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THE INFLUENCE OF GROWTH RETARDANTS AND CYTOKININS ON FLOWERING OF ORNAMENTAL PLANTS

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Summary

Growth retardants are applied in order to obtain short and well compact plants. They usually inhibit stem elongation, but also can influence the flowering of plants. The aim of cytokinin application is to obtain well branched plants without removing the apical meristem. Cytokinins usually increase the number of axillary shoots but also can influence flowering. Growth retardants and cytokinins can affect flower size, pedicel length, number of flowers, flower longevity, abortion of flower buds and number of days from potting plants to the first open flower. Flowering of growth retardant and cytokinin treated plants might depend on the method of growth regulator used (foliar spray or soil drench), plant species or even a plant cultivar, but in the highest degree it depends on the growth regulator rate used. These growth regulators, when are applied at rates appropriate for height and habit control, very seldom influence flowering of ornamental plants, but applied at high rates can delay flowering, diminish flower diameter or flower pedicel length and also can decrease the number of flowers per plant. In cultivation of bulb plants, growth retardants, used at very high rates, also cause abortion of flower buds.

Key words: growth retardants, cytokinins, ornamental plants, flowering

Growth retardants, applied in order to obtain short and well compact plants, inhibit stem elongation but also can influence flower size, pedicel length, number of flowers, flower longevity, abortion of flower buds and number of days from potting plants to their flowering. Cytokinins are used in order to obtain well branched plants without removing the apical meristem. They usually increase the number of axillary shoots but also can affect number of flowers, flower diameter, flower longevity and number of days to flowering.

Number of flowers

Growth retardants can have no influence on the number of flowers (Pobudkiewicz and Golds-berry, 1989 b; Pobudkiewicz and Nowak, 1992; Pobudkiewicz and Nowak, 1994 b; Whipker et al. 1994; Pobudkiewicz and Nowak, 1997) and also can reduce (Pobudkiewicz 2000 c; Pobudkiewicz et al. 2000) or increase (Yoo and Kang, 1999; Jung et al. 2000; Whipker et al. 2000) the number of flowers. Cytokinins usually increase the number of flowers (Jackson, 1975; Heins et al. 1981; Farina, 1984; Song et al. 1991; Lee et al. 1999; Ferrante et al. 2006) or have no influence on flower number (Vlachos, 1985; Tjia, 1986; Pobudkiewicz, 2005). Flower number can depend on the method of growth retardant application. For example, Starman (1991) showed that uniconazole applied as a soil drench to *Eustoma grandiflorum* 'Yodel Blue' increased twice the number of flowers, but used as a foliar spray markedly decreased it. Other studies have shown that irrespectively of the method of growth retardant application, the number of flowers per plant was reduced. For example, *Bougainvillea spectabilis* drenched or sprayed with paclobutrazol had fewer flowers than control plants (Karaguzel, 1999). The number of flowers on the plant can also depend on the growth regulator rate and plant cultivar. For example, flurprimidol significantly decreased the number of flowering shoots in dwarf alstroemeria 'Rosalina' (at 7.5-22.5 mg×dm^{-3}) and at higher concentrations (15-22.5 mg×dm^{-3}) in 'Dorotea' (Pobudkiewicz et al. 2000). Similarly, the number of Streptocarpus florets was decreased by flurprimidol at all tested concentrations (6-18 mg×dm^{-3}) in 'Pink Nana', but in 'Blue Nana' only at higher concentrations of 12-18 mg×dm^{-3} (Pobudkiewicz, 2000 c). Kim et al. (2000) reported that *Doritaenopsis* 'Happy Valentine' sprayed with BA at a lower concentration (100-200 mg×dm^{-3}) had much more flowers than plants treated with BA at higher concentrations of 400 mg×dm^{-3}. BAP at concentrations of 10-150 mg×dm^{-3} did not substantially affect flower production in *Boronia heterophylla* F. Muell. with 4 applications, but with 8 treatments there was a marked decli-

ne in flowering with increased BAP concentration (Richards, 1985). In *Chamelaucium uncinatum* Schauer 'Purple Pride' grown in pots, the timing of BA application was crucial for flowering (Dawson and King, 1993). Benzyladenine at 50 mg×dm^{-3} either depressed or promoted flowering depending on the interval between BA treatment and exposure to short days. BA application 2 months before the start of short day treatment promoted flowering.

