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Full Length Research Paper

Effect of the growth retardant Cycocel® in controlling the growth of *Dombeya burgessiae*

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Pink dombeya (*Dombeya burgessiae*) was tested for its potential as a flowering potted plant, using the growth retardant Cycocel® (2-chloroethyl)-trimethylammonium chloride. The treatments included a control, 0.5, 1, 2 and 3 mg/L of Cycocel® per pot and were applied when seedlings reached 7 - 8 cm in height. All treatments significantly reduced plant height. The plants treated with 0.5 mg/L were only marginally shorter than the control, while the height of plants treated with 1, 2 and 3 mg/L Cycocel®, were greatly reduced. Increased Cycocel® concentrations decreased plant width in all treatments, as compared with the control. At all applied concentrations, the deterioration of foliage greenness was observed. The highest concentration of Cycocel® (3 mg/L) resulted in cycocel-induced chlorosis. This was followed by the 2, 1 and 0.5 mg/L respectively, all showing symptoms of chlorosis; however to a lesser extent. Cycocel® treated plants exhibited greener foliage in the new leaves formed in the weeks after application compared with the control. It is important to mention that the new leaves formed in the weeks after application were not affected, and were in fact darker green with the higher concentrations of Cycocel® treatments.The fresh and dry weights of plants severely decreased with the increased Cycocel® concentrations. The highest concentration (0.3% a.i.) caused the largest reduction, with plants in this treatment only weighing 38% of the total fresh weight of the control and 35% of the total dry weight.

Key words: (2-Chloroethyl)-trimethylammonium chloride, chlorosis, dry weight, plant height.

INTRODUCTION

Dombeya is a genus of small trees (Johnson and Johnson, 1993) indigenous to South Africa (Coates-Palgrave et al., 1989). All species of *Dombeya* are noted for their flowers which are produced abundantly (Johnson and Johnson, 1993). However, the most striking and attractive species is *Dombeya burgessiae* with pale to rose-pink flowers that are long-lasting and exceptionally showy (Coates-Palgrave, 1992). *D. burgessia* is a widely cultivated garden plant and has traditionally been used as flowering screens and garden subjects (Johnson and Johnson, 1993). The flowering period of *D. burgessiae* has been identified as a potential attraction for this species to be produced as a potted plant.

In producing potted plants, height control is often necessary to achieve desirable plant size and shape (Chen and Meister, 2006; Milandri et al., 2008). The successful reduction of a plant's height through the use of growth retardants will determine whether a particular species can be manipulated and produced as a potted plant (Menhenett, 1984). A growth retardant which has been found to give good results in height control is Cycocel® (Pearse, 1974). Ornamental crops that are effectively controlled by Cycocel® include herbaceous crops, such as *Pointsettias* and *Geraniums*, as well as woody flowering crops such as *Hibiscus* and *Azaleas* (Olympic Horticultural Product, 2005). Although Cycocel® is versatile in its methods of application, it is usually applied as a foliar spray (Latimer et al., 2001).

With containerized plants becoming a major horticultural crop in recent years (Chen and Meister, 2006), there is a continued demand for new and interesting potted plants in South Africa and other parts of the world (Barzilay et al., 1992). South Africa has an extraordinary wealth of

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Table 1. Effect of different concentrations of cycocel® on plant height of *D. burgessiae* throughout the experimental period.

Treatment (m/gl)	Week 1	week 2	week 3	week 4	week 5	week 6
Control	63.0 ± 5.87a	77.7 ± 8.22ab	91.1 ± 8.70ab	95.0 ± 9.36a	96.3 ± 9.67ab	110.7 ± 6.22a
0.50	83.7 ± 5.69a	91.1 ± 5.67a	105.0 ± 6.13a	101.0 ± 5.22a	104.4 ± 5.97a	104.9 ± 5.84a
1.00	66.6 ± 3.44a	66.9 ± 3.19bc	73.1 ± 4.89c	77.4 ± 2.89b	78.3 ± 4.08bc	82.1 ± 4.40b
2.00	65.9 ± 6.08a	68.0 ± 5.42bc	74.7 ± 3.97bc	75.4 ± 5.42b	75.7 ± 4.80cd	75.0 ± 5.97bc
3.00	55.6 ± 5.15a	58.0 ± 4.65c	59.0 ± 4.48c	61.0 ± 5.49b	57.4 ± 6.03d	61.4 ± 5.46c
One-way ANOVA F-Statistic						
	3.76 ns	4.95**	9.13***	7.09***	8.31***	13.5***

