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Effect of different concentrations of benzyladenine and frequency of watering on growth and quality of *Dracaena sanderiana* and *Codiaeum variegatum*

M. Fuadi[1], M.T.M. Mohamed[1,2]*, N. S. Salleh[1,3], M.P. Anwar[2,4], Y. Awang[1] and R.M. Fauzi[1]

[1]Department of Crop Science, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia
[2]Institute of Tropical Agriculture, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia
[3]Department of Agrotechnology, Universiti Malaysia Terengganu, 21030 Kuala Terengganu, Malaysia
[4]Department of Agronomy, Bangladesh Agricultural University, Mymensingh 2202, Bangladesh
*Corresponding Author E-mail: mtmm@.upm.edu.my

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Abstract

The effect of benzyladenine concentration and watering frequency on the growth and quality of *Dracaena sanderiana* and *Codiaeum variegatum* was evaluated. Plants were treated with different benzyladenine concentrations of (0, 75, 150, 225 or 300 mg l^{-1}) and watering frequencies, daily, every 4, 7 or 10 days interval. Benzyladenine concentration and watering frequency interacted significantly for plant grade on both species. This interaction resulted in the highest grade at 225 mg l^{-1} benzyladenine and daily watering for *D. sanderiana* and 150 mgl^{-1} benzyladenine and daily watering for *C. variegatum*. No significant interactions between benzyladenine concentration and watering frequency were observed for photosynthesis rate, stomatal conductance, specific leaf area and fresh weight of either species. For *D. sanderiana*, the highest photosynthesis rate (5.70 mmol$m^{-2}s^{-1}$) occurred at 225 mg $l^{-1}$and decreased with increasing watering frequency. For *C. variegatum*, the highest photosynthesis rate (4.49 mmol$m^{-2}s^{-1}$) was recorded with benzyladenine concentration of 150 mg l^{-1}, and photosynthesis rate was found independent of watering frequency. For both species, stomatal conductance was recorded highest at 225 mg l^{-1}, but watering frequency failed to influence stomatal conductance. For better quality, *D. sanderiana* should be sprayed with benzyladenine at 225 mg l^{-1}, and *C. variegatum* with benzyladenine at 150 mg l^{-1} in combinations with watering at 4 days interval.

Key words

Benzyladenine, *Codiaeum variegatum, Dracaena sanderiana,* Growrh, Irrigation

Introduction

Floriculture industry largely comprises of production of cut flowers, cut orchids, foliage and other ornamentals plants. These industries have a good prospect, whether for domestic or international markets. The use of indoor plants, such as *Dracaena sp.* and *Codieaum sp.* has become more and more popular worldwide. *Dracaena sanderiana* or Sanders dracaena is also known as the Belgian Evergreen or Ribbon plant. *Dracaena sanderiana,* originated from India and tropical Africa, belongs to family Agavaceae (Aslam *et al.,* 2013). It is a small plant with 40 to 50 cm height. It has green lanceolate leaves with white marginal stripes on an upright stem. The plant is frequently used in gardens. Popularity of *Dracaenas* can be attributed to their superior performance in interior environments and their diversely colorful foliage which is enhanced by various leaf variegation patterns (Yokosuka *et al.,* 2000). Variegated cultivars of *Dracaena* are popular; however, varying environmental factors can change variegation from being strongly expressed to rarely noticeable. *Codiaeum variegatum* (croton), on the other hand, has been popular in tropical gardens for centuries, but, only in recent years, has become popular as an indoor plant. Crotons are about 1.5 to 2 m tall woody shrubs originating from the Malayan Peninsula, Sri Lanka and Southern India. Dwarf forms of this species are cultivated as ornamental pot plants. The importance of these plants as indoor ornamental plants, can be seen through

their presence in many hotels, houses, offices, airports and other public indoor places.

