mechanize all the operations and because the root system having been produced in soil is immediately suitable for lining out for budding, whereas the cultured roots from hardwood cuttings requires an extra year in the field before being lined out.

A fine workable soil is required to allow the efficient use of the special earthing equipment. A first grade rootstock of 8 to 10 mm should be planted for the stool establishment but any larger is liable to die after cutting down to ground level in the first year. Annual applications of well-rotted turkey manure at 20 tons/acre we find does aid rooting and helps to maintain a workable soil structure.

For the first two years the stools are harvested with hand pneumatic secateurs and in the third season we introduce an offset tractor-mounted sawblade, as the stool is strong enough to resist the pressure of this machine. It can harvest 1½ hectares a day which, depending on the rootstock, would be between 60 and 80,000 stocks off a mature stoolbed.

The life expectantcy of a stoolbed varies according to the type and is between 12 and 18 years. After this time it produces an ever-reducing quantity and would be uneconomical to keep in production. It is most important to cut as hard as possible into the stoolbed each year, which will maintain its vigor and the grade of rootstock. We generally find, with 'M.M. 106' as an example, that we have a grade-out of 30% each of 5 to 6mm, 7 to 8mm, 9 to 10mm, with 10% spoilage.

Earthing of the stoolbed is mechanical; we have designed our own machinery for this purpose. Herbicides and chemicals for the control of pests and diseases are applied with a tractor-mounted boom sprayer.

Harvesting is generally carried out in December when most leaves have dropped. It is very important to remember that most roots are produced during October and early November so harvesting earlier cannot be recommended.

LEYLAND CYPRESS — ROOTING AND EARLY GROWTH OF SELECTED CLONES

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Abstract. Data are presented for rooting, plant growth rates in containers, and field establishment for Leyland cypress trees of 8 different origins.

Cuttings taken in February gave best rooting in all cases and those from lateral branches rooted better than those from shoot tips. Growth rates were measured during a full season in containers. The influences of age of tree, method of staking, and soil type on establishment and growth, when transplanted into the field, were also studied.

Clones superior in rooting and growth to those commercially grown were identified. Staking was beneficial only on a light, sandy soil type.

Leyland cypress (× *Cupressocyparis leylandii*) is one of the most widely grown ornamental conifers in the U.K. It is particularly useful for shelter belt planting as it is resistant to wind and grows well on a wide range of soils. Furthermore, it has the advantage of being tolerant of urban conditions and it is of some interest as a specimen tree or for forest use.

× *Cupressocyparis leylandii* is a bigeneric hybrid of *Cupressus macrocarpa* and *Chamaecyparis nootkatensis*. The trees resulting from the various crosses that occurred over the years have been well documented by Ovens, Blight and Mitchell (15) and more recently by Jobling (10) and by Mitchell (13). There were originally 10 clones, eight arising at Leighton Hall, Montgomery, on two occasions (clones 1-6 in 1888 and clones 10 and 11 in 1911). The other two clones (20 and 21) arose at Stapehill, Dorset, in 1940, or thereabouts.

In addition the Forestry Commission allocated tree identity numbers (relating to the places where they had been planted) to stock-trees of unrecorded origin. They further deduced from historical records, tree dimensions and foliage characteristics, the probable clonal origins of these trees (15). All trees were considered, on this evidence, to have arisen from the Leighton clones. Thus, trees 121, 122 and 123 may have arisen from clone 1 and tree 120 from clone 2.

Specimen trees (clonally derived from either the original clones or numbered trees) were planted by the Forestry Commission at Alice Holt Research Station, Farnham, Surrey. Cuttings obtained from these mature trees were rooted and grown so as to form stock hedges at the Glasshouse Crops Research Institute. These stock plants served as a source of cuttings for subsequent propagation experiments. The selection of material for this study was made following critical examination of the habits of the mature trees and the advice of the research staff at Alice Holt, principally Mr. J. Jobling.

