BRIEF REPORTS

Technical Development in Seedling Production in Finland

LEO TERVO

Finnish Forest Research Institute
Suonenjoki Research Station
Juntintie 40
FIN-77600 Suonenjoki, Finland

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Over five million hectares of forest in Finland have been regenerated through cultivation. This represents a quarter of the total area of commercial forest. Annual regeneration areas have varied between 110,000 and 150,000 hectares over the last 30 years. The proportion of areas with seed derived trees has reduced from over a half in the early 1960's to a quarter of the total regeneration area.

The total number of seedlings produced was largest approximately 250 million seedlings per year. The number of seedlings delivered for forestation has reduced, and in 1998 the number approximately was 150 million seedlings. Seedlings are produced as bare rooted and container. Nowadays, the proportion of container seedlings is about 85 % of the total seedling production. Of the container seedling methods, Ecopot's share is the greatest. The proportion of hard plastic elements is increasinging quite rapidly.

The most interesting matters in the development of seedling production are connected with production hygiene, short day treatment, seedling storage, the use of plant protection chemicals and in general with environmental factors. Also, work atmosphere studies at nurseries after a twenty year break are again current. The consideration of mechanized planting is also a future challenge in seedling production methods.

Key words: seedling production, container seedlings, seedling production technique

Seedling production

Artificial regeneration has been employed in the regeneration of over five million hectares of Finnish forest, that is to say a quarter of the total area of commercial forestry. Annually, between 110,000 and 150,000 hectares have been planted or sown over the last 30 years. The proportion of sowing has diminished from over 50 % in the early 1960's to 25 % of the present day reforestation area (Kukkonen and Rikala 1997). In the early 1950's, the area planted and sown for forestry was about 30,000 hectares and by the beginning of the 1960's it had risen to 111,000 hectares (Metsätilastollinen vuosikirja 1969).

The numbers of seedlings delivered for forestation from Finnish forest tree nurseries are shown by tree species in Figure 1. Imports of forestry planting stock has been about 3 % of the total use of seedlings.

The total volume of annual seedling production for forestry since the beginning of the 1970's and until the end of the 198'0s was about 250 million seedlings.

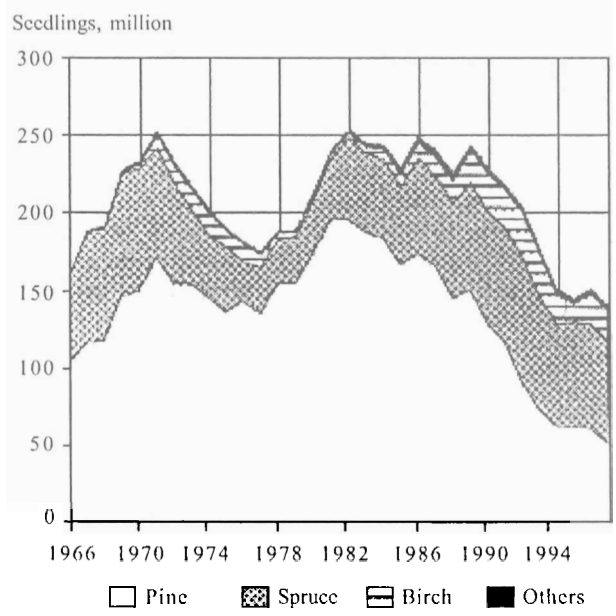

Figure 1. Numbers of seedlings delivered for forestry planting by tree species in 1966-1997 (Statistics provided by the Ministry of Agriculture and Forestry).

Since the beginning of the 1990's, the volumes delivered for forestry planting have been smaller; in 1998, the figure was about 150 million.

Seedling production methods

Planting stock for forestry is produced as container and bare rooted seedlings. The raising of bare rooted planting stock begins with broadcast sowing of the seed into seedbeds which are usually in the open. Often the sown areas are covered with gauze. This promotes seedling development and protects the seed and seedlings against birds and insects. Seedlings are also produced by raising them in small containers in greenhouses and these are then usually transplanted during the same growing season into the open. Seedlings raised, following broadcast sowing, in the open are lifted after one or two growing seasons to be transplanted mechanically into plant beds in the open. By transplanting it is intended to increase the density of the root systems, and by wider spacing to induce the plants to become sturdier. The age of transplanted pine seedlings delivered for planting out is two to three years, that of birch two years, and that of spruce three to four years. Bare rooted pine planting stock is also produced employing a method whereby the roots are pruned. This requires the seeds be sown in rows. During the following growing season the roots of the seedlings are pruned laterally and from underneath, usually by means of a J-shaped blade. A suitable pruning distance is about five centimetres to the sides and eight to ten centimetres deep (Parviainen 1980). Pruning the roots strengthens and promotes branching of the roots, thereby replacing transplanting. The pruning operation is done after the seedlings' height growth has ceased. Planting stock produced by the root pruning method is cheaper than that produced by transplanting. The planting out results have been promising.

