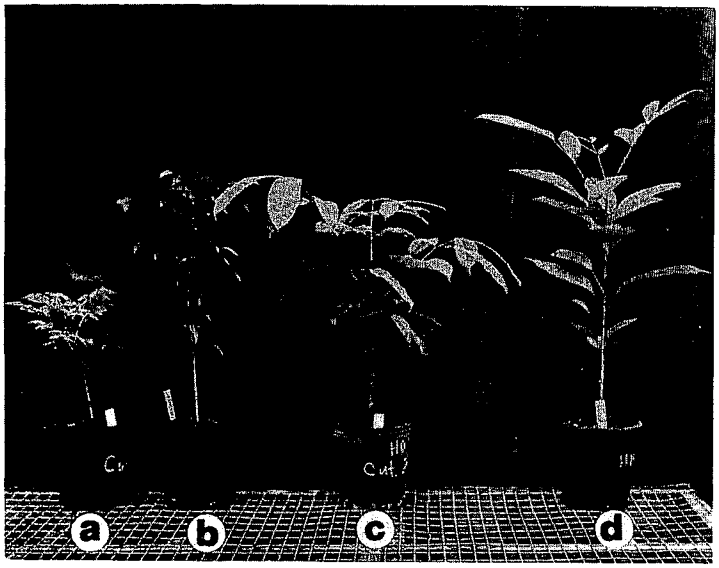

Fig. 2. Potted young mahogany plants. West Indian mahogany propagated from (a) cutting (b) seedling; Honduran mahogany propagated from (c) cutting (d) seedling.

Honduran mahogany seedlings, *i.e.*, 13.9, was about 1 cm/month greater than that of West Indies mahogany seedlings ($P < 0.01$ - Student's t-test(6)). Rooting of Honduran mahogany cuttings tended to be more delayed than that of West Indies mahogany, thus only two rooted cuttings were available at the beginning of the 2-month time interval. These grew a mean of 13.5 cm. Thus, growth of the mahogany cuttings can be said to have been satisfactory, although, at least in West Indies mahogany, growth of cuttings was slower than that of seedlings. West Indies mahogany seeds germinated earlier than Honduran mahogany seeds, but following germination, seedlings of the latter species were faster growing.

Except for four of 23 West Indies mahogany cuttings that died probably from being potted before roots had developed sufficiently, throughout the first season and as of early November 1988 the general vigor of cuttings and seedlings appeared to be excellent (Figs. 1 & 2). Cuttings developed a crook in the stem where the terminals were removed. This was more pronounced in the West Indies mahoganies and some West Indies mahoganies branched at this point (Fig. 1).

Mahoganies are generally prolific seed producers, and progagation by either fresh or stored seed is so readily accomplished (1) that propagation of these species by cuttings is unlikely to find a place in routine horticultural production. Vegetative propagation will be useful for special situations, such as clonal propagation of mahoganies with unusual desirable characteristics, and for research with the objective of developing improved genetic lines of mahoganies.

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VERTICAL DISPLACEMENT OF *DRACAENA FRAGRANS* KER-GAWL 'MASSANGEANA' CANE

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Additional index words. foliage plants, leaning cane, shipping, root growth.

Abstract. **Displacement of one or more canes from vertical alignment during shipping and/or handling is a problem associated with *Dracaena fragrans* (L.) Ker-gawl 'Massangeana' cane. This investigation evaluated different root inducing techniques and the forces required to vertically displace rooted *D. fragrans* canes. Canes were treated as follows: a) horizontal notching with one set of three 2-cm incisions above cane base, b) horizontal notching with two sets of three 2-cm incisions 6 and 12 cm above cane base, c) girdling at 12 cm above cane base, d) girdling at 6 and 12 cm above cane base, e) three longitudinal 12 cm incisions distributed every 120 degrees around the basal portion of the cane, and f) untreated control. Resistance to displacement from vertical alignment on multiple cane plantings was determined by measuring the horizontal pulling force required to move the largest cane (120 cm) from its vertical alignment. Double girdled and double notched canes required the greatest amount of force to displace from vertical alignment.**

