gone. If this shading is left on too long in spring, it has the tendency of delaying new growth of any plants under it. Once the shading is off and the plants are growing nicely, liquid feeding can be resumed at 10/14 day intervals.

Planting can commence any time after mid-April, until end of May, or even early June. It is usual for the nurserymen to plant their "bare-root" stock first and leave the jiffy-potted liners until last.

It is most important, from the initial potting stage, to planting, that the peat pots are not allowed to dry out as this will hinder the formation of roots and result in a stunted plant. Almost certainly, just prior to planting, each batch of potted liners should be given a thorough soaking, preferably the night before and once again in the morning.

When planting, make sure the peat pot is buried below soil level, as any part of the peat pot which is exposed to the weather will act as a "wick" and even though the surrounding soil looks wet, the roots of the plants will suffer from dryness. I have had excellent results from jiffy-potted liners, even when planted during a drought in May, without irrigation, whereas the bare root stock planted one month earlier, had succumbed through lack of moisture. The potted liners continue to grow without check and result in a heavier and quicker maturing plant, well worth the extra effort.

I hope to continue the series with further articles on jiffy-potted Conifers, bed raised Rhododendrons and Azaleas and "Long Tom" potted shrubs, showing how the greenhouse propagating benches can be utilised for the full 12 months.

'TAKING HARDWOOD CUTTINGS'

P. D. A. McMillan Browse,
Hadlow College,
Nr. Tonbridge, Kent

For those subjects which will respond, the propagation of plants from hardwood cuttings is undoubtedly the cheapest and most effective system of production. But the technique depends on a satisfactory level of productivity, otherwise resources are wasted by having to bulk up by other propagation systems. The object of this paper is to show how a technique can be developed for taking hardwood cuttings so that maximum productivity is achieved — for every cutting made and inserted represents expenditure and it is therefore important that the highest possible number regenerate in order to reduce costs to a minimum per liner produced. With 'easy' subjects this usually presents no problem but it is with those subjects which show only variable or marginal success that attention to detail can produce an economic system.

To do this it is necessary to look at all the factors affecting the regeneration of plants from hardwood cuttings and by

isolating each, determine its most suitable state; having done this, all these ideal states can be reassembled to produce a pattern from which a hardwood cutting can be produced, made and inserted.

As with all techniques of vegetative plant propagation there are basically two series of factors affecting the regeneration of hardwood material. These factors can be categorised as CAPACITY — i.e. the ability of the material to regenerate and PERFORMANCE — i.e. those factors which affect it after its removal from the parent plant.

1. *Capacity*

Those factors which affect the ability of the material to regenerate are inherent in the tissue at the moment the cutting is taken and have been entirely determined previously by the history of the parent plant. These can be divided into two series — SOURCE and SEASON.

A. *Source*

The parent material must initially be of high regenerative capacity — but how is this most easily achieved and what affects it? Although it is well known that 'juvenile' material roots most readily we are dealing with (by the nature of the plants we require, to propagate) material in the 'mature' phase and hence of lower regenerative ability. Material in the 'adventitious' phase exhibits similar regenerative power to juvenile material but as it is rarely a practical proposition to produce, it can be ignored. Hence improved regenerative ability must be developed in the mature phase. This is most marked in non-flowering material i.e. material which is in a vigorously growing condition — described as 'vegetative' material. In practice this can be most effectively produced by vigorous annual pruning to a short stool, so producing new, vigorous, vegetative shoots each year.

This regular reduction of the shoots to a stool annually and the subsequent regrowth requires careful attention to the condition of the material, for it obviously must be manured to allow this growth, however it has been shown that the balance of nutrients within the stems affects capacity and it has long been recognised that a low 'Carbon/Nitrogen ratio' was important in this respect but it was Garner and Hatcher who demonstrated that this low level of free nitrogen in the stem was developed where the stock plants were in vigorous root competition — as in a 'hedge' system.

From these remarks it will be seen that hardwood cutting material of high capacity requires the establishment and maintenance of stock lines or hedges which are pruned annually to a framework, regardless of the number of cuttings required so that suitable material is available each year despite a fluctuating demand.

How many stock plants will be required will depend on the number of cuttings required and how many cuttings can

be obtained from each shoot — this information can only be assessed from knowledge of the individual plant and local soil and climatic conditions. In the case of 'difficult' subjects only one cutting per shoot may be the limit for as a rule position on the shoot also affects capacity and in most cases it declines from the base of the annual growth to the tip. In 'easy' subjects position does not practically affect capacity and all the mature shoot may be used; in 'difficult' subjects there may only be sufficient capacity in the base of the shoot and, indeed, only in the basal portion of the years growth thus limiting production to this one basal cutting from each shoot.

B. *Season*

Seasonal fluctuation in the capacity of hardwood shoots to root is well known although the cause of this phenomenon is still obscure. The degree of mid season depression varies from plant to plant.

The highest regenerative capacity occurs during the 'leaf fall' and 'bud break' periods, but cuttings made at the latter period may suffer from having to support developing shoots before the root system is initiated and established. Thus the most satisfactory season, in practice, for taking hardwood cuttings is at, or soon after, leaf fall.

2. *Performance*

Having determined what material is the most suitable for propagation, we must now turn our attention to ensuring that the material has the chance to regenerate its root system and establish itself i.e. 'perform'. Again two series of factors are important and these we categorise as TREATMENT and ENVIRONMENT.

