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Successes and failures in forest tree cutting production in Finland

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This article is a review on the development work and experiences of vegetative propagation of forest trees in Finland. Some attempts and achievements in Scandinavian countries and the other world are also shortly commented.

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Early attempts in Finland

In Finland, experiments with rooting of cuttings were started by the Foundation for Forest Tree Breeding (FFTB) in 1962, with facilities donated by the Finnish Plywood Industry. Many species were included from the beginning, e.g. birches, Norway spruce, Scots pine, larches, hybrid aspen, alders, maple and elms (Fig. 1). The first results were very promising, leading to the conclusion that "it seems possible that cutting propagation will soon become a shortcut to the application of tree breeding results in practical reforestation" (FFTB 1962).



Fig. 1. Examples of cuttings rooted in early 1960's. From left: birch, alder, juniper, Scots pine and Norway spruce. (Photo: FFTB)

In the 1960's the attempts were focused on a single clone, the famous triploid curly birch "Olli-Visa" (*Betula pendula* v. *carelica*). However, the success of rooting varied greatly from year to year with this clone, and also with other broadleaved species and Scots pine and larches as well, and high mortality after transplanting outdoors and especially during the first winter proved to be big problems. With broadleaved species, best rooting results were generally achieved with sturdy current year's shoots forced in potted greenhouse plants in early spring. The general experience was that almost everything could be rooted (including e.g. roses and apple trees), but induced roots in summer cuttings were very tender. Already transplanting outdoors caused much, mortality, and most plants died during the next winter.

Gradually the interest was shifted to conifers, Norway spruce and Scots pine, with which previous year's resting shoots and early spring rooting in mist-irrigated greenhouses proved to be much better than current year's soft shoots. In 1969 average rooting in both species was 75 %, and with some clones up to 100 %. FFTB optimistically reported: "Rooting of spruce cutting is already so well governed that a shift from experimental scale to practical mass production scale can begin" (FFTB 1970).

Rooting experiments were still continued through the 1970's with many species, including birches, alders, hybrid aspen, *Pinus contorta*, larches, in addition to Norway spruce. In 1977, 80-95 % rooting was achieved with all mentioned species, but further raising remained problematic. Scots pine was dropped out in 1972, because of low availability of scions and poor growth form of the produced cutting plants (FFTB 1977).

Attempts shifted to Norway spruce

In the late 1970's the attention in FFTB was completely focused to Norway spruce, following the promising examples from Germany and Scandinavian countries (e.g. Kleinschmidt 1973, Roulund 1971). Through the 1970's, FFTB raised 150 000 to 300 000 spruce cuttings annually (Fig. 2). Clone testing was started, with some 2000 clones up to 1982. A few attempts were made for the mass production of spruce cuttings, but the results were not very promising because of plant quality problems, mainly due to the physiological ageing of clones (FFTB 1983).

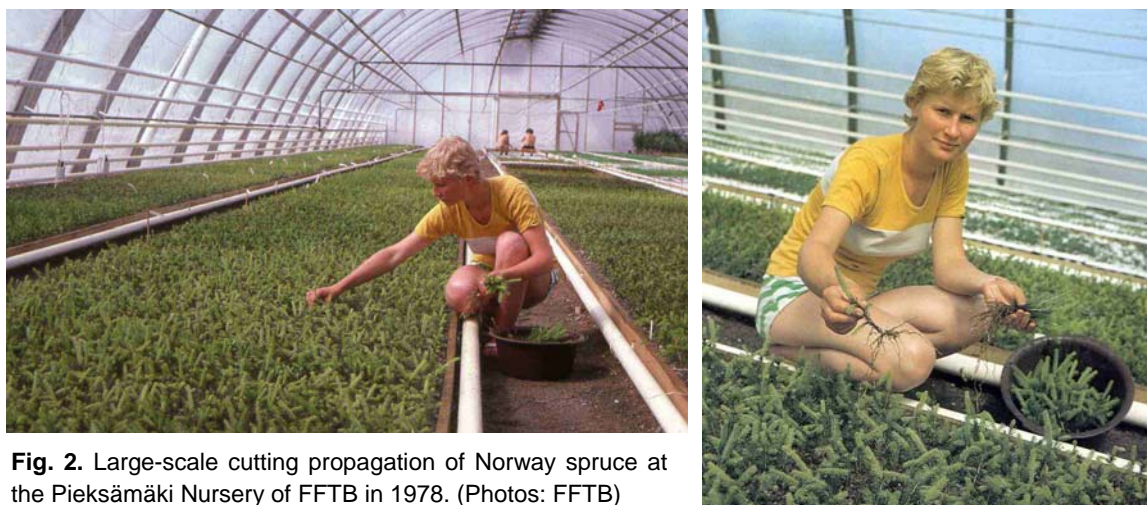


Fig. 2. Large-scale cutting propagation of Norway spruce at the Pieksämäki Nursery of FFTB in 1978. (Photos: FFTB)

