



## Using Paclobutrazol, Daminozide, Chlormequat, Propiconazole on Vegetative Growth and Flowering Control of Zinnia

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**Abstract:** PGRs such as paclobutrazol, daminozide, chlormequat and propiconazole help to alter various growth characteristics of plants and they are used commonly in the modern production system of ornamental plants. The objective of this work was to evaluate the effects of the optimum dose, decreasing and increasing amounts of the optimum dose of paclobutrazol, daminozide, chlormequat and propiconazole used in the modern production system of zinnia (*Zinnia elegans* Jacq.) vegetative growth parameters and flowering in a greenhouse experiment. Plant height was reduced with the administration of 2 g L<sup>-1</sup> of daminozide (T<sub>4</sub>) at a ratio of 20.87% compared to the control group. The plants treated with 1.5 ml L<sup>-1</sup> of chlormequat (T<sub>9</sub>) had the highest main stem diameter, flower stalk diameter (4.50 mm) and side branch length (16.17 cm). It was determined that the highest side branch diameter (3.78 mm) and number of flower buds (4.67 per plant) were manifested with T<sub>4</sub>. The treatment of T<sub>4</sub> can be used to increase the number of flower buds of zinnias. The result showed that the use of 2 g L<sup>-1</sup> of daminozide (T<sub>4</sub>) reduced the internode length compared to the control group at a rate of 58.60%. In summary, it was concluded that the chemicals and all the doses used in the experiment did not affect the deterioration of the flower quality of zinnias. On the contrary, it was concluded that more compact plants can be obtained by providing height control especially by applying different doses of daminozide. In order to shorten the production period of zinnias, it may be advisable to apply 0.25 ml L<sup>-1</sup> of propiconazole.

**Keywords:** Plant growth retardants, *Zinnia elegans* Jacq., plant height, compact plant form

### Paclobutrazol, Daminozid, Klormequat, Propiconazole Zinnia'nın Vejetatif Büyümesi ve Çiçek Kontrolü Üzerinde Kullanılması

**Öz:** Paclobutrazol, daminozide, chlormequat ve propiconazole gibi PGR'ler bitkilerin çeşitli büyüme özelliklerini değiştirmeye yardımcı olur ve bunlar süs bitkilerinin modern üretim sisteminde yaygın olarak kullanılır. Bu çalışmanın amacı, bir sera denemesinde, zinnia (*Zinnia elegans* Jacq.) vejetatif büyüme parametreleri ve çiçeklenmesinin modern üretim sisteminde kullanılan paclobutrazol, daminozide, chlormequat ve propiconazole'nin optimum dozu, dozlarının azaltılması ve artırılması etkilerini değerlendirmektir. Bitki boyu, kontrol grubuna kıyasla %20.87 oranında 2 g L<sup>-1</sup> daminozid (T<sub>4</sub>) uygulanarak azaltılmıştır. 1.5 ml L<sup>-1</sup> chlormequat (T<sub>9</sub>) ile muamele edilen bitkiler, en yüksek ana sap çapına, çiçek sapı çapına (4.50 mm) ve yan dal uzunluğuna (16.17 cm) sahiptir. En yüksek yan dal çapının (3.78 mm) ve çiçek tomurcuklarının sayısının (bitki başına 4.67) T<sub>4</sub> ile ortaya konulduğu belirlenmiştir. T<sub>4</sub> uygulaması, zinnia'nın çiçek tomurcuklarının sayısını arttırmak için kullanılabilir. 2 g L<sup>-1</sup> daminozid (T<sub>4</sub>) kullanımının, internod uzunluğunu kontrol grubuna kıyasla % 58.60 oranında azalttığını sonuçlar göstermiştir. Özetle, denemede kullanılan kimyasalların ve tüm dozların zinnia'nın çiçek kalitesinin bozulmasını etkilemediği sonucuna varılmıştır. Aksine, özellikle farklı dozlarda daminozid uygulanarak bitki boyu yükseklik kontrolü sağlanarak daha kompakt bitkilerin elde edilebileceği sonucuna varılmıştır. Zinnia'nın üretim süresini kısaltmak için, 0.25 ml L<sup>-1</sup> propiconazole uygulanması tavsiye edilebilir.