C. *Treatment*

For hardwood material the chief treatment are the application of hormone and/or fungicide to the base of the cutting — the former merely to encourage root initiation and the fungicide to prevent the action of any rotting fungi from destroying it — this latter being especially important with subjects having a hollow or soft pith. In most cases hormone powders are applied on the basis that it may do some good and will do no harm: except in the case of marginal subjects which may benefit from critical doses of hormone.

D. *Environment*

In the rooting of hardwood cuttings three sectors of the environment may affect performance.

The loss of water from the cuttings i.e. dessication, is often a limiting factor and can best be overcome by inserting the cutting to almost its entire length in the rooting medium, thus having only a minimum of the cutting exposed to the evaporative conditions of the aerial environment.

The rooting medium (i.e. the soil) should be well aerated to the base level of the cutting, in order to allow the movement

of oxygen and carbon dioxide to and from the highly active base of the cutting. The addition of sand will improve this factor if necessary, although ultimately this is a function of soil structure and can only be affected by the regular application of organic matter to the hardwood cutting bed.

The temperature of the rooting medium will affect the speed of root initiation — hence early season cuttings inserted while soil temperatures are still warm have a better chance of establishment.

Practical Considerations

Having discussed the various factors concerned in the successful propagation of plants from hardwood cuttings and making some practical applications of these — there are still several practical considerations outstanding, the most noticeable of these being the length of the cutting. Obviously the minimum size of the cutting is governed by its ability to servive and establish — i.e. it has a sufficient food reserve. It has been shown in terms of water loss that only a very small portion of the cutting should be exposed above soil level: but this condition also benefits the ultimate shape of the 'liner' to be produced because, when a hardwood cutting develops, only the top 1 or 2 buds break and produce shoots initially; hence a cutting with several inches exposed produces a plant on a 'leg' whereas a cutting with its top bud at or about ground level produces a plant with a crown at ground level. Its length therefore will be governed by the base level of the cutting.

Because the *ultimate* root system of the plant usually develops from the wounded base of the stem rather than from the roots produced along its length, the base of the cutting needs to be as shallow as is feasible; this is also compatible with maximum aeration. Furthermore a cultivation pan commonly occurs at nine inches or so and this also mitigates for shallow planting.

Arbitrarily balancing all these factors, it is our practice to recommend that hardwood cuttings should be made six inches in length, with a bud as close to the top as possible to eliminate chances of 'die back'; the basal cut is then made at six inches below this, disregarding its position in relation to a node and thus making a uniform batch of cuttings.

However, many plants have a soft or hollow pith and to prevent the 'die back' from the base of this type of cutting the cuttings are made to a node.

The question of whether a knife or secateurs should be used to make the cutting is a vexed one; probably cuttings can be made consistently more quickly with secateurs.

If well-shaped scissor-type secateurs are used and the wood is hard enough not to be damaged or crushed — secateurs are satisfactory; if, however, crushing or damage is caused by the secateurs then a sharp knife must be employed.

Finally insertion — however well prepared and light the

soil may be the cuttings should never be pushed in as this inevitably damages and scores the base of the cutting thus increasing the chances of fungal infection. A nick against a line should be taken out with a spade, the cuttings placed in it and the soil is then returned firmly around the cutting. The cuttings are left *in situ* until twelve months later when a strong field liner will have been produced.

In practice the majority of the following genera can be cheaply and effectively produced by this technique although the limiting factor is usually the climatic conditions causing waterlogging of the soil and hence ultimately rotting of the base of the cutting — cold temperatures, *per se* are not necessarily damaging if conditions are reasonably dry:— Cornus, Deutzia, Diervilla, Forsythia, Hypericum, Kerria, Leycesteria, Ligustrum, Lonicera, Philadelphus, Populus, Ribes, Salix, Sambucus, Spiraea, Symphoricarpus, Tamarix and Weigela.

P. M. ROBINSON: Do you see any benefit with the more tricky hardwood cuttings of sealing the tops with some form of grafting wax?

P. MACMILLAN BROWSE: No particular benefit.

ROBERT GARNER: Some years ago we collaborated with Boskoop in an experiment with hardwood cuttings. All the Boskoop cuttings arrived with a soft wax over the top half inch; they had been dipped in hot wax. We tried various waxes but got no beneficial results. Experiments with anti-dessicants have given very good results.

C. A. BOND: Have you tried the inversion of cuttings in a sand-pit? I read a paper on it where it has been tried on the more difficult cuttings. It is supposed to induce better rooting when the cuttings are turned the right way up in Spring.

P. MACMILLAN BROWSE: I am rather skeptical about the suggestion.

ROBERT GARNER: I believe the French did some investigation on this some years ago. The cuttings were inverted in the corner of a walled garden and as this was a warm spot we thought that the beneficial results may have been caused by a temperature effect.

BRIAN HUMPHREY: I am interested in the reference to the use of fungicides to hard wood cuttings particularly to those with hard pith.

P.MACMILLAN BROWSE: In the case of Weigela, Philadelphus and Ribes, having bark which flakes away from the base of the cutting and a large soft pith, there is the greatest danger of rotting. For these types fungicidal application may be especially beneficial. We have not fully tested the effect of fungicides as yet.