

Effects of soilless media pH on cut flower and tuber production in *Sandersonia aurantiaca*

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Abstract The effects of six target media pH levels (4.5, 5.0, 5.5, 6.0, 6.5) on cut-flower (glasshouse) and tuber production (outdoor) in *Sandersonia aurantiaca* (Hook.) were compared in two experiments. The effects of these pH levels on tuber storage and subsequent cut-flower production were assessed in a third experiment in a glasshouse. Actual media pH levels achieved varied from 4.1 to 6.1 in the glasshouse and from 4.4 to 6.5 outdoors. The pH levels in the glasshouse produced small differences in stem length but no significant differences in stem weight, flower number, or vase life. At the highest pH level, the number of stems harvested was less and the number of rejected flowers greater than at lower pH levels because of decreased stem length or physiological disorders, such as leaf chlorosis and leaf tip browning on the lower leaves. Leaf concentrations of S, Mn, and Zn declined with increasing pH level whereas Mg increased in the cut-flower experiment. The number of tubers lifted outdoors was least at the highest pH level but there was no difference in mean tuber weight. Tuber nutrient concentrations of N, Ca, Mn, Zn, and Cu declined with increasing pH level whereas Mg increased. There were no production differences at forcing with the

lifted tubers. For sandersonia cut-flower production a media pH range of 4.4–5.3 appears to be suitable, whereas for tuber production pH levels of 4.4–6.1 were best. As sandersonia production usually involves both growth phases, a range pH of 4.4–5.3 would be suitable with a target pH of 5.0–5.3 recommended for growth in peat-pumice media. This will ensure mid-range tuber and leaf nutrient concentrations and optimised production.

Keywords sandersonia; *Sandersonia aurantiaca*; pH; tuber; cut flower; soilless medium; nutrient concentration

INTRODUCTION

Sandersonia aurantiaca (Hook.) has become one of New Zealand's major export ornamental crops. Linked to the successful development of this new crop has been the ongoing improvement of production and growing methods for both cut flowers and tubers. Initial soil media recommendations for production (Reyngoud & Brundell 1985; Clark & Scott 1989) were based on standard flower-production values for ornamental crops—pH 5.5–6.5, Ca 9.5 meq/100 g, K 1.4 meq/100 g, P 50 µg/ml, and Mg 1.5 meq/100 g. The majority of sandersonia production was initially carried out in soil, but with the increasing use of artificial media (peat-pumice and bark based) these broad recommendations required revision as artificial media have differing nutrient retention capabilities. The effect of media pH on nutrient availability for the growth of sandersonia is unknown.

The pH of soils which can vary from values of 3 to as high as 10, can have a pronounced effect on soil minerals and micro-organisms, as well as plant root growth. Plants cope to varying degrees with differing pHs. The optimum pH for maximum crop growth can differ between cultivars and can be influenced by growing media, fertiliser practices, watering regimes, and growing environment. It is often not the pH *per se* that is the growth limiting

factor but secondary factors such as nutrient availability which are pH dependent.

The optimum soil pH for crop growth is generally lower in organic soils than in mineral soils. The availability of plant nutrients in organic soils can be low, with the availability of Fe, Mn, B, Cu, and Zn generally declining with increasing pH. However, elements such as N, P, K, S, Ca, and Mg are more available at higher pH (Mengel & Kirby 1982; Peterson 1982).

A pH of 6–7 is recommended for most bulbous crops (De Hertogh & Le Nard 1993). Dole & Wilkins (1999) recommend a pH of 5.4–6.0 for floriculture crops in soilless media and a pH of 6.2–6.8 for media containing at least 25% soil. The pH recommendation can be both crop and media specific. For example, with freesia production a pH of 6.6–7.5 is the general recommendation in soil (Imanishi 1993), whereas a pH of 5.9 is recommended in a peat/sand (Thomas et al. 1998). When gloriosa, a closely related genus to sandersonia, is grown in a peat medium, a pH of 5.8 is recommended (Carow 1976).

Table 1 Media fertiliser combinations.

Target pH	Fertiliser additions (kg/m ³)			
	Dolomite	Gypsum	MgSO ₄	Osmocote
4.5	0	2.0	4.0	2.0
5.0	1.0	1.0	2.0	2.0
5.5	2.0	0.5	1.0	2.0
6.0	3.5	0.25	0.5	2.0
6.5	5.5	0	0	2.0
7.0	8.0	0	0	2.0

Table 2 Media pH levels for Experiments 1 and 2.