The problem encountered by floriculture exporter is that these plants do not have a long shelf life. Foliage ornamental plants can be exported either by air or by ship. However, air transportation is more expensive and the space is limited, which is only suitable for small size and light plant materials. On the contrary, ship transportation is cheaper, with broader storage facility for high quantity export, and also suitable for all plant varieties. Therefore, the best alternative to reduce cost of transportation is ship transportation. Delivering of foliage plants through container transportation with least damage is a challenge in floriculture industry. As stated by Philosoph-Hadas *et al.* (2007), the main problem in the foliage plant industry is transportation and delivery under dark, humid and high temperature conditions during summer and cold during winter. The criteria of consumer preference for ornamental plants are good keeping quality, undamaged plants and free from plant diseases, which are difficult to meet unless transportation problems are resolved. During transportation, improper physical conditions *i.e.,* light, temperature and humidity can cause a reduction in plant quality. To overcome these problems, it is necessary to adapt the plants to these stressful conditions. The use of acclimatized plants for interior landscaping has increased dramatically in recent years. Acclimatization of plants under low light intensity prior to harvest, can greatly improve quality retention of foliage during post harvest period (Athanasiou *et al.,* 2010). Acclimatization, therefore, can greatly increase plant's potential for survival under changed/adverse conditions (Walter, 2005). Acclimatization techniques that can be used include application of plant growth regulators, nutrient management, controlled watering and manipulation of levels and durations of shading.

Cytokinins are a large group of plant hormones, and benzyladenine is one of the most active cytokinins (Buban, 2000). It has been identified as a natural cytokinin in number of plants (Van Staden and Crouch, 1996). Benzyladenine has recently been used as one of other sources that can maintain or increase the quality of various ornamental plants (Han, 2001). Application of benzyladenine has been reported to influence leaf senescence, leaf chlorosis and combating drought stress in plants (Waterland *et al.,* 2010). Tropical foliage plants thrive in their native environments where relative humidity is often 80% or greater. Water loss is a direct loss of saleable weight, but it also causes wilting or shriveling of fruits and vegetables and drooping of foliage plants, which renders the produce unacceptable to consumers. A loss of only about 5% in weight is often sufficient to show visible shriveling. Lin and Kao (1998) reported that cytokinins gave positive effects on water balance in rice when subjected to water stress. But, it is impossible to impose a strict watering schedule because plant's water requirement changes with time. The need for water depends on a number of factors, such as plant species, pot size, soil mixture characteristics, agro-climatic conditions and so on.

Studies on the interaction between concentration and watering frequency on *D. sanderiana* and *C. variegatum* under tropical conditions are still lacking. Therefore, the present study was conducted with a view to determine the effect of different concentrations of benzyladenine and frequency of watering on quality of *D. sanderiana* and *C. variegatum*.

Materials and Methods

Experiment was conducted in the shade house of the Horticulture Research Center, Malaysia Agricultural Research and Development Institute (MARDI), Serdang, Selangor, Malaysia (3°00' 21.34" N, 101°42' 15.06" E, 37 m elevation). The local climate was hot humid tropic with plenty rainfall. Laboratory works were carried out at the Plant Physiology and Postharvest Laboratories, Department of Crop Science, Universiti Putra Malaysia, Serdang, Selangor, Malaysia. *D. sanderiana* and *C. variegatum* stock plants were obtained from a nursery in Layang-Layang, Johor, Malaysia. Propagation media used was a mixture of 50% coco peat and 50% sand added to each hole of the seedling tray. Rooting hormone containing auxin, IBA (Seradix™) was used as basal dipping to enhance rooting. The plants were propagated in each (4 x 4 cm) of the seedling tray for three weeks. Stem cuttings (20 cm long) with three leaves were obtained from stock plants. Immediately after establishment in the trays, plants were moved to MARDI shade house. The plants were irrigated twice daily for 5 min each time using a mist spraying. Hager EH 711-228711 was used to regulate irrigation. The planting medium consisted of 3 parts top soil: 1 part coco peat: 1 part sand supplemented with 2 g of magnesium limestone to each pot (15 cm diameter). Immediately after seedling establishment for 3 weeks, each seedling was transplanted into pot. Each pot was placed on iron benches, at a spacing of 20 cm between pots and 30 cm between rows. The plants were irrigated twice daily using a mist sprayer. The plants were grown under shade (63%) obtained by suspending black flat-twisted polyethylene nettings for four months over the plants.

