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MORPHOLOGICAL TRAITS, DECORATIVE VALUE AND YIELD OF CORMS OF FREESIA (*Freesia* Eckl. ex Klatt) DEPENDING ON THE APPLIED CHITOSAN

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ABSTRACT

In terms of turnover value on the global wholesale flower markets, freesia has been for many years in the top ten of cut flowers. Achieving high quality inflorescences in a cultivation center without cooling the substrate is a huge challenge for the producers. The study was conducted in the years 2010–2012, during the summer-autumn season in an unheated foil tunnel. The material consisted of prepared daughter corms of 'Summer Beach' variety. Chitosan of 8 000 g·dm^{-3} molecular weight was used in the research. Chitosan application methods (watering or spraying), its concentration (0.0; 0.2 or 0.4%), and application frequency (every 7 or 14 days) were compared experimentally. During the experiment, the number of days from the beginning of sprouting until the end of flowering was determined, and the vegetative and generative organs were evaluated. The yield of daughter corms was assessed after the end of the cultivation. High temperatures prevalent in the time of generative organ formation prolonged the flowering period of 'Summer Beach' freesia but the inflorescences were typical and characteristic of the variety. The effect of chitosan depended also on the temperature during the cultivation. Irrespective of chitosan application method, its concentration and frequency of treatment, its presence delayed freesia heading at higher temperatures and accelerated the process at lower temperatures. Chitosan caused an increase in freesia height, number of generated shoots and leaves and leaf greenness index. It positively affected the quality of the resulting inflorescences. However, this effect was concentration and application dependent. Moreover, chitosan increased the ratio of daughter corm formation and total ratio of corm number and mass, and reduced the ratio of daughter corm mass gain.

Key words: growth, development, flowering, application method, concentration

INTRODUCTION

Horticultural producers have recently increased their interest in plant growth and development stimulants [Startek et al. 2005] that support their natural immunity to bacteria, viruses, and pathogenic fungi [Lipa and Pruszyński 2010] and significantly improve yield quality. One of the crucial parameters considered when choosing these substances is their low toxicity to the natural environment [Tomalak et al. 2010]. An application of chitosan may be such a solution. Although this compound is not present in plants, it exhibits a strong biological activity towards them, stimulates many physiological and biochemical processes [Nge et al. 2006, Falcon et al. 2008] and activates plant immunity response against different

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pathogens [Algam et al. 2010]. However, the effect of chitosan on plants depends on many factors, such as species [Obsuwan et al. 2010], variety [Uddin et al. 2004], plant development phase [Mondal et al. 2012], application method [Żurawik and Bartkowiak 2009 b], concentration [Mondal et al. 2012], number of treatments [El-Tanahy et al. 2012], or the conditions prevalent during cultivation [Żurawik and Bartkowiak 2009 a], which should be taken into account in the production. At lower doses chitosan affects plants relatively fast in the form of an aqueous solution [Pospieszny 1997]. During vegetation, it may be applied by means of watering [Sheikha 2011] or spraying [Obsuwan et al. 2010, Mondal et al. 2012].

With view of the above, the study was aimed at determining the effects of chitosan application method, concentration, and application frequency on the vegetative and generative parameters and the yield of 'Summer Beach' freesia daughter corms cultivated for cut flowers.

MATERIALS AND METHODS

The experiments were performed in an unheated foil tunnel (14°31'E and 53°26'N) in the years 2010–2012. The substrate was not cooled during the cultivation. Depending on the year, the experiment commenced on 6 May in 2010, 10 May in 2011, and 5 May in 2012. Irrespective of the planting date, the plants were always dug out after 240 days of cultivation. The research material involved daughter corms of 'Summer Beach' freesia variety weighting 9.84–11.13 g (2010), 5.63–6.48 g (2011), and 12.34–13.75 g (2012). Before planting, the corms were prepared for 15 weeks at 28–30°C and 80–85% relative air humidity. The corms were planted in the boxes of 45.5 dm^3 capacity, filled with substrate containing high peat de-acidified to pH 6.2 by adding 5 g of chalk and 5 g dolomite per 1 dm^3. Nutrient deficiency of nutrients was supplemented by using a multicomponent fertilizer Azofoska (N 13.6, P_2O_5 6.4, K_2O 19.1, MgO 4.5, B 0.045, Cu 0.180, Fe 0.17, Mn 0.27, Mo 0.040, Zn 0.045) at a dose of 1.5 $g \cdot dm^{-3}$. The plants were fertilized during vegetation and watered every 2 weeks with 0.2% solution of Peters Professional Floral Feed fertilizer (N 27.0, P_2O_5 15.0, K_2O 12.0, MgO 0.1, B 0.02, Cu 0.063, Fe 0.12, Mn 0.06, Mo 0.001, Zn 0.06) and Peters Professional Blossom Booster (N 10.0, P_2O_5 30.0, K_2O 20.0, MgO 2.0, B 0.20, Cu 0.015, Fe 0.12, Mn 0.06, Mo 0.01, Zn 0.015). Air temperature during the experiment was recorded using a Testo 175 H 2 device. The course of temperature with average decade values, and minimum and maximum temperatures in individual years is presented in Figure 1.

