CONTAINERIZATION IN SCANDINAVIA

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Abstract.--Sweden and Finland produced 150 and 75 million container plants, respectively, in 1974. Paper-pot accounts for 175 million. Production is largely mechanized, and plastic greenhouses are frequently used. The biological results indicate that spring and summer plantings yield satisfactory results. Soil preparation must be thorough, however.

Scandinavia includes the three countries Sweden, Norway and Denmark. But, when dealing with forests and forestry, Finland should also be included in the picture. Consequently, in the following discussion I shall take the liberty of including Finland in Scandinavia. I also feel I should preface my remarks with a brief description of the Nordic climate and forest industry in order to more clearly define our development and utilization of rooted or container plants.

CLIMATE

The Nordic countries all lie between latitudes 56 and 71 degrees. This is an extremely northerly location, particularly considering that the lion's share of Scandinavian forestry is concentrated around latitude 62 degrees. Days are long during the quite short summer period (June, July, and August). Although the northerly latitude would normally imply low atmospheric temperatures, the favorable influence of the Gulf Stream gives us a mean maximum temperature of approximately 20 degrees Centigrade (or about 68 degrees Fahrenheit). Typical of Scandinavia are the sunny but chilly spring months.

Western Norway receives a great deal of precipitation, nearly the most in Europe, with over 5,000 mm per annum. Annual precipitation east of the Scandinavian mountain range averages between 500 and 600 mm. Precipitation is distributed rather evenly throughout the year, with a slight maximum in August and a minimum during the spring.

FORESTRY

The Scandinavian forests cover an area of approximately 50 million hectares.

Table 1.--Forest areas in Nordic countries, in million hectares. 1 ha ~ 2.5 acres.

Sweden	Finland	Norway	Denmark	Total
24	19	6	0.5	50

Sweden and Finland dominate, with 24 and 19 million hectares, respectively. The vast majority of forest area is privately owned, much of it by small farmers.

Table 2.--Forest ownership, % of total forest area.

	Sweden	Finland	Norway
State	25	28	18
Companies	25	7	7
Private	50	65	75

Of the Nordic countries, Sweden has the greatest percentage of ownership by forest industry with 25 percent. State-owned forests amount

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to between 20 and 30 percent in all four countries.

Private ownership means that individual acreages are generally small. The areas felled are also limited in size, generally less than 5 hectares. Cutting areas in state- and corporately owned forests generally run between 10 and 30 hectares, occasionally even more. Limited cutting areas imply difficulties in mechanizing soil scarification and planting.

PRODUCTION OF PLANTS

Total plant production in Sweden, Finland and Norway currently amounts to more than 700 million per annum. It has been estimated that Swedish plant production, in any case, must be doubled by 1980. Rooted plants for industrial use are to be found only in Sweden and Finland, with respective totals of 150 and 75 million in 1974.

Table 3.--Plant production in million/year.

	Sweden	Finland	Norway	Total
Bare-root	220	165	100	485
Containerized	150	75	-	225
Total	370	250	100	720
% Containerized	40	30	0	31

In all probability, production of bare-root plants in Sweden will remain roughly the same, at approximately 200 million, during the near future, while production of rooted plants increases. The introduction of rooted plants will not replace bare-root production entirely.

Industrial production of rooted plants in Sweden between 1970 and 1974 is illustrated in Figure 1.

Paper-pots are by far the dominant type of container. With but few exceptions, model Fh 408 is the container used. Fh 408 has a diameter of 3.8 cm and a height of 7.5 cm. Nominal plant density is thus roughly 1,000 per square meter. The designation "Fh" indicates that the container fibers break down and disintegrate relatively slowly.

Multipot is used in Sweden only. This container yields a nominal plant density of roughly 800 per square meter.

Thus, the plants produced using paper-pot and multipot are small, considerably smaller than bare-root plants.

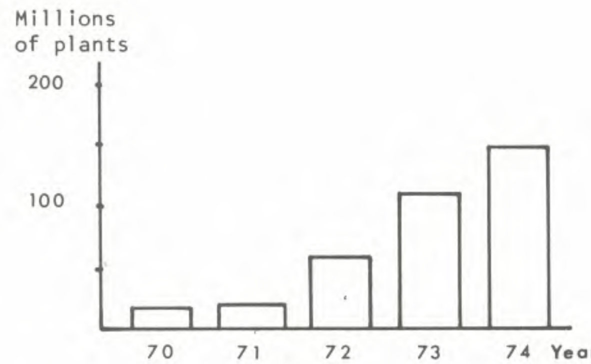

Figure 1.--Number of containerized plants produced in Sweden during years 1970-74.