The experiment was laid out in a randomized complete block design (RCBD) with four replications. Each replication consisted of three plants. Four month-old plants were sprayed with five different benzyladenine concentrations of (0, 75, 150, 225 or 300 mg l^{-1}) in combination with four different watering frequencies, daily at every 4, 7 or 10 days intervals. Each of the plants was watered with 50 ml water. Benzyladenine was sprayed once a week on the whole plant by hand sprayer until dripping over a six weeks period. The parameters studied in this experiment were photosynthesis rate, stomatal conductance, plant height, specific leaf area, fresh weights (leaf, stem and root) and plant grade. Photosynthesis rate and stomatal conductance were measured using a closed photosynthesis measuring system (Model LI-6200, LICOR Nebraska, USA). Data were taken from third leaf on the adaxial surface from the tip because it contains maximum chlorophyll content and its growth reached physiological maturity. Data were taken between 11 a.m. – 12.30 p.m. when light intensity was between 1400 to 2000 $\mu molm^{-2}s^{-1}$

and CO_2 concentration was between 350 to 410 µmolm^{-2} s^{-1}. The relative humidity in the chamber was 26% – 47% and the ambient temperature was 38°C-42°C.

Plant height was measured from the soil surface to the tip of the plant. The average plant height was calculated from measurement of three plants. Leaf areas of all the fully expanded leaves were measured. Leaf area was measured using Leaf Area Meter (LI-3100, LICOR Nebraska, USA). For dry weight, the leaves were first dried in an oven at 70°C for three days until the weight was constant. The dry weight reading was used to calculate the specific leaf area. Leaf, stem and root were separated before their fresh weights were taken. Combination of the components was taken as the average total fresh weights. After final treatments, plant quality was assessed. Each plant was visually graded on a scale of 1 to 5 (1 = poor, 3 = good and 5 = excellent quality). Excellent quality plants had medium to dark – green foliage with no chlorosis/necrosis and well-formed shapes with sufficient foliage. Data were analyzed using ANOVA technique. When ANOVA showed significant ($p \leq 0.05$) F values, Duncan Multiple Range Test (DMRT) was used to separate the means using Statistical Analysis System (SAS Institute, Cary, N. C., 1989). Simple regression analysis was conducted to quantify the relationship between different parameters.

Results and Discussion

Application of benzyladenine significantly ($p \leq 0.05$) affected photosynthesis rate in both *D. sanderiana* and *C. variegatum,* but watering frequency significantly affected the photosynthesis rate only in *D. sanderiana* (Table 1). No significant ($p \leq 0.05$) interaction between benzyladenine concentration and watering frequency on photosynthesis rate was observed (Table 1). In case of *D. sanderiana,* benzyladenine application significantly improved the photosynthesis rate as compared to control, irrespective of concentrations with no significant differences amongst them. In case of *C. variegatum,* on the other hand, benzyladenine concentration up to 150 mg l^{-1} significantly increased photosynthesis rate and thereafter no significant increments were recorded. Increasing watering frequency significantly increased photosynthesis rate in *D. sanderiana*; daily watering and watering at every 4 day resulted in the highest photosynthesis rate in *D. sanderiana.* Influence of benzyladenine on photosynthetic activities is well established (Sivakumar and Nath, 2000; Abd El-Aziz, 2007). Yuan and Greene (2000) confirmed from their study that benzyladenine application reduced photosynthetic activity but enhanced mitochondrial respiration in apple. Abd El-Aziz (2007) also reported that benzyladenine significantly increased photosynthetic pigment (Chlorophyll a, b, total chlorophyll and carotenoids) on *C. variegatum* plants. Singh *et al.* (2001), on the other hand, reported that BA application increased photosynthesis rate to some extent.

