The Influence of Watering, Shading, and Nitrogen Levels on the Growth of Container-Grown *Schlumbergera* x buckleyi

Mervyn I. Spurway and Michael B. Thomas
Horticulture Department, Lincoln University, Canterbury

Container-grown *Schlumbergera* x buckleyi grown in 6 peat : 4 sand (v/v) medium grew more strongly at 60% or 80% container capacity watering levels than at 40%. Flowering was also greater at the two higher watering levels. In a second experiment, 40% and 75% shading reduced growth over the autumn and winter growing period; however, unshaded plants were not as green as those under shade covers. Nitrogen (N) fertilisation above 300 g N·m^3 or equivalent to 40 g N·m^3 month, depressed growth. It was recommended to maintain media at 60% container capacity, to use a low level of shading to improve plant quality especially over summer, and to use low N rates equivalent to around 35 g N·m^3·month.

INTRODUCTION

The Christmas cacti are common flowering pot plants grown primarily for autumn and winter sales. There has been much confusion over the naming of these plants. The true Christmas cactus, *Schlumbergera* x *buckleyi* is a hybrid between *S. truncata* (the Thanksgiving cactus) and *S. russelliana*. Previously it was called *S. bridgesii*. The true Christmas cactus characteristically has scalloped-edged stem-segments (phylloclades), while those of the Thanksgiving cactus are toothed. The latter has been previously known as *Epiphyllum truncatum* and *Zygocactus truncatus*. Much hybridisation has taken place with these plants and many cultivars are derived from crosses between Christmas and Thanksgiving cacti. Collectively they are commonly known as Christmas cacti, holiday cacti, schlumbergeras, and zygocactus and their cultural requirements are similar.

The true Christmas cactus is an epiphytic member of the Cactaceae family. The natural habitat of the parent species is in the rainforest of the peripheral mountain ranges of eastern Brazil, just north of Rio de Janeiro. These plants grow at an altitude of 900 to 1800 m. As epiphytes, or surface growers, they cling onto the stems and branches of forest trees, absorbing as much water and nutrients from the accumulation of humus (decaying organic matter) as possible. Roots are kept well aerated, while the moist air prevents the roots from drying out. Their stem-segments function as leaves but do not as readily loose moisture by transpiration. Living in the tops of trees they get good, but filtered, light.

There has been little research into the cultural requirements of Christmas cacti. Experimental work has mainly concentrated on chemical, photoperiod, and temperature manipulation of flowering, while other recommendations are often based on grower experience. Boyle (1990) and Hammer (1980) suggested that Christmas cacti should be irrigated frequently to retain a moist growing medium for maximum growth. This recommendation is qualified in that the media must be high in organic material and well drained. Discussing potting mixes in general, Bunt (1976) suggested that a progressive reduction in growth will occur when plants, in general, receive an excessive amount of irrigation as the air capacity of the substrate is reduced to below 10%. Working with ferns, Khoo (1979) found that *Asplenium bulbiferum* grew better at 60% container capacity whereas *Adiantum raddianum* was superior at 80%.

Some growers recommend a drying-off period in early autumn to help induce flower bud formation, with plants only being watered if excessive wilting occurs. Normal watering is recommenced once tiny flower buds appear (Burke, 1983; Slade, pers. comm.). Boyle (1990) reported that this recommendation had not been supported by research and suggested that plants should not be allowed to shrivel or be overwatered during flower induction treatments. He also said the saturation of growing media for prolonged periods will reduce aeration and predispose the roots to attack by soil-borne diseases. Andersohn (1983) also stated that the Christmas cactus was sensitive to waterlogging and extreme drying of the root ball. Heins et al., (1981) concluded that the practice of moisture stressing Christmas cacti during flower initiation may have originated as a process of controlling disease, but became associated with inducing flower bud formation. They found the number of flower buds was reduced by high water stress during flower initiation.

The general recommendation for growing Christmas cacti is that they should be grown in full sun, but shaded from October to March, or from April to September in the Northern Hemisphere (Andersohn, 1983; Boyle, 1990). Boyle (1990) suggested that the light intensity should be maintained in the range of 15 to 30 klux, while Anon. (1991), suggested 15 to 25 klux. McConnell et al. (1981) reported plants being grown at 30 to 40 klux.

Work on African violets indicated they could be grown in reduced light of 50% to 70% shading, then exposed to higher light levels with 30% to 50% shading, to promote increased flower numbers (Anon., 1981). Thomas and Teoh (1983) found that reduced growth occurred with *Ficus macrophylla* when plants were grown under 40% and 75% shade. At no shade, increasing nitrogen (N) levels strongly promoted top growth, but at high shade, there was little or no effect. Nitrogen applied at 86 to 110 g $N{\cdot}m^3$ month gave best growth and quality. Working with ornamental peppers, Thomas and Leong (1984) found that high quality plants could be produced at 50 klux light level (0% shade) and 600 g $N{\cdot}m^3$. With ferns, Khoo (1979) reported no significant interaction between N levels and light intensity. *Asplenium bulbiferum* required a higher light level (12 to 16 klux) than *Adiantum raddianum* (6-10 klux). An N application of 100 to 120 g $N{\cdot}m^3$ month was recommended.