Chitosan of 8 000 $g \cdot mol^{-1}$ molecular weight and 0.2 or 0.4% concentration was used in the experiments. This compound was applied by watering or spraying the plants. Chitosan was applied for the first time at the stage of two leaves, and subsequent applications were repeated every 14 or 7 days. Together, 12 and 24 treatments were performed, respectively. Each time 10 cm^3 of the solution per plant was used. In the control version, the plants were properly watered or sprayed with water. A 1% solution of chitosan was prepared in the following way: 8 g of the compound was dissolved in 300 cm^3 of distilled water, and the solution was titrated until pH of 7.7 was achieved by adding 12 cm^3 1 M NaOH. Afterwards, the solution was supplemented with distilled water until 500 g. Subsequently, 500 g of 0.2 M CH_3COOH were added. To obtain solutions of lower concentration, 0.1 M CH_3COOH was used as a solvent.

The number of days from the beginning of sprouting to the beginning of flowering and from the beginning to the end of flowering was determined during the experiment. The flowering period was counted from the opening of the first flowers in the main inflorescences until withering of the last flower on a plant). Measurements of the vegetative organs were carried out at the end of the cultivation period. Plant height, the number of shoots and leaves on the main shoot, and total number of leaves per plant were determined, and a chlorophyll meter SPAD-502 was used for assessing leaf greenness index. Generative organs were measured since the opening of the first flower in an inflorescence in subsequently blooming plants. The measurements included total length of the main inflorescence shoot (from the substrate surface

to the base of the first flower in the main inflorescence), the length of main inflorescence shoot (from the first lateral branching to the base of the first flower in the main inflorescence), the length of main inflorescence spike (spike length from the base of the first flower in the inflorescence to the base of the terminal bud), diameter of the first flower in the main inflorescence (the widest section), the number of flowers in the main inflorescence spike (open flowers and properly formed buds), and the number of lateral inflorescence shoots (properly formed inflorescence shoots). The corms were dried and cleaned from dry shoots, leaves, and roots, and their yield was assessed by calculating the coefficient of new corm weight (the ratio of daughter corm weight after the vegetation period to the weight of the planted corms), number increase (the ratio of daughter corm number to the number of planted corms), and coefficient of total corm weight increase (the ratio of daughter and adventitious corm weight to the weight of the planted corms).

The study evaluated 12 experimental variants that combined the application method (2) × concentration (3) × frequency of chitosan application (2). The control variant included plants not treated with chitosan. It contained 45 corms divided into three repetitions of 15 corms. The results were statistically verified by means of a fully randomized three-factor analysis of variance for individual years and also collectively for all three years. The comparison of averages was performed using Tukeys test at the significance level of $\alpha = 0.05$.

