

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

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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.

Abstract

**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  $\times$  two treatments methods (spray and drench)  $\times$  two cultivars ('Kamome White' and 'Nagoya Red')  $\times$  sixteen treatments totally  $\times$  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  $\alpha = 5\%$ .

## RESULTS

The overall results of the effect of different concentrations of CCC on plant height stem length, leaf chlorophyll content and leaf brix degree ( $^{\circ}\text{B}$ ) 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 × tuberculata* 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 *Bougainvillea* (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).



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## 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 <sub>1</sub> )	12.96 <sup>b</sup>	2.05 <sup>a</sup>	11.24 <sup>b</sup>	5.04 <sup>b</sup>
Nagoya Red (A <sub>2</sub> )	13.55 <sup>a</sup>	2.03 <sup>a</sup>	17.75 <sup>a</sup>	6.05 <sup>a</sup>
Spray (B <sub>1</sub> )	12.99 <sup>b</sup>	2.05 <sup>a</sup>	14.31 <sup>a</sup>	5.55 <sup>a</sup>
Drench (B <sub>2</sub> )	13.52 <sup>a</sup>	2.03 <sup>a</sup>	14.68 <sup>a</sup>	5.54 <sup>a</sup>
Control (C <sub>1</sub> )	15.29 <sup>a</sup>	2.09 <sup>a</sup>	14.37 <sup>a</sup>	5.56 <sup>a</sup>
500 mgL <sup>-1</sup> (C <sub>2</sub> )	13.88 <sup>b</sup>	2.03 <sup>a</sup>	14.27 <sup>a</sup>	5.53 <sup>a</sup>
1000 mgL <sup>-1</sup> (C <sub>3</sub> )	13.08 <sup>c</sup>	2.03 <sup>a</sup>	14.38 <sup>a</sup>	5.54 <sup>a</sup>
1500 mgL <sup>-1</sup> (C <sub>4</sub> )	10.79 <sup>d</sup>	2.01 <sup>a</sup>	14.96 <sup>a</sup>	5.54 <sup>a</sup>
A <sub>1</sub> B <sub>1</sub>	12.73 <sup>c</sup>	2.07 <sup>a</sup>	10.80 <sup>b</sup>	5.05 <sup>b</sup>
A <sub>1</sub> B <sub>2</sub>	13.19 <sup>b</sup>	2.04 <sup>a</sup>	11.69 <sup>b</sup>	5.03 <sup>b</sup>
A <sub>2</sub> B <sub>1</sub>	13.26 <sup>b</sup>	2.04 <sup>a</sup>	17.83 <sup>a</sup>	6.05 <sup>a</sup>
A <sub>2</sub> B <sub>2</sub>	13.85 <sup>a</sup>	2.03 <sup>a</sup>	17.67 <sup>a</sup>	6.04 <sup>a</sup>
A <sub>1</sub> C <sub>1</sub>	15.23 <sup>a</sup>	2.12 <sup>a</sup>	11.63 <sup>c</sup>	5.06 <sup>b</sup>
A <sub>1</sub> C <sub>2</sub>	13.61 <sup>c</sup>	2.07 <sup>a</sup>	10.93 <sup>cd</sup>	5.03 <sup>b</sup>
A <sub>1</sub> C <sub>3</sub>	12.46 <sup>d</sup>	2.02 <sup>a</sup>	10.72 <sup>cd</sup>	5.01 <sup>b</sup>
A <sub>1</sub> C <sub>4</sub>	10.57 <sup>f</sup>	2.00 <sup>a</sup>	11.69 <sup>c</sup>	5.05 <sup>b</sup>
A <sub>2</sub> C <sub>1</sub>	15.35 <sup>a</sup>	2.07 <sup>a</sup>	17.11 <sup>ab</sup>	6.06 <sup>a</sup>
A <sub>2</sub> C <sub>2</sub>	14.15 <sup>b</sup>	2.00 <sup>a</sup>	17.61 <sup>ab</sup>	6.03 <sup>a</sup>
A <sub>2</sub> C <sub>3</sub>	13.71 <sup>c</sup>	2.04 <sup>a</sup>	18.04 <sup>a</sup>	6.07 <sup>a</sup>