Media pH levels	Experiment 1*	Experiment 2†	Experiments 1 and 2‡
1	4.1	4.4	4.3
2	4.4	4.8	4.6
3	4.5	4.8	4.7
4	5.0	5.5	5.2
5	5.3	6.1	5.6
6	6.1	6.5	6.1

*pH samples taken at 8 weeks from planting.

†pH, an average of samples taken at 8 weeks from planting and at tuber lifting.

‡pH, an average of samples taken at 8 weeks from planting in both experiments.

There are no published pH recommendations for soilless culture of sandersonia. Growers currently use standard flower recommendations. This study examines the effects of pH levels on sandersonia cut-flower and tuber production as well as tuber storage and forcing in the following season. This information will enable pH recommendations that optimise production and tuber quality in soilless culture to be developed.

METHODS

Experiment 1: stem quality

Standard forcing-size tubers (7–10 g) were used to assess the effects of media pH on stem quality using six target pH levels: 4.5, 5.0, 5.5, 6.0, 6.5, and 7.0. Treatments were replicated 4 times in a randomised block design with one tray/replicate.

Tubers that had been stored at 4°C for 4–5 months were pre-sprouted for 10 days at 23°C (Clark 1994). The forked tubers were then cut to produce two arms (tubers) of similar weight (c. 4.0 g). The tubers were given a protective fungicide dip (0.5 g/litre benomyl plus 2.0 g/litre thiram for 10 min) and planted on 27 November 1992 into polystyrene trays (595 × 420 × 190 mm) of soilless media. Into each tray (plot) 20 tubers were planted at 50 mm depth. The trays contained 25 litres of a blended 50:50 Hauraki peat:pumice mix into which a fertiliser mix of dolomite, gypsum, MgSO₄, and 5–6-month Osmocote (10:4.8:15, 1.2 (N:P:K, S) + trace elements) had been incorporated (Table 1). Before the addition of fertilisers, a sample of the peat-pumice was taken tested (pH 4.5) and used to calculate the rates of dolomite required to achieve the required pH levels. Variable rates of gypsum and MgSO₄ were used to balance the Ca and Mg supplied in the dolomite. Media samples were taken for analysis from each plot 8 weeks after planting to determine pH levels (Table 2). The pH levels were measured using a 1:2.1 media:water, v:v extract. Plants were grown in an unheated glasshouse with forced air circulation and ventilation at 20°C. The crop was supported with netting and sprinkler-irrigated with water (pH 6.2) daily at 3 litres/m².

Stems were harvested just above the second leaf when the second flower had reached anthesis. Stem length, stem weight, and flower number were recorded. Stems were graded so that any stems <300 mm or those with any physiological disorder were recorded as a reject. The vase life of up to five stems/plot was assessed under standard conditions

in distilled water at 20°C and a irradiance of 20–25 $\mu\text{mol}/\text{m}^2$ per s at bench height for 12-h days. Vase life was deemed to be complete when >50% of the flowers had senesced. Leaf samples (2–3 of the youngest mature leaves) were taken from the remaining harvested stems in each plot and bulked by plot for nutrient analysis (c. 8 weeks after planting). Nutrient analyses were carried out following wet-ash digestion using colorimetry, spectrophotometry, and atomic absorption by Celentis Analytical.

Experiment 2: tuber production

Small grade tubers (3–5 g) were used to assess the effects of media pH on tuber production. Using the same trial design and methods of Experiment 1, the effect of the six target pH levels were compared in a sheltered outdoor site in a randomised block design with four replicates.

Pre-sprouted and divided tubers (mean weight 1.9 g) were given the same fungicide dip as in Experiment 1 and planted on 27 November 1992 at 20 tubers/tray in a blended Hauraki peat:pumice mix. The crop was sprinkler-irrigated with water daily at 3 litres/ m^2 . Media samples were taken for analysis from each plot 8 weeks after planting and at tuber lifting to determine pH levels (pH levels are given as a average of the two samples) (Table 2). Leaf samples (2–3 of the youngest mature leaves) were taken when stems were cut back to just above the second flower at 10 weeks after planting. Leaf samples were bulked for analysis with those from Experiment 1 by treatment and rep. Leaf samples were bulked between experiments as media treatment pH values taken at Week 8 in both

experiments were similar (average results presented in Table 2) and samples were taken at the same stage of crop development. Watering was stopped after 18 weeks and the foliage left to senesce. On 19 May the tubers were lifted and weighed. Five tubers per plot were bulked for nutrient analysis and the remainder dipped in fungicide (0.5 g/litre benomyl plus 2.0 g/litre thiram for 10 min), placed in polystyrene boxes between layers of newspapers, and stored at 4°C.