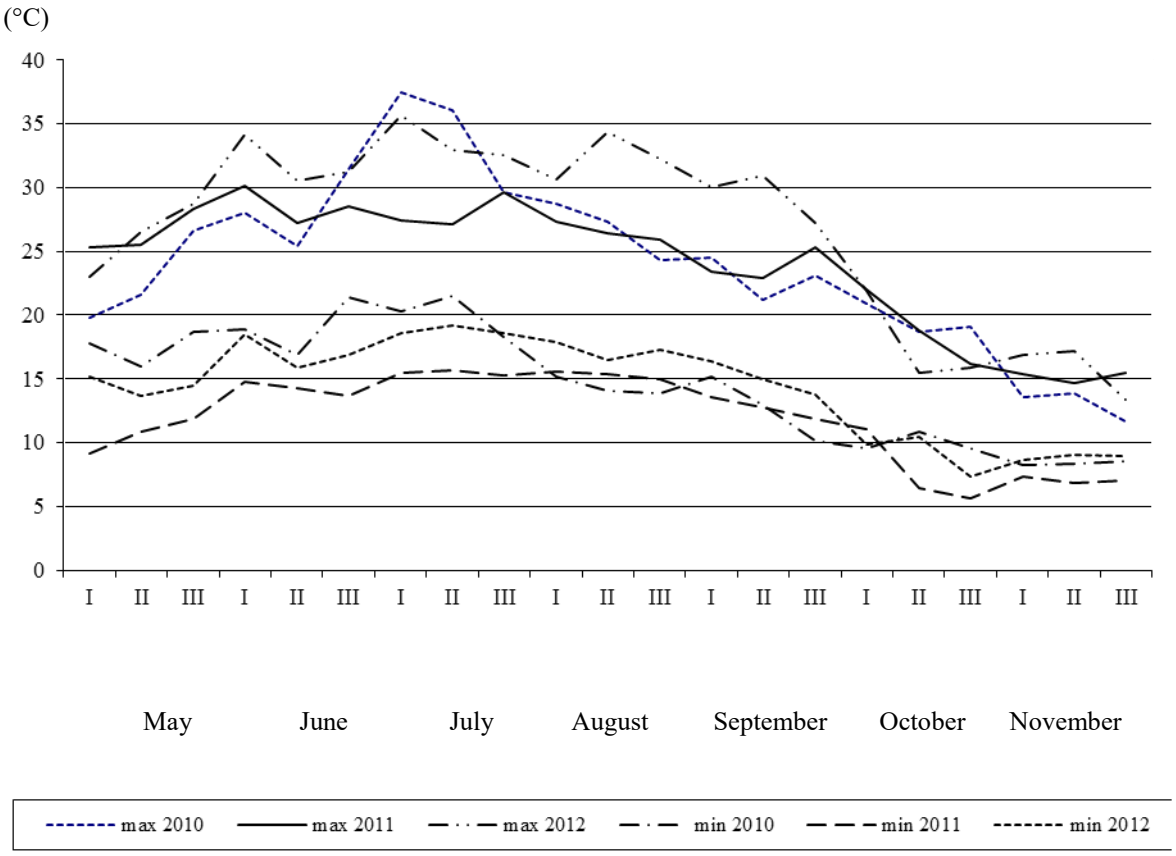
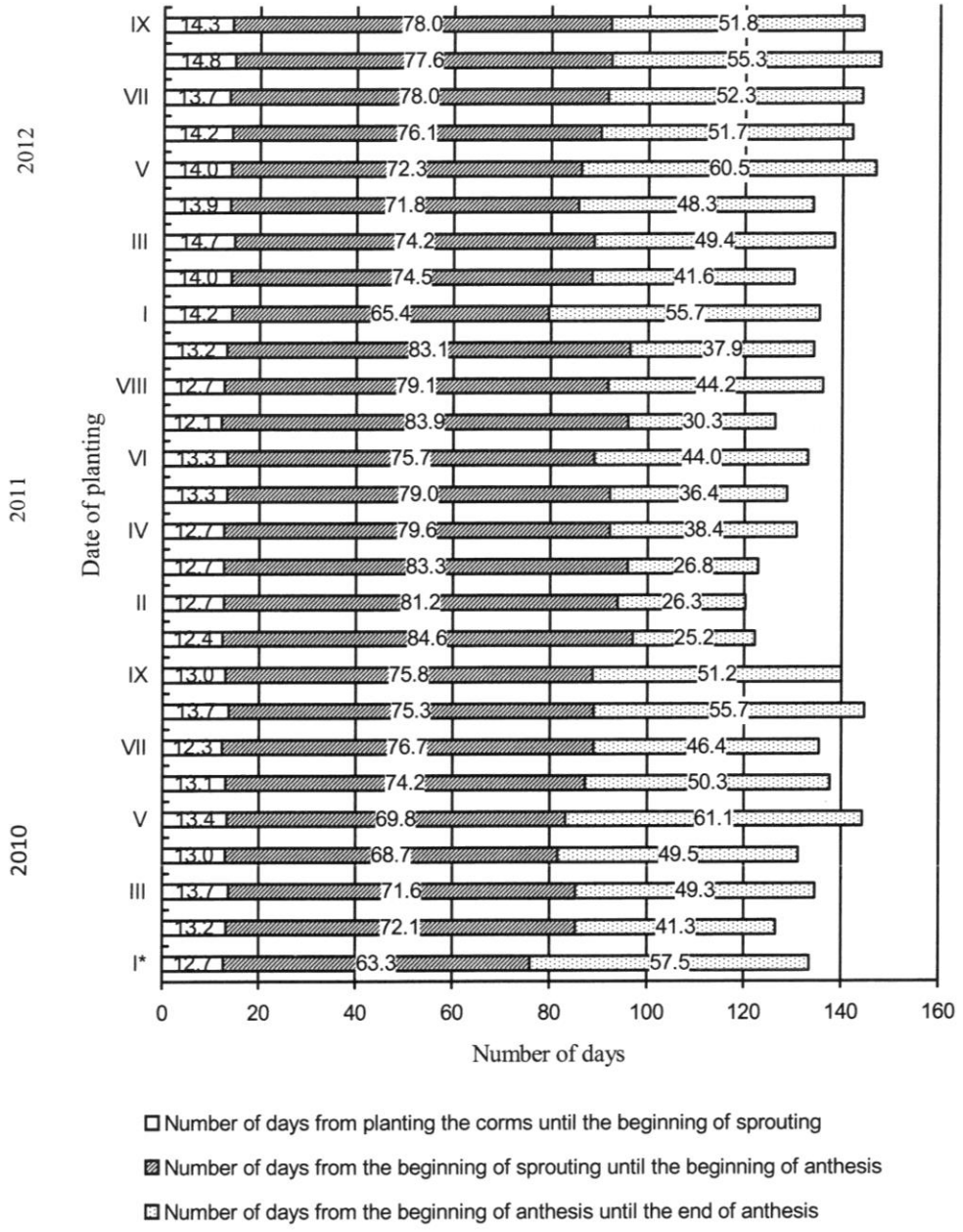


