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ROOTING, PLANT GROWTH, AND QUALITY OF *EPIPREMNUM AUREUM* AS AFFECTED BY CUTTING TYPE AND THICKNESS

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ABSTRACT: Two experiments were conducted during 2001 and 2002 seasons to study the effect of cutting thickness (< 5, 5 to 10, or >10 mm thickness referred as: thin, intermediate or thick cuttings), leaf existence on cutting (leafy or leafless cuttings) and their interactions as well as number of remained leaves/ cutting (one-leaf one-node, two-leaf two-node, or three-leaf three-node cuttings as well as three-leaf three-node cuttings containing the terminal bud) on rooting, growth and quality of pothos plant.

Using thick cuttings for pothos propagation significantly reduced percentage of rooted cuttings, but significantly enhanced all studied vegetative growth characters and root fresh and dry weights besides total dry weight (shoot + root)/ pot comparing to thin or intermediate cuttings. Produced pots had the same quality (fair quality, salable pots) and did not significantly differ when intermediate or thick cuttings were used.

Leaf existence on cutting had enhancing effect on all the studied rooting and growth parameters as well as chemical constituents comparing to leafless cuttings. Synergistic promoting effect was noticed on rooting, growth and quality of produced plants when thick or intermediate cuttings were leafy cuttings comparing to thin leafy or leafless cuttings or intermediate or thick leafless cuttings. Pots quality did not significantly differ in cases of using intermediate or thick one-leaf one-node cuttings. Sub terminal cuttings (one-, two-, or three-leaf node cuttings) enhanced plant growth and quality comparing to using the terminal ones.

Generally , two-leaf two-node cutting had the superior effect in enhancing vine length, average leaf area and leaf area/ plant and shoot and root fresh and dry weights and total dry weight/ plant as well as plant grade. Correlations coefficients exhibited significant relations between some growth parameters and chemical constituents and in turn quality of produced plants.

Key words: *Epipremnum aureum,* pothos, propagation, rooting, plant growth, cutting type, cutting thickness.

INTRODUCTION

The use of foliage plants for interior decoration or interior plantscaping has become an integral part of contemporary design, playing an important role in our life (Manaker, 1997). The wholesale value of foliage plants in the U S increased from $13 million in 1949 to $574 million in 2000 (USDA, 2001).

Pothos plant, devil's ivy or hunter's robe (*Epipremnum aureum*, *Epipremnum aureus* or *Pothos aureus*) and some other plants such as *Aglaonema, Dieffenbachia, Dracaena, Ficus, Hedera, Philodendron,* and *Syngonium* have been the backbone of the foliage plant industry for almost a half century. The continued interest in pothos is largely due to its adaptability to interior conditions and versatility as a pot, hanging basket, or totem plant (Chen *et al.*, 2002). It will probably continue to be one of the major foliage ornamental crops (Steinkamp *et al.*, 1992).

Cutting types and nodal position of herbaceous cuttings can influence shoot growth and finished quality of rooted liners (Hartmann *et al.*, 1997). Leaf-bud cuttings are often used for plants in short supply that have long internodes. Every node (joint) on the stem can be a cutting (Ingram and Yeager, 2003). Thomas (1999) stated that leaf-bud cuttings provide an excellent means of propagating many vine-types of foliage plants such as devil's ivy and grape ivy and can be used for large-leaved plants.

According to Wang and Boogher (1988), with golden pothos (*Epipremnum aureum*), a 3 cm or longer section below the node and fraction of the old aerial root should be remained on cuttings for most rapid axillary shoot development. Also, Chen *et al.* (2002) published that, commercially, *Epipremnum aureum* is predominantly propagated through single or double eye cuttings.

For other foliage plants, Pennisi *et al.* (2001) stated that juvenile ivy of *Hedera helix* L. can be easily propagated by tip cuttings or node cuttings, the latter yielded more cuttings per stock plant and was most common. Single node cutting, also called leaf bud cutting, contains a leaf and a bud, "eye," while double node cuttings contain two leaves and two buds. Also, three-leaf cuttings may be used. The very tip of the ivy vine is usually discarded. Two- and three-leaf cuttings usually root and grow faster than one-leaf cuttings.

As for cutting thickness effect, Hartmann *el al.* (1997) stated that on redodendrons, thin cuttings made from lateral shoots consistently gave higher rooting percentages than those taken from vigorous, strong terminal shoots. While, basal cuttings of *Hedra helix* and *Schefflera arboricola* develop longer shoots and more roots than apical cuttings. Awad *et al.* (1988) found that as cutting thickness of *Bougenvillea glabra* L increased from 3 to 12 mm significantly increased rooting (%), number of succeeded cuttings to produce vegetative growth and the length of the resulted branches, while number of sprouted buds per cutting was significantly decreased.

According to the available literature, there was little information about the effect of different cutting types on rooting, growth and quality of pothos plants. So, the present work was conducted to find out the effect of different cutting types and thickness on rooting and subsequent growth and quality of *Epipremnum aureum* plant.

