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a) STOCKPLANT PRUNING

b) STOCKPLANT DARK-PRECONDITIONING

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HRI-EAST MALLING

Note: The **Science Section** describes the third year's work, whereas the extended **Relevance to Nurserymen and Practical Application Section** presents an overview of the entire three year project. Details of work in the first two years are available in the Annual Reports for 1993 and 1994.

CONTENTS

RELEVANCE TO NURSERYMEN AND PRACTICAL APPLICATIONS

Application

The purpose of this project was to give nurserymen an understanding of how to manage and manipulate stockplants for the production of leafy cuttings, and thereby to create also increasing awareness of the benefits of using permanent stockplants.

The study was in two complementary parts. For a range of subjects considered to root easily or moderately, such as *Forsythia* x *intermedia* 'Lynwood', *Philadelphus* 'Virginal', *Weigela florida* 'Variegata' and *Garrya elliptica* 'James Roof', the aim was to investigate effects of stockplant pruning severity, timing and frequency on cutting production, rooting and establishment, including carry-over effects from one year to another.

For difficult-to-root subjects such as *Syringa vulgaris* 'Madame Lemoine' and 'Charles Joly', and *Corylus avellana* 'Aurea', the objective was to investigate the merits of dark-treatments on stockplants prior to cutting collection, with the aim of producing high yields of good quality liners quickly and efficiently. In many subjects that are currently grafted the production of self-rooted plants would eliminate off-type suckers to the benefit of both producer and customer. The extent to which a response to dark-preconditioning of the stockplant was dependent on, or could be substituted by, improved environmental control in the propagation house after cuttings were stuck was investigated also, and *Elaeagnus pungens* 'Maculata' was included along with *Syringa* and *Corylus*.

Summary

a) Stockplant pruning

The use of different stockplant pruning techniques provides nurserymen with greater opportunity to manage the number, timing and quality of cuttings obtained. The optimum pruning technique however, will vary with the desired objectives. For maximising cutting production throughout a whole season, light pruning techniques (removing approximately 50 to 80% of the previous season's wood) consistently proved the most beneficial over the three year experimental period. In addition, light pruning regimes provided an opportunity for batch production of cuttings throughout the growing season, with up to three separate harvests being possible.

Pruning time was also important and species such as *Forsythia* x *intermedia* 'Lynwood' LA79 and *Garrya elliptica* 'James Roof' responded best to early pruning in March, in contrast to *Philadelphus* 'Virginal' LA83 where most cuttings were obtained as a result of later pruning in May. Similarly, the extent to which flowering wood was removed proved critical, and in early summer-flowering species such as *Philadelphus* or *Weigela florida* 'Variegata' it was essential that light pruning was sufficient to remove flower buds, otherwise subsequent vegetative shoot production was severely curtailed.

Where the primary objective is not to enhance cutting numbers, but to improve cutting

vigour or quality, then a different stockplant pruning regime may be needed. It was demonstrated that severe pruning of stockplants (reducing the whole plant by 50-80%) can facilitate the production of fewer, but often larger and better quality, cuttings. Results from the second year of the project also suggested that in certain species, e.g. *Garrya* and *Philadelphus*, rooting and establishment success of cuttings was enhanced by severe pruning of the stockplants (Figure 1), especially in the latter part of the season. Stockplant management had more influence over rooting ability in the three species tested than other factors such as initial cutting size or the presence of an apical tip. The implementation of a severe pruning regime, however, often delayed the availability of cuttings in slow growing species such as *Viburnum carlesii* 'Aurora' by as much as four weeks, with resultant reduction in rooting potential later in the season.

Differences between pruning regimes were long-lasting, with cutting productivity still being greater from lightly pruned stockplants than from severely pruned hedges 15 months after the original pruning (Figure 2). Interestingly, it was also found that cutting yield in the second year after pruning was not significantly affected by heavy harvesting of cuttings in the previous year. In *Garrya* and *Philadelphus*, the number of cuttings harvested actually increased in many treatments between 1994 and 1995.

In addition to the effects of pruning time, the timing and frequency of cutting collection also played a role in determining cutting productivity. Early harvesting of cuttings (5-6 June) and repeat harvesting as new shoots reached an appropriate size, resulted in an overall greater number of cuttings being obtained compared to leaving cuttings on the hedge until either late July or mid-September. The early excision of cuttings often stimulated new shoot growth, that could be harvested at a later date. This treatment, however, significantly reduced the extent of secondary stem thinning in the stockplants during the summer in species such as *Forsythia* and *Garrya*. The extent to which this could influence long-term productivity is unclear, but results from the third year of the project tend to suggest that the loss of reserves by continually removing the new shoots may be minimal (providing primary and secondary stems are well-furnished with fully-functional leaves) compared to the severity of the original stockplant pruning treatment. Removing much of the mature wood by severe pruning, may have a greater effect on limiting cutting productivity than frequent 'grazing' of softwood cuttings during the growing season. Longer-term and more detailed analyses of stockplant performance would be required to understand fully the effects of pruning and harvesting on stockplant vigour and viability, and to ensure that any variation due to seasonal influences was eliminated, but it is clear that repeated cutting removal in any year need not be detrimental to the longer-term vigour of the stock hedge.

b) Stockplant dark-preconditioning

The availability of well-established field-grown hedges facilitates dark-pretreatments that greatly increase the rooting potential in cuttings of difficult-to-root subjects. Container-grown plants also respond to dark-pretreatment, but cutting production is relatively low and the process is therefore less cost-effective. However, there are two circumstances where containerised stockplants provide flexibility. Firstly, given pallet handling and an easily accessed dark room with ambient temperature approaching 20°C, the opportunity to dark-

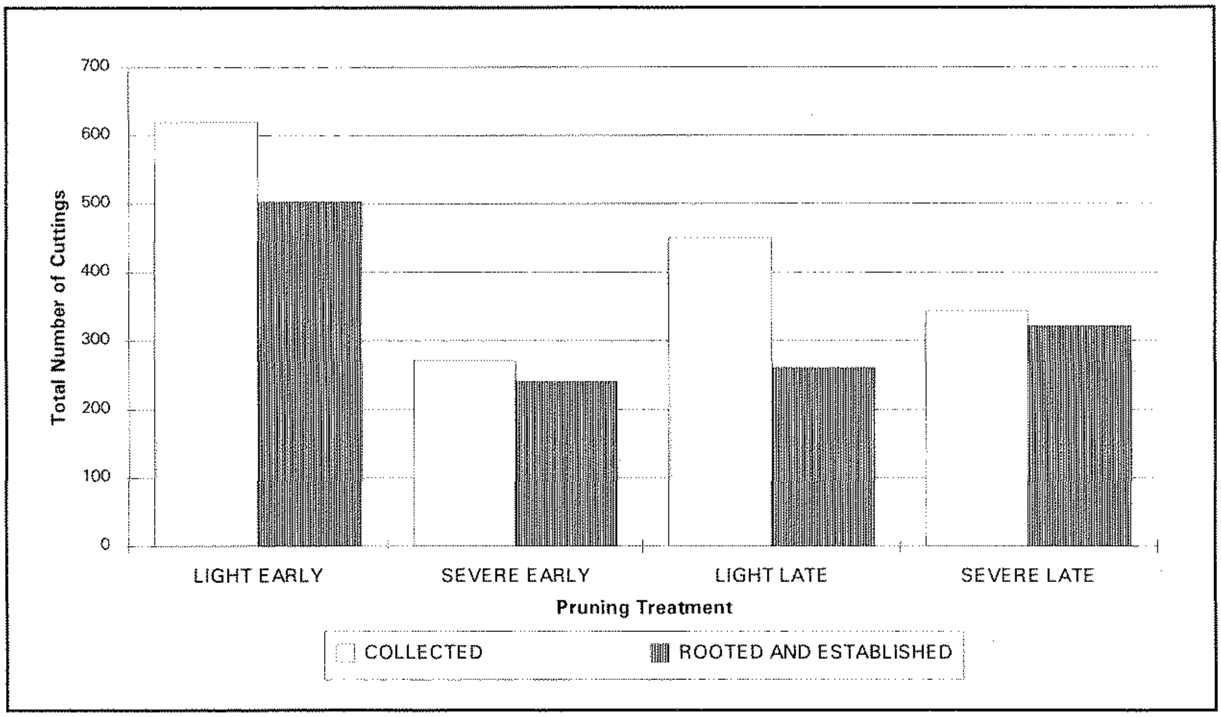

Figure 1. Productivity of pruning treatments on *Garrya* - Comparison between the number of cuttings collected and the number of cuttings that rooted and established in 1994.

Key: Light pruning = reducing previous season's growth by 50-80 %.
Severe pruning = reducing overall stockplant height by 50-80 %.
Early pruning = 31 March 1994.
Late pruning = 5 May 1994.

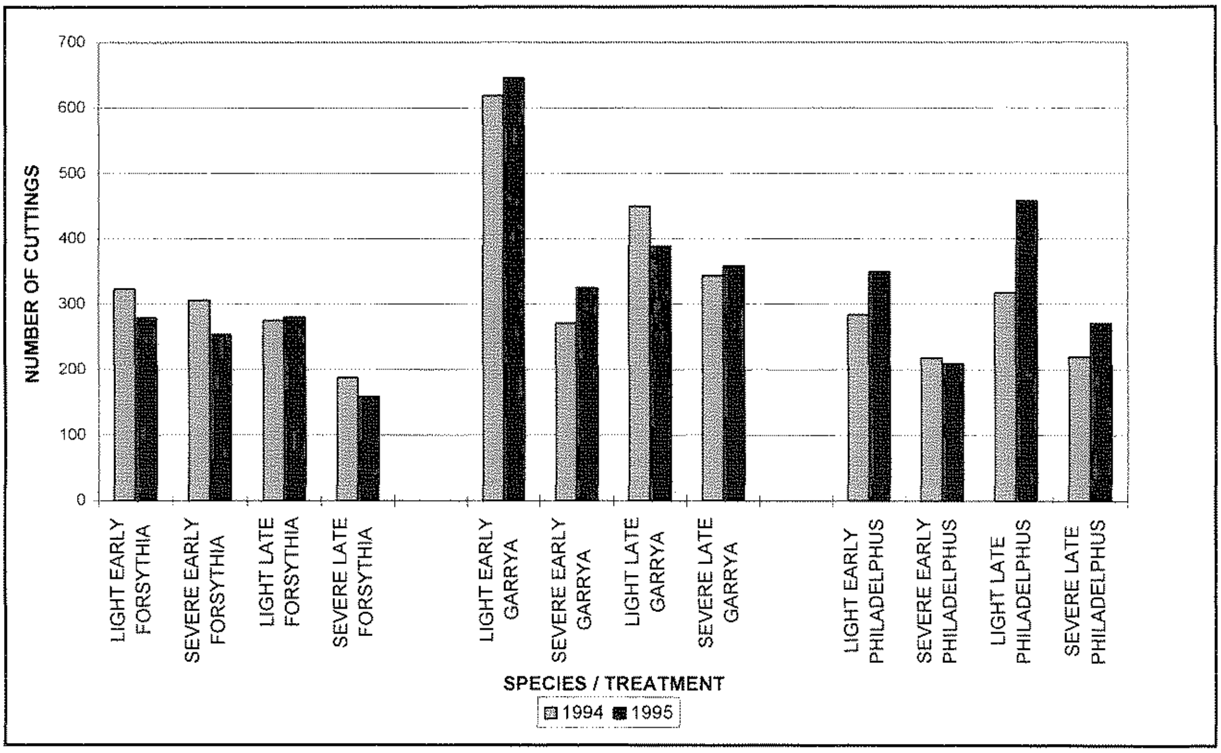

Figure 2. Mean number of cuttings harvested per plant in 1994 and 1995 after initial stockplant pruning in spring 1994.

Key: Light pruning = reducing previous season's growth by 50-80 %.
Severe pruning = reducing overall stockplant height by 50-80 %.
Early pruning = 31 March 1994.
Late pruning = 5 May 1994.
Stockplants not re-pruned during winter 1994/1995.

precondition large numbers of containerised plants conveniently might offset the relatively low productivity of each plant. Secondly, because rooting in difficult species such as *Syringa* is almost entirely dependent on a brief period of optimal shoot condition on the stockplant, containerised plants provide an opportunity to move plants into heated glass or under polythene to force early growth, or into cold store to delay cutting production. In associated MAFF-funded work the peak rooting period for *S. vulgaris* 'Mme Lemoine' and 'Charles Joly' was delayed by a month in parallel with a delay in shoot growth by prolonging the dormant state of plants in cold store.

