tions. A registered source is the Crown Commission Estate in Windsor.

Continental sources — Holland is probably the best source for *Quercus robur* and *Quercus rubra*. These are collected from roadside trees and have had two to three generations of selection. Germany, in particular Spessart, is regarded as the best source for *Quercus petraea* and is also good for *Quercus rubra*.

SHORT TERM STORAGE

The best advice is to sow when collected and thus avoid the problems of storage.

If immediate sowing is out of the question then the important storage criteria are that the seed should be cool and moist. Avoid stacking sacks of acorns as these will overheat and ruin the seed.

A PERSONAL VIEW OF THE ROLE OF A PROPAGATION RESEARCH WORKER

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Within the limits of their terms of reference the attitudes of research workers to applied research topics are coloured partly by their interest in the science of their subject and partly by their interest in the problems of the industry they serve. It does not follow that a science bias or an industry bias or even a middle of the road approach is necessarily best, but it is inescapable that the research worker serves two masters. His scientist overlords will assess his work on its scientific content and hopefully also will judge its value in the horticultural context. Nurserymen are exceptional if they concern themselves with the underlying science, understandably they want a technique which can be explained in precise terms so as to be able to judge its usefulness against the wide range of other interacting factors in nursery management, but they are prepared to leave the collecting of the relevant data and its interpretation to the scientist.

Division of labour. Horticulture is a co-ordinating science requiring knowledge of plant behaviour, soil science, chemistry, physics and so forth, with an ever present appreciation of the commercial background against which innovations and improved techniques will be measured. Within horticulture, propagation similarly draws on a wide range of knowledge and skills. A propagation research worker could legitimately study topics such as nursery soil sickness and specific replant disease (the province of the pathologist and soil scientist), factors affecting regularity of seed supplies for seedling rootstock production (the province of the reproduction plant physiologist), defoliation (the province of the abscission physiologist) as well as basic vegetative propagation. Thus the demands on his time can be enormous, with the result that he either skims the surface of many problems or deals with a few in depth to the exclusion of others. Rule number one is that if among your colleagues there are specialists working in topics relevant to nursery problems try to interest them in giving some of their time to your problem because they will contribute from a depth of knowledge which the co-ordinator does not have. At East Malling specific replant disease, fungal, bacterial and virus diseases, defoliation and chemical shoot control studies relevant to propagation are dealt with by specialists outside the Propagation Department.

Propagation objectives. There are three main objectives, namely relevance, reliability and speed of propagation.

"Relevance" is the reason for undertaking a research investigation. It was relevant recently to study problems in the budding of fruit trees because fruit growers were, and still are, demanding larger, more uniform and better feathered trees than in the past, to carry early crops and give earlier returns on highly capitalized intensive orchards. The outcome of the investigation was to discover that conventional T budding was an inefficient piece of carpentry with respect to matching the cambium of scion and stock and the introduction of chip budding on a wide scale resulted. Awareness of what is relevant is important because the opportunity to make progress may arrive unexpectedly. The initial reason for studying chip budding was to follow-up a pathologist's hunch that apple stem cankers caused by *Nectria galligena* could be caused by spores carried on budwood and that chip budding would minimize the risk, which proved to be the case.

"Reliability" is an essential component of all horticultural techniques, but especially in propagation where there is often no compromise; buds may either fail or grow, cuttings either die or survive, these differences usually being more important that the quality of growth of the survivors. Reliability can often be studied best by stepping outside the role of nurserymen and questioning all aspects of current practice. In the hormone treatment of cuttings concentration of the hormone in the powder or liquid formulation in the past has been considered as the main or even the only important variable. In fact dosage, which determines the rooting response, is determined in leafless hardwood cuttings by duration of dipping, how long the cutting has been removed from the stock plant, the depth to which it is dipped and the angle at which it is left to dry, the last two components being linked to the run-off from the epidermis and absorption through the cutting base of excess liquid. Any one of these factors will markedly affect the concentration response of the hormone. Another example of needing to question conventional practice is the discovery that in stoolbed management of the popular M.9 apple rootstock the best quality plants cannot be creamed-off for budding leaving the smaller ones to be used for extending the stoolbed, as has often been done in the past on the assumption that they will 'make-up'. In fact, productivity is severely reduced each year by establishing beds with inferior material.

"Speed" is basic to nursery production. Cuttings progressively deteriorate under mist and the most successful subjects propagated by this technique are fast rooting plants. Hardwood cuttings which are propagated at the slow-to-root time of year (midwinter), or of difficult clones, expend too much carbohydrate which cannot be replaced in the absence of leaves, and have insufficient reserves left for establishment later in the field. Speed is also essential in the management of research and the introduction of new material to the industry. Where propagation research is coupled to the development of improved plants such as new clonal fruit rootstocks, both the research workers testing their performance and the nurserymen planting up new stock beds require sufficient plants at one time to meet their purpose.