MATERIALS AND METHODS

This work was carried out during the two successive seasons of 2001 and 2002 under the glasshouse conditions of Efficient Productivity Institute, Zagazig University, Egypt, to study the effects of different cutting types and thickness on rooting and subsequent growth and quality of *Epipremnum aureum* plant. The present work included two experiments as follows:

First Experiment: Effect of cutting thickness and leaf existence

This experiment included six treatments as follows: thin cuttings (less than 5 mm), intermediate cuttings (between 5 to 10 mm), and thick cuttings (more than 10 mm) each with or without leaf (Photo 1). The experimental design was factorial between the three cutting thickness and the two levels of leaf existence (leafy or leafless cuttings) in a randomized complete block design. Three replicates were used for each of the six treatments, each replicate contained five pots.

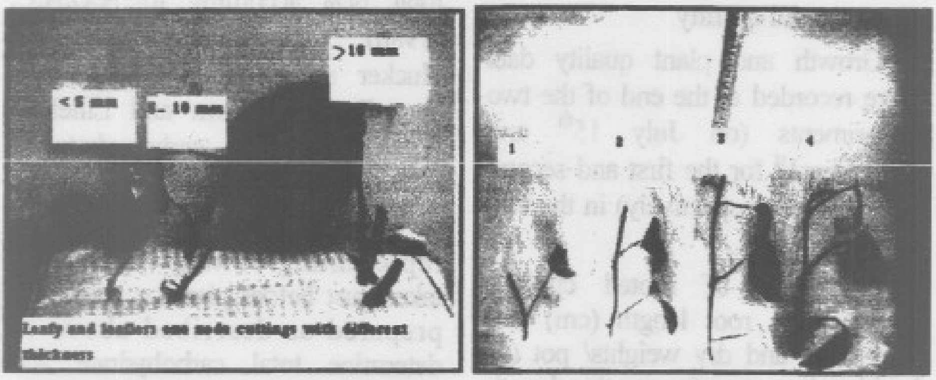
On April 1st, for the two seasons, one-leaf node cuttings (leaf-bud cutting) or one-node cutting (leafless cuttings) were prepared with different suggested thickness. All cuttings were prepared with the same length (9-10 cm) from the juvenile stems of the same plant (Photo 2). Cuttings were planted in 17 cm plastic pots, six cuttings / pot, filled with mixture of German peat moss + sand (1: 1, *V/ V*). The chemical and physical properties of the used potting mixture were as follows: 33.8% coarse sand, 8.4% fine sand, 7.2 %silt, 1.4% clay, 49.2% organic matter, 0.21% total N, 0.91% total P, 1.48% total K, 2.2 mmhos/ cm E. C. and 7.2 pH. Pots were left in the glasshouse conditions with a temperature ranged from 29 to 35°C, relative humidity between 80 to 89% and maximum light intensity from 1400 to 1700 foot candles (measured at 2 p.m. O'clock). This test was begun on April 1st and was terminated on July 15th during the two tested seasons.

Second Experiment: Effect of leaves number per cutting

Treatments implicated four cutting types: three sub terminal cuttings; *i.e.*, one-leaf one-node cuttings, two-leaf two-node cuttings, and three-leaf three-node cuttings besides terminal cutting containing 3 leaves and 3 nodes and the apical bud (Photo 1). Treatments were set up as a simple experiment in a randomized complete block design with four replicates, and each replicate contained 10 pots.

On August 1st in the two seasons, cuttings were prepared from the juvenile stems of the same plant (Photo 2). Cutting length and thickness were divided according to the cutting type; *i.e.*, 8, 17, 23, and 23 cm length for first, second, third, and fourth types, respectively. Cutting thickness was about 8 mm for the sub terminal cuttings (one, two, and three-leaf cuttings) and 6 mm for the terminal ones. Cuttings were planted as one cutting/ 8 cm plastic pot, filled with the same mixture medium as in the first experiment. Pots were left in the glasshouse with a maximum temperature ranged from 27 to 35°C, relative humidity between 85 to 93%, and maximum light intensity from 1400 to 1900 foot candles (measured at 2 p.m. O'clock). This experiment was carried out during the period between August 1st till December 1st for the two tested seasons.

Throughout the experimental period for the two experiments, pots were overhead irrigated two times/ week. Also, all treatments were foliar sprayed biweekly with solution contained 1 gm/ liter of Delta Spray fertilizer (19% N: 16% P_2O_5: 20% K_2O: 4% Mg+ trace elements; viz., B 0.25%, Mo 0.0005%, and Cu 0.01%) for enhance growth.



First Experiment **Second Experiment**

Photo 1: First Experiment = Cutting with different thickness with or without leaf.
Second Experiment = From left to right 1= one-leaf one-node cutting, 2= two-leaf two-node cutting, 3= three-leaf three-node cutting, and 4= terminal cutting (contain three-leaf three-node and the apical bud).

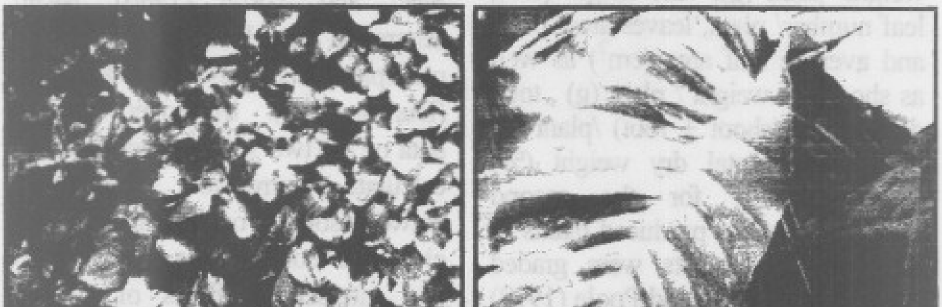


Photo 2: The mother plant which was used for preparing cuttings.
Left: Juvenile stems Right: Adult leaves

Recorded Data

Growth and quality

Growth and plant quality data were recorded at the end of the two experiments (on July 15th and December1st for the first and second experiments, respectively) in the two tested seasons.

