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KEYWORDS: DOUGLAS-FIR, POLLINATION, BREEDING PROGRAMME, RESEARCH STATION

ABSTRACT*

A visit was made an April 1-12 to the Cowichan Lake Research Station on Vancouver Island with the purpose of gaining skills in the area of Douglas-fir pollination in order to facilitate the New Zealand breeding programme.

Experience was gained in all aspects of Douglas-fir pollination. This included flower identification and isolation, phenology monitoring, pollen collection, extraction, application to flowers and storage.

Most pollination work was carried out at the Research Station with additional isolation at Bowser Seed orchard. A commercial seed merchant was also invited.

The following points are important in maximising efficiency in production of controlled pollination of Douglas-fir seed.

1. Flower and poll development can be rapid - especially in relatively warm weather.

2. Timing is critical with respect to pollen collection and flower pollination. Daily phenology checks are vital if fresh pollen is to be used.

3. An open polyhouse should be considered in areas where the likelihood of wet weather is high. Wet often equates with relative warmth in winter.

4. Judicious use of $GA_{4/7}$ is vital in ensuring flower and pollen production.

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* **Note: This material is unpublished and must not be cited as a literature reference.**

DOUGLAS-FIR BREEDING AT COWICHAN LAKE RESEARCH STATION, VANCOUVER ISLAND, BRITISH COLUMBIA

M. Miller

Report No. **July 1996**

NZFRI/INDUSTRY RESEARCH COOPERATIVES

DOUGLAS-FIR COOPERATIVE

EXECUTIVE SUMMARY

DOUGLAS-FIR BREEDING AT COWICHAN LAKE RESEARCH STATION, VANCOUVER ISLAND, BRITISH COLUMBIA

M. Miller

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M. MILLER

INTRODUCTION

A pollination training trip was made to Cowichan Lake Research station in the Pacific North West in order to gain skills which would enhance the success of the NZ Douglas-fir breeding programme. It was felt that in the limited time available it would be more efficient to work with one organisation especially since they had a strong liaison with Weyerhauser based in Washington. I was assured that both organisations used similar techniques and equipment. My host was Dr. Jack Woods. His email address is on FRI's email address listing.

Cowichan Lake Research Station is situated on a small peninsula at the southern end of Lake Cowichan about 63 km northwest of Victoria City.

The lake sits in a glacially scoured valley at about 150 metres above sea level. The surrounding mountains range from 400 → 1100 metres a.s.l. The name of the lake is a European version of the North American Indian name pronounced Co-it-zin. This can be roughly translated to "Valley of the Sun" or alternatively "The Warm Earth".

Meteorological records dating back 50 years show the Research Station to receive about 2000mm of rain per year. Summer is relatively dry with the five months of May to September contributing only about 270 mm total. November, December and January account for just under 1,000 mm or half of the yearly average.

The valley is considerably drier than the west coast of Vancouver Island. The relatively mild and moist climate provides a long growing season and therefore some of the most productive forest land in Canada - reputedly with the highest site index for Canadian Douglas-fir. Good trees on good sites will display an annual height increment of 1.0 to 1.5 metres.

Summer temperatures range to the mid twenties while in winter sub zero conditions may exist for weeks at a time. Soils surrounding the Research Station are glacially derived sandy loam. This overlays a hardpan induced by glacial compaction.

Forests are composed of 90% conifers. Douglas-fir occupies about 70% of productive forest cover. The eastern coastal strips (especially with Southern exposure) can be nearly solid Douglas-fir with a larger proportion of Hemlock, Sitka spruce and Western Red Cedar in damper northern areas. Other important forest species are Grand fir, Yellow cedar at high elevations, *P. contorta* and *P. monticola.*

Cowichan valley is in many ways analogous to Kaingaroa. It is the historical centre of forestry on Vancouver Island. In 1886 roads were pushed into the area in pursuit of quality farmland and the forest was initially considered a nuisance. However, commercial logging began in the same year and peaked in 1947 when 1.5 million cubic metres were produced by three mills. One of these closed in 1968 and another in 1982. Parts of the valley are now growing a third crop of trees.

The camp at the research station was established in 1929 and linked with unemployment relief programmes during the depression years. It housed and fed 100 people who were building roads and trails. The camp then served as a Forest Service planting and felling crew base. Until the 1960's the station served many purposes including a research centre for a range of studies. The nursery was established in 1963.

The tree improvement programme was introduced in the 1950's by Dr A.L. Orr Ewing - the driving force behind Douglas-fir improvement in British Columbia. This man was quite a character with a distinguished war record including being awarded the Military Cross and incarceration in Colditz. His personal interest in inbreeding studies had him doing his pollination work in his underwear to prevent possible pollen contamination!

In 1957 Douglas-fir plus tree selection began on a large scale and in 1963 a programme was begun to cross trees from widely separate provenances to investigate heterosis effects (the wide crossing programme). As a result a breeding arboretum representing the whole natural range of Douglas-fir was established - 320 locations from Mexico to central British Columbia.

