JEB
Journal of Environmental Biology

Journal Home page : www.jeb.co.in
E-mail : editor@jeb.co.in

ISSN: 0254-8704 (Print)
ISSN: 2394-0379 (Online)
CODEN: JEBIDP

Effect of chlormequat (cycocel) on the growth of ornamental cabbage and kale (*Brassica oleracea*) cultivars 'Kamome White' and 'Nagoya Red'

Abdollah Gholampour[1], Davood Hashemabadi[2]*, Shahram Sedaghathoor[2] and Behzad Kaviani[2]

[1]Department of Horticultural Science, Rasht Branch, Islamic Azad University, Rasht, 4147654919, Iran
[2]Department of Horticultural Science, Rasht Branch, Islamic Azad University, Rasht, 4147654919, Iran
*Corresponding Author E-mail: alicife@gmail.com

Publication Info

Paper received:
22 June 2013

Revised received:
19 December 2013

Accepted:
31 March 2014

Abstract

The effect of concentration and application method of chlormequat (cycocel), a plant growth retardant, on plant height and some other traits in *Brassica oleracea* cultivars 'Kamome White' and 'Nagoya Red' was assessed. Plant growth retardants are commonly applied to limit stem elongation and produce a more compact plant. The experiment was done as a factorial in randomized completely blocks design (RCBD) with four replications. Plants (40 days after transplanting) were sprayed and drenched with 500, 1000 and 1500 mg l^{-1} cycocel. In each experiment, control untreated plants. Data were recorded the 60 and 90 days after transplanting. Based on analysis of variance (ANOVA), the effect of different treatments and their interaction on all traits was significant at 0.05 or 0.01 level of probability. Treatment of 1500 mg l^{-1} cycocel resulted in about 50 and 20% shorter plants than control plants, 60 and 90 days after transplant. The growth of *Brassica oleracea* cultivar 'Kamome White' and 'Nagoya Red' decreased with increased cycocel concentration. Foliar sprays of cycocel controlled plant height of both cultivars. Results indicated that the shortest plants (9.94 and 11.59 cm) were those sprayed with 1500 mg l^{-1} cycocel in cultivar 'Kamome White' after 60 and 90 days, respectively. The largest number of leaves (33.94) and highest leaf diameter (9.39 cm) occurred in cv. 'Nagoya Red', when drench was used. Maximum dry matter (14.31%) accumulated in cv. 'Nagoya Red', treated with spray.

Key words

Brassicaceae, Chlormequat, Drench, Ornamental cabbage and kale

Introduction

Ornamental cabbage and kale (*Brassica oleracea*) (Brassicaceae) is an important landscape plant for fall, winter and spring gardens and parks. This attractive plant is resistant to cold. Commercial value of ornamental cabbage and kale depends on its height. Due to excessive stem elongation of ornamental cabbage and kale in fall and early winter, there is a challenge for maintaining a short, as shorter plants are more attractive and easier to handle during marketing and planting. Plant growth regulators are commonly applied to limit stem elongation and produce a more compact plant. Production of high quality, compact pot plants may be achieved through the use of plant growth retardants, including cycocel (Messinger and Holcomb, 1986; Tayama *et al*., 1990). Effectiveness of plant growth retardants depends on time and method of application, concentration, type of species and cultivar, and type of target organ as well physiological and environmental conditions (Pobudkiewicz and Nowak, 1994; James *et al*., 1999). The most common methods of application of growth retardants are foliar sprays and media drenches (Al-Khassawneh *et al*., 1996). Plant growth retardants can delay cell division and elongation of aerial parts the plant as well restrict gibberellins biosynthesis, resulting in reduced internodes and vegetative growth (Magnitskiy *et al*., 2006). Cycocel is applied as foliar spray and drench. Adding cycocel has also proved to be effective in controlling growth of some other plants (Al-Khassawneh *et al*., 1996; Rossini Pinto *et al*., 2005; Leclerc, 2006). Proper doses of cycocel foliar spray and

drench rate need to be assessed because they can either inhibit or promote growth and development of cabbage and kale plant growth depending on the amount used. Therefore, the aim of the current study was to evaluate the effect of different methods and concentrations of cycocel on some growth characters especially plant height in *Brassica oleracea* cultivars 'Kamome White' and 'Nagoya Red'.