Percentage of rooted cuttings (rooting %), root length (cm) and root fresh and dry weights/ pot (g) beside plant growth as: vine length (cm), leaf number/ pot, average leaf area and leaves area/ pot (cm^2) as well as shoot fresh and dry weights/ pot (g), total dry weight (shoot + root) /pot (g) and relative total dry weight (%) were recorded for the first experiment. While, root dry weight/ plant (g), vine length (cm), leaf number/ plant, leaves area/ plant and average leaf area (cm^2) as well as shoot dry weight / plant (g) , total dry weight (shoot + root) /plant (g) and relative total dry weight (%) were recorded for the second experiment. Also, produced plants of the two experiments were graded according to Chase and Poole (1992) on a scale of 1= dead; 2= poor quality; 3= fair quality; 4= good quality; and 5= excellent quality.

Chemical analysis

A random sample of leaves from each replicate was taken at the end of the first experiment and dried at 70°C for 72 hours, finely ground and chemically analyzed to determine total N% according to A.O.A.C. (1980), total P% according to Hucker and Catroux (1980), K% according to Brown and Lilleland (1946), and total carbohydrate % according to Dubois *et al.* (1956).

For second experiment, samples representing cutting types were taken just before planting and were prepared as described above to determine total carbohydrate and total N percentages (using the above mentioned methods); then, C/N ratio in different cutting types was calculated.

Statistical Analysis

The obtained data were statistically analyzed according to Steel and Torrie (1980). Mean separation was done using Duncan's multiple range test at 5% level (Duncan,1955). Moreover, pooled data of the two seasons were used to calculate correlation coefficients between some growth characters and chemical constituents under main and interaction effects of studied factors of the first experiment (n= 6 under cutting thickness, n= 4 under leaf existence, and n= 12 under cutting thickness X leaf existence) and under the effect of leaves number per cutting for the second experiment (n= 16) according to Svab (1973).

RESULTS AND DISCUSSION

First Experiment: Effect of cutting thickness and leaf existence

Rooting

Data in Table 1 show that propagating pothos plant with thin (< 5 mm thickness) or intermediate (5-10 mm thickness) cuttings resulted in the highest rooting (%) with no significant differences between them, while thicker cuttings (> 10 mm thickness) significantly reduced rooting (%) during the two tested seasons. Intermediate cuttings increased root length, but thicker cuttings enhanced root fresh and dry weights/ pot. However, the reduction in percentage of rooted cuttings in case of using thick cuttings may be caused as a result of the expected existence of inactive old tissues in these thick cuttings. Hartmann *et al.* (1997) attributed the variations in root formation on cuttings taken from different positions of the shoot to the marked differences in the chemical composition of such shoots which were known to exist from base to tip.

As for effect of leaf existence, the same Table 1 reflects that leafy cuttings significantly enhanced all studied root characters; *i.e.*, rooting (%), root length and root fresh and dry weights/ pot (g) during the two tested seasons comparing to using leafless one node cuttings. The highest root growth which resulted from using of leafy cuttings may be explained by the possibility of higher concentrations of photosynthetic and endogenous root- promoting substances arising in the attached leaves. Hartmann *et al.* (1997) stated that carbohydrates were important to rooting as building blocks of complex macromolecules, structural elements and energy sources.

When cutting thickness interacted with leaf existence (Table 1), mostly the remained leaf on cutting significantly enhanced all studied root characters under the effect of all used cutting thickness comparing to leafless cuttings during the two seasons. The highest rooting (%) and root growth as root length and fresh and dry weights/ pot were recorded under interaction treatment of leafy thick one-node cuttings. There were no significant differences between this treatment and using the leafy intermediate one-node cuttings in cases of rooting (%) and root length. However, the high rooting under the effect of using leafy thick cuttings is logically, since the synergistic effect of high storage carbohydrates in thick cuttings and the activity of retained leaves through photosynthetic processes and production of endogenous rooting-substances will support root formation and its growth (Hartmann *et al.*, 1997).

Table 1: Effect of different cutting thickness with or without leaf on rooting percentage and some root growth characteristics of *Epipremnum aureum* plant during 2001 and 2002 seasons

Treatments	Rooting (%)		Root length (cm)		Root fresh weight/pot (g)		Root dry weight/pot (g)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Effect of cutting thickness								
Thin cutting (< 5 mm)	96.9 a	88.0 a	28.9 a	31.0b	9.15c	9.33b	2.31a	1.98b
Intermediate cutting (5-10 mm)	92.1 a	78.7 a	30.8 a	36.4a	11.30b	12.00a	2.70a	2.85a
Thick cutting (>10 mm)	76.6 b	74.6 b	29.3 a	32.3b	13.00a	13.90a	2.61a	3.08a
Effect of leaf existence								
Leafless cutting	77.9 b	71.0 b	20.4 b	24.3b	3.85b	4.02b	1.22b	1.05b
Leafy cutting	99.2 a	95.8 a	38.8 a	42.2a	18.4a	19.5a	3.86a	4.22a
Effect of interaction (cutting thickness X leaf existence)								
Thin leafless one- node cutting	93.8ab	77.1 b	22.9 c	25.6c	2.96d	4.53d	1.03a	0.90d
Thin one-leaf node cutting	99.9 a	98.8 a	25.0 b	36.3b	15.33c	14.13c	3.60a	3.06c
Intermediate leafless one- node cutting	86.6 b	86.6ab	22.6 c	29.2c	4.96d	4.56d	1.66a	1.43d
Intermediate one-leaf node cutting	97.7ab	88.8ab	38.9ab	43.7a	17.63b	19.46b	3.73a	4.26b
Thick leafless one-node cutting	53.3 c	49.4 c	15.9 d	18.1d	3.63d	2.96d	0.96a	0.83d
Thick one-leaf node cutting	99.9 a	99.9 a	42.7 a	46.6a	22.30a	24.80a	4.26a	5.33a