Cuttings from eight individual trees were used in the rooting studies, some of which were true clones and others derived from the numbered trees. Tree numbers are, in general, referred to as clones for simplicity; their probable origins are shown in Table 1. For descriptive detail, see Ovens, Blight and Mitchell (15). Further studies of post-rooting development were then undertaken and this paper presents data for propagation, container growing, and field establishment of eight Leyland cypress clones.

MATERIALS AND METHODS

Rooting. Cuttings approximately 15 cm long were taken from four-year-old stock plants of all 8 clones listed in Table 1 at three monthly intervals, viz: 9 February, 10 May, 9 August and 9 November 1976 and retained in the rooting medium for three months.

Table 1. Leyland cypress — probable origin of eight trees.

Clone[1] or Tree Identity number[2]	Probable origin		Cultivar name
2	Leighton Hall, Montgomery,	1888	'Haggerston Grey'
10	Leighton Hall, Montgomery,	1911	'Naylor's Blue'
11	Leighton Hall, Montgomery,	1911	'Leighton Green'
21	Stapehill, Dorset,	1940	'Stapehill'
120	Cutting from Clone 2, planted in Kyloe Wood,	1906	*
121	Cutting from Clone 1,	1897	*
122	planted in Kyloe Wood,	1897	*
123	Northumberland,	1897	*

* These trees have been loosely known as Kyloe clones.
[1] One or two-digit numbers.
[2] Three-digit numbers.

Cuttings were of two types according to their position on the stock tree, i.e. from either the tips or lateral branches of vigorously growing lateral shoots. For details of this type of comparison see Deen (2). Bases of cuttings were dipped to a depth of 1 cm in a talc-based dust containing 0.3% 4-(3-indolyl) butyric acid (IBA). They were rooted in a medium of equal parts of medium grade Irish moss peat and Chichester grit (of maximum particle size 4.8 mm diameter), under intermittent mist controlled by an electronic leaf. A minimum basal temperature (in the rooting medium at cutting base level) of 20°C (68°F) was maintained, using electronic control units and thermistor sensors (21). Four cuttings were placed per 9 cm^2 plastic pot (compost depth 6 cm). Pots were randomly arranged across five rooting bays with equal numbers of treatments per bay. Fifty tip and fifty lateral cuttings were taken on each of the 4 dates.

Container growing. Rooted cuttings of all 8 clones were initially potted into 9 cm plastic pots, then into 14 cm black polythene containers (of capacity 2.5 l). The compost used was 75% Irish moss peat, 25% sand with fertilizer additions (per m^3) of Osmocote slow-release fertilizer (18:11:10), 3000 g; single superphosphate, 3000 g; magnesium limestone, 2250 g; and fritted trace elements (WM 255), 400 g.

Five gravel-based container beds, irrigated by individual drip lines (Volmatic Ltd) were used. Two plants of each cutting type (tip or lateral) per clone from the February propagation only were arranged in 5 randomized blocks. There were thus ten plants per cutting type used for assessment of establishment and early growth, giving 160 plants in the experiment. Guard plants were arranged around each block.

Plant height above compost level was measured at two-week intervals between 5 April and 24 November 1977, and growth curves were derived.

Field Establishment. On the basis of their high percentage rooting and apparent vigour in the early stages of container growth, plants of clone 21 and tree 121 were selected for comparison with the clones commonly grown commercially, 2 and 11.

The four staking treatments examined were: (1) unstaked; (2) light temporary cane (90 cm long bamboo); (3) heavy cane (150 cm long bamboo) and, (4) permanent stake (180 cm long metal pipe). Sixteen plants per clone (i.e. 256 plants) were ranked in order of height. These were then planted in a split-plot randomized block design on two different soil sites, the Glasshouse Crops Research Institute (GCRI) brickearth soil and a greensand at Duncton (22 km N.W. of Littlehampton on the South Downs). Within each block there were two paired plants per clone of each staking treatment, i.e., 32 plants per block.