The process of dark-preconditioning does not reduce the yield of cuttings in the propagation year in comparison to normal light-grown hedges, and there is no evidence that the brief two week dark period in early summer causes stockplants to lose vigour over the years.

The important effect of dark-preconditioning is that it improves rooting percentage, root quality, speed of weaning and subsequent growth. *Corylus avellana* 'Aurea' plants reached 0.5 m by the autumn of the propagation year when grown-on under polythene, and despite their brief season of growth *Syringa* cultivars had well exceeded this height by the mid-May following propagation less than a year earlier. Evidence that given good success at the propagation stage good yields of large 'liners' can be produced in a short time is shown in Table 1.

Table 1

Production of plants by dark-preconditioning stockplants and growing-on in 1 litre pots under polythene

	Syringa vulgaris 'Mme Lemoine'	*Syringa vulgaris* 'Charles Joly'	*Corylus avellana* 'Aurea'
Rooted and weaned (%)	96	100	98
Losses of weaned plants to the end of the first season (%)	5	0	0
Further losses over winter (%)	10	0	0
Plant height from the pot within 12 months of propagation (cm)	65	69	61

Very severe spring frosts in April 1995 killed a number of *Syringa* plants rooted the previous summer and overwintered outside in frames, irrespective of whether they were derived from a dark-preconditioned or a normal source. The nature of the problem is not fully understood because similar plants nearby of different ages, or of the same age but from different experiments, were unaffected, and *Corylus avellana* 'Aurea' in this project was also undamaged.

Whereas cutting quality and rooting potential determines yield and speed of production, the growing-on environment determines plant quality. Frost damage apart, plants grown-on in an outside frame were shorter, and with their laterals, better proportioned than those forced under polythene, and which generally had fewer laterals. For these experiments plants were retained 'pot thick' in their 1 litre pot carriers, making aphid control difficult in the *Corylus* under polythene, and also indicating that these rapidly growing plants needed nutrient supplement. Given different management to reflect the needs of rapidly growing plants under polythene nurserymen would be able to grow-on indoors or outdoors as required.

There was no evidence that the advantages of dark-preconditioning before cutting collection could be substituted directly by improved environmental control after collection, but marked interaction with environments was observed. Normal light-grown cuttings would continue to root if weaned very carefully, suggesting that the rapid high quality rooting of dark-preconditioned *Syringa* cuttings could be approached to some extent in light-grown cuttings by a longer rooting period in a carefully controlled environment, even though this would not substitute for the dark treatment.

In approximately one year in five June has many fewer sunshine hours than normal, and in these dull conditions the warmth of the enclosed Agritech wet-fog environment induced soft apical extension growth on lilac cuttings. This growth draws reserves away from the cutting base and some of the particularly difficult 'Mme Lemoine' rotted instead of rooted, and in most cases the soft extension growth shrivelled during the weaning phase. Well-managed cooler open-mist gave better results, and so if particularly dull conditions are encountered when propagating dark-preconditioned cuttings steps should be taken to keep the house relatively cool by ventilating without unduly stressing the cuttings. Under these conditions wet fog was not detrimental for 'Charles Joly' and for *C. avellana* 'Aurea', and *Elaeagnus pungens* 'Maculata' propagated significantly better in wet-fog than in mist. For this subject there was no indiction that dark-preconditioning was beneficial, but an artefact entered the experiment in that dark-pretreated shoots were longer than light-grown ones and their bases consequently thicker. Normally thick stems negate rooting and further comparisons need to be made with cuttings from both sources made to a similar length.

Action points for growers

1. Pruning techniques applied to stockplants will dictate cutting quantity, quality, rooting ability and time of cutting supply. Nurserymen can exploit such pruning techniques to aid the management of crop scheduling, enhance productivity and improve cutting and liner quality. Serious consideration should be given to establishing hedges of appropriate subjects.

2. For maximum cutting production prune stockplants lightly during early spring prior to

growth (February-March) and harvest cuttings early in the summer (June). Cutting removal will stimulate further growth flushes which can be harvested mid- to late summer (July-August). Up to three separate harvests may be obtained depending on species, but rooting and cutting quality may decrease with late harvesting (e.g. September).

3. Pruning stockplants hard in early spring by removing one-third to a half of the original framework will reduce overall numbers of cuttings but they will be larger and stronger. These generally root and establish better later in the season than cuttings from lightly pruned hedges, especially in the more difficult-to-root species such as *Garrya*. Although severe pruning reduces output per length of hedge, the higher success rate increases efficiency.

4. Covering hedges with ventilated black polythene-clad frames during late May and propagating dark-preconditioned cuttings three to four weeks later, after weaning shoots back into about 50% light, raises rooting potential of difficult subjects such as *Syringa vulgaris* 'Mme Lemoine' and 'Charles Joly', and *Corylus avellana*, 'Aurea', with improved root quality, speed of weaning and of liner production.

5. Large 'liners' in 1 litre pots can be raised in 12 months, but when grown-on under polythene adequate spacing and nutrition is necessary to cope with the exceptionally fast growth. Plants grown more slowly outside are well-proportioned, if smaller, and nurserymen have a choice of the type of plant they wish to produce.

6. Well-managed propagation environments will help to maximise rooting of cuttings from any source, but will not substitute for the dark-preconditioning benefit in recalcitrant species. Dull, warm conditions during the rooting phase will encourage soft apical growth at the expense of rooting because the bases of cuttings tend to rot. This type of growth does not survive the weaning stage, and while this in itself is not important, soft tip growth is best avoided by keeping the propagation environment cool during dull weather. Under these circumstances well-managed open mist can be as good or better than wet fog for the most sensitive species.

EXPERIMENTAL SECTION

Introduction

The two-pronged approach to understanding and improving stockplant management for cutting production continued with the final experiments on stockplant pruning and dark-preconditioning in this project being undertaken.

The objective of the stockplant pruning study was to determine the effects of removing large numbers of cuttings on the subsequent vigour of the stockplant and its future potential to produce cuttings. To this effect cuttings were again harvested from stockplants originally pruned in 1994 and the 'second year' productivity assessed. In addition, growth rates and cutting production were monitored after different harvest times during the summer, using new stockplants.

In the dark-preconditioning study plants of *Syringa vulgaris* 'Madame Lemoine' and

'Charles Joly' were overwintered and grown-on in 1995, and new propagations undertaken for these, with *Elaeagnus pungens* 'Maculata' added at the suggestion of the industry co-ordinator. The emphasis of the 1995 work was to investigate the relative performance of normal and dark-preconditioned cuttings in different propagating environments (wet fog and mist), and to find out whether well-managed stress-free propagation conditions would obviate the need for dark-preconditioning stockplants.

a) Stockplant pruning

Part 1

Materials and methods

This was a further stage in an experiment initiated in 1994 to determine 'stockplant stamina' using *Forsythia* x *intermedia* 'Lynwood' LA79, *Garrya elliptica* 'James Roof' and *Philadelphus* 'Virginal' LA83. Hedges were of 5, 11 and 8 years of age, respectively. Plants were originally either lightly pruned by removing approximately 50% of the previous year's growth (or slightly more in the case of *Philadelphus* to ensure removal of flower buds), or severely pruned leaving 'stooled-plants' between 50 and 100 cm in height. Stockplant pruning treatments were carried out at two dates - 'Early' pruning on 31st March 1994 and 'Late' pruning on 5th May 1994. Cuttings were harvested in batches during the summer of 1994 as shoots reached the appropriate size (generally longer than 15 cm). The number of harvests was dictated by species and pruning regimes, with three harvests being made for *Philadelphus* and from the light pruning treatments in *Forsythia* and *Garrya*. Only two harvests, however, were possible from the severely-pruned stockplants of the latter two species.

After the final harvest in September 1994, stockplants were left untreated, i.e. no further pruning was applied and plants were top-dressed with 200 kg ha^{-1} potassium nitrate fertiliser, applied in bands along the stockhedges during the winter. Cuttings were then harvested again as new shoots developed during summer 1995, and the number of cuttings from different treatments calculated. In some instances exceptionally long shoots yielded two cuttings. Where possible, a sub-sample of ten cuttings was removed from each treatment and prepared in a standardised manner. Stem bases were dipped in 1,250 mg l^{-1} IBA in 50% acetone solution and placed in 1 litre pots containing 50:50 peat:fine bark with 1 g l^{-1} Ficote 140 16:10:10 incorporated. Cuttings were rooted under fog using an Agritech fogger in a shaded polythene tunnel, with pots being placed on sand beds maintained at > 20°C. Rooting was assessed after plants were weaned, generally six to eight weeks after collection.

Results

Cuttings were harvested at two periods; in late June and in the third week of August 1995. For cuttings collected in June, rooting percentage was in excess of 90% for all treatments in each species. Rooting was not assessed in August due to the limited number of cuttings available in many treatments. This was primarily due to drought stress during the latter part of the summer restricting new growth.

For all three species, trends between treatments were similar to those of 1994, indicating that the influence of the original pruning treatment had a strong carry-over effect from one year to the next. In *Forsythia*, the lowest number of cuttings harvested was from the Severe-Late pruning treatment (Table 2), with the other three treatments yielding almost twice as many cuttings. The Severe-Early treatment actually produced fewer shoots than either of the light pruned treatments, but had a greater proportion of long stems, which could yield two cuttings. As in the previous year the Light-Early proved the most productive treatment in *Garrya* where over 600 cuttings were harvested per plant (Table 3). Similarly, with *Philadelphus* light pruning treatments produced most cuttings, although the later original pruning treatment still retained greater capacity than the earlier pruning, giving 458 compared to 350 cuttings per plant (Table 4).

Part 2

Materials and methods

The objective of this experiment was to determine the importance of timing of cutting removal on productivity and stockplant vigour. For example, whether early and repeated removal of shoots significantly reduces a plant's ability to accumulate photosynthates, thus inherently weakening the stockplant and resulting in overall less cutting production. Therefore, it is important for long-term stockplant viability to determine at what stage an individual shoot changes from being a net sink removing resources from the stockplant, to being a net producer of resources contributing to the stockplant, and then to manage cutting collection accordingly.

Plant species were *Forsythia* x *intermedia* 'Lynwood' LA79 and *Weigela florida* 'Variegata' LA83 as examples of deciduous subjects, and *Garrya elliptica* 'James Roof' as an evergreen subject. As in previous experiments, established hedges of *Garrya* (11 years) and *Weigela* (8 years) were used. As an additional factor a young two-year-old *Forsythia* hedge was used to determine the effects of pruning and cutting removal on stockplants that had only recently become established in the field. On 2 February, 1995, stockplants were pruned to encourage new shoot production in the following spring. *Forsythia* plants had the previous season's wood reduced by 50%, resulting in hedges of approximately 50 cm in height. *Weigela* was pruned back to a similar height by removing two-thirds of the previous year's wood. The previous season's growth on *Garrya* was also pruned back by about two-thirds, resulting in an overall plant height of between 120 and 150 cm.

