(Table 3). There were slight differences in shoot fresh weight and leaf area among treatments. Veierskov (6) showed that increased internode length of pea cuttings increased root number. The rates of shoot growth and budbreak on schefflera cuttings were significantly accelerated when 1.0-cm or longer internodes were left on the single-node cuttings (3). Because schefflera cuttings form roots all along the stem, long internodes on the cuttings offered a larger surface area for root formation. In golden pothos, increases in stored nutrients in the longer internodes might have triggered faster shoot growth. Poole et al. (4) recommended that pothos cuttings should be made about 2.5 to 5.0 cm in length, with most of the stem portion below the node.

Results from this study suggest that, in order to obtain uniform growth, vines of golden pothos stock plants should not be allowed to grow more than 14 to 15 leaves, allowing four to five nodes to be left on each stock plant. A 3-cm or longer internode section below the node and a fraction of the old aerial root should be retained on the cuttings for most rapid axillary shoot development.

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Influence of Photoperiod, Supplemental Light, and Growth Regulators on Growth and Flowering of *Pentas lanceolata*

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Additional index words. Galaxy flower, growth regulators, pinching

Abstract. **The influence of photoperiod, supplemental lighting, and pinching method on the growth and flowering time of *Pentas lanceolata* Benth. cultivated as a pot crop was determined. *Pentas* is a quantitative long-day plant (LDP). Plants given long days (LD) flowered 7 to 10 days earlier than those that received short days (SD). Light was supplemented during daylight hours only to distinguish from photoperiodic effect and 6 weeks of HID (640 ± 30 μmol·s^{-1}·m^{-2}) supplemental light also accelerated flowering. Height was retarded with chlormequat, but daminozide and ancymidol were ineffective. No growth regulator affected flowering time. Pinching delayed flowering time but increased the number of blooms per plant. Pinching to three nodes was more beneficial and resulted in faster flowering than pinching to one node. Chemical names used: 2-chloro-*N,N,N*-trimethylethanaminium (chlormequat); butanedioic acid mono (2,2-dimethylhydrazide (daminozide); α-cyclopropyl-α-(4-methoxyphenyl)-5-pyrimidinemethanol (ancymidol).**

Pentas is a member of Rubiaceae and consists of ≈30 species native to the tropical regions of South Africa and Madagascar (6). *P. lanceolata* is used as a cut flower crop in Europe, Japan, and California, and renewed interest in breeding has yielded new cultivars that have potential as potted crops. Little literature is available concerning flowering requirements of *Pentas*. However, Pappenhagen (7) found that flowers generally appear after five to seven nodes, and Kofranek and Kubota (3) found that flowering usually occurred on the fourth node. Although irradiance was not measured, yield and quality of cut flowers was greater in summer than in winter in Germany, but whether this was due to additional light, higher temperatures, or longer days was not discussed. Work in South Africa (8) showed chlormequat to be effective in retarding height, but no details concerning effectiveness of daminozide or concentrations of ancymidol were given.

In order to determine the potential of *Pentas* as a pot crop, the effects of photoperiod, light intensity, and methods of height control on the growth and flowering of several cultivars were investigated.

Table 1. The effect of photoperiod on flowering of rooted cuttings of *Pentas lanceolata*.

Cultivar	Days to flower after photoperiod treatment: LD	SD	Significance
Medium Pink	65	71	*
White Semi-Dwarf	60	67	*
Pink Red	62	73	*

*Significant between photoperiods using F test (5%).

Stock plants of several cultivars were grown in 25-cm pots under full light in glass greenhouses. Cuttings were obtained on 2 Feb from axillary shoots and rooted in 1 peat : 1 vermiculite (v/v) under intermittent mist.

