EFFECTS OF FLURPRIMIDOL AND CONCENTRATION OF NUTRIENT SOLUTION ON GROWTH AND FLOWERING OF TWO OSTEOSPERMUM CULTIVARS 'CREAM SYMPHONY' AND 'LEMON SYMPHONY'

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A B S T R A C T

The effect of flurprimidol spray application at 15, 30, and 45 mg dm^{-3} and concentration of nutrient solution of 1.3, 1.8, and 2.3 mS cm^{-1} on the growth and flowering of 'Cream Symphony' and 'Lemon Symphony' osteospermum were evaluated. Compared with control plants, some remarkable results measured at the time of flowering were obtained. One spray with flurprimidol at 45 mg dm^{-3} caused suitable growth retardation and increased shoot, flower bud and flower numbers. The effect of flurprimidol on flowering time was negligible. Plants treated with flurprimidol had darker green foliage than those untreated. Increasing concentration of nutrient solution decreased shoot, flower bud and flower numbers. The highest concentration of nutrient solution inhibited plant growth and caused small necrotic spots on the lowest leaves.

Key words: osteospermum, flurprimidol, growth retardation, mineral nutrition

INTRODUCTION

'Cream Symphony' and 'Lemon Symphony' are new cultivars of osteospermum bred in Japan. The Symphony group has medium size flowers, but it is very floriferous, thriving in even the hottest summer, whereas in many other cultivars the flowering is diminished by high temperatures. Both cultivars, as well as others from the Symphony group, can form a vivid display of colour when planted in mass and provide continuous colour until autumn.

One of the keys to successful production of osteospermum is height control. Growth retardants are recom-

mended in order to keep plant short and to improve plant habit. Older cultivars of osteospermum can be retarded using chlormequat chloride (CCC) (Hass-Tschirschke, 1996; Gibson and Whipker, 2000). Multiple application of CCC is required to obtain a good shape of plants. CCC can cause marginal chlorosis of leaves if sprayed at concentrations too high for the treated cultivar. For less vigorous cultivars daminozide applied twice is recommended (Gibson and Whipker, 2000), but it can delay flowering and be toxic for leaves of some cultivars (Olsen and Andersen, 1995).

Recently flurprimidol has been found as a highly effective growth retardant for ornamental plants. It has been demonstrated that flurprimidol is effective in limiting internode elongation of vigorous osteospermum cultivars (Olsen and Andersen, 1995). The effect of flurprimidol on cultivars from the Symphony group is unknown. Experiments were therefore carried out to examine the efficacy of a single spray with flurprimidol in the height control of the two cultivars from this new group of osteospermum. As the treatment with growth retardants affects many growth characteristics, e.g. internode length, branching, flowering, it can also affect the nutritional needs of plants. For this reason, the effect of mineral nutrient solution concentration on the growth of untreated and flurprimidol – treated plants was also investigated. High concentration of nutrient solution can also serve as an additional factor inhibiting plant growth (Ingestad, 1981; van Leeuven, 1993).

MATERIAL AND METHODS

Rooted cuttings of osteospermum 'Cream Symphony' and 'Lemon Symphony' *Osteospermum ecklonis* (DC.) Norl. were planted on March 17 into 10-cm-wide pots, using a sphagnum peat-based growing medium (pH 5.7, EC 0.9 mS cm^{-1}), amended with PG Mix mineral fertilizer at 1.2 g dm^{-3}. Plants were pinched on March 24; 3 pairs of leaves remained on the stem.

Plants were fertigated by subirrigation (ebb-and-flow benches, Clauhan Project A/S, Denmark). Commercially available fertilizers Peters Professional (27:15:12) and Peters Professional (5:11:26) in equal amounts were used for preparation of nutrient solution. EC (electrical conductivity) of nutrient solutions was: 1.3, 1.8, and 2.3 mS cm^{-1}, and pH 6.6, irrespectively of the EC. Macroelement contents of nutrient solutions were: EC 1.3: 97 N, 18 P, 50 K, and 5 Mg; EC 1.8: 146 N, 27 P, 75 K, and 7.5 Mg; EC 2.3: 219 N, 41 P, 125 K, and 12.5 Mg (in mg dm^{-3}). The irrigation frequency was one every 2 days or one per day, depending on size of plants and solar radiation. After the fertigation the surplus of nutrient solution was always led back to the reservoir. Fresh nutrient solution was added to the reservoir weekly. There were three sections of the benches fertigated separately.

