Hydroponic cultivation of *Barleria obtusa*: Effects of B-Nine® WSG to improve its commercial value as a bedding plant.

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ABSTRACT

***Barleria obtusa* is a fast growing, evergreen multi stemmed perennial covered with a mass of violet flowers in autumn that occur naturally in the Eastern and Northern provinces of South Africa. Because of their unique flowering time, and vigorous growth a test was conducted to determine if the growth of *B. obtusa* would be reduced and improve its commercial value as a bedding plant. Plants cultivated in a NFT hydroponic system, were treated with B-Nine® WSG foliar spray at concentrations of 2, 6, 10, 16 g/L (a.i.) per treatment on a weekly basis for 4 weeks, while the control remained untreated. Plant height as observed shows a significance difference between the control and treated plants with increasing the concentration applied. The control produced the most number of shoots as compared to treated plants however, the best results obtained at week 8 was treatment with 6 g/L. Compactness was measured using total surface area of the plants (a.i.) per pot and treatments with 2, 6, 10, 16 g/L were significantly different than the control. Total wet and dry weights of plants treated with the growth retardant were significantly affected than the control. With the results obtained, 6g/L showed significant results as to improve the commercial value of *B. obtusa* as a bedding plant.**

Key words: *Barleria obtusa*, bedding plant, B-Nine® WSG, Daminozide, horticulture, hydroponic, NFT system, plant growth retardant, pot plant.

INTRODUCTION

The Acanthus family is a large group of plants, confined in most parts of South Africa (Rourke, 1987: 109). The genus *Barleria* consists of 120 species with 50 of these species recorded on the Eastern and Northern provinces. *Barleria obtusa* is an evergreen multi stemmed perennial covered with mass of violet flowers in autumn. Physical and environmental conditions play a role on the growth habit of *B. obtusa* ranging from a meter high under full sun conditions and a spreading shape with a width of two meters under shady conditions (Isaacs, 2001).

The ability of this perennial species to grow in a wide range of soils and drought resistant properties it is often used by gardeners as a ground cover, planted along roadside and embankments (Isaacs, 2001 & Rourke, 1987: 109). *Barleria* species flowers vary from white, pale blue, rich mauve (Onderstall, 1996: 192) and the unique flowering time in autumn makes this plant ideal as a flowering bedding plant as many other plants do not flower at this time.

Pot-plant crops are grown and marketed in containers and classified as, foliage plants, flowering pot plants and bedding plants (Laurie *et al.,* 1979: 279). In general, many flowers are being used to express human sentiments within our communities, with many people not having the time and facilities required for growing flowers (Edmond *et al.,* 1975: 468). Flowering plants can also be used as a mean of attracting pollinators into gardens and orchards, due to the vast colourful range of flowers available. According to Carvalheiro *et al.* (2012), *B. obtusa* and *Aloe greatheadii* flowered throughout the mango flowering season attracting pollinators such as bees.

There is vast diversity of herbaceous perennial plant species that are grown for both retail and the landscaping sectors. However these perennials tend grow out of their pots, forcing many growers to prune back the plants which leads to higher labour costs and delaying production for two to four weeks (Latimer & Scoggins, 2012: 2).One such species is the *B. obtusa* where its growth shape tends to grow out of control (Onderstall, 1996: 192), therefore the use of plant growth retardant will suppress this kind of growth adding a benefit of being enjoyed as a bedding plant.

Plant growth retardants in ornamental plants are commonly applied in limiting stem elongation and produce a more compact, sturdy potted and bedding plant without

changing growth patterns (Bhat *et al.,* 2011: 95). Growth retardants, such as B-Nine® WSG are successfully used to obtain higher quality yield in floriculture and horticulture industry, delaying cell division and elongation of plant aerial parts as well as restrict gibberellins biosynthesis, resulting in reduced internode length and vegetative growth (Catchey, 1964; Hayashi *et al.,* 2001; Hopkins & Hüner, 2009: 62; Jones & Metzger, 2001). The correct dosages need to be assessed to ensure the application is cost effective, with low residual effect to crops (Kahar, 2008: 141).