Values presented here are means ± SE. **,***, ns = significant at P ≤ 0.01, 0.001, ns = not significant respectively. Means followed by the same letter are not significantly different from each other at P ≤ 0.05.

biological plant diversity (Wynberg, 2001). However, the economic utilization of species is limited to only a few plants (Coetzee et al., 1999). Other crops in which Cycocel® is effective are *Abutilon*, *Acalypha*, *Chrysanthemum* and *Hibiscus* (Herman, 1967). It is therefore important to recognize the diversity of flora in South Africa as a resource for new commercial products which could benefit South Africa in research and development (Wynberg, 2001).

Due to the fact that *D. burgessiae* is classified as a large bushy shrub or small tree up to 5 m in height (Coates-Palgrave, 1992), its natural growth habit is not suitable for pot plant production. However, the application of Cycocel® may induce economically viable results. Research into the use of growth retardant Cycocel®, may enable previously unavailable species to be produced as potted plants, which can prove economically more viable. There is therefore a need for concerted efforts to determine whether Cycocel® will successfully control the plant height of *D. burgessiae*. The aim of this study was to evaluate the effect of Cycocel® as a foliar spray on *D. burgessiae* and to assess its efficacy in pot-plant production.

MATERIALS AND METHODS

Experimental

Plants used in this experiment were grown from seeds sown in river sand mixed with sifted bark at a 1:1 ratio and germinated under intermittent mist in a greenhouse. Seedlings were individually transplanted into 15 cm pots 1L (upper diameter) containing perlite, when 2.5 - 3 cm in height. The plants were moved to an environmentally controlled greenhouse, at the Cape Peninsula University of Technology in Cape Town, South Africa, where the experiment was conducted. The pots were setup on a galvanised, steel table (2 x 0.85 m) that was covered with thick, waterproof plastic sheeting which was cut to size. Ten pots were placed into each of the five experimental blocks. The Cycocel® treatments (control, 0.5, 1, 2 and 3 mg/L) were applied in each block. Each pot functioned as an experimental unit. Drip irrigation was used to supply pots with the nutrient solution hourly. The nutrient solution comprised of dH_2O, CHEMICULT® [(Chemical Products (pty) Ltd, 133 Camps Bay, South Africa, 8040) (2 g L^{-1})] and a micronutrient blend bio-essentials (General Hydroponics Europe, France). The pH of the solution was maintained at 5.8. The greenhouse was fitted with Alunet (40% shade screen), where temperature and humidity were monitored on a weekly basis. Mid-day temperatures fluctuated between 16 and 20°C and relative humidity between 39 and 86%.

Treatment of plant growth regulators

D. burgessiae seedlings, 2.5 to 3 cm in height, were planted on 11th August, 2008. Cycocel® (2-chloroethyl)-trimethylammonium chloride) was applied as a single spray 1 week after transplanting. Treatment rates were 0.5, 1, 2 and 3 mg/L Cycocel®, applied with a hand-held sprayer in 10 ml dH_2O per plant. The control remained untreated.

Data collection

In this study, plant height, plant width and stem width were measured at weekly intervals. Foliage greenness was evaluated with rating at a scale of 1 to 5, where 5 represents complete greenness and 1 represents complete Cycocel-induced chlorosis (no green colour evident). This was based on other related assessments by Fleming and Palmer (1975), Rodriguez de Cianzio et al. (1979) and Xu et al. (2000). Fresh weight at harvest (6 weeks after Cycocel® application) as well as dry weight after drying at 60°C for 72 h was measured.

Statistical analysis

Data collected were analyzed for statistical significance using One-Way analysis of variance (ANOVA). Data were presented as mean values with predicted standard errors (S.E.). These computations were done with the software program STATISTICA [Software Programme version 2009 (StatSoft Inc., Tulsa, OK, USA)]. The Fisher least significant difference was used to compare treatment means at P ≤ 0.05 level of significance (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

A significant reduction in plant height was observed in all treatments supplied with Cycocel® (Table 1). The reduction effect was significant on plant height from week 2, with increased significance in weeks 3, 4, 5 and 6 after Cycocel® application compared with the control.