Application of benzyladenine significantly ($p \leq 0.05$) affected stomatal conductance in both *D. sanderiana* and *C. variegatum,* but watering frequency did not affect those in either species (Table 1). No significant ($p \leq 0.05$) interaction between benzyladenine concentration and watering frequency was observed. Application of 150 or 225 mg l^{-1} benzyladenine resulted in higher stomatal conductance compared to control in *D. sanderiana*. While in *C. variegatum,* 75 mg l^{-1} benzyladenine resulted in similar stomatal conductance with control, but application of 150, 225 and 300 mg l^{-1} benzyladenine resulted in higher stomatal conductance as compared with control. Thus, watering frequency had no effect on stomatal conductance of either species. Pospisilova *et al.* (2001) also confirmed increased stomatal conductance resulting from benzyladenine application.

Table 1 : Effect of benzyladenine concentration and watering frequency on photosynthesis rate, stomatal conductance, plant height and specific leaf area of *D. sanderiana* and *C. variegatum*

Treatment	Photosynthesis rate (µmolm^{-2}s^{-1})		Stomatal conductance (mmolm^{-2}s^{-1})		Plant height (cm)		Specific leaf area (cm^{2}g^{-1})	
	Dracaena sanderiana	*Codiaeum variegatum*	*Dracaena sanderiana*	*Codiaeum variegatum*	*Dracaena sanderiana*	*Codiaeum variegatum*	*Dracaena sanderiana*	*Codiaeum variegatum*
BA concentration (C)								
Control (0)	2.46^{b}	1.95^{c}	0.79^{b}	0.54^{c}	42.83^{a}	44.26^{a}	13.82^{b}	21.89^{b}
75 mg l^{-1} BA	4.99^{a}	2.56^{bc}	1.18^{ab}	0.64^{bc}	42.52^{a}	41.80^{ab}	18.58^{ab}	22.68^{ba}
150 mg l^{-1} BA	5.19^{a}	4.49^{a}	1.21^{a}	0.77^{ab}	41.28^{ab}	39.39^{b}	19.48^{a}	25.06^{a}
225 mg l^{-1} BA	5.70^{a}	3.40^{ab}	1.28^{a}	0.96^{a}	39.97^{b}	39.18^{b}	22.00^{a}	27.74^{a}
300 mg l^{-1} BA	4.74^{a}	3.22^{abc}	1.16^{ab}	0.89^{a}	39.88^{b}	38.58^{b}	20.57^{a}	25.20^{a}
Watering frequency (W)								
Daily	5.90^{a}	1.07^{a}	3.14^{a}	0.72 a	43.26^{a}	42.85^{a}	20.64^{a}	19.43^{a}
Every 4 days	5.45^{ab}	1.11^{a}	3.44^{a}	0/78^{a}	42.27^{ab}	40.85^{b}	17.11^{a}	17.61^{a}
Every 7 days	3.96^{bc}	1.23^{a}	2.85^{a}	0.74^{a}	40.36^{bc}	40.06^{b}	17.39^{a}	17.89^{a}
Every 10 days	3.16^{c}	1.10^{a}	3.06^{a}	0.79^{a}	39.30^{c}	38.63^{b}	20.42^{a}	19.22^{a}
Interaction (C x W)	NS	NS	NS	NS	NS	**	NS	NS

NS, *, **Non significant or significant at P ≥ 0.05, 0.01, respectively; Means with the same letter are not significantly different at p<0.05 (DMRT)

But our result is not in conformity with that of Rulcova and Pospisilova (2001), who reported that higher concentration of BA negatively affected stomatal conductance. Cochard *et al.* (2002) revealed that stomatal conductance determined the magnitude of stress in plant, and might regulate water loss.