B-Nine® WSG is a plant growth regulator containing an active ingredient of 85% Daminozide, it is highly mobile rapidly moving from the point of application to all parts of the plant enhancing more compact and shorter growth as compared to untreated plants (Jabado, 2008). It is absorbed by the leaf, moving within the plant into the growing points reducing inter-node length (Anonymous, 2015).

The cultivation of *B. obtusa* was therefore achieved through an ancient method that involves means of feeding a plant with adequate amounts of known nutrient solution and sufficient supply of oxygen to achieve satisfactory growth (Hopkins & Hüner, 2009: 62).

Experimenting *B. obtusa* with different concentrations of B-Nine®WSG supplemented which treatment produces desirable results without affecting flower size, thus effectively reducing stem and leaf size. Thus, this study aimed to investigate the growth of *B. obtusa* in response to different concentrations of B-Nine® WSG, in order to compact its growth and improve its commercial value as a bedding plant without negatively effecting the plant growth.

MATERIALS AND METHODS

Experimental

The experiment was conducted in an environmentally controlled greenhouse, at the Cape Peninsula University of Technology in Bellville, South Africa. The greenhouse fitted with Alunet (40% shade screen). Midday temperatures and relative humidity were recorded using a temperature and humidity data logger MT669 and were at an average of 26°C and 66% respectively.

Soon after root development cuttings were measured attaining initial data of the stem height, root length and total fresh weight of each of the 50 plants. Plants gently removed from cutting tray and peat moss washed-off. Plants pruned back in order to attain equal height of 5 cm and roots cut back to 10 cm, fresh weight of the plants measured and recorded, thereafter cuttings planted into 50 shrub pots with a diameter of 12 cm, containing peat moss and LECA (light expanded clay aggregate) at a ratio of 4:1 respectively. 5 sets of 10 replicas, each set functioning as a different treatment, set up on a designed NFT (Nutrient Film Technique) hydroponic system, which involves a shallow stream of nutrient solution circulating inside gently sloped gutters and back to the reservoir (Venter, 2010: 165).

Sterilisation of the hydroponic system was achieved by mixing Sporekill® [Efekto Ltd, 9 Karee Rd, Kraaifontein, 7570, South Africa] into the 50 litre reservoir and letting it run for 24 hours (10ml/10L), medium used was also sterilised using Sporekill® at the same dosage, thereafter rinsing both the system and medium 3 times with fresh water. Nutrient mix composed of NUTRIFEED® [Starke Ayres, Hartebeesfontein Farm, 9th Road, Bredell, 1619, South Africa](10g/5L), mixed in the 50 litre reservoir, dosage supplied during the first week was half due to acclimatisation of plants (5g/5L), thereafter the full dosage of (10g/5L) was used. The EC and pH of the nutrient solution maintained at a range of 1.5–1.7 and 5.2–6.5 respectively.

Foliar spray and concentration

Rooted cuttings of *B. obtusa* were planted into the hydroponic system on 31stJuly 2015 (week 31). B-Nine® WSG (with an active ingredient of 85% [Merck (Pty) Ltd, Belvedere Office Park, 1 Bella Rosa Street, Bellville, 7530, South Africa] was applied as foliar spray 3 weeks after plants acclimatised to greenhouse conditions and had sufficient new growth.

For excessive stem elongation for most common bedding plants can be effectively prevented by foliar spray with a concentration of 6 g/L (5,000 ppm) (Anonymous, 2015). Plants were sprayed with concentrations of 2, 6, 10 and 16 g/L B-Nine® WSG while the control remained untreated.

Data collection

Data was collected on a weekly basis, at midday. Parameters such as stem height, number of shoots and compactness under each treatment were recorded.