Hedges were then divided into three and designated as 'Early', 'Mid' and 'Late' harvest treatments. Each treatment was represented by three plants in the case of *Garrya* and *Weigela*, and ten plants in the case of the less-well established *Forsythia*. After the Early and Mid harvests growth was sufficient to allow repeat harvests on subsequent dates. Table 5 shows the timing and number of harvests for each treatment. At harvest the number of cuttings collected was counted and sub-samples of 'typical' cuttings were either propagated (20 cuttings) to assess rooting potential or assessed for size and weight (30 cuttings). An estimated index of total dry matter harvested was calculated from the number of cuttings collected for each treatment at any particular date multiplied by the mean dry weight at harvest of the sub-sample. Similarly, dry to fresh weight ratios were also determined, but

Table 2

Mean number of *Forsythia* cuttings per plant in 1995, after original stockplant pruning in spring 1994

Pruning Treatment	Harvest No.	Date	Total stems	Stems with 2 cuttings	Total Cutting No.
Light, early	1	29.6.95	246	26	272
	2	23.8.95	7	0	7
			253		**279**
Severe, early	1	29.6.95	209	45	254
	2	23.8.95	2	0	2
			211		**254**
Light, late	1	29.6.95	250	24	274
	2	23.8.95	6	0	6
			256		**280**
Severe, late	1	29.6.95	125	30	155
	2	23.8.95	4	0	4
			129		**159**

Table 3

Mean number of *Garrya* cuttings per plant in 1995, after original stockplant pruning in spring 1994

Pruning Treatment	Harvest No.	Date	Total stems	Stems with 2 cuttings	Total cutting no.
Light, early	1	27.6.95	428	22	450
	2	18.8.95	178	18	196
			606		**646**
Severe, early	1	29.6.95	147	34	182
	2	18.8.95	130	14	144
			277		**325**
Light, late	1	27.6.95	333	17	350
	2	18.8.95	36	2	38
			369		**388**
Severe, late	1	29.6.95	192	48	240
	2	18.8.95	113	5	118
			305		**358**

Table 4

Mean number of *Philadelphus* cuttings per plant in 1995, after original stockplant pruning in spring 1994

Pruning treatment	Harvest no.	Date	Total stems	Stems with 2 cuttings	Total cutting no.
Light, early	1	26.6.95	264	78	342
	2	21.8.95	8	0	8
			272		**350**
Severe, early	1	27.6.95	149	31	180
	2	21.8.95	26	4	30
			175		**210**
Light, late	1	26.6.95	335	78	412
	2	21.8.95	37	9	46
			371		**458**
Severe, late	1	27.6.95	200	42	242
	2	21.8.95	24	5	29
			224		**271**

Table 5

Cutting removal from stockplants and harvest dates

Species/Harvest	Early	Mid	Late
Forsythia			
1	6.6.95	-	-
2	31.7.95	31.7.95	-
3	13.9.95	13.9.95	13.9.95
Garrya			
1	5.6.95	-	-
2	27.7.95	27.7.95	-
3	5.9.95	5.9.95	5.9.95
Weigela			
1	6.6.95	-	-
2	26.7.95	26.7.95	-
3	11.9.95	11.9.95	11.9.95

to reduce errors due to desiccation, evapotranspiration or drought effects in the field at the different times of collection, cuttings were rehydrated by placement in water overnight (15 hours) and excess external moisture removed by paper towelling before fresh weights were recorded. A ratio of dry to rehydrated weight was then calculated and mean values obtained for each treatment.

To obtain more understanding of how stockplants respond to cuttings being excised, a number of tertiary shoots were identified and labelled on each plant, and throughout the course of the experiment detailed records were taken of shoot growth extension, shoot diameter increments and increments in the diameter of the secondary stem from which the tertiary shoot developed. In *Forsythia* there were three replicate shoots per plant, but ten shoots per plant in *Garrya* and *Weigela*. Results therefore were based on a total of 30 recordings per treatment at each assessment date. Recordings of shoot stem diameters were taken at 1 cm above the adjoining axes, whereas secondary stem diameters were recorded at 1 cm below axes, (Figure 3). Shoot diameters continued to be recorded, even when the apical part of the stem had been removed during cutting harvest.

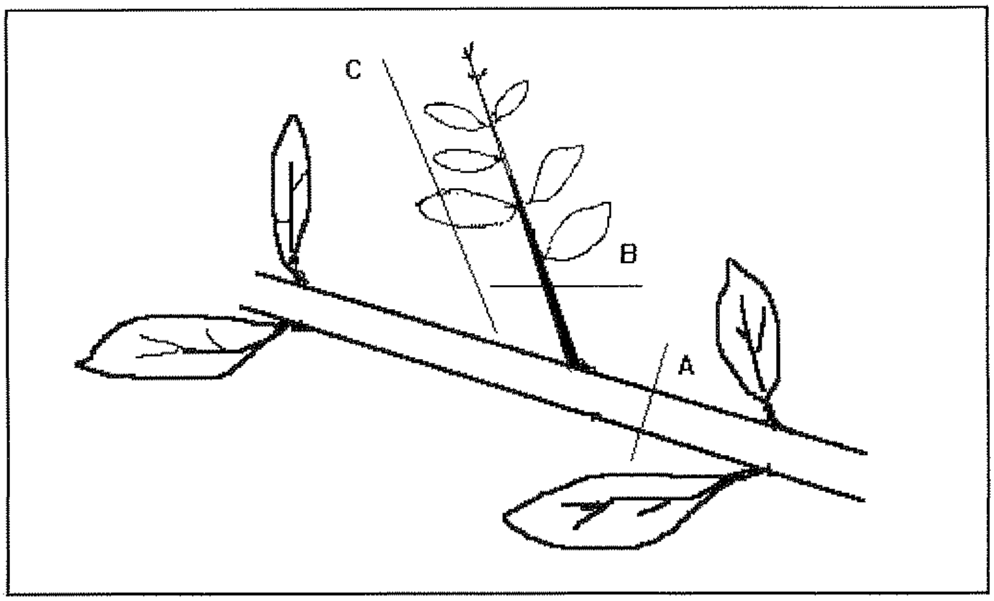

Figure 3. Measurements of growth increments on stockplants

Key: A = Measurement of secondary stem diameter 1 cm below node.
B = Measurement of new tertiary shoot diameter 1 cm above node.
C = Measurement of growth increases of new tertiary shoot extension.

Due to lack of rain during the 1995 summer, and following evidence of leaf wilting in *Forsythia* and *Weigela* hedges, irrigation was applied to the above species respectively on 4 and 16 August by means of seep hose laid along the ground at the base of plants. *Garrya* showed no symptoms of drought stress and irrigation was not applied.

Statistical analyses were carried out between treatments at each date using least significant difference (LSD) at the 5% level. This indicates the size of difference between individual treatment means that is considered to be due to treatments, with a 95% probability that the effects are not due to chance. To reduce the influence of secondary stem thickness or original shoot size on the subsequent results, a co-variate analysis of variance was used to determine significance.

Results

The young *Forsythia* hedge was less vigorous and produced fewer cuttings than the other two more established species. Results may have been influenced by the degree of drought stress, but generally Early removal of cuttings induced more shoots to be produced and resulted in overall greater numbers of cuttings to be harvested.

Forsythia

The Late harvest treatment was particularly poor with a mean of only 7 cuttings per plant being harvested (Table 6), considerably fewer than at the first harvest of the Early or Mid treatments. The reasons for this are unclear, but may relate to a higher proportion of shoots terminating growth earlier and becoming more lignified under the drought conditions; thick, heavily-wooded shoots were not used in this experiment. Other possible reasons include influence of previous plant history, as the stockhedge was relatively young, or even possible positional effects within the field. The cuttings removed from the Late treatment were generally longer and thicker than those from other treatments, resulting in a large dry matter index (14.77) for the relatively limited numbers of cuttings collected (Table 7). Similarly, these cuttings had a significantly higher dry/fresh weight ratio (0.228) than cuttings excised at the same time from the Early (0.206) or Mid treatments (0.208, Table 8). Greatest dry matter removal from the stockplants throughout the whole summer, however, was associated with the Early and Mid treatments, i.e. 27.84 and 28.20 dry matter indices, respectively (Table 7). Rooting ability was not affected by timing or frequency of cutting removal (Table 9).

Early removal of shoots reduced the diameter of the adjacent secondary stem from which the cutting was removed and limited expansion of the remaining stem below the excision point (Figures 4 and 5). The rate of increase in both the main stem and side shoot diameters in all treatments decreased after mid-August, although the shoots of the plants in the Late treatment elongated before they were excised, after the application of seep-hose irrigation (Figure 6). Despite irrigation, the dry/fresh weight ratio was less in cuttings of the Early treatment harvested in September, compared to those excised in June or July (Table 10).

Table 6

Forsythia - Mean number of cuttings per plant, and collection dates

	Harvest		
Date	Early	Mid	Late
6.6.95	12	-	-
31.7.95	4	12	-
13.9.95	10	8	7
Total	26	20	7

Table 7

Forsythia - Dry matter index (number of cuttings harvested x mean dry weight)

	Harvest		
Date	Early	Mid	Late
6.6.95	12.12	-	-
31.7.95	4.52	20.52	-
13.9.95	11.20	7.68	14.77
Total	27.84	28.20	14.77

Table 8

Mean ratio of dry to rehydrated fresh weight in cuttings collected in September, 1995

Species/Harvest	Date	Early	Mid	Late	LSD
Forsythia	13.9.95	0.206	0.208	0.228	0.010
Garrya	5.9.95	0.354	0.389	0.384	0.014
Weigela	11.9.95	0.248	0.245	0.248	0.007

Table 9

Rooting ability as affected by harvest time and frequency. Number of cuttings rooted and established (per 20)

Species/Harvest	Date	Early	Mid	Late
Forsythia				
1	6.6.95	20	-	-
2	31.7.95	20	20	-
3	13.9.95	20	20	20
Garrya				
1	5.6.95	19	-	-
2	27.7.95	19	18	-
3	5.9.95	14	14	12
Weigela				
1	6.6.95	19	-	-
2	26.7.95	20	20	-
3	11.9.95	20	20	20

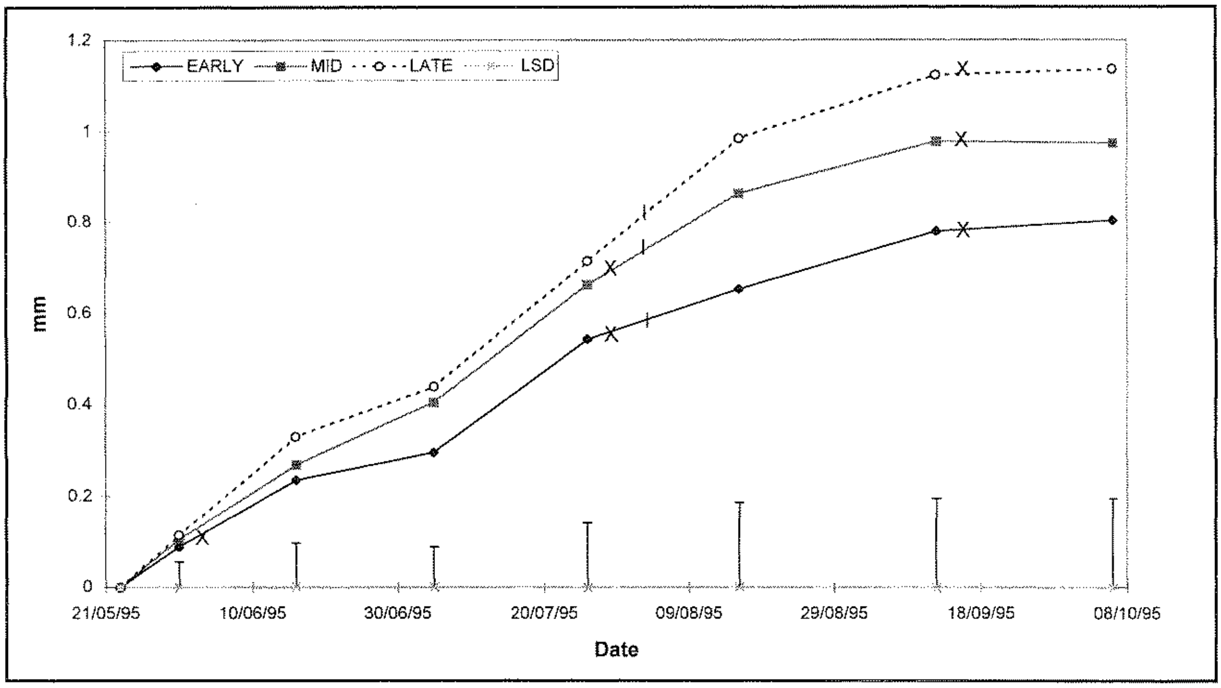

Figure 4. *Forsythia* - Effects of pruning time on increase in mean secondary stem diameter

