Effect of day length, growth regulators and fertilization on growth and development of Michaelmas Daisy (*Aster novi-belgii* L.)

Ines VRŠEK
Ksenija KARLOVIĆ
Vesna ŽIDOVEC

SUMMARY

Effect of day length, growth regulators and fertilization on the height, plant diameter, number of buds and inflorescences was monitored in the species *Aster novi-belgii* L. 'Mary Ballard' throughout three growing seasons in order to explore the possibility of its late-summer growing as a flowering pot plant.

The total number of buds and inflorescences was by 20% larger under natural day length compared to plants grown under the shortened photoperiod. Bud opening dynamics was more intensive under the natural day length conditions.

Comparison of the average number of open inflorescences per plant between plants grown under different photoperiod conditions revealed a significantly larger number of open inflorescences in plants grown under the short day conditions. Foliar application of daminozide was shown to be efficient in inhibiting the growth of asters up to 10%. Plant diameter was not much changed under the influence of daminozide, with the exception of second trial year, when it was reduced up to 25%. Daminozide application resulted in an increased number of buds in all trial variants. In all three years, significantly more flowers were determined in fertilized plants compared with non-fertilized, with the exception of plants grown under natural day length in first year of experiment.

KEY WORDS

daminozide, fertilization, photoperiod, *Aster novi-belgii*, Michaelmas Daisy

Department of Ornamental Plants and Landscape Architecture,
Faculty of Agriculture, University of Zagreb,
Svetošimunska 25, 10000 Zagreb, Croatia
E-mail: ines.vrsek@zg.tel.hr; karlovic@agr.hr; vzidovec@agr.hr

Received: April 26, 2002

Utjecaj duljine dana, regulatora rasta i gnojidbe na rast i razvoj zvjezdana (*Aster novi-belgii* L.)

Ines VRŠEK
Ksenija KARLOVIĆ
Vesna ŽIDOVEC

SAŽETAK

Tijekom tri vegetacijske sezone praćen je utjecaj duljine dana, regulatora rasta i gnojidbe na visinu, promjer biljaka, broj pupova i broj cvatova kod vrste *Aster novi-belgii* L. 'Mary Ballard' u cilju utvrđivanja mogućnosti kasnoljetnog uzgoja zvjezdana kao cvatuće lončanice.

Ukupan broj pupova i cvatnih glavica bio je 20% veći pod prirodnom duljinom dana u usporedbi s biljkama uzgajanim uz skraćene duljine dana. Dinamika otvaranja pupova kod glatkolisnog zvjezdana bila je intenzivnija pod uvjetima prirodne duljine dana.

Usporedbom prosječnog broja otvorenih cvatova po biljci uzgajanih pod različitim fotoperiodičkim uvjetima utvrđen je znatno veći broj otvorenih cvatova uzgajanih uz skraćenje duljine dana. Folijarna aplikacija daminozida pokazala se djelotvornom u inhibiranju visinskog rasta zvjezdana i to do 10%. Promjer biljke nije se znatno mijenjao uslijed utjecaja daminozida, osim u drugoj godini kad je došlo do smanjenja do 25%. Aplikacija daminozida rezultirala je povećanim brojem pupova u svim varijantama pokusa. U sve tri ispitivane godine utvrđeno je značajno više cvatova kod gnojenih biljaka u usporedbi s negnojenim biljkama uz iznimku biljaka uzgajanih uz prirodnu duljinu dana prve godine pokusa.

KLJUČNE RIJEČI

daminozid, fotoperiodizam, gnojidba, *Aster novi-belgii,* zvjezdan

Zavod za ukrasno bilje i krajobraznu arhitekturu,
Agronomski fakultet Sveučilišta u Zagrebu
Svetošimunska 25, 10000 Zagreb, Hrvatska
E-mail: ines.vrsek@zg.tel.hr; karlovic@agr.hr; vzidovec@agr.hr

Primljeno: 26. travnja 2002.

