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Rooting Fraser Fir Stem Cuttings[1]

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Abstract

Since 1978, propagation of Fraser fir (*Abies fraseri* (Pursh) Poir.) by rooting stem cuttings has been investigated. A number of factors influencing rooting have been studied and the results are summarized. In addition, procedures for collecting and rooting cuttings are presented.

Index words: Fraser fir, *Abies fraseri,* propagation, rooting, cuttings

Introduction

Fraser fir *(Abies fraseri* (Pursh) Poir.) is indigenous to restricted areas of the Southern Appalachians (3), and is extensively cultivated in North Carolina for Christmas trees, landscape usage, and Yuletide greenery. Although commercial propagation is solely limited to seed, we have been studying the propagation of Fraser fir by stem cuttings since 1978. This work was initiated to develop information to provide an alternative supply of plants if the seed supply ever became limiting as occurred in 1979 and 1980. This procedure would also have value in genetic improvement programs where it would be desirable to clone trees with outstanding Christmas tree or landscape characteristics. Vegetative propagation also represents a useful research tool for physiological studies involving this species.

Owing to numerous requests, we have decided to briefly summarize our results and experiences to date examining a number of factors affecting the regeneration of Fraser fir from stem cuttings. Also included are procedures for collecting and rooting cuttings. Anyone desiring the details of this work should refer to references 1, 2, 4 and 5 listed at the end of this report.

Factors Investigated Influencing Rooting of Cuttings

Time of collection. Our work has been done primarily with hardwood cuttings collected from early October (after several frosts) to late February. Plants are dormant in October and must undergo a period of low temperatures (winter) before resuming growth in the spring. The same phenomenon applies to rooting; cuttings collected in early fall are dormant and do not root or break bud. Those collected in late January or February root well with no additional chilling. We do not know the latest date in the spring when cuttings can be successfully collected and rooted, but performance would probably diminish toward the date of budbreak.

It is possible to accelerate the natural chilling process by collecting cuttings in the fall and storing them in sealed polyethylene bags in a cold room or refrigerator at 2° to 5 °C (35° to 40 °F). Auxin-treated cuttings root well following 4 to 6 weeks of chilling, but obtaining terminal budbreak is frequently a problem. Apparently, more chilling is required for budbreak than rooting. We do not understand the mechanisms which control budbreak, and are uncertain what role is played by the developing roots. For cuttings collected on a particular date, there is considerable year-to-year variation in rooting and budbreak. Currently, research is underway to examine the rooting of softwood and semi-hardwood cuttings, and to study the relationship between rooting and budbreak.

Type of cutting. Rooting varies by branch order and crown position. Cuttings from the lower crown usually root best because they are more juvenile than those from branches higher in the crown. Such differences become more pronounced as trees mature.

Branch order influences rooting in some conifer species, but we have no evidence of its effect in Fraser fir. We normally use tips from major lateral branches, i.e., secondary axes [first-order laterals (Fig. 1A)]. The main stem is the primary axis. Branches arising from large laterals are second- and third-order, etc. We have not noticed any unusual differences between the rooting of first- and second-order laterals. Dominance (extension growth) decreases from the top of the crown to the bottom, and from branches of low order (first) to higher orders (second, third or fourth). If cuttings are taken from the lower crown, length is rarely a problem for first-order laterals, but branches of higher order might be too short. This would be particularly true if fertility, disease, or pest problems were limiting growth.

We also do not know how the plagiotropic growth response, i.e., continuing to grow like a branch, varies with branch order. Since vigor largely controls the duration of plagiotropism in grafted Douglas-fir, we suspect

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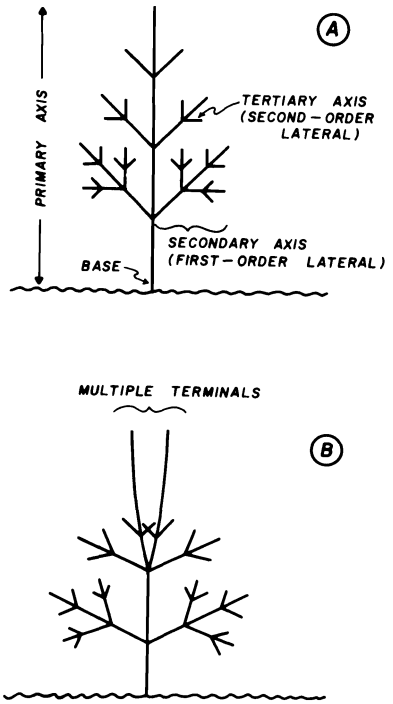

Fig. 1. Location on stock plants from which cuttings were collected.

that plagiotropism would be more pronounced in cuttings of higher order because they have less vigor. Consequently, we speculate that such cuttings would also require more time to attain transplantable size, and to assume an upright growth habit.