**Anahtar kelimeler:** Bitki büyüme geciktiricileri, *Zinnia elegans* Jacq., bitki boyu, kompakt bitki formu

#### 1. Introduction

Due to its wide adaptability, diverse forms in terms of plant size and quick flowering, flower colors and shapes the *Zinnia violacea* Cav. (formerly the *Z. elegans* Jacq.) is the most widely grown one-year herbaceous plant and also the most important among the other zinnia species in terms of economic value (Burlec et al. 2019). Another advantage of zinnias is its cultivation as a potted plant as well as its attractiveness and marketing. The control of plant growth and reduction of plant height are very important factors in potted ornamental

plant production (Hadizadeh et al. 2010). Therefore, it is essential to reduce the height of the plant and at the same time keep the plant quality at a desired level. One of the important effects of plant growth retardants (PGRs) is the control of plant height. The advantage of using plant growth retarders in crop production is to improve the appearance of the plant by maintaining the shape and size of the plant relative to the size of the pot (Christopher & Lopez;2010Meijon et al. 2009).

In the modern production system of ornamental plants, the use of PGRs is encouraged and PGRs help to

alter various growth characteristics of plants. However, their excessive use is a threat to the environment. Also commercially acceptable PGR formulations may influence consumer acceptance because they contain synthetic growth regulators. The synthesis of ecologically safe formulations of PGRs and their use at optimum dosage will increase their acceptability by manufacturers and consumers. Hence, the specific objectives of this study were to optimize the different PGRs (paclobutrazol, daminozide, chlormequat and propiconazole) and their different concentrations for *Zinnia elegans* and to elucidate the effects of zinnia potted plants and 12 treatments for standardizing this practice as a best management strategy.

## 2. Materials and Methods

*Zinnia elegans* ‘GIALLA’ seeds (Tasaco Agriculture Industry and Trade Inc. Antalya, Turkey) were planted in plug trays (molded plastic propagation trays with 1.5 cm<sup>3</sup> inverted cone-shaped pockets), on 21 June 2018-2019. The trays were placed in a climate-controlled research greenhouse. Temperatures inside the greenhouse were determined as 15±2 °C at night and daytime temperatures were determined as 27±2 °C. Plant growth retardants (different levels of paclobutrazol, daminozide, chlormequat and

propiconazole) (Table 1) were applied to all groups, except the control group, twice in two different growth stages: (1) at the stage where both cotyledon leaves appear and (2) at the stage where two-thirds of the seedling leaves appear. The zinnia seedlings (drench on leaves, stem and in growth medium) were irrigated with different doses of the plant growth retardants during two different growth stages in the greenhouse.

On 16 July 2018-2019, all seedlings were transplanted from the plug trays into pots (400 cc; 10.5x8 cm) in the greenhouse. Day 14 after transplant, all groups were given chemical fertilizer 15-5-30+ME water soluble fertilizer 2.0 g L<sup>-1</sup> (FERTIGOLD 15-5-30+ME) with the irrigation water. The experiment was carried out as a factorial experiment based on a completely randomized design with four factors including chlormequat at 3 levels, daminozide at 4 levels, paclobutrazol at 3 levels and propiconazole at 2 levels and the control group with 13 treatments (Table 1), 3 replications, and each replication included 5 pots. In total, 210 pots were used in this experiment. Irrigation was applied as needed to maintain growth medium moisture. Growth of the zinnias was monitored daily in the greenhouse from June through September and consecutively two years (2018-2019).

**Table 1.** Content, commercial name of plant growth retardants used in the study and their treatments codes and levels

**Çizelge 1.** Çalışmada kullanılan bitki büyüme geciktiricilerinin içerikleri, ticari adları ve uygulama kodları ve seviyeleri