Fig. 1. Maximum and minimum air temperature profile (C°) in the years 2010–2012



* Explanations:

I – control
II – chitosan watering 0.2% every 7 days
III – chitosan watering 0.2% every 14 days
IV – chitosan watering 0.4% every 7 days
V – chitosan watering 0.4% every 14 days
VI – chitosan spraying 0.2% every 7 days
VII – chitosan spraying 0.2% every 14 days
VIII – chitosan spraying 0.4% every 7 days
IX – chitosan spraying 0.4% every 14 days

Fig. 2. Number of days from planting the corms until the end of anthesis, depending on the application method, frequency of use and concentration of chitosan (2010–2012)

RESULTS AND DISCUSSION

According to Startek et al. [2005], temperature is the key factor determining the size and value of inflorescences in the production of freesia for cut flowers. Between corm planting and the appearance of inflorescence buds, substrate temperature should be kept at 15–16°C. In our study, air temperature in this period varied from 20°C to even 34°C for all the years (fig. 1). Despite so high temperatures in 2010 and 2012, freesia burst into bloom on time as declared by the cultivator. Only in 2011, despite lower temperatures of the cultivation, blooming started slightly later. The delay of the generative phase in that year was most likely caused by lower weight of the planted corms. Chitosan (1%) substrate additive did not accelerate flowering in *Calceolaria herbeohybrida* 'Midas' or *Campanula fragilis* 'Juane Bell' [Ohta et al. 2004 a]. However, when the compound was used for spraying *Dendrobium* 'Eiskul' [Limpanavech et al. 2008] and soaking freesia corms, it shortened the vegetative phase [Żurawik 2013]. In our study, the compound had a non-uniform effect on the course of developmental phases after applying it at 8 000 $g \cdot mol^{-1}$ molecular weight by watering or spraying. This effect depended on temperature prevalent during the formation of generative organs. In the years 2010 and 2012, when mean maximum and minimum air temperature was higher than in 2011 (fig. 1), the heading stage in chitosan treated plants was delayed as compared with the controls (fig. 2). The differences ranged from 5.4 to 13.4 days in 2010 and from 6.4 to 12.6 days in 2012. In both years, spraying with chitosan seemed more effective than watering. However, at lower temperatures observed in 2011, chitosan application accelerated spike formation. Inflorescence buds were obtained earlier as a result of increasing frequency of chitosan application and spraying the plants. These results corroborated the report by Salachna and Bartkowiak [2008], according to which the effect of chitosan on the course of the developmental phases depended on the conditions prevalent during cultivation. According to Żurawik [2013], chitosan at 10 000 $g \cdot mol^{-1}$ stimulated formation of a higher number of adventitious buds on a corm, thus increasing the number of developed inflorescences and prolonging the flowering period. This report was confirmed using chitosan of 8 000 $g \cdot mol^{-1}$ molecular weight in an experiment conducted in 2011 at lower cultivation temperatures and by planting corms of a lower weight. Regardless of the variant, chitosan prolonged the flowering period. Differences averaged from 1.1 days, in the plants watered every 7 days, to 19.0 days when chitosan was applied by spraying every 7 days. In 2010 and 2012, when greater corms were cultivated at higher temperatures, the number of days from the beginning of spike formation to the end of flowering was greater than in 2011 in all variants. These results corroborate the report of Motozu et al. [2000], who claimed that high fluctuation of air temperature from the moment of inflorescence bud formation to the beginning of flowering limited growth of inflorescences. As compared with control, in the years 2010 and 2012 the number of days from the formation of spikes until the end of flowering was lower only when the plants were watered with 0.2% solution every 7 or 14 days and 0.4% solution every 7 days. In 2010, this period was shorter also when the compound was applied by spraying with 0.2% solution every 14 days (fig. 2).

