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SECOND SESSION

ASPECTS OF PROPAGATION IN FORESTRY

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SUMMARY

Comparatively few forest trees are raised vegetatively but poplars and willows are grown in the open nursery from hardwood cuttings and several horticultural cultivars, including Leyland cypress and selected clones of elm, are produced under mist indoors. The methods of propagating these are discussed and brief reference is made to recent research on the subject.

INTRODUCTION

Every year some 100 million plants are raised from seed in Forestry Commission nurseries. Most of them are conifers, principally the spruces, pines and larches, and only about 1 percent are broadleaved trees, mainly oak and beech. Normally the seeds are sown broadcast on to raised beds; the subsequent seedlings take one or two seasons before they are large enough for lifting and transplanting, then the transplants need a further one or two years to reach a size suitable for forest use. In the south of the country, plants large enough for planting out can be raised in two years, but in the north three years are normally needed. The techniques of raising forest trees from seed are well known and are amply reported in forest literature.

In contrast, comparatively little vegetative propagation is undertaken by the Forestry Commission; probably fewer than 100,000 plants are produced annually, and only small quantities of stock raised vegetatively are actually planted in forest conditions. In the

production nurseries of the Forestry Commission propagation is limited to selected poplar cultivars grown for timber at wide spacing on low-lying fertile ground, to Leyland cypress, x *Cupressocyparis leylandii*, a valuable ornamental tree but whose future in forestry is still uncertain, and to a small number of poplars and willows raised especially for amenity. In practice much of the vegetative propagation undertaken by the Forestry Commission takes place in the Commission's Research Division nurseries, where different methods of clonal reproduction are being tested and clones are being raised for various types of experimental work. Methods of raising trees that are unable to produce fertile seed are also being examined. Though the number of plants grown is not large, work is conducted on a wide range of species including most of the common conifers and the main species and hybrids of elm. Methods of raising London plane, *Platanus acerifolia* are also being looked at.

In the private forest sector and in the horticultural trade the situation is quite different due to the sustained demand for trees for screening, shelter and ornament, and large numbers of cultivars are raised each year by vegetative means. Many different techniques are used, some of them peculiar to horticulture.

This paper discusses the methods of vegetative propagation commonly practiced in forest tree nurseries and briefly reviews the related research presently being conducted.

PROPAGATION IN THE OPEN NURSERY

Virtually all species and hybrids of willow and poplar, whether grown for timber or for amenity, are raised vegetatively. Dioecious flowering and the low viability of seed limit opportunities for sexual reproduction, and successful methods of vegetative plant production have inevitably evolved. But propagation from cuttings is seldom difficult and as successful cultivation in the field depends on the availability of tested selections, often derived from artificial breeding, the adoption of vegetative methods has been logical. Though scores of cultivars of poplar and willow are raised of widely differing performance, the nursery methods are reasonably standard and lead to uniformly good results. For convenience the genera are considered separately. London plane, the only other broadleaved tree commonly raised in the open from cuttings requires a different technique. This leads to variable and sometimes disappointing production although it is generally practiced.

Poplar. Cuttings may be collected and prepared for insertion at any time after leaf-fall, provided the shoots from which they are taken are well ripened. In practice there is no advantage in early insertion, and if cuttings are made ready in advance they may be safely stored in plastic bags in a cold chamber at a temperature of about +3°C. If cold storage facilities are not available they may be kept for short periods

in plastic bags in a cool, darkened room. Warm conditions promote root and shoot growth, and should be avoided. Though cuttings made from two-year old and even three-year old wood root adequately in most soils, root production is slow and the resulting plants are correspondingly small. Root initiation and development on one-year old wood is generally rapid, on the other hand, and unless propagation material of this age is in short supply older wood should not be used. The cuttings can be prepared from shoots from stumped nursery plants, from stools cut annually, or from shoots from standing or felled trees using vigorous epicormic growth or upright branches in the upper crown.

Poplar cuttings are mostly 23 to 25 cm long, and there is no advantage in using longer material. Shorter cuttings than this will root, but when less than about 15 cm long the quality of the plants grown from them is poor. Thin cuttings from the upper parts of shoots should not be used as they also produce weak plants and may even fail to root, but thick cuttings from the basal parts of shoots are acceptable provided they can be easily inserted in the soil. Cuttings without leaf buds will usually throw out shoots from adventitious buds but as there is a delay before growth starts, the resulting plants tend to be small. The top cut end of the cutting should be just above a leaf bud.