Means having same alphabetical letter(s) within each column did not significantly differ according to Duncan's multiple range test at 5% level.

Growth and quality

Generally, the highest growth parameters (with exception of leaf number/ pot); *i.e.*, vine length, leaves area/ pot and average leaf area (Table 2 and photo 3) and shoot fresh and dry weights/ pot as well as total dry weight/ pot (Table 3) were recorded under the effect of using thick cuttings comparing to thin or intermediate ones during the two tested seasons. There were no significant differences in several cases between using intermediate or thick cuttings in this respect. Awad *et al.* (1988) found that increasing cutting thickness of *Bougenvillea glabra* L from 3 to 12 mm significantly increased branches length. However, increasing growth parameters under thick cutting effect may be explain as due to the caused reduction in competition between survival plants in pot for nutrients and light, which resulted from reduction of percentage of rooted cuttings under the effect of the same treatment as mentioned above, as well as this thick cuttings may supply more nutrients and carbohydrates to the produced plants.

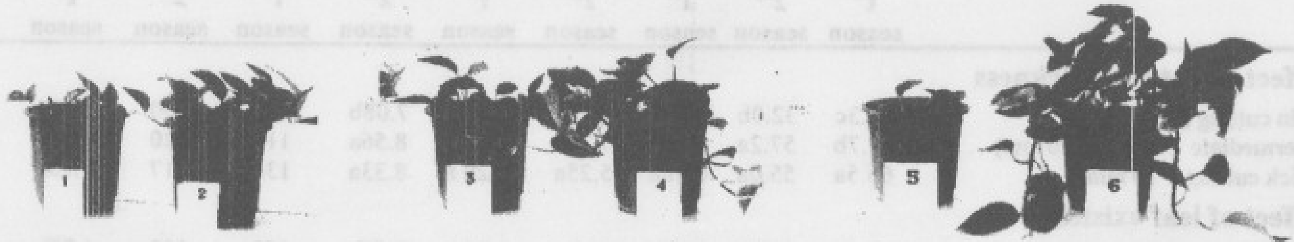
As for pot grade (Table 3 and Photo 3), using intermediate or thick cuttings resulted in moderate quality (3.25, 3.08 and 3.10, 3.01 grades for intermediate and thick cuttings during first and second seasons, respectively), while thin cuttings gave pots with poor quality (2.50 and 2.71 grades for first and second seasons, respectively). This may be due to more vegetative growth resulting from thick cuttings, which reflected in good plant quality.

Leafy cuttings significantly enhanced all studied growth characters; *i.e.*, vine length (cm) leaf No./pot, average leaf area and leaves area (cm^2) /pot (Table 2 and Photo 3) as well as shoot fresh and dry weights and total dry weight (g)/ pot (Table 3) comparing to leafless cuttings during the two seasons. The increments in growth as total dry weight % were more than four and five times in case of using leafy cuttings over than using leafless cuttings for first and second seasons, respectively. Also, data of the same Table 3 and Photo 3 show that using leafy cuttings resulted pots with high quality (4.11 and 4.05 grades comparing to 1.78 and 1.82 poor quality in case of using leafless cuttings during first and second seasons, respectively). The highest growth and quality which resulted from using of leafy cuttings may be explained by the possibility of higher concentrations of photosynthetic substances arising in the attached leaves which may enhance plant growth especially at early stages of development.

Table 2: Effect of different cutting thickness with or without leaf on vine length, leaf number and area/pot and average leaf area of *Epipremnum aureum* plant during 2001 and 2002 seasons

Treatments	Vine length (cm)		Leaf No./pot		Leaf area/pot (cm^2)		Average leaf area (cm^2)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Effect of cutting thickness								
Thin cutting (< 5 mm)	27.5c	24.3b	24.3b	23.3b	670a	495c	24.1 b	19.1c
Intermediate cutting (5-10 mm)	36.5b	38.6a	29.0a	26.3a	820a	618b	26.3ab	22.2b
Thick cutting (>10 mm)	43.2a	37.7a	21.4b	23.3b	906a	724a	33.3 a	26.2a
Effect of leaf existence								
Leafless cutting	23.4b	19.7b	15.9b	15.3b	267b	234b	16.4 b	15.6b
Leafy cutting	48.1a	47.4a	33.9a	33.2a	1329a	991a	39.4 a	29.4a
Effect of interaction (cutting thickness X leaf existence)								
Thin leafless one- node cutting	20.0d	15.6c	15.5a	15.4d	224c	198e	14.4 c	12.8a
Thin one-leaf node cutting	35.0c	33.0b	33.0a	31.1b	1116b	793c	33.8 b	25.5a
Intermediate leafless one- node cutting	25.3d	21.3c	22.1a	21.6c	411c	340d	18.6 c	15.7a
Intermediate one-leaf node cutting	47.6b	55.9a	36.0a	31.1b	1229b	896b	34.1 b	28.8a
Thick one-leafless node cutting	24.9d	22.2c	10.3a	9.0e	168c	165e	16.3 c	18.3a
Thick one-leaf node cutting	61.6a	53.2a	32.6a	37.6a	1643a	1284a	50.3 a	34.1a

Means having same alphabetical letter(s) within each column did not significantly differ according to Duncan's multiple range test at 5% level.



