Journal of Ornamental and Horticultural Plants
Available online on: www.jornamental.com
ISSN (Print): 2251-6433
ISSN (Online): 2251-6441

Controlling Ornamental Cabbage and Kale (*Brassica oleracea*) Growth via Cycocel

A. Gholampour[1], D. Hashemabadi[2*], Sh. Sedaghathoor[2] and B. Kaviani[2]
[1]MSc. Student, Department of Horticultural Science, Rasht Branch, Islamic Azad University, Rasht, Iran.
[2]Department of Horticultural Science, Rasht Branch, Islamic Azad University, Rasht, Iran.

Received: 5 January 2012 Accepted: 15 April 2012
*Corresponding author's email: davoodhashemabadi@yahoo.com

Abstract

Chlormequat (cycocel or CCC), the plant growth retardant, was evaluated for its ability to control plant height in *Brassica oleracea* cultivar 'Kamome White' and 'Nagoya Red'. Different concentrations of CCC (0, 500, 1000 and 1500 mg/L) were sprayed and drenched on plants 40 days after transplanting. Data were recorded the 60 and 90 days after transplanting. The 1500 mg/L of CCC resulted in about 50 and 20% shorter plants than the control plants, 60 and 90 days after transplant, respectively. The growth of *Brassica oleracea* cultivar 'Kamome White' and 'Nagoya Red' decreased with increasing the concentration of CCC. Foliar sprays of CCC controlled plant height of both cultivars. The least record of plant height was obtained by application of 1500 mg/L CCC via spraying method in cultivar 'Kamome White' after 60 and 90 days (9.94 and 11.59 cm, respectively). The effect of cultivar type has been significant at $p \leq 0.01$ level on all measured traits.

Keywords: Brassicaceae, Chlormequat, Drench, Plant height, Spray.

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 the cold. Due to excessive stem elongation of ornamental cabbage and kale in the fall and early winter, there is a challenge for maintaining a short, yet robust plant that will look proportional to the proper size. Shorter plants are more attractive and easier to handle during marketing and planting. Commercial value of ornamental cabbage and kale depends on its height.

Plant growth regulators are commonly applied to limit stem elongation and produce a more compact plant (Tayama *et al.,* 1992). To counteract excessive stem elongation, plant growth retardants like CCC are usually used (Messinger and Holcomb, 1986; Sachs and Hackett, 1972). These compounds can delay cell division and elongation of plant aerial parts as well restrict gibberellins biosynthesis, resulted in reduces internodes length and vegetative growth (Cosgrove and Sovonick-Dunford, 1989; Catchey, 1964; Sanderson, 1973; Magnitskiy *et al.,* 2006). Gibberellins play an important role in the growth and development of plants. Type of species and cultivar, time and method of application, concentration, and type of target organ as well physiological and environmental conditions are some important factors affecting on the influence of growth retardants on plants (Hojjati *et al.,* 2009; Khangoli, 2001; Holcomb and White, 1970; James *et al.,* 1999; Pobudkiewicz and Nowak, 1994). CCC is applied as foliar spray and drench (Shekari *et al.,* 2004). Determining the optimal CCC foliar spray or drench rates would offer other options for controlling ornamental cabbage and kale plant growth (Gibson and Whipker, 2000). Proper doses need to be assessed because they can either inhibit or promote growth and development depending on amount. Recommended stage and doses for CCC application are 3-4 true leaf and 500-3000 mg/L (Shekari *et al.,* 2004). Adding CCC has also proven to be effective in controlling growth of some other plants (Holcomb and White, 1970; Al-Khassawneh *et al.,* 2006; Leclerc *et al.,* 2006; Hojjati *et al.,* 2009; Karlovic *et al.,* 2004; Rossini Pinto *et al.,* 2005).

The purpose of this study was to evaluate the effect of different concentrations of CCC on some growth characters especially plant height in *Brassica oleracea* cultivars ‘Kamome White’ and ‘Nagoya Red’.