Though insertion of cuttings of late flushing cultivars can be delayed until mid-April, insertions should usually be completed by the end of March as poplars generally are early leafers.

Poplars respond to fertile nursery conditions and well-grown stock suitable for field planting can be raised in a single season from cuttings in a soil which is base rich, moist and well-drained. Fertility must be maintained by regular manuring, for example by application of compost or hop waste at 50 metric tons per hectare, and by dressing with a phosphatic-potassic fertilizer such as potassic superphosphate at 750 to 1000 kilos per hectare, at least every other year. Annual top dressings in mid-season of a nitrogenous fertilizer, at about 380 kilos per hectare, are also desirable. Acid conditions hinder growth of poplar and may lead to failure and liming should be carried out periodically to maintain the soil pH value at or above 6.0. When the pH value falls below about 5.0, conditions are becoming marginal.

Cuttings should be inserted vertically until the top cut end is level with the general soil surface. As the soil settles the upper 2 to 4 cm of the cutting will protrude from the bed.

As poplars are capable of developing a wide spread root system in the nursery, the plants are commonly lifted at the end of the first year whether large enough for field planting or not. Thus comparatively close spacings may be used in cutting beds, though for sustained vigor and to allow access to different parts of the bed the cuttings should not be closer together than 40 cm in rows or closer than 45 cm between rows. Heights in excess of 2 m are usually achieved in the first season

in a well-manured nursery, and the selection of stock for field planting should not ordinarily be difficult. Not all cultivars are so vigorous though, and in a cool, wet summer even normally vigorous poplars may grow slowly.

A rooting percentage in excess of 90 can usually be obtained for all the common cultivars except Grey poplar, *Populus canescens*, and if only selected, high quality cuttings are used the rooting percentage may reach 100. Grey poplar varies from clone to clone, but even in favorable circumstances the rooting percentage is seldom greater than 60. In practice most clones of this tree are very difficult to root from hardwood cuttings, and only the aspens, the *Leucoides* poplars, and *Populus deltoidea angulata,* a North American Cottonwood, present the propagator with greater problems.

One-year rooted cuttings too small for field planting, and any other stock to be retained in the nursery for a further season, should be lined out at a comparatively wide spacing to allow ample room for crown and root development. The transplants, as well as cuttings to be left in position for two or more years, should be 60 to 90 cm apart.

In some Forestry Commission and trade nurseries the plants are cut back immediately after transplanting, that is when they are still only one year old. Growth from the cut stump is invariably vigorous and sturdy, well-branched plants, larger than those grown in the first year, are obtained at the end of the second season. Cutting back ensures a regular supply of cutting material, and three-fold increases in plant production can be achieved annually with the method. But for a sustained supply of large numbers of cuttings, stools which are cut back annually are required.

Two-year and older plants that have not been cut back may be expected to have heights in excess of 3 m at lifting. If plants much taller than this are grown special planting techniques may be needed to keep them upright.

Willow. Traditionally, most willows including cricket bat willow, *Salix alba* var. *coerulea*, are generally planted out as sets. But rooted plants are raised at many nurseries and their use for ornamental planting is increasing. Their use in bat willow planting is recommended since the method ensures the production of good quality stock free from defects in that part of the stem destined to produce bat timber, that is the lower 2.3 to 3 m of the bole. Rooted plants are raised from both cuttings and sets. The method of raising plants from cuttings is similar to that described for poplar, using cuttings 18 to 25 cm long and 13 to 25 mm thick, and inserting them in January and February. Initially at close spacing, 15 to 23 cm within rows and 60 cm between rows, the cuttings are usually lifted after one year and transplanted to a wider spacing comparable to that used for poplar. The plants may be cut back at this stage. In both cutting and transplant beds only one shoot is allowed to develop, and it is relatively

easy to raise a plant with 2 to 3 m of clean stem and a well-developed head of branches.

When plants are raised from sets, usually grown on nursery stools $\frac{1}{M}$ though occasionally taken from the crowns of standing or felled trees, the sets are 2.5 to 3m long and are inserted 30 to 60 cm apart in rows and 60 to 90 cm apart between rows. If one-year old sets are used the plants usually remain in the nursery for two years, but if two-year's old, the plants can be lifted after only one year if growth has been good. Stools especially established for set production are rarely more than 90 cm apart, and are usually cut back to within 25 cm of ground level. The shoots growing from stools are sometimes thinned to ensure that only strong and straight sets are produced.

