Growth Substance, Light, Fertilizer, and Misting Regulate Propagation and Growth of Golden Pothos

Yin-Tung Wang¹

Texas A&M University Agricultural Research and Extension Center,
2415 East Highway 83, Weslaco, TX 78596

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Abstract. Foliar application of 500 or 1000 mg BA or PBA/liter to stock plants of golden pothos [*Epipremnum aureum* (Linden & Andre) Bunt.] induced axillary bud elongation but did not promote growth of cuttings taken from these stock plants. Cuttings from plants treated with BA + GA₄₊₇, each at 1000 mg·liter⁻¹, died. Plants grown under 1000 μmol·s⁻¹·m⁻² had more but smaller leaves than those under 420 μmol·s⁻¹·m⁻². Cuttings produced under the higher light level grew more rapidly. Leaf area increased while stem length decreased as Osmocote slow-release fertilizer (18N-2.6P-10K) increased from 4 to 16 kg·m⁻³. A 24N-3.5P-13.3K water-soluble fertilizer applied at the rate of 0.42 g/500 ml weekly produced the best plants and resulted in the best cutting growth. Cuttings taken from stock plants receiving Osmocote at 4 kg·m⁻³ grew slower than those produced at other rates. Placement of cuttings in a mist-propagation bed for 1 or more weeks resulted in an accelerated growth rate relative to nonmisted cuttings. Chemical names used: N-(phenylmethyl)-1H-purin-6-amine (BA); N-(phenylmethyl)-9-(tetrahydro-2H-pyran-2-yl)-9H-purin-6-amine (PBA); (1α,2β,4α,10β) 2,4a,7-trihydroxy-1-methyl-8-methylenegibb-3-ene-1,10-dicarboxylic acid 1,4a-lactone (GA₄₊₇).

Most tropical foliage plants are produced in soilless media under reduced light intensities. A carefully controlled fertilization program ensures good plant growth. Good quality *Syngonium podophyllum* plants were produced in a greenhouse with 5 to 19.5 g of Osmocote slow-release fertilizer per 15-cm pot, with reductions in plant growth at higher rates (Chase and Poole, 1987). These authors also observed that plants had lower quality when produced under 200 than under 700 μmol·s⁻¹·m⁻² photosynthetic photon flux (PPF). *Nephrolepis exaltata* 'Compacta' produced the greatest dry weight with a liquid fertilizer (20N-0.8P-16.6K) at a rate of 0.75 g·liter⁻¹ or with 9.5 kg·m⁻³ Osmocote (19N-2.5P-8.3K) (Gilliam et al., 1983). High quality peperomia was produced with 2.5 g Osmocote per 10-cm pot (19N-3P-10K) (Chase and Poole, 1984).

Environmental conditions under which stock plants are grown affect the growth of cuttings taken from these plants. Proper lighting enhanced the yields and subsequent

growth of cuttings (Anderson and Carpenter, 1974; Bertram et al., 1989; Vetanovetz and Peterson, 1985). Increasing shade level from 0% to 60% decreased the number and weight of cuttings produced by several *Codiaeum variegatum* cultivars, but cutting yields increased with higher fertilizer levels (Conover and Poole, 1983). However, there was no difference in the growth of *Syngonium podophyllum* 'White Butterfly' cuttings produced under 650 or 1200 μmol·s⁻¹·m⁻² (Wang and Boogher, 1987).

Epipremnum aureum (pothos) is economically the most important foliage species being produced in Florida (Florida Dept. of Agr.,

1989) and possibly the other major states that produce foliage plants. Although general production guidelines are available (Poole et al., 1984, 1985) and several studies have been conducted (Poole and Conover, 1988; Wang, 1987; Wang and Boogher, 1988) to optimize production, more specific information on cultural practices is needed for the most efficient production of this species. Treating cuttings of golden pothos with BA did not promote cutting growth (Wang, 1987); however, it remained unknown whether treating stock plants with growth regulators would promote cutting growth. The objective of this study was to determine the growth and propagation of golden pothos in response to applications of growth regulators and fertilizers, light levels, and misting.

