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ROOTING OF SCOTS PINE NEEDLE FASCICLES WITH DIFFERENT GROWTH SUBSTANCES AND MEDIA

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SELOSTE:

ERÄIDEN KASVUAINEIDEN JA KASVUALUSTOJEN VAIKUTUS MÄNNYN LYHYTVERSOJEN JUURTUMISEEN

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Needle fascicles of Scots pine *(Pinus sylvestris* L.*)* were rooted in a standard Jacobsen's germination apparatus. The apparatus was found to be suitable for rooting at least on a laboratory scale. The best rooting substrate was living *Sphagnum,* which remained sufficiently moist in the germination containers throughout the experiments. In a comparison of various growth substance treatments, the best result was obtained with a combination of IAA (100 mg/l) and thiamine (5 mg/l). The rooting percentage using these growth substances with *Sphagnum* as the rooting medium was in the first experiment 30 and in the second 48.

INTRODUCTION

Rooting and shoot development of needle fascicles in the genus *Pinus* have been investigated in numerous experiments (Rudolf and Nienstaedt 1964, Kummerow 1966, Libby and Concle 1966, Dingle 1969). In these studies, the influence of various rooting media and growth substances as well as the effects of day length, temperature, and the physiological stage or the age of the tree have been widely observed. The information revealed by these studies has made it possible to formulate suitable media and growth substances, although the precise technique for rooting needle fasciciles of pines has not yet been worked out.

It has been found to be rather difficult to induce root formation in shoots of Scots pine *(Pinus sylvestris* L.*).* However, both needle fascicles (Yli-Vakkuri 1973, Whitehill and Schwabe 1975) and long shoots (Persson and Bang 1959, Boeijink and Broekhuizen 1974) have been successfully rooted with the aid of a suitable growth substance in a well aerated and moist medium. Nonetheless, as rooting success in experiments carried out in different years has varied considerably, further studies on Scots pine are needed.

The aim of this study was to test the suitability of a standard Jacobsen's germination apparatus for rooting needle fascicles of Scots pine when various rooting media and growth substances are used. The studies have been preceded by numerous preliminary

experiments carried out at the Department of Silviculture, University of Helsinki, since 1969. The results of these studies have also been presented in a voluntary paper at the XVI IUFRO World Congress in Oslo 1976 (YLI-VAKKURI and PELKONEN 1976).

MATERIALS AND METHODS

The material in experiment A consisted of two-year old pine seedlings, previously grown in a nursery and lifted at the beginning of November, 1972. They were stored at a temperature of 4° C until the 15th of December and transplanted into fertilized peat in a greenhouse. The temperature in the greenhouse was maintained at about 20° C. The seedlings were illuminated continuously during the growing period in the greenhouse, and the needle fascicles were taken on March 1st, 1973, from the top shoots formed during the winter.

The seedlings used in experiment B were taken from the nursery at the beginning of November, 1973. The needle fascicles to be rooted were collected immediately after the seedlings were brought into the laboratory.

In both experiments, the needle fascicles were rooted in a standard Jacobsen's germination apparatus. In experiment A the apparatus was kept in a greenhouse and in experiment B at room temperature in the laboratory. In the greenhouse, the temperature of the apparatus was maintained at 25° C. Since no cooling was used, the temperature on sunny days rose to as high as 30° C. In the latter experiment, the needles were illuminated continuously, and as no temperature control was used, the temperature varied between 22 and 25° C.

The rooting media used in the germination containers in experiment A were living *Sphagnum*, damp cotton wool, and cellulose. These substrates were chosen on the basis of preliminary experiments in which peat, sand, vermiculite, and various water cultures had been used. On the basis of the results obtained in experiment A, only living *Sphagnum* was used in experiment B.