Materials and Methods

Plant materials and treatments : Seeds of ornamental cabbage and kale (*Brassica oleracea*) cultivars 'Kamome White' and 'Nagoya Red' were obtained from Takii and Sakata Company (Japan). Investigation was carried out on experimental field in Rudesar city, located in the northern part of Iran with annual mean rainfall of 958.6 mm; mean annual temperature of 17.3°C; mean annual relative humidity of 78% and mean annual evaporation of 1044.2 mm, respectively.

Seeds were sown on August, 23 2010 in pots filled with 50% cocopeat, 30% perlite and 20% sand. Uniform size seedlings (approximately 3-4 true leaves) were potted 40 days after seeding in plastic pots filled with clay, manure, compost and sand (1:1:1:1). Plants were treated with foliar and drench application @ 500, 1000 and 1500 mg l^{-1} cycocel, 40 days after potting. Control plants were sprayed and drenched with 6 ml per pot and 60 m l per plant water.

Growth parameters : First data was calculated 60 days after transplanting. Then plants were transferred to same pots and same soil. Second data was calculated 90 days after transplanting. Plant height was recorded 60 and 90 days after potting. Leaf number, leaf diameter and dry matter percentage were recorded 90 days after potting. Plant height and leaf diameter were measured by a ruler. Leaf number was obtained by counting the number of leaves from the center of each plot and their mean was calculated. To obtain the plant dry matter, they were cut from crown and dried at 105°C for 24 hr.

Statistical analysis : The experimental design was randomized completely blocks design (RCBD) with factorial arrangement of treatment consisting of four cycocel concentrations × two treatment methods (spray and drench) × two cultivars ('Kamome White' and 'Nagoya Red') × sixteen treatments totally × four replications, 64 plots and 256 pots). Data were subjected to analysis of variance (ANOVA) using MSTATC statistical software. Mean comparison was carried out by employing Duncan's Multiple Range test at α = 5%.

Results and Discussion

Based on the analysis of variance (Table 1), the effect of different treatments and their interaction on plant height after 60 and 90 days of transplanting was significant at 0.01 level of probability. There was no significant difference observed in the effect of cultivar + kind of method on plant height after 60 days, but was significant after 90 days. The interaction effect of cultivar + method + concentration on plant height after 60 and 90 days was significant at 0.01 and 0.05 level of probability, respectively. The effect of cultivar on plant height was significant after 60 and 90 days (Table 1), and 'Kamome White' was better than 'Nagoya Red'. Also, spray method had better effect on plant height after 60 and 90 days and caused shorter plant height than drench method. Plant height decreased linearly with increasing cycocel concentration (Table 2, Fig. 1 and 2). The effect of cycocel concentration on plant height, at both stage of measurement (60 and 90 days), was significant. Plants of *Brassica oleracea* cultivars 'Kamome White' and 'Nagoya Red' treated with cycocel were shorter than control plants (Fig. 1 and 2). 1500 mg l^{-1} cycocel treatment produced shortest plants (10.79 cm after 60 days and

Table 1 : Analysis of variance (ANOVA) for the effect of different concentrations of cycocel, application method and type of variety on plant height, number of leaves, leaf diameter and dry matter of ornamental cabbage and kale (*Brassica oleracea*)

Source of variations	df	Mean of squares				
		Plant height after 60 days	Plant height after 90 days	Number of leaves after 90 days	Leaf diameter after 90 days	Dry matter
Replication (R)	3	0.018	0.103	0.346	0.092	0.043
Cultivar (A)	1	5.581**	10.360**	0.00^{ns}	2.610**	59.946**
Method (B)	1	4.332**	3.446**	0.879*	0.696**	0.001^{ns}
Concentration (C)	3	56.666**	50.876**	177.279**	6.531**	0.026^{ns}
A × B	1	0.066^{ns}	0.086*	0.035^{ns}	0.071^{ns}	0.008^{ns}
A × C	3	0.901**	0.232**	0.560*	0.629**	0.054^{ns}
B × C	3	1.398**	0.602**	0.496^{ns}	0.150^{ns}	0.175^{ns}
A × B × C	3	0.158**	0.052*	0.569*	0.134^{ns}	0.057^{ns}
Error	45	0.019	0.013	0.178	0.060	0.144
Total	63	-	-	-	-	-
CV (%)	-	1.04	0.77	1.40	2.86	2.88

^{ns}: Non significant, *: Significant at 5%, **: Significant at 1%

Fig. 1 : The effect of different concentrations of cycocel on plant height of *Brassica oleracea* cultivar 'Kamome White'. Left to right; 0, 500, 1000 and 1500 mg l^{-1} cycocel

Fig. 2 : The effect of different concentrations of cycocel on plant height of *Brassica oleracea* cultivar 'Nagoya Red'. Left to right; 0, 500, 1000 and 1500 mg l^{-1} cycocel

12.56 cm after 90 days) than control plants (15.20 cm after 60 days and 16.66 cm after 90 days). Among all treatments, interaction effects of 'Kamome White' + spray method + 1500 mg l^{-1} of cycocel had least plant height (9.94 cm after 60 days and 11.59 after 90 days) (Table 2).