Measurements were recorded from the time of rooted cuttings were planted till week 39 when the experiment ended. Root length, wet and dry weights of shoots, wet and dry weights of roots and total wet and dry weights of plants were analysed. Shoot height, compactness and root length were measured with a ruler. Wet weight of shoots and roots were determined after separating the shoots and roots and with the help of a digital balance (0.01 g) weights were recorded. To obtain shoot and root dry weight, they were dried in an oven at 50°C for 24 hours and measured with a digital balance.

Statistical analysis

Mean values of stem height, number of shoots, compactness, wet and dry weight of shoots, roots and total weight of plants were analysed using 1-way analysis of variance (ANOVA). These computations analysed by a software program known as STATISTICA. The Fisher least significance difference (L.S.D.) used to compare treatment means at $P \leq 0.05$, $P \leq 0.01$ and $P \leq 0.001$ level of significance.

RESULTS

Foliar spray treatments of B-Nine® WSG at concentrations of 2, 6, 10 and 16 g/L a.i. at week 8 per pot significantly ($P \leq 0.01$) reduced stem height with increasing the concentration applied (Table 1). At week 4 and week 6 respectively the results obtained showed no significant difference (Table 1). The results obtained at week 8, show with an increase in concentration a.i at 16 g/L reduced the stem height significantly, while treatments with 6 g/L enhanced positive results as compared to treatments with 2 and 10 g/L (Table 1). Plant height as observed in (Figure 1) shows a significant difference in stem height between the treated plants and control after week 6, as the growth retardant was applied at week 5.

Compactness of the plant measured using surface area in cm^2 during week 2 of the experiment had no significant difference but on progression of the experiment there was significance at ($P \leq 0.001$) at week 4 up until the end of the experiment at week 8 (Table

2). Plants treated with growth retardant at concentrations of 6, 10 and 16 g/L significantly obtained similar positive results at week 6 and 8 as compared to the control (Table 2). Compactness of plants as observed in (Figure 2) shows a significance difference between the control and treated plants after application of growth retardant at week 5.

The reduced number of shoots per treatment recorded after the application of B-Nine® WSG was significant (P≤0.05) at week 6 and significant (P≤0.01) at week 8 (Table 2). However, during week 2 and 4 there was no significant difference on the number of shoots (Table 2) while the control plants significantly had the most number of shoots by the end of the experiment at week 8 as compared to the treated plants (Figure 3). At week 6 and 8 plants with treatments obtained similar positive results as compared to the control, however plants treated with 6 g/L had the least number of shoots as compared to the other treatments (Table 2).

The wet and dry weight of shoots per pot significantly (P≤0.001) was affected by the foliar application B-Nine® WSG (Table 3). Wet and dry weight of shoots at 2 and 6 g/L, 10 and 16 g/L respectively were similar, but differed as compared to the control treatment (Figure 4).

The wet and dry weight of roots decreased with the increase in concentration of foliar spray per pot significantly (P≤0.01) at wet weight and (P≤0.001) at dry weight (Table 3). Wet weight of roots a.i. at 2, 6 g/L and control were similar as compared to 10 and 16 g/L that were similar. Dry weight of roots a.i. at 2 g/L and the control obtained similar results, however treatments 6, 10 and 16 g/L obtained similar positive results (Table 3)

The total wet and dry weight (a.i. shoots plus roots) per pot significantly (P≤0.001) was affected by the foliar application B-Nine® WSG (Table 3). Wet and dry weight of shoots at 2 and 6 g/L, 10 and 16 g/L respectively were similar, but differed as compared to the control treatment (Table 3).

Overall appearance of *B. obtusa* with increasing the strength of B-Nine® WSG resulted in plants with shorter, more compact and darker green foliage (Figure 5). Shoot/root ratio of plants was affected with increasing strength of growth retardant, resulting in shorter shoots and reduced root mass (Figure 6).

