4.) Show them how to hold a knife and draw it through the wood, starting with a whip and tongue graft.

5.) Show them how to make a straight cut and keep them practising. Don't forget that boys and girls are not allowed to take knives to school these days like we were. Desks would have lasted longer if this had been the rule for my day!

6.) Show them how to tie a graft with plastic or rubber. Shows them the simple way of finishing a tie by passing the last turn under the thumb instead of tying a knot. One craft you can tell them about, but don't demonstrate it, is the material that was used to protect the graft: Cow manure and chopped straw mixed up and applied by hand.

You may learn something yourself. You will know your staff better, and you may have discovered a potentially very skilled young person for the future.

SUN FRAME PROPAGATION

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This paper reviews work the author was involved with while working at Efford Experimental Horticulture Station, Lymington, Hampshire. Work on field-grown nursery stock was started at Efford in 1981. Investigating aspects of propagation was a logical starting point. Following developments made with the rooting of cuttings under glass, it seemed likely that improvements could be made with the relatively cheap low tunnel or sun frame technique.

The sun frame technique for propagating softwood cuttings is not new — cold frames covered by Dutch lights were in use from the 19th century. Modern materials such as polythene sheeting for tunnels and automatic misting have brought it up to date. As the plant material from sun frames has been mostly destined for field planting and the landscape market, the range of species grown has been limited. If plant quality could be improved there would be an opportunity to extend the species range as a cheaper alternative propagation technique to heated glass. This would, in turn, create opportunities for supplying a range of markets such as containers and prepacks.

The two major problems encountered on nurseries who were using sun frames were:

1) maintaining the quality of rooted cuttings, and
2) the length of time spent in the frame (up to two years)

The two aspects became the main themes for investigation with trials examining the effects of spacing and nutrition on plant quality and development. However, before a description of these trials, the question, "What is a sun frame?" needs answering.

METHODS AND MATERIALS

Construction of sun frames. A sun frame consists of a raised bed 1.25 m wide with wood plank sides and can be of any length (12 m long at Efford). Approximately equal volumes of peat, lime-free sandy grit, and soil are mixed with a rotary cultivator to give a depth of compost of about 200 mm above normal soil level. The compost is covered with a thin layer of sandy grit (approx 10 mm — sufficient to help reduce weed germination). At Efford a 6 mm water pipe is used to make the main support hoops as they take the weight of the mist line. If the mist line were supported from the ground then galvanised wire hoops could be used. The hoops are placed at the ends of the frame and at 3 m intervals with plastic hoops in between to give additional support for the polythene cover.

A mist line giving good coverage of the bed and providing 100% relative humidity is essential for good rooting, so it is worth installing the best system that can be afforded. Automation is very useful although a manual system can be operated. At Efford the misting equipment consists of a 12 mm PVC water pipe with Macpenny No 2 brass mist jets spaced at 1 m intervals. A control panel allows each frame to be operated independently, while a time clock controls frequency of misting.

Cutting preparation and insertion. Cuttings are taken typically in mid- to late June, stripped of lower leaves and trimmed. The tips are pinched out to encourage branching, and any visible floral buds removed. A hormone rooting powder is used as a standard treatment. A nailboard of the required cutting spacing to mark out the bed is also useful, particularly for insertion of weaker stemmed species into the compost. Immediately after "sticking", the cuttings are drenched with an anti-*Botrytis* fungicide and, if necessary, an aphid killing insecticide. The frame is then covered with 150 gauge white polythene sheet which is attached by wooden lathes to the wood plank sides. Additional shading can be provided by a lightweight windbreak/shade netting, although experience suggests this may be unnecessary when mist is used. Bursts of mist are required about every 30 to 60 min.

during the day, depending on the weather. Alternatively an "artificial leaf" control system can be used.

