PROPAGATION OF SPRUCE BY STEM CUTTINGS

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ABSTRACT

Because numerous factors influence rooting and early growth of spruce (**Picea** spp.) cuttings, only the most important ones are mentioned in this paper. The factors considered are: species, population, individual, age of ortet, position of cutting on the tree and branch, type and length of cutting, time of year, chemical treatment, rooting medium, and temperature of the air and of the rooting medium.

INTRODUCTION

This paper is primarily a review of published reports on the propagation of spruce (*Picea* spp.) by stem cuttings. Because of space limitations, the reviewer will not summarise all works known to him, but instead make comments to cover several papers with a common subject. Previous reviews on rooting cuttings of spruce include those of Forestry Abstracts, 1941; Meahl, 1957; and Ferguson, 1968.

Propagation of *Picea* by cuttings is a problem which, as Ferguson (1968) indicated, "seems to come from the fact that many variables are involved, and to different propagators the variables take on different degrees of importance. This may be due to the fact that what he is doing is most important, or maybe one variable gave the best result for him so he thinks it should be the most important for all who are rooting *Picea*. . . ."

Because the variables which influence rooting and early growth of cuttings of spruce are numerous, only those which I consider most important will be mentioned herein. These include: species, population, individual, age of ortet, position of cutting on the tree and branch, type and length of cutting, time of year, chemical treatment, rooting medium, and temperature of the air and of the rooting medium.

REVIEW

Species, Population and Individual

Cuttings taken from different species, populations, and individuals vary in rooting capacity. For example, cuttings of Norway spruce (*Picea abies* (L.) Karst.) are easy to root, while those of red spruce (*P. rubens* Sarg.) are difficult (Girouard, 1970c). There is apparently greater variation in the rooting potential of cuttings taken from different trees of a given population, than of those from several populations of the same species

(Quintin, 1954). Trees which propagate readily from cuttings lend themselves to the development of clones (Faulkner *et al.,* 1967; Girouard, 1972; Karki, 1972; Kleinschmit, 1972 a, b, c; Lepistö, 1972 a, b, c; Metsänjalostussäätio, 1969-72; Ruden, 1972).

Age of Ortet

The age of an ortet from which cuttings are taken is often one of the most important factors affecting rooting response and early growth of ramets. For instance, when cuttings are obtained from trees 10 years of age or less, rooting is usually good; after 10 years it diminishes rapidly, and later more slowly. Rarely is it possible to obtain useful rooting of cuttings from trees older than 80 years (Ruden, 1972). Percent rooting, speed of rooting, root length and number, survival, and growth in and after the year of rooting, all decrease with increasing age of the parent tree (Kleinschmit, 1961, 1972b; Murygina, 1966; Girouard, 1970b,1971).

Related to the age factor is topophysis, a phenomenon whereby certain characteristics are retained by the plant parts for various periods. For example, in rooted lateral shoots, the transition from branching (plagiotropic) to upright (orthotropic) growth forms occurs more rapidly the younger the parent ortets (Frohlich, 1961). Cuttings from certain trees, young or old, may root but fail to lose the plagiotropic growth form even after 10 years on their own roots (Kleinschmit, 1961, 1972b).

To preserve the good rooting capacity phase, plants are propagated by cuttings taken periodically from older rooted cuttings. This is the standard method used in several countries for the propagation of easy-to-root clones (Kleinschmit, 1972a; Lepistö, 1972a). Another method, quite effective but little used to date, consists of training trees as hedges to arrest the normal decline in rooting percentage, quality of roots, and growth potential of cuttings (Girouard, 1972; Libby *et al.,* 1972).

To partially rejuvenate plant material, a series of grafting and cutting operations are used. First, scions from old trees, usually difficult to root, are top-grafted onto seedlings. Then from developing shoots, much more vigorous and upright than side-grafted scions, cuttings are taken which root with greater ease than those from original parent trees (Holst *et al.,* 1969).

Position of Cutting on the Tree and Branch

Cuttings are collected from healthy branches in the lower half or third of the crown, because they root and survive better than those from upper regions (Grace, 1939; Thimann and Delisle, 1939; Grace and Thistle, 1940; Girouard, 1970 a, b). Propagation material from higher branch orders (lateral shoots) takes root more readily than those from lower orders (terminal shoots), but it retains a plagiotropic habit of growth longer than do terminal shoots (Thimann and Delisle, 1939; Deuber, 1942; Frohlich, 1961; Savella, 1965). When saplings are cloned, it is general practice to take cuttings at random from shoots having a well-formed terminal bud. In addition, shoots with an excessively thick or thin stem are usually discarded.