Reports generally indicate that the Christmas cacti have relatively low nutritional requirements. Boyle (1990) recommended watering with 100 to 150 ppm N one to three times a week using a balanced N-P-K fertiliser. Another report (Anon., 1991) suggested N levels should be maintained between 75 to 125 ppm until plants have reached their desired height, at which time the fertiliser application should be halted during flower initiation, and then resumed with a low N ratio fertiliser. Proprietary fertilisers, used at half the recommended rate, were suggested as being suitable by Burke (1983) for home gardeners growing the Christmas cactus.

Backeberg (1976) said the use of an inorganic fertiliser which was low in nitrogen, but richer in phosphorus and potassium, would promote growth and better bud development.

Two experiments were carried out to investigate the effects of water, shade and nitrogen levels on the growth and development of the true Christmas cactus, *Schlumbergera* x *buckleyi*.

EXPERIMENT 1: WATERING

Potted plants were grown for 12 months under one of three watering regimes in which the medium was maintained at either 40%, 60%, or 80% container capacity.

Materials and Methods. Rooted cuttings, consisting of four to five stem-segments, were placed in 125-mm plastic pots lined with polythene to prevent water loss. Each pot was filled with 800 ml of air-dried potting mix based on 60% Southland (Mataura) sphagnum peat and 40% coarse manufactured sand. A standard fertiliser mix had been added based on an 8-9 month release "Osmocote" compound fertilizer. Each pot was check weighed and adjusted to 611 g of potting mix.

A few pots were weighed at 100% container capacity and from this (by deducting the weight of oven dried mix), a weight was determined at which each treatment replicate should be maintained to give 40%, 60%, and 80% container capacity. This figure included a total weight for the pot, polythene, label, fertiliser, medium, and plants. A sample of plants, top and washed roots, was weighed and found to have a mean weight of 11 g per plant.

The experiment was set up in December (summer) and carried out in a heated glasshouse with automatic fan ventilation. The minimum glasshouse temperature was 15°C while the maximum was approximately 5°C above ambient temperature. The plants were grown under 50% shadecloth. Each treatment consisted of five replicates of two plants per pot arranged in a randomised block design.

Pots were weighed each day. If any individual replicate had dropped below the treatment container capacity weight, it was rewatered to 10 g above this weight. Periodically the weight was adjusted for any increase in plant size.

Growth and flower assessments were carried out at various stages during the experiment with a visual rating being carried out just prior to harvest in November (after 12 months). This was based on a 1 to 5 scale for vigour and general appearance, with a very vigorous and high-quality plant being given a rating of 5. After harvest plant tops were oven dried and weighed. Results were analysed using computer programme Genstat 5.

Results. Container moisture levels had a strong influence on growth and development (Table 1). There was a highly significant increase in stem-segment numbers, dry weights, and visual ratings, from 40% to 80% container capacity, although there was no significant difference between 60% and 80% container capacity. The effect on stem-segment numbers became more significant with time. While there was a significant increase in flowering between 60% and 80% container capacity, flower numbers per plant were low.

Table 1. Effect of watering regime on the growth and development of the Christmas cactus.

Water regime (% container capacity)	Stem segment (number) Months after setting up 1	4½	6½	12	Visual rating	Dry wt (g)	Flower number
40	8.4	27.2	40.7	90.0	3.0	7.40	1.2
60	8.6	32.8	52.0	129.8	3.6	10.06	1.0
80	9.2	35.2	48.7	134.4	4.0	10.48	3.2
Significance	-	#	**	***	**	***	**
LSD (5%)	3.6	7.3	6.5	16.7	0.5	0.47	1.2
CV %	28	16	9	10	9	3	46

Significance levels: ***$p<0.001$; **$p<0.01$; *$p<0.05$; #p0.05-0.1
All figures are per plant.

EXPERIMENT 2: SHADE AND NITROGEN RESPONSE

In this two factor experiment plants were grown under three levels of shade (0%, 40%, and 75%) and in three levels of nitrogen (N) fertiliser (300, 600, and 900 g total $N \cdot m^3$). The plants were arranged in a split-plot design.

Methods and Materials. Tubelings of approximately 25 stem-segments were potted into 125 mm plastic pots containing the three levels of nitrogen. A medium of 60% Southland (Mataura) sphagnum peat and 40% coarse manufactured sand was used. The following base fertilisers were added per m^3 of mix: 2.5 kg superphosphate (9% P); 427 g sulphate of potash (39% K); 4.5 kg Dolomite lime; 1.5 kg agricultural lime; 150 g Sporumix A (trace elements); and 360 g Fetrilon (iron chelate). In addition Osmocote 26-0-0 (26% N), with a 3-4 month release period, was applied at three rates: 1,154 g, 2,300 g, and 3,462 g per m^3 providing 300, 600, and 900 g $N \cdot m^3$, respectively. Half of these rates were incorporated initially into the mixes with the rest being applied as a side dressing after 3½ months. Twenty-one plants, with one plant per pot, were potted into each nitrogen level.