Generally, the height of plants measured in weeks 4, 5 and 6 after Cycocel® application and treated with 1, 2

Table 2. Effect of different concentrations of Cycocel® on plant width of *D. burgessiae* throughout the experimental period.

Treatment (m/gl)	Plant width at start		Plant width week 2		Plant width week 3		Plant width week 4		Plant width week 5		Plant width week 6	
Control	115.4	±9.15a	136.9	±11.12a	156.0	±12.4a	169.7	±12.45a	170.6	±14.29a	190.6	±10.35a
0.5	116.7	±10.91a	110.1	±9.82a	130.1	±12.3a	136.6	±13.37b	128.0	±15.10b	145.7	±14.44b
1.00	112.3	±9.38a	110.7	±6.70a	123.4	±10.2a	126.4	±7.22b	123.4	±7.85b	134.6	±6.80b
2.00	110.7	±13.25a	108.6	±14.07a	116.4	±13.5a	121.4	±13.13b	116.7	±12.78b	131.7	±14.30b
3.00	109.0	±17.02a	116.0	±8.83a	126.4	±10.2a	115.7	±9.23b	110.1	±16.58b	119.4	±14.62b
One-way ANOVA F-statistic												
	0.07 ns		1.27 ns		1.65 ns		3.56*		3.04*		4.83**	

Values presented here are means ± SE. *,**, ns = significant at P ≤ 0.05, 0.01, ns = not significant respectively. Means followed by the same letter are not significantly different from each other at P ≤ 0.05.

Table 3. Foliage greenness on *D. burgessiae* as influenced by different Cycocel® concentrations.

Treatment (m/gl)	Foliage greenness at start		Foliage greenness week 2		Foliage greenness week 3		Foliage greenness week 4		Foliage greenness week 5		Foliage greenness week 6	
Control	5.00	±0.0a	4.90	±0.10a	5.00	±0.00a	4.90	±0.10a	5.00	±0.00a	5.00	±0.00a
0.50	5.00	±0.0a	3.70	±0.26b	3.40	±0.31b	3.90	±0.28b	3.90	±0.23b	3.60	±0.27b
1.00	5.00	±0.0a	3.00	±0.21c	3.10	±0.28b	3.40	±0.27b	3.70	±0.21b	3.70	±0.15b
2.00	5.00	±0.0a	3.10	±0.31bc	2.90	±0.38b	3.70	±0.26b	3.60	±0.16b	3.70	±0.15b
3.00	5.00	±0.0a	2.00	±0.21c	1.20	±0.13c	1.60	±0.22c	2.40	±0.22c	2.70	±0.21c
One-way ANOVA F-statistic												
	Ns		21.33***		27.74***		26.33***		24.41***		20.60***	

Rating system: 5.0 = no chlorosis, leaves entirely green, 1.0 = leaves completely chlorotic (no green colour evident). Values presented here means ± SE. ***, ns = significant at P ≤ 0.001, ns = not significant respectively. Means followed by the same letter(s) are not significantly different from each other at P ≤ 0.05.

and 3 mg/L Cycocel®, were shorter than the control. These reductions increased with the strength of a.i. applied (Table 1). The 3 mg/L Cycocel®, had the most significant effect on reducing plant height. This is likely due to the fact that Cycocel® completely blocks gibberellin production (Carvalho et al., 2008; Harada and Lang, 1965; Kende et al., 1963; Ninnemann et al., 1964); the primary plant hormones responsible for cell elongation (Latimer et al., 2001). The height of the plants treated with 0.5 mg/L exceeded the control throughout the experiment and were only marginally shorter in the last week.

The Cycocel® treatments had no significant effects on plant width, compared with the control in the 2nd and 3rd weeks after the application of growth regulator (Table 2). However, as compared with the control, a significant width reduction was observed in weeks 4, 5 and 6 where the greatest width reduction was observed in the treatment with 3 mg/L (Table 2). These results were probably due to the inhibiting effect of Cycocel® on gibberellin biosynthesis, in turn reducing shoot growth and elongation through cell division and cell elongation (Carvalho et al., 2008; Reid and Carr, 1967).