< 5 mm Cutting Thickness
(1) : Leafless Cutting
(2) : Leafy Cutting

5-10 mm Cutting Thickness
(3) : Leafless Cutting
(4) : Leafy Cutting

> 10 mm Cutting Thickness
(5) : Leafless Cutting
(6) : Leafy Cutting

Photo 3: Effect of different cutting thickness with or without leaf on growth and quality of *Epipremnum aureum* plant

Table 3: Effect of different cutting thickness with or without leaf on shoot fresh and dry weights, total dry weight (shoot + root) / pot as well as pot grade of *Epipremnum aureum* plant during 2001 and 2002 seasons

Treatments	Shoot fresh weight/pot (g)		Shoot dry weight/pot (g)		Total dry weight/pot (g)		Relative total dry weight/pot (%)		Pot grade[@]	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Effect of cutting thickness										
Thin cutting (<5 mm)	37.3c	32.0b	4.33b	5.10a	6.65 b	7.08b	100	100	2.50b	2.71 a
Intermediate cutting (5-10 mm)	47.7b	57.2a	5.25b	5.71a	7.95ab	8.56a	119	120	3.25a	3.08 a
Thick cutting (>10 mm)	66.5a	55.0a	6.58a	5.25a	9.20 a	8.33a	138	117	3.10a	3.01 a
Effect of leaf existence										
Leafless cutting	15.4b	15.3b	1.56b	1.61b	2.78 b	2.66b	100	100	1.78b	1.82 b
Leafy cutting	85.6a	80.9a	9.21a	9.10a	13.07a	13.32a	470	500	4.11a	4.05 a
Effect of interaction (cutting thickness X leaf existence)										
Thin leafless one- node cutting	12.6e	11.9e	1.13c	1.36c	2.16c	2.26e	100	100	1.66e	2.00cd
Thin one-leaf node cutting	62.1c	52.0c	7.53b	8.83a	11.13b	11.90c	515	526	3.33c	3.43 b
Intermediate leafless one- node cutting	23.0d	25.5d	1.90c	2.43b	3.56c	3.86d	164	170	2.33d	2.20 c
Intermediate one-leaf node cutting	72.4b	9.0ab	8.60b	9.00a	12.33b	13.26b	570	586	4.16b	3.96ab
Thick one-leafless node cutting	10.6e	8.4e	1.66c	1.03c	2.63c	1.86e	121	82	1.36e	1.26 d
Thick one-leaf node cutting	122.5a	101.6a	11.50a	9.46a	15.76a	14.80a	729	656	4.83a	4.76 a

@ Pots were graded on a scale of 1= dead; 2= poor quality; 3= fair quality; 4= good quality; and 5= excellent quality.
Means having same alphabetical letter(s) within each column did not significantly differ according to Duncan's multiple range test at 5% level.

As for interaction between cutting thickness and leaf existence, data presented in Tables 2 and 3 as well as Photo 3, generally, indicate that retained leaf on cuttings significantly enhanced all studied growth characters (vine length, leaf No. / pot, average leaf area and leaf area/ pot as well as shoot fresh and dry weights and total dry weight / pot) in all used cutting thickness comparing to using leafless cuttings during the two seasons. The highest growth were recorded under the effect of using leafy thick (>10 mm) cuttings. Also, pot quality (Table 3) was enhanced by using leafy cuttings. Thin (<5 mm) one-leaf node cuttings resulted moderate salable quality, while intermediate (5-10 mm) or thick (>10 mm) one-leaf node cuttings produced good pots quality comparing to poor quality in all leafless cutting thickness during the two seasons. The high quality of produced plants under the effect of using leafy thick cuttings was expected as a result of enhancing effect of the same treatment on root growth which in turn permit more absorption of soil nutrient solution and subsequently enhance plant growth and quality.

Chemical analysis

Effects of cutting thickness, leaf existences and their interaction on leaf chemical composition are shown in Table 4. Results indicate that using leafy cuttings for pothos propagation significantly increased total N, total P, K and total carbohydrate percentages in leaves of produced plants comparing to using leafless cuttings during the two tested seasons. Increasing total N, total P, and K percentages may be due to the enhancing effect of leaf existence on root spreading and growth, as mentioned above, which may permit more absorption of soil nutrient solution. While, increasing total carbohydrates (%) may be resulted as an indirect effect arisen from leaf existence effects on vegetative growth and in turn on photosynthesis processes.

Neither the main effect of cutting thickness nor its interactions with leaf existences significantly affect leaf chemical analysis of produced plants. This means that each of cutting thickness and leaf existence acted, in this regard, separately and did not alter the effect of other.