Nisula is a quite original Finnish variety that has been on the market for some time but has not been very widely used. It is shaped like a jelly-roll and is used, among other things, for transplanting seedlings. Peat pots are still used to a limited extent in Finland.

Table 4.--Type of container used, in millions, 1974

	Sweden	Finland	Total
Paper-pot	115	60	175
Multipot	35	-	35
Nisula	-	10	10
Peat pot	-	5	5
Total	150	75	225

To sum up, then, the two principal types of containers in Scandinavia today are paper-pot and multipot.

WHY ROOTED PLANTS?

During the 1960's the costs of planting rose sharply, while at the same time forest industries experienced a recession. To keep costs per hectare down to a reasonable level, spacing was stretched to the breaking point. The need for new clearing and planting techniques became obvious. Since the cost of labor was sky-rocketing, it seemed optimal to find ways of mechanizing the most labor-intensive aspects of the job, particularly planting routines.

To be economical, planting machinery requires rather intensive, year-round utilization. Bare-root plants, however, have a short planting season during the spring months and, consequently, do not lend themselves to mechanized planting procedures. Furthermore, precision in mechanized planting could be expected to be low, which places greater demands on the tolerance of the plant material. Efforts to develop rooted plants and planting machines got under way. Rooted plants allow the planting season to be extended. Furthermore, use of small rooted plants as much as doubled the productivity of manual labor in planting operations. The extended planting season also offers better opportunities to train personnel, which, in turn, also contributes to greater efficiency. Labor shortages also forced some forest owners to adopt less labor-intensive systems.

All these factors, taken together, caused a rapid and widespread conversion to use of the smaller rooted plants in the early 1970's. The advantages seemed great and the future bright -- so bright that R & D efforts to develop planting machinery practically came to a halt.

Considerable research and development efforts were devoted to plant production. Generally speaking, much of the experimentation with rooted plants was quite preoccupied with the container itself. Gradually, the focus broadened toward systems analysis of the planting process, in which the container assumed its part in a total, and quite complex, bio-technical system. This development made the practical utilization of rooted plants possible. Plant production became industrialized. In the next few years the largest Scandinavian tree nursery is expected to produce approximately 35 million plants annually. A number of nurseries currently produce between 15 and 20 million. Mechanization and automation, together with the need for highly trained specialists, will probably mean that the forest nursery of the future must produce at least 20 million plants per year.

SOME BIOLOGICAL ASPECTS

In any period of rapid technological development there is always the risk that the biological aspects will be ignored, particularly since such investigations usually take some time. But there is no way of getting around these questions, and sooner or later they must be faced.

Of course, the plant itself is the most crucial element in the whole plant production process.

Figure 2 schematically illustrates the phases of development the plant passes through. First, germination, then growth, and then the final phase. Optimization of the germination

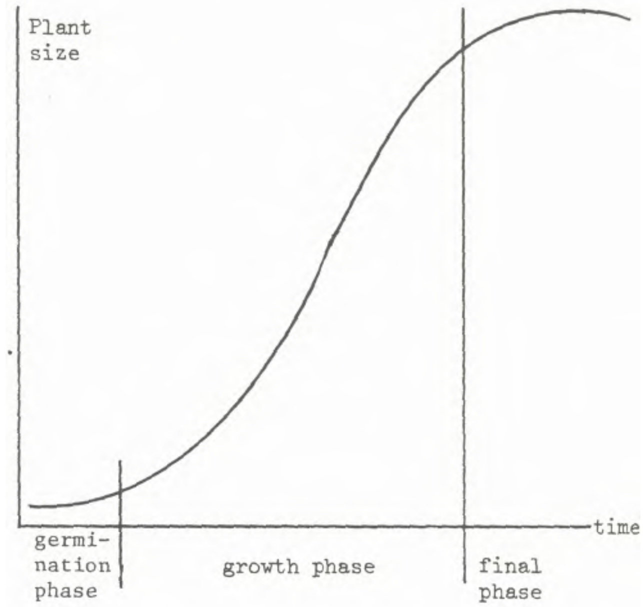

Figure 2.--Phases in plant development.

phase is especially important with respect to single-seed planting in containers. Losses in the form of "blanks" can easily occur if control over the germination environment is faulty.

A good growth environment means a rapid growth rate and, thereby, a short production period. Time is money, especially when the initial investment in containers and substrate is sizable. A good growth environment means that, to some extent, climatic fluctuations must be alleviated and the environment engineered to suit the plant's needs.