D. fragrans 'Massangeana' is a popular foliage plant used in interiorscapes. When propagated by canes, a number of buds (usually one to three) develop near the apical end, forming clusters of leaves commonly called 'heads' by tropical foliage plant growers. Because of this growth habit, 'Massangeana' are usually planted in multiple singlecane forms, using three or four canes of different lengths per container to produce a larger visual mass (Fig. 1). During shipping and/or handling, one or more canes frequently lose their vertical alignment in the container and lean against the side of the container. This problem is called 'leaning cane' by growers and interiorscapers and is

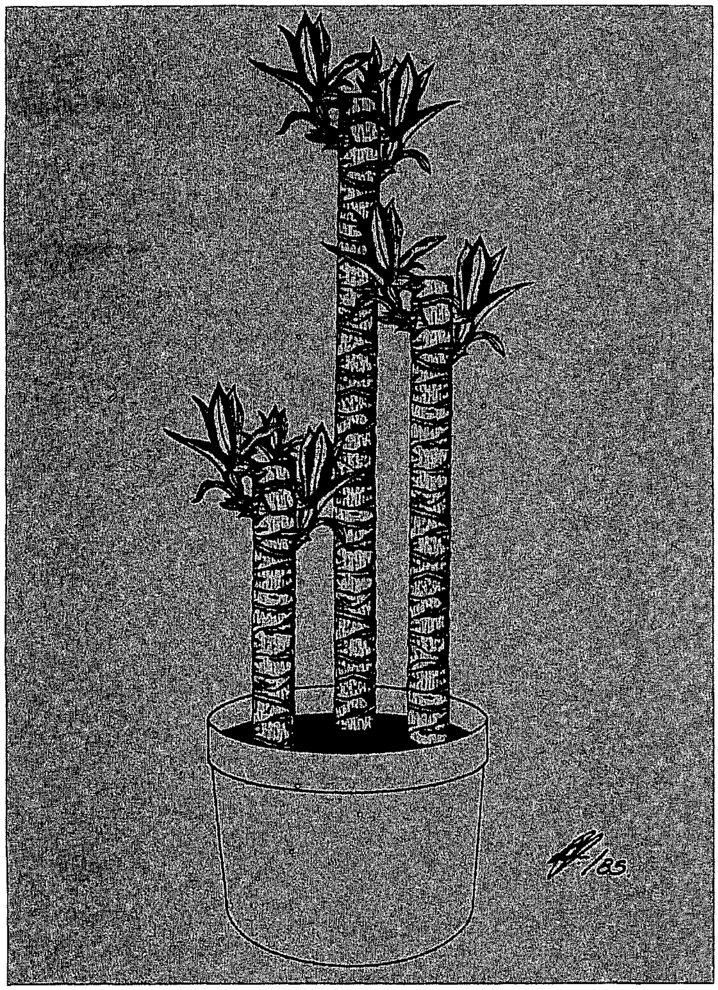

Fig. 1. A multiple cane planting of *D. fragrans* 'Massangeana.'

suspected to occur due to poor anchorage provided by the root system (4).

Almost all roots of *D. fragrans* cane develop around the basal end of the cane (7). Improved rooting of other plants has occurred with longitudinal incisions (6, 8), notching (3, 5), and girdling (1, 9). Increased root system development on *D. fragrans* above the base of the cane would provide increased anchorage and could reduce the incidence of 'leaning cane.'

The object of this study was to determine: (1) if cane wounding techniques would induce root system development above the basal end of the cane, and (2) what effect root system development above the basal end of the cane would have on the horizontal force required to displace *D. fragrans* cane from vertical alignment.

Materials and Methods

Experiment One. This experiment was a 6 (treatments) X 4 (sampling times) X 5 (replicates) factorial experiment. One hundred and twenty 65-cm long *D. fragrans* 'Massangeana' cane were obtained from a commercial source. After arrival, a 2-cm slice was removed from the base of all canes and the canes were placed basal end down in 20 cm of water and soaked overnight. Then, 20 canes each were treated as follows: a) girdling at 12 cm above cane base, b) girdling at 6 and 12 cm above cane bse, c) horizontal notching with one set of three 2 cm incisions 12 cm above cane base, d) horizontal notching with two sets of three 2 cm incisions 6 and 12 cm above cane base, e) three longitudinal 12 cm cuts distributed 120 degrees apart, and f) untreated control (Fig. 2). Each girdle, notch, or cut was 0.5 cm wide and 0.3 cm deep.

