

**Growth and flowering of *Impatiens walleriana* Hook
grown from transplants treated
with leaf- and soil-applied retardants**

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ABSTRACT

Transplants of *Impatiens walleriana* 'Cajun Lilac F₁' were grown in a greenhouse in pots in a peat substrate with the addition of sand. Daminozide, chlormequat and flurprimidol were used 1-3 times at 14-day intervals in foliar and soil applications. In May plants were transplanted to the soil. The dynamics of growth and flowering were investigated in plants grown outdoors. The strongest and longest-lasting inhibitory effect on the growth of bedding plants was found for daminozide and chlormequat in foliar application. Soil-applied flurprimidol had a stronger dwarfing effect than daminozide and chlormequat. Flurprimidol and chlormequat applied to the soil twice at a concentration of 690 mg l⁻¹ had a positive residual effect on plant flowering.

INTRODUCTION

The interest in bedding plants has been growing and the share of this group of plants in the overall production has been systematically increasing. Only good quality plants are purchased. One of the effective methods to improve the quality of bedding plants is to apply growth retardants. Their application results in the production of plants with a lower, more compact habit and regular shape. However, the reaction of various bedding plants to the action of growth retardants varies, thus their action needs to be tested in the cultivation of new species and cultivars appearing on the market (Latimer 1991, Ueber 2000).

The aim of the experiment was to determine growth and flowering dynamics of *Impatiens walleriana* 'Cajun Lilac F₁' grown from transplants subjected to the action of three growth retardants: daminozide, chlormequat and flurprimidol, both leaf- and soil-applied.

MATERIAL AND METHODS

In the years 2001 – 2002 two experiments were carried out in a greenhouse and in the field, in which the effect was assessed of leaf- and soil-applied retardants daminozide, chlormequat and flurprimidol on the growth and flowering of the *Impatiens walleriana* Hook 'Cajun Lilac F₁'.

Young plants were planted in 9-cm pots and grown in a greenhouse. Peat substrate was mixed with sand at 3:1 (v/v). The medium was enriched with 2 g slow-release mixed fertiliser Osmocote 3-4 M and 0.5 g brown Superba per 1 dm³. Every 10 days 0.1% solutions of mixed fertilisers were applied as top dressing: yellow Kristalon (13:40:13), blue Kristalon (19:6:20), and white Kristalon (15:5:30), 50 ml per pot. Once, at the beginning of culture, all the plants were fed with 0.1% lime saltpetre.

In the first experiment conducted from March to July 2001, the retardants were leaf-applied. The plants were first treated on 27 March 2001; the next treatments were applied on 10 and 24 April 2001: daminozide at the concentrations of 1275 mg l⁻¹ and 1700 mg l⁻¹ (B-Nine 85 SP at the concentrations of 0.15 and 0.2%, respectively); chlormequat at the concentrations of 460 mg l⁻¹ and 690 mg l⁻¹ (Cycocel 460 SL at the concentrations of 0.2 and 0.3%, respectively) and flurprimidol at the concentrations of 3.79 mg l⁻¹ and 7.58 mg l⁻¹ (Topflor 015 SL at the concentrations of 0.025 and 0.05%, respectively). The schedule of treatments is presented in Table 1.

The experiment consisted of 15 treatments (retardant × its application variant) with 30 replications in each, one plant being a replication.

Table 1. Schedule of retardant application to leaves

Variant of retardant application	Date of application								
	27.03	10.04	24.04	27.03	10.04	24.04	27.03	10.04	24.04
	Retardant (mg l ⁻¹)								
	Daminozide			Chlormequat			Flurprimidol		
0	0	0	0	0	0	0	0	0	0
I	1275	0	1275	460	0	460	3.79	0	3.79
II	1275	1275	1275	460	460	460	3.79	3.79	3.79
III	1275	1700	1700	460	690	690	3.79	7.58	7.58
IV	1700	1700	1700	690	690	690	7.58	7.58	7.58

Retardant-treated plants were transplanted to the field on 8 May 2001 at a 20 × 20 cm spacing. Every 14 days measurements were taken of their height, as well as the number of buds and flowers.

The results of the last measurement in the greenhouse and the last measurement in the field were processed statistically using the analysis of variance, and the means obtained were grouped using Duncan's test at the significance level $p = 0.05$.

The second experiment was conducted from March to September 2002. After a month of culture, the plants were watered with retardant solutions. Daminozide was applied at the concentration of 1700 mg l⁻¹ (B-Nine at the concentration of 0.2%), chlormequat at the concentration of 690 mg l⁻¹ (Cycocel 460 SL at the concentration of 0.15%) and flurprimidol at the concentration of 3.79 mg l⁻¹ (Topflor 015 SL at the concentration of 0.025%), 50 ml per pot. Two weeks later plants of variant II were watered with the same does at retardant solutions again.