The greenhouse environment was maintained at 20°C/16°C (day/night) temperature.

Flurprimidol (Topflor 015 SL) was applied once as a foliar spray at 15, 30, and 45 mg dm^{-3} three weeks after planting, when the plants were 7-8 cm high and side shoots were 1-6 cm long. The plants were treated with growth retardant until the foliage was thoroughly covered but the solution was not allowed to drip off (about 1.6 ml per plant). The control plants were sprayed with tap water at the same time.

All growth parameters were determined at the beginning of flowering, about 7 weeks after planting. All plants were measured.

The experiment employed a two-factorial design with 3 concentrations of nutrient solution and 4 concentrations of flurprimidol. There were 20 pots per treatment, each plant was treated as a replication. The data were statistically elaborated by an analysis of variance and means were compared with Duncan's multiple range t-test at P=0.05.

RESULTS AND DISCUSSION

Height of 'Cream Symphony' plants treated with flurprimidol at 45 mg dm^{-3} was significantly lesser than in the control, irrespectively of the concentration of nutrient solution (Tab. 1). For plants grown at the highest concentration of this solution (EC 2.3 mS cm^{-1}) flurprimidol spray at 30 mg dm^{-3} was just as effective in height control as 45 mg dm^{-3}. Similar results were obtained for the slightly taller cultivar 'Lemon Symphony' (Tab. 2). Flurprimidol at 45 mg dm^{-3} was the most effective in height control. The highest concentration of nutrient solution also inhibited plant growth.

Osteospermum appears to be less sensitive to flurprimidol than other species. Well-retarded plants were obtained with its relatively high rates, while *Anemone* and *Ranunculus* (Albrecht, 1987), *Cuphea ignea* (Pobudkiewicz, 2000b), *Pelargonium x hortorum* (Pobudkiewicz and Nowak, 1999) required lower amounts of this agent.

Treatment with flurprimidol at 45 mg dm^{-3} decreased the plant diameters of 'Cream Symphony', irrespectively of the concentration of nutrient solution. The highest concentration of this solution decreased significantly the diameters of all plants, both treated and untreated with flurprimidol. Similar results were obtained for 'Lemon Symphony'. The canopies of both cultivars treated with flurprimidol were smaller and more compact than those untreated. With certain other flowering potted plants (e.g. geranium), treatment with flurprimidol also decreased the plant diameter (Whipker et al., 1997).

Flurprimidol at 45 mg dm^{-3} increased the shoot number of 'Cream Symphony' and 'Lemon Symphony', irrespectively of the concentration of nutrient solution. Increasing concentration of this solution reduced the shoot number of both cultivars.

Table 1. The effects of nutrient solution concentration [EC] and flurprimidol application on growth of 'Cream Symphony' osteospermum

EC [mS cm^{-1}]	Flurprimidol [mg dm^{-3}]	Plant height [cm]	Plant diameter [cm]	Shoot number	Leaf length [cm]	Leaf width [cm]
1.3	0	30.4 e*	17.9 cd	15.5 def	5.9 c	2.2 cd
1.3	15	29.9 e	17.0 bc	16.6 fg	5.7 bc	2.1 bcd
1.3	30	29.2 de	16.7 bc	17.0 fg	6.0 c	2.3 d
1.3	45	25.3 ab	15.6 b	18.3 g	5.5 abc	2.2 cd
1.8	0	30.0 e	17.8 cd	12.1 bc	5.4 abc	1.9 abc
1.8	15	29.9 e	16.3 bc	13.9 cde	5.8 c	1.9 abc
1.8	30	27.5 bcd	16.7 bc	14.2 cde	5.5 abc	1.9 abc
1.8	45	26.2 abc	15.6 b	16.2 efg	5.5 abc	2.0 bcd
2.3	0	30.0 e	15.5 b	9.4 a	5.0 ab	1.6 a
2.3	15	28.4 cde	13.3 a	8.6 a	5.0 ab	1.9 abc
2.3	30	25.1 a	13.0 a	10.6 ab	4.9 a	1.8 ab
2.3	45	26.4 abc	13.7 a	13.6 cd	5.3 abc	1.9 abc
Significance						
EC		xx	xxx	xxx	xxx	xxx
Flurprimidol		xxx	xxx	xxx	ns	ns
EC x flurprimidol		xxx	xxx	xxx	ns	ns