Benzyladenine concentration and watering frequency significantly ($p \leq 0.05$) affected plant height of both *C. variegatum* and *D. sanderiana* (Table 1). However, interaction between benzyladenine concentration and watering frequency was found to be significant ($p \leq 0.05$) for *C. variegatum,* but not for *D. sanderiana*. Application of benzyladenine in both species resulted in no increase of plant height. Rather, application 150 mg l^{-1} benzyladenine or more significantly reduced plant height as compared to control. On the other hand, decreasing watering frequency significantly reduced plant height in both the species. In case of *D. sanderiana,* watering at every 4 days produced statistically similar plant height with daily watering, but thereafter increased watering interval gradually decreased plant height. While in case of *C. variegatum,* watering interval of 4, 7 and 10 days produced statistically similar plant height which was significantly lower than daily watering. Effect of benzyladenine concentration on plant height of *C. variegatum* was found dependent on watering frequency. Daily watering reduced plant height drastically with increasing benzyladenine concentrations, but the reduction was not so severe when watering was done at 4 or 7 days intervals. While, benzyladenine concentration did not produce any significant effect on plant height of *C. variegatum* when watering was done at 10 day intervals. Influence of benzyladenine application on plant height has been reported by many researchers (Ranwala and Miller, 1999; Catherine *et al*., 2000; Li and Liu, 2003). In fact, response of plant height to benzyladenine was variable. When benzyladenine was applied to *Lilium longiflorum*, plant height increased by ≈ 0.77 cm for every non-chlorotic leaf (Whitman *et al*., 2001). But, benzyladenine sprayed to the whole-plant at early growth stage caused significant stem elongation and deformed flowers (Heins *et al*., 1996).

Application of benzyladenine significantly ($p \leq 0.05$) affected specific leaf area of both *D. sanderiana* and *C. variegatum,* but watering frequency did not (Table 1). No significant ($p \leq 0.05$) interaction between BA concentration and watering frequency regarding specific leaf area was recorded. Application of BA resulted in significantly higher specific leaf area of both species compared to control irrespective of concentrations. All the watering frequency treatments resulted in statistically similar specific leaf area in both species. Increased leaf area might be due to leaf expansion as well as increased leaf number (Pandey and Singh, 2011). The longevity of leaves treated with BA was significantly longer than untreated as reported by Han (1995). The positive influence of benzyladenine application on leaf growth has been confirmed in different plants by other research groups (Abou Aziz *et al*., 2011; Hazrati *et al*., 2012).

Benzyladenine concentration significantly ($p \leq 0.05$) affected leaf, stem and root fresh weight of both *D. sanderiana* and *C. variegatum* (Table 2). However, watering frequency significantly ($p \leq 0.05$) affected only the leaf and stem fresh weight but not root fresh weight. Interaction between benzyladenine concentration and watering frequency showed no significant influence on parameters recorded. Application of benzyladenine resulted in significantly higher leaf and stem fresh weight as compared with control in both species. In case of *D. sanderiana,* both leaf and stem dry weight increased gradually with increasing

Table 2 : Effect of BA concentration and watering frequency on fresh weight (leaf, stem and root) and plant grade of *Dracaena sanderiana* and *Codiaeum variegatum*