INTRODUCTION

Aster novi-belgii L. is a perennial belonging to *Asteraceae* family that flower in the late summer or in the autumn and can reach a height of 1.5 m (Jelitto and Schacht, 1995). This species has a high potential as a flowering pot plant and is especially interesting for variety of colors and shapes and its ability to respond to different day lengths. However, many aster cultivars are too tall to be grown in pots and therefore growth regulators should control their height in order to obtain good-quality pot plants. Plant growth regulators are commonly applied to container grown plants to limit stem elongation and produce a more compact plant (Gibson and Whipker, 1999). Wicki –Freidl (1989) recommends the use of chlormequat and daminozide for height control of pot asters. Due to the influence of the genotype on the morphological properties of plants, responses of individual aster cultivars should be investigated. Whipker et al. (1995) found that daminozide application at 5000 mg liter^{-1} caused the greatest reduction in plant height in 'Butterfly Blue' and 'Purple Monarch' pot asters, causing 29 and 24% reduction, respectively. Flowering of many herbaceous perennials is influenced by vernalization and photoperiod (Clough et al., 2001; Whitman et al., 1996). The photoperiodic classification of plants classifies Aster novi belgii among long-short day plants whose flowering requires or is accelerated by vernalization (Thomas and Vince – Prue, 1997). Schwabe (1985) recorded the influence of different photoperiod lengths on the number of vegetative and inflorescence shoots, as well as on the number of aborted inflorescences in *A. novi beligii* 'Wimbledon'. A 16-hour day length resulted in the largest number of vegetative shoots, 14-hour day length in the largest number of inflorescence shoots, while the largest number of aborted inflorescences was recorded with the 8-hour day length.

Adequate fertilization has a strong influence on the plant habit and is therefore essential for a satisfactory quality of pot plants. Besides, the nutrient content of some plant species changes under the influence of growth retardants, which is attributed to changes in the transport of substances in plant sap or changes in the cat ion exchange capacity around the roots (Knavel, 1969).

The objective of the trial was to assess the possibility of growing *Aster novi-belgii* 'Mary Ballard' as a flowering pot plant in the late summer period. For this purpose, it is necessary to determine the response of asters to a single application of growth regulators, the effect of day length and fertilizer on aster growth and flowering.

MATERIALS AND METHODS

Top cuttings (10 cm) of stock plants of the species *Aster novi-belgii* 'Mary Ballard' were taken in June and put into a cold frame to form roots. Each rooted cutting was planted into 300 ml pot with a mixture of loamy soil and peat in a volume ratio 3: 1. The pots were arranged in a randomized order, 90 plants/m^2. Ten days after planting, plants were pinched and twenty days after planting plants were treated with daminozide at 2000 or 4000 mg liter^{-1}, plus an untreated control. Plants were fertilized for the first time twenty days after planting into pots with liquid fertilizer (4N-6P-8K) and than two weeks later, in a concentration of 15000 mg liter^{-1}, plus an untreated control.

Investigations were carried out during three years in two separate two-factor trials set up according to the randomized block design in 5 replications, 6 combinations with 15 plants per combination. In the first trial, plants were grown under natural day length (lat. 45°50'N, long. 16°0'E) whereas in the second trial plants were grown under a shortened day length. Day shortening was achieved by covering the plants with black plastic film and it started in the fourth week following planting. The film was pulled over from 18:00 HR to 08:00 HR daily. The plants were exposed to a cycle of 10 hours of light and 14 hours of darkness for five weeks. The total number of daylight hours from planting to the end of covering was 753 hours for plants grown under short day length while the plants grown under natural day length had 855 hours of light.

At the end of each trial year, the substrate was submitted to the following chemical analyses: acidity in water (pH), electrical conductivity (EC), and cat ions and anions in water extract 1:2. Leaf analyses were done at the end of the trial in each trial year per combinations of growth retardants and fertilization. Healthy, young and fully developed leaves were taken; the plant material was burnt and the obtained dry matter was used to prepare the solution for the determination of major macro- and microelements.

