Table 5. The effect of number of nodes remaining after pinch on height and days to flower of *Pentas lanceolata*.

	Nodes remaining					
	Time to flower			Height		
Cultivar	1	3	Significance	1	3	Significance
Medium pink	64	57	*	29	35	*
White Semi-Dwarf	66	52	*	24	30	*
Dark Red	65	52	*	31	37	*
Light Pink Semi-Dwarf	65	51	*	25	32	*

*Significant difference within rows using F test (5%).

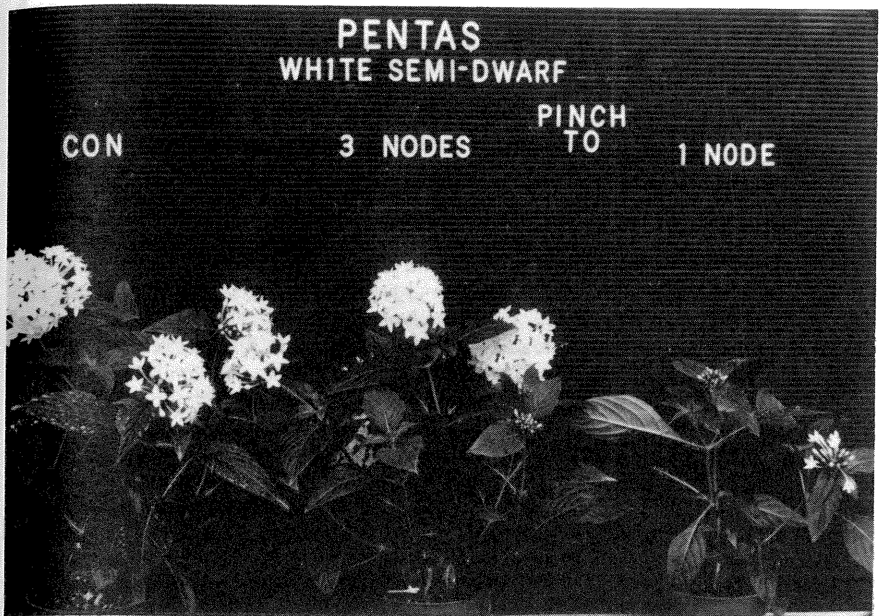

Fig. 3. The effect of pinching to one or three nodes on height and flowering of *Pentas lanceolata*.

ferent photoperiods inherent in literature concerning plant response to supplemental light.

Only chlormequat was effective in reducing height (Table 3; Fig. 1) and leaf surface area of *Pentas*. There were no differences in flowering time due to any of the treatments, which verifies data of Pearce (8) and Kofranek and Kubota (personal communication) using other cultivars of *Pentas*. Perhaps increased concentrations and/or multiple applications would render ancymidol and daminozide effective, but, at the concentrations applied, no height control resulted.

Both the number of pinches and the nodes remaining after pinching (Table 5) affected height and flowering time of *Pentas*. A single pinch delayed flowering by ≈1 week, whereas a second pinch delayed flowering even further (Fig. 2). Height was reduced and breaks were increased as the number of pinches was increased (Table 4). A single pinch was adequate for production in 10-cm pots. Allowing only one node to remain resulted in significant height reduction (Fig. 3) compared with three nodes; however, flowering was delayed (Table 5).

In summary, *Pentas lanceolata* may have potential as a pot crop. It demonstrates characteristics of a quantitative LDP, and flowering can be accelerated with 6 weeks of supplemental light under conditions tested. Daminozide and pinching may be used to control height and, although flowering is delayed with pinching, it is not affected with daminozide application.

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HortScience 23(2):351–353. 1988.

Tree Root Spread in Relation to Branch Dripline and Harvestable Root Ball

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Additional index words. transplanting, root ball, root depth, *Gleditsia triacanthos, Populus × generosa, Fraxinus pennsylvanica*

Abstract. **Ninety-one percent to 95% of field-grown 3-year-old root systems of *Gleditsia triacanthos* L., *Populus × generosa* A. Henry, and *Fraxinus pennsylvanica* Marsh were outside of the harvestable root ball. Seventy-seven percent of the *Populus* root system was growing beyond the branch dripline, whereas 59% and 54% were outside of the *Gleditsia* and *Fraxinus* driplines, respectively. Root spread to branch spread ratios are discussed.**