Correlation study

Correlation coefficients (under the effect of cutting thickness, leaf existences and their interaction treatments) between leaf chemical constituents of produced plant and its growth characters and quality are shown in Table 5.

Table 4: Effect of different cutting thickness with or without leaf on some leaf chemical constituents of *Epipremnum aureum* plant during 2001 and 2002 seasons

Treatments	Total N (%)		Total P (%)		K (%)		Total carbohydrate (%)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Effect of cutting thickness								
Thin cutting (< 5 mm)	2.48a	2.80a	0.32a	0.30a	2.11a	2.08a	14.1a	14.4a
Intermediate cutting (5-10 mm)	2.60a	2.91a	0.33a	0.32a	1.97a	2.03a	14.8a	15.1a
Thick cutting (>10 mm)	2.28a	2.80a	0.32a	0.30a	1.88a	2.22a	14.5a	14.1a
Effect of leaf existence								
Leafless cutting	2.02b	2.33b	0.31b	0.26b	1.70b	1.58b	12.8b	12.7b
Leafy cutting	2.88a	3.34a	0.34a	0.36a	2.27a	2.64a	16.1a	16.4a
Effect of interaction (cutting thickness X leaf existence)								
Thin leafless one- node cutting	2.10a	2.43a	0.31a	0.26a	1.93a	1.59a	12.9a	12.5a
Thin one-leaf node cutting	2.86a	3.16a	0.33a	0.35a	2.30a	2.56a	15.2a	16.4a
Intermediate leafless one- node cutting	2.13a	2.40a	0.31a	0.27a	1.70a	1.53a	13.3a	12.9a
Intermediate one-leaf node cutting	3.06a	3.43a	0.34a	0.36a	2.23a	2.53a	16.3a	17.3a
Thick one-leafless node cutting	1.83a	2.16a	0.30a	0.24a	1.48a	1.61a	12.2a	12.7a
Thick one-leaf node cutting	2.73a	3.43a	0.34a	0.36a	2.28a	2.83a	16.7a	15.5a

Means having same alphabetical letter(s) within each column did not significantly differ according to Duncan's multiple range test at 5% level.

Table 5: Simple correlation coefficients between some growth characters and chemical constituents of *Epipremnum aureum* plant under the effect of cutting thickness, leaf existence and their interactions (pooled data of 2001 and 2002 seasons)

Character	Pot grade	Vine length (cm)	Leaf No./ pot	Leaf area/pot (cm^2)	Average leaf area (cm^2)	Shoot dry weight/ pot (g)	Root dry weight/ pot(g)
				Under cutting thickness effect			
Total N %	0.038	- 0.247	0.336	- 0.700	- 0.787	- 0.267	0.181
Total P %	0.370	0.372	0.585	0.515	0.401	0.145	0.143
K %	- 0.463	- 0.449	- 0.076	- 0.496	- 0.526	0.672	0.133
Total carbohydrate %	0.629	0.393	0.587	0.001	- 0.094	0.449	0.214
				Under leaf existence effect			
Total N %	0.919	0.980	0.908	0.805	0.738	0.920	0.937
Total P %	0.853	0.902	0.868	0.798	0.752	0.859	0.895
K %	0.940	0.947	0.941	0.841	0.778	0.944	0.974 *
Total carbohydrate %	0.996 **	0.994 **	0.996 **	0.950 *	0.910	0.997 **	0.999 **
				Under cutting thickness X leaf existence effect			
Total N %	0.681 *	0.755 **	0.879 **	0.748 **	0.629 *	0.857 **	0.892 **
Total P %	0.825 **	0.795 **	0.843 **	0.770 **	0.684 *	0.840 **	0.859 **
K %	0.862 **	0.788 **	0.866 **	0.797 **	0.706 *	0.881 **	0.918 **
Total carbohydrate %	0.906 **	0.888 **	0.882 **	0.868 **	0.821 **	0.956 **	0.896 **

* Correlation is significant at 0.05 level. ** Correlation is significant at 0.01 level.

Under the effect of cutting thickness, the relations between growth and chemical analysis did not exhibit significant relations. While, under leaf existences effect root dry weight/pot positively and significantly correlated with K % in plant leaves. Also, the relations between total carbohydrate (%) on one hand and vine length, leaf No. and area/ pot, shoot and root dry weights/ pot and consequently pot grade on the other hand were positive and significant or high significant. This meaning that using leafy cuttings for propagation may support growth of produced plants through photosynthesis activity of the attached leaf, especially at the early stage of plant development, which reflected as more carbohydrate % in leaves of produced plant, so carbohydrate % positively and significantly correlated with growth and plant quality.

Data of the same Table 5 record, under interaction between cutting thickness and leaf existence treatments, significant and high significant positive interrelationships between leaf chemical constituents and all studied growth characters as well as plant quality. This implicate that the interaction treatment which enhance root growth exactly enhance absorption of N, P and K through soil solution and this will enhance plant growth as: vine length, leaf No. and area/ pot as well as average leaf area and shoot dry weight. Also, the enhancing effect on the total and individual leaf area will result more carbohydrate synthesis through photosynthesis process. Finally, the interference relations between plant growth and its chemical composition resulted positive and high significant correlations between N, P, K and total carbohydrate percentages and plant quality.