Plastic greenhouses offer a means of environmental control, and the precision of climatic engineering will increase in the future. This need not imply increased costs of production. During the final phase, the plants are given a final treatment to help them meet the often severe climate of the planting site. The needle weight of a plant is a function, among other things, of plant density during the nursery period. The greater the number of plants per square meter, the lower the needle weight and, thus, the lower the quality, measured in survival and growth rates. But lower plant density means higher costs of production per plant. In order to devise the proper system of production one must have in mind the size, or the "quality" desired. Survival or growth is not dependent on the plant alone. Figure 3 indicates other factors involved. Planting techniques, site preparation, and characteristics of the planting site affect plant quality and determine the rate of survival and growth of the new stand.

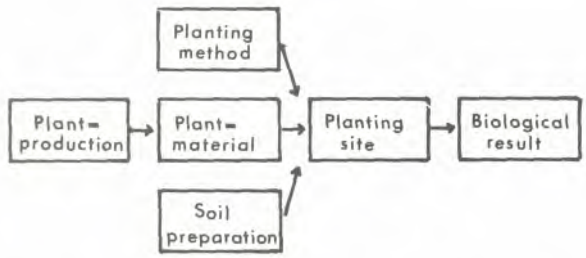

Figure 3.--Factors forming the biological result.

The rooted plant has a better "quality" than a bare-root plant of the same size. In principle, this superior quality can be used either to obtain a higher rate of survival and growth in the field or to simplify and economize planting procedures and keep costs down -- or even lower them. It would appear at present that the latter alternative has been chosen.

Three alternatives present themselves if better field results than those presently obtained are desired: plant quality can be improved even more, sites can be prepared more thoroughly and planting can be done more carefully. All these measures imply greater costs; it is a question of choosing the measure that has the greatest pay-off relative to its costs.

A NOTE CONCERNING TECHNOLOGY

Before going into the biological results in the field, I should like to describe briefly how paper-pot and multipot plants are produced and utilized today. Technology is developing rapidly, and much will have changed by 1975.

Both types of containers are used for both Scotch pine and Norway spruce. The substrate used is always low-humified peat, fertilized with one kilogram dolomite meal per cubic meter peat. Peat chips, manufactured by Hasselfors Bruk AB, are widely used in paper-pot culture. These bits of chopped compressed peat readily absorb water, which causes them to swell somewhat. The plants are watered by means of either fixed or roving nozzles. Liquid fertilizer -- a formula developed by Dr. Ingestad -- is also administered via the watering system.

Table 5.--Macroelement proportion in the liquid fertilizer of Dr. Ingestad.

	N	P	K	Ca	Micro
Proportion	100	13	65	0	+

Fertilizer is applied when the germination period is completed. Most nurseries use plastic greenhouses either during the entire production period or in its earlier stages. Some nurseries, however, practice open-air cultivation exclusively, and always with multipot. The period of plant production using open-air culture sometimes stretches over as much as two years. Approximately 95 percent of all rooted plants are one growing-season old or younger, however. All spring planting is done using plants that have spent the winter either stored in refrigerated houses or in the open air.

PAPER-POT

The sheet of paper-pots is stretched out on a plastic tray; Figure 4. Special machines for stretching the sheets are widely used to ensure an even geometric distribution. This is important for the subsequent sowing. The