Table 1. Analysis of variance of different concentrations of B-Nine® WSG on stem height of *Barleria obtusa.*

Treatments	Week 4	Week 6	Week 8
2 g/L	6.90±0.99^{ab}	9.40±1.17^{a}	11.20±2.21^{a}
6 g/L	6.80±1.62^{a}	9.60±1.43^{a}	10.70±1.64^{a}
10 g/L	7.70±0.95^{ab}	9.90±1.37^{a}	10.80±1.93^{a}
16 g/L	7.80±1.32^{ab}	9.20±1.14^{a}	10.10±1.60^{a}
0 g/L (Control)	7.90±0.74^{b}	9.80±0.79^{a}	14.00±2.36^{b}
One-Way ANOVA (F-Stat) Rep	2.040^{NS}	0.569^{NS}	6.168**

Values presented are ±SD. *, **, *** = significant at P≤0.05, P≤0.01 and P≤0.001. NS= Not Significant, SD= Standard Deviation. Means followed by dissimilar letter(s) in column are significantly different from each other P=0.05 according to Fischer's Least Significant Difference.

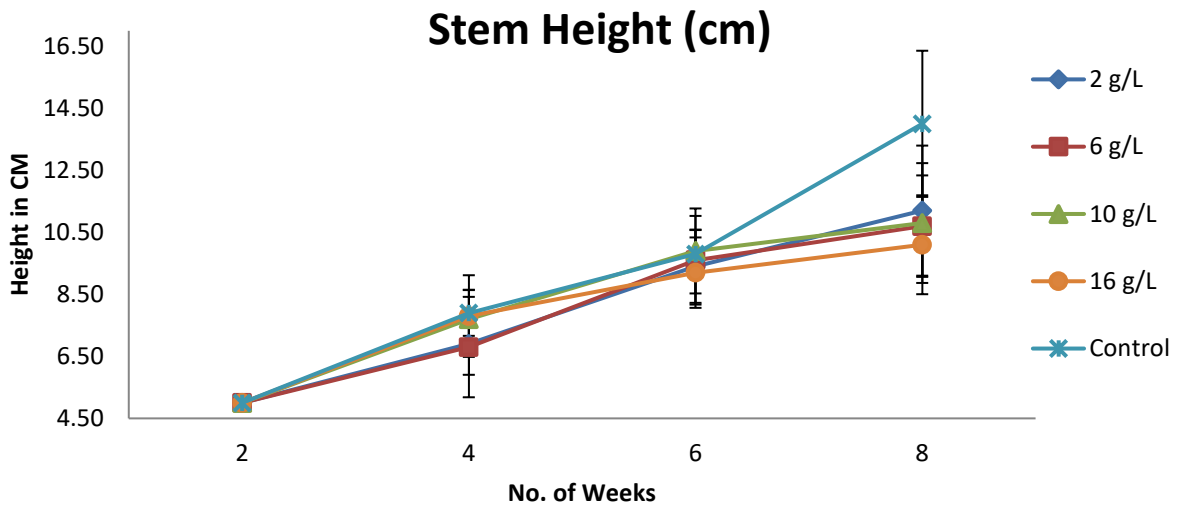

Figure 1. Effects of B-Nine® WSG on stem height of *Barleria obtusa* throughout the experimental period.

Table 2. Analysis of variance of different concentrations of B-Nine® WSG on compactness and number of shoots.