The experiment was carried out in similar glasshouse conditions to the previous experiment except for the shading. Hand watering was carried out when required.

Seven plants from each nitrogen level were treated to either 0%, 40%, or 75% shade. Average maximum light levels during the running of the experiment were estimated to be 312, 187, and 78 W m^2 (41 klux, 24 klux, and 10 klux) for the 0%, 40%, and 75% shade levels, respectively.

The experiment was set up in March and plant stem-segments were counted at this stage and just prior to harvesting in October, after 32 weeks of growth. At this stage plants were visually rated for quality and vigour (as per the watering experiment) and for chlorosis. The latter was based on a 1 to 5 scale with a score of 1 for pale chlorotic foliage and 5 for dark green foliage. A flower count was also carried out and on harvesting, plant tops were oven dried and weighed. Data were analysed using the Genstat 5 computer programme.

Results. Shading had a negative effect on growth as shown by reduced stem-segment numbers and, in particular, top dry weights (Table 2). There was no significant difference (at the 5% level) in dry weights between no shade and 40% shading. Shading had no significant effect on overall vigour and quality (visual ratings), with the significantly greener plants obtained under heavy shade (chlorosis ratings) compensating for the reduced plant size. Although flower numbers were greatest at 40% shade, there was great variability between replicates and results were not significant.

Increasing nitrogen levels depressed growth although this was only shown to be significant in dry weights. Plant quality was also reduced, as shown by a reduction in visual ratings. These effects were most significant when the nitrogen level was increased from 300 to 600 g N·m^3. Increasing nitrogen from 300 to 900 g N·m^3 had no significant effect on stem-segment numbers, chlorosis ratings, or flower numbers.

Table 2. Effect of shade and nitrogen levels on the growth and development of the Christmas cactus.

Factor	Stem-segment number	Visual rating	Chlorosis rating	Dry weight (g)	Flower number
% Shade					
0	78.1	3.5	2.4	8.53	1.9
40	71.5	3.5	3.3	7.53	3.6
75	63.1	3.3	4.6	5.18	1.4
Significance	*	-	***	***	-
LSD (5%)	9.66	0.66	0.71	1.33	2.67
CV %	12	16	17	16	98
Nitrogen g·m3					
300	76.1	3.9	3.4	8.06	2.7
600	68.1	3.2	3.5	6.70	1.6
900	68.4	3.3	3.6	6.48	2.5
Significance	-	*	-	**	-
LSD (5%)	11.07	0.56	0.43	1.06	1.44
CV %	25	26	20	24	99

Significance levels: ***$p<0.001$; **$p<0.01$; *$p<0.05$; #p0.05-0.1
Analysis adjusted for initial stem-segment number covariate.
There was no significant interaction between shade and nitrogen.

DISCUSSION

Results from the watering experiment support the recommendation for growing Christmas cacti under moist conditions (Hammer, 1980; Boyle, 1990). However, as there was no significant difference between maintaining the plants at 60% and 80% container capacity, there appears to be little benefit in high moisture levels

(80% container capacity) if there is a greater risk of soil-borne disease infection. Any potting mix that is used should be well drained and well aerated. While flower numbers were greatest with high media moisture conditions, numbers were generally low. Flowering could be promoted by the use of chemicals, e.g. 6-benzyladenine, and alterations to photoperiod and temperature (Anon., 1991). From other studies (Heins et al., 1981), there appears to be little evidence to support the use of a dry-down period during flower initiation to encourage more prolific flowering.

It has been suggested that Christmas cacti be grown in full sun except in summer when some shading is desirable (Andersohn, 1983; Boyle, 1990). In the second experiment, which was carried out from autumn to spring, maximum growth was achieved with no shade. However, plants with no shading were also more chlorotic suggesting decreased chlorophyll content as discussed by Thomas and Leong (1984). Results tend to indicate that where good natural light transmittance occurs in the greenhouse some shading may be beneficial, even outside the summer months. Plants were significantly greener, but not significantly smaller, when given 40% shade. A higher level of shade may reduce growth except under summer conditions. Even at 40% shading, in this experiment, light levels were probably within those that have been recommended (Boyle, 1990; Anon., 1991). Under greenhouse conditions where natural light levels may be lower, no shading may be necessary, except over the summer period.

Results show that the Christmas cactus is sensitive to even medium levels of nitrogen and should be grown with a low nitrogen base fertiliser or liquid feed. Beyond 300 g total N•m^3 (or 40 g N•m^3•month) there was a significant depression of growth. This supports the claim that these plants have a low nitrogen requirement (Backeberg, 1976; Burke, 1983). Unpublished work by the authors on the same species indicated growth response to nitrogen peaked at around 35 g N•m^3•month. This rate is low compared to recommendations for some other species (Khoo, 1979; Thomas and Teoh, 1983; Thomas and Leong, 1984). Comparative liquid feed rates of around 100 ppm N seem appropriate when Bunt (1976) spoke of normal rates of 200 ppm.

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