perience and they must be made to realize they are much more valuable to a firm, once they are well rounded in *education* and *experience*, and up to that point their value is limited to the amount of skill and production ability they have."

There is no one best way to train individuals for any profession. The most important suggestion of all is to develop closer contact with the people hiring our graduates and discover how our product measures up.

ADVENTITIOUS ROOT FORMATION IN THREE CUTTING TYPES OF *FICUS PUMILA L*[1]

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Abstract: Adventitious root formation was studied in juvenile and mature *Ficus pumila* L. (Creeping fig) using stem, leaf-bud and leaf cuttings to find the optimal type for root developmental sequencing research. Leaf-bud cuttings were superior to other types since mature leaf-bud cuttings responded positively to auxin treatment, adventitious rooting occurred *de novo* from internodal areas and rapid rooting was obtained to minimize environmental-physiological variables. Indole-3-butyric acid (IBA) was more effective than indole-3-acetic acid (IAA) in stimulating rooting of leaf bud cuttings.

Adventitious root formation (ARF) in woody plant materials has been studied in relation to application of exogenous growth regulators, endogenous biochemical levels and histological observations. Histological studies of stages in ARF have revealed information on effects of exogenous hormone application on physiological events (3,6,7). Plant material used in developmental sequencing experiments have been herbaceous annuals or hypocotyl cuttings. Biochemical (4) and histological (1,2) changes occur with maturity that decrease ARF so herbaceous materials may not adequately reveal physiological requirements of changing histological events in mature woody materials.

Ficus pumila L. (Creeping fig), a woody ornamental clinging vine was used in this experiment because it has juvenile and mature forms (Figure 1) with differing growth habits, leaf shapes and sizes. Juvenile stems have aerial roots in nodal areas and preliminary studies indicated differences in ARF between juvenile and mature cuttings.

Objective of one experiment was to establish optimal cutting types of *Ficus pumila* from stem, leaf-bud (LBC) and leaf

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Figure 1. *Above.* Juvenile (J) and mature (M) forms of *Ficus pumila.*

Figure 2. *Below.* Standard propagation techniques for *Ficus pumila* during experiments.

cuttings. Criteria used to judge cuttings included response to auxin treatment, degree of ARF via *de novo* root formation, and speed of ARF occurrance to minimize environmental-physiological influence. Experiments were also conducted to determine the most effective auxin and concentration for stimulating ARF.

MATERIALS AND METHODS

Cuttings were taken from *Ficus pumila* stock plants cultivated on the University of Florida campus at Gainesville. Stem cuttings, leaf-bud cuttings (LBC - lamina, petiole and 2.5 cm piece of stem with attached auxillary bud) and leaf cuttings (lamina and petiole) were obtained from juvenile and mature terminal shoots (Figure 1) and propagated under intermittent mist (Figure 2) in a sterilized rooting medium of mason sand maintained at 24°C and with a 2 hr night light interruption.

Experiment 1: Cuttings were initially treated with indole-3-butyric acid and 2-naphthalenacetic acid in combination (IBA/NAA) and indoleacetic acid (IAA) applied in a 15 sec basal soak. Juvenile stem and mature stem and leaf cuttings were treated with 10,000, 3000, 1000, 300, 100, 30, 10 mg/l IBA/NAA, and mature stem, LBC and leaf cuttings with similar concentrations of IAA. Juvenile stem cuttings were treated with 10,000, 1000, 10 mg/l IAA. Mature LBC were treated with 10,000, 1000, 100, 10 mg/l IBA/NAA.

There were 5 cuttings per experimental unit with 4 replications per treatment. The experiment was terminated after 90 days when percent rooting, root number and quality were measured. Quality scale ranged from 1 to 4 with 1 = no rooting, 2 = light rooting, 3 = medium rooting and 4 = heavy rooting.

Experiment 2: In a 2 × 3 × 2 factorial experiment, juvenile and mature LBC were treated with 10, 100, 1000 mg/l IAA and IBA applied as foliar applications at time of sticking. There were 10 cuttings per experimental unit with 4 replications per treatment. Juvenile and mature cuttings were terminated after 21 and 42 days, respectively, and percent rooting, root number and length were measured.

Data from both experiments were analyzed by analysis of variance procedure and compared at the 5% level of significance using Duncan's multiple range test.

Table 1. Adventitious root formation in *Ficus pumila* juvenile stem cuttings 90 days after auxin treatment.