Clonal tests showed up to 50 % superiorities in early height growth for the best clones, as compared to the average of clones and to seedling standards. Many of the best clones in the tests of FFTB proved to be provenance hybrids (Finland x Central Europe) (FFTB 1982, 1987) (Fig. 3). However, physiological ageing appeared to be an almost absolute obstacle for further utilization of best clones, although the physiologically juvenile period of clones could be prolonged to some extent by hedging or serial propagation. Even slight ageing caused problems in cutting production; leaned or crooked cuttings had to be graded out of commercial reforestation plant lots, because of the quality regulations, and this naturally increased the production costs of acceptable cuttings.

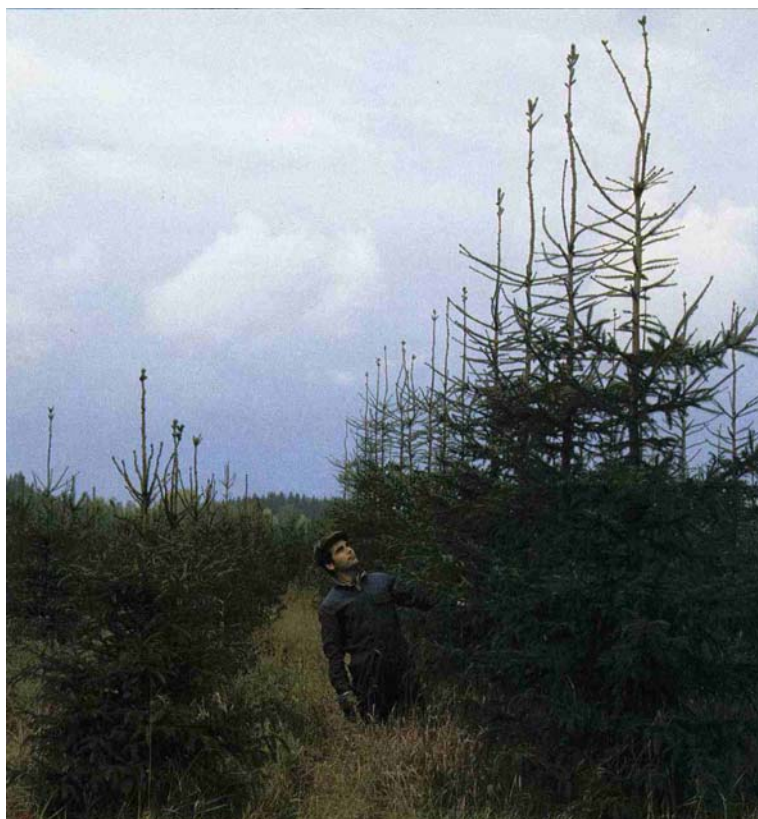


Fig. 3. A demonstration plot in Nurmijärvi, S. Finland. The single clone V 383 on the right was selected from a provenance hybrid family (Central Finland x Schielbach, Germany). At the age of 8 years from planting it surpasses the seedlings of the same family (on the left) by 78 % in height growth. (Photo:FFTB)

Experiments for the development of spruce cutting techniques were continued at a smaller scale through the 1980's. A few clonal mixtures were formed and registered, but they never reached any mass-scale production. In the 1990's interest has been shifted to bulk propagation of tested full-sib families (FFTB 1987, 1990). No commercial production has been started yet, but it may soon become a realistic alternative to seedling production, if seed production in seed orchards proves to be seriously limited by insect and disease problems. The conventional cutting propagation technique, at its present state-of-the-art, seems to be quite feasible for bulk propagation of seedling materials of Norway spruce, e.g. progeny-tested full sib families. With very young donor plants (3-6 years) rooting percentage is close to 100, and the growth form of cutting plants is quite comparable to seedlings. The price of cuttings will inevitably be higher than that of seedlings, however, because more human handwork is needed in the production of cuttings.