MATERIALS AND METHODS

Seeds of ornamental cabbage and kale (*Brassica oleracea*) cultivars ‘Kamome White’ and ‘Nagoya Red’ were prepared from Takii and Sakata Company (Japan), respectively. Investigation was carried out on experimental field in Rudesar city located in the northern part of Iran (N 38.8° and S 50.19°; altitude, -22 m above sea level; mean annual rainfall, 958.6 mm; mean annual temperature, 17.3°C; mean annual relative humidity, 78%; mean annual evaporation, 1044.2 mm; mean annual sunlight radiation, 2146.0 h). Seeds were sown in pots filled with 50% cocopeat, 30% perlite and 20% sand on August 23 2010. Uniform size seedlings (approximately 3-4 true leaf) were potted 40 days after seeding in plastic pots filled with clay, manure, compost and sand (1:1:1:1). Plants were treated with a foliar and drench application at rate of 500, 1000 and 1500 mg/L CCC, 40 days after potting. Control plants were sprayed and drenched only with 6 mL/pot and 60 mL/plant water, respectively. First data were calculated the 60 days after transplanting. Then plants were transferred to the same pots and same soils. Second data were calculated the 90 days after transplanting. Plant height, stem length (measured from crown to the first leaf), leaf chlorophyll content and leaf brix degree (°B) were recorded the 60 days after potting. Plant height, stem length, leaf chlorophyll content, leaf brix degree (°B), leaf number and diameter, and plant dry weight were recorded the 90 days after potting. Plant height, stem length and leaf diameter by ruler, brix degree by refractometer Atago (N-1α) and plant dry weight by digital balance were measured. To obtain the plant dry weight, they were cut from crown and dried at 105°C for 24 h. The experimental design was a randomized completely blocks design (RCBD) with a factorial arrangement of treatments containing of four CCC concentrations × two treatments 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 were carried out by employing Duncan's Multiple Range test at α = 5%.

RESULTS

The overall results of the effect of different concentrations of CCC on plant height stem length, leaf chlorophyll content and leaf brix degree (°B) in *Brassica oleracea* cultivars 'Kamome White' and 'Nagoya Red' after 60 and 90 days are summarized in Table 2.

Plant height

Based on analysis of variance (Table 3), the effect of different treatments and their interaction on the plant height after 60 and 90 days was significant at 0.01 level of probability. There is no significant difference 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 the plant height after 60 and 90 days was significant at 0.01 and 0.05 level of probability, respectively. The effect of cultivar on the plant height was significant after 60 and 90 days (Table 3), and 'Kamome White' was better than 'Nagoya Red'. Also, spray method had better effect on the plant height after 60 and 90 days and caused shorter plant height than drench method. Plant height decreased linearly with increasing the CCC concentration (Fig. 1). The effect of CCC concentration on plant height in both time of measurement (60 and 90 days was significant). *Brassica oleracea* cultivars 'Kamome White' and 'Nagoya Red' plants treated with CCC were shorter than the control plants (Table 1). 1500 mg/L CCC treatment produced the shortest plants (10.79 cm after 60 days and 12.56 cm after 90 days) than the 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 of CCC had the least plant height (9.94 cm after 60 days and 11.59 after 90 days) (Table 1, Fig. 1).

Stem length

The effect of different treatments on the stem length after 60 days was no significant, but the effect of cultivar, method, different concentrations of CCC, interaction between cultivars + concentration and method + concentration on the stem length after 90 days was significant at 0.01 level of probability (Table 3). 'Kamome White' cultivar with 2.32 cm length was better than 'Nagoya Red' with 2.62 cm (Table 2). Also, spray method with 2.41 cm had better effect on the stem length than drench method with 2.53 cm. Like plant height, stem length decreased linearly to increasing the CCC concentration. 1500 mg/L CCC treatment produced the shortest stem length (2.03 cm) than the control plants (2.85 cm). Interaction effect of cultivar and method with concentration on stem length was significant (Table 3). Among all treatments, least stem length (1.90 cm) and highest stem length (3.07 cm) were obtained in treatment of drench method + concentration of 1500 mg/L of CCC and control, respectively (Table 2).