Retardant-treated plants were transplanted to the field on 15 May 2002 at a 20 × 20 cm spacing. The experiment consisted of 9 treatments (retardant × its application variant) with 15 replications in each, one plant being a replication.

Measurements of plant height and the number of buds and flowers were carried out every month from May to September.

The results were processed statistically using the analysis of variance, and the means were grouped using Duncan's test at the significance level $p = 0.05$.

RESULTS

The growth and flowering of plants grown from transplants subjected to the action of leaf-applied retardants

Statistical analysis of the last measurement of the height of plants grown in the greenhouse showed that retardants had a significant effect on the height of *Impatiens walleriana* (Table 2).

Table 2. Height (cm) of plants after the application of retardants to leaves

Variant of retardant application	Date of measurement						
	28.03	11.04	25.04	8.05	22.05	5.06	19.06
	Greenhouse				Field		
Daminozide							
0	6.6	11.1	14.7	15.8 d*	13.1	13.2	13.3 bc
I	6.6	9.9	11.7	15.5 d	12.7	13.4	13.5 bc
II	6.4	9.3	9.6	13.0 c	10.5	11.0	13.9 c
III	6.2	9.4	15.9	13.5 c	9.1	11.7	11.8 ab
IV	6.7	9.2	10.1	13.3 c	9.2	11.5	10.7 a
Mean				14.2 b			12.6 a
Chlormequat							
0	6.6	11.1	14.7	15.8 d	13.1	13.2	13.3 bc
I	6.6	11.4	11.8	12.6 bc	11.8	12.7	13.3 bc
II	6.6	9.8	10.8	15.3 d	10.6	12.6	13.0 b
III	6.9	10.2	11.8	15.1 d	10.6	12.8	12.9 abc
IV	6.1	8.5	11.0	10.5 a	10.7	10.7	11.3 a
Mean				13.2 a			12.8 a
Flurprimidol							
0	6.6	11.1	14.7	15.8 d	13.1	13.2	13.3 bc
I	6.5	9.2	12.8	12.8 bc	10.6	11.2	13.0 b
II	5.8	8.8	11.6	12.4 b	10.5	11.4	13.3 bc
III	5.9	8.7	11.1	12.5 c	9.2	10.6	12.8 abc
IV	5.7	8.3	11.1	12.5 c	8.7	13.0	13.2 bc
Mean				13.2 a			13.1 a

*Means followed by the same letter do not differ significantly at $p = 0.05$

In comparison to control plants variant IV of chlormequat treatment, when plants were sprayed with a solution of this retardant at the concentration of 690 mg l^{-1} , was the most effective. Significant differences between the height of control plants and that of daminozide-treated plants (with the exception of the application at the concentration of 1275 mg l^{-1} repeated twice), recorded at planting on May 8, persisted until the completion of the trial only after the application of this retardant at the concentration of 1275 mg l^{-1} and 1700 mg l^{-1} and after the application at 1700 mg l^{-1} repeated three times.

While analyzing the number of buds and flowers in May, no differences were found between the actions of the applied retardants (Table 3). After transplanting to the soil the number of forming buds and flowers decreased. This downward trend lasted until June.

Table 3. Number of buds and flowers after application of retardants to leaves

Variant of retardant application	Date of measurement						
	28.03	11.04	25.04	8.05	22.05	5.06	19.06
	Greenhouse			Field			
Daminozide							
0	0	32.8	70.8	90.5 ab	57.6	50.1	61.6 a
I	0	27.5	74.3	91.9 abc	49.0	48.4	74.2 b
II	0	33.8	70.1	91.0 abc	49.4	38.0	68.2 ab
III	0	33.0	75.9	92.6 abc	60.0	38.2	70.4 ab
IV	0	22.2	74.9	95.4 bc	67.8	45.4	75.6 b
Mean				92.3 a			70.0 b
Chlormequat							
0	0	32.8	70.8	90.5 ab	57.6	50.1	61.6 a
I	0	24.3	75.1	94.1 abc	62.4	41.4	73.4 b
II	0	41.9	33.9	89.5 ab	57.6	40.4	67.6 ab
III	0	38.0	64.7	89.9 ab	59.4	46.4	71.8 b
IV	0	39.0	73.1	97.5 c	57.8	46.4	71.4 b
Mean				92.3 a			69.2 b
Flurprimidol							
0	0	32.8	70.8	90.5 ab	57.6	50.1	61.6 a
I	0	46.1	71.3	93.3 abc	61.6	54.0	67.4 ab
II	0	35.6	66.9	87.5 a	61.6	49.0	72.0 b
III	0	33.6	63.9	93.0 abc	66.4	57.4	67.6 ab
IV	0	35.6	70.2	90.8 ab	64.6	29.2	61.0 a
Mean				91.0 a			66.0 b

Explanation – see Table 2

At the moment of the completion of the observations of plants grown outdoors differences were recorded between the action of daminozide, chlormequat and flurprimidol.