Hardening off. Slits are cut in the polythene tunnel usually in early August. The polythene is removed and mist turned off about one week later. Netting may be necessary at this stage in very hot, dry conditions. This is removed in September. All further irrigation needed during growing on is provided by two lines of seep-hose per frame.

EXPERIMENTS AND RESULTS

Cutting densities. A series of trials were carried out during 1981-83 using *Hypericum* 'Hidcote', *Philadelphus virginalis* 'Burfordensis', and *Viburnum* × *bodnantense* 'Dawn'. These trials demonstrated the dramatic increase in both shoot and root growth achievable by increasing cutting spacings from a typical 50mm × 50mm to 75mm × 75mm and 100mm × 100mm. *Viburnum*, in particular, responded to the wider spacings, winter losses in the frame being greatly reduced. These benefits were also carried over into the field after planting out; larger plants from wider cutting spacings established better and produced high grade marketable plants more quickly.

Nutrition. In the early trials of sun frames a liquid feed applied through the seephose was found to be necessary. This was particularly so if the plants remained in the frame for another growing season. Following work with propagation under glass at Efford, the use of slow-release fertilizers was suggested as an alternative method of maintaining quality in the frame. The first trial in 1982 using 10 different deciduous shrub species gave dramatic results. The slow-release fertilizers, which were incorporated in the rooting medium before the cuttings were inserted, greatly improved both the growth and visual appearance of all species when compared with the unfertilized "standard treatment". The differences were very noticeable from mid-August onwards, both for Osmocote 16:9:9 (16 to 18 month formulation) and Ficote 16:10:10 (140-day formulation). Both materials were used at 2 kg/m^3, with a cutting spacing of 75mm × 75mm.

Growth was so much improved it became obvious that the terminal bud should be removed from cuttings before insertion to encourage a more bushy habit. This then became a standard practice. It was also found that a thick 75mm layer of sand over the rooting medium, as practised previously, was unnecessary. Cuttings grew better when able to root directly into the fertilized medium with only a 10 mm layer of sand.

Combining cutting density, nutrition, and time of planting out. The dramatic results following the use of slow-release

fertilizers, with their effects on the speed of propagation and quality of plant produced, opened up a new set of prospects worth investigation. A combined trial to look at the various factors involved was the next step. In 1983 a multifactorial trial was set up with the following treatments:

1	Slow-release fertilizers	Osmocote 16 9 9 + Mg (16-18 month) Ficote 16 10.10 (140 day)
2	Rate of fertilizer	nil 1 kg/m^3 2 kg/m^3
3	Cutting spacings	75 mm × 75 mm 100 mm × 100 mm 125 mm × 125 mm 150 mm × 150 mm
4	Transplanting times	autumn 1983 spring 1984 autumn 1984
5	Species	*Cornus alba* 'Elegantissima' *Forsythia* × *intermedia* 'Lynwood' *Potentilla fruticosa* 'Katherine Dykes'

Propagation results. All three species responded to both wider spacing and the slow-release fertilizers with increased root and shoot growth However, *Potentilla* and *Cornus*, in particular, showed little response to wider spacings on unfertilized plots. Generally, the 1 kg/m^3 of fertilizer gave as good a result as 2 kg/m^3. *Potentilla* appeared sensitive to the higher rate of Osmocote, root growth being poorer in this treatment (Table 1).

Table 1. Main effects of slow-release fertilizers and cutting spacing on shoot and root growth by October 1983

	Mean dry weight, g/plant					
	Shoots			Roots		
	Potentilla	*Cornus*	*Forsythia*	*Potentilla*	*Cornus*	*Forsythia*
1 Fertilizer kg/m^3 (figures averaged across spacings)						
Untreated, nil	3 5	1 0	3 2	1 1	1 0	1 5
Osmocote) 1	5 5	2 2	4 0	1 2	1 6	1 9
16 9 9) 2	4 7	2 4	6 2	0 7	2 0	1 9
Fricote) 1	3 8	2 7	6 4	1 2	2 5	2 2
16 10 10) 2	6 4	2 3	6 1	1 6	4 1	1 9
2 Cutting spacings (figures averaged across fertilizers)						
75 mm × 75 mm	3 7	1 5	3 8	0 7	1 5	1 4
100 mm × 100 mm	3 9	1 9	4 6	0 9	1 9	1 9
125 mm × 125 mm	5 0	2 5	5 7	1 4	2 7	2 0
150 mm × 150 mm	6 5	2 5	7 2	1 6	2 9	2 2

