REPORTS ON FOREST TREE IMPROVEMENT IN BRITAIN AND JAPAN

Chairman- H. C. Buckingham

FOREST TREE BREEDING IN BRITAIN

J. D. Matthews

Forest Geneticist, British Forestry Commission

Introduction

Systematic work on the improvement of forest trees by selection and breeding was begun by the research branch of the British Forestry Commission in 1948, but research into the effects of seed origin or provenance on the vigour, growth habit, disease resistance and other characteristics of the more important species, has been in progress since 1926. The results obtained from this work have recently been summarised by Macdonald et al (1957). Provenance research continues, being the concern of the two silvicultural sections in research branch, the northern section dealing mainly with species used in Scotland and northern England and the southern section with species used in England and Wales. The genetics section was given the task of producing by selection and breeding, superior varieties of pine, larch, Douglas fir and beech for use by both the State and Private sectors of forestry in Britain, and a programme of work was drawn up on the basis of recommendations made by the Forestry Commissioners advisory committee on forest research.

A superior variety or cultivar is one which, when grown on a range of sites, gives rise to vigourous crops possessing good habit of growth, resistance to the diseases or insect pests of economic importance, ability to withstand adverse conditions, ability to bear viable seed, ability to produce timber of good quality and in some cases, ability to produce valuable minor products. Such varieties may occur naturally and can be identified by means of provenance research; or they may have to be produced artificially by selection and breeding.

Conditions are favourable for the application of genetics to forestry in Britain. The type of forestry practised with its great range of species, and the emphases on the afforestation of bare land gives full scope for the use of new varieties. The science of genetics is active and interest in breeding new cultivars is widespread. Lastly there is in the arboreta and policies surrounding our great houses a particularly rich collection of tree species of very diverse origins available for the tree breeder.

Selecting Parent Trees and Seed Sources

The first step taken by the genetics section was to locate, mark, record, and preserve outstanding trees for use in breeding. A systematic survey was begun in 1951 and the register of "plus" trees (i.e. good phenotypes) now contains more than 2,700 entries representing fourteen coniferous and seven broadleaved species. Just over half of the selected trees have

been propagated by grafting or by the rooting of cuttings, and just over one third of the clones derived from the selected trees are now established in "tree banks", which will ultimately form a national collection of plus and other trees for future improvement work. My colleague A. F. Mitchell has made a special study of specimen trees in arboreta and has recorded the di mensions and locations of the finest examples of many species (Mitchell, 1958).

During this search for suitable parent trees attention was also paid to potential seed sources. These have been classified and recorded in a Register of Seed Sources. As interest grew in the possibilities of tree improvement by selection and breeding it became desirable to form tree seed associations to represent the interests of the seed and nursery trade, state and private forestry and the timber trade. The Scottish Forest Tree Seed Association was formed in 1956 and the Forest Tree Seed Association of England and Wales in 1959. The object of these voluntary associations is to encourage in all possible ways the use of forest tree seed of the best known origin and quality.

Registering seed sources is only a first step. Collecting seed from tall standing trees is the next and more difficult problem. Various methods of seed collection have been tested and the results of this work have been reported by D. T. Seal (1959). A combination of the Swiss tree bicycle for scaling the stems, nylon line and safety belt for moving about in the crowns, and rope scrambling net for collecting seed from trees with small and numerous cones, such as Thuja plicata, Chamaecyparis lawsoniana and Tsuga heterophylla, permits collection from all but the very largest trees. The problems of seed storage and seed testing have been the concern of G D. Holmes and G. Buszewicz of the southern silviculture section. (Holmes and Buszewicz 1958; Buszewicz 1960). There is now refrigerated storage space for more than 6),000 pounds of conifer seed which represents three years requirements and bridges the gap between good seed years.

Although seed collection from selected seed sources in Britain is increasing, the greater part of the seed used comes from abroad. This is because most of our plantations are still too young to bear much seed and older plantations are, because of the fellings in two world wars, few in number. This situation gives particular urgency to the formation of seed orchards, which, besides making seed easier to obtain, permit genetic improvement of the species concerned. But in spite of the seed orchard programme and increased collection from plantations and trees in Britain we shall for many years have to buy in much seed from abroad and for this reason British foresters have a special interest in the continued development of international trading in tree seed on sound lines.