Experiment 3: tuber storage and cut-flower production

Tubers from Experiment 2 were removed from storage on 3 November 1993 and the number of rotted tubers counted. The forked tubers were then cut to produce two arms (tubers) of similar weight and pre-sprouted at 23°C (Clark 1994). Tubers were given a protective fungicide dip (0.5 g/litre benomyl plus 2.0 g/litre thiram for 10 min) before planting on 17 November 1993 into polystyrene trays (595 \times 420 \times 190 mm) containing a commercial 50:50 Hauraki peat:pumice mix with incorporated fertilisers. The initial pH and available nutrient content of the potting mix was measured after extraction with water (1:2.1 media:water v:v) using colorimetry and atomic absorption methods (pH 5.6, Ca 36 mg/litre, K 109 mg/litre, P 13.2 mg/litre, Mg 22 mg/litre, and N 109 mg/litre). Tubers were planted at up to 28 tubers/tray. Losses as a result of rots meant that 28 tubers were not always available for all trays. Plants were grown in an unheated glass-house with forced air circulation and ventilation at 20°C. The crop was supported with netting and sprinkler-irrigated with water daily at 3 litres/ m^2 .

Table 3 *Sandersonia aurantiaca* cut-flower production and vase life at different media pH levels in Experiment 1. (SED = standard error of the differences; LSD = least significant difference; d.f. = degrees of freedom; NS = not significant.)

pH	Stem length (mm)	Stem weight (g)	Flower number/stem	Stems/plot harvested	Vase life (days)	Reject flower stems (%)
4.1	420	8.2	8.7	16.3	12.9	11.5
4.4	431	8.6	9.1	14.0	13.0	3.7
4.5	406	8.8	8.4	12.3	12.9	7.7
5.0	456	10.1	9.8	12.5	13.2	2.0
5.3	445	10.0	9.8	15.5	12.3	3.0
6.1	382	8.0	8.6	11.5	12.6	100
Significance (d.f. = 15)	$P < 0.1$	NS	NS	$P < 0.05$	NS	$P < 0.001$
SED	24.8	–	–	1.50	–	6.06
LSD (5%)	52.8	–	–	3.21	–	12.9
LSD (10%)	43.4	–	–	–	–	–

Table 4 *Sandersonia aurantiaca* leaf macronutrient (% dry weight) and micronutrient (ppm) concentrations at different pH levels in Experiment 1 and 2. (SED = standard error of the differences; LSD = least significant difference; d.f. = degrees of freedom; NS = not significant.)

pH	N (%)	P (%)	S (%)	Mg (%)	Ca (%)	Na (%)	K (%)	Mn (ppm)	Zn (ppm)	Cu (ppm)	Fe (ppm)	B (ppm)
4.3	4.18	0.39	0.25	0.26	0.47	0.27	1.59	346	39.0	33	94	122
4.6	4.04	0.43	0.24	0.30	0.56	0.28	1.60	321	31.5	31	89	109
4.7	3.87	0.38	0.21	0.31	0.59	0.32	1.43	269	25.3	36	81	103
5.2	3.63	0.35	0.22	0.39	0.54	0.31	1.51	219	24.0	32	84	103
5.6	4.07	0.34	0.23	0.48	0.54	0.30	1.66	198	26.0	32	103	108
6.1	4.05	0.38	0.21	0.50	0.45	0.29	1.73	136	21.0	32	106	103
Significance (d.f.=15)	NS	NS	$P < 0.05$	$P < 0.001$	$P < 0.05$	NS	NS	$P < 0.001$	$P < 0.001$	NS	$P < 0.05$	NS
SED	-	-	0.016	0.033	0.041	-	-	21.8	1.85	-	8.5	-
LSD (5%)	-	-	0.033	0.070	0.087	-	-	46.4	3.9	-	18.1	-

Stems were harvested just above the second leaf when the second flower had reached anthesis. Stem length, stem weight, and flower number were recorded. Leaf samples (2–3 youngest mature leaves) were taken at harvest for nutrient analyses (c. 8 weeks after planting). Nutrient analyses were carried out following wet-ash digestion using colorimetry, spectrophotometry, and atomic absorption by Celentis Analytical.