Treatment	Fresh weight (g)						Plant grade (Scale)	
	Leaf		Stem		Root			
	Dracaena sanderiana	*Codiaeum variegatum*	*Dracaena sanderiana*	*Codiaeum variegatum*	*Dracaena sanderiana*	*Codiaeum variegatum*	*Dracaena sanderiana*	*Codiaeum variegatum*
BA concentration (C)								
Control (0)	6.95^{c}	22.00^{b}	20.62^{b}	7.20^{b}	5.30^{a}	4.78^{a}	2.25^{c}	1.50^{c}
75 mg l^{-1} BA	7.06^{bc}	25.08^{ab}	21.49^{b}	7.94^{ab}	4.88^{ab}	4.39^{ab}	3.25^{b}	2.13^{b}
150 mg l^{-1} BA	7.56^{abc}	26.98^{a}	23.04^{ab}	9.17^{a}	4.71^{ab}	3.97^{ab}	3.25^{b}	4.00^{a}
225 mg l^{-1} BA	7.89^{a}	24.52^{ab}	24.54^{a}	8.60^{a}	4.21^{b}	3.38^{b}	4.13^{a}	3.75^{a}
300 mg l^{-1} BA	7.65^{a}	23.66^{ab}	23.25^{a}	8.42^{ab}	4.06^{b}	3.58^{b}	3.50^{b}	2.25^{b}
Watering frequency (W)								
Daily	8.54^{a}	27.24^{a}	26.66^{a}	9.01^{a}	5.11^{a}	4.01^{a}	4.40^{a}	3.70^{a}
Every 4 days	7.89^{b}	25.36^{ab}	23.97^{b}	8.44^{ab}	4.73^{a}	4.25^{a}	4.20^{a}	3.20^{b}
Every 7 days	6.91^{c}	22.85^{bc}	20.71^{c}	8.34^{ab}	4.54^{a}	4.36^{a}	2.80^{b}	2.20^{c}
Every 10 days	6.36^{c}	22.35^{c}	19.01^{c}	7.28^{b}	4.09^{a}	3.46^{a}	1.70^{c}	1.80^{c}
Interaction (C x W)	NS	NS	NS	NS	NS	NS	**	**

NS, *, ** Non significant or significant at P d" 0.05, 0.01, respectively; Means with the same letter are not significantly different at p<0.05 (DMRT)

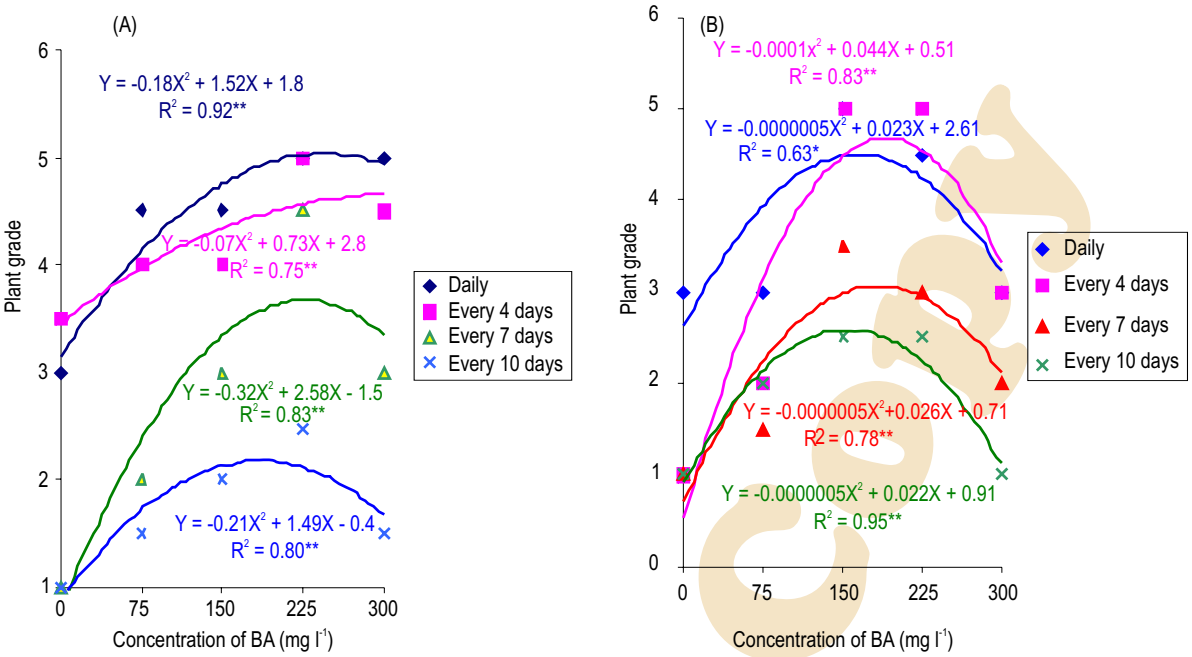

Fig 1 : Interaction effects between BA concentration and watering frequency on plant grade of (a) *Dracaena sanderiana* and (b) *Codiaeum variegatum*