For direct planting in the field, sets should be stout enough to stand upright without staking. For bat willow the stem must be at least 3 m long to allow the basal 60 cm to be placed in the ground, leaving 2 to 3 m of the clean stem above ground. When a mature bole of 3 m is required a clean set over 3 to 6 m long has to be produced. As such long clean sets are difficult to grow, rooted plants are to be preferred.

Other tree willows are raised in the same way, but as none is cultivated to produce bat timber free of defects, the techniques are less demanding. Only weeping willows require specialist treatment. Most willows may be expected to have a rooting percentage of 90 to 100 and, as with poplar, the numbers of cuttings that root are not significantly influenced by application of a root promoting growth substance.

London plane. This tree, assumed to be a hybrid between *Platanus occidentalis* and *P. orientalis*, the American and Oriental (European) planes, is traditionally raised from hardwood cuttings in the open nursery. Vegetatively raised stocks may also be obtained by layering but the technique is not common. Fertile seed is produced and mixed seedling populations may be raised. But to retain desirable bark, foliage, fruit and stem shape characteristics propagation must be asexual.

Cuttings are taken from well-ripened one-year old wood and are usually 17 to 23 cm long. Trials suggest that cuttings with only two or three buds from rapidly grown shoots do not root well and should be discarded. Cuttings with at least four buds should be chosen if possible. Terminal growth, which is too thin, should be avoided altogether. Stools cut back annually produce a sustained yield of suitable material, though pollarded trees pruned every year are a useful source of cuttings. But cuttings taken from trees more than about 20 years old appear to root less readily. The cut at the top of the cutting should be just above a bud and the basal cut just below a bud.

To ensure satisfactory results cuttings should be inserted shortly after leaf-fall and not later than early November. Insertion should be vertical and so long as the bark at the base is not stripped the cuttings may be pushed in. If damage is likely to occur the cuttings should be

rested against the vertical side of a narrow V-shaped trench, firming and leveling after the trench has been filled in. Not more than about 25 mm of the cutting should be above the soil surface. The spacing may be as close as 10 cm within rows and 25 cm between rows.

One month after insertion or as soon as it is reasonably dry the soil should be refirmed. In early spring the soil should again be refirmed and any cuttings lifted by frost pushed in to their original depth. At time of leafing and until first growth has hardened off in late July beds should be shaded with lath shelters placed about 45 cm above the soil surface.

Heights vary considerably in the first year from a few centimetres to 60 to 70 cm, but very few plants are vigorous enough for planting-out, and the rooted cuttings should be lifted and transplanted for one year. The rooting percentage is seldom higher than 70 and in some years it is likely to be a good deal less than this. Trials to improve the rooting of London plane are briefly discussed below.

PROPAGATION INDOORS

The range of tree species and the number of plants raised vegetatively in houses and other structures for forestry is comparatively insignificant. Apart from specialist production of the main species for various studies, only Leyland cypress and two or three elms, which cannot be raised from seed, are presently being grown for planting out. Some propagation is still undertaken in cold frames equipped with soil warming and overhead mist watering but there is an increasing trend towards propagation on benches in plastic and glass houses, as these provide greater opportunities for environmental control.

Elm. Though there is a large and varied elm population in this country, the only species that regularly produces fertile seed and can be raised in large numbers by conventional forest nursery techniques is Wych elm, *Ulmus glabra*. Smooth-leaved elm, *U. carpinifolia*, together with its varieties, also produces fertile seed, but production is seldom large and supplies are usually difficult to come by, so vegetative propagation is necessary. Fortunately most elms are able to reproduce themselves from sucker growth, and in both hedgerows and woodlands, continuity of stocking is obtained by this type of regeneration. Suckers may also be lifted and lined out in the nursery for a year or two to promote vigorous shoot and root growth, and then planted out at another site. Planting stock of English elm, *U. procera*, and of Dutch elm, *U. hollandica* var *hollandica*, is sometimes raised in this way. But the method is unreliable, since many apparently vigorous suckers lack adequate root development and fail after being detached from the parent tree; for a sustained program of plant production improved techniques are required.

The breeding and selection of elms for resistance to elm disease in the Netherlands, and trials of elms of potential forest value in this country have led to greatly increased work on vegetative propagation. So far, the rooting of softwood cuttings in mist during the growing season has proved to be the best method and the rooting of hardwood cuttings in the open nursery the worst, but no method has yet been adopted or tested for large scale plant production.