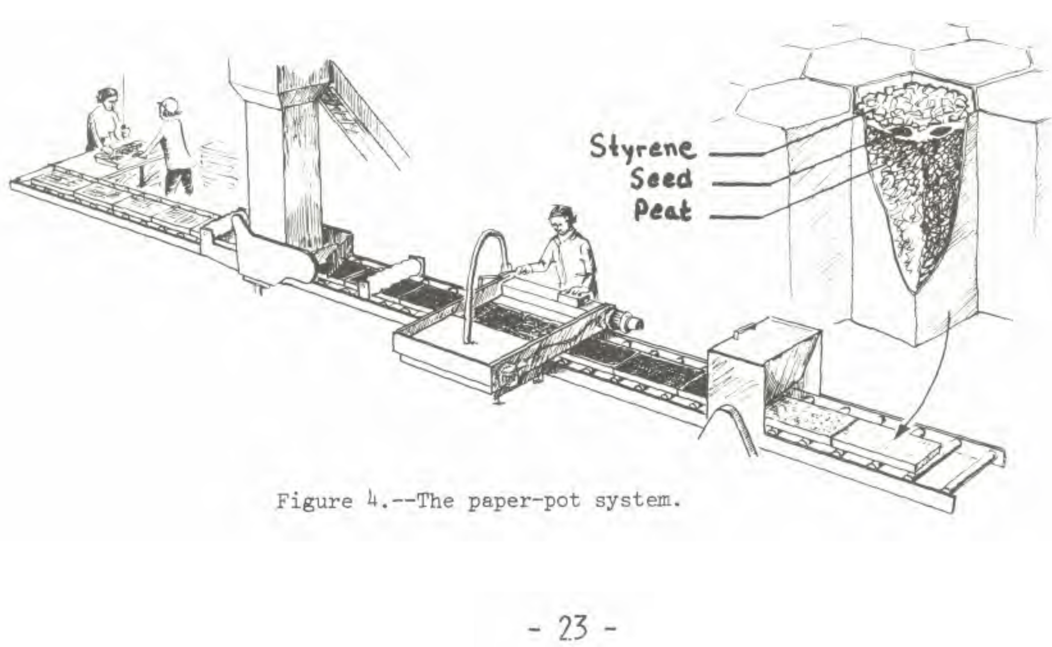

Figure 4.--The paper-pot system.

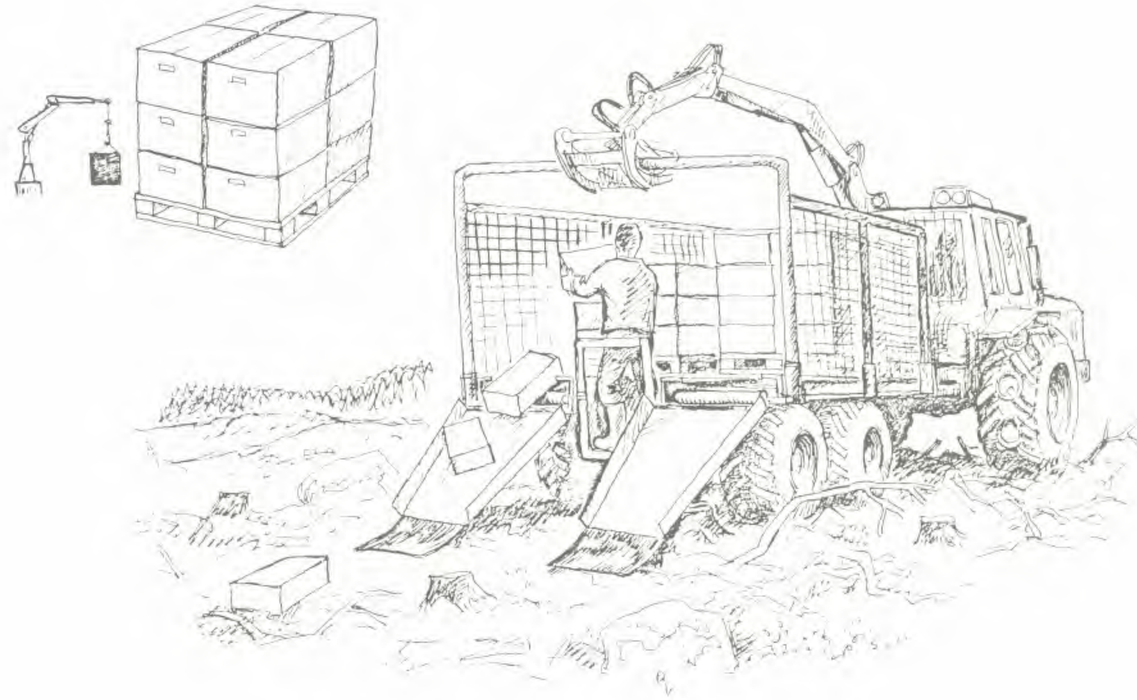

Figure 5.--Unloading the tractor.

tray is vibrated during the filling of peat. Chips are moistened prior to sowing; otherwise, the pots are watered after they have been deposited in the greenhouse. After sowing, a layer of styrene pellets is applied. The trays are then deposited in greenhouses. When the production period is nearing an end, the plastic is removed from the houses, or the trays are removed into the open air to make room for another crop of newly sown paper-pots.

In order to avoid the occurrence of "blanks" several seeds are sometimes sown. The plants are then thinned when planted. In most cases today, however, seeds are of such a quality and the climate control in the greenhouses is so well developed as to allow sowing one seed per pot.