Treatments	Week 2	Week 4	Week 6	Week 8
Compactness in cm²				
2 g/L	12.00±2.71^{a}	68.30±26.79^{c}	88.10±20.69^{b}	121.40±37.25^{b}
6 g/L	12.70±2.45^{a}	58.20±16.47^{bc}	81.70±26.30^{ab}	100.20±26.97^{ab}
10 g/L	10.90±2.77^{a}	37.90±9.01^{a}	58.20±15.30^{a}	69.30±19.25^{a}
16 g/L	10.80±3.26^{a}	45.80±13.11^{ab}	67.00±24.57^{ab}	69.10±23.53^{a}
0 g/L (Control)	12.50±5.56^{a}	114.40±33.88^{d}	201.40±42.64^{c}	251.70±57.31^{c}
One-Way ANOVA (F-Stat) Rep	0.6289^{NS}	18.8306***	44.9990***	45.2110***
Number of shoots				
2 g/L	1.65±0.53^{a}	2.44±0.88^{a}	3.78±0.97^{a}	5.67±1.32^{a}
6 g/L	1.70±0.82^{a}	3.30±1.06^{b}	4.30±1.25^{a}	4.60±1.58^{a}
10 g/L	1.60±0.52^{a}	2.50±1.08^{ab}	4.60±1.26^{ab}	5.30±1.49^{a}
16 g/L	1.50±0.53^{a}	2.70±1.06^{ab}	4.10±1.37^{a}	5.20±1.40^{a}
0 g/L (Control)	1.70±0.48^{a}	2.70±0.82^{ab}	5.60±1.07^{b}	7.20±1.30^{b}
One-Way ANOVA (F-Stat) Rep	0.2885^{NS}	1.2708^{NS}	3.6127*	5.1283**

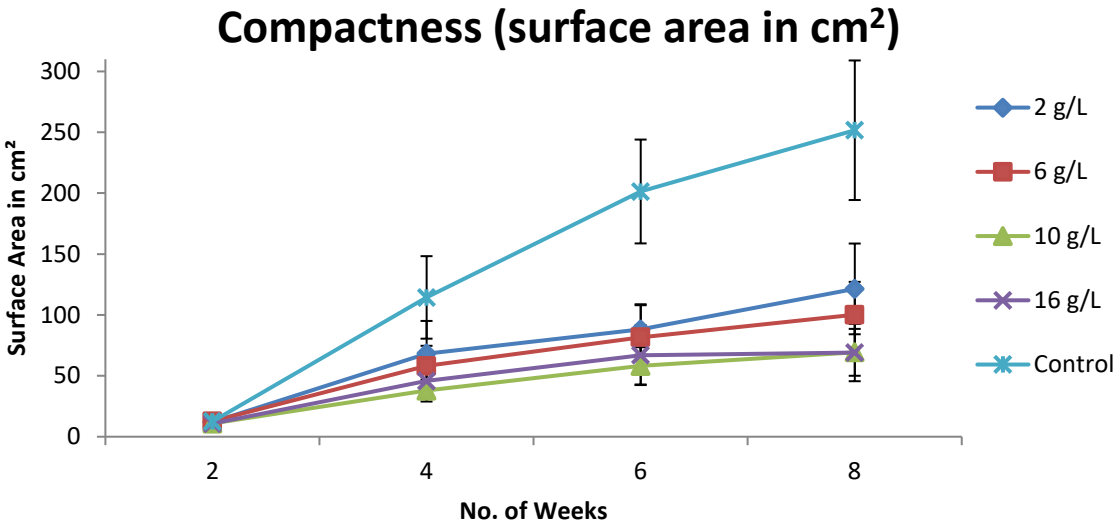

Figure 2. Effects of B-Nine® WSG on compactness in cm² of *Barleria obtusa* throughout the experimental period.