One of the most important application of plant growth retardant is elevation of plant quality, especially ornamental plants by reduction of vegetative growth. Plant growth retardants decrease the internode length and eliminate the apical dominance (Lee *et al.,* 1999). Plant growth retardants increase cytokinins which enhances the amount of leaf chlorophyll (Rossini Pinto *et al*., 2005). Some of the most important factors concerning plant growth retardants are type, time, number, application method and concentration of growth retardant (Cramer and Bridgen, 1998). Cycocel is an important plant growth retardant. Several studies have revealed effectiveness of cycocel in decreasing plant height (Rossini Pinto *et al*., 2005; Olivera and Browing, 1993; Garner, 2004; Karlovic *et al*., 2004; Hashemabadi and Zarchini, 2010). Studies of Al-Khassawneh *et al*. (2006) on growth and flowering of *Iris nigricans* showed that cycocel reduced plant height only at the highest drench concentration. These researchers revealed that cycocel spray at higher concentrations (1000-1500 mg l^{-1}) reduced plant height. In the current study, cycocel caused decrease in plant height in ornamental cabbage and kale (*Brassica oleracea*) cultivars 'Kamome White' and 'Nagoya Red'. Karlovic *et al*. (2004) reported decreasing height in Chrysanthemum by 2000, 3000 and 4000 mg l^{-1} cycocel. Hashemabadi and Zarchini (2010) showed that least stem length (29.93 cm) was obtained by using 1500 mg l^{-1} cycocel in rose. Saffari *et al.* (2004) sprayed *Rosa damascena* with cycocel and found that 3000 mg l^{-1} cycocel decreased stem

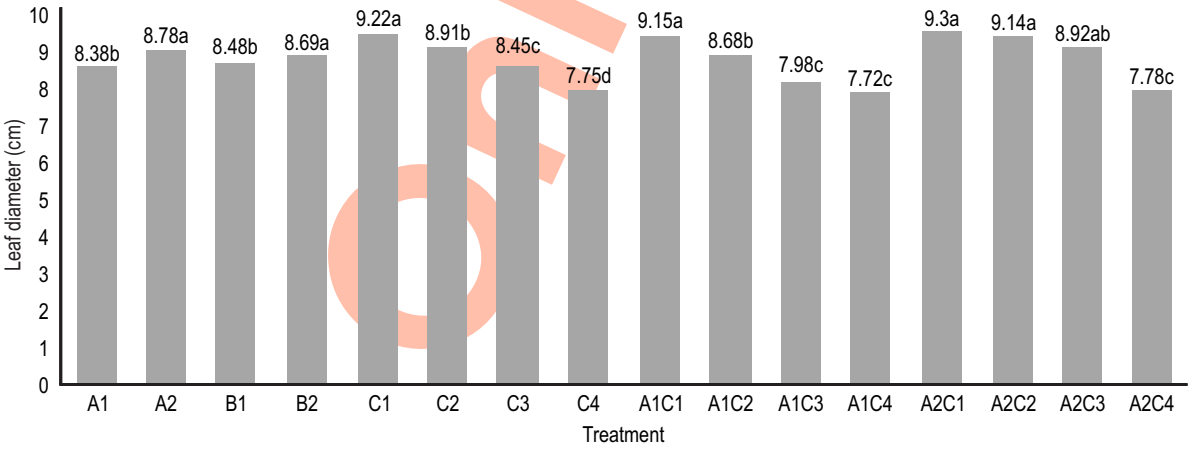

Fig. 3 : Effect of different treatments on leaf diameter of ornamental cabbage and kale (*Brassica oleracea*)

Table 2 : Mean comparison of the effect of different concentrations of cycocel, application method and type of variety on plant height, number of leaves, leaf diameter and dry matter of ornamental cabbage and kale (*Brassica oleracea*)