Leaf chlorophyll content

The effect of cultivar, as well as interaction effect of cultivar with method and concentration was significant. Based on analysis of variance (Table 3), the effect of cultivar on the leaf chlorophyll content after 60 and 90 days was significant at 0.01 level of probability. Chlorophyll index in 'Nagoya Red' showed significant superiority than that of 'Kamome White' after 60 and 90 days (Tables 1 and 2). Interaction effect of cultivar + method, cultivar + CCC concentration and cultivar + method + CCC concentration on chlorophyll index was significant based on mean comparison not based on analysis of variance (Tables 1, 2 and 3). The most chlorophyll index was calculated in treatments of 'Kamome White' + drench method + 1000 mg/L CCC (18.50) after 60 days and 'Nagoya Red' + drench method + 1500 mg/L CCC (20.14) after 90 days (Tables 1 and 2).

Leaf brix degree (°B)

The effect of cultivar, as well as interaction effect of cultivar with method and concentration was significant on leaf brix degree after 60 and 90 days (Table 3). Reciprocity of cultivar in interaction effect with concentration and method was no significant but its difference was significant (Table 3). Leaf brix degree of 'Nagoya Red' (7.39) had significant superiority than that of 'Kamome White' (6.00) after 90 days (Table 2). Interaction effect of cultivar + method, cultivar + concentration and cultivar + method + concentration had better effect in 'Nagoya Red' than 'Kamome White'. Totally, leaf brix degree after 90 days was more than that of 60 days (Tables 1 and 2). After 90 days, the most leaf brix degree (7.45) and the least of that (5.86) was obtained in treatments of 'Nagoya Red' + spray method + 1500 mg/L CCC and 'Kamome White' + drench method + 500 mg/L CCC, respectively (Table 2).

DISCUSSION

One of the most important applications of plant growth retardant is elevation of plant quality, especially ornamental plant by reduction of vegetative growth. Plant growth retardants decrease the internodes length and eliminate the apical dominance (Khangoli, 2001; Lee *et al.,* 1999). CCC is an important plant growth retardant. CCC caused transport of carbohydrates to the roots via decreasing shoot length (Leclerc *et al.,* 2006). Study of Hojjati *et al.* (2009) on *Zinnia* showed that the 2000 mg/L CCC caused the least amount of shoot carbohydrate. Plant growth retardants increase cytokinins which resulted in enhance the amount of leaf chlorophyll (Dole and Wilkins, 2005; 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). In current study, CCC caused decreasing of plant height in ornamental cabbage and kale (*Brassica oleracea*) cultivars 'Kamome White' and 'Nagoya Red'. Decreasing the plant height by CCC was observed in many species (Olivera and Browning, 1993; Garner, 2004; Karlovic *et al.,* 2004; Rossini Pinto *et al.,* 2005; Hashemabadi and Zarchini, 2010). Karlovic et al. (2004) reported decreasing height in Chrysanthemum by 2000, 3000 and 4000 mg/L CCC. Hashemabadi and Zarchini (2010) showed that the least stem length (29.93 cm) was obtained by using 1500 mg/L CCC in rose, poison. The stem length was 35.7 cm in control plant. These researchers showed a significant decrease in stem length under CCC application. Saffari et al. (2004) sprayed the Rosa damascena with CCC and revealed that 3000 mg/L CCC decreased stem length about 5 cm relative to control. Studies of Karlsson et al. (1992) on Begonia × tuberhybrida showed that the CCC (500 mg/L) resulted in 23% shorter plants than the control plants 15 weeks after transplanting. Increased application rates did not positively impact plant development when compared to the lower rates used in the study. CCC (1000 and 2000 mg/L) decreased *Zinnia* plant height (Hojjati *et al.,* 2009). Studies on several ornamental plants revealed that the maximum concentration of CCC for reduction of plant height is 1500 mg/L (Cathey, 1975; Schwartz *et al.,* 1985; Hedayat, 2001; Joyce *et al.,* 2004). Current study conforms to these studies. This growth retardant, also, reduced plant height in Euphorbia and Bougeinvillia (Shekari *et al.,* 2004), Rosa (Saffari *et al.,* 2004) and Pelargonium (Latimor and Beden, 1994). In ornamental cabbage and kale and many ornamental plants, spraying was the better than drenching for decreasing the plant height (Schwartz *et al.,* 1985; Garner, 2004; Hedayat, 2001). These results are consistent with our findings. Other plant growth retardants such as prohexadione-Ca, uniconazole, paclobutrazol, bayleton and daminozide are applied for decreasing the plants growth as spray or drench (Karlsson *et al.,* 1992; Gibson and Whipker, 2000; Bazzocchi and Giorgioni, 2003; Hojjati *et al.,* 2009).

