Limbs & Needles. 1997. 24(2):10,12-15.

Control-Pollination of Fraser Fir

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Control-pollination is a technique used in tree improvement to produce progeny that receive genes from each of two known parent trees. Control-pollination consists of transferring pollen from one tree to the receptive female reproductive organs of another tree while excluding all other pollen.

Control-pollination is necessary to:

1) establish and maintain a pedigreed breeding population,
2) control inbreeding in the breeding population and
3) hybridize and back-cross among species.

Until recently, control-pollination was viewed only as a technique used to produce a small amount of seed for breeding or research purposes. However, forest tree improvement programs world-wide are beginning to adapt control-pollination techniques to produce seed for operational planting stock. Specially designed and managed CP (control-pollinated) orchards are being established and used for this purpose. Such orchards produce seed with greater genetic gain and more genetic uniformity than wind-pollinated orchards and also eliminate pollen contamination problems. The feasibility of Fraser fir CP orchards needs to be examined.

This article gives an overview of performing control-pollinations in Fraser fir. Much of the information presented here has been borrowed directly from experience with and literature of southern pine species.

Pollen Collection

In Fraser fir and other conifers the structures bearing the male (or female) reproductive organs are referred to as ***strobili*** (singular = strobilus). The male strobili produce pollen. Male strobili are initiated in late summer of the year before emergence. Buds containing male strobili are swollen and obvious by January. Male strobili are clustered on the undersides of branches and are generally present in the lower half of mature trees.

Strobilus collection should occur when they are swollen and have begun to change in color from red to yellow. During typical years this occurs during early to mid-April.

The most productive collection method is to cut pollen-bearing lower branches from selected male parent trees and place then into buckets of water in a warm dry room or greenhouse under incandescent lights. As the strobili begin to shed pollen, they should be removed and placed into paper bags with the tops folded and stapled. These bags are then placed into a forced-air dryer at 85-100° F and low relative humidity (less than 50 percent). Usually pollen extraction is possible after less than 48 hours in the drier. To extract the pollen, the bags are shaken vigorously, one bottom corner of the bag is cut and the pollen is poured though an 80- or 100-mesh sieve to remove debris. Pollen treated in this manner generally has a moisture content less than 10 percent and can be refrigerated at a few degrees above freezing (35-37° F) in sealed plastic or glass containers for several weeks until needed. For long-term storage, pollen should be vacuum dried and stored below freezing in ampules or sealed foil laminate pouches.

Development of Female Stobili

The female reproductive organs of Fraser fir are also referred to as strobili or ***cones***. Buds containing female strobili begin swelling later than those containing male strobili but are obvious by late March to early April. Female strobili occur on the upper sides of branches and are generally concentrated in the upper crown. Occasionally, the same branch will possess both male and female strobili. In very rare instances, a cone may be bisporangiate (contain both sexes) with the male reproductive structure located on top of that of the female. Such a cone is capable of producing sound seed.

In order to achieve high seed yields from control-pollination, knowledge of the developmental sequence of female strobili is necessary. Although strobilus development is a continuous process, it can be divided into six stages to aid in control-pollination (Table 1). In Stage 1, the buds containing female strobili are small and are difficult to

Table 1. *Developmental stages of female strobili and appropriate control-pollination steps.*

Stage	Description	Control-Pollination Step
1	Buds containing female small with tight bud scales	
2	Buds enlarged with spreading bud scales but strobilus completely enclosed	Install isolation bags
3	Strobilus emerging through tip of bud scales	Late for bagging, conelets must be bagged *before* Stage 3
4	Strobilus extending at least $^1/_3$ to ½ beyond bud scales	Early for optimum pollination results
5	Strobilus fully extended from the bud scales and the space between bracts and bud scales open	Apply pollen for optimum results
6	Space between bracts and cone scales closed	Late for pollination, remove isolation bags