Treatments	Traits		
	Plant height after 60 days (cm)	Plant height after 90 days (cm)	Number of leaves after 90 days
Kamome White (A1)	12.96^{b}	14.61^{b}	30.22^{a}
Nagoya Red (A2)	13.55^{a}	15.41^{a}	30.22^{a}
Spray (B1)	12.99^{b}	14.78^{b}	30.10^{b}
Drench (B2)	13.52^{a}	15.24^{a}	30.34^{a}
Control (C1)	15.29^{a}	16.66^{a}	33.70^{a}
500 mg L^{-1} (C2)	13.88^{b}	15.89^{b}	32.08^{b}
1000 mg L^{-1} (C3)	13.08^{c}	14.92^{c}	28.84^{c}
1500 mg L^{-1} (C4)	10.79^{d}	12.56^{d}	26.25^{d}
A1B1	12.73^{c}	14.34^{d}	30.13^{b}
A1B2	13.19^{b}	14.87^{c}	30.31^{a}
A2B1	13.26^{b}	15.21^{b}	30.08^{b}
A2B2	13.85^{a}	15.61^{a}	30.36^{a}
A1C1	15.23^{a}	14.44^{b}	33.53^{a}
A1C2	13.61^{c}	15.40^{c}	31.97^{b}
A1C3	12.46^{d}	14.48^{d}	28.88^{c}
A1C4	10.57^{f}	12.09^{f}	26.50^{d}
A2C1	15.35^{a}	16.89^{a}	33.88^{a}
A2C2	14.15^{b}	16.37^{b}	32.19^{b}
A2C3	13.71^{c}	15.37^{c}	28.81^{c}
A2C4	11.02^{e}	13.02^{e}	26.00^{d}
B1C1	15.29^{a}	16.65^{a}	33.78^{a}
B1C2	13.65^{c}	15.68^{c}	32.06^{b}
B1C3	12.95^{e}	14.70^{e}	28.56^{c}
B1C4	10.11^{g}	12.07^{g}	26.00^{d}
B2C1	15.29^{a}	16.68^{a}	33.63^{a}
B2C2	14.10^{b}	16.09^{b}	32.09^{b}
B2C3	13.22^{d}	15.15^{d}	29.13^{c}
B2C4	11.47^{f}	13.04^{f}	26.50^{d}
A1B1C1	15.27^{a}	16.41^{b}	33.75^{a}
A1B1C2	13.52^{c}	15.08^{d}	32.00^{c}
A1B1C3	12.22^{e}	14.26^{f}	28.75^{d}
A1B1C4	9.94^{h}	11.59^{i}	26.00^{e}
A1B2C1	15.19^{a}	16.48^{b}	33.31^{ab}
A1B2C2	13.69^{c}	15.73^{c}	31.94^{c}
A1B2C3	12.70^{d}	14.70^{e}	29.00^{d}
A1B2C4	11.19^{g}	12.59^{h}	27.00^{e}
A2B1C1	15.31^{a}	16.89^{a}	33.81^{a}
A2B1C2	13.79^{c}	16.29^{b}	32.13^{c}
A2B1C3	13.68^{c}	15.13^{d}	28.38^{d}
A2B1C4	10.29^{h}	12.54^{h}	26.00^{e}
A2B2C1	15.39^{a}	16.88^{a}	33.94^{a}
A2B2C2	14.50^{b}	16.45^{b}	32.25^{bc}
A2B2C3	13.75^{c}	15.60^{c}	29.25^{d}
A2B2C4	11.75^{f}	13.49^{g}	26.00^{e}

In each column means followed by the same letters are not significantly different at 5 % level of probability using DMRT.

length by 5 cm as compared control. Increased application rates did not positively influence plant development when compared to the lower rates used in the study. Cycocel (1000 and 2000 mg l^{-1}) decreased *Zinnia* plant height (Hojjati *et al.*, 2009). The current study confirms to these studies. Cycocel, also, reduced plant height in *Euphorbia* and *Bougeinvillia* (Shekari *et al*., 2004), *Rosa* (Saffari *et al*., 2004) and *Pelargonium* (Latimer *et al*., 1994). In ornamental cabbage and kale and many ornamental plants, spraying was the better than drenching, for decreasing plant height (Garner, 2004). These results are consistent with our findings. Other plant growth retardants such as prohexadione-Ca, uniconazole, paclobutrazol, bayleton and daminozide are applied for decreasing plants growth as spray or drench (Gibson and Whipker, 2000; Bazzocchi and Giorgioni, 2003).