Cuttings of 'Medium-Pink', 'White Semi-Dwarf', and 'Pink Red' rooted in ≈21 days and were transplanted on 23 Feb. to 10-cm pots containing 1 peat : 1 vermiculite (v/v) (Fafard Co., S.C.), and pinched to three nodes. One-half of the plants were subjected to a 16-hr photoperiod (LD), while the other half were given a 9 hr photoperiod (SD). Black cloth was drawn over all plants at 5:00 PM and removed at 8:00 AM. Those subjected to LD received 8 weeks of supplemental incandescent irradiance (15 ± 3 μmol·s^{-1}·m^{-2}) for an additional 7 hr. Plants were fertilized with 200 ppm N as 15N–9.9P–13.9K with each irrigation. Tap water only was applied every sixth irrigation to reduce soluble salt accumulation. Greenhouse day temperatures fluctuated with ambient outside

Table 2. The effect of supplemental light on flowering time of rooted cuttings of *Pentas lanceolata*.

Cultivar	Time to flower (transplant to anthesis), Supplemental lighting: Intensity (μmol·s^{-1}·m^{-2})	Duration weeks: 0	2	4	6	Dunnett's difference[z]
Medium-Pink	330	78	77	77	74	7
	640	78	76	70	64	9
White Semi- Dwarf	330	82	83	79	78	6
	640	82	81	76	72	8

[z]Difference between numbers and control within rows must be more than Dunnett's difference (5%, one tail) to be significantly different.

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Table 3. The effect of growth retardants on height and flowering time of *Pentas lanceolata* 'Dark Red'.

Chemical	Height (cm)	Flowering time (days)	Leaf surface area (cm^2)
Control	32.5	68	625.4
Ancymidol (200 ppm)	34.6	71	657.8
Chlormequat (1500 ppm, twice)	23.5*	67*	453.8*
Daminozide (3500 ppm)	31.7	67	600.7

*Significantly different from control using Dunnett's two-tailed test.

Fig. 1. The effect of growth regulators on height and flowering of *Pentas lanceolata*.

Table 4. The effect of pinching on height and flowering of *Pentas lanceolata*.

	Medium Pink		White Semi- Dwarf		Light- Red	
No. pinches	Time to flower (days)	Height (cm)	Time to flower (days)	Height (cm)	Time to flower (days)	Height (cm)
0	55 a[z]	38 a	50 a	29 a	57 a	34 a
1	74 b	32 b	59 b	21 b	69 b	29 ab
2	83 c	27 b	62 b	18 b	77 a	22 b

[z]Mean separation with column according to Duncan's multiple range test (5%).

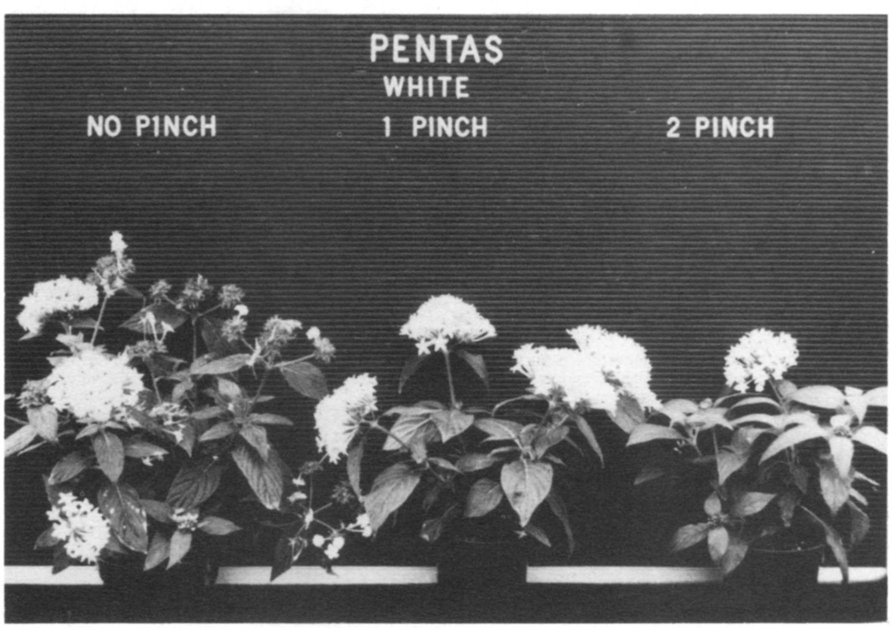

Fig. 2 The effect of number of pinches on height and flowering of *Pentas lanceolata*.

temperature, and night temperature during this experiment was not higher than 21° ± 3°C. Temperature under the black cloth was ≈1° to 2°C higher for plants subjected to LD when the incandescent lights were burning, compared with SD plants.