The initial raising of container seedlings usually takes place in greenhouses. Container birch and pine seedlings are usually grown for one growing season, and container spruce for one to two growing seasons. Container pine seedlings are also grown to the age of one and a half growing seasons. The commonest container types are paper pots, but different hard plastic containers are gaining popularity. Light coloured sphagnum peat, fertilized and treated with calcium, is the most common substrate.

The shift over from bare rooted to container planting stock in Finland began in the 1960's (Figure 2). The

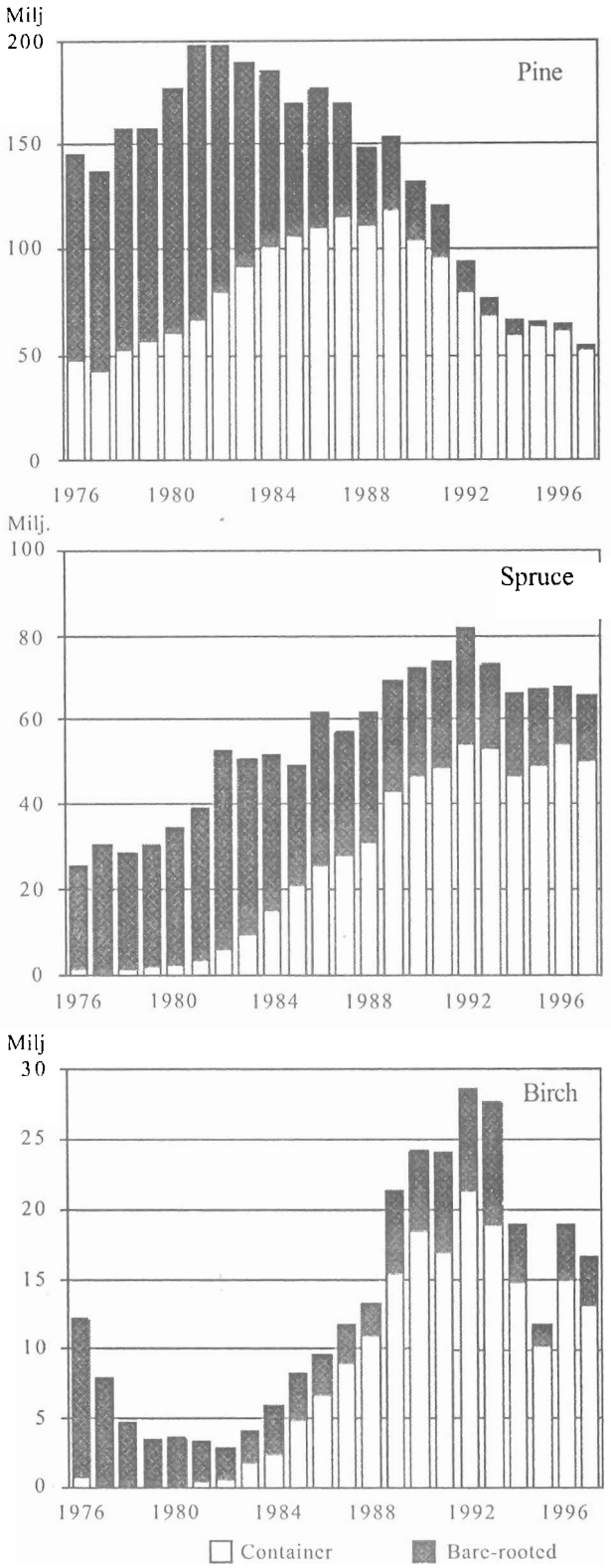

Figure 2. Proportions of bare rooted and container seedlings by tree species in 1976-1997 (Statistics provided by the Ministry of Agriculture and Forestry).

growth in the proportion of container stock was quite slow up to the early 1980's. At the outset of the 1980's their share was only about 25 %. Ten years later the figure had increased to 70 %. This development was also influenced by the considerable fall in total production since the end of the 1980's. The reduction in bare rooted planting stock was relatively greater. Nowadays, container planting stock account for about 85 % of all forestry seedling production.

