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THE EFFECT OF BENZYLADENINE ON THE FLOWERING OF *Campanula persicifolia* L. 'ALBA' CULTIVATED IN AN UNHEATED PLASTIC TUNNEL AND IN THE FIELD

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Abstract. The effect of BA on the flowering of *Campanula persicifolia* L. 'Alba' cultivated in an unheated plastic tunnel and in the field was examined. BA in the concentration of 100, 200, 400 mg·dm^{-3} was applied on the leaf twice in both years of the experiment duration. Plants not treated with benzyladenine were used as a control. It was concluded, that cultivation of *Campanula persicifolia* L. 'Alba' in an unheated plastic tunnel causes growth of fewer inflorescence stems but of better quality than in the field. Application of benzyladenine in the concentration of 400 mg·dm^{-3} in *Campanula persicifolia* L. cultivation in an unheated plastic tunnel results in an increased fresh weight of inflorescence stems and number of primary side stems. Application of benzyladenine in the concentration of 400 mg·dm^{-3} is recommended for *Campanula persicifolia* L. cultivated in the field due to better branching in the first and second year of flowering. Application of benzyladenine in the concentration of 200 and 400 mg·dm^{-3} on the leaf of *Campanula persicifolia* L. cultivated in the tunnel leads to the production of shorter inflorescence stems in the first and second year of flowering. In the field, only the older plants (in the second year of flowering) react similarly.

Key words: *Campanula persicifolia*, benzyladenine, cultivation place, flowering

INTRODUCTION

In the past few years there has been an increased interest in perennials which used to be only used for green areas and which now seem to be appropriate for cut flowers cultivation. *Campanula persicifolia* L. with thin, 30–90 cm long inflorescence stems, with blue or white flowers is a perfect perennial for cut flowers. Florists use them more and more frequently in flower compositions as they add a touch of romanticism to the

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bouquets. Single flowers can also be used in delicate flower bunches and garlands for occasions such as first communion, and also in buttonholes.

Campanula persicifolia L. blooms in early summer months. In order to prolong its availability period on the cut flowers market, cultivation under unheated plastic can be used.

An unheated plastic tunnel has been used for many years now in the cultivation of various ornamental plants species in order to accelerate plant flowering and obtain greater yield of inflorescence stems and better quality [Hetman and Pogroszewska 1995; 1996a; 1996b; Pogroszewska 1998; Wraga 1999; Janowska 2000; Szczepaniak 2000].

Additionally, flowering and plant growth can be influenced by the use of growth regulators. In case of some species, benzyladenine takes part in the process of flower bud initiation [Jankiewicz 1997; Suh 1997; Pobudkiewicz 2006]. Benzyladenine stimulates development of side buds which enhances ornamental quality of plants [Pobudkiewicz 2005]. Benzyladenine also causes more intensive branching which eventually leads to enhancement of plant size, for example of *Hosta spp*. [Garner et al. 1997; Keever and Brass 1998; Kotański et al. 2005] and *Hemerocallis* spp. [Leclerc et al. 2006].

The aim of the research was to examine the effect of benzyladenine (BA) applied in various concentrations on the flowering of *Campanula persicifolia* L. cultivated in an unheated plastic tunnel and in the field.

MATERIAL AND METHODS

The research was conducted in 2004 and 2005. Plants of *Campanula persicifolia* L. 'Alba' were planted in October 2003 into local soil in plastic tunnel without heating and in the field in patches 1.5 meters wide.

Benzyladenine was applied in the concentrations of 100, 200 and 400 $mg \cdot dm^{-3}$. Plants that were not treated with benzyladenine were used as a control. The preparation was applied twice on the leaf. First time when the plants reached the height of 16–20 cm (40 ml of preparation/plant). Second time when the plants reached 40 cm (60 ml of preparation/plant). Plants of *Campanula persicifolia* L. cultivated both in the tunnel and in the field were systematically fertilized and watered.

The tests were conducted in the first and second year of plant flowering through evaluation of the quantity and length of inflorescence, its fresh weight and number of primary side stems.

The experiment was set up in the system of random blocks in 3 repetitions, where a plot with 6 plants served as the repetition. The results were analyzed statistically by means of variance analysis for double classifications, evaluating the significance of differences by means of Tukey's confidence intervals at the level of significance of $\alpha = 0.05$.