The Breeding Projects

In 1948 there were two obvious applications for selection and breeding. The first was the mass production of the first generation hybrid Larix decidua x L leptolepis known as Dunkeld hybrid larch, which has been widely used in Britain for more than forty years. The second was the improvement of the native Scots pine (Pinus sylvestris). Selection of plus trees of European and Japanese larch was followed by the vegetative propagation of fifteen of the outstanding phenotypes and the grafted plants produced from these trees were planted in a seed orchard at Newton in Morayshire, Scotland during the years 1951 to 1953. Most of the clones of grafted plants flowered in 1956

and a partial diallel cross was attempted in which as many crosses as possible were made between the clones in the seed orchard. The early development of this seed orchard has been described by Mitchell (1959) and the height and diameter growth of the two year transplant derived from the partial diallel cross has been analysed in an attempt to estimate the heritability of these, characteristics in young larches. A summary of the results are presented later in this paper.

Since 1951 fifty acres of larch seed orchard have been established and because of the reduced use of larch which is anticipated these seed orchards should eventually satisfy the requirements for hybrid larch. These seed orchards will themselves be used for the further improvement of the larches and in the second stage of selection and cross breeding the clonal composition of the existing seed orchards will be changed and some new seed orchards planted to replace the existing ones. This procedure will permit the continuous introduction of new improved cultivars as they are developed.

In January 1953 a great gale swept over eastern Scotland and blew down a large area of mature Scots pine plantations the loss being estimated at more than 40 million cubic feet. Overnight it became imperative to increase selection and propagation in Scots pine if valuable genetic material was not to be lost. In 1953 more than 200 plus trees which had, fortunately, already been selected and marked were propagated by grafting; seed from these trees was also sown for one-parent progeny trials. These graftings and those from other trees subsequently went to form forty-five acres of Scots pine seed orchard; but a further 120 acres is needed to satisfy the anticipated demands for Scots pine seed and so the work of selecting and propagating plus trees and forming seed orchards continues. The long term plan for the breeding of the two needled pines was outlined by Matthews and McLean (1957) and this work is now being carried on by R. Faulkner and his colleagues from the northern research centre in Edinburgh, Scotland. It is intended that much interspecific cross breeding will be done among the two-needled pines and attempts have ready been made to cross Pinus sylvestris with Pinus niqra var . calabrica, the valuable variety of the European black pine which comes from Corsica. Mr. Faulkner is also making inter-provenance crosses in Pinus contorta which is an important species in Britain on heathland and moorland sites.

Two smaller breeding projects concern Douglas fir and beech (Fagus sylvatica). There are some magnificent plantations and individual tree Douglas fir in Britain and we wish to make more use of them both by collecting seed from existing trees and by forming seed orchards for the production of good cultivars. In beech, selection and breeding is directed particularly towards producing cultivars with increased vigour and improved stem form.

Finally there are the spruces and the hybrid Leyland cypress. Now that pulp mills and other large plants have been built in Britain to utilise home grown spruce, interest has quickened in the possibilities of selection and breeding for timber characteristics such as density and fibre dimensions Mr. B. J. Rendle and his colleagues at the Forest Products Research Laboratory are handling the wood structure aspects of this work. Selection and breeding will follow, once more is known about the variation which exists in the wood characteristics, particularly of Sitka spruce (Picea sitchensis).

The first generation hybrid between Cupressus macrocarpa and Chmae -cyparis nootkatensis is known as Leyland cypress (x Cupressocyparis leylandii). It promises to be a most useful tree combining as it does the growth rate of

C. macrocarpa with the frost hardiness and good timber characteristics of C. nootkatensis. At present existing trees are being multiplied vegetatively from summerood cuttings (Matthews et al, 1960) but controlled crosses have been attempted between selected trees of the two parent species as a prelude to the mass production of seed of this intergeneric hybrid.