The plants are packed in cartons (250 plants/carton) of dimensions to fit the standard European freight-flat. The flats are transported in vans an average of 150 kilometers (or somewhat less than 100 miles). They are then deposited by the roadside and loaded onto "forwarder" tractors. These tractors are equipped with special chutes by which the cartons can be unloaded one by one (Figure 5) Before the plants are unloaded on the planting site the breadth of the area to be planted is marked (broken line, Figure 6). The tractor drives down the middle of the area (heavy dots) and deposits the cartons at appropriate intervals. The planter fills his planting tray with plants and plants one row out to the edge of the planting area (dotted line), where he turns and plants another row on his way back to the carton. When he reaches the carton, he takes another load and continues in the same manner on the other side of the field, turns at the edge and returns, etc.

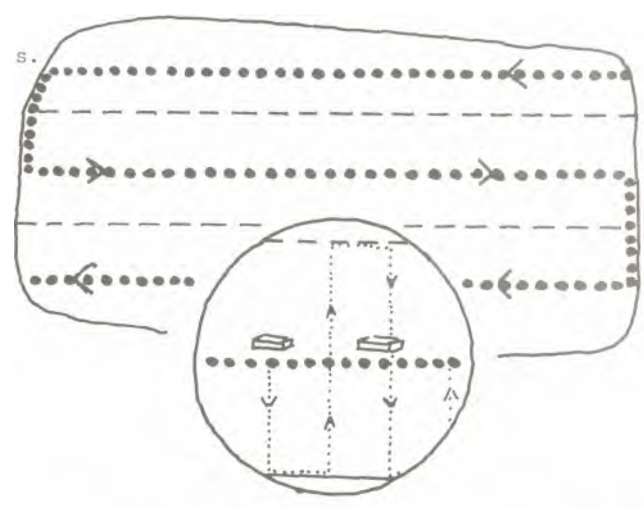

Figure 6.--Working principle on the regeneration area.

The most commonly used planting implement is the "Pottiputki" (Figure 7). The lower

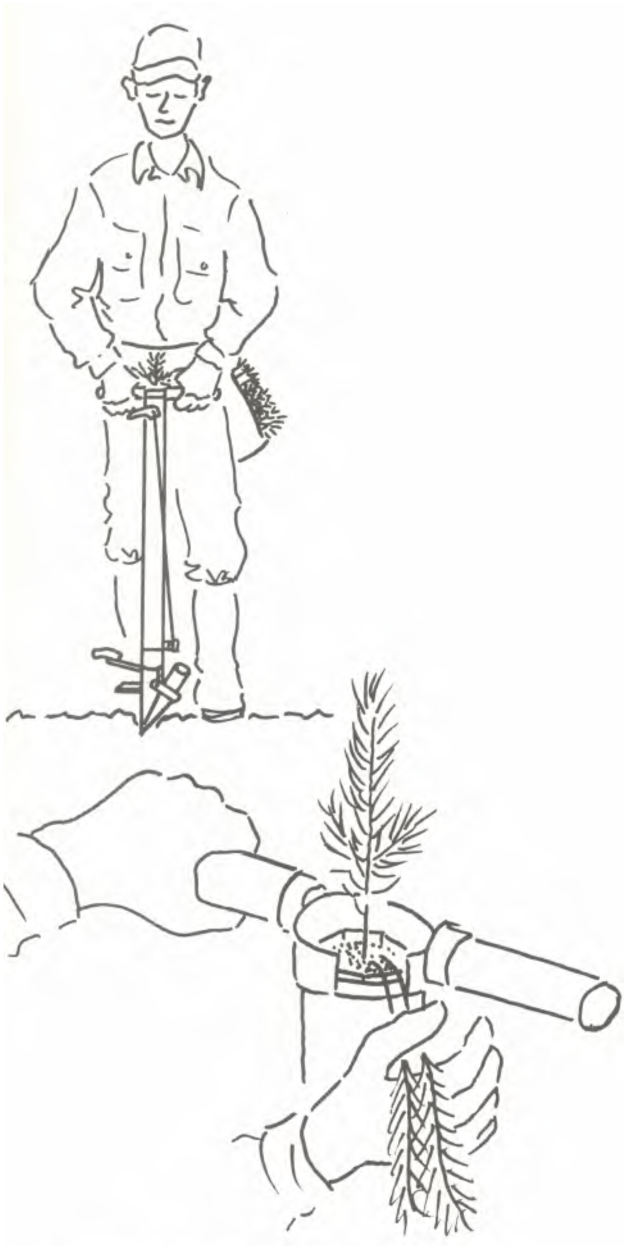

Figure 7.--Planting tool "Pottiputki".

portion of the tool, shaped like a duck-bill, can be opened by means of a foot-pedal after the tool has been pressed down into the soil. At the top of the tool a sharp blade is affixed, against which surplus plants can be cut away.