ACKNOWLEDGEMENTS

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

Literature Cited

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

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

Catchey, H.M. 1964. Physiology of growth retarding chemicals. Ann. Rev. Plant Physiol. 15: 271-302.

Cathey, H.M. 1975. Comparative plant growth retarding activites of ancymidol with ACPC, phosphon, chlormequat and SADH on ornamental plant species. Hort. Sci. 10: 204-216.

Cosgrove, D.L. and Sovonick-Dunford, S.A. 1989. Mechanism of gibberellin dependent stems elongation in peas. Plant Physiol. 89: 184-191.

Garner, W. 2004. PGR general uses and overview. Technical Service, 800: 4556-4647.

Gibson, B. and Whipker, B.E. 2000. Research progress report: the effect of B9, bonzi and sumagic on the growth of ornamental cabbage and kale. North Carolina Flower Growers Bulletin, 44: 6-9.

Hashemabadi, D. and Zarchini, M. 2010. Effect of some plant growth regulators on growth and flowering of *Rosa hybrida* "Poison". Plant Omics J. 3 (6): 167-171.

Hedayat, M. 2001. Application of growth retardants in greenhouse. First National Scientific and Practical Symposium on Flowers and Ornamental Plants of Iran. Jahad-e-Keshavarzi, Iran (In Persian).

Hojjati, M., Etemadi, N. and Baninasab, B. 2009. Effect of paclobutrazol and cycocel on vegetative growth and flowering of *Zinnia elegans*. Agricultural Sciences and Technologies and Natural Resources. 47: 649-656 (In Persian).

Holcomb, E.J. and White, J.W. 1970. A technique for soil application of growth retardant. HortSci. 5: 16-17.

James, L., Gibson, B. and Whipker, E. 1999. The effect of B9 + cycocel on the growth of *Brassica juncea* var. 'Rugosa Red Giant'. SNA Research Conference, 44: 284-287.

Joyce, G., Latimer, H., Scoggins, L. and Thomas, J. 2004. Using plant growth regulators on containerized herbaceous perennials. Virginia State University.

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

Karlsson, M.G., Werner, J.W. and Hanscom, J.T. 1992. Growth regulator effect in seed propagated *Begonia* × *tuberhybrida*. University of Alaska Fairbank. Circular, 90. July 1992.

Khangoli, S. 2001. Potential of growth regulators on height and flowering control in ornamental plants. First National Scientific and Practical Symposium on Flowers and Ornamental Plants of Iran. Jahad-e-Keshavarzi, Iran (In Persian).

Latimer, J.G. and Beden, S.A. 1994. Persistent effect of plant growth regulators on landscape performance of seed geraniums. J. Environ. Hort. 12 (3): 150-154.

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

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

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

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

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

Pobudkiewicz, A.K. and Nowak, J. 1994. The influence of florprimidol and uniconazole on growth of the CMM draft Dianthus caryophyllus L. 'Snowmass'. J. Fruit and Ornamental Plant Res. 2 (4): 135-142.

Rossini pinto, A.C., Rodrigues, T.D.J.D., Leits, C.I. and Barbosa, J.C. 2005. Growth retardants on development and ornamental quality of potted. 'Liliput' *Zinnia* elegans JACQ. Sci. Agric. 62: 337-345.

Sachs, R.M. and Hackett, W.P. 1972. Chemical inhibition of plant height. HortSci. 7: 440-447.

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

Sanderson, K.C. 1973. Screening chemicals for controlling growth and flowering of Forsythia intermedia Zabel. HortSci. 8: 477-479.

Schwartz, M.A., Payne, R.N. and Sites, G. 1985. Residual effect of chlormequat on garden performance in sun and shade of seed and cutting-propagated cultivars of geraniums. HortSci. 20: 368-370.

Shekari, F., Ebrahimzadeh, A. and Esmaeilpour, B. 2005. Plant growth regulators in agriculture and horticulture. Zanjan University Press, Iran (In Persian).