Even though cuttings from lateral branches root and break bud more easily than those from upright (orthotropic) shoots, we feel that serious consideration should be given only to upright shoots (multiple tops of seedlings and transplants, Fig. 1B). These will produce plants normal in growth and appearance.

Photoperiod (day length). Our studies have been conducted in heated greenhouses during the winter when natural day length is 10 to 13 hours, and light intensities are frequently low due to overcast conditions. In cuttings which have received a limited amount of chilling, say 3 weeks, rooting is greatly improved by interrupting the middle of the night with a 3-hour light break (100 W incandescent bulbs about 18 in above cuttings). At longer durations of chilling, e.g., 9 or 12 weeks, photoperiod does not appear to affect percent rooting. In contrast, interrupting the night produces significantly more and longer roots. Long-day conditions usually promote budbreak of dormant conifers, particularly early in the chilling cycle. In the one study we have done with Fraser fir cuttings, long days consistently promoted budbreak at all durations of chilling, but the difference was not statistically significant (2).

Stock plant age. Rooting capacity decreases with stock plant age. We routinely obtain 90 to 100% rooting of terminal shoots from 4- or 5-year-old transplants. This percentage decreases with age, and cuttings from older trees (over 30 years) root in very low percentages (6). Consequently, our work is normally confined to plants 4 and 5 years old. Many multiple shoots can be removed during routine pruning operations in seedbeds and transplant beds. Ultimately, the best procedure would be to develop a system (mechanical or chemical) for hedging seedlings and transplants to induce maximum production of orthotropic shoots (multiple stems).

We have little experience with rooting of large cuttings as would be obtained from shearing the main leader of older field-grown trees. We know that such cuttings root in lower percentages than lateral cuttings from the same trees, and suspect that they would also exhibit a more rapid decline in rooting capacity with tree age.

Genotype (tree-to-tree variation). Consistent with other species, there is great variation in rootability among trees. In one experiment, rooting ranged from 3 to 78%, depending on the stock plant from which cuttings were taken. Rooting percentages can also vary considerably from year to year. The only situation where a very low rooting percentage might be a problem would be in attempts to propagate individual trees with highly desirable Christmas tree traits, as in genetic improvement programs. Taken a step further, it might also be a problem if mass propagation is attempted with a few selected clones. In our experiments, we use only 1 or 2 cuttings from each plant to ensure a broad genetic base. Consequently, individual variability is of no consequence because our rooting percentages are averages for populations consisting of many individuals.

Length of cutting. We have tested cuttings ranging in length from 9 to 25 cm (3.5 to 10 in). Generally, rooting increases with cutting length, but budbreak tends to be better on shorter cuttings. We feel that length is not an important consideration, and thus suggest a length of 13 to 17 cm (5 to 6.5 in).

Wounding. When used in combination with auxin, wounding improves rooting. In the absence of auxin, wounding is of no benefit. Of the several wounding treatments examined, we obtained good results from 4 equally spaced vertical cuts into the base, each about 2.5 cm (1 in) in length and parallel to the long axis of the cutting. Massive swelling of the base occurs in auxin-treated cuttings in the area of the wounds (Fig. 2). Roots normally emerge near the cutting base; rarely along margins of wounds.

Auxin treatment. Treatment with an auxin (rooting hormone) is essential. With hardwood cuttings, we obtain good results with 5000 ppm indolebutyric acid (IBA) applied as a quick dip. Equivalent results can be obtained with Hormodin 3 (0.8% IBA in talc) or Naphthaleneacetic acid (NAA). The effect of auxin is enhanced if cuttings are first wounded.

Bottom heat. This involves the use of various heating devices in the rooting medium so that the temperature at the bases of the cuttings is higher than that of the buds. The most common approach is to use thermostatically controlled, electric heating cables to maintain adequate temperatures for rooting. Our experiments have been carried out in heated greenhouses where day temperatures were 16 to 27 °C (60 to 80 °F); rooting medium temperatures 13 to 24 °C (55 to 75 °F). Under these conditions, bottom heat (18 to 24 °C/65 to 75 °F) promotes rooting of Fraser fir cuttings. In general, the utility of bottom heat depends, in part, on ambient air tempera-

tures during rooting. Rooting is usually best when a cool or moderate air temperature is used in conjunction with a warm rooting medium. Bottom heat is beneficial when the propagator is unable to maintain warm air temperatures, as in outdoor propagation beds during spring. In such situations, a heated rooting medium promotes rooting. One should remember, however, that lower air temperatures slow budbreak.