*The means followed by the same letter(s) do not differ at P =0.05; ns, x, xx, xxx – non significant or significant at P=0.1, 0.05, 0.01, respectively

Table 2. The effects of nutrient solution concentration [EC] and flurprimidol application on growth of 'Lemon Symphony' osteospermum

EC [mS cm^{-1}]	Flurprimi-dol [mg dm^{-3}]	Plant height [cm]	Plant diameter [cm]	Shoot number	Leaf length [cm]	Leaf width [cm]
1.3	0	34.6 ef*	19.1 bc	13.1 bc	6.7 d	2.5 e
1.3	15	31.9 cd	19.0 bc	17.8 d	6.2 bcd	2.3 bcde
1.3	30	32.6 de	17.8 abc	16.9 d	6.3 bcd	2.4 de
1.3	45	28.0 ab	17.4 ab	17.7 d	6.3 bcd	2.3 bcde
1.8	0	35.3 f	19.8 c	11.2 b	6.5 cd	2.3 bcde
1.8	15	33.0 def	18.8 abc	13.6 c	6.0 bcd	2.1 bc
1.8	30	30.6 cd	18.9 bc	13.5 c	5.7 ab	1.9 ab
1.8	45	30.1 bc	16.5 a	18.6 d	5.7 ab	2.0 abc
2.3	0	32.2 cd	16.6 a	8.0 a	6.6 d	2.3 cde
2.3	15	32.0 cd	17.8 abc	12.5 bc	5.8 abc	2.2 bcd
2.3	30	30.0 bc	16.6 a	12.3 bc	5.3 a	1.8 a
2.3	45	26.2 a	15.7 a	12.8 bc	5.8 abc	2.1 bc
Significance						
EC		xxx	xxx	xxx	xxx	xxx
flurprimidol		xxx	xx	xxx	xxx	xxx
EC x flurprimidol		x	x	xxx	ns	ns

*Explanations see Table 1

Table 3. The effects of nutrient solution concentration [EC] and flurprimidol application on flowering of 'Cream Symphony' osteospermum

EC [mS cm^{-1}]	Flurprimidol [mg dm^{-3}]	Number of days from planting to flowering	Flower bud number	Flower number	Flower diameter [cm]
1.3	0	40.7 ab	12.2 de	6.7 de	5.9 c
1.3	15	41.6 abc	13.1 e	6.3 cde	5.8 c
1.3	30	46.3 d	11.8 de	7.4 de	5.8 c
1.3	45	43.3 abcd	12.8 e	5.9 bcde	5.7 c
1.8	0	39.5 a	9.0 abc	8.2 e	5.6 c
1.8	15	40.8 ab	9.0 abc	7.3 de	5.5 c
1.8	30	39.1 a	9.7 bcd	8.0 e	5.7 c
1.8	45	40.1 a	13.4 e	7.6 e	5.8 c
2.3	0	40.1 a	6.9 a	5.2 abcd	4.5 a
2.3	15	45.4 cd	7.6 ab	3.1 a	5.0 b
2.3	30	44.8 bcd	7.2 ab	4.0 ab	4.6 ab
2.3	45	42.2 abcd	10.2 cd	4.2 abc	5.0 b
Significance					
EC		xxx	xxx	xxx	xxx
Flurprimidol		xx	xxx	ns	ns
EC x flurprimidol		ns	ns	ns	ns

*Explanations see Table 1

Flurprimidol had no effect on leaf dimensions of 'Cream Symphony', however they were reduced by the increasing concentration of nutrient solution. In 'Lemon Symphony', leaf dimensions decreased in flurprimidol – treated plants grown at EC 1.8 and 2.3 mS cm^{-1}, and also in response to the increasing concentration of nutrient solution.

Effect of flurprimidol on the flowering time of 'Cream Symphony' was negligible, but 'Lemon Symphony' treated at 45 mg dm^{-3} flowered about 4 days later (Tab. 3 and 4). A significant delay in flowering was seen in plants treated with over-strong concentrations of this agent (Pobudkiewicz and Nowak, 1992). In some plants flowering time was not affected by flurprimidol or varied with the cultivar and growth retardant rate (Pobudkiewicz, 2000a). The effect of concentration of nutrient solution on flowering time was negligible for both cultivars.