RESULTS

In the first year of flowering *Campanula persicifolia* L. cultivated in an unheated plastic tunnel produced over 16% fewer inflorescence stems than in the field, but the quality of yield was better (tab. 1).

Table 1. The effect of benzyladenine on growth and flowering of *Campanula persicifolia* L. 'Alba' cultivated in unheated plastic tunnel and in the field

Tabela 1. Wpływ benzyloadeniny na wzrost i kwitnienie dzwonka brzoskwiniolistnego 'Alba' uprawianego w nieogrzewanym tunelu foliowym i w polu

	Stężenie BA BA concentration mg · dm^{-3}	I rok kwitnienia 1st year of flowering		II rok kwitnienia 2nd year of flowering	
		pole – field	tunel – tunnel	pole – field	tunel – tunnel
Liczba pędów kwiatostanowych Number of inflorescence stems	0	11.8 ab*	9.3 c	42.0 bc	28.5 d
	100	12.5 a	9.7 bc	50.1 ab	32.1 d
	200	12.7 a	11.1 abc	50.4 a	33.0 d
	400	12.9 a	11.7 ab	56.9 a	34.5 cd
	średnia – mean	12.5 A	10.4 B	50.0 A	32.0 B
Długość pędów kwiatostanowych Length of inflorescence stems, cm	0	74.2 c	95.1 a	83.0 c	97.9 a
	100	74.0 c	90.1 ab	80.6 c	92.8 b
	200	73.2 c	89.2 b	76.2 d	94.5 b
	400	72.2 c	88.1 b	74.2 d	80.9 c
	średnia – mean	73.4 B	90.5 A	78.2 B	91.5 A
Świeża masa pędów kwiatostanowych Fresh weight of inflorescence stems, g	0	18.7 c	44.4 b	28.0 cd	33.1 b
	100	20.4 c	45.6 b	30.0 c	33.4 b
	200	20.1 c	45.6 b	30.0 c	35.3 ab
	400	22.1 c	57.3 a	26.3 d	36.7 a
	średnia – mean	20.5 B	48.1 A	28.4 B	34.7 A
Liczba rozgałęzień I-rzędu Number of primary shoots	0	12.8 e	17.9 c	13.6 e	12.8 e
	100	13.2 e	19.9 b	16.0 cd	15.4 d
	200	13.9 e	20.1 b	17.1 bcd	18.0 ab
	400	15.7 d	22.5 a	17.6 abc	19.1 a
	średnia – mean	13.5 B	20.1 A	16.0 A	16.4 A

*Means followed by the same letters are not significantly different at $\alpha = 0.05$ level of probability. Means of each year were compared separately

*Średnie oznaczone tą samą literą nie różnią się między sobą istotnie przy poziomie istotności α=0,05. Ocena istotności różnic dla każdego roku została dokonana oddzielnie

In the first year of the research, inflorescence stems of *Campanula persicifolia* L. cultivated in an unheated plastic tunnel were 23% longer, had twice bigger fresh weight and produced nearly 50% more primary side stems than stems of plants cultivated in the field.

Benzyladenine, just as cultivation site, had influence on the yield of *Campanula*. Plants cultivated in the plastic tunnel and treated with benzyladenine in the concentration of 400 mg·dm^{-3} produced nearly 26% greater yield than control plants.

Benzyladenine in the concentration of 200 mg·dm^{-3} and 400 mg·dm^{-3} applied on the plants cultivated in the plastic tunnel led to production of 6–7% shorter stems than in case of control plants. Plants both from the tunnel and from the field showed a tendency to decreased length of inflorescence stems and increased fresh weight of stems as a result of benzyladenine concentration growth. BA applied in the highest concentration (400 mg·dm^{-3}) on the plants in the tunnel, aided the plants in production of inflorescence stems with fresh weight almost 30% greater than the fresh weight of the control stems.

Plants growing in the field and treated with benzyladenine in the concentration of 400 mg·dm^{-3} produced one fifth of primary stems more than control plants. Plants in the

unheated plastic tunnel treated with bio-regulator in all concentrations produced more primary side stems than the control plants. Benzyladenine in the concentration of 400 mg·dm^{-3} had the best effect, as in comparison to the control, it increased the number of primary stems by one fourth.