Eighty cuttings rooted in Jan. 1984 were transplanted and grown similarly to the previous experiment. After 2 weeks, plants were pinched and given an additional 330 $\mu mol \cdot s^{-1} \cdot m^{-2}$ (≈2.7 klux) or 640 ± 30 $\mu mol \cdot s^{-1} \cdot m^{-2}$ (≈5.4 klux) irradiance during daylight hours only from 400-W metal halide lamps, for 0 (control), 2, 4, or 6 weeks. Each treatment consisted of 10 single-plant replications. The time to anthesis of the first flower was recorded, and data were compared to control by Dunnett's test. No comparisons between cultivars were attempted for any of the studies in this work.

Ten seven-week-old plants were sprayed (≈10 ml/plant) with either 3000 ppm chlormequat using two applications of 1500 ppm, 7 days apart; 3500 ppm daminozide; or 200 ppm ancymidol. Plants were grown in the greenhouse under conditions similar to those previously stated. The height of the plant, flowering time, and leaf surface area were recorded at time of anthesis. Data were compared with control using Dunnett's two-tailed test.

Seventy cuttings were rooted, potted in 10-cm pots, and grown similarly to the first experiment. Two pinching experiments were performed. In the first experiment, 10 plants were either not pinched or pinched one or two times by removing ≈2 to 3 cm of terminal growth from each shoot and allowing two to three nodes to remain below the pinch. The initial pinch was done 17 days after transplanting. In the second part of the pinching experiment, 20 plants were pinched leaving three nodes, whereas only one node remained on the remaining 20. The time of flowering and height were recorded in both experiments and Duncan's multiple range test was used to determine differences between treatments.

Kofranek and Kubota (personal communication) stated that *Pentas* was self-inductive. My data support that statement, as all plants flowered regardless of photoperiod. However, all cultivars tested flowered significantly faster under LD than SD (Table 1), indicating that *Pentas lanceolata* may be a quantitative LDP. It is doubtful that the additional light intensity or rise in temperature (1° to 2°C) under the cloth was responsible for accelerated flowering.

Although flowering was accelerated under many light regimes, only 6 weeks at the highest light intensity resulted in significantly faster flowering (Table 2). These data indicate that supplemental lighting may be an important factor for pot production, because significant results occurred with only daylight lighting. Much research (1, 2, 4, 5) with supplemental irradiation is based on 16- to 18-hr lighting and has often been done in areas of greater winter cloud cover than experienced in Athens, Ga. The results also show the significance of supplemental lighting without the questionable effects of dif-

Table 5. The effect of number of nodes remaining after pinch on height and days to flower of *Pentas lanceolata.*

	Nodes remaining					
	Time to flower			Height		
Cultivar	1	3	Significance	1	3	Significance
Medium pink	64	57	*	29	35	*
White Semi-Dwarf	66	52	*	24	30	*
Dark Red	65	52	*	31	37	*
Light Pink Semi-Dwarf	65	51	*	25	32	*

*Significant difference within rows using F test (5%).