Before the application of Cycocel®, all plant leaves were entirely green with no evidence of chlorosis (Table 3). In weeks 2 - 6 the deterioration of foliage greenness was significant (P ≤ 0.001) in all treatments, which increased with the strength of a.i. of Cycocel® applied. The highest concentration of Cycocel® (3 mg/L) resulted in numerically greater incidences of cycocel-induced chlorosis. This was observed as an unsightly yellowing at the margins of the leaves of plants. However, plant leaves were not entirely yellow, for there was a small amount of green colour still evident.

Foliar applications of Cycocel® often resulted in a phytotoxic response (chlorosis) in plants (Jabado, 2008; Latimer et al., 2001). The cause of this chlorosis is not completely clear (Read and Bryan, 1972). However, it has been reported that discoloured areas usually regain most or all green colour within a month or two after treatment (Pearse, 1974). In addition to the unsightly damage caused, the quality of the plants may be depressed (Read and Bryan, 1972). The drench method of application is said to be safer, as there is considerably less possibility of causing damage to plants (Pearse, 1974). Foliar applications are most commonly used in commercial practise

Table 4. Plant dry weight and fresh weight, partitioned into roots and stems, 6 weeks after Cycocel® application of *D. burgessiae.*

Treatment (m/gl)	Fresh root weight at end		Fresh shoot weight at end		Total fresh weight (g)		Dry root weight at end		Dry shoot weight at end		Total dry weight (g)	
Control	5.99	±0.64a	5.69	±0.88a	11.7	±1.50a	0.63	±0.07a	1.04	±0.13a	1.7	±0.19a
0.5	4.81	±0.64ab	4.49	±0.58ab	9.3	±1.15ab	0.54	±0.07ab	0.79	±0.12ab	1.3	±0.18ab
1.00	4.07	±0.25bc	3.29	±0.29bc	7.4	±0.54bc	0.41	±0.04bc	0.60	±0.05bc	1.0	±0.09bc
2.00	2.89	±0.44cd	2.52	±0.43c	5.4	±0.84cd	0.32	±0.04cd	0.45	±0.08c	0.8	±0.12c
3.00	2.22	±0.28d	2.16	±0.43c	4.4	±0.69d	0.24	±0.04d	0.40	±0.08c	0.6	±0.10c
One-way ANOVA F-statistic												
F –statistic	9.75***		6.80***		8.59***		8.49***		7.80***		8.69***	

Values presented here are means ± SE. ***, ns = significant at P ≤ 0.001, ns = not significant respectively. Means followed by the same letter(s) are not significantly different from each other at P ≤ 0.05.

(Latimer et al., 2001), as it is a more convenient method when producing large numbers of plants. Read and Bryan (1972) found that application of the growth regulator Alar (Daminozide) prior to treatment with Cycocel® or in combination with Cycocel® applications can markedly reduce or totally eliminate the visual symptoms of cycocel-induced chlorosis. It is important to mention that the new leaves formed in the weeks after application were not affected, and were in fact darker green with the higher concentrations of Cycocel® treatments. In a similar study involving Cycocel®, Pearse (1974) also reported that foliage colour was improved to a darker and more intense green with a healthy glossy appearance.

In all treatments, the total fresh and dry weights were significantly (P ≤ 0.001) reduced with the increasing strength of a.i. applied (Table 4). The highest concentration of Cycocel® (3 mg/L) caused the largest reduction in the fresh root and shoot weight, as well as in the dry root and shoot weight. The plants in this treatment only weighed 38% of the total fresh weight of the control and 35% of the total dry weight, respectively. These results were followed by treatments of 2, 1 and 0.5 mg/L which yielded 46, 63 and 79% of total fresh weight and 47, 59 and 76% of the total dry weight of the control, respectively. The control yielded the largest total plant fresh and dry weights. The observed results were probably due to the dwarfing effect of Cycocel®, reducing both plant height and width (Tables 1 and 2). Similar to our data, Rajala et al. (2002) also reported that Cycocel® induced a reduction in growth of leaves of wheat, oat and barley seedlings.

Conclusion

This investigation has produced results suggesting that Cycocel® could well be used to control the growth of *D. burgessiae* to improve its commercial feasibility in the flowering potted plant market. Supply of Cycocel® at 3 mg/L produced plants with desired characteristics for container production. Further studies are required to combine Cycocel® with other plant growth regulators.

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