The plants treated with a daminozide solution applied twice at the concentration of 1275 mg l⁻¹ and three times at the concentration of 1700 mg l⁻¹ (variants I and IV) flowered more abundantly than the control plants, forming by 20.4 and 22.7%, more buds and flowers respectively.

More abundant flowering was also found for chlormequat-treated plants (variants I, III and IV), when plants were sprayed two times with retardant at 460 mg l⁻¹; once at 460 mg l⁻¹ and twice at 690 mg l⁻¹ and three times with the retardant solution at the concentration of 960 mg l⁻¹.

In case of flurprimidol, more (by 16.8% in relation to the control) buds and flowers were formed by plants treated three times with this preparation at the concentration of 3.79 mg l⁻¹.

The growth and flowering of plants grown from transplants subjected to the action of soil-applied retardants

The conducted statistical analysis performed for measurements taken on plants in the greenhouse in May did not show any differences between the actions of individual retardants. The only observed differences were those within individual variants of retardant applications (Table 4).

Table 4. Height (cm) of plants after the application of retardants directly to peat-substrate

Variant of retardant application	Date of measurement				
	V Greenhouse	VI	VII	VIII	IX Field
Daminozide					
0	8.7 b	10.2	11.3	12.4	13.3 c
I	8.7 b	9.0	10.8	11.5	11.8 bc
II	7.5 a	9.4	10.1	11.0	11.3 bc
Mean	8.3 a				12.1 b
Chlormequat					
0	8.7 b	10.2	11.3	12.4	13.3 c
I	8.2 b	9.3	10.8	11.0	11.7 bc
II	6.3 a	7.8	9.5	10.2	10.6 b
Mean	7.7 a				11.8 a
Flurprimidol					
0	8.7 b	10.2	11.3	12.4	13.3 c
I	7.2 a	8.0	8.7	9.1	9.9 a
II	6.8 a	7.2	8.1	8.8	9.4 a
Mean	7.5 a				10.8 a

Explanation – see Table 2

The best growth inhibiting effect in May was found for the second soil application of a daminozide solution at the concentration of 1700 mg l⁻¹ and that of chlormequat at the concentration of 960 mg l⁻¹, as well as one or two soil applications of a flurprimidol solution at the concentration of 3.79 mg l⁻¹. Plants treated with these concentration variants were lower than control plants by 13.7 and 27.5, 17.2 and 21.8%, respectively. In case of flurprimidol the growth retarding effect persisted until the completion of observations of plants cultivated outdoors. In September plants watered with a solution of this retardant were lower than controls.

For the three applied preparations, statistically significant differences were found between the action of daminozide and that of chlormequat and flurprimidol

in the beginning of plant growing (Table 5). Plants watered once with a chlormequat solution at the concentration of 960 mg l⁻¹ flowered less abundantly, producing by 23.1% fewer buds and flowers than control plants.

Similar properties were also shown for flurprimidol applied once and twice at the concentration of 3.79 mg l⁻¹ as its use resulted in the formation of 18.4% and 17.8% fewer buds and flowers.

From June to August a decrease was observed in the intensity of flowering. In turn, in September in the plants treated twice with chlormequat and both of flurprimidol does a marked increase was found in the number of buds and flowers. In case of chlormequat the number of buds and flowers increased by 138%, while for flurprimidol applied once by 145.7% and twice by 108.4% in comparison to control plants. Statistical analysis of the last measurement of plants in the ground performed in September showed significant differences between the actions of individual retardants.