Six blocks were planted on the GCRI site comprising plants from the February, August, and November propagations and two blocks at the Duncton site (plants from the May propagation). Plants were spaced 2 m apart within rows.

Blocks were arranged so that the trees formed long lines at right angles to the prevailing wind. On the flat GCRI site this comprised two rows 100 m apart with one row containing trees ranked 1-8 and the other the smaller trees (ranked 9-16). At Duncton one long row was planted half way down a long windswept hill with one block containing trees ranked 1-8 and the other trees ranked 9-16. Guard trees were planted at the end of each row.

Plant height was measured when in containers before planting (April 1978), in the autumn of the first year of establishment (November 1978) and in the summer of the following year (July 1979).

Angle Measurements. The angle at which the trees had grown was obtained by (1) measuring the divergence from the vertical (angle a1) of approximately 80 cm of 1978 growth (above the level of the stake, excluding the tip) and (2) measuring the angle of lean (angle a2) of the whole tree (Figure 1).

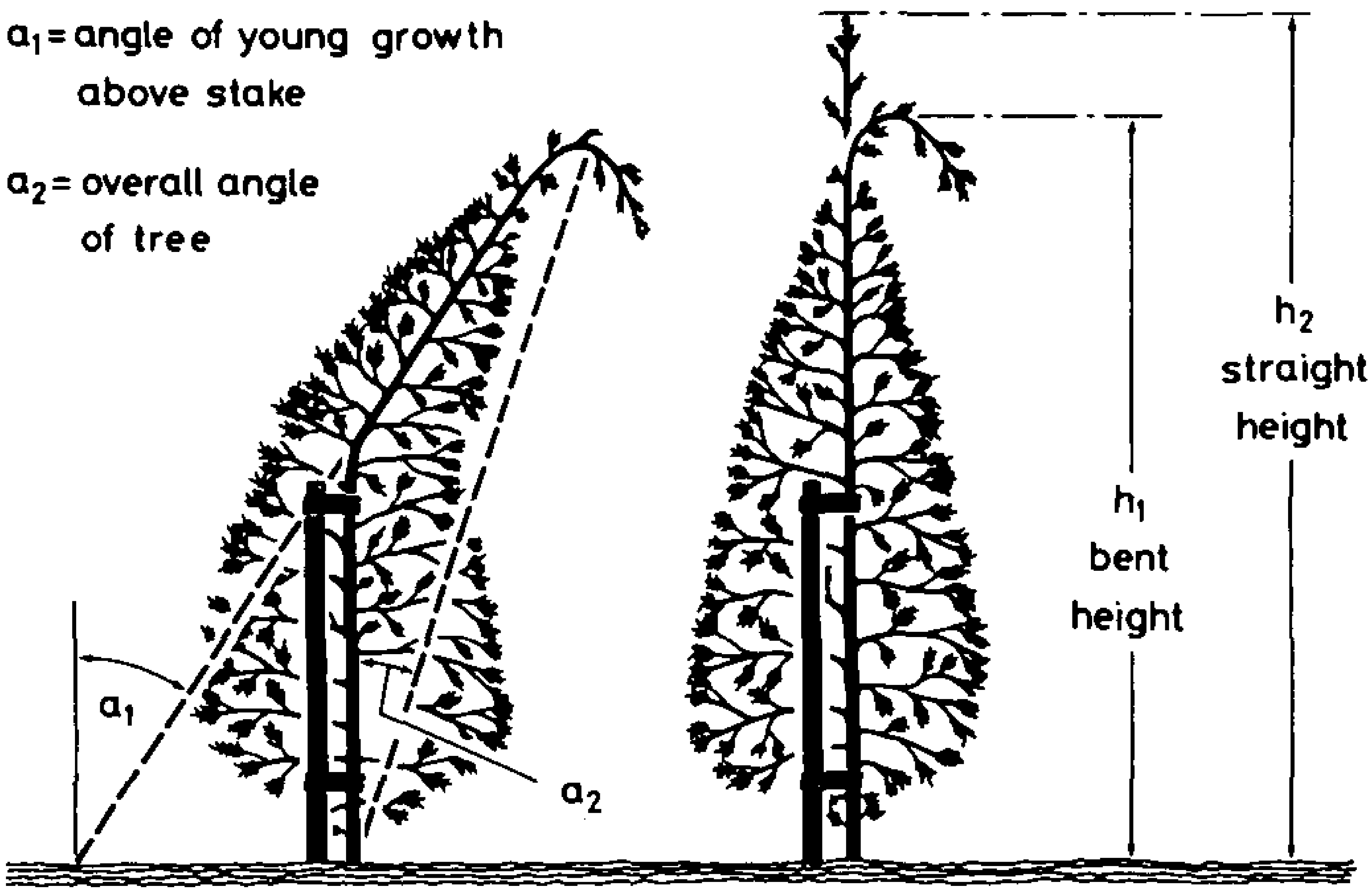

Figure 1. Height and angle measurements made in the field, July 1979.

RESULTS

Propagation. Clear differences were seen for percentage rooting (analyses on angular-transformed data) with respect to the parent tree, position on the stem from which the cutting was taken and time of year. Differences resulting from differing stock plant origins and type of cutting (a positional effect) are shown in Table 2. Clone 21 (Stapehill) and the Kyloe trees (120, 121, 123) rooted well for both cutting types, whilst clones 11 and 10 rooted poorest.