The needle fascicles were treated by keeping the base of the needles in petri dishes containing different growth substances for six hours in experiment A and for eight hours in experiment B. The following treatments were used:

Experiment A

IAA ..... 100 mg/l H_2O
IBA ..... 50 » »
NAA ..... 100 » »
IAA 100 mg/l + thiamine 5 mg/l
Distilled water as control

Experiment B

IAA ..... 100 mg/l
IAA 100 mg/l + thiamine 5 mg/l
Thiamine ..... 5 mg/l
Kinetin ..... 5 mg/l
Seed extract 2 g Pine seed 25 ml H_2O
Distilled water as control

The treatments were varied randomly between different germination containers, and the needle fascicles from different seedlings were carefully mixed in both experiments. In experiment A, a total of 300 needle fascicles was used, five in each germination container. For every combination of substrate and growth substances, there were thus 20 needle fascicles in four germination containers. In experiment B, 150 needle fascicles were used so that for every treatment there were 25 needle fascicles in five containers.

RESULTS AND DISCUSSION

The rooting of needle fascicles was checked two months after the start of experiment A. The best result i.e. 30 per cent rooting was given by a combination of IAA and thiamine with a *Sphagnum* substrate. In the case of the other treatment used, the rooting activity did not differ from the control. The longest root was 7 cm and the shortest one 0.5 cm long. The average rooting percentage for all the treatments was 3.7. No roots were formed when IAA alone was used. The results of experiment A are shown in greater detail in Table 1.

Experiment B was examined five times and the rooted needle fascicles were then

Table 1. The rooting of needle fascicles of Scots pine grown in germination containers with different media and treated with various growth substances. Experiment A.

Growth substance	Growth medium	Number of needle fascicles	Rooted number	Rooted per cent	Growth substances treatment number	Growth substances treatment per cent
IAA	Sphagnum	20	0	0		
	Cotton wool	20	0	0	0	0
	Cellulose	20	0	0		
IAA + thiamine	Sphagnum	20	6	30		
	Cotton wool	20	0	0	8	13.3
	Cellulose	20	2	0		
IBA	Sphagnum	20	0	0		
	Cotton wool	20	0	0	1	1.7
	Cellulose	20	1	5		
NAA	Sphagnum	20	1	5		
	Cotton wool	20	0	0	1	1.7
	Cellulose	20	0	0		
Control	Sphagnum	20	0	0		
	Cotton wool	20	1	5	1	1.7
	Cellulose	20	0	0		
Total		300	11	3.7		

Table 2. The rooting of needle fascicles of Scots pine in *Sphagnum* at different times and with various growth substances. Experiment B.

Treatment	Number of needle fascicles	Number rooted on the date of survey 2—1	2—15	2—6	3—25	4—10	Sum	Per cent
IAA + thiamine	25	6	1	1	3	1	12	48
IAA	25	4	—	2	—	1	7	28
Thiamine	25	—	—	—	1	1	2	8
Kinetin	25	—	—	—	—	—	—	—
Seed extract	25	—	—	—	1	—	1	4
Control	25	1	—	—	—	1	2	8
Total	150						24	16

Table 3. The average length of the roots at different times and with various treatments. Experiment B.

Treatment	The average length of the roots in cm Date of survey				
	2—1	2—15	3—6	3—25	4—10
IAA + thiamine	4.3	3.0	1.0	3.0	0.5
IAA	4.5	—	1.5	—	0.3
Thiamine	—	—	—	3.0	0.3
Kinetin	—	—	—	—	—
Seed extract	—	—	—	5.0	—
Control	5.0	—	—	—	0.5

removed from the germination containers. The first survey was made three months after the experiment was started. Also in this experiment, the best result was obtained with the combination, IAA and thiamine. In this case, IAA alone had a better effect on rooting than the control or any of the other treatments. When only thiamine was used, no positive effect was found. The best treatment gave 48 per cent rooting. The results from experiment B are shown in greater detail in Tables 2 and 3.

The needle fascicles remained rather green throughout the experiment. The condition of the needles was checked on the 10th of April, when the experiment was terminated. The number of green needle fascicles for every treatment is shown in the following table. There were 25 needle fascicles in each treatment at the beginning of the experiment.

IAA + thiamine	IAA	Thiamine	Kinetin	Seed extract	Control
		Number of green needle fascicles			
23	21	22	17	18	20

The results of these experiments show that the needle fascicles of Scots pine *(Pinus sylvestris* L.*)* can be rooted and that the success of rooting can be improved by providing suitable growth conditions and treatment with growth substances. The standard Jacobsen's germination apparatus proved to be suitable for rooting needle fascicles.