A <sub>2</sub> C <sub>4</sub>	11.02 <sup>e</sup>	2.02 <sup>a</sup>	18.23 <sup>a</sup>	6.04 <sup>a</sup>
B <sub>1</sub> C <sub>1</sub>	15.29 <sup>a</sup>	2.08 <sup>a</sup>	14.23 <sup>a</sup>	5.61 <sup>a</sup>
B <sub>1</sub> C <sub>2</sub>	13.65 <sup>c</sup>	1.97 <sup>a</sup>	14.32 <sup>a</sup>	5.53 <sup>a</sup>
B <sub>1</sub> C <sub>3</sub>	12.95 <sup>e</sup>	2.07 <sup>a</sup>	13.90 <sup>a</sup>	5.54 <sup>a</sup>
B <sub>1</sub> C <sub>4</sub>	10.11 <sup>g</sup>	2.09 <sup>a</sup>	14.79 <sup>a</sup>	5.52 <sup>a</sup>
B <sub>2</sub> C <sub>1</sub>	15.29 <sup>a</sup>	2.11 <sup>a</sup>	14.50 <sup>a</sup>	5.51 <sup>a</sup>
B <sub>2</sub> C <sub>2</sub>	14.10 <sup>b</sup>	2.10 <sup>a</sup>	14.22 <sup>a</sup>	5.53 <sup>a</sup>
B <sub>2</sub> C <sub>3</sub>	13.22 <sup>d</sup>	1.99 <sup>a</sup>	14.86 <sup>a</sup>	5.53 <sup>a</sup>
B <sub>2</sub> C <sub>4</sub>	11.47 <sup>f</sup>	1.93 <sup>a</sup>	15.13 <sup>a</sup>	5.57 <sup>a</sup>
A <sub>1</sub> B <sub>1</sub> C <sub>1</sub>	15.27 <sup>a</sup>	2.13 <sup>a</sup>	11.61 <sup>d</sup>	5.10 <sup>b</sup>
A <sub>1</sub> B <sub>1</sub> C <sub>2</sub>	13.52 <sup>c</sup>	1.99 <sup>a</sup>	10.18 <sup>e</sup>	5.05 <sup>b</sup>
A <sub>1</sub> B <sub>1</sub> C <sub>3</sub>	12.22 <sup>e</sup>	2.06 <sup>a</sup>	10.23 <sup>e</sup>	5.02 <sup>b</sup>
A <sub>1</sub> B <sub>1</sub> C <sub>4</sub>	9.94 <sup>h</sup>	2.08 <sup>a</sup>	11.19 <sup>d</sup>	5.02 <sup>b</sup>
A <sub>1</sub> B <sub>2</sub> C <sub>1</sub>	15.19 <sup>a</sup>	2.12 <sup>a</sup>	11.64 <sup>d</sup>	5.03 <sup>b</sup>
A <sub>1</sub> B <sub>2</sub> C <sub>2</sub>	13.69 <sup>c</sup>	2.14 <sup>a</sup>	11.69 <sup>d</sup>	5.01 <sup>b</sup>
A <sub>1</sub> B <sub>2</sub> C <sub>3</sub>	12.70 <sup>d</sup>	1.97 <sup>a</sup>	11.22 <sup>d</sup>	5.00 <sup>b</sup>
A <sub>1</sub> B <sub>2</sub> C <sub>4</sub>	11.19 <sup>e</sup>	1.93 <sup>a</sup>	12.19 <sup>e</sup>	5.08 <sup>b</sup>
A <sub>2</sub> B <sub>1</sub> C <sub>1</sub>	15.31 <sup>a</sup>	2.04 <sup>a</sup>	16.86 <sup>b</sup>	6.12 <sup>a</sup>
A <sub>2</sub> B <sub>1</sub> C <sub>2</sub>	13.79 <sup>c</sup>	1.95 <sup>a</sup>	18.47 <sup>b</sup>	6.01 <sup>a</sup>
A <sub>2</sub> B <sub>1</sub> C <sub>3</sub>	13.68 <sup>c</sup>	2.08 <sup>a</sup>	17.58 <sup>ab</sup>	6.07 <sup>a</sup>
A <sub>2</sub> B <sub>1</sub> C <sub>4</sub>	10.29 <sup>h</sup>	2.09 <sup>a</sup>	18.39 <sup>a</sup>	6.01 <sup>a</sup>
A <sub>2</sub> B <sub>2</sub> C <sub>1</sub>	15.39 <sup>a</sup>	2.09 <sup>a</sup>	17.39 <sup>ab</sup>	6.00 <sup>a</sup>
A <sub>2</sub> B <sub>2</sub> C <sub>2</sub>	14.50 <sup>b</sup>	2.06 <sup>a</sup>	16.75 <sup>b</sup>	6.04 <sup>a</sup>
A <sub>2</sub> B <sub>2</sub> C <sub>3</sub>	13.75 <sup>c</sup>	2.01 <sup>a</sup>	18.50 <sup>a</sup>	6.07 <sup>a</sup>
A <sub>2</sub> B <sub>2</sub> C <sub>4</sub>	11.75 <sup>f</sup>	1.94 <sup>a</sup>	18.07 <sup>a</sup>	6.06 <sup>a</sup>