Based on the analysis of variance (Table 1), the effect of application method of cycocel, variety, concentration, interaction effect of variety and concentration and interaction effect of variety, method and concentration on leaf number were significant at 0.05 level of probability. Also, the effect of different concentration of cycocel on leaf number was significant at 0.01 level of probability. Mean comparison obtained from the data showed that the largest number of leaves per plant (33.94 and 33.88) was obtained from 'Nagoya Red' treated with drench without cycocel (control) and variety of 'Nagoya Red' without cycocel, respectively (Table 2). The production of leaf by drench method was higher than spray method.

Based on analysis of variance (Table 1), the effect of application method of cycocel, variety, concentration and interaction effect of variety and concentration on leaf diameter were significant at 0.01 level of probability. But, interaction effect of variety and method, method and concentration as well as variety, method and concentration on leaf diameter were not significant on leaf diameter. Mean comparison obtained from the data showed that maximum leaf diameter (9.39 cm) was obtained from 'Nagoya Red' treated with drench and without cycocel (control) (Table 2). Minimum leaf diameter (7.51 cm) was obtained from 'Kamome White' treated by spray with 1500 mg l^{-1}

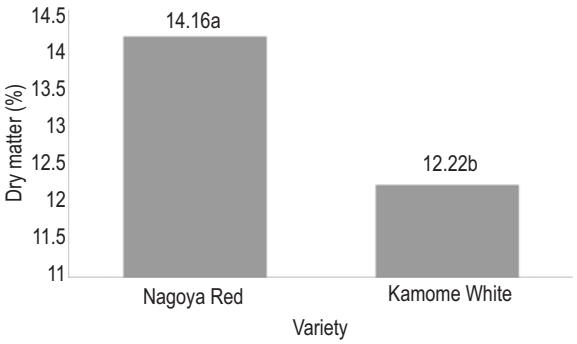

Fig. 4 : Effect of different treatments on dry matter of ornamental cabbage and kale (*Brassica oleracea*)

cycocel (Fig. 3). Results showed that leaf diameter in 'Kamome White' (8.38 cm) variety was less than that of 'Nagoya Red' (8.78 cm).

Studies of Al-Khassawneh *et al.* (2006) on growth and flowering of *Iris nigricans* showed that maximum number of leaves (average of 12.2-13.6) was obtained when plants were untreated with cycocel and paclobutrazol, sprayed with 250 mg l^{-1} paclobutrazol, or drenched with 0.25 mg l^{-1}. Our finding is consistent with these results. Study of Agrawal and Dikshit (2008) on *Achras sapota* demonstrated positive effect of cycocel on leaf number. The current study showed that the highest dry matter percentage was obtained from untreated plants with cycocel. In agreement with our finding, Al-Khassawneh et al. (2006) also showed that untreated plants had highest dry leaf weight. Study of Garib Sahi (2009) on *Zinnia elegans* revealed that spraying plants with 2000 mg l^{-1} cycocel and 1 mg l^{-1} $CaCl_2$ increased dry weight of leaves and roots.

Table 1 shows that only the effect of variety on dry matter was significant at 0.01 level of probability and other treatments had no significant effect on this trait. Table 2 shows that dry matter percentage in 'Nagoya Red' (14.16%) was higher than that of 'Kamome White' (12.22%). Mean comparison obtained from the data showed that highest dry matter percentage (14.31%) was obtained from 'Nagoya Red' treated by spray without cycocel (Table 2). Least dry matter percentage (11.99%) was calculated from 'Kamome White' treated with drench without cycocel (Fig. 4).

In conclusion, 1500 mg l^{-1} of cycocel resulted in shorter plants than control plants. The growth of *Brassica oleracea* cultivar 'Kamome White' and 'Nagoya Red' decreased with increase in cycocel concentration. Foliar sprays of cycocel controlled plant height of both cultivars.

Acknowledgments

The authors would like to thank the Islamic Azad University, Rasht Branch, especially Dr. Amirteimouri for their financial support.

References

Agrawal, S. and S.N. Dikshit: Studies on the effect of plant growth regulators on growth and yield of sapota (*Achras sapota* L. cv. 'Cricket Ball'). *Ind. J. Agric. Res.*, **42,** 207-211 (2008).

Al-Khassawneh, N.M., N.S. Karam and R.A. Shibli: Growth and flowering of black iris (*Iris nigricans* Dinsm.) following treatment with plant growth regulators. *Sci. Hortic.*, **107,** 187-193 (2006).