Reports discussing chitosan effect on vegetative growth of decorative plants are not unanimous. The compound stimulated growth of *Eustoma grandiflorum* 'Peter blue line 2' [Ohta et al. 2004 b], *Dendrobium* 'Eiskul' [Limpanavech et al. 2008], or *Freesia hybrida* [Salachna and Bartkowiak 2008, Żurawik and Bartkowiak 2009 b]. However, Tamala et al. [2007] shared a different view, according to which chitosan spraying did not affect the height of cultivated *Curcuma* 'Laddawan' plants. In our study, irrespective of the application method and treatment frequency, chitosan increased the height of freesia plants. This increase, as compared with control, ranged from 4.7% when the plants were treated with a solution of lower concentration to 5.8% when the solution of higher concentration was applied (tab. 1). According to Żurawik [2013], an increase of chitosan 10 000 $g \cdot mol^{-1}$ molecular weight solution concentration from 0.2 to 0.4% considerably enhanced the height of 'Silver Beach' freesia. This was not confirmed when chitosan of lower molecular weight, i.e. 8 000 $g \cdot mol^{-1}$, was used in the cultivation of 'Summer

Table 1. Morphological properties of vegetative organs depending on the concentration, application method and frequency of chitosan use (mean for the years 2010–2012)

Trait	Concentration (C) (%)	Application method (A)		Ferquency of use (F)		Mean
		watering	spraying	I*	II	
Plant height (cm)	0.0	87.9	88.2	87.5	88.6	88.1
	0.2	92.0	92.3	93.2	91.1	92.2
	0.4	92.3	94.1	94.7	91.7	93.2
Mean		90.7	91.5	91.8	90.5	
$LSD_{0.05}$	A – n.s., C – 1.52, F – 1.03, A × C – n.s., A × F – n.s., C(F) – 2.15, F(C) – 1.79, A × F × C – n.s.					
Number of shoots (pcs.)	0.0	1.7	1.7	1.6	1.7	1.7
	0.2	2.2	2.4	2.2	2.4	2.3
	0.4	2.3	2.2	2.4	2.2	2.3
Mean		2.1	2.1	2.1	2.1	
$LSD_{0.05}$	A – n.s., C – 0.27, F – n.s., A × C – n.s., A × F – n.s., C × F – n.s., A × F × C – n.s.					
Number of leaves set on main shoot (pcs.)	0.0	9.9	10.0	10.0	9.9	10.0
	0.2	10.1	10.3	10.0	10.4	10.2
	0.4	10.3	10.9	10.5	10.7	10.6
Mean		10.1	10.4	10.2	10.3	
$LSD_{0.05}$	A – 0.17, C – 0.25, F – n.s., A(C) – 0.29, C(A) – 0.35, A × F – n.s., F(C) – 0.29, C(F) – 0.35, A × F × C – n.s.					
Total number of leaves per plant (pcs.)	0.0	16.4	16.3	16.1	16.6	16.4
	0.2	21.5	23.8	22.3	23.1	22.7
	0.4	22.5	22.3	22.0	22.9	22.4
Mean		20.1	20.8	20.1	20.9	
$LSD_{0.05}$	A – n.s., C – 3.08, F – n.s., A × C – n.s., A × F – n.s., C × F – n.s., A × F × C – n.s.					
Greenness index of leaves (SPAD)	0.0	54.9	54.9	55.1	54.7	54.9
	0.2	58.3	59.6	59.9	58.0	59.0
	0.4	59.3	59.2	59.7	58.8	59.2
Mean		57.5	57.9	58.2	57.2	
$LSD_{0.05}$	A – n.s., C – 0.92, F – 0.62, A × C – n.s., A × F – n.s., C × F – n.s., A × F × C – n.s.					