Hormonal effect on cutting growth (Expt. 1). Golden pothos in 4-liter hanging baskets were grown under 73% light-exclusion fabric. BA or PBA each at 500 or 1000 mg·liter⁻¹, the combination of BA and GA₄₊₇, each at 1000 mg·liter⁻¹ (Promolin formulation, Abbott Laboratories, North Chicago, Ill.) or water (control), all with Tween 20 at the rate of 1 ml·liter⁻¹, was sprayed on the foliage of two baskets per treatment. After 3 weeks, lengths of the axillary buds between the second and sixth nodes were recorded on six vigorous shoots from each treatment. Preparation of cuttings followed recommendations in previously published reports (Wang, 1987; Wang and Boogher, 1988). Single-node leaf-bud cuttings (used in this and all subsequent experiments) were taken from these nodes, planted one per 0.5-liter pot filled with a peat-lite potting mix (Sunshine No. 1, Fisons Western, Vancouver, B.C.), and placed in a mist propagation bed. Misting time was 5 sec every 5 min during the daylight hours. Date on which the first leaf of each cutting unrolled was recorded. Cuttings were removed from the mist bed after 3 weeks, placed on a greenhouse bench with 340 μmol·s⁻¹·m⁻² maximum

Table 1. Effect of foliar application of growth regulators to stock plants of *Epipremnum aureum* on the length of the axillary buds and on cutting growth during 12 weeks (Expt. 1).

Treatment (mg·liter ⁻¹)	Axillary bud length (cm)	Cutting growth				
		First leaf unfolding (days)	Stem length (cm)	Leaf no.	Leaf area (cm ²)	Shoot fresh wt (g)
Control	0.4	26.3	15.7	4.8	142	9.2
BA 500	1.4	25.8	8.4	3.8	111	8.4
1000	1.6	24.8	7.4	3.8	113	7.4
PBA 500	1.4	19.5	15.9	5.2	151	9.6
1000	1.7	21.3	11.2	4.2	136	8.3
BA + GA ₄₊₇ 1000	3.1	---	---	---	---	---
LSD _{0.05}	0.4	3.4	2.8	0.6	22	1.5

²Dashed line = all plants dead.

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¹Associate Professor.

Table 2. Effect of light level and fertilizer rate and type on the growth of *Epipremnum aureum* during 4 months (Expt. 2).^z

Treatment	Leaf no.	Leaf area ^y (cm ²)	Stem length (cm)	Shoot fresh wt (g)
Light ($\mu\text{mol}\cdot\text{s}^{-1}\cdot\text{m}^{-2}$)				
420	13.7	63.0	74.9	49.7
1000	14.7	54.7	77.1	47.6
Significance ^x	**	**	NS	NS
Fertilizer				
Osmocote ($\text{kg}\cdot\text{m}^{-3}$)				
4	14.1	51.3	78.8	44.5
8	14.1	59.4	75.9	48.6
12	14.1	59.5	73.0	48.4
16	13.9	61.4	68.2	47.3
Significance	NS	L**Q*	L*	NS
Soluble fertilizer (SF, $\text{kg}\cdot\text{m}^{-3}$) ^w				
2.8	14.9	62.5	83.9	54.6
SF vs. Osmocote ^v	**	**	**	**

^zNo significant interaction between light level and fertilizer rate.

^yThe uppermost, fully expanded leaf.

^x** and *, significant at $\alpha = 0.01$ and 0.05 , respectively. NS = nonsignificant. L and Q = linear and quadratic response, respectively.

^wTotal 24N-3.5P-13.3K fertilizer applied during a 10-week period.

^vSignificance determined by single-degree-of-freedom contrast.

Table 3. Growth of *Epipremnum aureum* cuttings during 87 days as a function of light level and fertilizer rate and type applied 10 stock plants (Expt. 2).^z

Previous treatment on stock plants	Cutting growth			Shoot fresh wt (g)
	Leaf no.	Total leaf area (cm ²)	Stem length (cm)	
Light ($\mu\text{mol}\cdot\text{s}^{-1}\cdot\text{m}^{-2}$)				
420	4.4	162	9.5	10.0
1000	6.2	217	14.5	12.9
Significance ^y	**	**	**	**
Fertilizer				
Osmocote ($\text{kg}\cdot\text{m}^{-3}$)				
4	4.7	150	9.2	8.6
8	5.8	211	13.6	12.4
12	5.1	186	11.9	11.3
16	5.1	198	11.6	12.3
Significance	Q*	L*Q*	Q*	L**Q*
Soluble fertilizer (SF, $\text{kg}\cdot\text{m}^{-3}$) ^x				
2.84	5.8	203	13.7	12.5
SF vs. Osmocote ^w	**	NS	*	NS

^zNo significant interaction between light level and fertilizer rate.

^y** and *, significant at $\alpha = 0.01$ and 0.05 , respectively. NS = nonsignificant. L and Q = linear and quadratic response, respectively.