Plant height was monitored during the trial (measured from pot rim to the plant top height); as well as plant diameter (measured at the most branched-out plant part); and the number of colored buds and inflorescences per plant.

Obtained data on these traits were processed by the analysis of variance (ANOVA) per investigation years, separately for plants grown under natural day length and separately for those grown under shortened photoperiod. Statistical analysis of the interaction relations of the traits and years tested was carried out by the standard method, based on the estimation of the least squares for general linear models using the GLM procedure.

RESULTS AND DISCUSSION

Plant height

In the first two trial years, daminozide had no inhibitory effect on shoot length in plants grown under natural day length. Fertilization had no effect either and there was no significant interaction. In the third trial year, application of 4000 mg liter^{-1} daminozide resulted in 10% lower plants compared to the control.

Under short day length, asters responded to the application of growth regulators in all three years (Figure 1). Highly significant differences between treated and untreated variants were recorded in the first two years and at a P≤0.05 level in third trial year. In first and second, plants sprayed with growth regulators in a 4000 mg liter^{-1} concentration were by 8% lower than untreated plants. There was no significant difference between treatments with lower and higher concentrations in either trial year. In the last year, a statistically significant difference (P≤0.05) was recorded between plants treated with 4000 mg liter^{-1} daminozide and the control.

Plants grown under short day, to which liquid fertilizer was applied, were in first trial year of experiment by 2.5% higher than untreated plants.

In first trial year of experiment, a difference in height was recorded between plants grown under natural day length and those for which day length was shortened, was larger when daminozide was applied (Figure 2). In these combinations, short day plants were lower than plants grown under natural day length. Dalla Guda et al. (2001) also report higher aster plants with the long day compared to the short day. Plant height is an aster trait that is strongly influenced by the photoperiod (Dalla Guda et al., 1994).

No statistically significant difference was recorded for second trial year between these two plant groups. In last year, differences in height were not as regular as in first. In combinations without growth retardants, plants grown under a shortened photoperiod were shorter (by 1-1.2 cm) than those grown under natural day length, while with the application of 4000 mg liter^{-1} daminozide the difference was 0.3-0.6 cm. With 2000 mg liter^{-1} daminozide, plants were 0.2 to 0.9 cm higher that those grown under natural day length conditions.

Plant diameter

Approximately equal plant diameters of plants grown under natural day length were recorded in all trial variants in the first and last trial years, and there was not a single statistically significant difference. In the second trial year, plant diameter decreased with increasing daminozide concentrations. Thus, the smallest diameter was obtained with the application of 4000 mg liter^{-1} daminozide. The difference between this trial variant and the control was 25%, which is a statistically highly significant difference. The difference between the plants treated with 2000 mg liter^{-1} and 4000 mg liter^{-1} of daminozide was also at P≤0.01 level. Whipker et al. (1995) report the reduction of plant diameter with the application of growth retardants too for two *Aster novi-beligii* cultivars, and for other species by other authors (Nell et al. 1980; Tayama and Carver 1992; Whipker et al. 1994).

No statistically significant differences in plant diameter were recorded for short-day plants in the first and last trial years. It was only in second trial year that the variant treated with 4000 mg liter^{-1} daminozide had a 25% smaller diameter than untreated plants. It was also this concentration that led to the smallest diameter, since a significant difference (P≤0.05) was recorded between this variant and the variant treated with 2000 mg liter^{-1} daminozide. The largest diameter among the tested interactions was achieved in the combination without fertilization and without growth regulators. The value obtained in this combination was similar to that obtained without application of growth regulators but with fertilization. These two combinations had a larger diameter than all the other combinations in which growth retardants were applied, at P≤0.01 level.

Comparison of plant diameters achieved under the natural day length conditions and those under the shortened photoperiod in first trial year revealed that the difference was the most expressive in the combination treated with the higher daminozide concentration and without fertilizer application (1.2 cm). In the second trial year, plant diameters achieved under the natural day length were 0.9 cm smaller in control plants and 0.8 cm smaller in the combination involving fertilization and treatment with the higher growth regulator concentration. In the combination where plants were not treated with growth retardants but were fertilized, the plant diameter was 0.4 cm larger under natural day length (Figure 3).