Treatmens no	Treatments code	Levels	Used plant growth retardant	Commercial name of plant growth retardant	Composition
1	T <sub>0</sub>	Control	Without plant growth retardant	-	-
2	T <sub>1</sub>	0.6 ml L <sup>-1</sup>	Paclobutrazol	Bonzi	4 g/l (0.39% w/w) Paclobutrazol
3	T <sub>2</sub>	0.9 ml L <sup>-1</sup>	Paclobutrazol	Bonzi	4 g/l (0.39% w/w) Paclobutrazol
4	T <sub>3</sub>	1.2 ml L <sup>-1</sup>	Paclobutrazol	Bonzi	4 g/l (0.39% w/w) Paclobutrazol
5	T <sub>4</sub>	2.0 g·L <sup>-1</sup>	Daminozide	Alar 85	85.14% w/w Daminozide
6	T <sub>5</sub>	4.0 g·L <sup>-1</sup>	Daminozide	Alar 85	85.14% w/w Daminozide
7	T <sub>6</sub>	6.0 g·L <sup>-1</sup>	Daminozide	Alar 85	85.14% w/w Daminozide
8	T <sub>7</sub>	8.0 g·L <sup>-1</sup>	Daminozide	Alar 85	85.14% w/w Daminozide
9	T <sub>8</sub>	1.0 ml L <sup>-1</sup>	Chlormequat	Cycocel	11.8% Chlormequat
10	T <sub>9</sub>	1.5 ml L <sup>-1</sup>	Chlormequat	Cycocel	11.8% Chlormequat
11	T <sub>10</sub>	2.0 ml L <sup>-1</sup>	Chlormequat	Cycocel	11.8% Chlormequat
12	T <sub>11</sub>	0.25 ml L <sup>-1</sup>	Propiconazole	Tilt 250E	250g/l Propiconazole
13	T <sub>12</sub>	0.55 ml L <sup>-1</sup>	Propiconazole	Tilt 250E	250g/l Propiconazole

Characteristics evaluated was the time until the first appearance of the first flower buds, plant height, main stem and flower diameter, leaf chlorophyll (using chlorophyll meter (SPAD-502, Konica Minolta Sensing, Inc., Japan)), stomatal conductance (using a porometer (Sc 1 Porometer, Decagon Devices Inc., WA, USA)), number of side branches, number of flower buds, flower stalk diameter, length of internodes, leaf area (using CI 202 Portable digital brand leaf area meter) and the fresh and dry weight of the plants. All data in the present study were processed by SPSS (Statistical Package for Social Sciences, Version 22.0) and the means were separated

by Duncan’s multiple range tests.

## 3. Results and Discussion

The effects of different levels of the plant growth retardants were significant for plant height at a 1% probability level. The mean comparison of data in different treatments (Table 2) showed that plants treated with 2 g L<sup>-1</sup> of daminozide (T<sub>4</sub>) had the lowest height (17.67 cm). Plant height was reduced in T<sub>4</sub> at a rate of 20.87% when compared to the control (T<sub>0</sub>) and T<sub>12</sub>, T<sub>5</sub>, T<sub>6</sub> and T<sub>7</sub> treatments were in the same statistical group with T<sub>4</sub>. PGRs are widely used in the control of plant

height of a large number of plants. Daminozide treatments are used for height control in floriculture; potted *Mussaenda* 'Queen Sirikit' (Cramer and Bridgen 1998), ornamental cabbage and kale (Gibson & Whipker 2001), *Calendula officinalis* L. (Hashemabadi et al. 2012) and potted 'Lilliput' *Zinnia elegans* Jacq. (Pinto et al. 2005). It has been reported that different concentrations of uniconazole decreased total plant height by more than 20% in 'Red Pigmy' and 'Golden

Emblem' cultivars (Whipker et al. 1995). Propiconazole (Tilt 250E) has effected the root growth of *Triticum durum* (Meksem et al. 2007) and increased the green leaf area and seed yield of grass (Rolston et al. 2004). Moreover, no previous studies using Propiconazole on ornamental plants as plant growth regulators have been encountered. In the present study, plant height was reduced in T<sub>7</sub> by a 11.20% ratio when compared to the control (T<sub>0</sub>).