Number of days to flowering

In ornamental plants, growth retardants and cytokinins can delay flowering, accelerate it or have no influence on number of days from potting plants to their flowering. Delay of flowering is often observed, especially when growth regulators are applied at very high rates. For example, flurprimidol at high concentrations of 30–50 mg×dm^{-3}, delayed flowering of asiatic hybrid lily 'Prima' by a few days (Pobudkiewicz and Nowak, 1992) and at 22.5 mg×dm^{-3} delayed flowering of dwarf alstroemeria (Pobudkiewicz et al. 2000). Foley and Keever (1991) reported that benzyladenine at 200 mg×dm^{-3} delayed flowering by 13 days of *Dianthus caryophyllus* L. 'Knight Hybrid Scarlet'. The acceleration of flowering of growth retardant and cytokinin treated plants is not often observed. Following growth retardant application, earlier flowering was observed in *Lisianthus* (Starman, 1991), *Bougainvillea spectabilis* Willd. (Karaguzel, 1999) or seed propagated geranium *Pelargonium* × *hortorum* L. H. Bailey (Pobudkiewicz, 2000 c). Benzyladenine accelerated flowering in *Zantedeschia elliottiana* when the rhizome was soaked in BA solution (50-100 mg×dm^{-3}) during 30 minutes, prior to potting (Tjia, 1986). Earlier flowering was also noticed in BA treated *Bougainvillea* 'Taipei Red' (Liang and Chang, 1998) and *Oncidium* 'Aloha' (Lee et al. 1999). Flowering time of growth retardant treated plants sometimes can depend on plant species. For example, days to flowering of pot carnation 'Snowmass' (Pobudkiewicz and Nowak, 1994 a) were unaffected by double flurprimidol treatment at very high concentration (45 mg×dm^{-3}), but this retardant at very low concentration (7.5 mg×dm^{-3}) delayed flowering of chrysanthemum cvs. 'Altis' and 'Surf' (Pobudkiewicz and Nowak, 1997). Other studies conducted on *Eustoma grandiflorum* 'Yodel Blue' (Starman, 1991) and *Pelargonium* × *hortorum* 'Red Elite' (Starman et al. 1994) showed that the method of growth retardant application influenced the number of days to anthesis. In those experiments, foliar uniconazole treatment delayed flowering by 3 days, but drench application accelerated flowering by 4 days. It was reported that flurprimidol spray treatment increased days to flowering in oriental lily 'Mona Lisa', while soil drench unaffected flowering (Pobudkiewicz and Treder, 2006). The results of other studies conducted on *Dianthus* (Pobudkiewicz and Nowak, 1994 a), *Euphorbia* (Pobudkiewicz et al. 1995), *Pelargonium* (Pobudkiewicz and Nowak, 1999), *Globba* (Pobudkiewicz and Podwyszyńska, 1999), *Cuphea* (Pobudkiewicz, 2000 a), *Streptocarpus* (Pobudkiewicz, 2000 b) and *Lilium* (Pobudkiewicz and Treder, 2006) indicate that irrespective of growth retardant rate, plant species, or method of application, growth retardants had no influence on the number of days from potting plants to their flowering. Days to flowering of *Cyclamem persicum* 'Vuubaak' (Sakai et al. 1979) and pot carnation 'Snowmass' (Pobudkiewicz, 2005) were unaffected by BA at 50 mg×dm^{-3} and 50–300 mg×dm^{-3} , respectively.

Flower size

The influence of growth regulators on flower size depends on plant species, method of application and growth regulator rate. Flower size of growth retardant treated plants can depend on plant species, or even a cultivar. For example, flurprimidol diminished the flower diameter of asiatic hybrid lily 'Prima' (Pobudkiewicz and Nowak, 1992), but had no influence on the flower diameter of pot carnation 'Snowmass' (Pobudkiewicz and Nowak, 1994 a). Both flurprimidol and daminozide had no influence on floret size of dwarf alstroemeria 'Dorotea', but those retardants diminished the floret size of 'Rosalina' (Pobudkiewicz et al. 2000). The method of growth retardant application affected the tepal length of oriental lily 'Mona Lisa' (Pobudkiewicz and Treder, 2006). Foliar flurprimidol treatments suppressed lily tepal length, but soil drench only had little effect on it. Growth retardants, when used at rates optimum to improve plant habit, might not influence the flower size (Pobudkiewicz and Nowak, 1994 a; Pobudkiewicz and Nowak, 1997), but when used at high rates they often slightly diminish flower diameter. For example, Pobudkiewicz and Treder (2006) reported that tepal length of 'Mona Lisa' was not suppressed by single flurprimidol spray at lower concentrations (10-20 mg×dm^{-3}), but higher concentrations (30-40 mg×dm^{-3}) and all double treatments (10-40 mg×dm^{-3}) significantly reduced tepal length, comparing with the control. A smaller flower diameter of plants treated with growth retardants at high rates was also observed in asiatic hybrid lily 'Prima' (Pobudkiewicz and Nowak, 1992), *Poinsettia* (Pobudkiewicz et al. 1995), *Pelargonium* (Pobudkiewicz and Nowak, 1999), *Chrysanthemum indicum* (Jung et al. 2000), *Cuphea* (Pobudkiewicz, 2000 a) and *Streptocarpus* (Pobudkiewicz, 2000 b). BA at 500 µM diminished the inflorescence length of *Salvia splendens* Kerr Gawl 'Flamex 2000' (Ferrante et al. 2006), but BA applied

at concentrations of 50-300 mg×dm^{-3} had no influence on flower diameter of pot carnation 'Snowmass' (Pobudkiewicz, 2005).