In the last trial year, plants grown under shortened photoperiod had larger diameters in all combinations, ranging from 0.5 cm in the control to 1.4 cm in the combination of unfertilized plants treated with 2000 mg liter^{-1} daminozide.

Number of buds

The average number of buds in plants grown under natural day length with the application of growth retardants was in all trial years significantly larger compared to the control (Figure 4).

In first trial year, plants treated with 2000 mg liter^{-1} daminozide had 32.4% more buds than untreated plants. Whipker and McCall (2000) also achieved 18% more flower buds in container grown sunflowers

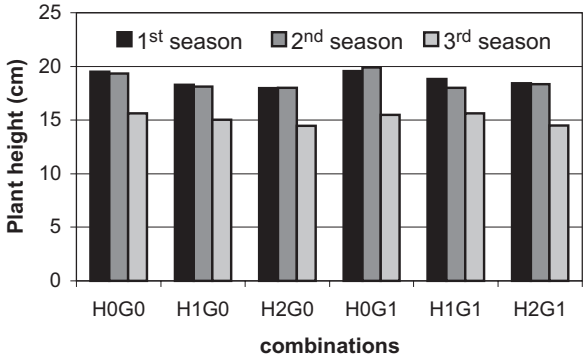

Figure 1. Plant height under short day conditions

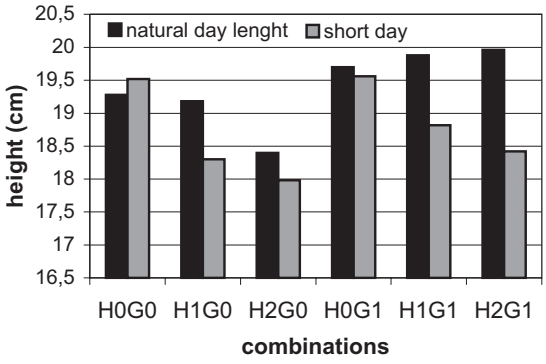

Figure 2. Plant height in 1992

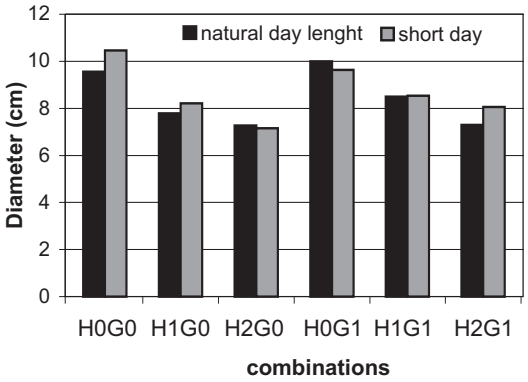

Figure 3. Plant diameter in 1993

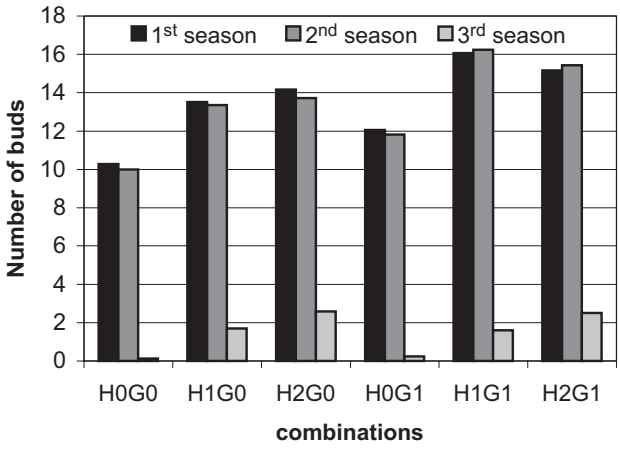

Figure 4. Number of buds under natural day length

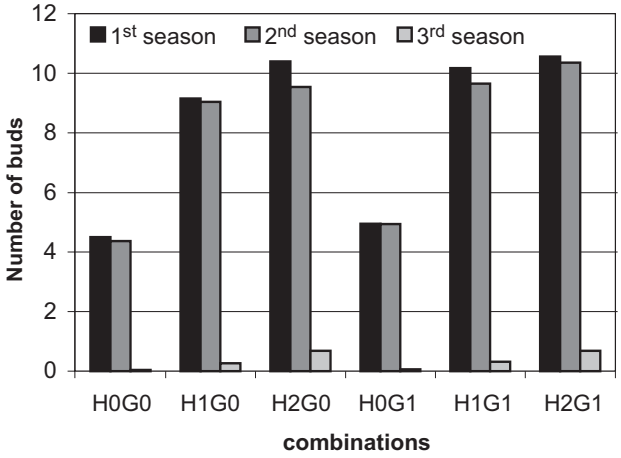

Figure 5. Number of buds under short day conditions

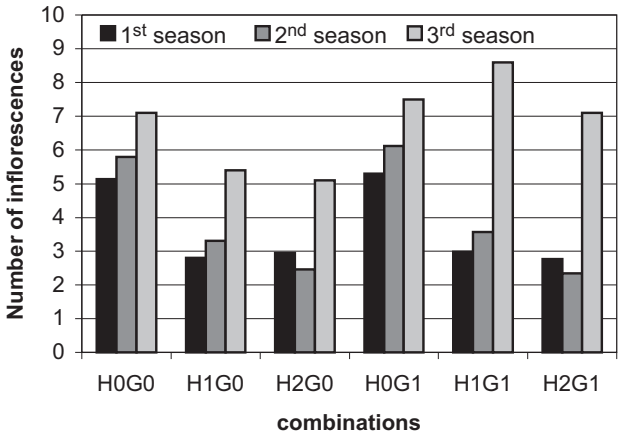

Figure 6. Number of inflorescences under natural day lenght