Second Experiment: Effect of leaves number per cutting

Growth and quality

Generally using two- or three-leaf node cuttings resulted in the highest growth values of vine length (cm) and leaf No./ plant. While, the average leaf area and leaf area / plant (cm^2) as well as shoot and root dry weights and total dry weight / plant (g) were enhanced by using two-leaf two-node cutting comparing to the all using cutting types during the two tested seasons. Total dry weight (%) was enhanced by using two-leaf two-node cuttings, while it suppressed by using either sub terminal or terminal three-leaf three-node cuttings comparing to one-leaf one-node cuttings during the two seasons (Table, 6). The same data (Table 6) also show that the highest plant quality was recorded by using the sub terminal cuttings (one- two- or three-leaf node cuttings) with no significant differences between them. The terminal cuttings resulted in the lowest plant quality during the

Table 6: Growth, plant quality and cutting chemical constituents as affected by number of leaves per cutting of *Epipremnum aureum* plants during 2001 and 2002 seasons

Root and shoot growth

Treatments	Root dry weight/plant (g)		Vine length (cm)		Leaf No./plant		Leaf area / plant (cm^2)		Average leaf area (cm^2)		Shoot dry weight/ plant (g)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
One-leaf one-node cutting	0.610a	0.552a	71.0c	76.3a	13.4b	14.0ab	293b	247b	21.8a	17.6a	2.89b	3.81bc
Two-leaf two-node cutting	0.725a	0.917a	97.9ab	104.2a	18.5ab	17.8ab	370a	346a	20.0a	19.4a	3.85a	5.17a
Three-leaf three-node cutting	0.657a	0.837a	114.8a	88.5a	22.3 a	18.7a	208c	130c	9.32b	6.95b	2.20d	3.08c
Terminal cutting	0.745a	0.655a	75.4bc	82.2a	14.7 a	13.0b	230bc	155c	15.6ab	11.9ab	2.66c	4.25b

Total dry weight, cutting chemical constituents and plant quality

Treatments	Total dry eight (shoot + root) / plant (g)		Total dry weight (%)		Total carbohydrate (%)		Total N (%)		C : N Ratio		@Plant grade	
One-leaf one-node cutting	3.50b	4.36bc	100	100	15.02 a	15.68 a	3.37 b	3.73 ab	534 c	601 c	4.12ab	4.20a
Two-leaf two-node cutting	4.57a	6.09a	130	139	14.05ab	14.43 a	3.41 b	3.81 ab	986 b	1389 b	4.65a	4.75a
Three-leaf three-node cutting	2.86c	3.92c	81.7	89.9	14.82 a	16.31 a	3.16 b	3.26 b	1520 a	2297 a	4.22ab	4.20a
Terminal cutting	3.41b	4.90b	97.4	112	13.04 b	14.30 a	4.72 a	4.34 a	1364 a	1560 b	3.52b	3.35b

@ Plants were graded on a scale of 1= dead; 2= poor quality; 3= fair quality; 4= good quality; and 5= excellent quality

Means having same alphabetical letter(s) within each column did not significantly differ according to Duncan's multiple range test at 5% level.

two experimental seasons. Pennisi *et al.* (2001) on *Hedera helix* L. stated that two-leaf node and three-leaf node cuttings usually rooted and grew faster than one-leaf node cuttings. Also, Chen *et al.* (2002) published that commercially, *Epipremnum aureum* (pothos) is predominantly propagated through single or double eye cuttings. However, the enhancing effect of two or three-leaf node cuttings may be due to the more storage metabolites in these cuttings, also the 2 or 3 remained leaves may supply the developed roots and shoots with more photosynthetic substances through their photosynthesis process, in addition, the 2 or 3 developed lateral buds may synthesis more internal growth substances which enhance root and shoot growth.

Chemical analysis

Chemical analyses of the used cuttings in Table 6 shows that the highest total carbohydrates (%) were found in the sub terminal cuttings (one, two or three-leaf node cuttings) with no significant differences between them, and the least value in this respect was recorded in the terminal cuttings during the two seasons. Opposite trend was noticed for total nitrogen (%). Consequently, C: N ratio tended to increase in sub terminal cuttings than the terminal ones. The high carbohydrate percentage in sub terminal cuttings might be a responsible factor for enhancing growth of produced roots and shoots especially at early growth just after propagation. While, increasing the contents of carbohydrate and N in cutting as the remained leaves number increased (1, 2, 3 remained leaf) may be the contributed factor in enhancing rooting and subsequent growth of two-leaf two-node cuttings comparing to one-leaf one-node cuttings. Gautheret (1962) on *Helianthus tuberosus* and Greenwood and Berlyn (1973) on *Pinus lambertiana* pointed that glucose or sucrose in the medium was essential for root formation on stem segments placed for rooting under aseptic conditions.