Treatment (mg/l)	Percent Rooting[x]	No. Roots[x]	Quality[xy]
IBA-NAA			
10,000	90ab	11.6ab	2.8bc
3,000	90ab	10.3abc	3.1ab
1,000	95ab	12.5a	3.3ab
300	100a	9.5bc	3.0abc
100	100a	9.0c	3.3ab
30	100a	8.5c	3.4ab
10	100a	9.8bc	3.2ab
IAA			
10,000	100a	11.5ab	3.2ab
1,000	80b	8.3c	2.5c
10	100a	10.9bc	3.0abc
Control	95a	8.8c	2.9abc

[x]Means followed by different letters are significantly different at 5% level, Duncan's multiple range test.
[y]Quality scale ranged from 1-no rooting, 2-light rooting, 3-medium and 4-heavy rooting.

Figure 3-7. Origin of adventitious roots in juvenile and mature cuttings of *Ficus pumula*. Figure 3-4, stem cuttings; Figure 3, after 40 days: unrooted mature (M) and rooted juvenile (J); Figure 4, 90 days experiment: rooted J. unrooted and rooted M. Figure 5-7, leaf bud cuttings; Figure 5-6, after 40 days; Figure 5, juvenile: (Left) *de novo* rooting, (Right) nodal area rooting; Figure 6, mature: roots from nodal areas of etiolated shoots; Figure 7, 90 days experiment: unrooted M. and J. leaf cuttings vs. rooted leaf bud cuttings.

RESULTS

Experiment 1. Juvenile stem cuttings treated with 1000 mg/l and 10,000 mg/l IBA/NAA and 10,000 mg/l IAA had more roots than controls, but controls had higher percent rooting and quality (Table 1) than auxin treatments. Macroscopic examination revealed little ARF at base of cuttings with the majority occurring in nodal areas from preformed root initials (Figure 3). Rooting was observed in all treatments by day 18.

Table 2. Adventitious root formation in *Ficus pumila* mature stem cuttings 90 days after auxin treatment.

Treatment (mg/l)	Percent Rooting[x]	No. Roots[x]	Quality[xy]
IBA-NAA			
10000	65a	8.3ab	2.7a
3000	80a	8.3ab	2.8a
1000	80a	9.5a	3.0a
300	80a	7.4abc	2.6a
100	70a	6.5abc	2.4a
30	80a	7.0abc	3.1a
10	60a	4.5abc	2.2a
IAA			
10000	55a	4.8abc	2.3a
3000	85a	5.5abc	2.3a
1000	85a	6.7abc	2.6a
300	55a	3.7bc	2.1a
100	80a	5.7abc	2.2a
30	60a	4.8abc	2.2a
10	55a	4.0abc	2.0a
Control	40a	2.0c	1.8a

[x] Means followed by different letters are significantly different at 5% level, Duncan's multiple range test.

[y] Quality scale ranged from 1-no rooting, 2-light rooting, 3-medium rooting and 4-heavy rooting.

ARF occurred readily at the base and nodal areas of control juvenile LBC (Figure 5).

At day 48 mature LBC sampled from 10,000 and 1000 mg/l IBA/NAA and 3000 mg/l IAA had roots whereas control did not, but by day 90 no auxin treatment was better than control (Table 3). Roots were sometimes initiated from nodal areas of etiolated shoots originating from axillary buds (Figure 6).

No ARF occurred in juvenile leaf cuttings and only 10% rooting was recorded in mature leaf cuttings treated with 1000 mg/l IBA/NAA, but this was not significantly different from controls. Juvenile leaves were sessile and mature petioles were considerably smaller than species normally propagated by leaves such as *Peperomia* (Figure 7).

Experiment 2: There were no differences between juvenile LBC treated with 1000 mg/l IBA or IAA in percent rooting or

Table 3. Adventitious root formation in *Ficus pumila* mature leaf bud cuttings 90 days after auxin treatment.

Treatment (mg/l)	Percent Rooting[x]	No. Roots[x]	Quality[xy]
IBA-NAA			
10000	55a	4.5ab	2.1a
1000	65a	5.3a	2.2a
100	45a	0.6b	1.3a
10	45a	2.8a	1.6a
IAA			
10000	20a	1.3ab	1.4a
3000	25a	1.5ab	1.9a
1000	25a	1.3ab	1.4a
300	25a	1.1ab	1.3a
100	20a	1.0ab	1.3a
30	40a	2.5ab	1.7a
10	40a	2.6ab	1.7a
Control	60a	2.9ab	2.3a

[x] Means followed by different letters are significantly different at 5% level, Duncan's multiple range test.