In the second year of flowering 3 times more inflorescence stems were obtained in the unheated plastic tunnel compared to the first year. The yield of inflorescence stems from the field obtained in the second year of flowering was 4 times greater than in the first year.

In the second year of the experiment, similarly to the first, plants of *Campanula persicifolia* L. cultivated in the unheated plastic tunnel produced 36% smaller yield of inflorescence stems compared to the plants cultivated in the field. However, the quality of inflorescence stems evaluated by their length and fresh weight was higher in the tunnel. Plants cultivated in the unheated tunnel produced inflorescence stems which were nearly by one fifth longer and had their fresh weight by over one fifth greater than the plants cultivated in the field (tab. 1).

Cultivation site did not significantly affect the quantity of primary side stems in the second year of cultivation.

Plants treated with benzyladenine in the concentration of 200 and 400 mg·dm^{-3} cultivated in the field produced a greater yield of inflorescence stems than the control plants by 20% and over 35% respectively. A tendency that was observed in the plastic tunnel was that of an increased yield in case of increased concentration of benzyladenine.

Interaction of the researched factors was marked by shorter inflorescence stems of the plants cultivated in the tunnel and affected by BA in the concentration of 100, 200 and 400 mg·dm^{-3}, and of the plants cultivated in the field and affected by benzyladenine in higher concentrations of 200 and 400 mg·dm^{-3}. The strongest effect was noted when benzyladenine in the concentration of 400 mg·dm^{-3} was applied to the plants in the field, resulting in the slower growth of inflorescence stems, which were over 10% shorter than stems of the control plants.

Plants in the plastic tunnel which were treated with BA in the concentration of 400 mg·dm^{-3} produced inflorescence stems that had their fresh weight by over 10% greater than the fresh weight of the control plants. No significant effect of BA on the fresh weight of stems produced by the plants in the field was noted.

Benzyladenine differentiated the quantity of primary side stems produced by plants cultivated in both the unheated plastic tunnel and in the field. BA was most effective in the concentration of 400 mg·dm^{-3} because it led to production of almost 30% more primary side stems in the field and of almost 50% in the tunnel.

DISCUSSION

It was noted in this experiment that planting *Campanula persicifolia* L. in an unheated plastic tunnel results in a decreased inflorescence yield compared to cultivation in the field. Similar decrease of the number of inflorescence stems in plastic tunnel cultivation was noted by Hetman and Pogroszewska [1997] in their research on *Liatris spicata* L. and by Pogroszewska and Sadkowska [2006] in their research on *Astilbe* × *arendsii* Arends.

However, the results of other researches on different ornamental plant species show that the yield of inflorescence stems of plants growing in an unheated plastic tunnel can be greater than yield of plants cultivated in the field. It was proved by Hetman and Pogroszewska [1996a] in case of *Helleborus* × *hybridus* hort., by Pogroszewska [1998] in case of *Iris sibirica* L., by Wraga [1999] in case of *Moluccella laevis* L., by Janowska [2000] and Janowska and Schroeter [2001] in case of *Dianthus barbatus* L. and by Puczel and Waźbińska [2003] in case of *Craspedia globosa* Benth.

In this particular research inflorescence of *Campanula persicifolia* L. cultivated in the plastic tunnel had a better quality than stems cultivated in the field, which confirms the results of research on *Liatris spicata* L. [Hetman and Pogroszewksa 1997], *Iris sibirica* L. [Pogroszewska 1998], *Moluccella laevis* L. [Wraga 1999] and *Astilbe* × *arendsii* Arends [Pogroszewska and Sadkowska 2006]. Own research however, does not confirm the results obtained by Szczepaniak [2000] in a research on *Erigeron hybridus* Bergm. 'Dunkelste Aller'. Despite abundant flowering, plants of this species cultivated in the plastic tunnel produced inflorescence stems of poor quality.

In the conducted experiment benzyladenine applied in the concentrations of 200 and 400 mg·dm^{-3} to plants cultivated in the field led to production of greater quantity of inflorescence stems compared to the control plants. Positive reaction of plants to BA (in the concentration of 300 mg·dm^{-3}) reflected by more abundant flowering was observed by Davies et al. [1996] in research on *Gypsophila paniculata* L. 'Bristol Fairy' and 'Bridal Veil', and by Pogroszewska and Sadkowska [2007] who obtained the greatest quantity of *Astilbe* × *arendsii* Arends stems as a result of benzyladenine applied in the concentration of 200 mg·dm^{-3}.