Type of Cutting

Cuttings used are basically of three types: plain, with remnant bud scales, and with a heel of bark. Plain cuttings are made with secateurs by cutting shoots a short distance from their base (Deuber and Farrar, 1939; Farrar, 1939, 1942a; Grace *et al.,* 1940;

Girouard, 1970 a, b, c, 1971, 1972; M. Lepistö, pers. comm. 1972). Cuttings with remnant bud scales are made by sliding a knife just below the scaly, swollen base of lateral shoots (Larsen, 1946, 1955; Pedersen, 1965; Krussman, 1966; Savella, 1965; Rauter, 1971b; M. Lepistö, pers. comm. 1972). Cuttings with a heel of bark are made by tearing or cutting lateral shoots at nodes; such a cutting possesses not only the swollen base of the shoot but also a piece of bark from a supporting branchlet (Deuber and Farrar, 1939; Farrar, 1939; Farrar and Grace, 1942a, b; Girouard, 1970a, b, 1971; H. Roulund, pers. comm. 1972). All needles at the base of cuttings should be left intact because they have a beneficial effect on rooting.

Although the type of cutting can affect rooting percentage, number and length of roots, survival, and shoot formation, the effects vary with the length of the rooting period, age of the ortet, tree species, rooting medium, and season of the year (Farrar and Grace, 1942a, b; Girouard, 1970b, 1971). Often the extra time and care needed to prepare cuttings with remnant bud scales or a heel of bark, rather than plain cuttings, are unjustified.

Length of Cutting

One study performed in the early 1940s (Grace and Farrar, 1945) with cuttings of 4 to 8, 8 to 15, and 15 to 25 cm showed:

(a) that long cuttings form the greatest number of roots and shoots per rooted cutting, plus the largest and most upright plants four years after rooting:

(b) that intermediate length cuttings root best of all.

Few investigators have reported good results with cuttings 10 cm or longer (Farrar, 1939; Boulard and Quintin, 1953; Rauter, 1971b). Generally cuttings 5 to 8 cm long are used (Larsen, 1946; Sheat, 1948; Oliver and Nelson, 1957; Savella, 1965; Girouard, 1970b, 1971, 1972; M. Lepistö pers. comm. 1972; Rundquist and Stefansson, 1973).

At first glance, the idea of using full length cuttings to produce the largest plants possible within a given period appears good, but in practice it is not always so. For example, plants produced by full length cuttings vary considerably in height and vigour; these variations are undesirable when clones must be compared for growth performance at a young age.

Time of Year

The best time for taking and planting cuttings depends largely on the propagation structure available.

In greenhouses, cuttings are generally made from autumn until spring with "hardwood" material, that is to say, lignified shoots with well-formed buds, from last season's growth (Zimmerman, 1926; Farrar, 1939; Grace, 1939c; Hitchcock and Zimmerman, 1939; Kirkpatrick, 1940; Thimann and Delisle, 1942; Doran, 1954; Teuscher, 1956; Briggs, 1964; M. Lepistö, 1969—unpubl.; Rauter, 1971a; Ruden, 1972). According to one report (Rubanik and Parshina, 1972) the optimum period for planting cuttings under controlled lighting conditions is late April to early May, before the beginning of shoot extension. Propagation at this time, in open benches under intermittent mist, also results in fewer problems with *Botrytis cinerea* Fr., a fungus causing gray mould on young succulent shoots (Dobry, 1965; Girouard, 1970a; Kleinschmit, 1972b). Extension of daylength to at least 16 hours, with incandescent or fluorescent lamps, has a positive effect on root and shoot formation (Anon., 1972;

Rubanik and Parshina, 1972). Cuttings which root often do so within one to five months (Grace and Farrar, 1940b; Girouard, 1970c; Kleinschmit, 1972b; Ruden, 1972).

For outdoor propagation in coldframes, cuttings are customarily made during the summer from semi-lignified shoots of the current seasons growth, once shoot elongation is nearly complete and buds are forming (Komissarov, 1938, 1969; Farrar and Grace, 1942b; Sheat, 1948; Gathy, 1958; Pedersen, 1965; Krussmann, 1966; Mamedov, 1966; Murygina, 1966; Sansdrap, 1968), and occasionally during autumn from lignified shoots (Grace *et al.,* 1940; Grace and Farrar, 1945b; Sheat, 1948). In both cases the cuttings are left to root in the frames until late summer of the following year. If the outdoor beds are equipped with an intermittent mist system, the cuttings are made from either lignified or semi-lignified shoots of the last season's growth, depending upon the number of frost-free days in the region. The cuttings are rooted before the late summer (Savella, 1965; Day and Breen, 1969).