distinguish from lateral branch buds. In Stage 2, the female buds are conspicuously enlarged and readily distinguished from vegetative buds. This is the stage where isolation bags should be installed. In Stage 3, the tips of the female strobili begin to emerge through the bud scales. Strobili at this stage are too advanced to bag since they are capable of producing sound seed if naturally pollinated. To reiterate, ***strobili must be bagged <u>before</u> Stage 3***. In Stage 4, strobili continue to emerge from the bud scales. Successful pollination can occur at this stage but will be sub-optimal. In Stage 5, the strobilus has completely emerged from the bud scales. The bracts are extended so that the openings between the scales and bracts are maximized. Pollination should be made at this stage for optimum success. In Stage 6, the scales enlarge so that the opening between them and the bracts is closed. Pollination at this stage will be unsuccessful and the isolation bags should be removed.

Figure 1 shows the development of female and male strobili in the N.C. Division of Forest Resources' Lodge Seed Orchard near Crossnore for 1983. Note the brief slow-down in development that occurred between May 10th and 20th. A period of cold weather and/or rain often delays strobilus development in this manner. For 1983, isolation bags should have been installed around April 30th, pollination performed around May 20th and bags removed in early June. However, this schedule will vary from year to year. During the spring of 1997, development progressed such that at a site near the Lodge Orchard, isolation bags were installed on April 16th, pollination was performed on April 24th and bags were removed on May 6th. Vigilant monitoring of strobilus development is critical

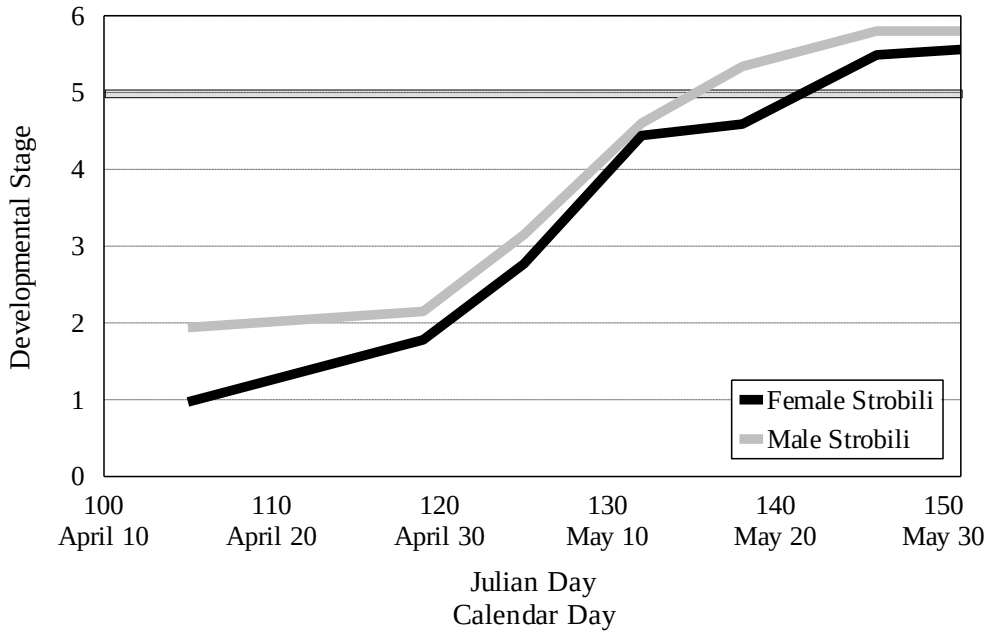

Figure 1. *Progression of developmental stages of Fraser fir female and male strobili in the N.C. Division of Forest Resources' Lodge Seed Orchard near Crossnore. Data are for 1983. This progression varies yearly as well as by location.*

in order to correctly time the steps involved in control-pollination.