Production of bare rooted planting stock

Technical development in the production of bare rooted seedlings has not been significant. This has also affected the rate of increase in production of container seedlings. The machinery and equipment used at forestry nurseries were usually adopted from agriculture. Technical development of the production of bare rooted planting stock was carried out at the nurseries and it was at its peak in the late 1970's with the Foundation for Forest Tree Breeding and the Finnish Forest Research Institute being the most prominent developers. This was the period when root pruning machines, sowing machines and lifting machines, for example, were developed (Harstela and Tervo, 1982, 1983). These also involved modifications of agricultural machines already in use, for example sowing machines and the Harter lifting machine (Figure 3) (Harstela and Tervo, 1982, 1983.). Conveyer based lifting machines have been in use in Central Europe and in the United States for a long time.

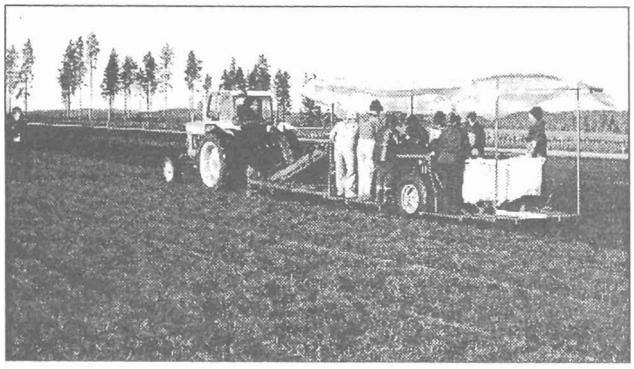

Figure 3. Harter lifting machine at METLA's Suonenjoki Research Station in 1980.

After Haller (1978), the use of these machines has resulted, for instance in damage to seedling shoots. The technical development of bare rooted seedling production by Harstela and Tervo (1982, 1983.) also included ergonomic study of the work involved. The studies conducted revealed that the job of manually lifting bare rooted spruce seedlings is considerably facilitated by cutting the seedling beds between the lines of seedlings in addition to the usual undercutting and vibrating. Harstela's study (1977) also looked into the opinions of nursery workers regarding the work methods and work arrangements. Markku Pitkäniitty at the Foundation for Forest Tree Breeding developed various machines and devices for treating seed as well as a machine for lifting bare rooted seedlings.

Finnish machine manufacturers were more interested in developing the production of container seedlings than of bare rooted seedlings. Sowing and transplanting machines made by such Finnish manufacturers as Lännen Tehtaat Oy and Tume are in use at forestry nurseries. The Danish manufacturer Egedahl is probably the best known foreign machine manufacturer in Finland. They have a comprehensive range of equipment for the various stages of production of bare rooted seedlings.

The Suonenjoki Research Station of the Finnish Forest Research Institute, together with the Regional Occupational Health Institute of Kuopio, conducted a study looking into the technical aspects of plant protection spraying and the operatives' exposure to chemicals while spraying (Figure 4). The technical development work also took into account environmental matters; for example a plant protection spray based on a recycling principle (Tervo, 1984, Tervo et al., 1991).

Figure 4. A plant protection sprayer, functioning by recycling principle, developed at METLA's Suonenjoki Research Station

Production of container planting stock

Spruce and pine were planted solely as container seedlings in Germany at the end of the 17th century and during the 18th century. At that time the plants were lifted and transferred with a ball of soil around the roots

from among dense natural copses to fill in sparser parts of young stands (Huuri, 1969). Despite good results attained, the difficulty of transporting restricted the application of this method. Bare rooted plants continue to be commonly used in forestry in Central Europe.

In the 1960's, interest towards raising container seedlings grew also in Finland. Reasons for this included threat of shortage of labour and of seasonal skilled forestry planters (Nisula, 1978). Concern over the possibility of labour shortage has subsequently proved to be groundless. Both the widespread use of horticultural peat and of greenhouses have contributed to the launching of container seedling production. Greenhouses have also been used to produce seedlings for transplanting for further raising in the open.