Tree roots spread horizontally beyond the dripline of the branches (2, 3, 5, 7). Watson (6) presented a model of nursery-grown trees where roots appeared to extend to three times the dripline. Gilman (3) indicated that *Gleditsia triacanthos* roots on plants in the ground for 3 years spread about three times as far as the branches. Two studies showed that a small portion (2% to 5%) of the root system of unroot-pruned, field-grown nursery trees was harvested during transplanting operations (6,7). One study compared and quantified the amount of roots growing outside of the dripline with the portion growing within the dripline (7). In this study, entire root

Received for publication 8 June 1987. Florida Agriculture Experiment Station Journal Series no. 8298. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

Table 1. Root length within and outside harvested root ball of three transplanted tree species.[z]

Species	Root length within ball (m)	Root length within ball (%)	Root length outside ball (m)	Root length outside ball (%)
Gleditsia triacanthos	3.0 a[y]	8.5 a[x]	34.34 a	91.5
Populus × *generosa*	6.43 b	5.3 a	115.02 b	94.7
Fraxinus pennsylvanica	3.57 a	7.7 a	42.83 a	92.3

[z]Six trees of each species were excavated.
[y]Mean separation within columns by Duncan's multiple range test at the 5% level.
[x]Ratio of roots within ball to outside ball was equal for all species by χ^2 analysis at the 5% level.

Table 2. Root length within crown diameter intervals.

Species	Within drip-line (DL) (m)	Within drip-line (DL) (%)	DL-2DL (m)	DL-2DL (%)	2DL-3DL (m)	2DL-3DL (%)	>3DL (m)	>3DL (%)
Gleditsia triacanthos	14.4 a[z]	40.6	15.1	42.6	5.5	15.5	0.5	1.3
Populus × *generosa*	27.4 b	22.6	51.5	42.4	34.1	28.2	8.4	6.9
Fraxinus pennsylvanica	21.7 a	45.8	22.5	46.4	2.2	7.8	0	0

[z]Rows with different letters have different root distributions by χ^2 analysis at the 5% level.

Table 3. Mean crown and root spread of three transplanted tree species.

Species	Mean[z] crown diam (m)	Mean root spread diam (m)	Root spread : crown spread ratio
Gleditsia triacanthos	2.03 a[y]	3.96 ab	1.95
Populus × *generosa*	2.25 a	5.66 a	2.52
Fraxinus pennsylvniaca	1.33 b	2.24 b	1.68

[z]Mean of six replicates for each species.
[y]Mean separation within columns by Duncan's multiple range test at the 5% level.

systems were excavated to determine a) the portion of the tree root system harvested during transplanting and b) the portion of the root system present beneath the branch dripline.

Ten replicates of 3-year-old *Gleditsia triacanthos, Populus* × *generosa,* and *Fraxinus pennsylvanica* were planted bare-root in 60-cm-diameter hand-dug-holes, 45 cm deep, in April. 1978 on a sassafras sandy-loam (fine-loamy, siliceous, mesic, Typic Hapludults) in East Brunswick, N.J. in a randomized block design with one plant of each genus in each of 10 blocks. Trees were spaced on 3-m centers and maintained with 1.96 kg N/100 g of ammonium nitrate. All other macro- and micronutrient levels in the soil were adequate. A 60-cm-diameter circle was maintained weed-free around the base of each plant with *N*-(phosphonomethyl) Glycine (glyphosate) herbicide. Other portions of the plot were mowed weekly during the growing season. Trees were overhead-irrigated six times during the first growing season, to bring the total rain and irrigation water to 2.5 cm/week. No further irrigation was applied to the study area.

In Spring 1981, roots of the three trees in six random blocks were excavated with hand trowels and shovels. Root location was mapped onto graph paper. Mean root spread was calculated by averaging the distance between the trunk and root tips in the north, east, south, and west cardinal directions. Root length of roots 2mm and larger in diameter was measured in the field immediately following excavation with a metric stick while the roots were intact with the tree. A projection of the branch dripline was indicated on each drawing. Trunk diameter at 15 cm above ground was recorded at harvest and used to determine the standard-sized root ball for transplanting (1). Mean distance between the trunk and dripline (crown radius) was calculated by averaging the north, south, east, and west dripline radii. A circle with this radius was projected onto the root drawing. Two additional circles were added representing two and three times this radius. The portion of total length of the root system located within each of these areas was calculated for all 18 trees. A fourth circle was added indicating a standard-sized transplanting root ball. The portion of total root length within this circle was compared with the portion growing outside the circle. Adjustment was made for the taper of the cone-shaped root ball.