Table 2. Leyland cypress — percentage rooting. Each value is a mean of 200 cuttings.

Clone or tree number	Percent rooted	
	Lateral cuttings	Tip cuttings
21	84 a[1]	63 ab[1]
120	83 a	61 ab
121	80 ab	68 a
123	77 ab	59 ab
122	73 b	51 bc
2	71 b	54 bc
11	57 c	48 c
10	51 c	58 bc

[1] Within each column, values sharing a common letter do not differ significantly at $P < 0.05$.

When the two easy-rooting clones 21 and 121 were compared with clones 2 and 11 (those found commonly in commerce) the effect of different propagation times was clear. Table 3 shows that the best time for taking cuttings of all clones was February; May and August did not differ significantly, whilst November gave the poorest rooting.

Table 3. Leyland cypress — percentage rooting during all propagations from selected trees.[1]

Clone or tree number	Propagation 1 (Feb.)	2 (May)	3 (Aug.)	4 (Nov.)	Overall rooting (percent)
21	99	75	79	38	73
121	96	70	76	54	74
2	87	65	66	32	63
11	70	54	45	39	52
Mean	88	66a	67a	41	

[1] Means for propagation times sharing a common letter do not differ significantly at $P < 0.05$.

These results identify trees superior in rooting ability to clones 2 or 11 and that the usual propagation time (November) gave poorest results.

Container growth. Extension growth in containers for the period April-November 1977 is shown in Figure 2. Data are plotted as growth increments (so reflecting growth rates) rather than as absolute heights. Clone 10 ('Naylor's Blue') was slowest and after initially rapid growth, clone 21 also grew slowly. Clones 2 and 11 exhibited similar growth increases as did those derived from the Kyloe trees (120, 121 and 123). Tree 122 had the fastest rate of growth.