At first, container seedlings were produced by transplanting bare rooted seedlings into various types of containers, for example peat pots, rolls and veneers. At the end of the 1960's, the paper pot method invented in Japan by Takagi and Masuda (1967) was also introduced into Finland. The seeds are sown directly into paper pot containers filled with horticultural peat. The paper pot method found widespread use within a very short time, and in its present form (Ecopot) it continues to be the most popular method in use in Finland. Pentti Nisula at the Finnish Forest Research Institute invented and constructed the Nisula roll plant method (Nisula, 1978). This method has been in use at several Finnish forestry nurseries but its use as a method of producing pine container seedlings ended in Finland at the end of the 1980's. The method was used in raising birch seedlings as recently as the early 1990's. The Nisula roll plant method has also been used abroad.

Some re-forestations using container seedlings have failed due to root deformation. Parviainen (1976) stated that root growth in some containers is restricted to a certain part of the container. Intertwining of roots was observed with bare rooted seedlings. In the case of seedlings raised in paper pots it was observed that roots tended to corkscrew, not observed in other container types, which was thought to be caused by the root growth inhibiting effect of the paper (Parviainen 1976). Paper pots seedlings are mainly planted with paper. When ecopot seedlings are ready for planting, they are separated from each other by stripping away the non-dacayning laminate wall between every row of pots.

These observations led to the development of new containerisation methods. One example of these new methods aimed at avoiding root deformation was the Vapo container (Figure 5), developed by the Finnish

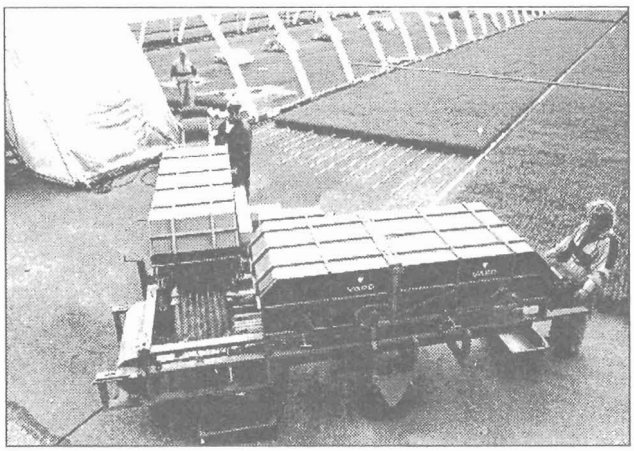

Figure 5. The Vapo container seedling method at METLA's Suonenjoki Research Nursery.

Forest Research Institute and Vapo Oy. This method is such that the seedlings are raised without a conventional container. A two centimetre thick fertilized and compressed peat plate, which swells to a thickness of about eight centimetres on being irrigated, serves as the substrate. The seeds are sown into depressions formed at regular intervals on the plate. During the growing season, the substrate and the seedling roots are cut between the seedlings. As a result of root cutting, the roots become denser and bind the substrate (Huuri, 1969; Parviainen 1985; Harstela and Tervo, 1985; Parviainen and Tervo, 1989). Experiences concerning root pruning of both bare rooted and container planting stock go back to the early years of forestation (Huuri, 1969). Regardless of the advantageous root development, the method has not become widespread. In Finland, the Vapo method of raising container seedlings is used only at a few forestry nurseries. In Brazil, the method has been tested on a practical scale. It was compared with commonly used seedling production methods used there. The forestation results obtained have been promising for the Vapo containers (Parviainen et al., 1996).

Ecopots (Ps-408-708) account for 76 % of the production of pine seedlings and containers made of hard plastic for more than 16 % (Figure 6). In the case of spruce, Ecopots have a share of 74 % and that of hard plastic containers (Plantek, Panth and Vapo cell) is 17 %. In birch seedling production, Ecopots have a share of 34 % and hard plastic Plantek containers 30 %. The share of Enso and Finbox containers is 16 % and that of Vapo peat pots 10 %. The share of hard containers has increased and this trend can be expected to continue. The selling price of two years old container spruce seedlings is about 10 % lower than four years old bare rooted spruce seedlings.