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.

Treatment	Traits	Plant height (cm)	Stem height (cm)	Chlorophyll index	Brix degree
Kamome White (A <sub>1</sub> )		14.61 <sup>b</sup>	2.32 <sup>b</sup>	15.28 <sup>b</sup>	6.00 <sup>b</sup>
Nagoya Red (A <sub>2</sub> )		15.41 <sup>a</sup>	2.62 <sup>a</sup>	18.23 <sup>a</sup>	7.39 <sup>a</sup>
Spray (B <sub>1</sub> )		14.78 <sup>b</sup>	2.41 <sup>b</sup>	16.49 <sup>a</sup>	6.72 <sup>a</sup>
Drench (B <sub>2</sub> )		15.24 <sup>a</sup>	2.53 <sup>a</sup>	17.03 <sup>a</sup>	6.67 <sup>a</sup>
Control (C <sub>1</sub> )		16.66 <sup>a</sup>	2.85 <sup>a</sup>	16.90 <sup>a</sup>	6.71 <sup>a</sup>
500 mgL <sup>-1</sup> (C <sub>2</sub> )		15.89 <sup>b</sup>	2.63 <sup>b</sup>	16.44 <sup>a</sup>	6.66 <sup>a</sup>
1000 mgL <sup>-1</sup> (C <sub>3</sub> )		14.92 <sup>c</sup>	2.38 <sup>c</sup>	16.66 <sup>a</sup>	6.72 <sup>a</sup>
1500 mgL <sup>-1</sup> (C <sub>4</sub> )		12.56 <sup>d</sup>	2.03 <sup>d</sup>	17.02 <sup>a</sup>	6.71 <sup>a</sup>
A <sub>1</sub> B <sub>1</sub>		14.34 <sup>d</sup>	2.28 <sup>cd</sup>	14.94 <sup>b</sup>	6.05 <sup>b</sup>
A <sub>1</sub> B <sub>2</sub>		14.87 <sup>c</sup>	2.37 <sup>c</sup>	15.62 <sup>b</sup>	5.96 <sup>b</sup>
A <sub>2</sub> B <sub>1</sub>		15.21 <sup>b</sup>	2.55 <sup>b</sup>	18.04 <sup>a</sup>	7.39 <sup>a</sup>
A <sub>2</sub> B <sub>2</sub>		15.61 <sup>a</sup>	2.69 <sup>a</sup>	18.43 <sup>a</sup>	7.38 <sup>a</sup>
A <sub>1</sub> C <sub>1</sub>		14.44 <sup>b</sup>	2.65 <sup>bc</sup>	15.09 <sup>c</sup>	6.03 <sup>b</sup>
A <sub>1</sub> C <sub>2</sub>		15.40 <sup>c</sup>	2.52 <sup>c</sup>	15.11 <sup>c</sup>	5.94 <sup>b</sup>
A <sub>1</sub> C <sub>3</sub>		14.48 <sup>d</sup>	2.13 <sup>d</sup>	15.55 <sup>c</sup>	6.05 <sup>b</sup>
A <sub>1</sub> C <sub>4</sub>		12.09 <sup>f</sup>	2.00 <sup>d</sup>	15.37 <sup>c</sup>	5.99 <sup>b</sup>
A <sub>2</sub> C <sub>1</sub>		16.89 <sup>a</sup>	3.04 <sup>a</sup>	18.72 <sup>a</sup>	7.38 <sup>a</sup>
A <sub>2</sub> C <sub>2</sub>		16.37 <sup>b</sup>	2.73 <sup>b</sup>	17.78 <sup>ab</sup>	7.37 <sup>a</sup>
A <sub>2</sub> C <sub>3</sub>		15.37 <sup>c</sup>	2.64 <sup>bc</sup>	17.76 <sup>ab</sup>	7.38 <sup>a</sup>
A <sub>2</sub> C <sub>4</sub>		13.02 <sup>e</sup>	2.07 <sup>d</sup>	18.68 <sup>a</sup>	7.42 <sup>a</sup>
B <sub>1</sub> C <sub>1</sub>		16.65 <sup>a</sup>	2.86 <sup>a</sup>	16.86 <sup>ab</sup>	6.70 <sup>a</sup>
B <sub>1</sub> C <sub>2</sub>		15.68 <sup>c</sup>	2.58 <sup>b</sup>	15.50 <sup>b</sup>	6.69 <sup>a</sup>