Intermittent mist also contributes to cool rooting medium temperatures whether the propagation house is heated or not. Low rooting medium temperatures, e.g., about 16 °C (60 °F), inhibit or slow rooting and should be avoided. Unless mist water is preheated, it can be very cold, especially during winter. Thus, bottom heat may be required to avoid excessively low rooting medium temperatures.

Procedure for Collecting and Rooting Cuttings

Collect cuttings from "healthy" stock plants which are free of insects, diseases, or nutritional problems. The initial length of cuttings can vary, but the final length following all preparations should be 13 to 15 cm (5 to 6 in). When taking cuttings, it is important that they not dessicate. Drying reduces the rate of rooting and, if severe, completely inhibits rooting or kills the cuttings. To avoid dessication, place cuttings in plastic bags as they are collected, but avoid heat buildup within the bags. An easy way to do this is to store bags in a cooler with ice.

Immediately prior to treating cuttings with auxin, remove the needles from the basal 4 cm (1.5 in), and make a fresh cut on the base of each cutting by removing a short portion of stem 3 to 4 mm (0.1 to 0.2 in) in length. This will facilitate uptake of the root-promoting chemical applied to the cutting, particularly if the cuttings have received post-severance chilling.

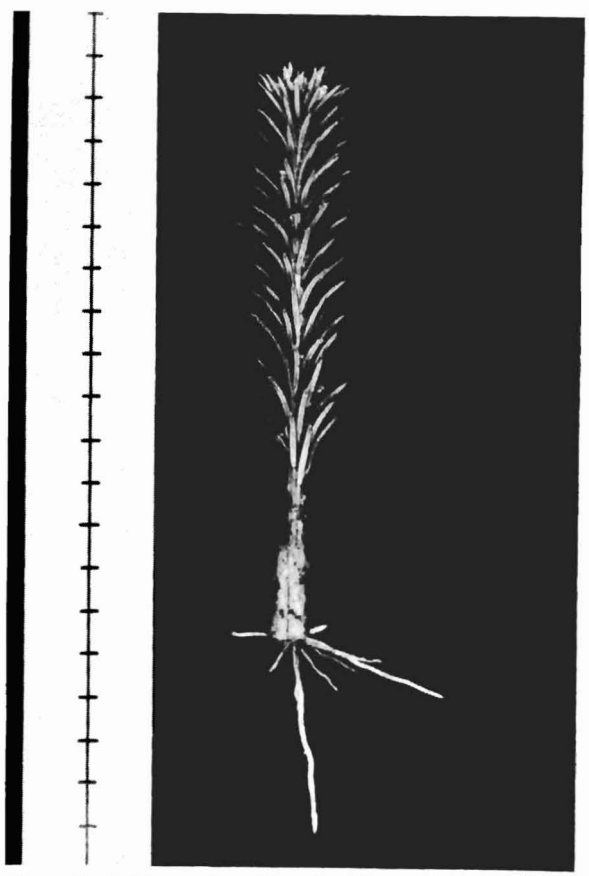

Fig. 2. Rooted Fraser fir cutting after 10 weeks in a mist bed. Scale divisions = 1 cm (0.4 in).

Next, wound cuttings as previously described. Cuts should penetrate the bark and go into the wood without splitting the stem. Once wounded, treat the cutting bases with a root-promoting chemical such as indolebutyric acid (IBA). The method we prefer is to prepare a 0.5% (5000 ppm) solution of IBA by dissolving the pure chemical in 50% isopropyl alcohol. The basal 2 cm (0.75 in) of each cutting should be dipped into this solution for 1 second, removed and dried for 15 minutes before insertion into the rooting medium.

Another way ot treating the cuttings with IBA is to use a commercial auxin-talcum powder formulation (rooting powder) containing 0.8% (8000 ppm) IBA, such as Hormodin 3. When using a rooting powder, first moisten the base of each cutting with water, treat the basal 2 cm (0.75 in) with this material, gently tap the base of the cutting to remove excess powder, and insert the cutting into the rooting medium using a dibble (a pencil or wooden plant label will suffice). Using a dibble prevents the rooting powder from rubbing off the cuttings when they are inserted into the rooting medium.