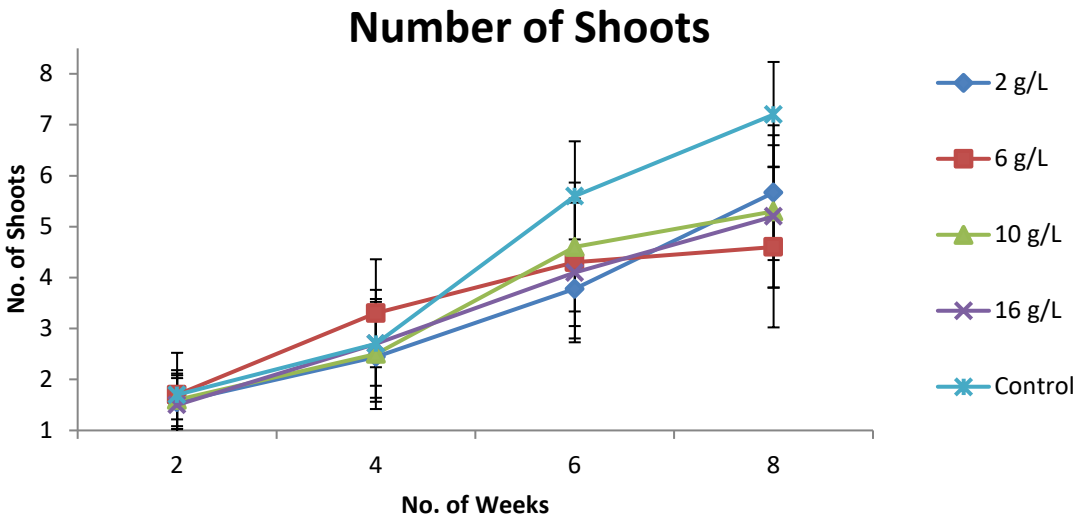

Figure 3. Effects of B-Nine® WSG on number of shoots of *Barleria obtusa* throughout the experimental period.

Table 3. Analysis of variance of different concentrations of B-Nine® WSG on evaluated parameters.

Treatments	Shoot wet weight	Shoot dry weight	Root wet weight	Root dry weight	Total wet weight	Total dry weight
2 g/L	13.97±3.88^{b}	2.28±0.62^{b}	7.40±2.43^{a}	0.58±0.17b^{c}	21.37±6.05^{b}	2.86±0.77^{b}
6 g/L	11.29±2.68^{b}	1.89±0.37^{b}	6.80±1.32^{a}	0.54±0.10^{ab}	18.09±3.61^{b}	2.44±0.44^{b}
10 g/L	7.33±1.33^{a}	1.30±0.28^{a}	4.70±2.00^{b}	0.43±0.11^{a}	12.03±3.13^{a}	1.72±0.37^{a}
16 g/L	7.07±1.83^{a}	1.36±0.32^{a}	4.58±1.86^{b}	0.48±0.14^{ab}	11.65±3.67^{a}	1.84±0.44^{a}
0 g/l (Control)	20.22±4.16^{c}	3.41±0.66^{c}	6.79±1.88^{a}	0.69±0.15^{c}	27.01±5.45^{c}	4.10±0.76^{c}
One-Way ANOVA (F-Stat) Rep	33.0459***	32.8176***	4.6629**	5.6556***	20.5408***	27.2894***

Values presented are ±SD. *, **, *** = significant at P≤0.05, P≤0.01 and P≤0.001. SD= Standard Deviation. Means followed by dissimilar letter(s) in column are significantly different from each other P=0.05