The Techniques of Tree Breeding

Vegetative propagation by grafts and cuttings follows a pattern which will be familiar to many tree improvement workers. Most of the grafting is done in January and February under glass and in late March, April and early May outdoors. We annually attempt some 20,000 grafts. Polyethylene bag protection has proved useful for outdoor grafting of the larches. Grafting under glass is essential whem scion wood is taken direct from old plus trees of Scots pine and European larch but the better secondary scion wood taken from existing graftings of these species can be grafted outdoors, often direct onto rootstocks established on seed orchard sites. The plagiotropic growth of scions derived from older trees of larches and Douglas fir has given much trouble. In the larches staking and pruning eventually leads to the formation of a strong leading shoot and normal upright development, but in Douglas fir the problem is not yet fully solved.

The use of propagation frames equipped with electronically controlled "mist" watering equipment has greatly improved the speed and success of rooting summerwood cuttings of Leyland cypress, clones of white and aspen poplar which are difficult to root, and elms. (The work done on poplars and elms at Alice Holt is under the charge of Mr. J Jobling of the southern silviculture section).

Professor P. F. Wareing and his colleagues in the University College of Wales at Aberystwyth are making a special study of the physiology of flo wering and juvenility in forest trees. The results of their work on geotropic effects in flowering and shoot growth of larch (Longman and Wareing, 1958) has been applied in larch seed orchards, where branches of the seed trees are tied into a downward pointing position during the dormant season. The terminal shoots of the treated branches cease to grow vigorously and the branches become fruitful. A disbudding technique for inducing male flowering in Scots pine is being tested under field conditions with the object of developing a practical procedure for seed orchards. In beech we have evidence of the need to grow the grafts as rapidly as possible in their early years so that they quickly reach a large size and produce a complex lower branch system both of which are essential for good flowering of both sexes.

The results of work on the collection, ripening, extraction, storage and testing of pollen has been reported by R. Worsley (1959a, b) who was able to ripen off male flowers on cut branches of forty-six species by altering light intensity, day length, air temperature and humidity. The pollen was extracted and tested by two groups of methods, those of germination in various media and vital staining. The simple vital staining technique which emerged is now used in the field, a trailer caravan having been fitted out as a mobile field laboratory for this and other operations necessary for controlled pollination in the seed orchards.

Progeny testing is a vital part of tree breeding and the design, layout and assessment of one and two-parent progeny trials is under constant review. Mr. Faulkner is testing methods for raising progenies with the object of reducing experimental error and increasing the accuracy of estimates of combining ability and heritability. In the present scheme the seed of larches,

pines and spruces is being sown in seed pans and a specified minimum number of plants from each progeny are pricked out into nursery seed beds at the late cotyledon or early primary needle stage. The number of blocks in the nursery layout is related to the forest trials, which are usually three in number, the progenies being planted on sites favourable, moderately favourable and unfavourable to their growth. The one year seedlings are undercut in the seed beds and left further year for planting as "1U1" plants thus eliminating transplanting.

One type of field experimental layout combines the functions of field trial and seed orchard. Thirty to sixty progenies have been planted out in single-tree plots at wide spacing and replicated twenty or more times. In their early years the trees have ample room to develop and show their vigour, growth habit and other characteristics as individuals. They will also flower more quickly than in closed stands, thus permitting early selection and further cross breeding. Ultimately such field trials will be converted to seed orchards.

A final point of technique relates to estimates of combining ability and heritability. In the Newton larch seed orchard referred to earlier nine Japanese larch (J) and three European larch (E) clones were crossed in as many combinations as possible. The progenies were assessed as 1+1 transplants and the combining abilities of the parent clones and heritability of height and diameter growth have been estimated by analysis of variance. Three parent clones showed high general combining ability. The parent trees had also been, when selected in the forest, the most outstanding phenotypes.

103 progenies totalling 9,545 plants were raised and measured, and data from 79 of the progenies were used in the analysis. The superiority of the inter-species crosses ExJ and JxE over the intraspecies (JxJ) combinations, was striking. Heritability in the narrow sense, (that due to additive genetic variance) was small for both height and diameter growth of two year transplants. This result emphasises the need for adequate progeny testing. Finally it appears from the data we have analysed that the male parent plays little part in determining the size of its progeny at two years of age. We shall continue our observations on the growth and other characteristics of these progenies and hope to learn many interesting things from them.

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