**Table 2.** The effect of treatments on the some morphological characters of *Zinnia elegans* Jacq.

**Çizelge 2.** Uygulamaların *Zinnia elegans* Jacq.'in bazı morfolojik özellikleri üzerindeki etkisi

Treatment	Plant height (cm)	Main stem diameter (mm)	Side branches diameter (mm)	Flower stalk diameter (mm)	Side branch length (cm)	Number of side branches (number plant <sup>-1</sup> )	Number of flower buds (number plant <sup>-1</sup> )	Flower diameter (mm)
T <sub>0</sub>	22.33±0.2 a-d	5.77±0.7 b-e	3.13±0.2 a-d	3.45±0.2 bc	13.80±4.2 a-c	6.33±0.6 <sup>ns</sup>	2.33±0.6 bc	53.26±4.8 b
T <sub>1</sub>	22.77±1.2 a-d	5.97±1.0 a-e	3.05±0.5 a-d	3.66±0.4 bc	12.03±2.3 b-d	5.67±0.6	1.67±1.2 c	69.95±9.2 a
T <sub>2</sub>	24.20±1.7 ab	5.13±0.1 de	2.86±0.5 b-e	3.18±0.1 c	11.00±1.8 a-c	5.67±1.5	2.33±0.6 bc	73.73±1.8 a
T <sub>3</sub>	25.37±0.9 a	5.91±0.1 b-e	3.17±0.1 a-d	3.56±0.4 bc	14.07±0.3 b-d	6.33±0.6	2.00±0.0 bc	77.57±3.9 a
T <sub>4</sub>	17.67±2.4 e	6.23±1.0 a-d	3.78±0.4 a	3.55±0.1 bc	10.93±0.6 b-d	7.67±2.1	4.67±1.5 a	50.50±6.7 b
T <sub>5</sub>	20.43±2.9 c-e	5.04±0.4 e	2.35±0.4 de	3.63±0.5 bc	10.63±1.3 d	8.00±2.0	2.00±0.0 bc	44.22±7.8 b
T <sub>6</sub>	19.20±1.4 de	5.90±0.4 b-e	2.50±0.8 de	3.94±0.2 ab	8.50±3.3 cd	9.33±4.2	1.67±0.6 c	9.57±0.7 c
T <sub>7</sub>	19.80±1.1 de	6.31±0.9 a-c	3.45±0.4 ab	4.05±0.6 ab	11.73±0.8 b-d	7.33±1.5	3.67±1.5 ab	69.31±8.4 a
T <sub>8</sub>	22.87±0.9 b-d	5.46±0.4 c-e	3.38±0.3 a-c	3.96±0.7 bc	14.87±1.8 d	6.00±2.0	3.67±0.6 ab	69.56±4.6 a
T <sub>9</sub>	23.63±0.3 a-c	7.03±0.1 a	3.48±0.3 ab	4.50±0.1 a	16.17±2.8 a	7.00±1.0	3.67±1.5 ab	68.66±2.5 a
T <sub>10</sub>	21.37±2.7 a-d	5.46±0.4 ab	2.18±0.3 e	3.37±0.3 ab	9.47±0.3 ab	6.33±0.6	3.00±1.0 a-c	68.67±7.0 a
T <sub>11</sub>	22.80±1.3 a-d	6.87±0.5 c-e	2.55±0.7 c-e	3.34±0.3 bc	14.80±1.2 ab	5.67±0.6	2.67±1.5 bc	75.01±5.3 a
T <sub>12</sub>	19.83±3.8 de	5.35±0.3 e	2.46±0.6 de	3.84±0.6 a-c	9.73±2.4 d	6.00±1.0	1.33±0.6 c	66.10±7.4 a
Mean	21.71±2.7	5.84±0.8	2.95±0.6	3.69±0.5	12.13±2.9	6.72±1.8	2.67±1.3	61.24±18.6

Values are shown as mean ± standard error. Different letters in the same column indicate significant differences between means (P < 0.05) based on the Duncan's multiple range test.

The maximum main stem diameter was obtained with T<sub>9</sub> as 7.03 mm. T<sub>10</sub> was in the same statistical group with T<sub>9</sub>. Cycocel is a plant growth retardant that is widely used in reducing the growth of a large number of plants. In the present study, plants treated with 1.5 ml L<sup>-1</sup> of cycocel (T<sub>9</sub>) had the highest main stem diameter, flower stalk diameter (4.50 mm) and side branch length (16.17 cm). It was determined that the highest side branch diameter (3.78 mm) and number of flower buds (4.67 per plant) were in T<sub>4</sub>. T<sub>7</sub> and T<sub>9</sub> were in the same statistical group with T<sub>4</sub> (Table 2). The PGRs have been applied to alter various characteristics in ornamental plants including an increase in the number of flowers (Carey et al. 2013; Sajjad et al. 2017). Treatment with cycocel at concentrations of 2000, 4000 and 6000 ppm had no effect on the final height of *Arundina graminifolia* (Wanderley et al. 2014). It was determined that the plant growth regulators (ancymidol, benzyladenine, chlormequat chloride, daminozide, ethephon, paclobutrazol and uniconazole) can control stem elongation and can be effective in promoting branching by the application for kalanchoe plants (Currey & Erwin 2012). In addition, Cycocel can reduce the height of the flowering branches in the "Red Elite" geranium (Olivera & Browning 1993; Taherpazir & Hashemabadi 2016). As a result of our study, it was concluded that the treatment of T<sub>4</sub> can be used to increase the number of flower buds of zinnias.

