Table 1. The influence of light intensity (PPF) and medium temperature on root formation and subsequent growth of *Codiaeum variegatum* 'Gold Dust' cuttings.

				40 days after transplanting			
PPF ($\mu mol \cdot s^{-1} \cdot m^{-2}$)	Medium temp (°C)	No. roots	Root length (cm)	No. new leaves[z]	Leaf length[y] (cm)	No. lateral shoots	Stem growth (cm)
290	28	17.0	6.5	6.1	16.0	8.0	6.2
	10–16	17.6	2.0	4.4	12.4	7.8	3.7
90	28	15.8	4.4	5.0	13.0	6.2	4.0
	10–16	16.8	0.9	4.0	10.4	4.9	2.5
LSD (0.05)		NS	0.5	0.5	1.5	1.2	0.9

[z]Longer than 2 cm.
[y]The longest new leaf.
[NS]Not significant.

Table 2. The influence of light intensity (PPF) and medium temperature on root formation and subsequent shoot growth of *Ficus benjamina* cuttings.

				70 days after transplanting	
PPF ($\mu mol \cdot s^{-1} \cdot m^{-2}$)	Medium temp (°C)	Root ball diam (cm)	Root length (cm)	Width[z] (cm)	Height (cm)
290	28	7.4	7.9	60.9	61.9
	10–16	3.4	4.8	59.0	57.9
90	28	7.4	7.4	57.5	57.8
	10–16	1.9	2.9	58.0	62.3
LSD (0.05)		1.1	1.3	NS	NS

[z]The average of two measurements made at perpendicular angles.

Although the thermostat controlling the forced-air heaters was located at bench level, temperature of unheated rooting medium was always <16°C, due to the discharge of cold water from the misting system. Root initiation and subsequent elongation were both restricted at lower temperatures. In addition to promoting root growth, heated medium also promotes the use of photosynthates from the foliage and the production of dry matter (11).

Whether improved root growth on cuttings increases shoot growth is dependent on plant species, as well as on the environmental factors under which cuttings were rooted. Researchers studying factors affecting rooting need to direct their attention to subsequent shoot growth after transplanting of rooted cuttings.

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Effect of Nodal Position, Cutting Length, and Root Retention on the Propagation of Golden Pothos

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Abstract. **Growth was reduced from leaf-bud golden pothos [*Epipremnum aureum* (Linden & Audre) Bunt.] cuttings taken from an apical node with the most recent, fully expanded leaf. Days to first leaf unfolding increased as cuttings were taken more basipetally from the second apical node to node 14. Accelerated growth of the axillary shoot and increases in leaf number, stems length, leaf area, and shoot fresh weight were associated with cuttings from the apical nodes. Shoot growth was accelerated when cuttings had a 3-cm or longer internode below the nodes. Retaining a 6 to 8-mm section of the old aerial root on cuttings promoted axillary shoot growth.**

Golden pothos is among the most important foliage plants produced commercially. Growers cut the long vines into single node, leaf-bud cuttings for propagation. Nonuniform growth of axillary shoots has been observed among cuttings of golden pothos. Basal cuttings in *Schefflera arboricola* and *Hedera helix* develop longer shoots and more roots than apical cuttings (3, 5). Nodal position also may affect shoot growth after rooting in golden pothos.

The length of the internode below the node in golden pothos varies from one cutting to another, depending on the propagator. As

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Table 1. Effect of cutting position on new shoot growth in golden pothos.

Nodal no.	Days to first leaf unfolding	No. leaves	Stem length (cm)	Top fresh wt (g)	Total leaf area (cm^2)
1	41.7	2.2	3.3	4.3	69.1
2	31.9	3.3	6.6	6.1	96.2
3	33.6	3.0	5.8	5.3	93.9
4	31.2	3.1	6.9	6.0	92.8
5	35.0	3.2	7.3	6.4	100.2
6	34.3	3.2	6.1	6.2	98.3
7	35.2	2.8	5.2	5.3	83.5
8	36.4	2.8	4.2	4.9	81.2
9	37.8	2.8	4.3	4.9	77.2
10	39.1	2.5	3.8	4.5	70.3
11	39.7	2.6	3.6	4.6	76.5
12	40.1	2.7	3.9	4.6	74.5
13	39.1	2.6	3.6	4.6	77.7
14	38.1	2.5	3.5	4.4	70.1
$LSD_{0.05}$	5.6	0.4	1.6	1.1	16.1

Schefflera arboricola cutting stem length increased from 0.5 to 3.0 cm, percentages of rooting and budbreak, root number, and plant height all increased (3). Similar results were observed in *Hedera helix* (5), *Pisum sativum* (6), and *Acer rubrum* (2), where root number is dependent on the length of internode remaining on the cuttings or on the size of cuttings. Golden pothos generally produces one, occasionally two, large aerial roots immediately below a node. Complete removal of these aerial roots facilitates planting; however, retaining a small fraction of these roots may promote rapid establishment of a functional root system and result in improved plant growth.

The objectives of this study were to determine the effect of nodal position, cutting stem length, and partial retention of nodal roots on the growth of golden pothos from single-node leaf-bud cuttings.