Inherent rooting ability. After a few years' researching into difficult-to-root subjects it becomes obvious that the knowledge available to the researcher does not match up to the size of the problem and that a dual approach is necessary; to improve the technique and search for plants which have easy propagating characteristics. There is every reason to enlist the help of mother nature and with the help of the plant breeder this is becoming increasingly effective. New apple rootstocks are being bred which propagate far more readily from large hardwood cuttings than their predecessors which were raised by stooling, and a cherry rootstock (Colt) is now available which produces preformed roots on many of its shoots by the end of the current growing season, requiring only to be cut off the parent bush and planted. It can be shown also that among a small population of seedlings grown up as individual stock plants for cuttings of, for example, *Tilia cordata*, there exists a wide range of rootability, giving the opportunity to vegetatively propagate species hitherto raised only by seed.

Systems. It is both uneconomic to do too little or too much towards propagating plants by cuttings and it is necessary to identify relevant characteristics of the plant to be propagated and to match the propagating procedure accordingly. For example, the proportion of cuttings of Colt which do not exhibit preformed roots by the autumn, perhaps surprisingly, require inputs of bottom heat and rooting hormone to ensure a high level of establishment despite growing on the same bush adjacent to pre-rooted cuttings. The early leafing Quince C rootstock for pears can be propagated in the autumn by direct planting without the benefit of bottom heat, in midwinter bottom heat is essential, and in February it is too late to obtain many established cuttings with or without bottom heat.

Mechanisms and principles. Underlying the successful application of improved propagation techniques is an understanding of the mechanisms and principles of propagation. While not essential for the introduction of a new technique this deeper understanding is desirable for three reasons. Firstly, it allows extrapolation to situations and species which have not been the subject of the actual experiment, an impossible objective in view of the many thousands of woody plants in cultivation. Secondly, an understanding of the mechanism will suggest new ways to tackle a problem; to understand the mechanism of seasonal fluctuations in rooting ability of cuttings may lead to chemicals being applied to the cutting to make-up for internal deficiencies or, more likely, suggest ways of growing stock plants which ensure high endogenous levels of the active substance. Thirdly, an understanding of the mechanism assists in the forceful promotion of a new technique. There is no doubt that the explanation of relative efficiency of union formation helped to introduce chip budding into commercial nursery production in place of T budding.

Spin-off. It is impossible to research into all the species that nurserymen propagate and priorites are determined in relation to their economic importance and the feasibility of a research study. Research effort can be conserved by linking the applied studies on a number of species to more basic work necessarily carried out with only one or two subjects. It is sensible, and in fact the only practical approach with current restrictions on staffing and equipment, to apply spin-off wherever possible. Chip budding has possibly had a greater impact in ornamental nurseries than in fruit nurseries because in the former both bud-take and tree quality is improved in difficult-to-bud species. An investigation of factors which might influence the success of chip budding in *Acer platanoides* 'Crimson King' showed that the basic techniqe worked out for apples was entirely relevant and no modifications were needed. In fruit tree propagation the experimenter is handling clonal material and his experiments will be more sensitive and show treatment effects better than with heterogeneous populations of cuttings from seedling ornamental understocks, even though results may apply to the latter.

It is likely that differences in cutting response due to the method of applying auxin, or factors associated with poor field establishment through depletion of carbohydrate will apply equally to a wide range of woody plants; it is important that the in-depth investigation is carried out with a reliable subject and that spin-off is applied to those subjects of interest to nurserymen but less suitable as research tools. Many ornamental species, including clonal forms, have such a low level of response to propagation treatments that they are unsuitable for research. Investigations cannot easily be made with subjects which, for example, already root from cuttings at 90% or at zero per cent. Those with intermediate performance offer the best chance for understanding the essential processes and many clonal fruit plants are in this category.

A current example of useful spin-off is the development of clones of *Prunus avium* × *P. pseudocerasus* hybrids with the ease of rooting from cuttings already described for Colt. These are primarily intended to produce smaller sweet cherry trees in orchards to facilitate picking and protection from birds. Their value as easy-to-propagate rootstocks which induce good growth and profuse flowering in ornamental cherries suggests that a major advantage will accrue to non-fruit nurserymen, by giving them an opportunity to become less dependent on imported *P. avium* seedlings for the production of flowering cherries.

Development. New techniques arising from research often fail because of simple horticultural malpractice. Planting hardwood cuttings in bins of over-wet compost, planting them into the field as bare root cuttings when shoots have begun to grow in spring and planting them too shallowly so they desiccate are typical examples. This underlines the need for development to follow research either under the direction of the experimenter or with his collaboration if another agency is involved. At East Malling the presence of a commercial scale nursery for the production of plants for research and for the nursery industry gives an ideal opportunity for ironing out snags and for ensuring that the technical inputs are balanced by sensible horticulture.

Because growing methods differ so much between nurseries, and because important background factors such as labour availability, proportion of skilled labour, land availability and so forth are different on each holding, research workers are rarely in a position to actually recommend that a certain technique is taken up, because they have no guarantee that it will be carried out to the letter and with the necessary background management. Modern techniques derived from research are usually the result of a series of experiments, each giving one clearly defined answer to be fed into the final recipe. Frequently, success at one stage depends on having met previous conditions correctly, and often the importance of this is ignored. It seems that the best objective for the research worker is to ensure to his satisfaction that the technique is workable on a field scale, to emphasize important conditions, and to offer a number of different approaches to nurserymen in the knowledge that their organization will not always be geared to one particular technique.