Breeding Arboreta

Clones in the current breeding programme have been established in both a field situation and in a **polyhouse** which is uncovered in summer.

This allows flexibility in the breeding work in that all operations can be carried out in any weather on some examples of all clones. Also, the slightly warmer conditions under cover induce the flowers and pollen to mature approximately one week earlier than on the same clone outside. In a crossing programme this fact alone will allow crosses to be made (with fresh pollen) that otherwise could not be done.

The clones in the field breeding arboretum were grafted to compatible rootstocks and transplanted in late winter one year after grafting. In this way it was hoped to establish strong healthy plants which could later be induced to flower. The field site is on a well drained, relatively dry broad ridge which is considered ideal for Douglas-fir.

I noted very little plagiotropic growth. Jack Woods felt that healthy compatible rootstock was an important factor in reducing plagiotropism. All trees in the field breeding arboretum had been girdled with a full circumference joining knife cut down to the xylem. Two out of three ramets in each clone were also injected with $GA_{4/7}$ by filling a 3 mm hole bored at 45° downwards through the stem until it reaches the cambium on the other side.

The semi open polyhouse is of relatively simple construction. End walls are corrugated plastic while the roof cover is clear polythene. This lasts at least a couple of years but is removed each summer. Replacement cost is currently about NZ$500. The sides are open to about 1.5 m.

The scions for the polyhouse ramets were collected in January or February and were grafted to compatible rootstock established in beds. This is purposefully done about 2-3 weeks before vegetative bud flush on the rootstock and helps with development of a good graft union before the scion wants to grow. These grafts were grown on for two years and then lifted about 2-3 weeks prior to vegetative bud flush and potted (later than normal transplanting to purposely stress the trees). The potting mix contains decomposed sawdust, peat and perlite. They were then given a stem injection of $GA_{4/7}$ at about the time of vegetative bud flush. These ramets are aptly named the tortured trees.

Plants are often a little weak after stressing so are often tied to overhead support - pollination bags can also be stapled to these. There must be care taken not to over-water these potted plants as root-rot can be a problem.

Isolation

Flowers are isolated from outside pollen in early April. Paper bags with a plastic window are used and are considered adequate for the weather experienced at this time of year. The research station has plenty of rain (about 130 mm) during April but usually very little serious wind. The procedure for isolating is as follows:

1. Identify female flowers. These are usually near the tip of the first and second order branches and may be abundant or very scarce. They are generally larger than either vegetative buds or male pollen buds which are rounded and usually on the underside of the branch. The vegetative tip bud is a good standard to compare to possible flower buds. It is reddish, relatively small and unswollen.

   Checking the phenology of buds after peeling off the outer scales will help on those clones where the difference between male and female buds is not immediately obvious. A peeled pollen bud has the appearance of fish roe, i.e. small round nodules. The bud becomes more corn-cob like in appearance as it matures.

   On the female flower bud the bracts are obvious and resemble layered rats tails. Flowers generally take on a yellow tinge prior to opening.

2. Remove pollen catkins which would otherwise be included inside the isolation bag. Pollen buds are normally within 150 mm of the branch tip but are easily overlooked because they are located on the underside of the branch.

3. Perhaps gather several flower bearing branches together and tie lightly to facilitate bagging.

4. Wrap non absorbent cotton wool around the stem(s) to pad the open bag end.

5. Secure with a tight surgeons knot (i.e. a granny knot with one extra loop) using stout manilla string. The string allows a more secure fastening (compared to twist ties) but must be thick enough not to damage hands when pulled tight.

6. Clone and bag number are written directly on the isolation bag with indelible marker pens.

7. A plastic 'chicken ring' is attached to the stem after the 1st pollination - colour coded by programme.

This system is parallelled by Weyerhauser but they use a wire support inside the isolation bag. They possibly have a more exposed orchard situation.

The pollination bags can be left on while the cones develop which has added benefits of identification, protection and exclusion of the *Megastigmus* grub.

The use of large cheap mountaineering bumbags proved ideal as gear containers for the isolation job.

Jack Woods felt that frosts at Lake Cowichan don't affect flowers inside pollination bags but he has definitely lost unprotected flowers to unseasonable frosts. He expects up to 30 seed per cone from the field breeding arboretum but about half that from the tortured trees in the polyhouse where the same clones are represented.

Normally there is no bagging of any flower which has begun to open - early receptivity is very high. Flower development happens very quickly at this stage especially in warm weather. Many flowers abort before opening and particularly so in the stressed polyhouse environment.

There is much dependence upon 'tracking forms' (Appendix 1). The information is collated every day to help Jack manage has crossing programme.

Additional phenology checks are carried out regularly to monitor flower and pollen maturation progress of each clone (Appendix 2). It is a major job adding information to the database and deciding upon which crosses are to be made. This juggling act situation arises mainly from the insistence upon using fresh pollen if at all possible.

Pollen Application

Usually done twice per flower over a three or four day period. Paintbrushes are used when pollen is in short supply - the pollination bag obviously has to be opened and restapled when using brushes. The puffers used at the research centre seemed less effective than the equivalent New Zealand models, i.e. less observable pollen being introduced into the bag. The needle shouldn't be used on the plastic window as this is liable to tear.