Chemical Treatment

Auxins, fungicides, nutrient solutions and glucose used separately or in combination have been reported to promote rooting and/or survival of cuttings.

With auxins, promotion was noted for indole-acetic acid (IAA) (Grace, 1940; Grace *et al.,* 1940; Larsen, 1946; Bullard and Quintin, 1953; Quintin, 1954; Kleinschmit, 1961; Mamedov, 1966; Rauter, 1971a) and indole-butyric acid (IBA) (Komissarov, 1938; Hitchcock and Zimmerman, 1939, 1940; Griffith, 1940; Kirkpatrick, 1940; Doran, 1952; Kleinschmit, 1961; Day and Breen, 1969; Runquist and Stefansson, 1973), but harmful effects of these compounds on rooting were also reported (Deuber and Farrar, 1939; Grace and Farrar, 1940a; Grace *et al.,* 1940; Grace and Thistle, 1940; Larsen, 1946; Stewart, 1948; Teuscher, 1956). For root promotion with IAA, cuttings were generally soaked 18 to 24 hours in solution containing 50 to 200 ppm of the auxin (Larsen, 1946; Bulard and Quintin, 1953; Quintin, 1954; Teuscher, 1956; Komissarov, 1969), dipped in talc containing 100 to 3,000 ppm of potassium salt of the acid (Wells, 1953; Kleinschmit, 1961, pers. comm. 1972), or sprayed with a 5 ppm solution of IAA after insertion in the rooting medium (Mamedov, 1966). With IBA, root promotion resulted at times when cuttings were soaked 20 to 24 hours in a 20 to 100 ppm aqueous solution (Komissarov, 1938; Hitchcock and Zimmerman, 1939; Griffith, 1940; Kirkpatrick, 1940; Doran, 1952; Runquist and Stefansson, 1973), quick-dipped in a 20,000 ppm solution (Enright, 1959), or dusted, base only, with talc containing 1,000 to 5,000 ppm of the active compound (Hitchcock and Zimmerman, 1939; Kleinschmit, 1961; Savella, 1965). Noteworthy, however, is the fact that many plant propagators have succeeded in rooting cuttings of spruce without use of auxins (Grace and Farrar, 1945b; Sheat, 1948; Larsen, 1955; Doran, 1957; M. Lepistö, 1969-unpubl.; Rauter, 1971b; Roulund, 1971; Girouard, 1972; Ruden, 1972).

Fungicidal treatments, used primarily to prevent decay of tissues at the basal end of cuttings, have been found to promote rooting and survival in some propagation material. Reports mention treatments of ethyl mercuric phosphate at 50 ppm in talc (Grace, 1940; Grace *et al.,* 1940), Phygon XL, actually 2,3-dichloro—1, 4-naphthoquinone mixed with equal parts of magnesium sulphate (Doran, 1952), and Captan orthocide 50 (Day and Breen, 1969; Rauter, 1971b). Data justifying use of Captan alone or with an auxin in talc have never been published.

There is evidence that weak nutrient solutions, added to cuttings in the rooting medium at various intervals promote root and shoot formation, and survival. In one report (Grace, 1939b) a modified Hoagland's solution was mentioned, but in other papers, the solutions were poorly defined (Larsen, 1946; Mamedov, 1966; Roulund, 1971).

There are two reports concerning the use of glucose to stimulate rooting (Bulard and Quintin, 1953; Quintin, 1954). They indicate that cuttings with bark removed at the base should be soaked for 2 hours in a solution containing 20,000 ppm of glucose and 200 ppm of IAA. The treated debarked base is then cut off before placing the cuttings in the rooting medium.