The humidity in the germination containers remained high and constant enough for callus formation and the development of new roots. Although the capacity of Jacobsen's apparatus is sufficient only for research purposes, it could be easily developed for larger scale rooting.

It has been earlier noted by many authors that the rooting medium must be well aerated and moist (cf. MERGEN and BLANCHE 1964). In this study, these properties were found to be optimal in living *Sphagnum*. It remained green and living throughout the experiments and helped to regulate the amount of water in the germination containers. The greatest disadvantage was growth of the *Sphagnum* which took place to such an extent that it had begun to shade the needles by the end of the experiments.

The most effective treatment was the combination IAA (100 mg/l) and thiamine (5 mg/l). In addition, IAA alone improved the rooting in the latter experiment even though the rooting percentage was only half of that given by the best treatment. It is difficult to make a comparison between IAA and IBA because IBA was not used together with thiamine. Many authors have already found, however, that IBA alone is very effective in promoting the rooting of needle fascicles of the genus *Pinus*. The importance of interaction between different growth substances has been shown in earlier studies

(HYUN and HONG 1971, HARE 1973, LUUKKANEN 1974, CHENG 1976).

The high rooting percentage given by the best treatment in these experiments shows that the rooting activity of needle fascicles of Scots pine can be strongly improved with the methods used in these experiments. Further studies are still needed before the most suitable technique for the stimulation of shoot growth of needle fascicles can be achieved.

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SELOSTE:

ERÄIDEN KASVUAINEIDEN JA KASVUALUSTOJEN VAIKUTUS MÄNNYN LYHYTVERSOJEN JUURTUMISEEN

Tutkimus käsittää kaksi koetta, joilla on pyritty selvittämään Jacobsenin idätysaltaan soveltuvuus männyn neulaskimppujen juurruttamiseen. Samalla on tutkittu muutamien kasvuaineiden ja -alustojen vaikutusta juurten muodostumiseen. Käsittelyt on valittu alustavien kokeiden perusteella, joita on tehty useiden vuosien aikana (YLI-VAKKURI 1973).

Tutkimuksen tulokset osoittivat Jacobsenin idätysaltaan soveltuvan hyvin männyn lyhytversojen juurruttamiseen, koska kosteus idätyskupeissa pysyy jatkuvasti tasaisena ja riittävän korkeana. Idätysaltaan kapasiteetti riittää sellaisenaan tutkimustarkoituksiin, mutta sen toimintaperiaatteen pohjalta voitaisiin helposti kehittää laite myös laajempaan käyttöön.

Parhaaksi kasvualustaksi osoittautui elävä rahkasammal, joka pysyi kokeiden ajan idätyskupeissa riittävän kosteana ja ilmavana. Eri kasvuaineista parhaan tuloksen antoivat IAA (indolyletikkahappo) (100 mg/l) ja tiamiini (5 mg/l) yhdessä käytettyinä. Tätä kasvuaineyhdistelmää ja rahkasammalta käytettäessä juurtumissadannes oli ensimmäisessä kokeessa 30 ja jälkimmäisessä 48.

KÄRKKÄINEN, MATTI O.D.C. 521.23 + 521.5

1976. Auxiliary observations on the measurement of the cross-sectional area of aspen logs. — SILVA FENNICA Vol. 10, No. 4, 9 p. Helsinki.

In this study the area, 8 diameters, and 16 radii were measured of 174 discs representing aspen logs in a mill. The average difference between the largest and smallest diameter was 18 mm, or 7 per cent of the longest diameter. The difference between the largest and smallest radius was 29 mm, or 22 per cent of the longest radius. The diameter was on the average 2,4 mm longer than the two corresponding radii.
The exact area of each disc was measured using a planimeter. In comparison, the area based on the circle formula the diameter being the arithmetic mean of largest and smallest diameters overestimated the area by 1,7 per cent.
The results also indicated that the use of random direction in the measurement of diameter overestimated the cross-sectional area on the average by 1,8 per cent.
The study is partly a continuation of the earlier study (KÄRKKÄINEN 1975 a) where the bibliography is presented. As far as the results are comparable they support each other.

Author's address: The Finnish Forest Research Institute, Unioninkatu 40 A, SF-00170 Helsinki 17, Finland.