Key: X = Date of cutting collection
I = Start of irrigation

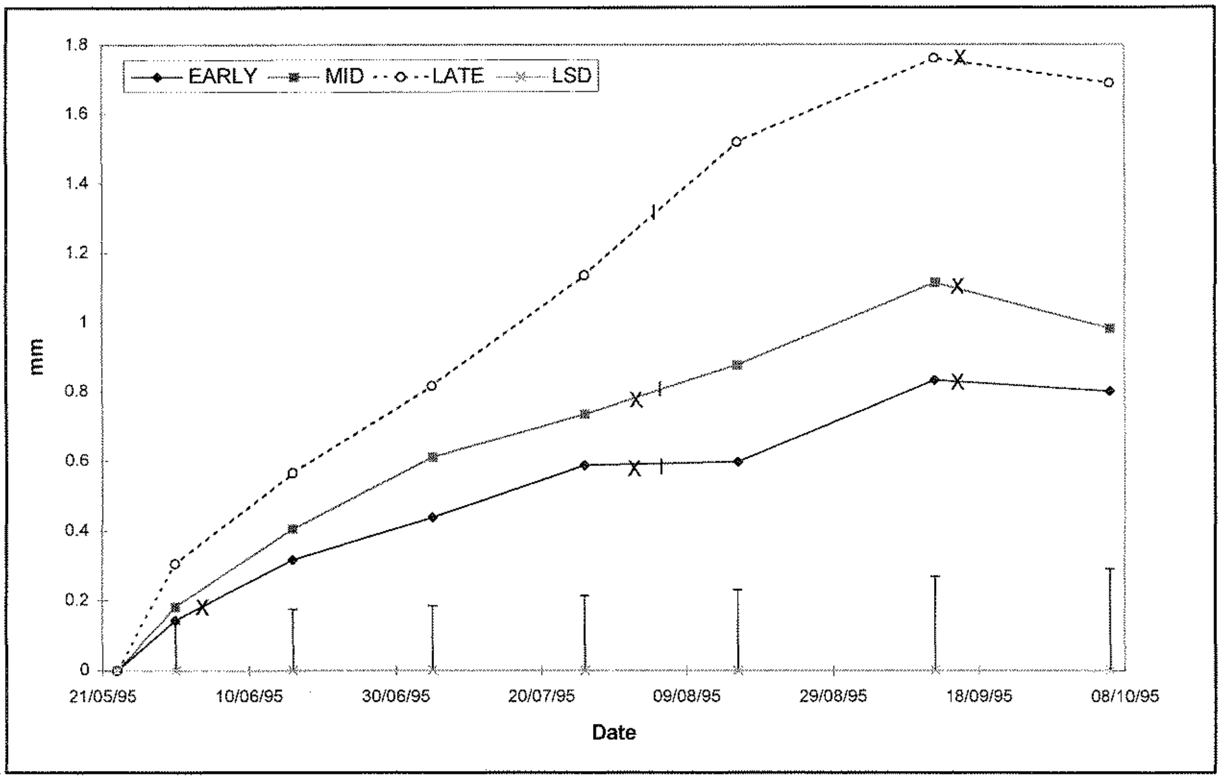

Figure 5. *Forsythia* - Effects of pruning time on increase in mean tertiary shoot diameter

Key: X = Date of cutting collection
I = Start of irrigation

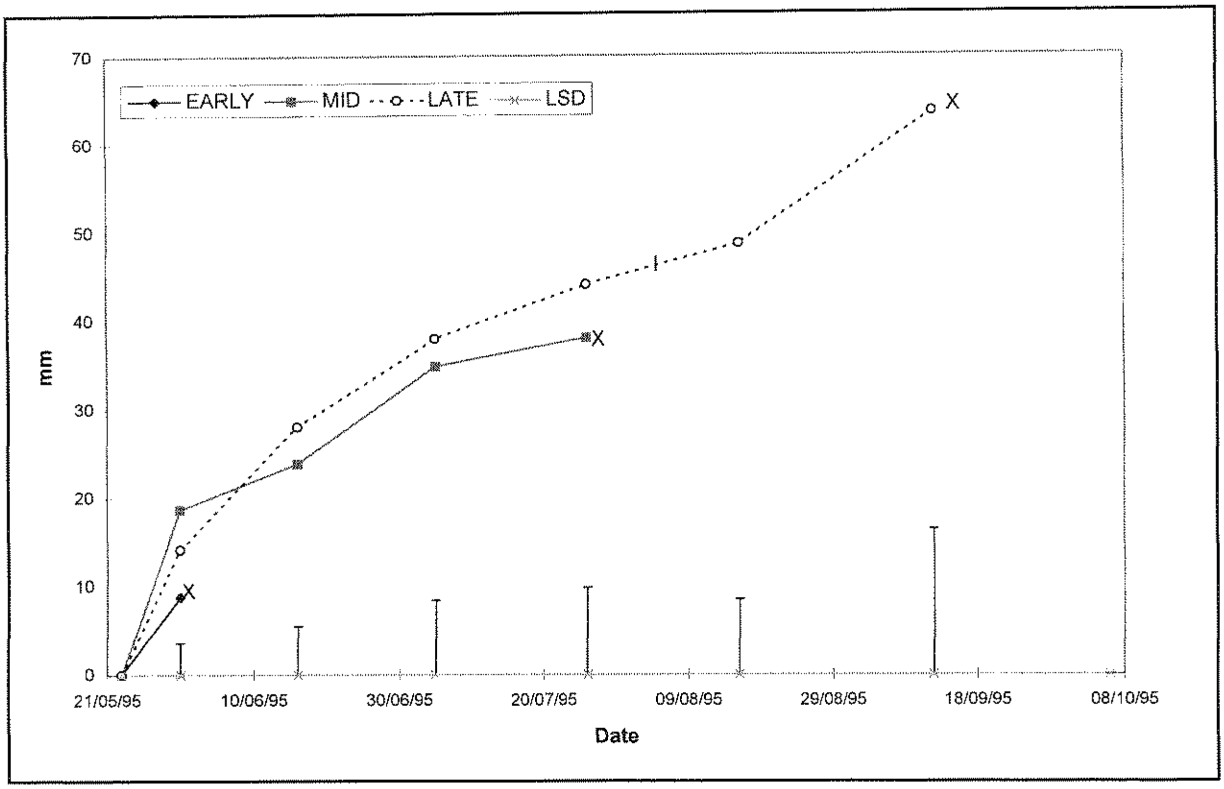

Figure 6. *Forsythia* - Effects of pruning time on increase of mean tertiary shoot length

Key: X = Date of cutting collection
I = Start of irrigation

Table 10

Change in mean ratio of dry to rehydrated fresh weight in cuttings collected from the Early harvested stockplants and subsequently re-harvested

	Harvest			
Species	1	2	3	LSD
Date	6.6.95	31.7.95	13.9.95	
Forsythia	0.304	0.296	0.206	0.006
Date	5.6.95	27.7.95	5.9.95	
Garrya	0.261	0.266	0.354	0.015
Date	6.6.95	27.6.95	11.9.95	
Weigela	0.214	0.248	0.248	0.022

Garrya

Early removal of *Garrya* cuttings with repeat harvesting in July and September resulted in more than twice the total number of cuttings being produced (774) compared to Mid (331) and Late (326) collection (Table 11). Largest and heaviest cuttings, however, were from the Late harvest treatment with a dry matter index of 2898 (Table 12). Removing cuttings early in the season reduced stem thickening on the stockplants compared to Mid and Late harvests (Figure 7) and shoot diameter below the excision point actually decreased after removal of the apical section of the shoot (Figure 8). Shoot extension was rapid through early and mid-summer with the rate of growth slowing by mid-August (Figure 9). *Garrya* generally appeared unaffected by drought stress with no external symptoms of leaf or stem wilting apparent, This was reflected by higher dry/fresh weight ratios in cuttings from the Mid and Late treatments (Table 8) and indeed with September harvested cuttings in the Early treatment (Table 10). Rooting percentage decreased with later harvesting of cuttings (Table 9), but this may relate as much to less suitable rooting conditions in September (lower light levels or cooler temperatures in the fog tunnel), as physiological differences in the cuttings.

Weigela

As with *Garrya* the greatest numbers of cuttings was accumulated from the Early harvest treatments, although the highest yield from any single collection was in the Late treatment (201 cuttings per plant - Table 13). The dry matter index also indicated that the greatest removal of dry matter actually occurred with the single Late harvest (Table 14). Trends in stem girth throughout the summer were more difficult to interpret than in the other two species and possibly related as much to changing moisture balance within stockplants as to treatment effects (Figures 10 and 11). For example, shoot diameter generally increased after irrigation (Figure 11). Early removal of cuttings tended to limit expansion of the adjacent main stems during early June, but stem diameter increased rapidly during early July and this may have been related to axillary bud activity and new shoot development.

Shoot elongation was still apparent as late as August and the largest cuttings were available after the last harvest date in September (Figure 12). After harvesting in September there was no significant difference in dry/fresh weight ratios of cuttings collected from different treatments (Table 8). There was an upward trend, however, in dry/fresh weight ratios of the Early treatment with cuttings collected in July and September (0.248) compared to June (0.214, Table 10). Rooting ability, however, was uniform throughout the summer (Table 9).

Conclusions

Continuing the 1994 stockplant pruning experiment into 1995, showed that effects on cutting production from different pruning treatments in 1994 were still evident a year later. In terms of overall cuttings produced, the Light-Early pruning treatment was most beneficial in *Forsythia* and *Garrya*, whereas Light-Late gave best results in *Philadelphus*.

Table 11

Garrya - Mean number of cuttings per plant, and collection dates

	Harvest		
Date	Early	Mid	Late
5.6.95	461	-	-
27.7.95	251	284	-
5.9.95	62	47	326
Total	774	331	326

Table 12

Garrya - Dry matter index (number of cuttings harvested x mean dry weight)

	Harvest		
Date	Early	Mid	Late
5.6.95	798	-	-
27.7.95	605	1798	-
5.9.95	111	108	2898
Total	1514	1906	2898

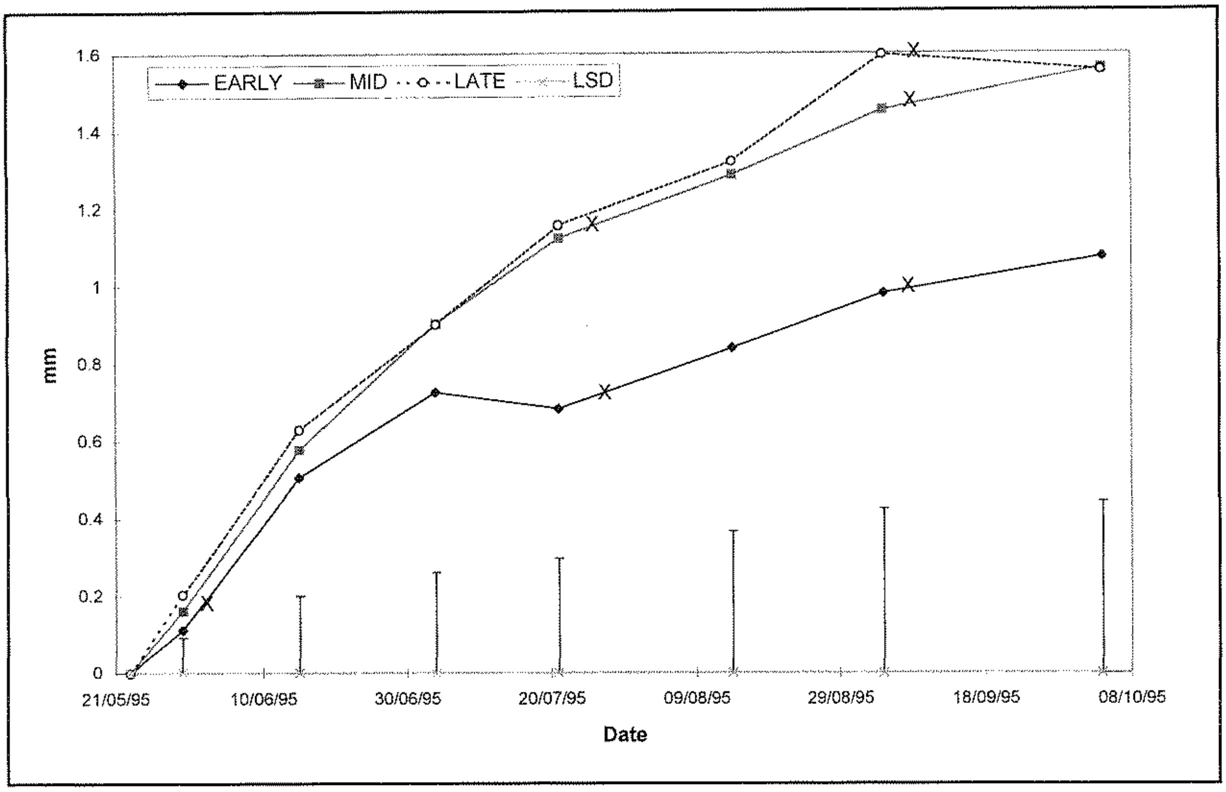

Figure 7. *Garrya* - Effects of pruning time on increase in mean secondary stem diameter