Statistical analysis

Data from all experiments were analysed by analysis of variance (Genstat 5). Transformations were carried out where necessary but as the level or patterns of significance were similar, only the raw data are presented.

RESULTS

Media pH levels varied from 4.1 to 6.1 in Experiment 1 and from 4.4 to 6.5 in Experiment 2 (Table 2). Note that the Experiment 2 pH levels were averaged over the whole tuber growth period, whereas those of Experiment 1 were taken at flowering only.

Experiment 1: stem quality

The media pH levels produced only small differences in stem length, with a decline at the highest level (pH 6.1), although this was only significant at $P < 0.10$ level (Table 3). There were no differences in stem weight, flower number, or

Table 5 *Sandersonia aurantiaca* tuber numbers, weight, and storage rots at different media pH levels in Experiment 2. (SED = standard error of the differences; LSD = least significant difference; d.f. = degrees of freedom; NS = not significant.)

pH	Tuber numbers (/plot)	Tuber weight (g)	Storage rots (%)
4.4	13.5	11.6	14.3
4.8	12.3	9.1	9.0
4.8	13.5	11.9	12.5
5.5	14.8	11.0	17.8
6.1	16.5	11.4	3.5
6.5	10.0	8.6	6.2
Significance (d.f.=15)	$P < 0.01$	NS	NS
SED	1.45	-	-
LSD (5%)	3.10	-	-

Table 6 *Sandersonia aurantiaca* tuber macronutrient (% dry weight) and micronutrient (ppm) concentrations at different media pH levels in Experiment 2. (SED = standard error of the differences; LSD = least significant difference; d.f. = degrees of freedom; NS = not significant.)

pH	N (%)	P (%)	S (%)	Mg (%)	Ca (%)	Na (%)	K (%)	Mn (ppm)	Zn (ppm)	Cu (ppm)	Fe (ppm)	B (ppm)
4.4	3.16	0.45	0.17	0.10	0.08	0.12	1.40	23.5	27.0	6.5	40.5	6.8
4.8	2.97	0.46	0.15	0.11	0.08	0.11	1.63	15.5	23.0	4.5	32.0	5.8
4.8	2.53	0.41	0.13	0.12	0.06	0.12	1.56	11.5	15.8	2.8	30.0	5.3
5.5	2.44	0.40	0.13	0.13	0.06	0.12	1.48	9.5	15.3	3.3	33.7	4.8
6.1	2.30	0.31	0.14	0.14	0.06	0.12	1.46	7.0	12.5	3.0	30.3	6.5
6.5	2.16	0.33	0.13	0.14	0.07	0.11	1.48	7.5	11.8	2.5	39.2	6.3
Significance (d.f.=15)	$P < 0.05$	NS	NS	$P < 0.01$	$P < 0.05$	NS	NS	$P < 0.001$	$P < 0.001$	$P < 0.05$	NS	NS
SED	0.301	—	—	0.0076	0.0071	—	—	2.53	2.20	1.11	—	—
LSD (5%)	0.64	—	—	0.0163	0.0151	—	—	5.40	4.69	2.36	—	—

vase life. The number of stems harvested was significantly less ($P < 0.05$) at the highest pH level. The number of rejected flowers was significantly ($P < 0.001$) greater at the highest pH level, with all stems being rejected because of their short stems or physiological disorders, such as leaf tip browning and necrosis on the lower leaves, chlorotic, and distorted leaves. These disorders were also observed on a several stems at pH 5.3. Leaf nutrient concentrations of S, Mn, and Zn declined significantly ($P < 0.05$) with increasing pH level (Table 4). Concentrations of Mg increased with increasing pH level, Fe concentrations were least at pH 4.7–5.2, whereas Ca concentrations were significantly greater at pH 4.6–4.7.

Experiment 2: tuber production

The number of tubers lifted were lowest ($P < 0.01$) at pH 6.5 (10/plot) with the greatest tuber numbers (16.5/plot) at pH 6.1 (Table 5). There were no significant differences in lifted tuber weights between different media pH levels.

Tuber nutrient concentrations of N, Mn, Zn, and Cu declined significantly ($P < 0.05$) with increasing pH level (Table 6). The N concentration was greatest at the lowest pH level, but only compared to the highest pH levels (pH 6.1–6.5). The Ca concentration was greatest at the lowest pH level compared to media pH at levels 4 and 5 (pH 5.5–6.1). The Ca and N levels for the two pH 4.8 treatments produced variable differences, the average of which were not significantly different to the lowest pH level. The concentration of Mg increased with increasing pH level ($P < 0.01$).