Once cuttings have been inserted into the rooting medium, pay attention to their moisture needs. Cuttings cannot take up appreciable moisture until roots are properly developed. Therefore, attempts must be made to reduce moisture loss during rooting and perhaps replace moisture lost during collection, storage, and treatment. Severe moisture stress can prevent rooting or kill the cuttings. Use intermittent mist to reduce moisture stress. This is probably the most effective way of rooting Fraser fir cuttings although it may be possible to root cuttings in a polyethylene covered structure, provided dessication is minimized.

Do not overmist or keep cuttings too wet. Wet conditions encourage growth of the fungal pathogen *Botrytis,* which attacks new foliage. This disease can spread rapidly with devastating results. A second precautionary measure is to spray cuttings weekly with appropriate fungicides. It is best to alternate fungicides to reduce chances that the pathogen will develop tolerance. Good sanitation also reduces incidence of the disease. If the fungus is observed on a cutting, remove the cutting immediately.

Excessive water can be a problem; so can drying. Always be alert for "dry spots" or uneven mist patterns in the mist bed.

Temperature and light. Natural day length and light intensity is adequate for rooting. Supplemental incandescent light during the night can enhance rooting, and may be particularly helpful in bringing about budbreak.

Ambient air temperatures at the top of cuttings should not exceed 30 °C (84 °F), preferably 16 to 24 °C (60 to 75 °F). Relatively low air temperatures are permissible if the rooting medium is heated, but budbreak may be depressed. Rooting medium temperatures should be 18 to 24 °C (65 to 75 °F).

Other Considerations When Rooting Cuttings

Rooting medium. Many different rooting media could be used, but they should all be well drained. We

have realized excellent results with 1 peat:1 sand (by vol). Another potentially good medium might be 1 peat: 1 perlite (by vol). Avoid media which hold excessive moisture.

Time in the mist bed. If taken at the proper physiological stage of growth, treated with a root-promoting compound of the proper concentration and provided the cuttings have been placed under proper rooting conditions, they should begin rooting within 2 to 4 weeks, and have substantial root systems by 10 to 12 weeks (Fig. 2). You can determine if a cutting has rooted by giving it a gentle upward tug. If it stays firmly in place, roots are probably present; otherwise, the cutting will slip upward in the rooting medium. It is probably best to leave cuttings in place until secondary (branch) roots have formed. Once these roots have formed, cuttings are ready for transplanting.

Small containers or mist beds? Much of our research has involved rooting Fraser fir cuttings in raised greenhouse benches. We have also rooted cuttings in small, individual containers and flats. Of the three methods, the best is probably small, individual containers. This is known as "direct rooting" or "direct sticking." Regardless of container type, it should be well drained. Direct propagation reduces "transplant shock" or the delay in growth which may result following transplanting. Transplant shock is often the result of direct root injury, which commonly occurs when cuttings are spaced close together as in a flat or bed. In a mist bed, roots grow together and become intwined. Thus, when lifting takes place, roots of individual cuttings are easily damaged or broken. This is not a problem if cuttings are rooted individually in small containers.

Handling following rooting. Handling following rooting depends, in part, on the system used to root cuttings (open mist bed vs. individual containers in a mist bed). The basic objective is to develop a good root system in a minimum of time. Remember, a nonrooted cutting is all top with no roots. When roots form, the shoot:root ratio begins to decrease. Cuttings rooted in an open mist bed will probably require at least one transplanting into pots before they can be finally placed in a transplant bed. Cuttings rooted in containers might or might not need additional potting, depending on the size of the container.

In the first few weeks following transplanting, cuttings should be fertilized, shaded, and watered frequently until well established. Once established, cuttings should receive the same attention as that given to seed propagated transplants.

In our experience, we feel that cuttings will probably require at least 2 years in a transplant bed to attain adequate size for field planting. Observations have only been underway for a short time, but it appears that rooted cuttings from orthotropic (upright) shoots will make trees normal in appearance and shape.

Significance to the Nursery Industry

Although many factors have been examined which influence the rooting response of Fraser fir stem cuttings, additional questions need to be addressed before this propagation technique can be utilized on a large scale. Results thus far have indicated that Fraser fir can be propagated by stem cuttings and at present may be of value in situations where a limited number of plants are needed. An obvious advantage of propagating Fraser fir by stem cuttings, as opposed to seed propagation, is that the stem cutting approach permits cloning of selected trees for perpetuating individual genotypes.

Our results would indicate that the best rooting response is obtained by treating cuttings 13 to 17 cm (5 to 6.5 in) in length, taken in late January or February, with a light wound followed by a 1 second basal dip with 5000 ppm IBA. Also, the results and procedures reported herein may be of use to nurserymen who propagate other fir *(Abies)* species for Christmas trees, landscape usage and Yuletide greenery.

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