No significant differences were observed in the number of side branches with the treatments. The mean comparison of data in different treatments showed that all the treatments except T<sub>6</sub> significantly increased flower diameter as compared to T<sub>0</sub>. The numerically highest flower diameter was determined in T<sub>3</sub> (Table 2). Although there was no statistically significant difference in flower diameter among different levels of plant growth retardants, results showed that the use of plant growth retardants increased flower diameter compared to the control. It is believed that the impact of growth retardant on flower diameters depends on the frequency of the use of growth retardant, environmental conditions, species sensitivity to growth retardants and methods (Pinto et al. 2005).

In the evaluation of zinnias, the longest internode length was determined in T<sub>0</sub> (31.35 mm), T<sub>3</sub> (33.47 mm) and T<sub>10</sub> (27.74 mm); the shortest internode length was observed in T<sub>4</sub> (12.98 mm) (Table 3). The result showed that the use of 2 g L<sup>-1</sup> of daminozide (T<sub>4</sub>) reduced the internode length compared to the control with at a ratio of 58.60%. However, no significant differences were observed in chlorophyll content (SPAD) among the treatments. Maximum stomatal conductance was obtained from the plants in T<sub>9</sub> (21.70 mmol (H<sub>2</sub>O) m<sup>-2</sup> s<sup>-1</sup>), T<sub>7</sub> (21.47 mmol (H<sub>2</sub>O) m<sup>-2</sup> s<sup>-1</sup>) and minimum stomatal conductance was observed in the plants of T<sub>5</sub> (9.57 mmol (H<sub>2</sub>O) m<sup>-2</sup> s<sup>-1</sup>) (Table 2). Leaf area is a key

feature in plant growth affected by growth retardants. In fact, photosynthesis increases in parallel with the amount of leaf area. In this study, leaf area increased with the treatment in T<sub>5</sub> (53.56 cm<sup>2</sup>) and decreased with T<sub>4</sub> (23.33 cm<sup>2</sup>). Leaf area increased in T<sub>5</sub> by 20.72% ratio compared to the control (T<sub>0</sub>) (Table 3). It is suggested that the reducing effect of growth retardants

on the leaf area is associated with the prevention of the synthesis of GA, the enhancement of ABA and the prevention of cell elongation (Taherpazir and Hashemabadi 2016). The fresh and dry weight of plants was not affected by the treatments in this study (Table 3).