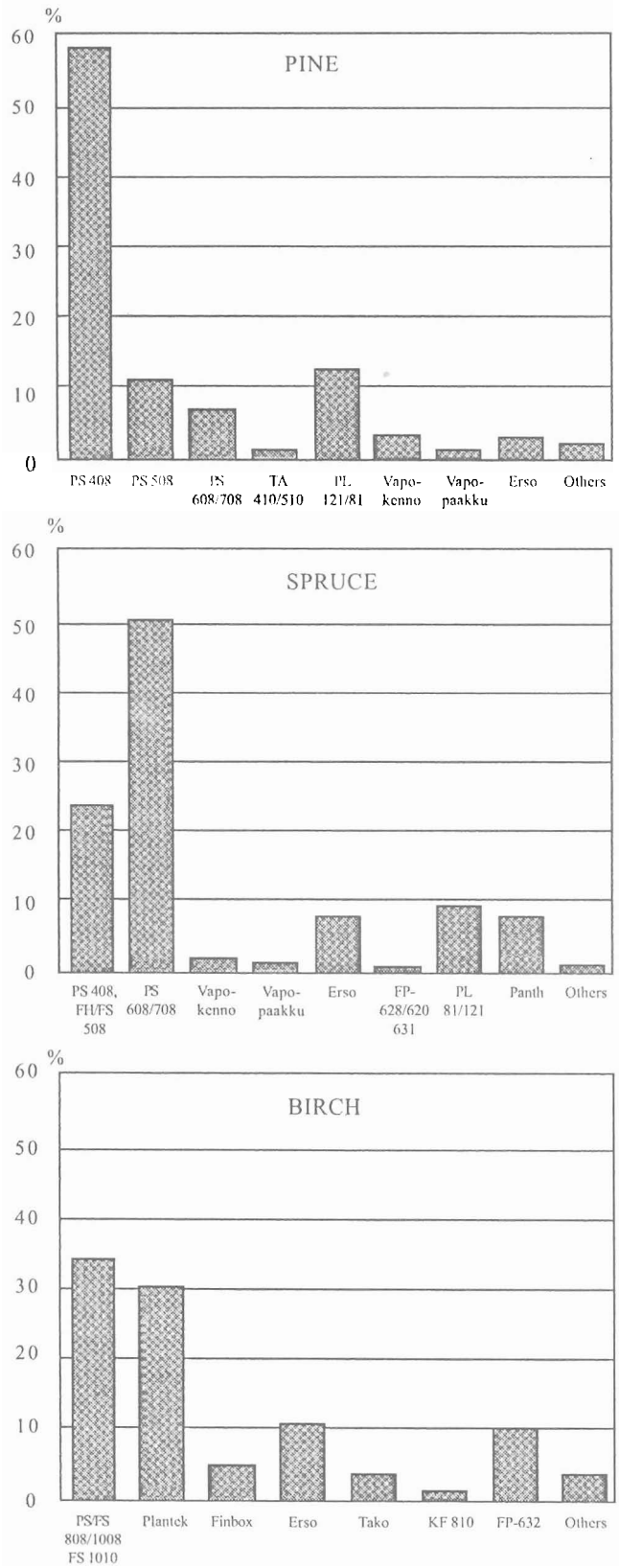

Figure 6. Proportions of various container plant types by tree species in 1997 (Statistics provided by the Ministry of Agriculture and Forestry).

Development and future outlook

Greenhouses and horticultural peat were adopted on a larger scale in forestry nurseries in the 1960's. Greenhouses enable several crops of seedlings to be raised during a single growing season and the growing conditions can be regulated by means of irrigation and ventilation. Also, the use of shading is common practice especially during the initial stage of raising spruce.

Light coloured sphagnum peat is generally used as the substrate. It is available in different degrees of coarseness: coarser peat is suitable for filling large containers and finer peat for filling small containers. Also different mixtures of horticultural peat and, for instance, perlite have been experimented with. Mixtures improve the porosity of the substrate and penetrability by water.

The containers are filled mechanically. Conveyors integrated with new filling lines are such that they do not disturb the composition of horticultural peat as much as earlier screw conveyors did (Heiskanen et al., 1996). The feeding and filling of hard plastic containers is highly automated.

The sowing of conifer seed succeeds technically well with present day sowing machines. Even single seed sowing with sufficient precision is possible. The sown areas are generally covered with a layer of sawdust or crushed stone with a particle size of two to four millimetres. This improves the conditions for germination and prevents at least to some extent moss growth on the surface of the substrate. In the Vapo method of raising container seedlings, the seeds are sown into depressions and thus a covering layer is not necessary.