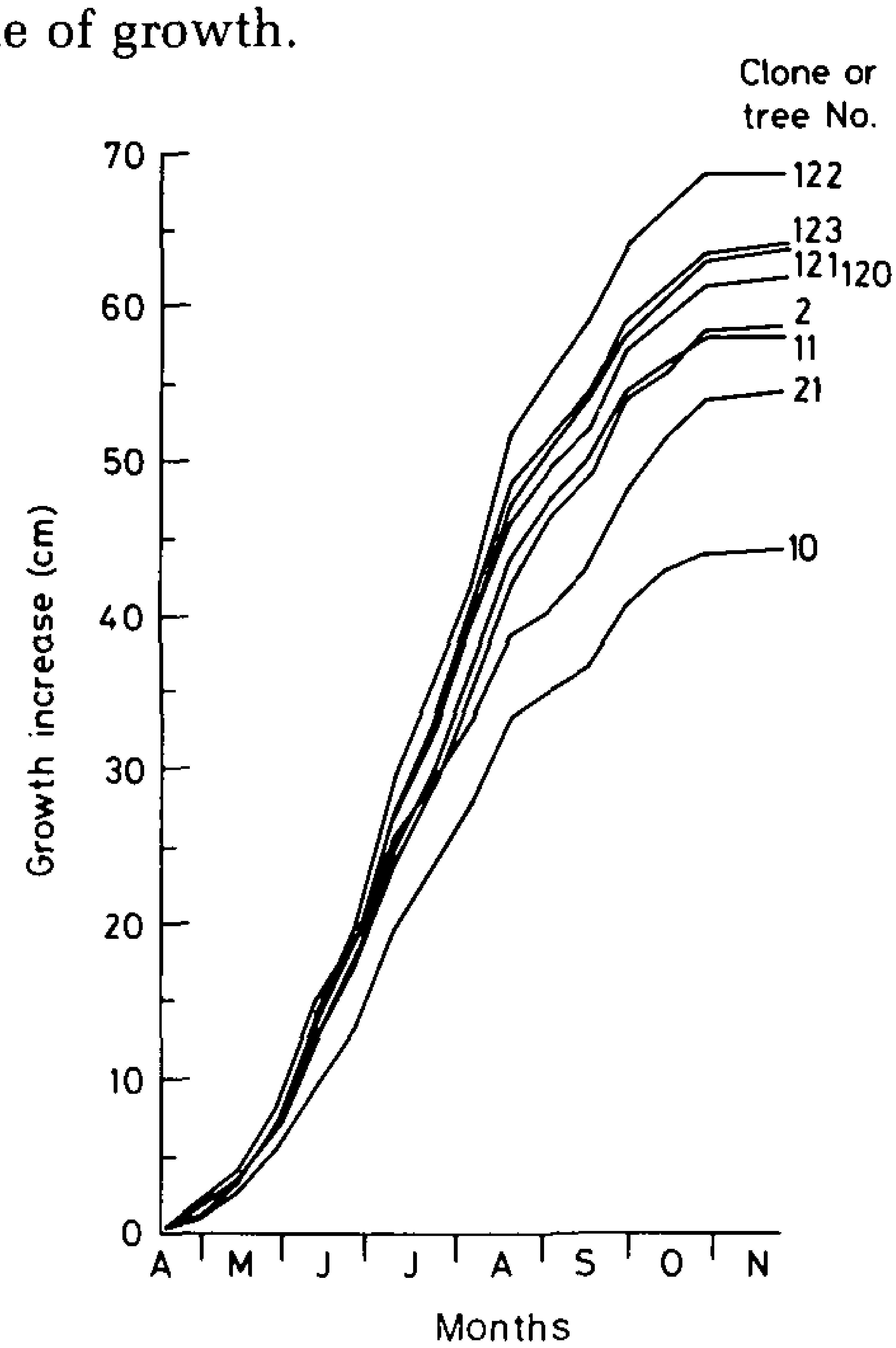

Figure 2. Mean increase in extension growth of plants in containers recorded between April and November 1977.

The duration of the growing period was similar for all trees, although in terms of absolute height the trees performed differently. For example clone 11 was consistently 10 cm taller than clone 2 at each measurement time, although the extension rates were almost identical. This reflects the interaction of a number of variables such as original cutting size, speed and extent of rooting where this occurred, and immediate post rooting growth.

The heights of container plants recorded in April 1978, immediately prior to field planting at the GCRI site, are given in Table 4. There was a considerable difference in height between the plants of the February propagation and the August and November ones, as rooting earlier in the year gave a longer growing period. The later the lifting from the rooting bench the greater was the difference in height between clones 2 and 11, suggesting that clone 11 made earlier and more vigorous flushes of growth in the spring. Had growth rates been derived for the plants of these later propagations the curves might have differed in amplitude and slope from those obtained for the February propagation. Averaging over all propagations the ranking for absolute heights after one season of growth was clone 11 > 121 > 21 > 2.