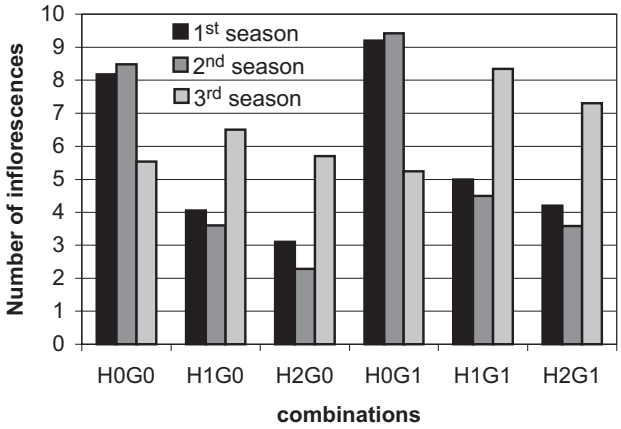

Figure 7. Number of inflorescences under short day conditions

H0G0 = control;
H1G0 = 2000 mg liter^{-1} of daminozide, without fertilization;
H2G0 = 4000 mg liter^{-1} of daminozide, without fertilization;
H0G1 = without daminozide, 15000 mg liter^{-1} of fertilizer;
H1G1 = 2000 mg liter^{-1} of daminozide and 15000 mg liter^{-1} of fertilizer;
H2G1 = 4000 mg liter^{-1} of daminozide and 15000 mg liter^{-1} of fertilizer

with the use of daminozide. Results similar to the first research year were also obtained in second trial year when, at the lower concentration of daminozide, there were 35.7% more buds than in the control. In second trial year, the number of buds was as much as 14 times larger than in the control with the application of 4000 mg liter^{-1} daminozide. A highly significant difference in the number of buds was determined between the lower and higher growth retardant concentrations.

Application of liquid mineral fertilizer resulted in a 14% larger number of buds in first trial year and a 17% larger number of buds in second trial year compared to the unfertilized variant.