**Table 3.** The effect of treatments on the some morphological characters of *Zinnia elegans* Jacq.

**Çizelge 3.** Uygulamaların *Zinnia elegans* Jacq.'in bazı morfolojik özellikleri üzerindeki etkisi

Treatments	Length of internodes (mm)	Chlorophyll content (SPAD)	Stomatal conductance (mmol (H <sub>2</sub> O) m <sup>-2</sup> s <sup>-1</sup> )	Leaf area (cm <sup>2</sup> )	Plant fresh weight (g)	Plant dry weight (g)	Duration to first flower buds apperance (day)
T <sub>0</sub>	31.35±5.0 a***	41.92±0.7 <sup>ns</sup>	18.43±1.2 ab***	42.46±1.3 b-d***	28.26±6.2 <sup>ns</sup>	3.46±0.7 <sup>ns</sup>	45.33±7.5 ef***
T <sub>1</sub>	24.88±1.4 ab	41.32±2.2	14.07±3.7 b-d	39.92±0.2 b-d	28.64±3.2	3.67±0.7	51.00±10.5 c-e
T <sub>2</sub>	27.78±7.8 ab	43.79±1.5	13.57±2.3 b-d	29.52±1.1 e	26.74±4.8	3.80±0.6	47.33±1.5 ef
T <sub>3</sub>	33.47±2.3 a	41.90±0.9	14.23±2.1 b-d	38.76±0.5 b-d	32.99±2.7	4.43±0.7	43.33±1.5 ef
T <sub>4</sub>	12.98±4.5 d	45.53±1.6	15.37±3.3 bc	23.33±11.7 f	24.52±3.1	2.83±0.3	58.33±2.1 bc
T <sub>5</sub>	19.29±5.4 b-d	46.43±3.9	9.57±0.6 d	53.56±0.9 a	27.67±4	3.47±0.9	55.67±2.1 bd
T <sub>6</sub>	15.29±1.2 cd	45.00±1.3	15.80±2.8 bc	36.87±0.4 cd	22.50±7.1	2.86±0.8	59.33±3.1 b
T <sub>7</sub>	21.22±2.7 bc	45.33±1.0	21.47±1.3 a	43.14±0.7 bc	30.57±2.9	4.02±0.5	45.33±1.5 ef
T <sub>8</sub>	31.20±1.2 ab	44.77±1.8	14.33±2.2 b-d	37.70±4 b-d	29.40±4.6	3.91±0.6	49.33±0.6 a-c
T <sub>9</sub>	27.97±2.7 ab	43.97±3.9	21.70±6.2 a	44.22±0.4 b	35.62±3.4	4.52±0.5	50.67±2.1 c-d
T <sub>10</sub>	27.74±4.2 a	46.00±3.6	15.00±3.6 b-d	42.71±1.0 b-d	29.16±4.2	3.62±.4	55.33±4.2 d-f
T <sub>11</sub>	25.44±4.8 ab	45.17±1.8	11.30±1.7 cd	36.02±3.9 d	29.58±6.9	2.48±2.1	42.67±2.1 f
T <sub>12</sub>	21.87±8.1 bc	48.77±4.0	14.97±1.8 b-d	38.00±0.3 b-d	28.51±2.5	3.75±0.2	81.67±2.5 a
Mean	24.65±7.2	44.61±2.9	15.37±4.1	38.94±7.6	28.78±5.0	3.60±0.9	52.72±10.6

Control (T<sub>0</sub>); Paclobutrazol concentrations 0.6 (T<sub>1</sub>), 0.9 (T<sub>2</sub>) and 1.2 ml L<sup>-1</sup> (T<sub>3</sub>); Daminozide concentrations 2.0 (T<sub>4</sub>), 4.0 (T<sub>5</sub>), 6.0 (T<sub>6</sub>) and 8.0 g·L<sup>-1</sup> (T<sub>7</sub>); Chlormequat concentrations of 1.0 (T<sub>8</sub>), 1.5 (T<sub>9</sub>) and 2.0 ml L<sup>-1</sup> (T<sub>10</sub>) and Propiconazole concentrations 0.25 (T<sub>11</sub>) and 0.55 ml L<sup>-1</sup> (T<sub>12</sub>).

While the time until the first appearance of flower buds decreased with the use of 0.25 ml L<sup>-1</sup> of propiconazole (T<sub>11</sub>), it increased in T<sub>12</sub>. T<sub>0</sub>, T<sub>2</sub>, T<sub>3</sub> and T<sub>7</sub> were in the same statistical group with T<sub>11</sub>. ‘Mustang’ geranium (*Pelargonium hortorum*) treated with paclobutrazol flowered earlier than the control plants (Cox 1991). Khaimov and Mizrahi (2006) and Cardoso and Habermann (2014) reported that PGRs have been applied to achieve early flowering in ornamental plants. The results of this study parallel the results of these researchers.

#### 4. Conclusion

In the present study, plant height was reduced with 8 g L<sup>-1</sup> of daminozide by 11.20% compared to the control. The plants treated with 1.5 ml L<sup>-1</sup> of cycocel had the highest main stem diameter, flower stalk diameter and side branch length. It was determined that the highest side branch diameter and number of flower buds were achieved with 2 g L<sup>-1</sup> and 8 g L<sup>-1</sup> daminozide. Leaf area increased with 4 g L<sup>-1</sup> of daminozide at a rate of 20.72% compared to the control. In summary, it was concluded that the chemicals and all the doses used in the experiment did not affect the deterioration of the flower quality of zinnias. On the contrary, it was concluded that more compact plants can be obtained by providing height control especially by administering different doses of daminozide. At the same time, it is estimated that potted zinnia plants which have been subjected to

height control are less likely to incur physical damage during transport. In addition, no signs of phytotoxicity were encountered in any of the treatments.

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