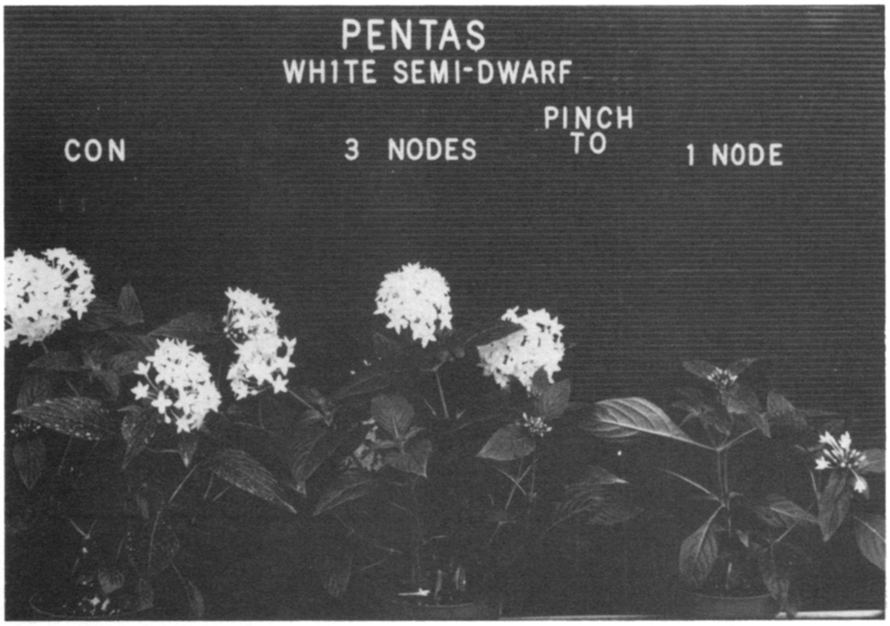

Fig. 3. The effect of pinching to one or three nodes on height and flowering of *Pentas lanceolata.*

ferent photoperiods inherent in literature concerning plant response to supplemental light.

Only chlormequat was effective in reducing height (Table 3; Fig. 1) and leaf surface area of *Pentas*. There were no differences in flowering time due to any of the treatments, which verifies data of Pearce (8) and Kofranek and Kubota (personal communication) using other cultivars of *Pentas.* Perhaps increased concentrations and/or multiple applications would render ancymidol and daminozide effective, but, at the concentrations applied, no height control resulted.

Both the number of pinches and the nodes remaining after pinching (Table 5) affected height and flowering time of *Pentas.* A single pinch delayed flowering by ≈1 week, whereas a second pinch delayed flowering even further (Fig. 2). Height was reduced and breaks were increased as the number of pinches was increased (Table 4). A single pinch was adequate for production in 10-cm pots. Allowing only one node to remain resulted in significant height reduction (Fig. 3) compared with three nodes; however, flowering was delayed (Table 5).

In summary, *Pentas lanceolata* may have potential as a pot crop. It demonstrates characteristics of a quantitative LDP, and flowering can be accelerated with 6 weeks of supplemental light under conditions tested. Daminozide and pinching may be used to control height and, although flowering is delayed with pinching, it is not affected with daminozide application.

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Tree Root Spread in Relation to Branch Dripline and Harvestable Root Ball

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Abstract. **Ninety-one percent to 95% of field-grown 3-year-old root systems of *Gleditsia triacanthos* L., *Populus × generosa* A. Henry, and *Fraxinus pennsylvanica* Marsh were outside of the harvestable root ball. Seventy-seven percent of the *Populus* root system was growing beyond the branch dripline, whereas 59% and 54% were outside of the *Gleditsia* and *Fraxinus* driplines, respectively. Root spread to branch spread ratios are discussed.**

Tree roots spread horizontally beyond the dripline of the branches (2, 3, 5, 7). Watson (6) presented a model of nursery-grown trees where roots appeared to extend to three times the dripline. Gilman (3) indicated that *Gleditsia triacanthos* roots on plants in the ground for 3 years spread about three times as far as the branches. Two studies showed that a small portion (2% to 5%) of the root system of unroot-pruned, field-grown nursery trees was harvested during transplanting operations (6,7). One study compared and quantified the amount of roots growing outside of the dripline with the portion growing within the dripline (7). In this study, entire root

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