Table 4. Leyland cypress — height (cm) of container-grown plants after one season's growth (measured in April 1978).

Propagation	Clone or tree number			
	21	2	121	11
1 (Feb)	90.5	96.2	105.3	106.4
3 (Aug)	63.9	56.7	73.5	75.9
4 (Nov)	59.4	53.9	60.5	82.9
s.e. diff (within rows) ± 4.11 (9 d.f.)				
s.e. diff (within columns) ± 3.98 (9 d.f.)				
Clone means	71.3	68.9	79.8	88.4

Field Establishment. The effect of plant size on establishment is shown in Table 5. Comparison of plant heights in containers (prior to planting) with later field recordings (November 1978 and July 1979 (straight heights — see Figure 1)) indicated that whilst plants from the February propagation were significantly taller than the others before planting, this difference was substantially reduced, and heights were not significantly different from those plants of other propagation dates. These data suggesting that smaller trees of Leyland cypress establish better than larger ones are in agreement with growers' observations for this and other genera.

Mean plant heights for the various clones during establishment and in the field are presented in Table 6. In all cases, except one, the order of absolute heights was the same as in the

Table 5. Leyland cypress — effect of plant height (cm) on establishment.

	Propagation			
	1 (Feb)	3 (Aug)	4 (Nov)	Significance
Ht. in containers (April, 1978)	99a	67	64	**
Ht. in field (November, 1978)	151	137	135	n.s.
Ht. in field (July, 1979) (bent)	171	157	155	n.s.
Ht. in field (July, 1979) (straight)	195	182	178	n.s.

a. Significantly different from other row means at $p < 0.01$.

containers, viz: clone 11 > 121 > 21 > 2. Differences between height in containers in April (when field planted) and in November (after the first summer's growth in the field) and subsequently between November and July showed clone 21, which grew more slowly in the early stages, to have a faster rate of subsequent growth than the others.

Table 6. Leyland cypress — mean plant heights (cm) averaged for plants propagated in February, August and November 1976, during establishment and subsequently in the field.

	Clone or tree No.				
	21	2	121	11	S.E. (diff)
Container grown for one season (Recorded April 1978)	71.3	68.9	79.8	88.4	±2.40 (9 d.f.)
Field growth (Recorded Nov. 1978)	140.5	127.4	144.0	154.3	±1.91 (9 d.f.)
Field growth (Recorded July 1979)	189.1	169.9	185.5	196.2	±1.60 (9 d.f.)
Growth differences					
April-November	69.1	58.5	64.3	65.9	
November-July	48.7	42.2	41.5	41.9	

Staking. Statistically, only within-site comparisons are valid. Nevertheless, when data are averaged over all clones, it can be seen (Table 7) that during the initial establishment period, unstaked plants in the greensand grew less than any staked plants. Different staking treatments resulted in little difference in plant height.

On the brickearth there were no significant differences between treatments during establishment (Table 7). Subsequent measurements in July 1979 again indicated little difference between treatments on the brickearth, height means for all clones (cm) being: unstaked 42.1, temporary cane 43.7, cane 44.2, stake 44.3. Similarly on the greensand the differences were reduced to non-significant levels, the means being: unstaked 41.3, temporary cane 45.4, cane 44.5, stake 42.7. Except in the initial establishment stage on a lightly sandy soil, there seems little effect of staking on tree height growth.

Table 7. Leyland cypress — staking treatments on two sites.[1]

Height diff. (cm) between April and November, 1978	Unstaked	Temp. cane	Cane	Stake	Significance
Duncton (Greensand)	45.7 a	59.6	62.0	60.3	*
GCRI (Brickearth)	63.9	64.9	67.3	61.7	n.s.

a. Significantly different from other row means at $p < 0.05$.
[1] Figures are averaged over four clones.