The first mobile irrigation systems were in use at the end of the 1960's. Models developed by Nisula for greenhouses and for Nisula roll seedlings raised in the open became available in the early 1970's (Nisula, 1976, 1978). In the course of his research and development work, Nisula (1976) investigated the varying evaporation of moisture from the substrate inside greenhouses, and irrigation requirement based on weighing. When raising seedlings in the open, it is sufficient for irrigation to be applied evenly throughout the area. In greenhouses, evenness of irrigation is not enough because of the variation in evaporation in different parts of the greenhouse which has to be taken into account in irrigation (Nisula, 1976). The use of liquid fertilizers became common with the development of irrigation equipment. Mobile irrigators are widely used in present day raising of container seedlings both in greenhouses and in the open.

The trend towards hard plastic "open wall" containers is very pronounced. Mechanization and automation of different work phases in this method are easy. Also, it is technically easier to carry out the mechanization of grading and packing than when dealing with, for instance, Ecopots.

Present day automation and technology would provide technical possibilities for automation of container seedling production. When choosing the degree of automation, it is necessary to assess the risks and capital costs associated with automation when in relation to manual alternatives. Rational technical development is necessary. The production technology used should be such that it for its part enables healthy and vigorous plants to be raised. When automating production, one must also bear in mind that seedling production also requires able and skilled staff.

The most interesting current issues relate to plant production hygiene, short day treatment, seedling storage, the use of plant protection chemicals, and to environmental factors in general. Also, studies of the work atmosphere at forestry nurseries are of interest after a break of twenty years. Issues concerning plant production need some clarification following Finland's joining the European Union. Keeping production costs under control has lead partly to the use of small container seedlings; for instance the use of one year old spruce seedlings has increased. Planting out results have been positive. On the other hand, there is growing interest in the use of larger containers, for example in Canada. Also, planting out almost in the whole growing season has been attempted, at least with birch, with good results. These experiments are being extended also to other tree species. In Sweden, conifer seedlings have been machine planted almost in the whole growing season.

Finland's container seedling production has been at the "same" level for quite some time. Now, new investments are being made. On the other hand, nurseries have conducted critical evaluations of their operations. Some nurseries have been closed and companies have centralized their production. Also, new private producers have appeared and obviously more will come to the market.

References

Haller R. 1978. Maschinen und Geräte für den Forstplanzgarten-Stand. 1977. Forsttechnische Informationen 2: 12-16.

Harstela P. 1977. Taimitarhatyöntekijöiden mielipiteitä työmenetelmistä ja työjärjestelyistä. Metsäntutkimuslaitos. Metsänviljelyn kocasenan tiedonantoja. 23: 1-14.

Harstela P. ja Tervo L. 1982. Paljasjuuristen taimien tuotannon teknologia. Metsäntutkimuslaitoksen tiedonantoja 49. Suonenjoen tutkimusasema. 1-91.

Harstela P. ja Tervo L. 1983. Technology of the production of bare-root seedlings. Paljasjuuristen taimien tuotannon teknologia. Metsäntutkimuslaitoksen julkaisuja 110. Comm. Ins. For. Fen. 51 p.

Harstela P. ja Tervo L. 1985. Kuutiopaakkutaimimenetelmä. Tuotannon teknologia. Metsäntutkimuslaitoksen tiedonantoja 171. Joensuun tutkimusasema. s. 31-44.

Heiskanen J., Tervo L. and Heinonen J. 1996. Effects of Mechanical Container-filling Methods on Texture and Water Retention of Peat Growth Media. Scand. J. For. Res. 11:351-355.

Huuri O. 1969. Paakkutaimien käyttö kautta aikojen. Metsälehti 1969 (38):6-7.

Kukkonen H. ja Rikala R. 1997. Siemen- ja taimihuolto. Tapion Taskukirja. Toim. Häyrinen, M. Metsätalouden kehittämiskeskus Tapio. Kustannuosakeyhtiö Metsälehti. s. 240-249.

Metsätilastollinen vuosikirja 1969. Yearbook of Forest Statistics. Fol. For. 96: 66. Helsinki 1970. Maa- ja metsätalousministeriön tilastot. Moniste.