Flurprimidol at 45 mg dm^{-3} increased the flower bud number of 'Cream Symphony' grown at 1.8 and 2.3 mS cm^{-1}, and also in 'Lemon Symphony', irrespectively of the concentration of nutrient solution. The number of flowers and flower diameters of both cultivars were unaffected by flurprimidol. However, a decrease of inflorescence diameter

Table 4. The effects of nutrient solution concentration [EC] and flurprimidol application on flowering of 'Lemon Symphony' osteospermum

EC [mS cm^{-1}]	Flurprimidol [mg l^{-1}]	Number of days from planting to flowering	Flower bud number	Flower number	Flower diameter [cm]
1.3	0	42.5 a*	12.1 def	5.5 bc	6.2 c
1,3	15	41.8 a	13.6 efg	6.5 c	6.0 bc
1.3	30	46.4 b	15.3 gh	4.5 abc	5.8 bc
1.3	45	46.6 b	16.3 h	3.2 ab	5.8 bc
1.8	0	41.5 a	10.8 bcd	5.3 bc	5.9 bc
1.8	15	42.9 a	11.4 cd	7.0 c	5.9 bc
1.8	30	40.7 a	10.6 bcd	7.0 c	5.9 bc
1.8	45	45.5 b	14.0 fg	9.3 d	5.9 bc
2.3	0	41.5 a	9.6 abc	4.8 abc	5.6 ab
2.3	15	42.0 a	8.7 ab	5.7 c	5.8 bc
2.3	30	42.0 a	8.2 a	6.2 c	5.3 a
2.3	45	45.9 b	11.8 de	2.7 a	5.5 ab
Significance					
EC		xx	xxx	xxx	xxx
Flurprimidol		xxx	xxx	ns	ns
EC x flurprimidol		xxx	x	xxx	ns

*Explanations see Table 1

in flurprimidol treated geranium was earlier observed (Pobudkiewicz, 2000a). The highest concentration of nutrient solution (EC 2.3 mS cm^{-1}) limited the numbers of flower buds and flowers, as well as the diameters of 'Cream Symphony' flowers, and the flower bud number of 'Lemon Symphony'.

Plants treated with flurprimidol had darker green foliage than those untreated. Beneficial effect of new growth retardants on leaf colour of pot plants was earlier observed (Tjia, 1986; Maus, 1987; Pobudkiewicz, 2000b). At flowering, small necrotic spots on the lowest leaves were seen on plants grown at the highest concentration of nutrient solution (EC 2.3 mS cm^{-1}). For this reason, such a high concentration of this solution cannot be recommended as a dwarfing factor for osteospermum.

CONCLUSIONS

One application with flurprimidol at 45 mg dm^{-3} effectively suppressed shoot elongation of osteospermum of the Symphony group. Very good quality plants of both cultivars can be obtained using the lowest concentration of nutrient solution tested (1.3 mS cm^{-1}) since its higher concen-

trations decreased shoot, flower bud and flower numbers.

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WPŁYW FLUROPRIMIDOLU I STĘŻENIA POŻYWKI NAWOZOWEJ NA WZROST I KWITNIENIE DWÓCH ODMIAN OSTEOSPERMUM 'CREAM SYMPHONY' I 'LEMON SYMPHONY'

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S T R E S Z C Z E N I E

Badano wpływ fluroprimidolu w stężeniach 15, 30 i 45 mg dm^{-3} oraz stężenia pożywki nawozowej: 1,3, 1,8 i 2,3 mS cm^{-1} na wzrost i kwitnienie dwóch nowych, japońskich odmian osteospermum: 'Cream Symphony' i 'Lemon Symphony'. Jedno opryskiwanie roślin roztworem fluroprimidolu w stężeniu 45 mg dm^{-3} hamowało nadmierny wzrost wydłużeniowy pędów oraz zwiększało liczbę pędów, pąków kwiatowych i kwiatów. Wpływ fluroprimidolu na termin kwitnienia był nieznaczny. Rośliny traktowane fluroprimidolem miały intensywniej zabarwione liście niż rośliny kontrolne. Wraz ze wzrastającym stężeniem pożywki nawozowej obserwowano spadek liczby pędów, pąków kwiatowych i kwiatów. Rośliny nawożone najbardziej stężoną pożywką były znacznie niższe i miały drobne, nekrotyczne plamy na dolnych liściach.

Słowa kluczowe: osteospermum, fluroprimidol, hamowanie wzrostu, żywienie mineralne