The efficiency of the planter will vary depending on the nature of the terrain and the type of soil preparation. Given normal terrain with soil preparation, productivity ranges between circa 200 and 220 plants per man hour.

MULTIPOT (KOPPARFORS)

Multipot systems have heretofore experienced a considerably lower degree of mechanization than paper-pot. (Figure 8). During 1974, however, machinery will be available for the application of peat and sowing. The central principle in the system is that the same handling unit is treated throughout the nursery production phase, transport and planting. This offers certain advantages, but demands a lot of the material, which implies higher costs. Flexibility declines, and the containers must be re-used. Return transport, for various reasons, implies higher costs than for "no-return" containers. At present, plant thinning and filling of "blanks" is performed during the nursery production phase. The earlier thinning can be performed, the greater the biological advantages and the better the quality of the plant. But thinning is a very labor-intensive procedure that is practically impossible to mechanize.

Multipot plants are transported in large, open frames, and it is consequently difficult to arrange as rational a means of unloading at the planting site as is the case with cartons. Greater manual resources for carrying the plants are required (Figure 9). The shape of the peat plug is more distinct with multipot than with paper-pot. The planting tool is

Figure 8.--
The multipot system.

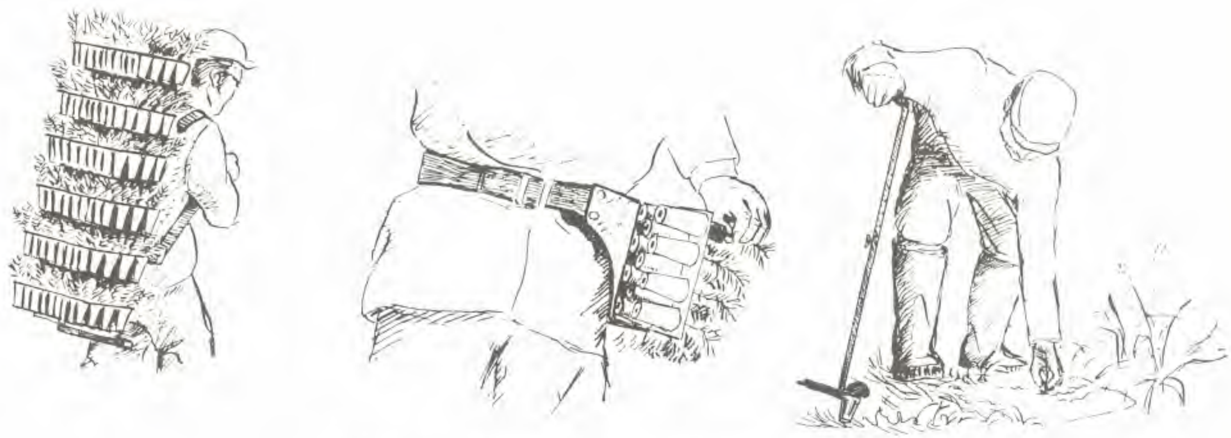

Figure 9.--Working on the site with multipot.

therefore shaped so as to fit the plug exactly, which results in better contact between the plug and the surrounding mineral soil.

BIOLOGICAL FOLLOW-UP

Whenever new forest culture methods are put into practice it is necessary to follow them up in the field. In order to avoid unnecessary errors and to quickly assess the utility of various methods, immediate feedback of the biological results observed is essential.

Thus, in 1972 a project entitled "Biological follow-up of rooted plants in industrial planting" was initiated. It is being carried our at the Royal College of Forestry in Stockholm in collaboration with the firms using rooted plants. The aim is to conduct a comprehensive biological follow-up of a statistical sample of industrial plantings. The first inventory is conducted the autumn of the year of planting, at which time the initial conditions are assessed. Sample plots and plants are marked for future reference. The next inventory of the samples is conducted during the autumn of the following year. A final inventory is made the autumn of the third year.

These inventories are performed according to standardized, computer-based routines, known under the designation PTAX. The personnel who conduct the inventories are given special training. The relationship of plant development to various factors associated with planting is examined -- mainly such factors as time of planting, container type, plant production technique, soil preparation, planting implements used, soil type, etc.

We are presently investigating 1972 and 1973 plantings, and 1974 plantings will be included this coming autumn.