* Explanations: I – every 7 days, II – every 14 days, n.s.– not significant difference

Table 2. Characteristics of flowering depending on the concentration, application method and frequency of chitosan use (mean for the years 2010–2012)

Trait	Concentration (C) (%)	Application method (A)		Ferquency of use (F)		Mean
		watering	spraying	I*	II	
Total length of main inflorescence shoot (cm)	0.0	48.6	52.6	50.7	50.6	50.6
	0.2	50.9	51.9	51.5	51.3	51.4
	0.4	53.3	54.4	53.9	53.8	53.9
Mean		50.9	53.0	52.0	51.9	
$LSD_{0.05}$	A – 1.13, C – 1.67, F – n.s., A × C – n.s., A(F) – 1.60, F(A) – 1.60, C × F – n.s., A × F × C – n.s.					
Length of main inflorescence shoot(cm)	0.0	11.3	11.3	11.3	11.3	11.3
	0.2	12.0	12.1	12.5	11.5	12.0
	0.4	13.2	12.3	12.9	12.6	12.8
Mean		12.2	11.9	12.2	11.8	
$LSD_{0.05}$	A – n.s., C – 0.94, F – n.s., A × C – n.s., A × F – n.s., C × F – n.s., A × F × C – n.s.					
Length of main inflorescence spike (cm)	0.0	7.7	7.7	7.7	7.6	7.7
	0.2	7.5	7.1	7.5	7.2	7.3
	0.4	8.7	6.8	8.3	7.3	7.8
Mean		8.0	7.2	7.8	7.4	
$LSD_{0.05}$	A – 0.36, C – n.s., F – 0.36, A(C) – 0.62, C(A) – 0.74, A × F – n.s, C × F – n.s., A × F × C – n.s.					
Number of flowers in main inflore-scence spike (pcs.)	0.0	9.4	9.4	9.7	9.1	9.4
	0.2	10.1	9.3	9.3	10.1	9.7
	0.4	10.7	9.0	10.0	9.6	9.8
Mean		10.0	9.2	9.7	9.6	
$LSD_{0.05}$	A – 0.27, C – 0.39, F – n.s., A(C) – 0.46, C(A) – 0.55, A × F – n.s., C(F) – 0.55, F(C) – 0.46, A × F × C – n.s.					
Diameter of the first flower in the main inflorescence spike (cm)	0.0	5.9	5.9	6.0	5.8	5.9
	0.2	6.0	6.0	5.9	6.0	6.0
	0.4	6.2	6.1	6.3	6.0	6.2
Mean		6.0	6.0	6.1	5.9	
$LSD_{0.05}$	A – n.s., C – 0.18, F – 0.12, A × C – n.s., A × F – n.s., C × F – n.s., A × F × C – n.s.					
Number of lateral inflorescence shoots (pcs.)	0.0	1.3	1.3	1.2	1.3	1.3
	0.2	1.6	1.8	1.7	1.7	1.7
	0.4	1.6	1.7	1.6	1.7	1.7
Mean		1.5	1.6	1.5	1.6	
$LSD_{0.05}$	A – n.s., C – 0.19, F – n.s., A × C – n.s., A × F – n.s., C × F – n.s., A × F × C – n.s.					