Poplar had significantly more root length than ash or locust both inside and outside the harvestable root ball (Table 1). However, the ratio of root length inside the root ball to root length outside the ball was consistent among species. From 91.5% to 94.7% of root length was outside of the root ball if these trees were to be dug according to the American Assn. of Nurserymen standards. This amount of root reduction is likely to cause dramatic stress on transplanted trees, leading to a prolonged acclimatization period after landscape installation.

Locust root length distribution within crown diameter intervals was statistically similar to ash; however, both had more root length within the dripline and less beyond two times the dripline than poplar (Table 2). All three species had greater root length outside the branch dripline than within. Poplar was the extreme, with 77.4% of root length beyond the branches. Locust and ash had 59.4% and 54.2% of total root length, respectively, beyond the dripline. Thirty-five percent of poplar roots was located greater than two times the distance from the trunk to the branch dripline; however, only 16.8% and 7.8% of locust and ash root length, respectively, was in this region. Poplar roots and branch crowns extended farthest from the trunk of the three species excavated (Table 3). Ash had the smallest crowns and the least root spread diameter. Increasing root spread among species corresponded with an increase in the root spread to crown spread ratio. This ratio may be a characteristic for each species, or, perhaps as root spread increases with tree age across all species, the ratio of root spread to crown spread increases. A constant ratio may be reached at a given age. Further study in this area is needed.

It has been known for some time that tree roots extend beyond the dripline (4). This work represents the first attempt to quantify the relationship between horizontal root distribution and branch spread. Recent root pruning studies (4, 7) reported that root pruning can be used as a tool in promoting a dense, compact root system in the root ball region. A compact root system is desirable, given the huge percentage of roots left in the nursery when transplanting unroot-pruned, field-grown trees. It would be desirable to determine whether a root-pruned plant with more compact root system will resume pretransplanting growth rate faster than an unroot-pruned plant. It has been suggested that a tree will not resume pretransplanting growth rate until the original root : shoot ratio has been established (2). This growth may take some time since the root system is reduced so drastically at transplanting.

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HortScience 23(2):353–354. 1988.

Effect of GA_3 and BA on Lateral Shoot Production on Anthurium

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Additional index words. topping, growth regulator, propagation, apical dominance

Abstract. **Juvenile anthurium (*Anthurium andraeanum* Andre) plants were treated by topping and/or with foliar sprays of GA_3 and BA. With increasing concentration (0 to 500 ppm) of GA_3, topped plants showed an increase in lateral shoots. With increasing concentration (0 to 1000 ppm) of BA, the number of lateral shoots increased on both topped and intact plants. Topping alone increased lateral shoots. Chemical names used: *N*-(phenylmethyl)-*1H*-purin-6-amine (BA), gibberellic acid (GA_3).**

Anthuriums are vegetatively propagated to ensure uniformity of cultivars. Conventional methods of propagation involve sprouting of vegetative buds positioned opposite each leaf, at alternate nodes (1). Topping (manual removal of the terminal portion) of mature plants induces development of one or more lateral shoots, which are planted as cuttings once roots have developed. Excised vegetative buds are used in tissue culture propagation of anthuriums (4). Propagation by topping of mature plants is slow, whereas tissue culture propagation is economically prohibitive for many commercial growers.

Higaki and Rasmussen (3) used various growth regulators to increase shoot development on mature anthurium plants. Foliar treatment with BA at 1000 ppm induced more shoot formation than BA at 0, 100, 500, and 1500 ppm, or (2-chloroethyl)phosphonic acid (ethephon) or N-(phenylmethyl)-9-(tetrahydro-2*H*-pyran-2-yl)-9*H*-purin-6-amine (PBA) at 100, 500, 1000, or 1500 ppm. Nakasone and Kamemoto (6) observed no effect on stem length, flower production, or flower size of anthuriums treated with 10, 25, 50 or 100 ppm GA, either with one application or four monthly applications. During a previous experiment in which GA_3 effects on anthurium flowering were studied, increased side shoot production was observed in mature plants treated with GA_3 concentrations of 250 to 1000 ppm (unpublished data).