Vegetative propagation programs with traditional techniques of rooted cuttings have been carried out in many countries, with better success than in Finland. In Lower Saxony, Germany, some 1 million cutting were produced for reforestation in 1970's and 1980's, at a 1,3 -fold price

as compared to seedlings. Obviously this program does not continue at the same level any more. Hilleshög company in Sweden produced a few million Norway spruce cuttings in some years in late 1970's and 1980's, also at a price of about 1,3 x seedling price. Hillsehög's activity was slowed down obviously because of increasing production costs, due to the ageing of clones and extra costs caused by new regulations for the mixing of clones in commercial production. There have been several cooperative Norway spruce cutting programs in Sweden: the South Swedish program in late 1970's (together with Hilleshög), the Central Swedish program in 1980-1992, and the New Central Swedish program in 2000-2004. All these programs were slowed down obviously because of the high production costs of cuttings, and resulting low demand in practical forestry (e.g. Högberg et al.1995, Lindgren 2006).

The onset of micropropagation

Quite new ideas for the clonal propagation of reforestation material emerged in the 1980's. Tissue culture method through organogenesis was first developed for birch in the University of Helsinki. Laboratory-based "micropropagation" was soon adopted by some Finnish companies for mass multiplication of birch clones (FFTb 1991). Commercial production lasted only a few years, however. The production costs were high, and the market of cloned plants remained small in practical forestry. The low demand on the forest owner's side was maybe mainly due to the lacking information of genetic gains attained through clonal selection.

Micropropagation of conifers was intensively studied in FFRI, Forest Research Institute and some universities and companies in late 1980's and early 1990's. Clonal plantlets were attained in many cases from very young seedling materials (FFTb 1985-1991). Micropropagation may be applied for the production of cloned material for research purposes, but the methods proved to be quite too slow and tedious for any practical applications.

In late 1980's the method of inducing and rooting of fascicular shoots in Scots pine was studied in the FFRI. Induction of fascicular buds with hormone treatments was successful in young and old trees, but the rooting of induced dwarf shoots was very variable. Physiological ageing proved to be decisive also with this method; generally only dwarf shoots induced on the topshoots of quite young seedling materials could be rooted (FFTb 1985-1990). The work was slowed down in the 1990's.

In late 1980's Finnish paper industry became highly interested in hybrid aspen. It was considered as a very good raw material for fine printing papers. Selection and testing of aspen clones from 20-30 years old plantations was started, clonal propagation methods through tissue culture were developed, large-scale commercial production of micropropagated plants was initiated, and the establishment of aspen plantations in practical forestry was promoted (FFTb 1995-1998). However, again the forest owners' interest remained low, maybe mainly due to the high cost of clonal plants. Therefore a cheaper, more traditional method of aspen cloning was developed, based on the rooting of root pieces in greenhouse conditions. Anyhow, the use of cloned aspen has remained at a very low level in practical forestry.

Concluding remarks

Somatic embryogenesis together with cryopreservation gives great promises for commercial production of tested Norway spruce clones in the future. This is the main current interest area in the study and development of vegetative propagation of forest trees in Finland, as well as in many other countries (FFTB 1993-1994, Lindgren 2006). There are no practical applications yet, but most optimistic guesses suggest that "artificial seed" may become even cheaper than seed orchard seed. In the longer run, tree breeders hope somatic embryogenesis to open the way to physiological rejuvenation and efficient clonal propagation of older trees tested or selected in progeny tests.

There are still some success stories going on with conventional cutting propagation and clonal forestry of spruce species. Some 1500 ha are planted annually with *Picea mariana* in Eastern Canada, and some 2500 ha with *Picea sitchensis* in Ireland and Scotland (e.g. Lindgren 2006). And of course, in other parts of the world clonal forestry has become quite well-established with some species (e.g. *Eucalyptus* spp., *Acacia* sp., *Cupressus* sp., *Pinus* sp.) and with some species it even has a very long tradition (e.g. *Cryptomeria* in Japan, poplars and willows in Europe).

At present, only a few clones of curly birch and some ornamental forms of forest trees are vegetatively propagated in a commercial scale in Finland, for special wood production and landscaping purposes.

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