* Explanations as in the table 1

Table 3. Yield of corms depending on the concentration, application method and frequency of chitosan use (mean for the years 2010–2012)

Trait	Concentration (C) (%)	Application method (A)		Ferquency of use (F)		Mean
		watering	spraying	I*	II	
Coefficient of new corms number increase	0.0	1.14	1.19	1.18	1.16	1.17
	0.2	1.70	1.79	1.73	1.76	1.75
	0.4	2.03	1.94	2.24	1.73	1.99
Mean		1.62	1.64	1.72	1.55	
$LSD_{0.05}$	A – n.s., C – 0.197, F – 0.134, A × C – n.s., A × F – n.s, C(F) – 0.278, F(C) – 0.232, A × F × C – n.s.					
Coefficient of new corms weight increase	0.0	3.39	3.40	3.42	3.37	3.40
	0.2	3.04	3.06	3.06	3.04	3.05
	0.4	3.02	2.87	2.99	2.90	2.94
Mean		3.15	3.11	3.16	3.10	
$LSD_{0.05}$	A – n.s., C – 0.173, F – n.s., A × C – n.s., A × F – n.s., C × F – n.s., A × F × C – n.s.					
Coefficient of corms number increase total	0.0	2.94	3.18	3.06	3.06	3.06
	0.2	3.96	4.09	4.23	3.82	4.03
	0.4	4.37	4.11	4.65	3.84	4.24
Mean		3.76	3.79	3.98	3.57	
$LSD_{0.05}$	A – n.s., C –0.478, F – 0.325, A × C – n.s., A × F – n.s., C × F – n.s., A × F × C – n.s.					
Coefficient of corms weight increase total	0.0	3.62	3.69	3.67	3.63	3.65
	0.2	4.78	4.13	4.87	4.04	4.46
	0.4	4.59	4.27	4.76	4.10	4.43
Mean		4.33	4.03	4.43	3.92	
$LSD_{0.05}$	A – 0.283, C – 0.415, F – 0.283, A × C – n.s.,A × F – n.s., C(F) – 0.588, F(C) – 0.489, A × F × C – n.s.					

* Explanations as in the table 1

Beach' variety. However, the frequency of chitosan application was confirmed to affect plant height. Freesias treated every 7 days were higher than those exposed to chitosan every 14 days. A significant correlation between concentration and application frequency was also identified (tab. 1). Żurawik and Bartkowiak [2009 b] used chitosan of 20 000 g·mol^{-1} molecular weight and 0.2% concentration and demonstrated its stimulating effect on freesia shoot formation that depended on the application method. In our study, when chitosan of 8 000 g·mol^{-1} molecular weight was used, neither its method of application, nor treatment frequency significantly affected the investigated parameter. However, both concentrations of chitosan increased the number of shoots by 35.3%. Treating *Curcuma* 'Laddawan' plants with chitosan solution did not change the number of developed leaves [Tamala et al. 2007]. In our research, this information was not confirmed and our results are compatible those published by Żurawik and Bartkowiak [2009 b], who claimed that freesias treated with chitosan solution of 20 000 g·mol^{-1} molecular

weight and 0.2% concentration developed fewer leaves than control plants. In the reported experiment, 'Summer Beach' freesias produced more leaves when chitosan was applied by spraying than by watering, irrespective of chitosan concentration. More leaves on the main shoot were also obtained by using 0.4 than 0.2% solution. The relationships between application method and concentration and treatment frequency and concentration were variable. Our study did not confirm the report by Żurawik [2013], who claimed that the greatest number of leaves in 'Silver Beach' freesia were developed as a result of spraying the plants every 7 or 14 days with chitosan solution of 10 000 g·mol^{-1} molecular weight. Total number of leaves produced by the plants was not significantly affected by either frequency or method of chitosan application. However, the use of chitosan at 0.2 or 0.4% significantly increased total number of leaves per plant. When compared with controls, these differences were 38.4 and 36.6%, respectively. Salachna and Bartkowiak [2008] reported an increase of leaf greenness index following corm soaking in 0.2% chitosan. However, they linked this effect to molecular mass of the solution. In our study, chitosan of molecular weight 8 000 g·mol^{-1} significantly improved leaf greenness index irrespective of the application method, treatment frequency or concentration (0.2 and 0.4%). As compared with control plants, the differences were 4.1 and 4.3 SPAD, respectively. Independent of concentration and application method, plants treated every 7 days with chitosan solution were distinguished by stronger intensity of leaf greenness that the ones treated every 14 days (tab. 1).