Bazzocchi, R. and M.E. Giorgioni: Effect of prohexadione-Ca, uniconazole and paclobutrazol on ornamental kale growth and performance under high temperature. *Acta Hortic.*, **614,** 499-505 (2003).

Cramer, C.S. and M.P. Bridgen: Growth regulator effects on plant height of potted *Mussaenda* 'Qeen Sirikit'. *HortSci.*, **33,** 78-81 (1998).

Garib Sahi, B.: Effect of cycocel spray and calcium chloride on the growth and flowering of *Zinnia elegnas* Taeq. The 2th Kurdistan Conf. Biol. Sci., pp. 39-43 (2009).

Garner, W.: PGR General uses and overview. *Technical Service*, **800,** 4556-4647 (2004).

Gibson, B. and B.E. Whipker: Research progress report: The effect of B_9, bonzi and sumagic on the growth of ornamental cabbage and kale. *North Carolina Flower Growers Bull.*, **44,** 6-9 (2000).

Hashemabadi, D. and M. Zarchini: Effect of some plant growth regulators on growth and flowering of *Rosa hybrida* "Poison". *Plant Omics J.*, **3,** 167-171 (2010).

Hojjati, M., N. Etemadi and B. Baninasab: Effect of paclobutrazol and cycocel on vegetative growth and flowering of *Zinnia elegans*. *Agric. Sci. Technol. Nat. Resource*, **47,** 649-656 (2009) (In Persian).

Karlovic, K., I. Vrsek, Z. Sindrak and V. Zidovec: Influence of growth regulators on the height and number of inflorescence shoots in the chrysanthemum cultivar. *Rev. Agric. Consp. Sci.*, **69,** 63-66 (2004).

James, L., B. Gibson and E. Whipker: The effect of B_9 + cycocel on the growth of *Brassica juncea* var. Rugosa Red Giant. *SNA Res. Con.*, **44,** 284-287 (1999).

Latimer, J.G. and S.A. Beden: Persistent effect of plant growth regulators on landscape performance of seed geraniums. *J. Environ. Hortic.*, **12,** 150-154 (1994).

Leclerc, M., C.D. Caldwell and R.R. Lade: Effect of plant growth regulators on propagule formation in *Hemerocallis* spp. and *Hosta* spp. *Hort. Sci.*, **47,** 651-653 (2006).

Lee, J.H., E.S. Jin and W.T. Kim: Inhibition of auxin-induced ethylene production by SA in mungbean hypocotyls. *J. Plant Biol.*, **42,** 1-7 (1999).

Magnitskiy, S.V., C.C. Pasian, M.A. Bennett and J.D. Metzger: Controlling plug height of verbena, celosia, and pansy by treating seeds with paclobutrazol. *Hort. Sci.*, **47,** 158-167 (2006).

Messinger, N.L. and E.J. Holcomb: The effect of chlormequat chloride, ancymidol, BAS 106 and SD 8339 on selected *Dianthus* cultivars. *Hort. Sci.*, **21,** 1397-1400 (1986).

Olivera, C.M. and G. Browning: Studies on the induction of flowering in juvenile *Prunus avium* L. *J. Hort. Sci.*, **68,** 731-739 (1993).

Pobudkiewicz, A.K. and J. Nowak: The influence of florprimidol and uniconazole on growth of the CMM draft *Dianthus caryophyllus* L. 'Snowmass'. *J. Fruit Ornam. Plant Res.*, **2,** 135-142 (1994).

Rossini Pinto, A.C., Td.J.D. Rodrigues, C.I Leits and J.C. Barbosa: Growth retardants on development and ornamental quality of potted '*Liliput*' *Zinnia elegans* JACQ: *Sci. Agric.*, **62,** 337-345 (2005).

Saffari, V.R., A. Khalighi, H. Lesani, M. Babalar and J.F. Obermaier: Effect of different plant growth regulators and time of pruning on yield components of *Rosa damascena* Hill. *Int. J. Agric. Biol.*, **6**, 1040-1042 (2004).

Shekari, F., A. Ebrahimzadeh and B. Esmaeilpour: Plant growth regulators in agriculture and horticulture. Zanjan Univ. Press, Iran (2004) (In Persian).

Tayama, H.K. and S.A. Carver: Zonal geranium growth and flowering responses to six growth regulators. *Hort. Sci.*, **25,** 82-83 (1990).