Tayama, H.K., Larson, R.A., Hammer, P.A. and Rolls, T.J. (eds.) 1992. Tips on the use of chemical growth regulators on floriculture crops. Ohio Florists' Assn., Columbus, Ohio.

Tables

Table 1. Mean comparison of the effect of different concentrations of cycocel, application method and type of variety on plant height, stem height, chlorophyll index and brix degree of ornamental cabbage and kale (*Brassica oleracea*) after 60 days.

Traits Treatment	Plant height (cm)	Stem height (cm)	Chlorophyll index	Brix degree
Kamome White (A_1)	12.96^{b}	2.05a	11.24^{b}	5.04^{b}
Nagoya Red (A_2)	13.55^{a}	2.03^{a}	17.75^{a}	6.05^{a}
Spray (B_1)	12.99^{b}	2.05^{a}	14.31^{a}	5.55^{a}
Drench (B_2)	13.52^{a}	2.03^{a}	14.68^{a}	5.54^{a}
Control (C_1)	15.29^{a}	2.09^{a}	14.37^{a}	5.56^{a}
500 mgL^{-1} (C_2)	13.88^{b}	2.03^{a}	14.27^{a}	5.53^{a}
1000 mgL^{-1} (C_3)	13.08^{c}	2.03^{a}	14.38^{a}	5.54^{a}
1500 mgL-1 (C_4)	10.79^{d}	2.01^{a}	14.96^{a}	5.54^{a}
A_1B_1	12.73^{c}	2.07^{a}	10.80^{b}	5.05^{b}
A_1B_2	13.19^{b}	2.04^{a}	11.69^{b}	5.03^{b}
A_2B_1	13.26^{b}	2.04^{a}	17.83^{a}	6.05^{a}
A_2B_2	13.85^{a}	2.03^{a}	17.67^{a}	6.04^{a}
A_1C_1	15.23^{a}	2.12^{a}	11.63^{c}	5.06^{b}
A_1C_2	13.61^{c}	2.07^{a}	10.93^{cd}	5.03^{b}
A_1C_3	12.46^{d}	2.02^{a}	10.72^{cd}	5.01^{b}
A_1C_4	10.57^{f}	2.00^{a}	11.69^{c}	5.05^{b}
A_2C_1	15.35^{a}	2.07^{a}	17.11^{ab}	6.06^{a}
A_2C_2	14.15^{b}	2.00^{a}	17.61^{ab}	6.03^{a}
A_2C_3	13.71^{c}	2.04^{a}	18.04^{a}	6.07^{a}
A_2C_4	11.02^{e}	2.02^{a}	18.23^{a}	6.04^{a}
B_1C_1	15.29^{a}	2.08^{a}	14.23^{a}	5.61^{a}
B_1C_2	13.65^{c}	1.97^{a}	14.32^{a}	5.53^{a}
B_1C_3	12.95^{e}	2.07^{a}	13.90^{a}	5.54^{a}
B_1C_4	10.11^{g}	2.09^{a}	14.79^{a}	5.52^{a}
B_2C_1	15.29^{a}	2.11^{a}	14.50^{a}	5.51^{a}
B_2C_2	14.10^{b}	2.10^{a}	14.22^{a}	5.53^{a}
B_2C_3	13.22^{d}	1.99^{a}	14.86^{a}	5.53^{a}
B_2C_4	11.47^{f}	1.93^{a}	15.13^{a}	5.57^{a}
$A_1B_1C_1$	15.27^{a}	2.13^{a}	11.61^{d}	5.10^{b}
$A_1B_1C_2$	13.52^{c}	1.99^{a}	10.18^{e}	5.05^{b}
$A_1B_1C_3$	12.22^{e}	2.06^{a}	10.23^{e}	5.02^{b}
$A_1B_1C_4$	9.94^{h}	2.08^{a}	11.19^{d}	5.02^{b}
$A_1B_2C_1$	15.19^{a}	2.12^{a}	11.64^{d}	5.03^{b}
$A_1B_2C_2$	13.69^{c}	2.14^{a}	11.69^{d}	5.01^{b}
$A_1B_2C_3$	12.70^{d}	1.97^{a}	11.22^{d}	5.00^{b}
$A_1B_2C_4$	11.19^{g}	1.93^{a}	12.19^{c}	5.08^{b}
$A_2B_1C_1$	15.31^{a}	2.04^{a}	16.86^{b}	6.12^{a}
$A_2B_1C_2$	13.79^{c}	1.95^{a}	18.47^{b}	6.01^{a}
$A_2B_1C_3$	13.68^{c}	2.08^{a}	17.58^{ab}	6.07^{a}
$A_2B_1C_4$	10.29^{h}	2.09^{a}	18.39^{a}	6.01^{a}
$A_2B_2C_1$	15.39^{a}	2.09^{a}	17.39^{ab}	6.00^{a}
$A_2B_2C_2$	14.50^{b}	2.06^{a}	16.75^{b}	6.04^{a}
$A_2B_2C_3$	13.75^{c}	2.01^{a}	18.50^{a}	6.07^{a}
$A_2B_2C_4$	11.75^{f}	1.94^{a}	18.07^{a}	6.06^{a}