Angle measurements. Data in Table 8 show that, as expected, there were differences in the degree to which the stems were blown over. Least bending occurred in the permanently staked treatment, followed by the heavy cane. There was little effect of a temporary cane; if anything, the latter may have exaggerated wind-rock.

Table 8. Leyland cypress — effect of staking on tree angle.

	Staking treatments				
	Unstaked	Temp. cane	Cane	Stake	S.E. (diff)
Angle of tree above stake ht. (degrees) (a1)	22.2	24.9	17.4	12.6	±1.99 (126 d.f.)
Angle of whole tree (degrees) (a2)	15.1	17.5	9.7	5.7	±0.91 (126 d.f.)

DISCUSSION

For the GCRI site and conditions, propagation of Leyland cypress was optimal under mist from February-taken cuttings (overall mean 88%). Later propagations gave progressively less success. Similar results for rooting have previously been reported for Leyland cypress (9,10,11,16,19). In contrast Van Elk (3,4,5) indicated February to be the poorest rooting time and late autumn the best. Other workers have found the summer or autumn periods to be most conducive to rooting (1,8,14). These differences are difficult to interpret, perhaps reflecting local environmental conditions during propagation. For further discussion see Deen (2).

Differences in rooting behavior among different clones, presented here, indicate that clones exist superior to the commonly grown 2 and 11, in particular clones 21, 120 and 121. As all stock material was of identical chronological age, the observed rooting differences were thought not to reflect differences in stock plant age, although Halliwell (7) has pointed out how important this can be. If tree 120 is derived from clone 2 as Ovens, Blight and Mitchell (15) logically conclude, then it is surprising that it does not root similarly, particularly when trees 121, 122 and 123, all thought to derive from the original clone 1, have reasonably consistent rooting patterns. It is not impossible that during the years as subsequent cuttings have been taken, there has been genetic divergence from the original mother-tree, although the generation times involved here are small. Another explanation could be that relating the final shape and performance of the tree to cutting origin, as cuttings from different positions on the stock tree are known to root differently (17). Furthermore, the ultimate tree shape can be determined by the position from which the cutting was taken and the juvenility of stock material, with juvenile and adult foliage differing markedly in appearance. Welch (20) introduced the term cultivariants (different varieties of the same cultivar resulting merely from differing cutting types) for this phenomenon. It is also possible that whilst clones 120-123 are derived from one of the original six clones they may not have originated from clones 1 or 2 as Ovens, Blight and Mitchell (15) suggest but from others of the group.

Further more detailed rooting studies have been undertaken and are being reported separately. Deen (2) also reviewed other factors responsible for the rooting of cuttings of this bigeneric hybrid.

The extension growth data obtained for the container-grown plants showed that in November, plants from the February-taken cuttings were significantly larger than those from later propagations. This is not unexpected as plants from early cuttings had the summer period in which to grow. Data in Table 4 were for the GCRI site alone and, therefore, included only material propagated in February, August or November. When May-propagated material was included the mean heights (in cm) before planting for each propagation date were: February, 99.6; May, 69.5; August, 67.5; and November 64.2. The growth curves of Fig. 2 reflect growth differences rather than absolute heights, showing that as well as rooting more successfully than clones 2 and 11 cuttings derived from the trees planted in Kyloe Wood also had faster growth rates. In particular tree 122 is outstanding.

Whilst it is extension growth rate that has been examined here, plants having identical growth curves (for example clones 2 and 11) may differ markedly in absolute heights (reflecting different cutting sizes and post-rooting, pre-planting extension growth). Clone 11 grew faster from the cutting stage onwards, producing plants approximately 10 cm taller than those of clone 2 by April 1977. This difference was maintained from April to November during the container growing stage.