Now, by way of conclusion, I should like to present some of the findings of the study of 1972 plantings. Figure 10 shows the mortality

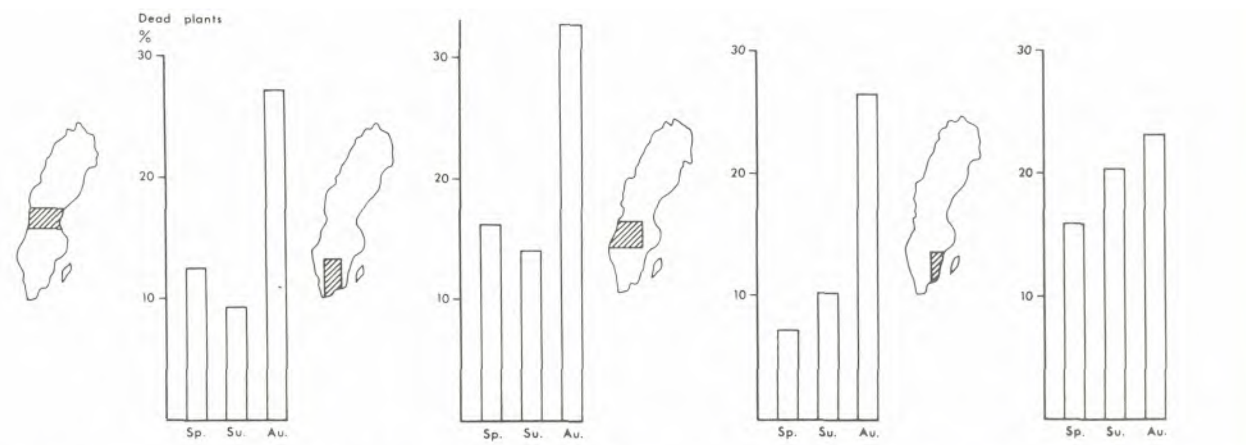

Figure 10.--Mortality rates for different planting seasons and regions in Sweden. Paperpot planted on scarified areas, 1972. Investigation, autumn 1973. Sp = Spring; Su = Summer; Au = Autumn.

rate found in 1973 in the second inventory in four different regions with different planting seasons. In all the areas considered, the soil has been scarified and planted with paper pot 408, the most widely used type of container. The boundary between spring and summer has been drawn at the third week in June, and that between summer and autumn the second week in August.

The results of autumn plantings are less than satisfactory, with mortality rates of 25-30 percent. Summer plantings, on the other hand, are quite successful, with results on a par with those of spring plantings. Further, one should note that at the second inventory the spring plantings have experienced two growth periods on the site, while autumn plantings have experienced only one. A comparison of the various regions reveals that mortality increases the farther south one comes (Figure 11).

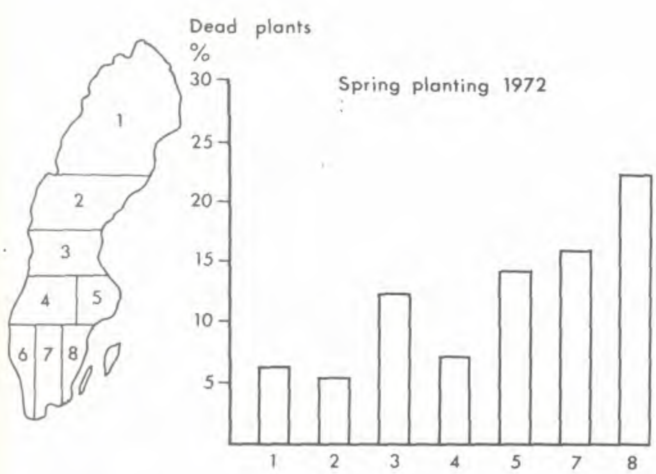

Figure 11.--Mortality rates for different regions in Sweden. Paper-pot planted on scarified areas in spring 1972. Investigation autumn 1973.

The reasons for this are several. One important factor is the type of soil preparation performed. The first inventory, autumn 1972, took note of the number of plants planted outside the soil-prepared patches. This proportion was very slight in region 1, but increased progressively toward the south. In the southernmost regions such plantings amounted to between 25 and 50 percent of the total planting. The plant's chances of survival are considerably less if it is planted in unprepared soil, which in turn affects the frequency of survival for the area as a whole.