Means sharing same letter in a column are statistically similar not significantly.

Table 2. Mean comparison of the effect of different concentrations of cycocel, application method and type of variety on plant height, stem height, chlorophyll index and brix degree of ornamental cabbage and kale (*Brassica oleracea*) after 90 days.

Traits / Treatment	Plant height (cm)	Stem height (cm)	Chlorophyll index	Brix degree
Kamome White (A_1)	14.61^{b}	2.32^{b}	15.28^{b}	6.00^{b}
Nagoya Red (A_2)	15.41^{a}	2.62^{a}	18.23^{a}	7.39^{a}
Spray (B_1)	14.78^{b}	2.41^{b}	16.49^{a}	6.72^{a}
Drench (B_2)	15.24^{a}	2.53^{a}	17.03^{a}	6.67^{a}
Control (C_1)	16.66^{a}	2.85^{a}	16.90^{a}	6.71^{a}
500 mgL^{-1} (C_2)	15.89^{b}	2.63^{b}	16.44^{a}	6.66^{a}
1000 mgL^{-1} (C_3)	14.92^{c}	2.38^{c}	16.66^{a}	6.72^{a}
1500 mgL-1 (C_4)	12.56^{d}	2.03^{d}	17.02^{a}	6.71^{a}
A_1B_1	14.34^{d}	2.28^{cd}	14.94^{b}	6.05^{b}
A_1B_2	14.87^{c}	2.37^{c}	15.62^{b}	5.96^{b}
A_2B_1	15.21^{b}	2.55^{b}	18.04^{a}	7.39^{a}
A_2B_2	15.61^{a}	2.69^{a}	18.43^{a}	7.38^{a}
A_1C_1	14.44^{b}	2.65^{bc}	15.09^{c}	6.03^{b}
A_1C_2	15.40^{c}	2.52^{c}	15.11^{c}	5.94^{b}
A_1C_3	14.48^{d}	2.13^{d}	15.55^{c}	6.05^{b}
A_1C_4	12.09^{f}	2.00^{d}	15.37^{c}	5.99^{b}
A_2C_1	16.89^{a}	3.04^{a}	18.72^{a}	7.38^{a}
A_2C_2	16.37^{b}	2.73^{b}	17.78^{ab}	7.37^{a}
A_2C_3	15.37^{c}	2.64^{bc}	17.76^{ab}	7.38^{a}
A_2C_4	13.02^{e}	2.07^{d}	18.68^{a}	7.42^{a}
B_1C_1	16.65^{a}	2.86^{a}	16.86^{ab}	6.70^{a}
B_1C_2	15.68^{c}	2.58^{b}	15.50^{b}	6.69^{a}
B_1C_3	14.70^{e}	2.31^{de}	17.48^{ab}	6.76^{a}
B_1C_4	12.07^{g}	1.90^{f}	16.11^{ab}	6.72^{a}
B_2C_1	16.68^{a}	2.84^{a}	16.95^{ab}	6.71^{a}
B_2C_2	16.09^{b}	2.67^{b}	17.37^{ab}	6.62^{a}
B_2C_3	15.15^{d}	2.45^{cd}	15.83^{ab}	6.68^{a}
B_2C_4	13.04^{f}	2.17^{e}	17.94^{a}	6.69^{a}
$A_1B_1C_1$	16.41^{b}	2.65^{b}	14.56^{g}	6.08^{b}
$A_1B_1C_2$	15.08^{d}	2.49^{c}	14.44^{g}	6.04^{b}
$A_1B_1C_3$	14.26^{f}	2.08^{e}	15.76^{e}	6.08^{b}
$A_1B_1C_4$	11.59^{i}	1.89^{f}	15.00^{g}	5.99^{b}
$A_1B_2C_1$	16.48^{b}	2.66^{b}	15.62^{e}	5.98^{b}
$A_1B_2C_2$	15.73^{c}	2.54^{c}	15.78^{e}	5.84^{b}
$A_1B_2C_3$	14.70^{e}	2.17^{d}	15.34^{f}	6.03^{b}
$A_1B_2C_4$	12.59^{h}	2.11^{e}	15.73^{e}	5.99^{b}
$A_2B_1C_1$	16.89^{a}	3.07^{a}	19.16^{b}	7.33^{a}
$A_2B_1C_2$	16.29^{b}	2.68^{b}	16.56^{e}	7.35^{a}
$A_2B_1C_3$	15.13^{d}	2.54^{c}	19.21^{b}	7.44^{a}
$A_2B_1C_4$	12.54^{h}	1.91^{f}	17.22^{d}	7.45^{a}
$A_2B_2C_1$	16.88^{a}	3.02^{a}	18.28^{c}	7.44^{a}
$A_2B_2C_2$	16.45^{b}	2.79^{b}	18.99^{b}	7.39^{a}
$A_2B_2C_3$	15.60^{c}	2.73^{b}	16.32^{e}	7.32^{a}
$A_2B_2C_4$	13.49^{g}	2.23^{c}	20.14^{a}	7.39^{a}