B <sub>1</sub> C <sub>3</sub>		14.70 <sup>c</sup>	2.31 <sup>de</sup>	17.48 <sup>ab</sup>	6.76 <sup>a</sup>
B <sub>1</sub> C <sub>4</sub>		12.07 <sup>g</sup>	1.90 <sup>f</sup>	16.11 <sup>ab</sup>	6.72 <sup>a</sup>
B <sub>2</sub> C <sub>1</sub>		16.68 <sup>a</sup>	2.84 <sup>a</sup>	16.95 <sup>ab</sup>	6.71 <sup>a</sup>
B <sub>2</sub> C <sub>2</sub>		16.09 <sup>b</sup>	2.67 <sup>b</sup>	17.37 <sup>ab</sup>	6.62 <sup>a</sup>
B <sub>2</sub> C <sub>3</sub>		15.15 <sup>d</sup>	2.45 <sup>cd</sup>	15.83 <sup>ab</sup>	6.68 <sup>a</sup>
B <sub>2</sub> C <sub>4</sub>		13.04 <sup>f</sup>	2.17 <sup>e</sup>	17.94 <sup>a</sup>	6.69 <sup>a</sup>
A <sub>1</sub> B <sub>1</sub> C <sub>1</sub>		16.41 <sup>b</sup>	2.65 <sup>b</sup>	14.56 <sup>g</sup>	6.08 <sup>b</sup>
A <sub>1</sub> B <sub>1</sub> C <sub>2</sub>		15.08 <sup>d</sup>	2.49 <sup>c</sup>	14.44 <sup>g</sup>	6.04 <sup>b</sup>
A <sub>1</sub> B <sub>1</sub> C <sub>3</sub>		14.26 <sup>f</sup>	2.08 <sup>e</sup>	15.76 <sup>c</sup>	6.08 <sup>b</sup>
A <sub>1</sub> B <sub>1</sub> C <sub>4</sub>		11.59 <sup>i</sup>	1.89 <sup>f</sup>	15.00 <sup>g</sup>	5.99 <sup>b</sup>
A <sub>1</sub> B <sub>2</sub> C <sub>1</sub>		16.48 <sup>b</sup>	2.66 <sup>b</sup>	15.62 <sup>c</sup>	5.98 <sup>b</sup>
A <sub>1</sub> B <sub>2</sub> C <sub>2</sub>		15.73 <sup>c</sup>	2.54 <sup>c</sup>	15.78 <sup>c</sup>	5.84 <sup>b</sup>
A <sub>1</sub> B <sub>2</sub> C <sub>3</sub>		14.70 <sup>c</sup>	2.17 <sup>d</sup>	15.34 <sup>f</sup>	6.03 <sup>b</sup>
A <sub>1</sub> B <sub>2</sub> C <sub>4</sub>		12.59 <sup>h</sup>	2.11 <sup>e</sup>	15.73 <sup>c</sup>	5.99 <sup>b</sup>
A <sub>2</sub> B <sub>1</sub> C <sub>1</sub>		16.89 <sup>a</sup>	3.07 <sup>a</sup>	19.16 <sup>b</sup>	7.33 <sup>a</sup>
A <sub>2</sub> B <sub>1</sub> C <sub>2</sub>		16.29 <sup>b</sup>	2.68 <sup>b</sup>	16.56 <sup>c</sup>	7.35 <sup>a</sup>
A <sub>2</sub> B <sub>1</sub> C <sub>3</sub>		15.13 <sup>d</sup>	2.54 <sup>c</sup>	19.21 <sup>b</sup>	7.44 <sup>a</sup>
A <sub>2</sub> B <sub>1</sub> C <sub>4</sub>		12.54 <sup>h</sup>	1.91 <sup>f</sup>	17.22 <sup>d</sup>	7.45 <sup>a</sup>
A <sub>2</sub> B <sub>2</sub> C <sub>1</sub>		16.88 <sup>a</sup>	3.02 <sup>a</sup>	18.28 <sup>c</sup>	7.44 <sup>a</sup>
A <sub>2</sub> B <sub>2</sub> C <sub>2</sub>		16.45 <sup>b</sup>	2.79 <sup>b</sup>	18.99 <sup>b</sup>	7.39 <sup>a</sup>
A <sub>2</sub> B <sub>2</sub> C <sub>3</sub>		15.60 <sup>c</sup>	2.73 <sup>b</sup>	16.32 <sup>c</sup>	7.32 <sup>a</sup>
A <sub>2</sub> B <sub>2</sub> C <sub>4</sub>		13.49 <sup>g</sup>	2.23 <sup>c</sup>	20.14 <sup>a</sup>	7.39 <sup>a</sup>