Table 7 *Sandersonia aurantiaca* cut-flower production in Experiment 3 from tubers produced in different media pH levels in the previous season. (d.f. = degrees of freedom; NS = not significant.)

pH pre-history	Stem length (mm)	Stem weight (g)	Flower no. /stem
4.4	477	12.8	10.1
4.8	467	12.1	9.5
4.8	425	11.0	8.1
5.5	449	11.2	8.9
6.1	484	11.4	9.5
6.5	376	8.7	8.4
Significance (d.f.=15)	NS	NS	NS

Table 8 *Sandersonia aurantiaca* leaf macronutrient (% dry weight) and micronutrient (ppm) concentrations in Experiment 3 from tubers produced in different media pH levels in the previous season then grown at a common pH of 5.6. (SED = standard error of the differences; LSD = least significant difference; d.f. = degrees of freedom; NS = not significant.)

pH	N (%)	P (%)	S (%)	Mg (%)	Ca (%)	Na (%)	K (%)	Mn (ppm)	Zn (ppm)	Cu (ppm)	Fe (ppm)	B (ppm)
4.4	6.52	0.58	0.36	0.42	0.97	0.34	2.24	402	31.8	5.25	143	311
4.8	6.13	0.59	0.33	0.37	0.84	0.26	2.30	379	29.0	4.75	182	289
4.8	6.10	0.61	0.37	0.43	0.97	0.32	2.31	449	29.5	4.75	131	287
5.5	6.60	0.59	0.37	0.45	0.92	0.31	2.18	407	27.3	5.00	173	274
6.1	6.38	0.56	0.36	0.43	0.78	0.32	2.28	357	32.2	4.50	164	224
6.5	7.05	0.54	0.38	0.52	0.81	0.34	1.99	470	22.0	5.75	257	423
Significance (d.f.=15)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	$P < 0.01$	$P < 0.001$
SED	—	—	—	—	—	—	—	—	—	—	25.4	25.8
LSD (5%)	—	—	—	—	—	—	—	—	—	—	54.1	54.9

Experiment 3: tuber storage and cut-flower production

There were no significant differences between the different media pH levels in the number of tuber rots during storage (Table 5). The harvested stems showed no differences in stem length, stem weight, or flower number between pH levels (Table 7). Leaf nutrient concentrations showed no differences apart from Fe and B which increased significantly ($P < 0.05$) from pH level 6.1–6.5 (Table 8). No leaf disorders were observed.

DISCUSSION

Media pH affected both *sandersonia* cut-flower and tuber production but had little effect on subsequent forcing.

The target pH levels ranged from 4.5 to 7.0. Levels of pH 4.1–6.1 in Experiment 1 and 4.4–6.5 in Experiment 2 were achieved. The pH achieved is dependent on the media, for example the acidity of the peat used and the type and particle size of the liming agent used, and on environmental factors, such as temperature, the amount of irrigation, and the time period over which the liming agent has to dissolve (Bunt 1976). Experiment 1 was carried out in a glasshouse using freshly mixed media and controlled irrigation with the flowers being picked after 8 weeks. The pH levels are consequently lower than those of Experiment 2 which was conducted outdoors with similar media and regular irrigation but was also affected by rainfall and was carried out over a 20-week production period, with pH values being the average of samples taken at flowering and lifting.

In Experiment 1, the highest pH level of 6.1 all stems were commercially unacceptable. They were rejected either on stem length, as they were less than 300 mm, and/or because of physiological leaf disorders, such as leaf chlorosis and leaf tip necrosis. Leaf test results from the bulked samples of Experiment 1 and 2 showed that the Mg concentration doubled from 0.26 to 0.50% between pH of 4.3 and 6.1, whereas the Mn and Zn concentrations halved from 346 to 136 ppm and 39 to 21 ppm, respectively. There were small S, Ca, and Fe differences with changes in media pH.

Similar leaf chlorosis symptoms occurred at the highest pH level in Experiment 2. Tuber nutrient concentrations patterns were similar to the leaf nutrient concentrations of Experiment 1 and 2. For example, tuber concentrations of Mn and Zn

declined with increasing pH, as did N and Cu concentrations. Tuber Mg concentrations increased with increasing pH, and Ca levels were greater at the lowest pH. The increasing Mg concentration with increasing pH and declining Mn, Zn, and Cu concentrations are as expected for nutrient availability in peat (Mengel & Kirby 1982; Peterson 1982). The incidence of leaf chlorosis at the highest pH corresponds with reduced tuber numbers lifted. It is possible that the leaf chlorosis was an indication of poor plant vigour which resulted in a higher incidence of disease and tuber rots before lifting.

