINK 1961), and lets olive fruits keep their green colour longer (TSANTILI et AL. 2002).

Proteins are an important component of plant cells. They regulate their life processes and are a part of the material building cell structures and tissues. They are responsible for most of the biochemical reactions in living organisms. An elevated protein content obtained in calla lily leaves on application of benzyladenine accorded with expectations and corroborated earlier studies of useful plants (KLÄMBT 1976, TAGEKAMI and YOSHIBA 1997, PRUSIŃSKI and BORKOWSKA 2002).

The saccharides produced in the process of photosynthesis are the chief building and reserve material of plant organisms. Intensive photosynthesis favours the accumulation of greater amounts of carbohydrates. There is only scant information in the available literature about changes in the content of saccharides in ornamental plants after the application of growth regulators. KOZŁOWSKA et AL. (2007) report changes in sugar

content in the leaves of *Z. elliottiana* after the application of gibberellic acid for rhizome soaking depending on the development stage. In their study, at the initial stage of vegetative growth, the content of hydrocarbons, especially fructose and glucose, in the leaf blades of plants treated with gibberellic acid was higher than in the control. The content rose as the leaves developed, to decline when the plants entered the generative stage, while the total hydrocarbon content in the leaves of control plants was then twice as high. Changes in sugar content in cut leaves of *Z. aethiopica* and *Z. elliottiana* have been examined by SKUTNIK et AL. (2004). Initially, the content of reducing sugars kept increasing as ageing advanced, then dropped to 60-80% of the initial figure. Conditioning of leaves in a solution of benzyladenine did not stop this process. What turned out to be effective was gibberellic acid, which retarded the degradation of saccharides in the leaves of *Z. aethiopica* and *Z. elliottiana* and boosted their content in them. DOWNS et AL. (1997) report a favourable effect of benzyladenine on sugar content in the inflorescences of broccoli because it inhibited their degradation that starts at the moment of harvesting. In turn, SMOLEŃ and SADY (2009) proved benzyladenine to have a favourable effect on sugar content in the fleshy part of the radish taproot.

Conclusions

1. BA at concentrations of 100-600 mg·dm^{-3} reduces the yield of leaves in cultivar 'Mango', and at concentrations of 350-600 mg·dm^{-3} – in cultivar 'Albomaculata'.
2. Leaves growing from rhizomes soaked in BA at concentrations of 100-600 mg·dm^{-3} have a higher greenness index and a higher protein and sugar content.

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WPŁYW BENZYLOADENINY NA WIELKOŚĆ I JAKOŚĆ PLONU LIŚCI CANTEDESKII (*ZANTEDESCHIA* SPRENG.)

Streszczenie. Moczenie kłączy o obwodzie 15-18 cm u odmian 'Black Magic' i 'Mango' oraz o obwodzie powyżej 20 cm u odmiany 'Albomaculata' z pąkami liściowymi o długości 0,5-2 cm, w roztworze benzyloadeniny o stężeniu 100, 350 i 600 $mg \cdot dm^{-3}$ trwało 30 i 60 min. Po tym zabiegu lekko podsuszone kłącza sadzono do doniczek o średnicy 20 cm. BA o stężeniu 100-600 $mg \cdot dm^{-3}$ ograniczało plon liści odmiany 'Mango', a o stężeniu 350-600 $mg \cdot dm^{-3}$ – odmiany 'Albomaculata'. Liście wyrastające z kłączy moczonych w BA o stężeniu 100-600 $mg \cdot dm^{-3}$ mają większą wartość indeksu zazielenienia oraz większą zawartość białka i cukrów.

Słowa kluczowe: rośliny ozdobne, liście, plon, jakość, regulatory wzrostu

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