GA_3 has been shown to enhance bud development in other plants. GA_3 spray application in May or June stimulated lateral budbreak of *Skimmia japonica,* with effects only slightly modified by sprays of N^6-benzylaminopurine (BAP) and 2,3,5-triiodo benzoic acid (TIBA); GA_4 had no effect (8). Branching of *Hedera helix* was enhanced and secondary lateral shoots were produced on pruned plants when GA_3 was applied as a foliar spray (5). Injections of GA_3 into *Musa* lateral buds before floral initiation stimulated bud development into suckers (7).

Use of juvenile plants, which have more nodes per unit stem length than do mature plants, appears to be a potentially rapid and inexpensive method of propagating anthuriums, as topped juvenile anthurium plants were found to produce more suckers than untopped plants (2).

Experiments were conducted to determine whether GA_3 and/or BA could replace topping in promoting shoot development in juvenile anthurium plants and/or enhance shoot development on topped plants.

The first experiment used a split-plot design, with five replicates and five plants per replicate. Test plants were juvenile, 10 to 15 cm in height 'Marian Seefurth' anthuriums growing in polyethylene bags in volcanic cinder medium under 80% Saran shade. Topping treatments comprised the main plots, with one-half of the plants topped and one-half left intact. In topped plants, stems were cut with the basal portion retaining at least two leaves and the upper section retaining at least one or two adventitious roots. The GA treatment subplots were 0, 125, 250, 375, and 500 ppm GA_3, with 0.05% Tween 20 surfactant. GA_3 was applied once as a foliar spray to runoff in Jan. 1985. Plants were sprayed 5 to 10 min after topping. The number of new lateral shoots was counted 6 months after treatment.

The second experiment was a split-plot design with four replicates, with topping as the main plot. Experimental units consisted of four 'Mauna Kea' anthurium plants, 10 to 15 cm in height, grown in cinder–peat medium in polyethylene bags under 80% shade. BA treatments were 0, 500, and 1000 ppm aqueous solutions with 0.05% Tween 20 surfactant. Topped plants were sprayed within 5 to 10 min after topping in Jan. 1985. GA_3 treatments of 0 and 500 ppm aqueous solutions with 0.05% Tween 20 were applied as

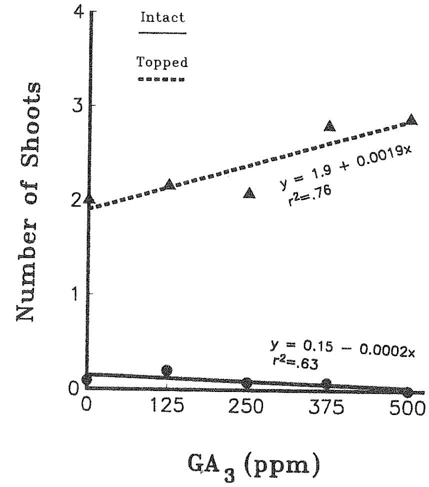

Fig. 1. Effect of topping and GA_3 on 'Marian Seefurth' anthurium lateral shoot production.

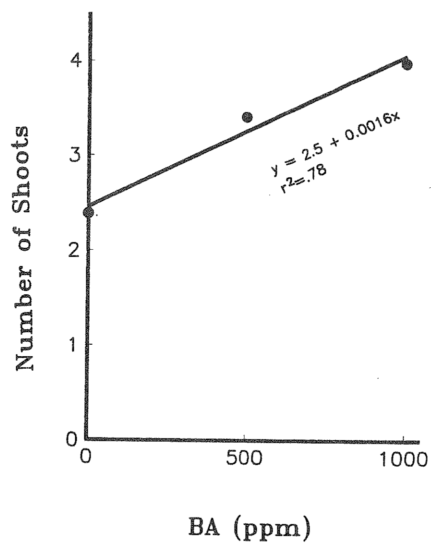

Fig. 2. Effect of BA on 'Mauna Kea' anthurium lateral shoot production.

Table 1. Effect of GA_3 and topping treatments on 'Mauna Kea' anthurium shoot production.

Topping treatment	GA_3 (ppm)	No. shoots
Intact	0	1.6 c[z]
	500	2.0 b
Topped	0	3.3 b
	500	5.8 a

[z]Mean separation by Duncan's multiple range test, 5% level.

Received for publication 11 May 1987. Journal Series no. 3199 of the Hawaii Institute of Tropical Agriculture and Human Resources. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.