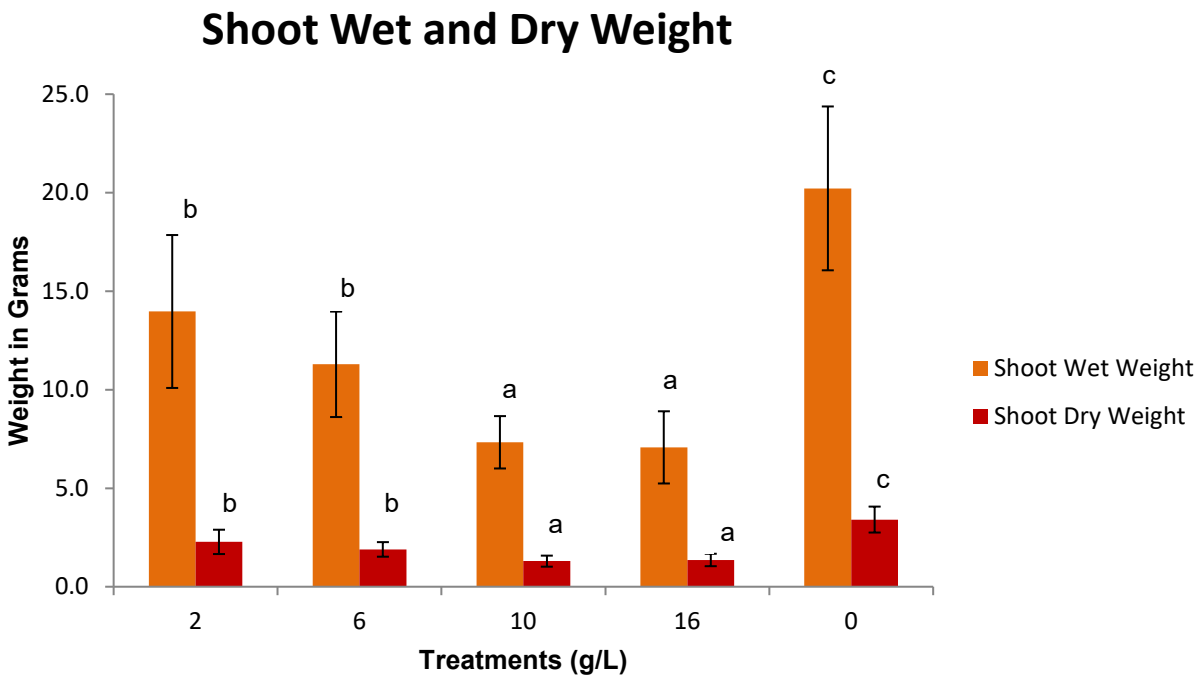

Figure 4. Effects of B-Nine® WSG on shoot wet and dry weight of *Barleria obtusa* throughout the experimental period.

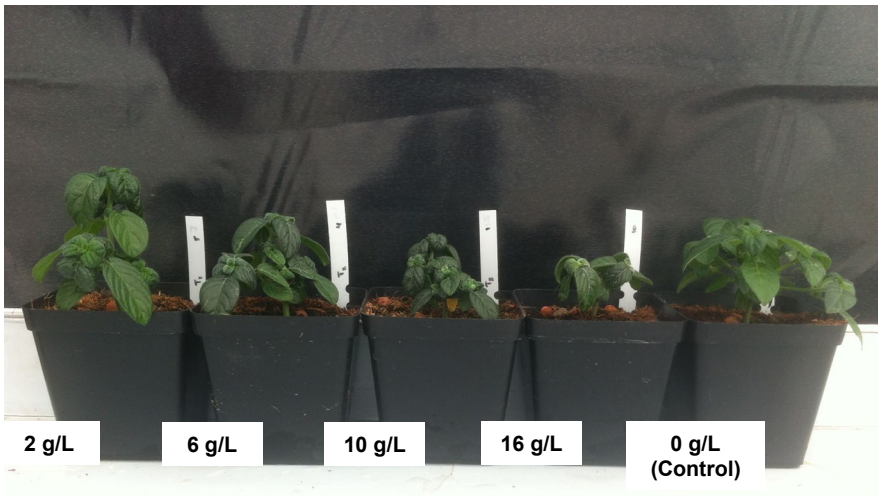

Figure 5. Effects of B-Nine® WSG on *Barleria obtusa* throughout the experimental period. Stem height and compactness of plants were affected with increase in strength of growth retardant, resulting in plants with shorter, more compact and darker green foliage.

Figure 6. Effects of B-Nine® WSG on shoot/root ratio of *Barleria obtusa* throughout the experimental period. Shoot/root ratio of plants was affected with increasing strength of growth retardant, resulting in shorter shoots and reduced root mass.