According to Win et al. [2005], chitosan application enhanced inflorescence length in *Dendrobium* 'Misten'. This finding was not confirmed by Tamala et al. [2007] in *Curcuma* 'Laddawan'. In our study, the plants sprayed with chitosan produced inflorescence stems of greater total length than those watered with chitosan solution. The plants treated with higher concentration of chitosan (0.4%) produced the inflorescence stems of the greatest total length, as compared with control and those treated with 0.2% chitosan. A different relationship was reported for the length of the main inflorescence shoot. Regardless of the application method and treatment frequency, longer shoots developed only in plants treated with 0.4% chitosan, as compared with control. Spraying freesia with chitosan solution resulted in shortening of the main inflorescence when compared with the plants watered with this compound. Treating freesia with chitosan every 7 days enhanced the length of the main inflorescence by 5.4%, as compared with the plants exposed to chitosan every 14 days. According to Żurawik [2013], treating 'Silver Beach' freesia with chitosan solution of 10 000 g·mol^{-1} molecular weight, irrespective of the application method and concentration, increased the number of flowers. This was confirmed in 'Summer Beach' freesia treated with a solution of chitosan of lower molecular weight. More flowers in the main inflorescence than in the control plants were noticed only in the variant treated with 0.4% of chitosan. With reference to this trait, a significant correlation was reported between concentration and application method and between concentration and application frequency. The freesias treated with chitosan at 0.4% produced also flowers of greater diameter than those treated with chitosan at 0.2% and control ones. However, neither the method of chitosan application nor treatment frequency affected freesia flower diameter. Irrespective of the application method and frequency, the plants treated with 0.2 and 0.4% chitosan produced more side branches of the inflorescence than the control plants. The differences reached up to 30.8% (tab. 2).

According to Hasegawa and Kanechika [2005], Ramos-Garcia at al. [2009], Żurawik and Bartkowiak [2009 a], chitosan stimulated the yield of underground organs in geophytes. Salachna et al. [2008] linked this to the molecular weight of chitosan. Żurawik [2013] reported that both in the controlled environment and in production, irrespective of the group of cultivated freesia, chitosan of 10 000 g·mol^{-1} molecular weight increased the total number and weight of corms and the coefficient of daughter corm number gain. Our research confirmed this report when chitosan of 8 000 g·mol^{-1} molecular weight was applied in the cultivation of 'Summer Beach' freesia. Irrespective of chitosan application method and treatment frequency, it improved total corm weight and number gain at both concentrations. Chitosan used in our research reduced the coefficient of daugh-

ter corm weight gain. As compared with control plants, in freesias treated with 0.2 and 0.4% chitosan it was by 10.3 and 13.5% lower. In a study on 'Silver Beach' freesia, Żurawik [2013] reported an increase in the coefficient of total corm number and weight gain as well as in daughter corm number in plants treated with 0.4% chitosan. These reports were confirmed only for the coefficient of daughter corm number gain. Application of chitosan of lower molecular weight and 0.4% concentration resulted in this coefficient growth by 13.7% than as compared with 02% chitosan. Chitosan treatment every 7 days resulted in 10.9% higher coefficient of daughter corm number gain, 11.5% higher coefficient of total corm number gain, and 13.0% higher coefficient of total corm weight grain than in the plants exposed to chitosan every 14 days (tab. 3).

CONCLUSIONS

1. Chitosan of 8 000 $g \cdot mol^{-1}$ molecular weight affected the beginning of spike formation of 'Summer Beach' freesia in unanimous manner. Its effect depended on the conditions prevalent during cultivation. It accelerated spike formation at lower temperatures and delayed it at higher temperatures.

2. Irrespective of the application method and treatment frequency, freesia exposure to 0.2 and 0.4% chitosan stimulated plant growth, improved leaf greenness index and increased total number of produced shoots and leaves.

3. The effect of chitosan on the quality of inflorescences depended on its application method. Watering the plants increased the length of the main inflorescence and the number of flowers, while spraying improved total length of the inflorescence stem.

4. Chitosan application at 7-day intervals positively affected vegetative traits and increased daughter corm yield, as compared with treatments at 14-day intervals.

5. Chitosan application in the reproduction of propagating material improved the growth of freesia daughter corm number gain coefficient, total corm number and weight gain coefficient but it also reduced daughter corm weight gain coefficient.

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