Key: X = Date of cutting collection

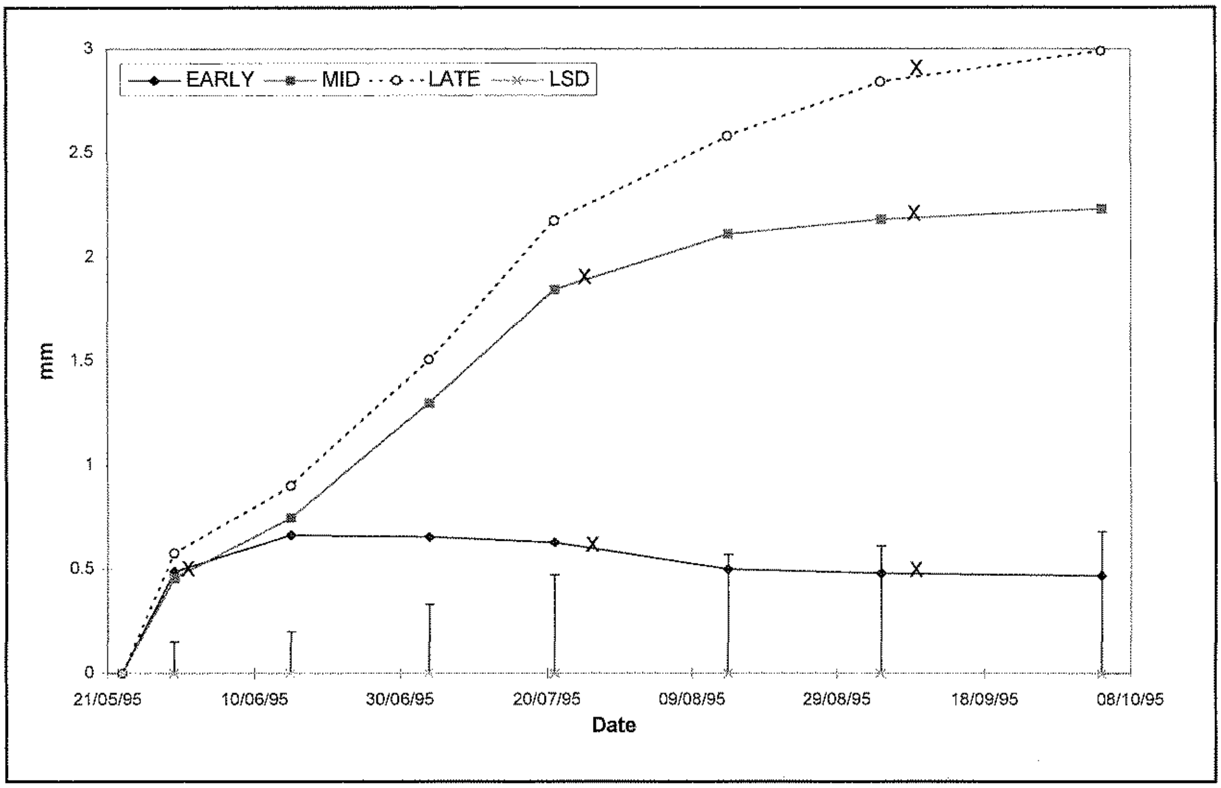

Figure 8. *Garrya* - Effects of pruning time on increase in mean tertiary shoot diameter

Key: X = Date of cutting collection

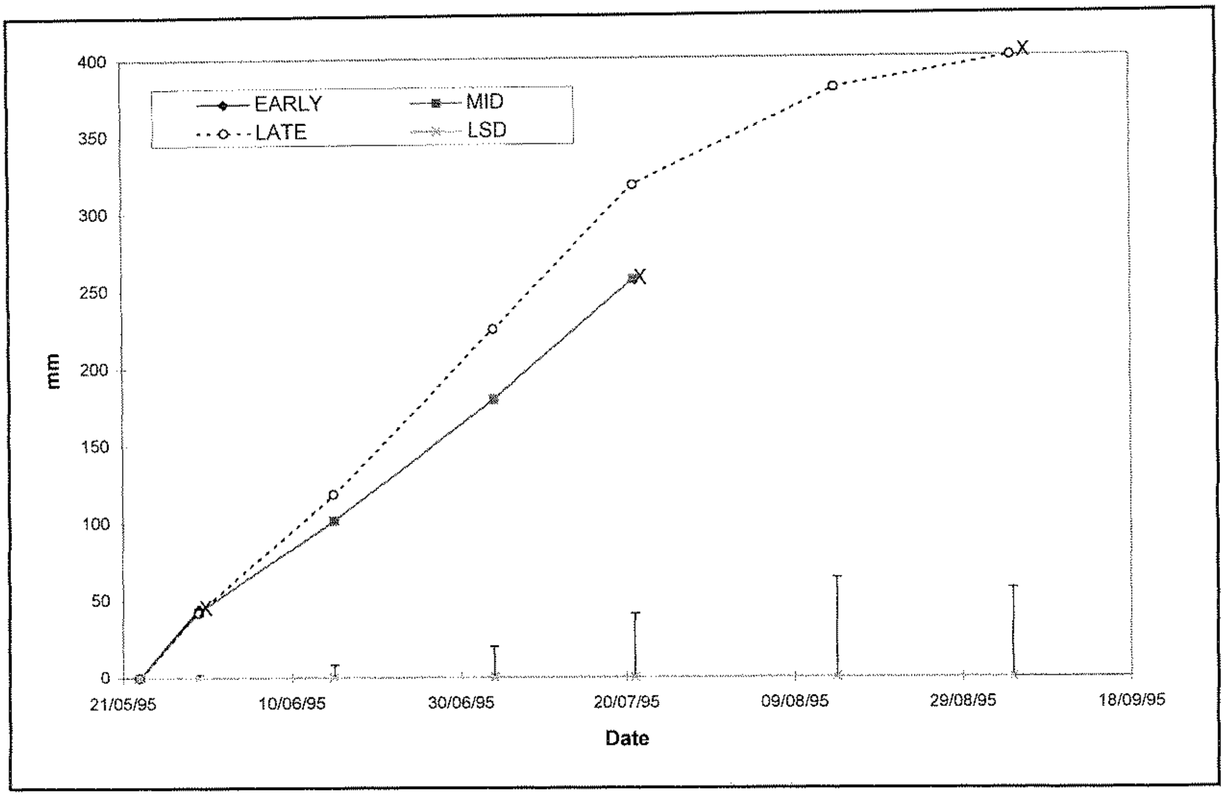

Figure 9. *Garrya* - Effects of pruning time on increase in mean tertiary shoot length

Key: X = Date of cutting collection

Table 13

Weigela - Mean number of cuttings per plant and collection dates

	Harvest		
Date	Early	Mid	Late
6.6.95	158	-	-
26.7.95	127	151	-
11.9.95	41	26	201
Total	326	177	201

Table 14

Weigela - Dry matter index (number of cuttings harvested x mean dry weight)

	Harvest		
Date	Early	Mid	Late
6.6.95	79	-	-
27.7.95	150	219	-
11.9.95	38	18	412
Total	267	237	412

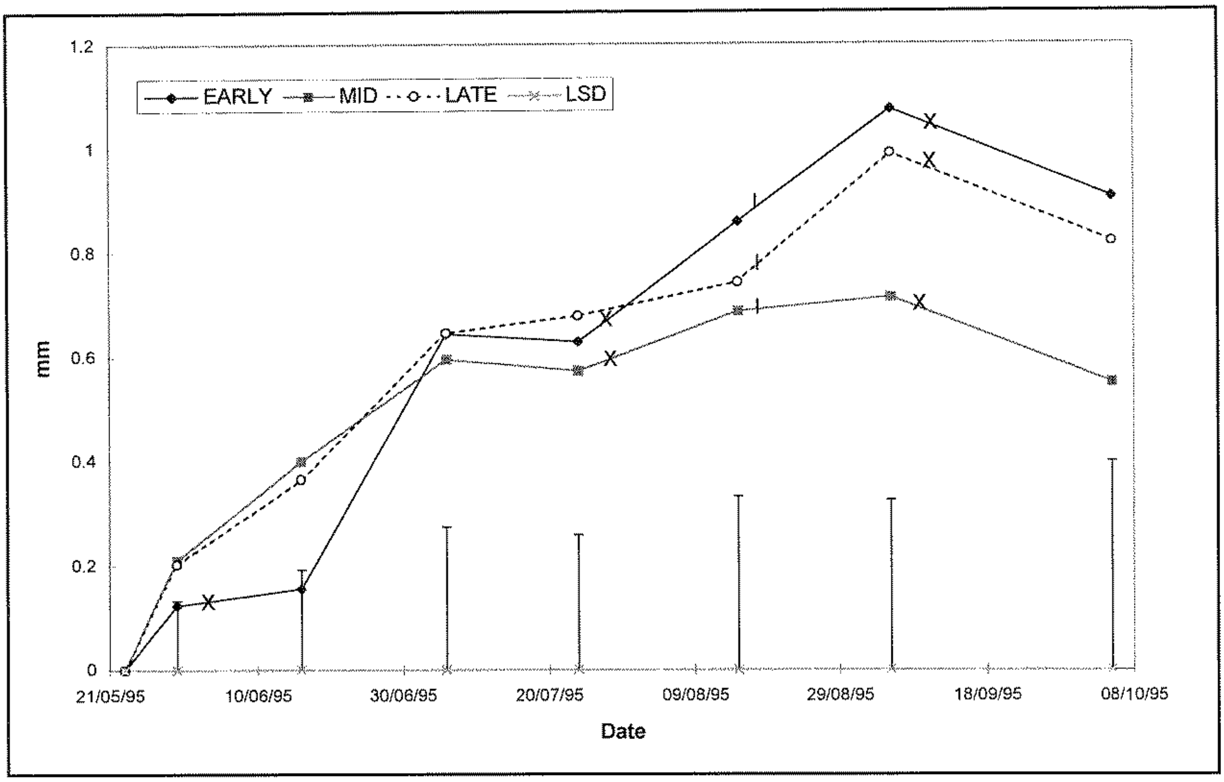

Figure 10. *Weigela* - Effects of pruning time on increase in mean secondary stem diameter

Key: X = Date of cutting collection
I = Start of irrigation

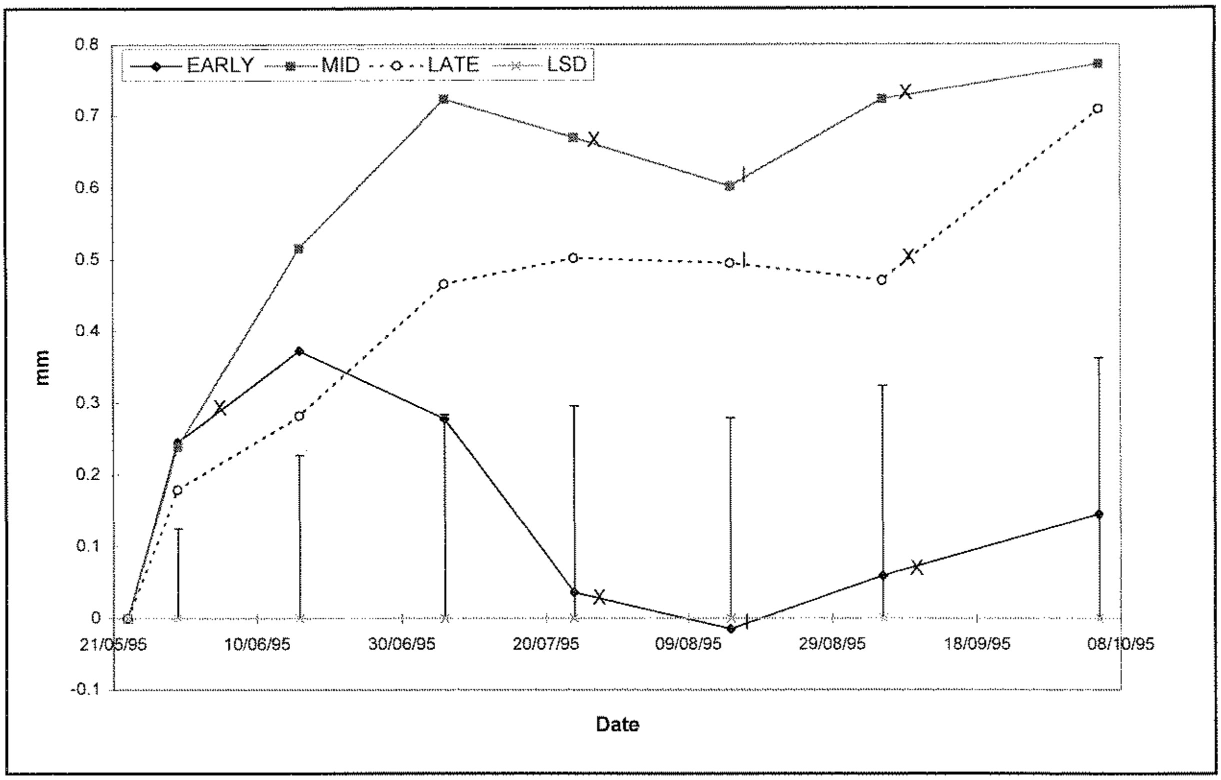

Figure 11. *Weigela* -Effects of pruning time on increase in mean tertiary shoot diameter