Among the tested growth retardant and fertilizer interactions, the significantly largest number of buds was achieved in the combination of 2000 mg liter^{-1} daminozide and fertilization.

Plants grown under short day responded to the application of growth retardants and fertilizers similarly to those grown under natural day length (Figure 5). A significant difference ($P \leq 0.01$) between plants treated with the growth retardant and untreated plants was recorded for all the three trial years. The plants treated with 4000 mg liter^{-1} daminozide gave 2.2 times more buds than the control in the first trial year, 2.1 times more in the second trial year, and as many as 13.6 more in the last trial year. Application of liquid fertilizer increased the number of buds by 6.7% in first trial year and by 8.8% in the second trial year.

The difference in the number of buds between plants grown under natural day length and those grown under short day was notable in all three trial years. In the first trial year, plants grown under natural day length had a larger number of buds in all trial combinations. Increase in the number of buds was also observed with the application of growth retardants. A similar situation was recorded in the second trial year whereas in the last trial year the number of buds was much smaller than in the preceding two years, due to exhaustion of stock plants. No difference between plants grown under natural day length and under shortened photoperiod was recorded in last trial year. Application of growth retardants increased the number of buds, the increase being higher in plants grown under natural day length.

Number of inflorescences

In the first two years, a significant difference was recorded in plants grown under natural day length between plants treated with the growth retardant and the control (Figure 6). Application of 4000 mg liter^{-1} daminozide in first trial year resulted in a 45% smaller number of inflorescences that in the untreated variant. The difference was even larger in second trial year, amounting to 59.7% fewer inflorescences with the application of the highest retardant concentration compared to the control. The effect of daminozide was also reflected in a delay of aster flowering, confirmed also by the results of Whipker et al. (1995), which eventually resulted in a smaller total number of inflorescences, since the number of inflorescences was measured only once.

Application of liquid mineral fertilizer resulted in 4.2% more inflorescences in second and 32% more inflorescences in last third trial year than in the control variant, while there was no statistically significant difference between fertilized and unfertilized variants in first trial year.

Cultivation under conditions of short day led to a similar plant response in the first two trial years with respect to the growth retardant factor (Figure7). In 1992, the variant treated with 4000 mg liter^{-1} daminozide had 58% fewer inflorescences than the control variant. A highly significant difference was determined also between plants treated with different growth retardant concentrations; the smallest number of inflorescences was achieved with the highest retardant concentration. Influence of daminozide on the reduction of the number of inflorescences has been confirmed also by trials involving other flower species (Gregov, 1992; Nell et al. 1980; Rodriques et al. 1993). In second trial year, treatment of plants with the higher concentration of daminozide resulted in 67.3% fewer inflorescences than when no growth retardant was applied. The difference between the higher and lower concentrations was significant at $P \leq 0.01$. The averagely larger number of inflorescences, with the application of growth retardant, was recorded in last trial year in the treatment with the lower daminozide concentration.

A significant difference between fertilized and unfertilized plants was recorded in all three trial years; fertilization increased the number of inflorescences by 20% in first, 22% in second, and 17.8% in third trial year.

The total number of buds and inflorescences was by 20% larger in plants grown under natural day length than in plants grown under shortened photoperiod. This result may be related to the number of hours that particular trial variants spent under daylight in the given photoperiod. Plants grown under natural day length had higher total hours of daylight available until flowering than plants grown under shortened day length, which obtained 12% less basic assimilation light in 36 inductive cycles in a 10-hour day. This points to the conclusion that the regulating the length of light exposure can influence flowering, as the most important photoperiod induced morphosis. The dynamics of bud opening in asters was more intensive in the natural day length conditions.

Late-summer growing of *Aster novi-beligii* 'Mary Ballard' under the conditions of open-field production and short day conditions resulted in a larger number of open inflorescences per plant, but not a larger total number of buds and inflorescences, which indicates that this short days can be used to produce flowering pot plants for a scheduled production time. However, the intensity of flowering, as well as the other important parameters, is lower in comparison with plants grown under natural day length.