Single canes were potted in standard black plastic 2-gal containers filled with dolomite-amended (4.15 Kg m^{-3}) Canadian peat moss. The containers were placed in a greenhouse under 80% light exclusion in a completly randomized design. Media was watered as needed and fertigated with 100 mg/l N every irrigation after bud break. The fertilizer solution was prepared from a 20-10-20 N-P_2O_5-K_2O fertilizer. Greenhouse heating and venting controls were set at 18°C night and 25°C day. Five canes of each treatment were sampled at day 51, 72, 93, and 114 after planting. At each sampling date, root length was determined by using the intersection method as described by Bohm (2).

Experiment Two. Twenty-five 65-cm, twenty-five 93-cm, and twenty-five 120-cm long canes were obtained from a commercial 'Massangeana' cane broker. Upon arrival, a 2-cm slice was removed from the base of all canes and they were placed basal end down in 20 cm of water and soaked over night. Based on results obtained in experiment one, five canes of each length were treated as follows: (a) horizontal cane notching with one set of three 2-cm incisions 12 cm above cane base, (b) complete girdles at 6 and 12 cm above cane base, (c) horizontal notching with two sets of three 2-cm incisions 6 and 12 cm above cane base. Ten canes were left untreated. On 1 May 1985, all canes were potted in standard black plastic 3-gal containers. Each container had three canes, one 65-cm cane, one 93-cm cane, and one 120-cm cane (Fig. 1). All canes in the same container had the same treatment. Other environmental and cultural factors were the same as experiment one.

At the end of 5 months, the 10 containers with untreated canes were divided into two lots of five containers each. One lot had the outside of canes wrapped with shipping tape after a one inch thick Styrofoam support had been placed in the center of the three canes. The other lot served as the control. Results in experiment one had shown

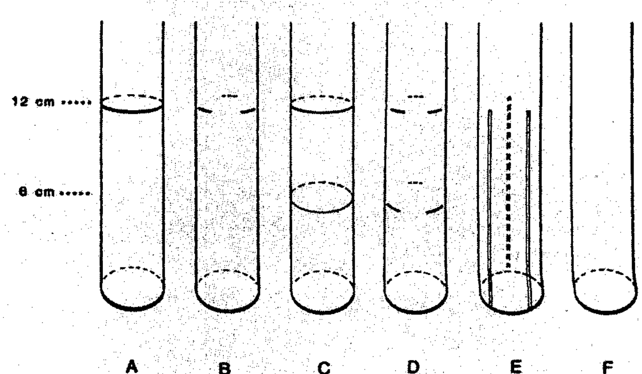

Fig. 2. Diagramic representation of preplanting wounding techniques. A) One girdle, B) One set of notches, C) Two girdles, D) Two sets of notches, E) Longitudinal scoring, F) Control.

that variability in 'head' development meant variability in root development. Consequently, plants in all containers were assigned a rating based on uniform 'head' development. One multiple cane planting in each treatment with the greatest variability was used to establish procedures for vertical displacement testing.

The effect of improved root system distribution and the Styrofoam support system on the resistance of *D. fragrans* 'Massangeana' canes to vertical displacement forces was determined by measuring the horizontal pulling force required to move the tallest cane through a 28° arc. Pulling force was measured on the 120 cm canes using a DPP 30 Chatillon tension tester anchored with a non-elastic polypropylene string attached to the top of the canes 5 cm below the terminal apex. Pulling force measurements were taken at 5° increments, starting at 13°, using a large protractor to determine degrees from vertical alignment. A preformed concrete mold (30 Kg weight) was used to hold the containers in place during the pulling procedure. An additional 40 Kg weight was added to the container mold so it would not move when the highest forces were applied.