^xTotal 24N-3.5P-13.3K fertilizer applied during production of stock plants.

^wSignificance determined by single-degree-of-freedom contrast.

PPF, and fertilized weekly with 24N-3SP-13.3K water-soluble fertilizer (W.R. Grace, Foglesville, Pa.) at $0.84 \text{ g}\cdot\text{liter}^{-1}$. Plants were evaluated for leaf number, total leaf area, stem length, and fresh weight after an additional 9 weeks of growth. There were five pots each with a single plant as an experimental unit and treatments were replicated six times in a randomized complete-block (RCB) design. The least significant difference was used to compare any treatment effect with the control.

Axillary bud length increased after applications of BA, PBA, or the combination of BA and GA₄₊₇, on stock plants, with the latter most effective (Table 1). Spraying the mixture of BA and GA₄₊₇, on stock plants resulted in the complete loss of cuttings during propagation. PBA at both concentrations

reduced the time required to unfold the first leaf, while BA had no effect. BA at 500 and 1000 mg-liter⁻¹ and PBA at 1000 mg-liter⁻¹ suppressed stem elongation and reduced leaf production rate. Some cytokinins inhibited the oxidation of *ent*-kaurene to kaurene (one step in the biosynthesis of GA), thereby inhibiting stem elongation (Coolbaugh, 1984). The suppressed stem elongation following the application of BA was also observed in *Syngonium podophyllum* (Wang and Boogher, 1987).

The successive leaves produced by the remaining shoots on the stock plants treated with BA + GA₄₊₇ became narrower and soon terminal inflorescences started to develop. As the axillary shoots grew, a result of the loss of apical dominance, terminal inflorescences were formed after several small, nar-

row leaves were produced. GA has been reported to induce flowering in several aroid species (Harbaugh and Wilfret, 1979; Henny, 1980). Cuttings receiving BA and GA₄₊₇ may have died due to inflorescence development or hormonal imbalance and a lack of roots. *Syngonium podophyllum* plants derived from cuttings treated with PBA before planting had weak root systems (Wang and Boogher, 1987) and cuttings treated with GA died (Y.T.W., unpublished data).

Light and fertilizer effect on stock plant and cutting growth (Expt. 2). Cuttings were taken from stock plants cultured as above and planted three in a 1.5-liter pot. The potting mix consisted of 2 peat moss : 2 bark : 1 perlite (by volume). After being held in a mist propagation bed for 3 weeks, half of the plants were placed in a greenhouse with $420 \mu\text{mol}\cdot\text{s}^{-1}\cdot\text{m}^{-2}$ maximum PPF and the others in one with $1000 \mu\text{mol}\cdot\text{s}^{-1}\cdot\text{m}^{-2}$ PPF. Treatments included applying 18N-2.6P-10K Osmocote fertilizer at 6, 12, 18, or 24 g per pot (equivalent to medium at 4, 8, 12, or 16 kg-m⁻³) on the medium surface 6 weeks after removal from the mist bed. Plants in another treatment were fertilized weekly with 500 ml of water containing 0.42 g 24N-3.5P-13.3K soluble fertilizer during the experiment (a total amount of $2.8 \text{ kg}\cdot\text{m}^{-3}$). Plants were irrigated two or three times each week when the medium surface became dry. Plants were evaluated 4 months after planting for number of leaves per stem, stem length, area of the uppermost, fully expanded leaf, and shoot fresh weight. Fertilizer rates (considered as the subplot) within each light level (main plot) were arranged in a RCB design with 10 replications.

Cuttings from plants receiving all the previous treatments were planted four per 1.5 liter pot, placed in a mist bed for 3 weeks, and later moved to a greenhouse receiving $420 \mu\text{mol}\cdot\text{s}^{-1}\cdot\text{m}^{-2}$ maximum PPF. All plants were given water-soluble 24N-3.5P-13.3K fertilizer weekly as previously described. Data were collected on leaf number, total leaf area, stem length, and shoot fresh weight 87 days after planting. Plants were arranged in a split-plot design using a single pot as an experimental unit, with the previous light level as the main plot and the fertilizer treatment as the subplot, replicated 10 times. Linear and quadratic regression analyses were used for determining the effect of Osmocote rate on plant growth. The difference between the water-soluble fertilizer and Osmocote was determined by single-degree-of-freedom contrast.