Similarly this trend was observed when the trees were planted out and establishment examined. Clone 11 maintained its superiority over clone 2 (see Table 6). Unfortunately clone 11 rooted poorly in these experiments (in accord with grower observation) but differing from data obtained by the Forestry Commission (9). The only apparent difference in technique is Jobling's use of vermiculite instead of grit in the rooting medium. Apart from poor rooting, clone 11 possesses the desirable characteristics of dense, flattened foliage, and of forming a well-shaped tree. In contrast, clone 2 (which is most widely grown) rooted poorly, has a weak open habit, and forms a poorly shaped tree, which was the smallest of all the clones examined.

Clone 121 possesses many of the desirable characteristics required. It grows strongly (Table 6), roots well, and produces a densely furnished tree, very dissimilar to clone 2.

Young container-grown plants of clone 21 grew more slowly than all except clone 10 (Figure 2) but after field planting, it was the fastest growing of the four clones (21, 2, 121, 11 — see Table 6). This clone is more sparsely furnished than the other clones, with flattened branches and forms a good specimen tree. It does have the advantage of easy rooting.

When the practical problem of necessity of staking is considered, the data indicate that only in a sandy soil early in establishment is there any benefit from support, as assessed from height measurements (Table 7). However, the degree of bending of the 1978 growth and the overall angle from the vertical to which the trees bent was decreased by the more permanent staking treatments (Table 8), temporary canes having little effect.

There were no losses from uprooting (blowing-out) of unstaked trees, although they were blown to a more acute angle than the staked ones (Table 8). A clonal difference was seen, clone 2 responding most. Mean values of unstaked trees on the GCRI site for the top tree angle (a1) were: clone 21, 16.9°; clone 11, 21.3°; clone 121, 22.2°; clone 2, 28.5°. A similar pattern of susceptibility to blowing over was recorded for the whole tree angle (a2), values being: clone 21, 12.8°; clone 11, 13.6°; clone 121, 13.8°; and clone 2, 20.1°.

Height growth was slower in unstaked trees earlier in development (Table 7) but thereafter no significant differences were evident.

Firm staking obviously holds the main stem of the tree upright but this may lead to more crooked trees, bent above the height of the stake and to stems with less taper that are more liable to break on removing the support. This stage has not yet been reached in this experiment nor has the tension to which the main stem was subjected been measured. However, previous work on deciduous trees has concluded that flexible stakes or supports which allow some main stem movement were optimal for stability, root development and trunk taper formation (6,12,18).

In conclusion, there are available trees superior in rooting, container growth and field establishment, to those most commonly found in commerce. The use of these trees would seem well justified if the maximum potential of this important bigeneric hybrid conifer is to be realized.

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PROPAGATION OF *PRUNUS TENELLA* 'FIREHILL'

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The attempts to propagate *Prunus tenella* 'Firehill' by layering and by softwood cuttings in the internal mist unit were failures, mainly because we could not get even the small percentage that rooted to grow on to become saleable plants. I will not tell you how many years we had been trying, but will only go back to 5 years ago when the winter bareroot wax-dipped bench grafting programme was started and P. 'Firehill' was one of the subjects tried.

The first problem, and a major one, was trying to find any suitable material for scions. However, by some means or other, about 100 scions were grafted with a take of 20 to 25%. These plants were potted and the subsequent growth was quite good thanks mainly to the understock. It was decided to try budding that summer and strange to relate the success rate was similar, a take of around 25%, and again the growth response the following year was very good. Now we have solved the problem of good quality material for grafting and budding and the routine procedure of using the strong growth from field-budded plants for the winter grafting has established itself. The one thing I must point out is that each year has produced better results and field budding takes are now 90 to 95% and the winter grafting takes 80 to 90%.

To summarize: to be successful with any propagation programme one must, and I cannot emphasize this point too strongly, have the very best quality material to work with.

I am sure some of you must be asking why bud and graft? Well, the answer is this: the budded plants are for sale in winter for bare-root planting some 15 to 18 months after budding. The winter-grafted plants are potted the spring following graft-