Means sharing same letter in a column are statistically similar not significantly.

Table 3. Analysis of variance (ANOVA) for the effect of different concentrations of Cycocel, application method and type of variety on plant height, stem height, chlorophyll index and brix degree of ornamental cabbage and kale (*Brassica oleracea*).

Mean square								df	Source of variations
After 90 days				After 60 days					
Brix degree	**Chlorophyll Index**	**Stem height**	**Plant height**	**Brix degree**	**Chlorophyll Index**	**Stem height**	**Plant height**		
30.664**	139.831**	1.433**	10.36**	16.301**	677.333**	0.006 ns	5.581**	1	Cultivars (A)
0.035 ns	4.623 ns	0.217**	3.446**	0.003 ns	2.141 ns	0.007 ns	4.332**	1	Methods (B)
0.012 ns	1.075 ns	1.946**	50.876**	0.003 ns	1.581 ns	0.021 ns	56.666**	3	Concentrations (C)
0.023 ns	0.316 ns	0.012 ns	0.086**	0.00 ns	4.319 ns	0.001 ns	0.066 ns	1	A × B
0.010 ns	1.630 ns	0.147**	0.232**	0.005 ns	2.308 ns	0.009 ns	0.901**	3	A × C
0.007 ns	11.319*	0.059**	0.602**	0.016 ns	0.773 ns	0.059 ns	1.398**	3	B × C
0.028 ns	5.161 ns	0.006 ns	0.052*	0.003 ns	2.717 ns	0.002 ns	0.158**	3	A × B × C
0.025	3.879	0.007	0.013	0.006	2.102	0.035	0.019	45	Errors
-	-	-	-	-	-	-	-	63	Total
2.36	11.75	3.42	0.77	1.37	10	9.13	1.04	-	c.v.

**: Significant at α = 1%, *: Significant at α = 5%, ns=Not significant

Figures

Fig. 1. The effect of different concentrations of CCC on plant height of *Brassica oleracea* cultivar 'Kamome White'. Left to right; 0, 500, 1000 and 1500 mg/L CCC.

Fig. 2. The effect of different concentrations of CCC on plant height of *Brassica oleracea* cultivar 'Nagoya Red'. Left to right; 0, 500, 1000 and 1500 mg/L CCC.