Softwood cuttings root three to five weeks after insertion in a heated rooting medium provided wilting is prevented by copious watering; two or three separate insertions may be made during the growing season. Experimentation has shown that cuttings should be about 15 cm long and, after removal of lower leaves and treatment with a growth substance, inserted to a depth of 5 to 6 cm. A rooting medium of 50% sphagnum peat, 25% coarse sand and 25% horticultural grit has given satisfactory service in trials but recent work suggests that the sand may be eliminated. Soil temperatures of 21° to 24° C appear to be required to promote early callus development and rooting, but cutting survival depends on adequate watering, especially during the critical period immediately after insertion when recovery from handling is often in the balance. Shading and ventilation to prevent air temperatures rising above about 20° C are also necessary.

Though cuttings may be taken from trimmed hedges and standing trees, stock plants established in the nursery close to the propagating beds ensure minimal handling and delay between collection and insertion. Elm cuttings travel reasonably well for short periods in plastic bags, but storage in a heated room quickly leads to wilting. The cuttings must be prepared in a cool shed. Cuttings may be stored in a cold chamber at + 3° C for some days provided they are lightly packed in plastic bags. The effects of prolonged storage at this temperature have not been properly tested.

The application of indolyl-butyric acid (IBA) dust in talc to the cutting base immediately prior to insertion improves root initiation. Recent trials suggest that treatment with napthylacetic acid (NAA) dust in talc may be even more beneficial, and work to test the effects of different concentrations of this chemical has been started. Treatment with IBA in solution, using a wide range of solvents, has not so far improved root initiation in elm cuttings. The effects, if any, of application of a fungicide with the growth substance are being examined.

The rooting percentage of softwood elm cuttings varies considerably and sharp fluctuations are common from one cultivar to another. The success rate is usually greater at the beginning of the summer than at the end. Commelin elm, *U. hollandica* cv Commelin, a product of Dutch breeding with high resistance to Elm disease, and currently being recommended for general planting, is among the easiest to raise, while English elm, *U. procera*, the most common British elm, is one of the most difficult. A rooting percentage of 60 to 80 may be expected with the easiest rooting clones.

After weaning, rooted softwood cuttings may be lined out in the open nursery, shading and watering as required in the first few days to prevent wilting. By the end of the season the plants raised from the earliest inserted cuttings should be 40 cm tall, and those grown from the last insertions 20 cm tall. In contrast, hardwood cuttings of elm are difficult to root and even in a heated medium the rooting percentage is usually low. Applications of a growth substance in dust form have not produced significant benefits, though the use of solutions may be advantageous and different formulations of IBA and NAA are presently being tested.

Poplar. Species and hybrids of poplar that are difficult to propagate from hardwood cuttings in the open nursery may be readily rooted in mist units equipped with bottom heat. Cuttings from the apical parts of vigorous stock plants root within three weeks of insertion and weaning can usually start after four or five weeks. After transference to the open nursery, when watering and shading may be needed for a short while, the rooted cuttings may reach heights in excess of 60 cm before seasonal growth terminates.

The cultural techniques for poplar are similar to those described for elm, though root promoting growth substances tend to be more beneficial in terms of both speed of rooting and number of cuttings rooted, and wilting is less likely prior to and after insertion. The aspens and the *Leucoides* poplars root least readily from softwood cuttings, while the black (*Aigeiros*) and balsam (*Tacamahaca*) poplars are easiest to root.

London plane (*Platanus acerifolia*). Experiments are currently being conducted to see if London plane can be raised in commercial quantities from softwood cuttings. There is no experience of the treatments required to initiate root growth, and during the preliminary phases of the study the tests on London plane have been similar to those conducted on elm. Early trials show that although cuttings quickly wilt after removal from the stock plants, recovery is rapid in mist, and the presence of large leaves is not a hindrance. Treating cuttings with growth substances in solution has not, so far, greatly improved rooting, but application of NAA dust in talc to the cutting base has been beneficial. Defoliation prior to insertion causes a decrease in the number of cuttings rooted.

Hairs which are easily detached from the leaf under-surface during cutting collection and preparation have proved to be a serious problem. They affect workers in much the same way as pollen and other irritants, and cause symptoms of hay fever.