Results and Discussion

Experiment One: Measurable roots were not present on canes until the second sampling date, 72 days after planting. However, it was not evident until the third sampling date, 93 days after planting, that the production and development of roots above the cane base was influenced by treatment prior to potting (Table 1). The site of root emergence in wounded plants was immediately above the incision, except in longitudinally scored canes, where the site of root emergence followed no specific pattern. All notched or girdled cane produced a root system at the cane base. The best root systems above the cane base were found on double girdled cane. Broschat and Donselman (3) reported root emergence occurred above girdles in cuttings of *Hilbiscus rosa-sinensis*, a dicotyledonous species, but they reported no root formation at the base of the cuttings. *D. fragrans* canes wounded with one or two girdles, developed roots immediately above each girdle and at the cane base. Anatomical differences between *D. fragrans* and *H. rosa-sinensis* account for the difference in response to girdling. Girdles on *H. rosa-sinensis* cut through the phloem, preventing the downward transport of carbohydrates and root promoting hormones to the base of the cutting. Hormonal concentrations increased above the girdle on *H.rosa-sinensis*, promoting adventitious root formation. In *D. fragrans*, a monocotyledonous species, the vascular bundles are embedded in parenchymatous tissue located internally to the vascular cambium, and leaf traces can be found at different depths in the stem axis (10). Thus, root promoting substances could be translocated past the girdled zones, inducing root initiation at the cane base.

Experiment Two. Statistical differences in the force required to displace cane from vertical alignment were found between treatments when the displacement angle equaled or exceeded 18° (Table 2). Containers with the styrofoam support system exhibited no more resistance to vertical displacement forces than the control. Greater horizontal forces were required throughout the experiment to vertically displace canes with two sets of notches or two girdles

Table 2. Influence of pre-planting cane wounding and post-harvest treatment on horizontal pulling force (ft.-lbs.) required to move *Dracaena fragrans* 'Massangeana' canes from their vertical alignment.

	Displacement from vertical (degrees)			
Treatment[z]	13	18	23	28
One set notches	4.17 b[y]	6.67 bc	9.44 bc	11.77 ab
Two girdles	6.76 a	10.44 a	12.87 a	13.71 a
Two sets notches	6.27 ab	9.07 ab	11.24 ab	13.01 a
Styrofoam support	4.16 b	5.69 c	8.02 c	10.44 b
Control	4.73 ab	6.25 c	8.00 c	10.63 b

[z]Treatments as follows: one set of notches 12 cm above cane base; two girdles, one at 6 cm and one at 12 cm above cane base; two sets of notches, one at 6 cm and one at 12 cm above cane base; Styrofoam support in center of canes, outside of canes wrapped with shipping tape, control had no wounding.
[y]Means within columns followed by equal letters are not significantly different at the 0.1 level, by Waller-Duncan t test.

Table 1. Root length at specified positions on *Dracaena fragrans* 'Massangeana' canes at 72, 93, and 114 days after potting.

	Days after potting								
	72			93			114		
	Root length (cm)			Root length (cm)			Root length (cm)		
Treatment[z]	At 6 and/or 12 cm above cane base	At cane base	Total	At 6 and/or 12 cm above cane base	At cane base	Total	At 6 and/or 12 cm above cane base	base	Total
One Girdle	27.2a[y]	224.0 a	251.2 a	47.6 b	1639.0 a	1686.6 a	289.7 b	2388.2 ab	2677.9 a
One set of notches	6.0 a	372.2 a	378.2 a	9.3 b	1089.9 ab	1099.2 a	267.7 b	3397.7 a	3665.4 a
Two girdles	48.1 a	282.3 a	330.4 a	639.1 a	273.4 b	912.5 a	1725.3 a	1167.5 b	2892.8 a
Two sets of notches	43.5 a	340.2 a	383.7 a	73.6 b	562.5 ab	636.1 a	427.0 b	3227.6 a	3654.6 a
Longitudinal scoring	48.6 a	364.7 a	413.3 a	0.0 b	1052.1 ab	1052.1 a	94.8 b	2677.7 ab	2772.5 a
Control	38.7 a	525.2 a	563.9 a	0.0 b	1064.1 ab	1064.1 a	0.0 b	2555.3 ab	2555.3 a

[z]Treatments as follows: one girdle at 12 cm above cane base; one set of notches 12 cm above cane base; two girdles, one at 6 cm and one at 12 cm above cane base; two sets of notches, one at 6 cm and one at 12 cm above cane base; longitudinal scoring had three longitudinal 12 cm cuts 120 degrees apart, control had no wounding.
[y]Means within columns followed by the same letters are not significantly different at the 0.05 level, by Waller-Duncan t test.