Pollen Collection

The preference for using fresh pollen and the rate at which pollen can mature and be shed necessitates early and constant monitoring of the maturation state, i.e. a daily check of each clone.
At the best there can be a 24 hour turnaround time between pollen collection and subsequent application to flowers.

Pollen is normally stripped into 500 ml plastic containers. Jack has his own technique which is admittedly very fast. The little and ring finger trap the container against the palm of the left hand (facing upwards!). Thumb and forefinger of the same hand hold the end of a pollen bearing branch and lift it up exposing the pollen catkins. The thumb and forefinger of the right hand then strip into the container. One full 500 ml container yields about 10-50 mls of pollen - this is enough for Jacks needs each year. Any excess is stored in case of a shortfall the following year.

The pollen extraction room is set at about 30°C and 40% humidity. Small collections, e.g. 100 mls or less are suspended in paper bags while large lots are dried in a forced warm air situation for 48 hours. Under these conditions pollen will dry to about 5-7% moisture content and is then used or stored. Very small lots, which are usually brushed on, are put in ziplock bags while large lots go into jars. Day to day storage is in a refrigerator while long term storage would normally be in heat-sealed bags at -20°C.

Bowser Seed Orchard

Some time was spent isolating flowers at Bowser Seed Orchard, which is about 2 hours north of Cowichan Lake. These were a 'top-up' to the normal programme as a sort of insurance.

Bowser was chosen as an orchard site because of the relatively harsh conditions which should encourage flowering. It is elevated but dry in summer. There is a full irrigation system installed for both supplementary watering in summer and automated misting in spring to retard flower and pollen development relative to the surrounding natural stands. Sensors are used to detect temperature and humidity changes. In a warm spring, pollen and flower development can be retarded as much as three weeks - in cool conditions the system is not so effective with only about 1 week delay relative to the surrounding Douglas-fir. For our isolations here we used additional inner mesh bags made of flyscreen type material to give extra support to the paper bags. The constant misting and higher winds of this region can destroy paper bags very quickly if they are not supported.

Commercial Cone Collection

Commercial cone collections of Douglas-fir and other species often employ a suspended 'cone rake' flown beneath a helicopter. My search for information led me to

Don Piggott, a local seed merchant and past researcher who distinguished himself by falling 75 feet while cone collecting. He suffered five fractures to his leg bones and three arm fractures. His preference for flying over climbing these days is understandable. Occasionally they harvest squirrel caches - especially of Douglas-fir and Sitka spruce. At certain times this is very lucrative.

In his yard he had a damaged FANDRICH cone rake. The fibre glass cone shaped body had been holed by a broken branch. Usually it is slung below a Huges 500 D - it weighs about 150 kg and is suspended around 12 metres below the aircraft. It is lowered over the crown of the tree and then lifted. Teeth at the top of the rake cut off branches up to 40 mm thick and strip cones. Up to six trees will normally be collected per load. When the outer cage is full enough to warrant a drop off the cone rake is flown to a collection point, the outer cage unclipped by ground crew to deposit the cones and branches then clipped back on to continue aerial collection.

More sophisticated models include a small circular saw which can remove the tree top or a set of flailing fingers which effectively remove cones and twigs only.

FANDRICH cone rakes cannot be purchased in British Columbia, only rented. Rental is charged on the basis of the volume of cones collected, e.g. $36 per hectolite for Douglas-fir. Normally three to six hectolites per hour is expected. In exceptional situations it costs more to hire the cone rake than the helicopter because of the volume of cones being collected; sometimes twice as much. This applies more to other species such as grand fir.

Western Red Cedar seed currently sells for $20,000 (Ca) per kilogram so these expensive collection techniques are economically justifiable.

The dried cones of many species are sold for Christmas decorations and pot pourri.

CONCLUSION

We already have most of the skills and techniques required to successfully breed Douglas-fir. A number if issues are important in maximising efficiency.

1. Flower and pollen development can be very rapid with major phenology changes each day (especially in warm weather).

2. Timing is critical, flowers are most receptive in their first few days after opening and pollen extraction is most effective on catkins which are very close to shedding. If fresh pollen is to be used, daily phenology checks are vital - but time consuming.

3. In a wet environment an open polyhouse will allow work to continue in otherwise impossible conditions and also gives flexibility to the breeding programme.

4. Judicious use of $GA_{4/7}$ is vital in ensuring flower and pollen production. Do not treat all ramets of each clone every year as the continuous stress will de detrimental to the plants health.

It is very possible to achieve the same results in New Zealand and early indications from the crossing programme begun at Waikuku orchard in 1995 bear this out.

APPENDIX 1

POLLINATION FILED CARD

Clone:____________ **Location:**______________ **Year**______________

Bag No.	Ramet No.	No. Stob	Date bag	Pollen parent	Ring Colour	Date Pollinated 1	2	Cones Collected	Date Collected