Key: X = Date of cutting collection
I = Start of irrigation

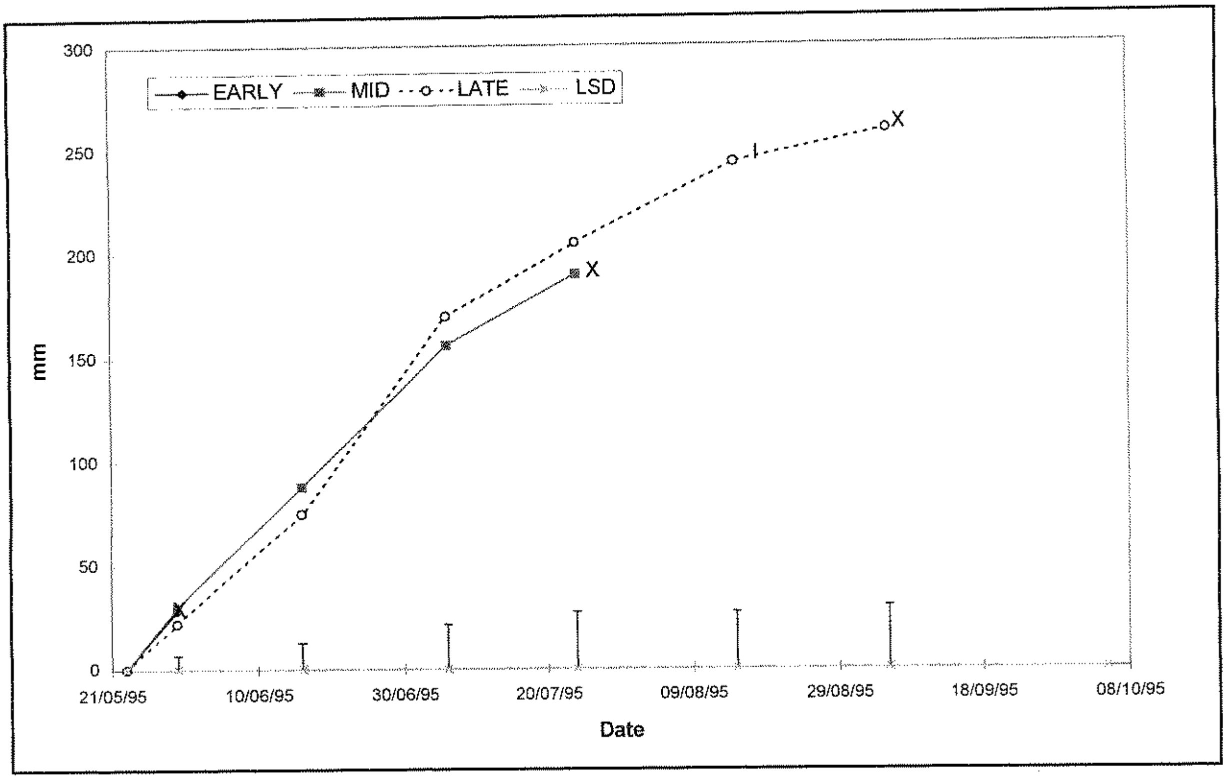

Figure 12. *Weigela* - Effects of pruning time on increase in mean tertiary shoot length

Key: X = Date of cutting collection
I = Start of irrigation

In *Forsythia*, with the exception of the Light-Late treatment, cutting production was less in the second year for each treatment compared to the results for 1994, but whether this was due to reduced plant vigour or weather effects such as limited water availability in the second year, is not clear. In contrast, cutting production generally increased between 1994 and 1995 with *Garrya* (especially the early pruned treatments) and *Philadelphus* (notably Light-Early, Light-Late and Severe-Late). This suggests that, although effects of pruning treatments may still be apparent after 15 months, in many cases the yield itself in the second year is not significantly affected by heavy harvesting of cuttings in the previous year. These results have probably been compounded by weather factors, but nevertheless they suggest that repeated cutting removal over at least a few years may not be as detrimental to the vitality and vigour of mother plants as previously envisaged. Adequate stamina for repeated cutting removal, however, assumes stockplants are well-established and have been properly managed, (i.e. with winter fertiliser application, weed control, adequate spacing, irrigation as necessary and avoiding excessive removal of wood).

Timing of cutting removal from stockplants was important in determining cutting production. Removing cuttings from stockplants early in the season and making repeated harvests from such plants, increased the overall number of cuttings obtained for all species tested, but in the case of *Forsythia* and *Garrya*, reduced the extent of secondary stem thickening, presumably due to less photosynthates being translocated back from the new shoots into the existing stem system. This may also have had an effect on carbohydrates available to new shoots, because the Late harvested cuttings in *Forsythia* had higher dry/fresh weight ratios than cuttings from either Early or Mid treatments when collected in September. Lower dry/fresh weight ratios however, did not appear to affect rooting ability in these cuttings. Similarly in *Garrya*, there appeared to be no advantage conferred in terms of rooting by having higher ratios of dry matter content in the cuttings because later harvests had greater dry weights but reduced rooting percentages, possibly reflecting increased lignification as well as carbohydrate. The lateness of season and external environmental factors, however, are likely to have strongly affected rate and extent of rooting during September, compared to that of cuttings propagated in June or July, especially in a relatively difficult-to-root subject such as *Garrya*, and given the ability of the wet fog system used at East Malling to support early summer cuttings of this stress-prone subject.

Results for *Weigela* differed in a number of ways from those of the other two species, and the Late harvest treatment was relatively productive in terms of cutting numbers compared to the Mid harvest treatment in this species. Results, however, may have been influenced by the application of irrigation on 16 August which encouraged shoot growth during August and September. Similarly, there was no significant difference in levels of secondary stem thickening between treatments at the end of the season, although the largest increases were actually associated with the Early harvest treatments. In the stockplants of the Early treatment, secondary stem thickening was initially slow, but increased more rapidly than in other treatments after mid-June and this possibly related to the development of new small shoots in the axils of the original excised shoot. Such bud swelling and subsequent shoot extension could account for the increase in secondary stem thickness near the node.

Early and repeat harvesting would appear to reduce the amount of carbohydrate accumulated in the more mature wood of the stockplant, and over a number of years this could have a significant effect on stockplant size and possibly long-term vigour. Early cutting removal, however, does appear to stimulate further shoot growth during mid-summer and thus increase overall production; in the case of *Garrya* this was in excess of 100% compared to Mid or Late harvesting periods. Additionally, the loss of any reserves by continually removing the new shoots may be minimal (providing primary and secondary stems are well-furnished with fully functional leaves) compared to the severity of the original stockplant pruning treatment. Implementing a severe pruning regime, by removing much of the mature wood, may have a greater effect on limiting cutting productivity than frequent 'grazing' of softwood cuttings during the season.

It is difficult to identify the contribution that tertiary shoots make to overall carbohydrate production in the stockplant compared to that from existing leaves on primary and secondary branches, especially as photosynthates will be translocated relatively large distances. Nevertheless, results suggest (most notably in the case of *Garrya*) that early removal of cuttings (approximate size 12-20 cm) reduced secondary stem thickening to a greater extent than leaving cuttings until the Mid harvest date (approximate size 17-32 cm). Indeed, there was no statistical difference in secondary stem thickening between Mid and Late harvested stockplants. Therefore, after new shoots reach a certain size (in this particular example approximately 20 cm) they appear to no longer tax the resources of the parent plant and probably photosynthesise and produce sufficient reserves to support their own cell respiration and growth.

In conclusion, the frequency and extent to which cuttings can be removed from stockplants will primarily depend on the original pruning treatment, with these results indicating that light pruning early in the season generally gives highest yields. Secondly, it is important to avoid excessive pruning and harvesting of recently planted stockplants. These results again suggest, however, that well-established plants can tolerate up to three cutting harvests a year over a number of consecutive years without excessive detriment to plant vigour.

b) Stockplant dark-preconditioning

Materials and methods

The stockplant hedges, general management, method of covering plants for dark-preconditioning and cutting-collection details were as described previously in the 1994 Annual Report.

Aspects of the work specific to the third year were as follows:

Overwintering of plants propagated in 1994

Having potted on into 1 litre pots after weaning, plants from each propagation treatment were subdivided and placed pot-thick in 'Empot' carriers either standing on mypex in an outdoor frame and with overhead irrigation, or on a capillary 'Efford bed' in a polythene house. Survival and growth were measured during the winter (see Annual Report for 1994, pp 22, 23 and 25) and because those in the polyhouse were expected to produce strong upright growth the next spring half the plants in each treatment combination were pruned by shortening back (mainly the original cutting) by half its height.

Plants of all three subjects were overwintered in the same frame and polyhouse, without irrigation until growth began in spring 1995.

Overwinter survival and growth during 1995 were recorded.

1995 propagations

Dark-preconditioned and normal light-grown cuttings of *Syringa vulgaris* 'Madame Lemoine' and 'Charles Joly', *Corylus avellana* 'Aurea', and *Elaeagnus pungens* 'Maculata' were propagated in 7 cm square (0.35 litre) pots containing equal parts of fine bark and peat as previously described, with each variety and source of cutting placed in both wet fog (Agritech) and open mist. The fog house was well-sealed to retain high humidity and with visible fog being present for most of the daylight period. Especially heavy fog was produced in sunny periods to provide generous leaf wetting and high humidity, under the control of the East Malling 'evapo-sensor' (Harrison-Murray, 1995). Mist was provided overhead in a ventilated polythene house, with side curtains to the bed to prevent cross draughts. Control was by 'artificial leaf', giving good leaf-wetting in daylight hours, but not as high humidity as in fog. In both environments the pots in their carriers were stood on sandbeds to facilitate drainage, with bottom heat provided at a minimum of approximately 20°C.

After weaning by placing cuttings from both environments under mist with rapidly reducing frequency during the course of a week, cuttings were transferred to an open-sand bed in a less-shaded part of the polythene house and hand-watered daily.

Survival was recorded and established cuttings were demonstrated at HDC Study Days on 19th and 20th July, along with one-year-old plants from the previous season.

The calendar of operations for the 1995 propagations is shown in Table 15.

An ancillary experiment with *S. vulgaris* 'Mme Lemoine' investigated cheaper ways of dark-preconditioning shoots than with the metal-framed structures used experimentally. At intervals, shoots on opposite sides of the hedge were left unpruned and then tied together to form a hoop over which a black polythene sheet was placed, anchored by concrete blocks.

Recording and statistics

At collection cuttings were described to include length, number of leaves, the diameter of the proximal internode and the dry matter content of the stem. These last two characteristics are affected particularly by dark-preconditioning. Observations were made of the appearance of cuttings when subjected to marked change in conditions at weaning, and establishment was assessed in terms of the proportion of cuttings which at the end of weaning had rooted through the bottom of the pot, had not rooted through but were alive and resisted a gentle tug, or were severely wilted or necrotic and proved to be dead on removal.

Thirty cuttings were propagated for each treatment combination of variety, stockplant management and propagation environment, giving 60 cuttings for assessment of overall main effects in each of the four subjects.

Within any treatment combination cuttings were graded into three experimental replicates (I = large, III = small) and the carriers were placed adjacent to one another in very uniform conditions. This was preferred to randomising treatments because of the likely interference between cuttings which grew at different rates during propagation.

Data were analysed statistically by appropriate methods. The probability values attached to data in tables of 0.1, 1.0 and 5.0% are the likelihood of treatments differing by chance (*NS* = no significant difference). Therefore, a 5% probability implies a 95% chance that differences are due to treatments and not to random effects. To assist in comparing data

Table 15

Calendar of operations 1995

	S. vulgaris 'Madame Lemoine'	*S. vulgaris* 'Charles Joly'	*Corylus avellana* 'Aurea'	*Elaeagnus pungens* 'Maculata'
Apply black polythene covers	28th April	28th April	5th May	5th May
Start weaning into light	12th May	12th May	22nd May	22nd May*
Collect cuttings, propagate in wet fog or mist	31st May	1st June	5th June	15th June
Wean in reducing mist	26th June	26th June	3rd July	3rd July
Move from mist, hand water	3rd July	3rd July	10th July	14th August
Record establishment	11th August	11th August	11th August	5th September

* Cover removed over an extended period. In all cases frames were progressively opened so that shoots were receiving approximately 50% light at cutting collection, which guards against sun scorch, and is a higher level than the 20% light experienced in the propagation bed.

the least significant difference (LSD) is given. This is the smallest difference between any two mean values that is significant at the 5% level of probability.