Metsätilastollinen vuosikirja 1997. Skogsstatistisk årsbok. Finnish Statistical Yearbook of Forestry. Metsäntutkimuslaitos. Skogsforskninginstitutet. Finnish Forest Research Institute. Helsinki

Nisula P. 1976. Muovihuoneen sadetuskone. Summary: A springler for a plastic greenhouse. Fol. For. 258. 1-14.

Nisula P. 1978. Rullataimimenetelmä taimitarhalla ja metsänviljelyn toimenpideketjussa. Koulitut männyn taimet. Summary: The Roll Transplant Method In The Nursery And In The Forestation Work Chain. The Pine Transplants. Comm. Ins. For. Fen. 93(5) 1-112.

Parviainen J. 1976. Männyn eri taimilajien alkukehitys. Initial development of root systems of farious types of nursery stock for Scots pine. Fol. For. 268:1-21.

Parviainen J. 1980. Juurten leikkaaminen männyn paljasjuuristen taimien kasvatusmenetelmänä. Zusammenfssung: Wurtzelschnitt Als Anzuchtsmethode Bei Wurzelnachten Kiefernpflanzen. Metsäntutkimuslaitoksen julkaisuja 98.2. Comm. Ins. For. Fen. 1-131.

Parviainen J. 1985. Kuutiopaakkutaimimenetelmä. Menetelmän biologinen tausta ja yksivuotisten taimien kasvatuskokemuksia. Metsäntutkimuslaitoksen tiedonantoja 171. Joensuun tutkimusasema. 1-30.

Parviainen J. and Tervo L. 1989. A new approach for production of Containerised Coniferous seedlings using Peat sheets coupled with Root pruning. Forestry Supplement, Vol 62. 87-94.

Parviainen J., Tervo L., Carneiro J. and Soares R. 1996. Establishment and managemenet of tree plantations in southern Brasil. Finnish-Brazilian cooperation in forest research. Metsäntutkimuslaitoksen tiedonantoja 594. The Finnish Forest Research Institute, Research Paper 594, 53 p. Joensuu.

Takagi A. ja Masuda T. 1967. Paperiastiaryhmä taimien kasvatusta tai vastaavaa varten. Suomalainen patentti 48401:1-18.

Tervo L. 1984. Uudelleenkierrätysperiaatteella toimiva kasvinsuojeluruisku taimitarhalla. Metsäntutkimuslaitoksen tiedonantoja. Suonenjoen tutkimusasema. 164. 32 s.

Tervo L., Kangas J. and Kurttio P. 1991. A Nursery Sprayer with the Recycling principle. Scand. J. For. Res. 6:259-270.

УСОВЕРШЕНСТВОВАНИЕ ТЕХНИКИ ВЫРАЩИВАНИЯ ПОСАДОЧНОГО МАТЕРИАЛА В ФИНЛЯНДИИ

Л. Терво

Резюме

В Финляндии лесные культуры созданы на площади, превышающей 5 миллионов га. Это составляет четверть всего коммерческого леса. За последние 30 лет ежегодно лес восстанавливался на площади от 110000 до 150000 га. Часть леса, восстановленного посевом семян, сократилась с половины в ранние 1960-ые, годы до четверти в настоящее время.

Наибольшее количество посадочного материала, выращиваемого в отдельные годы, достигало до 250 миллионов штук за один год. В настоящее время количество посадочного материала, выращиваемого для создания лесных культур, уменьшилось, и составило 150 миллионов экземпляров в 1998 году. Посадочный материал выращивается как с закрытой корневой системой, так и с открытыми корнями. В настоящее время посадочный материал с закрытой корневой системой составляет около 85 % от всего объёма. В производстве посадочного материала с закрытой корневой системой, метод Экопота является основным. Однако часть производства посадочного материала в твёрдостеночных контейнерах заметно увеличивается.

Усовершенствование выращивания посадочного материала связано с гигиеной выращивания, регулированием длины светлого периода, условиями хранения, использованием химических средств защиты растений и с использованием факторов окружающей среды. Исследования условий труда в питомниках, спустя 20 лет, стали опять актуальными. Возможность механизирования лесопосадочных работ в будущем также влияет на методы выращивания посадочного материала.

Ключевые слова: выращивание посадочного материала, посадочный материал с закрытой корневой системой, техника выращивания посадочного материала.