Benzyladenine in the concentrations of 100, 200, and 400 in own research led to increased number of primary side stems. Similar reaction was presented by Pobudkiewicz [2005] in case of *Dianthus caryophyllus* L. 'Snowmass'. Lubell et al. [2005] also inform about the increased number of stems of *Epimedium* × *rubrum* Morren and *Helleborus* × *hybridus* L. after BA application. The reaction of plants to benzyladenine, however, depends on their variety which was proved by Garner et al. [1997] in research on *Hosta* Tratt., and by Grabowska and Witomska [2006] in research on *Hemerocallis* sp.

In the conducted research benzyladenine that was applied in higher concentrations (200 and 400 mg·dm^{-3}) led to production of shorter inflorescence stems by *Campanula persicifolia* L. plants. Benzyladenine also stopped the growth of stems of *Gypsophila paniculata* L. 'Bristol Fairy' and 'Bridal Veil' cultivated in the conditions of long day and warm night [Davies et al. 1996].

CONCLUSIONS

1. Cultivation of *Campanula persicifolia* L. 'Alba' in an unheated plastic tunnel causes growth of fewer inflorescence stems but of better quality than in the field.

2. Application of benzyladenine in the concentration of 400 mg·dm^{-3} in *Campanula persicifolia* L. cultivation in an unheated plastic tunnel results in an increased fresh weight of inflorescence stems and number of primary side stems.

3. Application of benzyladenine in the concentration of 400 mg·dm^{-3} is recommended for *Campanula persicifolia* L. cultivated in the field due to better branching in the first and second year of flowering.

4. Application of benzyladenine in the concentration of 200 and 400 mg·dm^{-3} on the leaf of *Campanula persicifolia* L. cultivated in the tunnel leads to the production of shorter inflorescence stems in the first and second year of flowering. In the field, only the older plants (in the second year of flowering) react similarly.

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WPŁYW BENZYLOADENINY NA KWITNIENIE DZWONKA BRZOSKWINIOLISTNEGO *Campanula persicifolia* L. 'ALBA' UPRAWIANEGO W NIEOGRZEWANYM TUNELU FOLIOWYM I ODKRYTYM GRUNCIE

Streszczenie. Zbadano wpływ BA na kwitnienie dzwonka brzoskwiniolistnego (*Campanula persicifolia* L.) 'Alba' uprawianego w nieogrzewanym tunelu foliowym i w gruncie. BA w stężeniach: 100, 200, 400 mg·dm^{-3} zastosowano dolistnie, dwukrotnie w obu latach trwania doświadczenia. Jako kontrolę uprawiano rośliny nietraktowane benzyloadeniną. Stwierdzono, że uprawa dzwonka brzoskwiniolistnego (*Campanula persicifolia* L.) 'Alba' w nieogrzewanym tunelu foliowym powoduje uzyskanie mniejszej liczby pędów kwiatostanowych, ale lepszej jakości niż w gruncie. Zastosowanie benzyloadeniny o stężeniu 400 mg·dm^{-3} w uprawie dzwonka w nieogrzewanym tunelu foliowym powoduje zwiększenie świeżej masy pędów kwiatostanowych i liczby pędów bocznych pierwszego rzędu. Celowa jest aplikacja benzyloadeniny w stężeniu 400 mg·dm^{-3}, na rośliny dzwonka uprawiane w odkrytym gruncie, ze względu na lepsze ich krzewienie się, w pierwszym i drugim roku kwitnienia. Dolistne zastosowanie benzyloadeniny w stężeniu 200 i 400 mg·dm^{-3} na rośliny dzwonka uprawiane w tunelu powoduje wytwarzanie krótszych pędów kwiatostanowych w pierwszym i drugim roku kwitnienia. W polu podobnie reagują tylko rośliny starsze (w drugim roku kwitnienia).

Słowa kluczowe: *Campanula persicifolia*, benzyloadenina, miejsce uprawy, kwitnienie

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