Another important factor impinging upon plant survival is the presence of weevils (Hylobius abietis). Weevils are far more prevalent in southern Sweden than in the north. The damage done by weevils is to some extent influenced by the type of soil preparation performed. The weevil menace is less on larger soil-prepared patches. Figure 12 shows how the mortality rate is related to patch size. The small plants considered here obviously require careful soil preparation and, above all, enough usable patches. On average, some 30 percent of all plantings in the whole of Sweden were performed outside soil-prepared

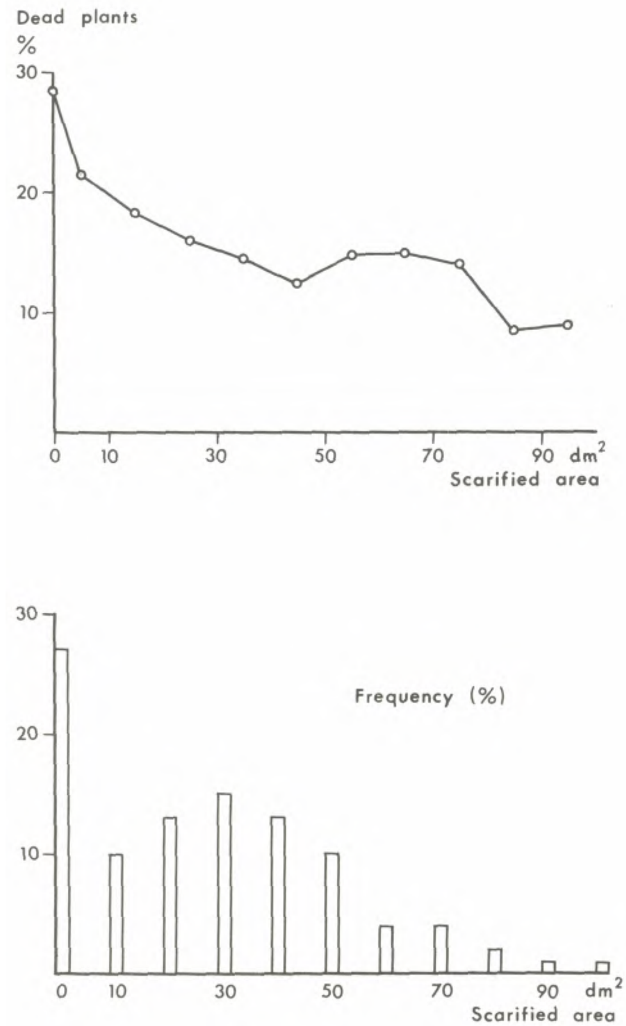

Figure 12.--Mortality rates in scarified patches of different sizes. Sample distribution in bottom figure.

patches -- despite the fact that all the sites studied had been soil prepared. If we cannot improve our soil preparation procedures, we must produce larger plants.

The generally poor results obtained from autumn plantings no doubt derive from the fact that the harshness of the planting site climate exceeded the stress tolerance of the plant material. Consequently, efforts must be made to design the final phase of nursery culture so as to increase the stress tolerance of the plants. Research in this area is in progress.

Finally, it may be of interest to see which factors account for the greatest mortality. Table 6 indicates that average mortality for the whole of Sweden amounted to 16.5 percent. Rodents accounted for the greatest share of the damage. In Scandinavia the rodent population peaks roughly every four years, and 1973 was such a year. Thus, the average for any longer period of time should be lower than this figure. Insects, and above all weevils, are a continual menace, however. "Freezing up" seems to be associated with autumn plantings where soil preparation has been performed immediately before planting. Local soil characteristics and amount of moisture are also relevant factors. Vegetation as a source of mortality has to do with the small plant size and poorly performed soil preparation.

Table 6.--Which factors account for mortality.

Source	Mortality rate (%)
Rodent	5.5
Insect	4.4
Freezing up	2.4
Vegetation	2.3
Mechanical	0.8
Frost	0.6
Fungus	0.3
Bird	0.2
Total	16.5

Question: What aspect of soil preparation is critical, for example, soil moisture, competition, etc.?

Hulten: Seedling mortality rate decreases as size of patch cleared increases, for several reasons. On large patches, the planter has more choice of microsite. Moisture is not a critical problem, but weevil damage is widespread in Scandinavia. Weevil damage tends to be greater near the edge of the patch; therefore, the larger the opening, the more trees the weevils don't reach. Competition from other vegetation can also be important.

Question: Do you have any problems with frost heaving?

Hulten: Yes. Frost heaving is more serious on the larger patches and when scarification is done immediately before planting, especially autumn planting.

Question: Is your figure of 200 seedlings planted per man-hour average or maximum?

Hulten: This is average for a skilled crew, but does not include time spent going after more seedlings.

Question: Do you ever thin seedlings in the greenhouse or is it all done in the field just before planting?

Hulten: With the paper-pot system thinning is normally done during planting, but with the multipot system you can thin in the greenhouse, if you have a small crop. From a biological standpoint it is best to thin as early as possible, but if you have 35 million plants, you can't thin them all early.