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Breeding Hybrid Larch in Britain

INFORMATION NOTE

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SUMMARY

The hybrid vigour obtained when Japanese and European larch (JL and EL) are crossbred has long been recognised by tree breeders. Tree breeders began selecting EL and JL plus-trees in the early 1960s. This work was followed by cross-species controlled pollination between plus-trees to create hybrid larch (HL) families. Progeny tests designed to compare the performance of HL families across a range of suitable sites were planted from the mid-1970s to early-1990s. These tests allowed an estimation of the value of each mother tree when crossed with the alternate species.

Ten-year height and stem straightness data collected from over 43 progeny tests have now been analysed. This will enable the re-selection of the best EL and JL plus-trees to create a HL breeding population. Genetic gains of 15–20% for 10-year height and 20–25% for 10-year stem straightness are predicted for 100% hybrid families relative to a JL seed stand control. All selected EL and JL parent trees will be retained in two geographically separated clonebanks. Future controlled pollinations of the best EL parents with the best JL parents to produce HL families will be carried out in the clonebanks according to demand by the nursery and forestry industries.

INTRODUCTION

The larch grown commercially in Britain is either European (*Larix decidua* Miller), Japanese (*L. kaempferi* Lambert) or a hybrid between these two (*L.* x *eurolepsis* Henry). Collectively, larch represents nearly 10% of the total conifer area in Britain (Forestry Commission, 2003). It is a pioneer species, with a fast initial growth rate, capable of colonising mineral or disturbed sites. European larch was first introduced to Britain in 1629, and was planted on a wide-scale in central Scotland from the 1750s onwards. Japanese larch was introduced in the 1860s but it was not until 1885 that large-scale planting commenced.

European larch (EL) and Japanese larch (JL) quickly became popular with foresters, gaining a reputation as a good nurse for hardwood species; casting a light shade so allowing ground vegetation to persist; a degree of fire tolerance and high amenity value. The timber is highly valued for good durability and is used in the manufacture of outdoor furniture, bridges and fences as well as boat-building. The Japanese variety was observed to generally grow faster than its European counterpart, although with perhaps poorer stem form, and showed little sign of shoot canker which can be a problem for EL on less suitable sites. EL flushes earlier than Japanese larch – often well-advanced by the end of March – putting it at serious risk of frost damage.

CHOICE OF SEED ORIGIN

EL occurs naturally in 5 distinct areas across central Europe (Lines, 1987). Most of the early introductions were from the Alps, while today planting stock of Sudeten mountains origin (Czech republic) is recommended as the best combination of good growth rate, good stem-form, later flushing and resistance to canker.

JL occurs on a group of volcanic mountains in central Honshu, Japan. Most seed has been imported from Japanese plantations, thought to be of Nagano origin, which provenance trials have shown to be the most suitable for much of Britain (Lines, 1987). However, for both EL and JL, the best adapted seed sources are likely to come from British-registered seed stands of which there are currently 17 JL and 16 EL in the National Register of Approval Basic Material (Forestry Commission, 2002).

Hybrid larch was first observed on the Duke of Athol's estate at Dunkeld, Perthshire, central Scotland around

1904 and the hybrid is often referred to as 'Dunkeld larch' in many parts of the world. HL became popular as a commercial forestry species due to its vigour, which was thought to exceed either parent, and its resistance to canker. Although hybridisation between EL and JL can occur naturally, most hybrids are produced by controlled pollination. There are 2 HL seed stands in the National Register of Approved Basic Material (Forestry Commission, 2002) although the seed collected from these stands will be a mixture of pure EL, pure JL and hybrid families.

THE FORESTRY COMMISSION LARCH BREEDING PROGRAMME

The first task in the larch breeding programme was to select EL and JL 'plus-trees' (highly selected phenotypes with well above average growth rates and stem quality). Breeders then needed to assess the attributes of each plus-tree when cross-pollinated with the alternate species to produce HL families. Unlike other species in which open-pollinated material from the parent plus-trees could be used for genetic testing (Sitka spruce, Lee 2001; Scots pine, Lee 2002), breeders had to be sure that seed fertilisation would be 100% from the alternate species. Controlled pollination was therefore essential.

Because selected plus-trees were generally too tall for controlled pollination *in situ*, the work had to be delayed until grafted-copies planted in clonebanks became ready to flower. This caused a delay of around 10 years between the selection of a plus-tree and planting the HL progeny from that tree in comparative progeny trials.

Female flowers on grafted copies of plus-trees were isolated from background pollen and then pollinated with a mixture of pollens (commonly 15–20) collected from grafted copies of plus-trees from the alternate species. The exact components of the pollen mix would vary from year to year but was always taken to be a representative sample of plus-trees for that species.

A total of 527 EL and 328 JL plus-trees were selected in the early 1960s, the latter half of the 1970s and the early 1980s. Selection was mainly according to the high selection intensity principles detailed in Fletcher and Faulkner (1972). Around 330 plus-trees (EL and JL combined) were subsequently tested as parents of hybrid families over this period – 40% of the original selections.