Increasing the light intensity from 420 to $1000 \mu\text{mol}\cdot\text{s}^{-1}\cdot\text{m}^{-2}$ increased leaf production but decreased individual leaf size (Table 2). Stem length and shoot fresh weight were unaffected. *Syngonium podophyllum* grown under $200 \mu\text{mol}\cdot\text{s}^{-1}\cdot\text{m}^{-2}$ had 32% fewer leaves and 27% less weight than those produced under $700 \mu\text{mol}\cdot\text{s}^{-1}\cdot\text{m}^{-2}$ (Chase and Poole, 1987). In this current study, the low light intensity of $420 \mu\text{mol}\cdot\text{s}^{-1}\cdot\text{m}^{-2}$ might have provided adequate energy for satisfactory growth. Osmocote rate had no effect on leaf number or shoot fresh weight. A weekly

Table 4. Effect of misting time on the growth of axillary shoots of *Epipremnum aureum* cuttings during 14 weeks (Expt. 3).

Weeks in mist bed	First leaf unfolding (days)	Leaf no.	Total leaf area (cm ²)	Shoot length (cm)	Fresh wt (g)
0	28.8	5.1	235	12.1	12.1
1	21.7	7.2	295	22.2	18.9
2	20.2	7.5	314	25.5	20.2
3	19.3	8.4	299	30.4	20.3
4	20.3	8.8	305	35.3	20.6
5	20.6	8.5	286	33.3	19.5
Significance ^a	L**Q**	L**Q**	L**Q**	L**Q**	L**Q**

^aL and Q = linear and quadratic response, respectively.

**Significant at $\alpha = 0.01$.

application of the water-soluble fertilizer at 0.42 g/pot gave results as good as or better than Osmocote. Osmocote at the rate of 4 kg·m⁻³ resulted in smaller leaves than did higher levels. Stem length decreased as rate of Osmocote increased. Water-soluble fertilizer produced longer stems and greater fresh weights than any rate of Osmocote.

Cuttings from golden pothos produced under 420 $\mu\text{mol}\cdot\text{s}^{-1}\cdot\text{m}^{-2}$ grew more slowly than cuttings from plants produced under 1000 $\mu\text{mol}\cdot\text{s}^{-1}\cdot\text{m}^{-2}$ (Table 3). Osmocote at the rate of 8 kg·m⁻³ and the water-soluble fertilizer produced plants with the greatest number of leaves and the longest stems. Total leaf area and shoot fresh weight were mostly unaffected by fertilization except they were smaller at the Osmocote rate of 4 kg·m⁻³.

Getting growth in response to misting (Expt. 3). Cuttings of golden pothos were taken from the apical second to seventh nodes of stock plants, grown under 420 $\mu\text{mol}\cdot\text{s}^{-1}\cdot\text{m}^{-2}$ maximum PPF, and fertilized weekly as described above. Cuttings were planted, one per 0.5-liter pot, in Sunshine Mix No. 1. The cuttings, except the controls, which were placed directly on a greenhouse bench after planting, were placed in a mist propagation bed with a mist interval of 5 sec every 5 min. One-fifth of the cuttings were removed after 1, 2, 3, 4, and 5 weeks and placed on the bench noted above. All plants on the greenhouse bench received water-soluble fertilizer weekly as already described. Date of first leaf unfolding was recorded for each plant. Leaf number, total leaf area, stem length, and fresh weight of the shoot were recorded 14 weeks after

planting. Treatments, both in the mist bed and on the greenhouse bench, were arranged in a RCB design. Each treatment had five pots, each with a single plant, as an experimental unit replicated six times. Data were subjected to regression analysis.

Misting cuttings for at least 1 week shortened the time required to produce the first leaves (Table 4), but longer periods had little additional effect. Leaf number and shoot length increased as misting time increased. Previous findings demonstrate accelerated root development resulted in faster shoot growth (Wang and Boogher, 1988). Misting pathos cuttings might have facilitated the rapid development of roots and reduced the internal water stress, resulting in enhanced growth rates. Total leaf area and shoot fresh weight did not become greater for cuttings misted 3 weeks or longer.

Results from these experiments and another study (Wang, 1987) suggest cytokinin or GA application to stock plants or cuttings does not benefit axillary shoot growth on cuttings of golden pathos. Although 420 $\mu\text{mol}\cdot\text{s}^{-1}\cdot\text{m}^{-2}$ PPF appeared to be adequate for finished plant production, stock plants require higher light levels for optimum cutting production and subsequent growth. The use of a water-soluble fertilizer may lower production cost and result in less environmental contamination due to the reduced amount of fertilizer in the run-off water when compared to the amount of Osmocote required to produce comparable growth.

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