Expt. 1. Long vines of golden pothos with 14 fully expanded leaves were taken from 25-cm hanging baskets grown under a maximum photon flux (PPF, 400–700 nm) of 650 $\mu mol \cdot s^{-1} \cdot m^{-2}$. Cuttings were made and grouped according to their position on the vines, from the most recent fully expanded leaf (node 1) to the basal (node 14). Cuttings had 1-cm internode above the node and 4 cm below it. Cuttings were placed singly in 7-cm square plastic pots filled with Sunshine Mix No. 1 (Fisons Western, Vancouver, B.C., Canada) and maintained in a mist propagation bed for 2 weeks with 145 $\mu mol \cdot s^{-1} \cdot m^{-2}$ maximum PPF. The mist interval was 10 sec every 10 min from dawn to dusk. Potted cuttings then were moved to a shadehouse providing a maximum PPF of 415 $\mu mol \cdot s^{-1} \cdot m^{-2}$. Plants were irrigated as necessary and fertilized once a week with water containing 0.84 $g \cdot liter^{-1}$ 24N–3.4P–13.4K water-soluble fertilizer (24N–8P–16K foliage fertilizer, W.R. Grace & Co.). Air temperatures ranged between 18° to 36°C. Individual cuttings were labeled with the date on which the first leaf unfolded. Plants were harvested 80 days after planting. Data collected included number of leaves, stem length, top fresh weight, and total leaf area.

Expt. 2. Pothos cuttings from the same source, each with a single major aerial root, were planted either with all aerial roots completely removed or with 6 to 8 mm of the root remaining. Length of internode remaining on cuttings followed those in Expt. 1. Plants were grown in a shadehouse providing a maximum PPF at 650 $\mu mol \cdot s^{-1} \cdot m^{-2}$. The other cultural practices were similar to those in Expt. 1. Air temperatures ranged between 24° and 40°C. Variables recorded were: days to first leaf unfolding, stem length, and shoot fresh weight 55 days after planting.

Table 2. Effect of root retention on shoot development from golden pothos cuttings.

Treatment	Days to first leaf unfolding	No. leaves	Stem length (cm)	Shoot fresh wt (g)
With root	21.6*	4.5*	11.9*	8.3*
Without root	24.3	3.5	7.0	5.4

*Significantly different at the 5% level, F test.

Expt. 3. Cuttings were obtained from stock plants that received 440 $\mu mol \cdot s^{-1} \cdot m^{-2}$ maximum PPF, growing in 15-cm pots on benches. Only cuttings from the second to the eighth apical node were used. Internodes were cut to 1, 2, 3, 4, or 5 cm below the node. There was 0.5 cm of stem above the node on all cuttings. Plants received the same cultural practices as in Expt. 1. The number of leaves, stem length, shoot fresh weight, and total leaf area were determined 70 days after planting.

All three experiments had five cuttings per treatment replicated five times in a randomized complete block design.

Table 3. Effect of pothos cutting length on shoot growth.

Internode length below the node (cm)	No. leaves	Stem length (cm)	Shoot fresh wt (g)	Leaf area (cm^2)
1	4.1	14.6	10.6	170.1
2	3.9	12.8	9.7	157.9
3	4.6	18.8	11.3	174.8
4	4.7	18.3	11.4	181.2
5	4.6	18.2	11.0	171.9
$LSD_{0.05}$	0.4	3.1	1.3	19.0

Cuttings from the node with the first fully expanded leaf node did not perform as several modes below it, but were equivalent to cuttings from 10 and higher-order nodes (Table 1). Hansen (3) found that single-node *Schefflera arboricola* cuttings from the uppermost fully expanded leaf performed poorly. Such cuttings required a longer time to break lateral buds, had lower rooting percentages and fewer roots, and did not grow as fast as cuttings from lower nodes. This difference may be related to the maturity of the tissues in the relatively young leaf and internode or to the distance between the cutting and root system. When the first node is not considered, the time required to produce the first leaf increased as cuttings were obtained from successively more basipetal nodes. Nodal position has been determined to affect the rate and percent of budbreak in another plant species (3).

All cuttings used in this experiment developed axillary shoots, probably due to initial selection of good propagation material. Leaf number and shoot length decreased with increasing age of the cuttings. Length of the axillary shoots on cuttings from nodes 4 and 5 were almost twice as long as those from nodes 10 through 14 (Table 1). In contrast, cutting position had no effect on shoot growth of *Hedera canarinesis* cuttings (1). Top fresh weight and leaf area generally increased in plants from nodes 2 through 6 (Table 1). The accelerated growth rate of apical cuttings was likely related to increased rate of leaf emergence, which allowed more time for shoot development. Thus, using young cuttings may reduce the production time, since leaf number and shoot length have a determining effect on plant quality and salability.

Effect of root retention and cutting length on growth. Root retention had a dramatic effect on axillary shoot growth. Cuttings with pre-formed roots required less time to unfold the first leaves and had more leaves and longer shoots than those without roots (Table 2). Golden pothos cuttings do not form new roots on the internodes or at the base of the internodes. Instead, roots are formed at the cut end of the old roots, if the roots are partially retained, and on nodes of the new shoots. Thus, cuttings without aerial roots had slower initial growth than those with aerial roots until new roots formed on the nodes of the axillary shoots, whereas cuttings with a small fraction of the old aerial root retained quickly developed functional root systems, promoting rapid growth of the new shoots.

The most obvious effect of internode length of cuttings on plant growth was on leaf number and stem length. Cuttings with a 3-cm or longer internode below the node produced leaves faster and had longer axillary shoots (22% or more) than those with shorter stems

(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.

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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*.

	Time to flower (transplant to anthesis)					
	Supplemental lighting					
	Intensity	Duration weeks				Dunnett's
Cultivar	(μmol·s^{-1}·m^{-2})	0	2	4	6	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.