In Experiment 3, the tubers with different pH pre-histories and nutritional status produced no differences as cut flower. Mn concentrations which were very low in the tubers produced at high pH, resulted in leaf tests showing no significant differences in Mn concentrations. Leaf concentrations of Fe and B were greater if tubers were grown at the highest pH in the previous season. The reasons for these increased leaf concentrations are unclear as the original tuber Fe and B concentrations were similar for all pH levels. The leaf nutrient concentrations in Experiment 3 (pH 5.6) were generally higher than those in Experiments 1 and 2 for the same pH level. The media used in Experiment 3 was a commercial mix and it is probable it contained higher levels of added nutrients than those used in Experiments 1 and 2 for which only pH levels were tested.

The leaf chlorosis and necrosis symptoms that occurred at the highest pH in both Experiments 1 and 2 are typical symptoms of Mn deficiency, although the concentration of 136 ppm at pH 6.1 would not be considered low for most ornamental crops (Sutcliffe & Baker 1974; Dole & Wilkins 1999). Zn deficiency can result in a reduction in leaf expansion and stem elongation (Sutcliffe & Baker 1974; Dole & Wilkins 1999). In Experiment 1, stem length tended to decline at higher pH, but the Zn leaf concentration of 21 ppm at pH 6.1 is within the expected range for ornamental crops (Dole & Wilkins 1999). Low pH in soilless media can lead to B and Mn toxicity and poorer flower quality in some crops (Hendriks & Schappf 1986). However, leaf concentrations were not at levels considered toxic for most crops and no toxicity symptoms were observed in this study at pH as low as 4.1 suggesting that sandersonia can tolerate low pH. The concentration limits for deficiency and toxicity of most macroelements and microelements for sandersonia are still not defined, but these results suggest that the levels for sandersonia may be lower than in other crops.

Calcium levels were highest in the leaf tissues at the mid-range pH in Experiments 1 and 2 and in the tubers from the lowest pH in Experiment 2. The Ca concentrations were over a narrow range, 0.45–0.59% for leaf samples and 0.06–0.08 for tubers, and are within the expected range for sandersonia. Previous studies have shown Ca percentage concentrations of 0.49–1.12 for leaf and 0.04–0.28 for tubers in soilless media (Clark & Burge 1999b, 2000). Ca is generally less available in peat or soil at low pH and Ca deficiency can cause leaf edge burn (Bunt 1976; Boon et al. 1984; Dole & Wilkins 1999). Peterson (1982) showed a decline in Ca availability in soilless media from pH 6.5 but an increased availability at pH 5.0–5.5. Gypsum was used as the Ca source at the lower pH treatments whereas Ca was applied as dolomite in all other treatments. Ca may have been more available from the gypsum at the low pH.

The declining concentrations of N in the tuber with increasing pH is of interest as N is generally reported to increase in availability with increasing pH (Sutcliffe & Baker 1974; Cradock 1985). However, in the nutrient availability chart of Peterson (1982) N availability showed decline at pH 4.7 and 6.2 in soilless media, whereas in peat Bunt (1976) showed a small decline at higher pH levels, but only greater than 8.5 compared to highest pH of 6.5 recorded in this study. In the current study N availability was not dependent on release by soil micro-organisms but was supplied by slow-release fertilisers. Sandersonia grows naturally in marginal areas in South Africa, which are often of low pH, and appears to have adapted to growing under low available N conditions (Du Plessis et al. 1989). Studies by Clark (1997) and Clark & Burge (1999a,b) have shown that sandersonia growth is best under low to medium N levels, with 28 g N/m² the recommended rate. Although there were differences in tuber N concentrations with N declining from 3.16% at the lowest pH to 2.16% at the highest, there were no flower production differences from these tubers. Clark & Burge (1999b) showed that tuber N differences did not affect flower stem size, but that tuber size was the critical factor.

It is concluded that for sandersonia cut-flower production a media pH range of 4.4–5.3 is suitable, whereas for tuber production, pH levels of 4.4–6.1 give best results. As sandersonia production usually involves both growth phases a range pH of 4.4–5.3 would be suitable with a target pH of 5.0–5.3 recommended for growth in peat-pumice media.

This will ensure mid-range tuber and leaf nutrient concentrations and optimise subsequent production from tubers.

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