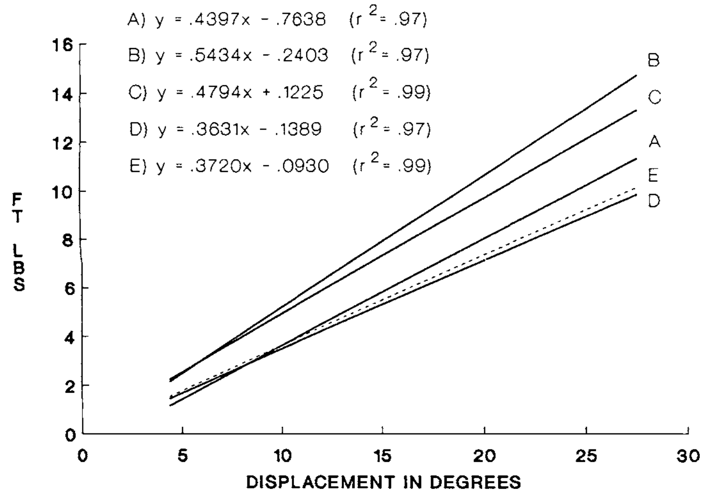

Fig. 3. Predicted regression lines and coefficients of determination for pulling force required to displace *D. fragrans* 'Massangeana' cane from vertical alignment. Treatments were as follows: A) horizontal cane notching with one set of three 2-cm long incisions 12 cm above cane base, B) complete girdles at 6 and 12 cm above cane base, C) horizontal notching with two sets of three 2-cm long incisions 6 and 12 cm above cane base, D) Styrofoam support in center of canes, outside of canes wrapped with shipping tape, and E) untreated control.

(Fig. 3, Table 2). Regression equations (Fig. 3) revealed double girdled canes had a greater resistance to displacement from vertical alignment than the other treatments.

In experiment one, there were no statistical differences in total root length between the treatments used in experiment two, but double girdled canes had a larger root system above the cane base than the other treatments (Table 1). Thus, root system development above cane base increased resistance to vertical displacement forces. Therefore, if growers used techniques to induce root development above the base of the cane, 'leaning cane' would be less likely to occur during shipping and/or handling.

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IN VITRO PROPAGATION AND POST-TRANSPLANT PERFORMANCE OF BLACK TUPELO

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Additional index words. Nyssa sylvatica var. *sylvatica*, acclimatization, micropropagation, tissue culture, woody plants

Abstract. **A micropropagation protocol for black tupelo (*Nyssa sylvatica* var. *sylvatica* Marsh.) was developed and the post-transplant performance of 1.5-cm rooted microcuttings was evaluated. Maximal shoot proliferation (9-fold increase per 4-week culture cycle) from nodal stem explants occurred on either Murashige & Skoog [MS] or Woody Plant Medium [WPM] supplemented with 1.0 mg/liter N^6-benzyladenine [BA]. Addition of 1-napthaleneacetic acid [NAA] to either medium resulted in stem swelling and reductions in shoot multiplication and elongation. Untreated microcuttings were effectively rooted (96%) *ex vitro* in plug trays containing Vergro Klay Mix. However, 100% rooting was achieved by predipping the basal end of the microcuttings in 100 mg/liter indolebutyric acid [IBA]. Rooted microcuttings were acclimatized to greenhouse conditions with 100% transplant survival. Within 10 months post-transplant, plants were highly branched and had attained shoot lengths exceeding 1.3 m.**

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In vitro propagation has become a well established practice for the efficient and rapid large-scale clonal propagation of hundreds of herbaceous species (6). In contrast, research on and commercial application of woody plant micropropagation is limited (2). Presently, the most successful method to propagate woody plants *in vitro* has been through proliferation of shoots from shoot-tips or lateral buds. This technique has had a sigificant impact on production of temperate tree fruit crops (5). Sommer and Wetztein (11) have cited a total of 103 woody dicotyledonous tree and shrub species that have been successfully micropropagated in this manner since 1971. However, micropropagation of many other woody plant species has not been feasible due to difficulties associated with surface sterilization, tissue browning, or poor rooting responses (3,6).