The rooting of hardwood cuttings of London plane in heated beds is also being examined; there is already evidence that material prepared in March and inserted after treatment with a growth substance in a medium maintained at a temperature of 21° to 24° C may produce roots after only three weeks. Notably after dipping in an IBA solution,

roots are formed on the lower 4 cm of the cuttings, in contrast to the formation of roots on elm only at the base of the cutting. Different types of cutting and different formulations of IBA and NAA are being compared.

Both the softwood and hardwood cutting techniques with London plane are likely to lead to higher rooting percentages than are obtained with conventional methods in the open nursery and further trials in heated beds seem justified. But the handling of rooted cuttings of London plane raised indoors has not been studied and problems may arise as more intensive production methods are tried. Experience with elm suggests that losses due to death of roots may occur on lining out

Leyland cypress. Overhead misting with hard water is believed to be responsible for depressed rooting and survival figures in nurseries in eastern and southern England. Recent trials in Forestry Commission nurseries in these regions have shown that when cuttings in heated beds are watered by hand with rain water, higher rooting percentages are obtained than when watering is done only from mains supplies with a high lime content. It is not clear from the work if the benefits are partly related to reduced irrigation rates due to hand watering, but this seems likely. There is evidence to suggest, however, that automatic mist, whether from the mains supply or not, need only be resorted to in prolonged spells of clear, warm weather. The effects of the accumulation of sodium and calcium ions in the rooting media are being studied.

Variations in root initiation among different clones are being examined in the hope of improving the production of little used, though apparently desirable, clones. It seems likely that clones which are not widely grown may have been overlooked only because of their poor rooting and survival rates in cutting and transplant beds. Attempts are being made to improve the survival of these by using better propagation techniques. Clone 'Leighton Hall No. 11', a vigorous type suitable for hedging, is receiving special attention. The commonly grown, easily rooted, clone is 'Haggerston No. 2'.

The relationship between soil temperature and root initiation is also being studied. So far, it has been seen that by increasing soil temperature from the range 21° — 24° C to 28° — 30° C, improvements have been obtained in rooting percentage, while reductions in temperature to 15° — 19° C have been found to depress the rooting percentage. The implication of this information, especially in commercial nurseries, is being reviewed. Speed of rooting is already known to be influenced by soil temperature, but there is less experience of the effects of temperature on cutting survival and plant production.

PROPAGATION FOR SPECIALIST USE

The Forestry Commission tree improvement program depends on the successful vegetative propagation of selected plus trees chosen for future seed orchards. The methods vary from species to species, but in practice Western red cedar, (*Thuja plicata*), Lawson cypress (*Chamaecyparis lawsoniana*), Western hemlock (*Tsuga heterophylla*) and Sitka and Norway spruce (*Picea sitchensis* and *P. abies*) are raised from cuttings, while Scots pine (*Pinus sylvestris*), Douglas-fir (*Pseudotsuga menziesii*), and European and Japanese larch (*Larix decidua, L. leptolepis*) are raised by grafting. The different techniques required have been discussed in recent forestry literature.

RECENT DEVELOPMENTS IN COLD STORAGE AT TILHILL

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The cold stores at Tilhill are of Danish design, that is an indirect cooled house, or jacket cooled. The stores, one of 10,000 cubic feet capacity and one of 22,000 cubic feet, were both constructed by our own labor working to plans sent from Denmark. The advantage in having such facilities, as many members know, is that nursery stock can be stored bare-root for many months, which means that a greater bulk of stock can be stored; also it is much easier to control humidity than in a direct-cooled house.

Mr. Dufresne, who is a refrigeration expert from Denmark, will be giving a separate paper on technical questions on jacket cooled stores, and I am sure he will answer any questions that members put to him. The first question to which we wanted an answer was, "How long could stock be stored and still remain viable?" For our trial we used 2-year seedlings *Picea abies (P. excelsa)*; these were tied in bundles, bare-root, and put horizontally in slotted crates. Seedlings were put in the store in December, 1968. We transplanted 200,000 of the stock on 25th August, 1969 and achieved a 90% take. The plants were not damaged by autumn frost and made 3 to 5 inches of growth.

As it was too expensive to run our large stores, the balance of the stock, approximately 20,000, was transferred to a mobile refrigerated

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Ed 's note. Mr. Jackson then showed slides of his cold store, his methods of stacking and of transplanted cold stored plants including *Larix europea, Fagus sylvatica, Acer platanoides* and *Picea abies (P. excelsa).*