Bagging

Isolation bags must be placed over female strobili prior to Stage 3 development. Special wet-strength kraft paper isolation bags are recommended. These can be purchased in various sizes with or without clear plastic windows for viewing strobilus development. Traditionally, sausage casing has been be used for control-pollination of forest trees. Sausage casing can be purchased in various lengths with or without end caps. Folding and stapling is required if end caps are not purchased. Two disadvantages of sausage casing are 1) that it requires internal support such as a double-looped 12-gauge aluminum wire to prevent damage to the enclosed strobili and 2) excessive heat build-up may occur.

A lift truck is the safest and most convenient method to gain access to the upper crown of reproductively mature Fraser fir. From a lift truck and by careful branch selection, multiple strobili can be enclosed within a single isolation bag. The branch tip extending beyond the outer most strobilus of each branch can be pruned to increase the number of strobili per bag. Experience this spring using 6½ ” x 15½” bags yielded an average of 6-7 strobili per bag with a range of 1 to 23 strobili per bag. Non-absorbent cotton or polyester foam collars are applied around the branch at the point where the bag is secured. Pull-ties are convenient to secure the bag and should be tightly applied to resist being blown off by wind.

Pollination

Pollen is applied when strobili reach late Stage 4 or Stage 5. Strobilus development needs to be carefully monitored since strobili may be influenced by the presence of the isolation bag. Heat build-up within sausage casings will often greatly accelerate strobilus development. Since there is some variation within a tree and even between strobili within a bag , a consensus assessment must be used to decide on pollination time.

Pollen can be applied in the bags via several methods. Commonly used methods include camel hair brushes, squeeze bulb syringe systems and sophisticated pollinators utilizing compressed air. Camel hair brushes are tedious but are useful when only a small amount of pollen is available. Other pollinators are quicker but require more pollen.

Pollen should be kept refrigerated or on ice until it is used. Since isolation bags must be pierced for pollination, the resulting holes must be covered with weather-proof tape to prevent pollen contamination. At least 2 cc of pollen should be applied in each bag. Best results are obtained if 1 cc of pollen is applied in each of two visits to each bag to better ensure that all strobili are pollinated at the appropriate developmental stage. If the same pollinator is used for different pollen lots, it must be sterilized when changing pollen lots by thoroughly washing with alcohol.

As pollen is applied, a durable tag containing the identification of the female and male parents should be attached on the branch just below the base of the isolation bag. It is

helpful to tie flagging or webbing around the branch in this position as well. Using spray paint to mark bags as they are pollinated is also helpful.

Release & After-Care

Once all the strobili in a bag have reached Stage 6, the isolation bag may be removed. This generally occurs 1-2 weeks after pollination. Bags that remain on the tree too long may damage elongating strobili. After pollination, the strobili rapidly develop and fertilization occurs four to six weeks later. By mid-summer the strobili have reached full size, however, maturation continues to proceed and the scales harden and become woody.

Control-pollinated cones must be protected from insect attack. The balsam fir seed chalcid (*Megastigmus specularis*) is particularly damaging to Fraser fir seed. Protection can be accomplished via caging or spraying regularly with insecticides.

Control-pollinated cones should be collected in late August or early September and the ripening process continued under controlled conditions so as not to lose seed due to cone disintegration.

Research Needs

Although it is feasible to perform control-pollinations among select Fraser fir trees, future research needs to address the following :

1) understanding specifics of Fraser fir pollination,
2) accelerating and enhancing pollen production using girdling, grafting into the lower crown of reproductively mature trees or other techniques,
3) accelerating and enhancing female strobilus production using gibberellin applications, grafting into the upper crowns of reproductively mature trees or other techniques and
4) examining options for the establishment and management of CP orchards.

Research directed in these areas will help optimize seed yield from Fraser fir control-pollinations, reduce the time between selection from Christmas tree progeny tests and breeding and provide Christmas tree growers with higher quality, more uniform seed for planting stock. Research addressing some of these issues is already underway and additional research will be initiated during the next several years.

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