Correlation study

Correlation coefficients under the effect of remained number of leaves on the used cuttings (Table, 7) indicate that plant quality was mainly affected by C : N ratio in cutting tissues as well as each of vine length and leaf area of produced plant, since the interrelationships between plant grade on one hand and C: N ratio in cutting as well as vine length and leaf area/ plant (cm^2) on the other hand were significantly positive. At the same time, significantly negative relation was noticed between plant grade and total N % in cutting, meaning that cuttings which contain more N % combined with low carbohydrate % produce

Table 7: Simple correlation coefficients between some chemical constituents of *Epipremnum aureum* cuttings and subsequent growth characters under the effect of number of leaves/ cutting (pooled data of 2001 and 2002 seasons)

The character	1	2	3	4	5	6	7	8	9
Y- Plant grade	0.613*	0.435	0.241	0.562*	0.415	0.123	0.088	-0.638**	0.596*
1- Vine length (cm)	-	0.630**	-0.323	0.070	0.155	0.129	0.040	-0.447	0.338
2- Leaf No./ plant		-	-0.601*	-0.062	0.046	0.099	0.183	-0.474	0.568*
3- Average leaf area (cm^2)			-	0.806**	0.511*	0.132	-0.068	0.147	-0.140
4- Leaf area/ plant (cm^2)				-	0.772**	0.279	0.020	-0.067	0.153
5- Shoot dry weight/ plant (g)					-	0.075	-0.384	0.232	-0.220
6- Root dry weight/ plant (g)						-	0.243	0.096	0.283
7- Total carbohydrate %							-	-0.349	0.628**
8- Total N %								-	-0.776**
9- C : N Ratio									-

* Correlation is significant at 0.05 level. ** Correlation is significant at 0.01 level.

plants with poor quality. This was true, the above mentioned results recorded poor plant quality for the terminal cuttings which contain high N % and low C : N ratio in their tissues comparing to the sub terminal ones (one, two or three- leaf node cuttings) which contain high C : N ratio . Also, the same data at Table 7 show that the produced leaf No./ plant was significantly and positively correlated with vine length. While, opposite trend (significant negative relation) was found between leaf No./ plant and the average leaf area. This was logically accepted, increasing leaf No./ plant will permit more competition between the produced leaves for the essential metabolites resulting in reduce the average leaf area. Additionally, the pertinence between average leaf area and leaf area/ plant was significantly positive; indicating that leaves area/ plant was depended upon the area of individual leaf rather than leaf No./ plan. In turn, leaf area/plant was significantly and positively correlated with plant quality.

Conclusion and Recommendation

It could be concluded that the best results for growth characters, consequently the highest plant quality were obtained when leafy intermediate or thick cuttings (5-10 or > 10 mm thickness) were used for pothos propagation. Using sub terminal cuttings having two-leaf and two-node had the superior effect in this respect. While, thin cuttings (< 5 mm thickness) and terminal ones resulted in poor growth and quality.

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تأثير نوع العقلة المستخدمة وسمكها على تجذير ونمو وجودة نبات البوتس

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أجريت تجربتان خلال موسمي ٢٠٠١ و ٢٠٠٢ لدراسة تأثير سمك العقلة (استخدمت عقل رفيعة سمكها أقل من ٥ مم ، وعقل متوسطة السمك سمكها من ٥-١٠ مم ، وعقل سميكة سمكها أكبر من ١٠ مم) وكذلك وجود أو عدم وجود الورقة عليها (جرب استخدام عقل تحمل ورقة وأخرى عديمة الورقة) بالإضافة إلى التفاعل بين سمك العقلة وحالة وجود أو عدم وجود الورقة عليها ، أيضاً درس أثر عدد الأوراق التي تحملها العقلة عند زراعتها (استخدم عقل تحتوى على ورقة واحدة وعقدة واحدة ، وعقل تحتوى على ورقتين وعقدتين، وعقل تحتوى على ثلاث ورقات وثلاث عقد ، وعقل رابعة تحتوى على البرعم الطرفي بالاضافة إلى ثلاث ورقات وثلاث عقد) على تجذير ونمو وجودة النباتات الناتجة منها.

أظهرت النتائج أن استخدام عقل سميكة لإكثار نبات البوتس أدى إلى انخفاض معنوي في نسبة العقل التي أعطت جذوراً ولكنها أدت إلى زيادات معنوية في كل قياسات النمو الخضري المدروسة والوزن الجاف لكل من المجموع الخضري والجذري والوزن الجاف الكلي/ أصيص (جم) مقارنة باستخدام العقل الرفيعة أو متوسطة السمك، وأنتجت العقل المتوسطة السمك والسميكة أصصاً متشابهة في جودتها (أصص قابلة للبيع).

كان لوجود الأوراق على العقلة أثر كبير على زيادة كل قياسات النمو والتحليل الكيميائي التي درست مقارنة باستخدام العقل عديمة الأوراق ، كذلك لوحظ تأثير قوى على حث النمو وجودة النباتات الناتجة عند استخدام عقل متوسطة السمك أو سميكة تحمل أوراقاً مقارنة باستخدام العقل الرفيعة (سواء المورقة أو عديمة الأوراق) أو المتوسطة السمك أو السميكة العديمة الأوراق. كانت الأصص الناتجة من استخدام عقل مورقة متوسطة السمك أو سميكة ذات جودة متشابهة، كما أدى استخدام العقل التحت طرفية (ذات ورقة واحدة أو ورقتين أو ثلاث ورقات) إلى زيادة النمو وجودة النباتات الناتجة مقارنة باستخدام العقل الطرفية.

وعموما فقد كان لاستخدام العقلة ذات الورقتين والعقدتين أعلى الأثر في زيادة طول النبات الناتج ومتوسط مساحة الورقة الواحدة واجمالي مساحة أوراق النبات والوزن الغض والجاف للمجموع الخضري والجذري للنبات وكذلك جودة النباتات الناتجة. أظهرت دراسة معاملات الارتباط وجود علاقات معنوية بين بعض قياسات النمو والتركيب الكيميائي وكذلك جودة النباتات والأصص الناتجة.