[y] Quality scale ranged from 1-no rooting, 2-light rooting, 3-medium rooting and 4-heavy rooting.

root length and both had higher percent rooting than controls, but those receiving 1000 mg/l IBA averaged 10.4 roots per cutting compared to 4.5 for those receiving IAA (Table 4). The other treatment that produced a higher rooting percentage than controls was 100 mg/l IBA. No chemical treatment increased root length.

IBA at 1000 mg/l was the only treatment that resulted in in-

Table 4. Effects of IBA, IAA and GA_3 on adventitious root formation in *Ficus pumila* juvenile leaf bud cuttings after 21 days.

Treatment (mg/l)	Percent Roots[x]	No. Roots[x]	Root Length[x]
IBA			
10	48cde	1.7cd	1.2abc
100	73abc	3.7bc	1.2abc
1000	100a	10.4a	1.6a
IAA			
10	70abcd	2.5bcd	0.9abc
100	53bcde	2.0bcd	1.2abc
1000	85ab	4.5b	1.6a
GA_3			
10	20e	0.5d	0.5c
100	30e	0.8d	0.7bc
1000	25e	1.1cd	0.3c
Control + Surfactant	35de	1.2cd	1.4ab

[x] Means followed by different letters are significantly different at 5% level, Duncan's multiple range test.

creased percent rooting, root number and length in mature LBC (Table 5).

IBA was selected as the most effective auxin to be used for future rooting experiments with *Ficus pumila*.

Table 5. Effects of IBA, IAA and GA_3 on adventitious root formation in *Ficus pumila* mature leaf bud cuttings after 42 days.

Treatment (mg/l)	Percent Rooting[x]	No. Root[x]	Root Length
IBA			
10	0b	0b	0b
100	10b	0.2b	0.3b
1000	75a	5.9a	2.9a
IAA			
10	0b	0b	0b
100	0b	0b	0b
1000	8b	0.1b	0.2b
GA_3			
10	0b	0b	0b
100	0b	0b	0b
1000	0b	0b	0b
Control	0b	0b	0b
Control + Surfactant	0b	0b	0b

[x] Means followed by different letters are significantly different at 5% level. Duncan's multiple range test.

DISCUSSION

LBC was the most satisfactory cutting type since juvenile stem cuttings rooted predominantly from nodal areas and not *de novo* as desired and mature stem cuttings rooted too slowly, even with auxin treatment. *Ficus pumila* could not be propagated by leaf cuttings. Juvenile leaves were sessile, while petioles of mature leaves would only callus at the base with poor rooting. Leaf propagation has largely been confined to herbaceous species thus *Moraceae* genera are not commonly propagated by leaves (5).

Control juvenile LBC rooted with ease while auxin-treated mature LBC rooted faster than controls. Roots originated from nodes in juvenile cuttings and from etiolated shoots formed from axillary buds in mature LBC. Nodal areas had to be above the rooting medium in later experiments for ARF *de novo* at base of cutting.

Reasons for faster ARF in auxin-treated LBC vs stem cuttings were not clear. LBC has only 1 leaf vs 4 to 5 leaves of stem cuttings which probably caused differences in quantity of such physiological materials as endogenous growth regulators, inhibitors and carbohydrates. There may have been a tendency to insert the base of stem cuttings further into the medium for better support where differences in carbon dioxide, oxygen and water saturation in pore spaces occurred.

LBC treated with IBA was established as the best system for ARF studies on developmental sequences in juvenile vs. mature *Ficus pumila.*

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EFFECTS OF FREEZING-THAWING (FAST AND SLOW) IN PLANTS

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A very informative paper by Dr. Robert Wright on the physiology of plant tops during winter appears in the 1977 IPPS Proceedings (Southern Region) (4). Following is a summary of certain concepts presented by Dr. Wright that are pertinent to a consideration of the effects of fast or slow freezing and thawing in plants.

Acclimation is the seasonal transition of plants from a tender growing condition to a hardy overwintering condition in species that go into a rest period. During rest internal factors prevent growth until certain biochemical and physiological requirements have been satisfied. After these changes have occurred, it is possible for growth to resume when there are good environmental conditions. Shortened days in fall and winter with decreased temperatures trigger various biochemical,