Weather

June 1995, the month when cuttings were being propagated in the distinctly different wet fog and open mist environments, was unusually dull. There were 45 (19%) fewer sunshine hours than in May, and 75 (29%) fewer than in July. The particularly critical week of 11th June, when root initiation would have been advanced in the two *Syringa* cvs, and starting in *Corylus* was particularly dull, with a total of only 5.8 hours of sunshine. Normally June is a sunny month, for example June 1994 had 99 (53%) more sunshine hours than June, 1995.

Weather during propagation is important because dark-preconditioned cuttings require higher light levels than normal cuttings in order to realise their rooting potential (Howard and Ridout, 1992; Howard and Harrison-Murray, 1995). If they are not able to accumulate photosynthates they develop necrosis and often rot entirely in dull warm conditions.

Results

Overwintering and growing-on of 1994 propagated cuttings

S. vulgaris 'Mme Lemoine' and 'Charles Joly'

The most notable effect was the loss of many plants in the outside frame (Table 16) from severe frosts (air -3.2°C and ground -8.0°C) which occurred over a number of nights in mid-April after new shoots had begun to grow. Although the blackened wilted shoots were typical of infection by the bacterial pathogen *Pseudomonas syringae*, which is endemic in lilacs and whose pathogenicity is enhanced by stresses such as frost, no evidence of the disease organism could be detected in laboratory cultures.

There is no explanation for the fact that plants of 'Mme Lemoine' derived from cuttings forced under clear polythene and propagated in mid-May suffered significantly less damage than others. Also of interest was the fact that in the same frame were plants of the same two lilac varieties either from other experiments or previous years, which did not show the same severity of damage. It was not possible to say retrospectively whether new shoot growth was at the same stage of frost susceptibility in the different batches of plants.

At the same time, plants in the polythene house were growing vigorously in response to raised ambient air temperatures. None suffered obvious frost damage and most survived (Table 16). In the absence of frost damage the numbers of plants growing as liners in 1995 reflected the success of the initial 1994 propagation treatments. As shown in the Annual Report for 1994 p 21, for the difficult-to-propagate 'Mme Lemoine' the treatment order (with % establishment success in brackets) was dark-preconditioning (96%) > forcing under clear polythene (84%) > normal light-grown cuttings (71% in both mid-May and early June). Reference to the 1994 Annual Report indicates that the remarkably good results of normal light-grown cuttings was associated with a prolonged weaning period during which cuttings

Table 16

Mid-May 1995 survival of 1994-propagated *Syringa vulgaris* cvs, as a percentage of those alive in early January. Losses outside were asssociated with severe spring frosts.

	Overwinter environments	
Cutting sources	Polythene	Outside frame
'Mme Lemoine'		
Normal, propagated mid-May	100	35
Forced under clear polythene and propagated mid-May	100	88
Normal, propagated early June	100	22
Dark-preconditioned, propagated early June	90	26
P for polyhouse v outside = 0.1%, for treatments = 1.0%, LSD = 22.4		
'Charles Joly'		
Normal, lightly-pruned hedge, propagated early June	100	64
Dark-preconditioned, lightly-pruned hedge, propagated early June	100	61
Normal, severely-pruned hedge, propagated early June	100	49
Dark-preconditioned, severely-pruned hedge, propagated early June	100	78
P for polyhouse v outside = 0.1%, for treatments = *NS*, LSD = 21.0		

continued to root.

Plants in 1995 grew earlier and faster in the polythene house, such that when measured in mid-May 1995, less than a year from taking the cuttings, they were significantly taller than the survivors of those overwintered and grown-on in the outside frame, although lateral production was similar in the two batches of 'Mme Lemoine' and more laterals were produced on outside plants of 'Charles Joly' compared to those in the polyhouse. The normal light-grown cuttings of 'Mme Lemoine' propagated in mid-May produced the largest plants, whereas the normal severely-pruned source of 'Charles Joly' produced the smallest plants, and little importance is attached to these effects compared to the effects of the growing environment. Pruning, by reducing the height of plants (mainly the original cutting) by approximately half in mid-winter had little effect on growth or lateral production. Taken over both varieties and all treatment combinations pruning reduced the average plant height from 70.4 to 69.0 cm, and the number of laterals from 4.5 to 3.0 (by reducing the length of stem over which laterals could emerge). A further growth-record in early September showed that most growth had occurred by the earlier mid-May record, with only a further 19% increase in the height of the polyhouse plants, averaged over all sources. It was mainly the smaller plants when measured in mid-May that continued to grow later, but September growth data are not strictly comparable with those in May because a few plants were removed for demonstration at the Study Days, and therefore September data are not shown.

Growth responses as determined in mid-May, are shown in Table 17.

Corylus avellana 'Aurea'

This subject suffered no obvious frost damage, although 50% of the established plants from the normal light-grown lightly-pruned source failed to overwinter outside, whereas virtually all of those from the dark-preconditioned bushes (irrespective of pruning severity) and from the normal severely-pruned bushes survived outside, and virtually all plants from all treatments survived in the polyhouse.

Growth was earlier and faster in the polythene tunnel, but the normal problem of aphid control on this species was exacerbated in these vigorously growing pot-thick plants.

The main effect shown in Table 18 is that growth by mid-May was much more advanced in the polythene house than outside and with the overall effect of dark-preconditioning significantly increasing numbers of laterals. The effects of pruning (averaged in this table) were considerable. Pruning reduced plant height from an overall average of 71 to 49 cm, and reduced laterals from an average of 9.4 to 3.7 by removing stems with lateral-producing potential.

1995 propagation

Syringa vulgaris 'Mme Lemoine'

Cuttings were prepared to 22-25 cm (approx. 9 in) by trimming below a node and

Table 17

Size of *Syringa vulgaris* plants propagated in 1994 and measured in mid-May 1995, given as height from compost (cm), and number of laterals in brackets

Cuttings sources	Overwinter environments: Polyhouse (average of pruned and unpruned plants)	Overwinter environments: Outside frame
<u>'Mme Lemoine'</u>		
Light-grown, propagated mid-May	94.9 (2.9)	35.3 (5.6)
Forced under clear polythene and propagated mid-May	*70.3 (3.0)	39.5 (2.9)
Light-grown, propagated early June	*66.8 (3.2)	FD
Dark-preconditioned and propagated early June	*65.0 (3.3)	FD
P Height: for polyhouse v outside = 0.1%, for treatments = 1.0%, LSD = 17.7		
P Nos. of laterals: for polyhouse v outside = *NS*, for treatments = 5.0%, LSD = 1.5		
<u>'Charles Joly'</u> (all propagated early June)		
Light-grown, moderately-pruned hedge	69.9 (3.8)	33.1(6.4)
Dark-preconditioned moderately-pruned hedge	63.6 (4.1)	33.4(7.0)
Light-grown, severely-pruned hedge	57.4 (4.6)	FD
Dark-preconditioned severely-pruned hedge	68.8 (5.3)	31.1(7.2)
P Height: for polyhouse v outside - 0.1%, for treatment = 5.0%, LSD - 11.8		
P Nos. of laterals: for polyhouse v outside = 0.1%, for treatment = *NS*, LSD = 2.4		

FD = Inadequate sample due to frost damage

* = Treatments showing most growth **after** the record, such that final differences were small

removing one pair of leaves, ensuring that the cutting retained one pair of fully expanded leaves, with usually immature leaves at another node and within the apex. The stem measured at the proximal internode was thinner, and the total stem had a lower percent dry matter content, in cuttings from the dark-preconditioned source compared to the normal light-grown source (Table 19).

During the rooting period a number of dark-preconditioned cuttings in the 'wet fog', and to a lesser extent control cuttings in the open mist, developed necrosis, the stem rotting extensively and all leaves abscissing. This is typical of a response to exceptionally low light conditions aggravated by higher temperatures in the closed fog environment. The problem was no doubt exacerbated by cuttings in the warm dull fog conditions producing soft extension growth which did not occur in the cooler mist conditions.

Weaning took place during a hot stressful period, and in contrast to 1994, the planned programme of rapid weaning within a one week period was adhered to as a severe test of the material.

All cuttings that had been transferred directly from wet fog visibly wilted. Cuttings which had been dark-preconditioned looked particularly stressed due to necrosis, and the rapid die-back of the succulent new apical growth that developed during propagation. Least adversely affected were the dark-preconditioned cuttings in open mist which did not produce stress-sensitive succulent new growth or develop extensive stem necrosis. Cuttings of different treatment combinations showed different degrees of apparent adverse reaction to abrupt weaning, suggesting that of greater importance than the extent and nature of tip growth was the frequency and quality of rooting.

In both propagation environments the majority of dark-preconditioned cuttings were recorded as established on the basis of roots emerging from the pots and with only a few needing to be judged on the basis of not wilting and being resistant to gentle tugging.

On the other hand, the majority of light-grown control cuttings were judged as established on the basis of not wilting, but without emerging roots, suggesting that rooting was slower in these cuttings from the normal source.

Results confirmed that the appearance of the tops and especially the dieback of new growth in the wet fog, gave an impression of more severe stress than was actually the case. Highest establishment was of dark-preconditioned cuttings in open mist followed by those in wet fog. Light-grown control cuttings in both fog and mist established poorly (Table 20).

The attempt at producing dark-preconditioned cuttings in a cheap structure was only partly successful because the hoop of branches did not allow sufficient space for shoots to grow and many were damaged when their tips touched the hot black polythene, suggesting that a self-support system needs to be developed over two years. An interesting response was that many shoots with damaged tips produced laterals, which is difficult to achieve by removing shoot tips of lilac grown in the light.

Little new growth had occurred when plants were measured in early August, but those propagated in wet fog were consistently slightly taller than those from open mist, indicating

Table 18

Size of *Corylus avellana* 'Aurea' plants propagated in 1994 and measured in mid-May 1995, given as height from the compost (cm), and number of laterals in brackets

Cutting source (all propagated early June)	Overwinter environment	
	Polyhouse (average of pruned and unpruned plants)	Outside frame
Light grown, moderately-pruned	60.8 (6.0)	35.3 (5.8)
Dark-preconditioned, moderately-pruned	59.9 (7.8)	46.7 (9.4)
Light grown, severely-pruned	53.8 (5.5)	36.4 (6.9)
Dark-preconditioned, severely-pruned	61.4 (7.2)	44.3 (8.1)

P Height: for polyhouse v outside = 0.1%, treatements = *NS*, LSD = 11.8

P Nos. of laterals: for polyhouse v outside = *NS*, treatments = 5.0%, LSD = 2.8

Table 19

Pre-rooting characteristics of *Syringa vulgaris* 'Mme Lemoine' cuttings

	Normal light-grown	Dark-preconditioned
Cutting length (cm)	25.5	21.5
Number of leaves retained	8.6	8.6
Proximal stem diameter (mm)	4.4	3.5
Percent stem dry matter	19.4	16.0

that some of the new growth forced during propagation had survived.

Syringa vulgaris 'Charles Joly'

Cuttings of both sources were approximately 22 cm (9 in) in length with an average of 7.6 retained leaves. Cuttings from the dark-preconditioned source compared to normal light-grown ones had thinner stems (3.6 v 4.1 mm) and lower dry matter content (15.8 v 20.6%).

This more ready-rooting variety was less adversely affected by dull warm conditions in the wet-fog than 'Mme Lemoine', but control cuttings from that environment were the most stressed during weaning, and this was confirmed by establishment records, whereas the combination of dark-preconditioning and wet fog gave the highest establishment although inherent variation prevented differences reaching significance. (Table 21).

When measured in early August control cuttings from wet fog were 31% taller than those from open mist, and dark-preconditioned cuttings from wet fog were 58% taller. Although in absolute terms relatively little growth occurred, this demonstrates that the soft tip growth which occurred during the rooting stage had a higher survival capacity when supported by the better root system of this easier-to-propagate variety compared to 'Mme Lemoine'.

Corylus avellana 'Aurea'

At collection cuttings from both the light-grown and dark-preconditioned sources were approximately 16.5 cm long (6½ in) with an average of 4.5 retained leaves. Again, for dark-preconditioned cuttings compared to light-grown ones, the proximal stem diameter was slightly smaller (2.9 v 3.1 mm) and the percent total stem dry matter lower (16.5 v 18.7%).