Flower pedicel length

Growth regulators can influence the length of flower pedicel. Thanks to it, flowers are placed on the same level, what makes the plant very attractive. Floret pedicel length of seed propagated geranium *Pelargonium x hortorum* L.H. Bailey depended on the geranium cultivar and the rate of flurprimidol (Pobudkiewicz, 2000 c). The tested retardant at a low concentration (7.5 mg×dm^{-3}) had no effect on the pedicel length, but it markedly reduced it when used at the highest concentration (22.5 mg×dm^{-3}). Foliar spray of flurprimidol more efficiently diminished pedicel length of oriental lily 'Mona Lisa' than soil drench, which had only little effect on it (Pobudkiewicz and Treder, 2006). Shorter pedicels were also observed in dwarf pot roses 'Orange Sunblaze' (Pobudkiewicz and Goldsberry, 1989 a), asiatic hybrid lily 'Prima' (Pobudkiewicz and Nowak, 1992) and chrysanthemum 'Altis' and 'Surf' (Pobudkiewicz and Nowak, 1997) following growth retardant application.

Flower longevity

Growth retardants and cytokinins used in order to improve plant habit sometimes influence flower longevity, but it does not happen very often. For example, floret longevity of dwarf alstroemeria 'Rosalina' and 'Dorotea' was significantly shorter, when flurprimidol was applied at concentrations of 15 mg×dm^{-3} and above, but it was not affected by low concentration, 7.5 mg×dm^{3} (Pobudkiewicz et al. 2000). Greater flower longevity was observed in paclobutrazol treated *Episcia cupreata* 'Pink Panther' (Stamps and Henny, 1986). BA at 500 µM prolonged the flower longevity of *Salvia splendens* Kerr Gawl cv. 'Flamex 2000' (Ferrante et al. 2006). Growth retardants had no influence on flower longevity of asiatic hybrid lily 'Prima' (Pobudkiewicz and Nowak, 1992), chrysanthemum cvs. 'Altis' and 'Surf' (Pobudkiewicz and Nowak, 1997), *Pelargonium* (Pobudkiewicz and Nowak, 1999), *Cuphea* (Pobudkiewicz, 2000 a), seed propagated geranium (Pobudkiewicz, 2000 c), easter lily cv. 'Nellie White' (Ranwala et al. 2000) and oriental lily 'Mona Lisa' (Pobudkiewicz and Treder, 2006).

Flower bud abortion

Flower but abortion is usually observed in bulb plants treated with growth retardants at very high rates. For example, there was no bud abortion observed when oriental lily 'Mona Lisa' was sprayed with flurprimidol once at (10-40 mg×dm^{-3}) and twice at lower concentrations (10-20 mg×dm^{-3}). Double flurprimidol spray at higher concentrations increased the number of aborted buds. There were 19.4% and 32% of aborted buds on the plants treated with 30 and 40 mg×dm^{-3}, respectively (Pobudkiewicz and Treder, 2006). Similarly, in asiatic hybrid lily 'Prima' there was no bud abortion observed on the plants treated with flurprimidol at low concentration (10 mg×dm^{-3}) and on the control plants but higher concentrations: 20, 30, 40 and 50 mg×dm^{-3} increased bud abortion by 8%, 25%, 50% and 58%, respectively (Pobudkiewicz and Nowak, 1992).

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Wpływ retardantów wzrostu i cytokinin na kwitnienie roślin ozdobnych

Streszczenie

Retardanty wzrostu, stosowane w celu uzyskania niskich i zwartych roślin, hamują wydłużanie się pędów, ale wpływają także na kwitnienie roślin. Cytokininy natomiast stosowane są głównie do stymulacji rozkrzewiania się roślin, bez usuwania wierzchołka pędu. Zwiększając liczbę pędów bocznych, poprawiają one pokrój rośliny, ale wpływają też na jej kwitnienie. Retardanty i cytokininy mogą wpływać na wielkość kwiatu, długość szypułki kwiatowej, liczbę kwiatów na roślinie, trwałość kwiatu, liczbę dni od posadzenia do zakwitania roślin lub opadanie pąków kwiatowych. Na kwitnienie roślin traktowanych retardantem lub cy-

tokininą mogą mieć wpływ: metoda stosowania regulatora wzrostu (dolistna lub do podłoża), gatunek rośliny a nawet i odmiana, ale w najwyższym stopniu wpływa stosowana dawka regulatora wzrostu. Retardanty lub cytokininy stosowane w dawkach odpowiednich do otrzymania roślin niskich i o dobrym pokroju, rzadko wpływają na ich kwitnienie, natomiast stosowane w wysokich dawkach mogą zwiększyć liczbę dni od posadzenia roślin do ich zakwitania, zmniejszyć wielkość kwiatu, skrócić szypułki kwiatowe oraz zmniejszyć liczbę kwiatów na roślinie. W uprawie roślin cebulowych, retardanty wzrostu stosowane w bardzo wysokich dawkach, powodują opadanie pąków kwiatowych.