Rooting Medium

For many years, the standard rooting medium has been medium-to-coarse sand (Hitchcock, 1928; Komissarov, 1938; Farrar, 1939; Deuber, 1940; Deuber and Farrar, 1940; Ferguson, 1968; Rauter, 1970; Lepistö, 1972a). Experiments performed during the late 1930s showed that addition of a well-decomposed peat of sedge origin was vastly superior to sand alone, or to a peat moss of sphagnum origin mixed with sand. The ideal mixture contained two volumes of sand and one of peat (Farrar and Grace, 1940, 1941, 1942a, b; Grace and Farrar, 1940a, b, 1945a, b; Grace *et al.,* 1940; Doran, 1952). To my knowledge, no report published after 1945 mentions use of peat of sedge origin. The reasons for this may be that the material was too expensive, not readily available, or that plant propagators failed to recognise differences between peats of different origin. In the early 1950s, tests with fresh sphagnum moss, mulched or mixed with sand, gave interesting results (Anon., 1972; Runquist and Stefansson, 1973). Since then, a mixture of fresh sphagnum moss and sand, 1 : 1 by volume, has become quite popular in several Scandinavian countries (Gathy, 1958; Roulund, 1971; Anon., 1972; M. Lepistö, unpubl.). Perlite and BR.8 blocks have given good results but are expensive compared with other materials (Girouard, 1970b, 1971; Roulund, 1971; Armson and Bidwell, 1971). Recent unpublished data, obtained by the reviewer, indicate that sphagnum moss mixed with sand is superior for outdoor propagation to perlite or a mixture of peat moss and sand.

Temperature of the Air and Rooting Medium

Under greenhouse conditions, where the relative humidity of the air may vary from 65 to 95%, efforts are made to maintain air temperature between 10 and 22°C (Girouard, 1970c; Roulund, 1971; Ruden, 1972; M. Lepistö, pers. comm. 1972), and the rooting medium no lower than 13°C (Roulund, 1971). With cool houses, air temperature is not allowed to go below 5°C (Lepistö, 1972a).

In outdoor frames, covered with glass or plastic, but lacking a bottomheat installation, the air temperature can rise rather quickly on sunny days to 27°C or higher. To prevent overheating, the frames are usually protected with wooden lathes or factory cotton shades, and the sashes sprayed with shading compounds. In addition, in hot weather the cuttings are syringed at least twice a day and the sashes left slightly raised (Grace and Farrar, 1945b; Larsen, 1955; Pedersen, 1965; Mamedov, 1966; Murygina, 1966; Rubanik and Pal'gova, 1968; Komissarov, 1969; Roulund, 1971). With outdoor beds sheltered with plastic panels and equipped with intermittent mist high temperatures are usually no problem (Deuber, 1940). There are indications that cuttings of some species require specific levels of bottom heat for maximum rooting (van Doesburg and Ravensberg, 1962; Jesinger and Hopp, 1967; Rauter, 1970; Sandved, 1972). Much additional information is needed, however, before specific temperatures can be recommended for various tree species.

SUMMARY

A review of the literature permits certain summary statements to be made concerning the propagation of spruce by stem cuttings.

1. Cuttings taken from different species, populations, and individuals vary in rooting capacity.
2. Rootability of cuttings diminishes rapidly with increasing age of the ortet.
3. To preserve the good rooting capacity phase of a tree, cuttings are taken from slightly older rooted cuttings.
4. Cuttings collected from the lower third or half of the crown root better than those from upper regions.
5. Lateral shoots root more easily than terminal shoots.
6. Plain cuttings, made by cutting shoots a short distance from their base, are adequate for many species.
7. Although cuttings 5 to 8 cm in length are most commonly used, slightly longer shoots are probably better to produce strong, upright plants within a short period of time.
8. For rooting in greenhouses, cuttings are made from lignified shoots of the last season's growth before flushing occurs.
9. For use in coldframes, cuttings are made generally during the summer from semi-lignified shoots when shoot elongation is nearly complete and buds are forming.
10. In outdoor beds equipped with intermittent mist, both lignified and semi-lignified shoots can be used, but must be rooted before late summer.
11. For mass propagation of clones, some nurserymen treat cuttings with IBA in talc at a concentration of 3,000 ppm, while others obtain excellent results without the use of auxins.
12. Cuttings basal-dipped in Captan can at times root and survive better than untreated material.
13. In several countries medium-to-coarse sand is the standard rooting medium but is gradually being replaced by a mixture of fresh sphagnum moss and sand, 1 : 1 by volume.
14. To favour root regeneration, the temperature of the air is maintained between 10° and 22°C and the rooting medium no lower than 13°C.
15. Weak nutrient solutions added to cuttings in the rooting medium at various intervals have a beneficial effect on root and shoot formation, and survival.
16. As labour costs increase and operations become larger, automated systems will become increasingly popular.

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