Table 5. The number of buds and flowers after the application of retardants directly to peat-substrate

Variant of retardant application	Date of measurement				
	V Greenhouse	VI	VII Field	VIII	IX
Daminozide					
0	80.7 b	60.3	45.7	12.5	23.6 ab
I	79.1 b	57.5	34.2	11.0	15.6 a
II	77.4 b	53.2	42.5	12.0	22.2 ab
Mean	79.1 b				20.4 a
Chlormequat					
0	80.7 b	60.3	45.7	12.5	23.6 ab
I	62.0 a	54.3	17.6	11.8	25.8 b
II	75.2 b	69.1	16.1	11.3	56.3 c
Mean	72.6 a				35.2 b
Flurprimidol					
0	80.7 b	60.3	45.7	12.5	23.6 ab
I	65.8 a	59.1	14.5	33.4	58.0 c
II	66.3 a	60.2	18.3	23.2	49.2 c
Mean	70.9 a				43.6 c

Explanation – see Table 2

DISCUSSION

The effects of retardants are temporary and reversible. They depend not only on the concentration of the preparation and the method of its application, but also on the susceptibility of the treated species (Barret and Nell 1989). Consumers expect the purchased plants to be decorative throughout the whole period of their growth, and not only at the moment of their purchase. For this reason it is essential to know the persistency of the effects of growth retardants, as well as their residual effect on plants. In the conducted experiment all the applied retardants inhibited the growth of *Impatiens walleriana* 'Cajun Lilac F₁' transplants.

Flurprimidol may be used both in foliar and soil applications. At both modes it exhibits a strong growth inhibiting effect (Pobudkiewicz 1995, Startek 2003). In the experiment conducted by the authors of this study this retardant when leaf-applied did not have an effect on the height of plants towards the end of plant growth. This is confirmed by the study of Startek and Dobrowolska (2003), who obtained higher plants at both application methods of Topflor in *Impatiens walleriana* of the Fiesta group. In turn, soil application of this preparation had an advantageous residual effect on the investigated character.

Treating plants with growth retardants may have a positive effect on their flowering. This advantageous residual effect was observed after soil application of flurprimidol.

Chlormequat has a weaker effect on *Impatiens walleriana*. Its foliar application repeated three times at the concentration of 690 mg l⁻¹ permanently inhibited plant growth throughout the whole growing period. Soil application of chlormequat had an advantageous effect on the abundance of flowering.

B-Nine containing daminozide is recommended primarily for foliar treatments, since its effectiveness in soil application is low as it was reported by Nowak and Grzesik (1997). This was also confirmed in this study. Daminozide in foliar application had a short-time effect and inhibited growth only in the initial period of growth, except when applied three times at the concentration of 1700 mg l⁻¹. Latimer (1991) on the basis of his experiments stated that the action of daminozide inhibits plant growth for 5-7 weeks since planting in the soil and after that time plants treated with this growth retardant reach the same height as controls.

Foliar application of daminozide did not have an effect on the flowering of *Impatiens walleriana* 'Cajun Lilac F₁' transplants. An advantageous residual effect of this growth retardant applied twice at the concentration of 1275 mg l⁻¹ and three times at the concentration of 1700 mg l⁻¹ was observed towards the end of soil cultivation.

CONCLUSIONS

1. Daminozide and chlormequat in foliar applications had the strongest and longest-lasting growth inhibiting effect on *Impatiens walleriana* 'Cajun Lilac F₁' grown in the field.
2. Foliar application of daminozide and chlormequat had an advantageous effect on plant flowering.
3. When soil-applied, flurprimidol inhibited plant growth the longest.
4. Flurprimidol and chlormequat soil-applied twice at the concentration of 690 mg l⁻¹ had an advantageous effect on the flowering of soil-cultivated plants.

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WZROST I KWITNIENIE NIECIERPKA WALLERIANA
(*IMPATIENS WALLERIANA* Hook) UPRAWIANEGO Z ROZSADY
PODDANEJ DZIAŁANIU RETARDANTÓW STOSOWANYCH DOLISTNIE
I DOGLEBOWO

Streszczenie: Rozsadę niecierpka walleriana ‘Cajun Lilac F₁’ uprawiano w szklarni w doniczkach, w substracie torfowym z dodatkiem piasku. Zastosowano daminozyd, chloromekwat i flurpirimidol 1-3 razy w odstępach 14-dniowych: dolistnie i doglebowo. W maju rośliny posadzono do gruntu. Prześledzono dynamikę wzrostu i kwitnienia roślin uprawianych w gruncie. Najsilniej i najdłużej hamowały wzrost roślin uprawianych w gruncie daminozyd i chloromekwat zastosowane dolistnie. Flurpirimidol zastosowany doglebowo miał silniejsze właściwości skarłające niż daminozyd i chloromekwat. Flurpirimidol i chloromekwat zastosowany doglebowo dwukrotnie w stężeniu 690 mg l⁻¹ wywierał pozytywny następczy wpływ na kwitnienie roślin.

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