As was the case for *Syringa* soft terminal growth that developed in the dull warm conditions of the wet fog shrivelled during the rapid weaning process, but the importance of this was minimal where rooting due to dark-preconditioning was heavy. Dark-preconditioning enhanced establishment significantly, whereas mist favoured better growth, no doubt because of the loss of the soft growth developed in the wet fog (Table 22).

By mid-August significant growth had occurred in all but the poorest-rooted treatment combination (Table 22).

Elaeagnus pungens 'Maculata'

The effect of a prolonged period of dark-preconditioning was to enhance the normal slow growth, such that cuttings were longer than normal light-grown controls (17.3 v 11.9 cm) but had approximately the same average number of leaves (5.7). The longer cutting from the dark-preconditioned source resulted in a thicker proximal stem (3.1 v 2.7 mm) but the percent dry matter content was still less (20.3 v 26.8%) compared to light-grown

Table 20

Percent establishment post-weaning of *Syringa vulgaris* 'Mme Lemoine' cuttings

	Open mist	Wet fog
Light-grown control	23	33
Dark-preconditioned	70	60

P Light-grown v dark-preconditioned = 0.5%

LSD for all comparisons = 33.9

Table 21

Percent establishment post-weaning of *Syringa vulgaris* 'Charles Joly' cuttings

	Open mist	Wet fog
Light-grown control	73	43
Dark-preconditioned	77	87

P = *NS*, LSD = 48.7

controls. Had cuttings been prepared to the same length it is likely that those dark-preconditioned would have had thinner stems at their base than the normal light-grown ones.

The main effect on rooting and establishment was due to propagation environment, with cuttings in the wet fog significantly out-performing those in open mist, although more leaves abscissed from the former during subsequent weaning than from the open mist cuttings. Establishment data are given in Table 23. Because the condition of those not rooting-through, but apparently alive, was not easily determined, these data are shown separately and trends for both classes of cutting were similar. No growth occurred subsequent to weaning.

Discussion

With respect to 1994 rooted cuttings grown-on in 1995, the number of *Syringa* plants produced was closely related to the effectiveness of the initial propagation stage, with the singular exception of losses due to severe spring frosts in those overwintered outside. In retrospect, it is difficult to understand why these plants suffered more losses than others of different age and origin nearby, especially because any difference in hardiness would be expected to apply to the overwintering plant, not the new growth developing in spring.

Whereas, in the absence of frost damage, production relates closely to initial propagation success, plant quality relates closely to growing conditions. Plants overwintered in the polyhouse started into growth early and grew rapidly, but at close density produced no more laterals than the survivors of those grown outside, so that the latter were more compact and of better quality. It was also clear that if plants were to be forced under polythene, not only would they need more space, but the compost would need supplementary fertilizer, which is difficult to apply effectively on capillary beds other than by occasional liquid-feeding.

Even so, given that lilac plants grow annually for only about 10 weeks, the use of large cuttings rooted and established rapidly give rise to large and good quality liners within 12 month period from cutting collection.

Similar conclusions can be drawn for *Corylus avellana* 'Aurea'. The propagation stage determines production success and growing-on conditions determine plant quality, with those grown outside being more compact than those forced in the polyhouse. Dark-preconditioning severely-pruned hedges provides the best foundation for success.

The 1995 propagation results were interesting from two distinct points of view.

June was an abnormally dull month, which when combined with the shaded but relatively warm conditions in the sealed wet fog propagation house, encouraged tissue breakdown and necrosis, with entire cuttings rotting in extreme cases. Dark-preconditioned cuttings are particularly vulnerable for two reasons.

As part of the dark-preconditioning enhancement of rooting potential they become semi-starved, producing less stem material with no loss of leaf area, such that given good

Table 22

Percent establishment post-weaning of *Corylus avellana* 'Aurea' cuttings, with height from pot by mid-August (cm) in brackets

	Open mist	Wet fog
Light-grown control	27 (32)	10 (18)
Dark-preconditioned	93 (36)	93 (27)

P Establishment: Light-grown v dark preconditioned = 0.1%, LSD for all comparisons 19.9

P Height: mist v fog = 5.0%, LSD for all comparisons = 14.0

Table 23

Percent establishment of *Elaeagnus pungens* 'Maculata' as cuttings rooting through the pot, with the total of these and those alive but non-rooted-through cuttings in brackets

	Open mist	Wet fog
Light-grown control	43 (53)	60 (93)
Dark-preconditioned	33 (47)	70 (70)

P Rooted through: mist v fog = 5.0%, LSD for all comparisons = 30.2

P Rooted through and alive: mist v fog = 1.0%, LSD for all comparisons = 27.5

photosynthesising conditions during rooting, these cuttings with a relatively high leaf:stem ratio produce more carbohydrate than is needed to sustain the cutting, to the benefit of the rooting process (Howard and Ridout, 1992). If the environment will not sustain the required rate of photosynthesis dark-preconditioned cuttings are particularly liable to rot. Furthermore, dark-preconditioned cuttings tend to continue shoot growth during propagation, which is soft and immature when forced in dull warm conditions and is a further drain on resources.

Soft new growth dies back when cuttings are weaned rapidly, but the appearance of these plants often implies more serious losses than is actually the case, because these experiments have shown that establishment depends mostly on the production of a good root system. For *Syringa vulgaris* 'Mme Lemoine' and *Corylus avellana* 'Aurea' the benefits of dark-preconditioning cuttings were clear, despite the detrimental effects of dull June weather which resulted in underperformance of these cuttings in wet fog in 1995.

For the easier-to-root *Syringa vulgaris* 'Charles Joly' the combination of dark-preconditioning and wet fog actually gave the greatest establishment level, underlining the inherent advantage of plant material and propagation conditions that lead to rapid rooting.

Given that in 1995 the most obvious benefit for rooting both *Syringa* cvs and *Corylus avellana* 'Aurea' was to dark-precondition cuttings, it is clear that in a year when dull weather caused conditions in wet fog to be too dull and warm, well-managed open mist could be effective.

Because the difficult *Syringa vulgaris* 'Mme Lemoine' is particularly sensitive to low light conditions during propagation after dark-preconditioning on the hedge, more dark-preconditioned cuttings established after propagation in open mist than in wet fog. For normal light-grown cuttings open mist gave better results than wet fog for both *Syringa vulgaris* 'Charles Joly' and *Corylus avellana* 'Aurea'.

In the context of this year's objective to investigate whether a well-managed propagation environment can substitute for the stimulus of dark-preconditioning the answer for *Syringa* and *Corylus* is that it cannot, but that the high rooting potential can be realised in well-managed mist, especially in dull years when cuttings of 'Madame Lemoine' underperform in wet fog.

The exception was *Elaeagnus pungens* 'Maculata'. There was little obvious response to dark-preconditioning in terms of shoot growth, other than the production of longer shoots in the warmer darker environment, and dark-preconditioning had little benefit for this subject, whereas wet fog was consistently superior to open mist in achieving high levels of rooted and established cuttings from early summer propagation. In retrospect this was not a fair test of the benefits of dark-preconditioning for this subject because the use of longer cuttings caused the stem base to be thicker than the base of normal light-grown cuttings, thus reversing one of the main beneficial effects of the dark-preconditioning process.

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Harrison-Murray, R.S. (1995). Improving irrigation efficiency for nursery stock in containers. *Horticultural Development Council HNS Sector, Final Report*, pp 27.

Contract between HRI (hereinafter called the "Contractor") and the Horticultural Development Council (hereinafter called the "Council") for a research/development project.

PROPOSAL

1. TITLE OF PROJECT **Contract No: HNS/41**

STOCKPLANT MANAGEMENT AND PRECONDITIONING

2. BACKGROUND AND COMMERCIAL OBJECTIVE

The benefit of maintaining stockhedges as a reliable source of true-to-type cuttings is being recognised increasingly by nurserymen. As a result, it is now realistic to consider the opportunities to use stockplant treatments either to increase the number of cuttings produced, or to raise their rooting potential, or to alter the time at which suitable shoots are ready for collection. Such treatments have so far been applied only at a research level and the purpose of this proposal is to test their applicability to a range of HNS subject and to develop techniques that would be practicable on a commercial nursery.

3. POTENTIAL FINANCIAL BENEFIT TO THE INDUSTRY

This is difficult to quantify because the benefit will take the form of opportunities to improve efficiency at the propagation stage, resulting in production targets being met with less space, less peak labour, and with greater reliability. This, combined with the possibility of extending the range of high-value but difficult subjects that can be brought economically to the market, must help fend-off competition from continental Europe.

4. SCIENTIFIC/TECHNICAL TARGET OF THE WORK

The aim is to produce guidelines on how stockplant pruning can be used to manipulate the timing, quantity and quality of cuttings produced, and also on techniques for temporarily modifying the stockplant environment to make cuttings easier to root and/or to force early production of cuttings.

5. CLOSELY RELATED WORK - COMPLETED OR IN PROGRESS

Dark pretreatment of stockplants is one of the many factors being considered under HNS 27, that may influence, either directly or as a consequence of improved rooting, the establishment of cuttings once they have rooted. Earlier very detailed MAFF studies with apple rootstocks demonstrated that dark treatment can transform the rooting ability of a responsive difficult-to-root subject and provided a firm strategic base for work with other species. Currently, MAFF project L102A is using a number of HNS subjects to explore the mechanism of the response. Earlier attempts to test the technique on a commercial nursery met with some success (e.g. collaborative trials with Mr D.Rowell, ADAS, using lilac) but practical problems, such as control of Botrytis infection, and the difficulty of providing a suitable structure to enclose plants in the field, have prevented its widespread application. There is now much more relevant experience on which to base a practical system.

There has been little work on the effects of stockplant pruning in HNS but recent experience at East Malling suggests that marked stimulation of rooting in softwood cuttings by severe winter pruning is the exception rather than the rule, in contrast to the situation with hardwood cuttings. Instead, very severe pruning not only tends to reduce the number of softwood cuttings, but also to delay the time at which they are available, because the shoots develop from the more deeply dormant buds near the base of the previous season's growth. Growth can be further delayed if winter pruning is delayed until the distal buds are on the point of breaking. This suggests that pruning could be exploited to spread the time over which cuttings are at the ideal stage for rooting and thus to ease labour management. The sort of black polythene enclosures used to exclude light for preconditioning also have the effect of raising temperatures significantly and thus offer a means of further advancing the start of the summer cutting season. Such forcing brings with it an increased risk of frost damage but it is worth examining whether this can be avoided by modifying the covers slightly.

6. DESCRIPTION OF THE WORK

A range of established hedges, including some from the clonal selection scheme, are available. The work will involve collecting data on the number of cuttings produced, the time they are ready for propagation, and their rooting ability, using stockplants of a range of species subjected to a variety of pruning protocols and dark pretreatments. To justify the time and effort involved in these treatments, subjects to be included for dark preconditioning must be sufficiently difficult-to-root as to be on the borderline of economic viability. By contrast, pruning treatments provide the opportunity to modify the timing and quantity of cutting production in bread-and-butter lines as well as for difficult high value subjects that must be rooted early in order to become well established in the first year.

With respect to pruning, the aim will be to observe the range of responses amongst the selected subjects in order to try to make generalisations which can serve as guidelines to nurserymen in programming the production of their cuttings. A key assessment will be the relative effects of treatments on the length of time between pruning hedges and the production of cuttings.

In relation to dark pretreatments, experiments will be designed to address the following questions:

(a) Is it possible to dark-treat container-grown stock simply by moving the plants into a dark building at the appropriate time, or are the more substantial reserves of well-established field-grown plants essential?

(b) Can the low tunnel (or "black cloche") approach, that has been successfully applied to apple and to *Cotinus coggygria* after pruning the stockplants to ground level, be extended to other HNS subjects? Can it be scaled up slightly to encompass subjects that would be killed by such severe pruning?

(c) How can larger plants be covered cost-effectively?

(d) Which subjects respond to darkness, and are any just as capable of responding to heavy shade, so reducing the problems of weaning from complete darkness into the light of the propagation bench?

(e) Does the nature of the environment in which the cuttings are rooted influence the response which is observed? In some cases preconditioning may make a subject more tolerant of sub-optimal environment; in others it will be essential to provide the most supportive conditions possible.

7. COMMENCEMENT DATE AND DURATION

October 1992 for 3¼ years to provide three full seasons work and to key in with staffing for other projects.

8. STAFF RESPONSIBILITIES

Within the general supervision of Dr. R.S.Harrison-Murray and Dr. B.H.Howard (HRI, East Malling), subject to restructuring and providing additional leadership in conjunction with other projects..

9. LOCATION

HRI-East Malling.