A similar pattern of shoot weights was observed for the dormant cuttings lifted in March, 1984. For *Cornus* and *Forsythia*, root weights had greatly increased during the mild winter, especially at the wider cutting spacings. Also the depression in growth of *Potentilla* at the high rate of Osmocote observed in October, was less evident.

Establishment and growth from the frame. For field planting from the frame, growth of all species was improved from the spring planting. It was best where slow-release fertilizers had been used during propagation. *Potentilla*, in particular, suffered from autumn plantings with very poor establishment, especially the untreated and Osmocote-fertilized plots.

Containerised plants responded to transplanting times in a similar way. Virtually none of the early batch of *Potentilla* survived. This may have been due to the relatively soft growth of autumn-transplanted plants. The differences due to spacing and nutrition during propagation seem to disappear much earlier in containerised plants than those in the field.

Plants left in the frame for another season generally appear overcrowded, but at some spacings the quality may be good enough for marketing direct from the frame.

FUTURE PROSPECTS

Work on testing a wider range of deciduous shrubs for propagation by this method is now in progress. Great success has been achieved, for instance, with *Rosa rugosa* species and cultivars, e.g. *Rosa rugosa* 'Frau Dagmar Hastrup'. Often considered a difficult subject, excellent quality plants have been produced by the sun frame method.

With some modifications (no mist line is required) hardwood cuttings of some evergreen and conifer subjects can be propagated in sun frames. More work will be done to establish production schedules for this aspect.

The range of markets for material from sun frames has been extended beyond field grown shrubs to include containers and possibly the pre-pack market. 'Direct sticking' of cuttings into pots inside a sun frame remains an area for further investigation.

SUMMARY

1. Sun frame propagation is a relatively low cost technique which, with the use of some modern materials, can give good quality plants suitable for a number of outlets.

2. Lower cutting densities and the incorporation of slow-release fertilizer into the rooting medium have given dramatic improvements in growth and quality, together with a significant reduction in propagation time.

3. Because the technique is relatively cheap compared with using heated glass, it may be possible now to propagate a wider range of species economically by this method.

4. Eventually some production schedules suitable for particular market requirements for individual, or groups of species may be developed.

Question to Joanna Wood: Is supplementary shading necessary?

Joanna Wood. We thought that supplementary shading would be necessary and I used it in my trials on the East coast. Margaret Scott has carried out trials at Efford without shading and there have been no problems. As the light intensity levels are higher on the South coast, we would conclude that supplementary shading is not necessary.

Question to Joanna Wood: How is weed control achieved in the sun frames?

Joanna Wood: We were putting on a fairly deep layer of sand onto the beds but found this sand layer to be unnecessary as the weeds are so lush and lank that they are easily removed by hand after the covers are removed. With no sand layer the roots of the cuttings can exploit the slow-release fertiliser more quickly.

STARTING A NURSERY AFTER COLLEGE

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I shall give a brief account of why we started a nursery and include a short history of Welland Vale Nurseries. I will then outline the various problems and limiting factors we encountered and describe how we attempted to solve them.

The idea of starting a nursery was first discussed among various friends while still in the first year of our Ordinary National Diploma (OND) course at Pershore. At that time several people were interested in the project. However, by the end of the third year interest had waned and, on leaving college in the summer of 1972, only 3 people remained committed to the idea — these being Trevor Burns, who now deals with sales, Nick Cox, from whom we parted company after one year, and myself.