DISCUSSION

The type of growth inhibition is dependent on concentration of growth retardant applied and species of plant, thus at low concentrations, growth retardants reduce cell elongation, however at higher concentrations the reduction is increased due to reduced cell division (Warner & Erwin, 2003). The risk of plants with very long stems and their requirement of more space, labour and higher transport costs increase the importance of plant height control in the production of ornamental plants (Larson, 1985; Hayashi *et al.*, 2001; Karolin *et al.,* 2004). *B. obtusa* stem height was significantly reduced due to the effect of growth retardants decreasing internode length and apical dominance (Lee *et al.,* 1999). According to Velmurugan and Vadivel (2003) and Kazaz *et al.* (2010), observed B-Nine® WSG significantly reduced stem height of *Chrysanthemum morifolium* 'Ramat', thus affecting the stem height of *B. obtusa*. Lewis *et al.* (2004), observed decrease in poinsettia plant height as the concentrations of foliar spray applied chlormequat chloride and B-

Nine® WSG were increased up to 15 and 40 g/L, respectively, but the interaction between these retardants depend on the cultivar. Thus, the influence of growth retardants and their interaction on plant height depend on the concentration, species and cultivars (Lodeta *et al.,* 2010). Some of the most important factors concerning plant growth retardants are application method, type, time, number and concentration of growth retardants (Cramer & Bridgen, 1998). B-Nine® WSG has been used to control heights of many plant species such as *Epidendrum radicans, Zinnia elegans*, Chrysanthemum, Poinsettia and *Erysimum marshallii* (Lewis *et al.,* 2004 & Lodeta *et al.,* 2010).

As suggested by Jabado (2008), the active ingredient Daminozide present in B-Nine® WSG, is highly mobile rapidly moving from point of application to all parts of the plant enhancing more compact and shorter growth as compared to untreated plants. Thus, compactness of *B. obtusa* as observed showed a significance difference between the control and treated plants after application of growth retardant at week 5.

Number of shoots of *B. obtusa* was significantly decreased with the application of B-Nine® WSG, as it is a shoot growth inhibitor, inhibiting gibberellins biosynthesis (Marosz & Matysiak, 2005).

Studies of Bhat *et al.* (2011) on growth and flowering of *Erysimum marshallii* showed that the wet and dry weight of shoots, roots and total plant was decreased by the foliar spray application of B-Nine® WSG, thus the results obtained in this experiment show the same on *B. obtusa*.

Increase in concentration of B-Nine® WSG resulted in plants with shorter, more compact and darker green foliage. This was due to the decreased leaf area therefore chlorophyll concentration is densely packed leading to darker green leaves (Gardner, 1987).

Problem with many growth retardants has been finding an efficient application method that produces consistent results (Barrett *et al.,* 1994; Lodeta *et al.,* 2010). The overall visual qualities of *B. obtusa* by the end of the experiment was significant at concentration of 6 g/L, as physical appearance of the plant was not extensively retarded to the point of poor quality.

Observed by Rai & Brist (1991), flowering was delayed on application of B-Nine® WSG, due to the suppression of growth, thus less assimilates were available for flowering, however the duration of 8 weeks of this experiment was not sufficient to induce flowering.

This information, combined with previously identified effects of B-Nine® WSG on many plant species provide a basis for improving the cultivation practices of bedding plants, but further work is needed to understand floral inductive requirements of *B. obtusa.*

CONCLUSION

In conclusion, plant growth retardants influence growth and flowering of plants, concentration levels and application frequencies are important factors in determining plant quality. Excessive concentrations result in plants which are extensively retarded and often of poor quality. It is important to determine the optimum concentration levels and frequencies, as well as the most economical and practical application methods in order to produce commercially acceptable plants. Factors such as seasonal temperature and cultivar differences could also exert an influence. From this study it appears that B-Nine® WSG at concentration of 6 g/L can effectively be used to control the vigorous growth of commercially grown *B. obtusa* and other related bedding plants.

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