ANALYSIS OF HYBRID LARCH PROGENY TEST DATA

Further complications in the testing of hybrid larch families have been:

- each species flowers in early spring when damaging frosts and gales may still occur;
- the species do not flower at exactly the same time;
- the number of full seeds per cone is often less than 10 (contrast with Sitka spruce, >30);
- there are problems associated with pollen storage and assessments of pollen viability.

Sowing of progeny tests was consequently further delayed until sufficient seed was accumulated over several pollination years. Progress was slow but 71 progeny tests were eventually planted in 18 different years between 1959 and 1994. Planting was interrupted between 1964 and 1973 when the larch breeding effort was halted due to a temporary lack of demand for HL.

The most recently planted hybrid larch progeny tests have now been assessed for 10-year height and stem straightness. This has given breeders the opportunity to collate data from all the different tests over the years and assess parental breeding values. This process will allow re-selection of the best parent EL and JL plus-trees which could then be cross-pollinated in the clonebanks to create superior hybrid families for commercial use.

However, analysing the data has revealed further problems. Some of the early progeny tests were not hybrid families, but EL x EL or JL x JL. Also, particularly in the early years, the standard against which performance was measured was not consistent between tests.

Forty-three tests were identified that contained reliable height or stem straightness data. Performance of the hybrid families and plus-tree breeding values for the parents were assessed relative to a JL seed stand which was the most common standard within these tests. Ten-year height and stem straightness breeding values were estimated for nearly 200 EL plus-trees and 50 JL plus-trees – that is 50% of the original EL selections but less than 20% of the original JL selections. This reflects the problems associated with storing the EL pollen for 12 months before pollinating JL female flowers.

RE-SELECTION OF SUPERIOR EUROPEAN LARCH AND JAPANESE LARCH PLUS-TREES

Nearly every hybrid larch family was found to grow faster and straighter than the JL seed stand. This may be a result of hybrid interaction between the two species but an element can be attributed to the extra gain from plus-tree selection. The top 100 EL plus-trees and all the JL plus-trees will now be grafted and retained in replicated clonebanks so that genetic material is not lost.

Breeders can now sift further amongst the re-selected EL and JL parents to create hybrid families that will give the best gain combinations for vigour and stem straightness.

PRODUCTION OF HYBRID LARCH PLANTING STOCK

Four HL seed orchards already exist (Forestry Commission, 2002). Each orchard contains grafted copies of around 20 untested EL plus-trees and 20 untested JL plus-trees. The orchards are considered as *Qualified* under the new Forest Reproductive Material Regulations (Anon, 2002). Due to the lack of flowering synchronicity between component trees, seed harvested from these orchards is not 100% HL but a mixture of pure EL, pure JL and an element of HL. The proportion of HL varies according to the mother species. Ennos and Tang Qian (1994) found 58% HL when seed was harvested from EL mother trees, but just 14% when it was harvested from JL mother trees.

The only way to guarantee 100% HL seed is to carry out controlled pollination between EL and JL parents. The small quantities of HL seed produced could then be multiplied-up using vegetative propagation techniques (Mason, 1989). Early attempts at a HL vegetative propagation programme at Forest Enterprise's Delamere Nursery was abandoned due to low rooting percentages, leading to higher costs relative to the Sitka spruce programme, and a consequent lack of demand. Forest Research has recently been engaged in work to further improve the cost-effectiveness of HL vegetative propagation. Some success has been obtained in increasing the number of available cuttings from each stockplant and improvement of rooting success by optimising the timing of cutting insertion into suitable medium (Harrison *et al.*, 2002). New pre-commercial trials based on these modified techniques are planned for Wales in the near future.

GENETIC GAINS

Family heritability was found to be low for both height (0.48) and stem straightness (0.46). The genetic correlation between height and stem straightness was very close to neutral (0.1) which allows breeders to easily identify a large number of fast-growing families with good stem straightness.

Existing (untested) seed orchards are predicted as giving around 5% improvement for diameter and 5% for stem straightness, relative to a JL seed stand (weighted for assumed HL content of 20%). Following the re-selection of superior EL and JL parents in this study, the gains from controlled pollination followed by vegetative propagation should be 15%–20% for 10-year height and 20–25% for stem straightness, depending on the relative importance placed on each trait. Some outstanding individual HL families can be identified with predicted gains in excess of 20% for 10-year height and 30% for 10-year straightness but the only way such gains can be realised is through controlled pollination and vegetative propagation. These gains are large considering the relatively small numbers of plus-trees tested.

CONCLUSIONS

All relevant HL progeny test data for height and stem straightness have now been analysed. Progress has been slow due to various problems, including: the need to produce a hybrid between two species that do not flower at exactly the same time; low seed yield per cone; frequent frosting of flowers; pollen that does not store easily and a delay of cross-pollination work until grafted copies produced sufficient flowers in clonebanks. Breeding values have now been estimated for around 200 EL and 50 JL parent plus-trees.

Grafted copies of each of the re-selected EL plus-trees and all the JL plus-trees will be planted in two clone banks, located in different parts of the country, ensuring that controlled pollination to produce superior HL families can be carried out if future demand requires it.

Controlled pollination and vegetative propagation can be used to produce HL planting stock offering considerable gains for 10-year height and stem straightness well in excess of those obtained from existing seed orchards.

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