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 <sup>ns</sup>	5.581**	1	Cultivars (A)
0.035 <sup>ns</sup>	4.623 <sup>ns</sup>	0.217**	3.446**	0.003 <sup>ns</sup>	2.141 <sup>ns</sup>	0.007 <sup>ns</sup>	4.332**	1	Methods (B)
0.012 <sup>ns</sup>	1.075 <sup>ns</sup>	1.946**	50.876**	0.003 <sup>ns</sup>	1.581 <sup>ns</sup>	0.021 <sup>ns</sup>	56.666**	3	Concentrations (C)
0.023 <sup>ns</sup>	0.316 <sup>ns</sup>	0.012 <sup>ns</sup>	0.086**	0.00 <sup>ns</sup>	4.319 <sup>ns</sup>	0.001 <sup>ns</sup>	0.066 <sup>ns</sup>	1	A × B
0.010 <sup>ns</sup>	1.630 <sup>ns</sup>	0.147**	0.232**	0.005 <sup>ns</sup>	2.308 <sup>ns</sup>	0.009 <sup>ns</sup>	0.901**	3	A × C
0.007 <sup>ns</sup>	11.319*	0.059**	0.602**	0.016 <sup>ns</sup>	0.773 <sup>ns</sup>	0.059 <sup>ns</sup>	1.398**	3	B × C
0.028 <sup>ns</sup>	5.161 <sup>ns</sup>	0.006 <sup>ns</sup>	0.052*	0.003 <sup>ns</sup>	2.717 <sup>ns</sup>	0.002 <sup>ns</sup>	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  $\alpha = 1\%$ , \* : Significant at  $\alpha = 5\%$ , ns=Not significant

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## 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.