benzyladenine concentration up to 150 mg l^{-1} and thereafter remained unchanged. While for *C. variegatum,* benzyladenine applied at > 75 mg l^{-1} resulted in no improvement in fresh weight of leaf and stem. Benzyladenine application did not bring any improvement in root fresh weight for either species. Rather, application 225 and 300 mg l^{-1} benzyladenine resulted in lower root fresh weight as compared to control, although application of 75 and 150 mg l^{-1} benzyladenine resulted in statistically similar root fresh weight with control in both the species. Similar findings have been reported by Abou Aziz *et al.* (2011) who observed that BA application resulted in enhanced plant growth.

Increasing watering frequency significantly improved leaf and stem fresh weight of both species (Table 2). In case of *D. sanderiana,* both leaf and stem dry weight were recorded highest when watering was done daily. Watering at every 7 and 10 days interval resulted in statistically similar and lowest leaf and stem dry weight. In case of *C. variegatum,* watering daily and at 4 day intervals produced statistically comparable and highest leaf fresh weight. On the other hand, highest stem fresh weight was recorded when watering was done daily or at every 4th or 7th day. Root fresh weight remained unchanged in response to watering frequency treatments, in both the species.

Increased watering frequency was vital to the leaf and stem growth of *D. sanderiana* in order to obtain good foliage production. Benzyladenine was required for foliage and stem growth of *D. sanderiana* but it should be applied along with daily watering. Cytokinins ordinarily inhibit elongation of stem sections and stimulate leaf enlargement. Influence of benzyladenine on shoot and root growth has also been documented by Koech *et al.* (2005). Influence of BA on fresh weight of *Lilium longiflorum* has also been reported by Emami *et al.* (2011). Stem fresh weight decreased linearly with watering frequency. The results showed that the application of BA was effective only when watering frequency was increased. Probably water helps in the transportation and distribution of applied BA. Cytokinins in higher plants are synthesized mainly in the root system and transported via transpiration system to the above ground parts where they regulate growth and development (Van Staden and Crouch, 1996).

There was a significant ($p \leq 0.05$) interaction between BA concentration and watering frequency on plant grade of *D. sanderiana* (Table 2). Effect of BA concentration on plant grade was dependent on watering frequency. Watering daily resulted in increasing plant grade reaching optimum at 225 mg l^{-1} BA concentration (Fig. 1a). However, watering at every 7th and 10th day resulted in lower plant grade even though the grade increased with increasing benzyladenine concentrations reaching optimum at benzyladenine concentrations between 150 – 225 mg l^{-1}. There was also a significant ($p \leq 0.05$) interaction between BA concentration and watering frequency on plant grade of *C. variegatum* (Table 2) where different concentrations reacted differently to watering frequency. Watering at every 4 days resulted in increasing plant grade reaching optimum at 150 mg l^{-1} BA concentration (Fig. 1b). However, watering at every 7th and 10th day resulted in lower plant grade even though the grade increased with increasing BA concentrations. Optimum

concentration was found between 150 – 225 mg l^{-1}, after which plant grade began to deteriorate. Plants watered at every 10th day had poor plant grade, which was significantly different to plants watered daily and every 4 day (Fig 1). The results indicated that *D. sanderiana* needed higher BA concentration than *C. variegatum* for good plant grade. Lukaszewska *et al.* (2008) also reported that Scarlet salvia (*Salvia splendens* Sello) and geranium (*Pelargonium hortorum* L.H. Bail.) treated with 200 mg dm^{-3} benzyladenine improved plant quality under normally watered conditions.

The present study confirms the effect of benzyladenine concentration and watering frequency on the quality of *D. sanderiana* and *C. variegatum*. For better quality, *D. sanderiana* should be sprayed with 225 mg l^{-1} benzyladenine and *C. variegatum* with 150 mg l^{-1} in combination with watering at 4 day interval.

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