CONCLUSIONS

1. Foliar daminozid treatment was useful in inhibiting plant height growth. The effect of daminozid treatment was stronger when the plants were grown under short day conditions.
2. Plant diameter was not changed significantly at the plants that were treated with daminozid, except in the second trial season when treated plants were of a 25% smaller diameter.
3. Daminozid application and fertilization has resulted in a higher number of inflorescence buds in all trial variants, especially when the plants were grown under natural day length.
4. There were a significantly smaller number of open inflorescences when daminozid was applied in 4000 mg liter^{-1}. Fertilization had a positive effect on number of inflorescences too.
5. The total number of buds and inflorescences was by 20% larger in plants grown under natural day length than in plants grown under shortened photoperiod.

REFERENCES

Clough, Emily A., A.C.Cameron, R.D. Heins and W.H. Carlson. 2001. Growth and development of *Oenothera fruticosa* is influenced by vernalization duration, photoperiod, forcing temperature, and plant growth regulators. J. Amer. Soc. Hort. Sci. 126(3):269-274.

Dalla Guda C., E. Scordo. 1994. Effetti del fotoperiodo sulla morfologia di Aster ibridi. Colture Protette 5:87-92.

Dalla Guda C., E. Scordo, E. Farina. 2001. Architettura di Aster e Crisantemo allevati sotto diversi regimi fotoperiodici e livelli di DIF. Italus Hortus 8(1) 34-38. (Abstr.)

Gibson, J.L and B.E. Whipker. 1999. The effect of B-Nine, Bonzi and Sumagic on the Growth of Ornamental Cabbage and Kale. Snare Search Conference. 44: 281-283.

Gregov, Zrinka. 1992. The effect of growth regulators on the vegetative and reproductive growth of chrysanthemums. Poljoprivredna znanstvena smotra. 57 (3-4), 397 - 413.

Jelitto, L., W. Schacht. 1995. Hardy herbaceous perennials. Timber Press, Portland.

Knavel, D.E. 1969. Influence of Growth Retardants on Growth, Nutrient Content, and Yield of Tomato Plants Grown at Various Fertility Levels. J. Amer. Soc. Hort. Sci. 94:32-35.

Nell, T.A., G.J. Willfret, B.K. Haarbaugh. 1980. Evaluation of application methods of ancymidol and daminozid for height control of chrysanthemum. HortScience. 15(6) 810-811.

Rodriquez, D., T.D. Davis, J.M. Parsons, N. Sankla. 1993. Use of growth retardants in the production of container grown Salvia farinacea longispicata 'Indigo Spires'. Plant Growth Regulat. Soc. Amer. Quaterly, 21(4) 180-189.

Schwabe, W.W. 1985. CRC Handbook of flowering, Volume V, CRC Press, Boca Raton, Florida, USA

Tayama, H.K.; S. A. Carver. 1992. Residual efficacy of uniconazole and daminozide on potted 'Bright Golden Anne' chrysanthemum. HortScience. 27(2) 124-125.

Thomas, B., D. Vince-Prue. 1997. Photoperiodism in plants. Academic Press, San Diego.

Wicki-Freidl, P., 1989: Mal eine Hauptkultur, Gb+Gw, 89 (31):1494-1496

Whipker, B.E. and I. McCall. 2000. Response of poted sunflower cultivars to daminozide foliar sprays and paclobutrazol drenches. HortTechnology 10(1) 209-211.

Whipker, B.E., R. T. Eddy, and P. A. Hammer. 1994. Chemical growth retardant height control of ornamental kale. HortScience 29(4):329.

Whipker, B.E., R. T. Eddy, Farah, Heraux, A. Hammer. 1995. Chemical growth retardants for height control of pot asters. HortScience 30(6):1309.

Whitman, C.M., Heins, R.D., Cameron, A.C., Carlson, W.H. 1996. Cold treatments, photoperiod, and forcing temperature influence flowering of *Lavandula angustifolia*. HortScience 31(7)1150-1153.

acs67_22