LEHTONEN, I., WESTMAN, C. J. and KELLOMÄKI, S. O.D.C. 111.772 + 111.104

1976. Nutrient cycle in a Scots pine stand: II Amount and quality of precipitation in a Scots pine stand at the pole stage. — SILVA FENNICA Vol. 10, No. 4, 11 p. Helsinki.

This study forms part of a project designed to elucidate the total nutrient budget of a Scots pine *(Pinus silvestris)* stand in Central Finland (61° 50′ N; 24° 20′ E) during the 1974 growing period. Precipitation has been devided up into precipitation, throughfall and stemflow.
The acidity of the rainwater was found to increase in the order — precipitation, throughfall and stemflow. The electrolyte content of the rain water from throughfall and stemflow was higher than that of precipitation. The nutrient contents of precipitation were rather low. Throughfall and stemflow were found to leach some nutrients from the trees. This was most clear in the case of potassium. The total amounts of nutrients reaching the ground in throughfall were found to be smaller than those in precipitation. On the other hand, the amounts of potassium, calcium and magnesium in stemflow were clearly greater than those in precipitation.

Authors' adress (Lehtonen): The Finnish Forest Research Institute, Unioninkatu 40 A, SF-00170 Helsinki 17, Finland.

HEISKANEN, HEIKKI O.D.C. 962

1976. Basic problems of the wage system for forest work — SILVA FENNICA Vol. 10, No. 4, 11 p. Helsinki.

It has been in Finland publicly discussed to replace the present straight piece rate by a time rate. The low earnings of aged forest workers, its health hazards, its tendency to cause conflicts and considerable income differences are the main drawbacks of the piece rate and the proneness to increase labor costs is the essential fault of the time rate mentioned in the discussion. One possible solution for these problems is an efficiency bonus (prevents the labor costs from increasing and decreases the income differences) combined with a bonus for age (guarantees high incomes for aged wage earners), a maximum efficiency standard (prevents health hazards) and a group incentive (prevents conflicts).

Author's address: University of Helsinki, Institute of Social Policy, Franzeninkatu 13, SF-00500 Helsinki 50, Finland.

KELLOMÄKI, SEPPO and HARI, PERTTI O.D.C. 173. 2: 161.32

1976. Rate of photosynthesis of some forest mosses as a function of temperature and light intensity and effect of water content of moss cushions on photosynthetic rate. — SILVA FENNICA Vol. 10, No. 4, 8 p. Helsinki.

The photosynthetic rate of *Pleurozium schreberi* (Willd.), *Hylocomium splendens* (Hedw.) and *Dicranum undulatum* (Sw.) grown in plastic containers was monitored with infrared gas analyzer in open air under natural weather conditions. It proved that the photosynthetic rate of wet moss cushions was satisfactorily predicted by temperature and light intensity. In dry moss cushions this kind of model gave too high an estimate for photosynthetic rate. Water requirements of each moss species were found to be moderate, and water content of moss cushions limited photosynthetic rate only under serious water deficiency.

Authors' address: University of Helsinki Department of Silviculture, Unioninkatu 40 B, SF-00170 Helsinki 17, Finland.

WESTMAN, C. J. O.D.C. 232.329.6-425.1

1976. Fertilization of containerized Scots pine seedlings with different nitrogen fertilizers. SILVA FENNICA Vol. 10, No. 4, 18 p. Helsinki.

The paper deals with fertilizing containerized (paper-pot VH-608) Scots pine (Pinus silvestris) seedlings with ammonium sulphate, potassium nitrate and urea in conjunction with planting out.
The results show that none of the fertilizers used were bound in the peat. The nitrogen content in the above ground part of the seedlings increased clearly. Fertilization with ammonium sulphate resulted in the greatest increment and this increase appears to be permanent. The wintering process was somewhat delayed by the fertilization. The seedling mortality rate for all the treatments has been quite appreciable. However, fertilization particularly with ammonium sulphate on the poorer of the two sites studied has had a positive effect on seedling survival. Furthermore, it appears that fertilizer treatments have decreased growth after planting, but in the case of ammonium sulphate this decrease has changed into a clear growth increment.

Author's address: University of Helsinki, Department of Silviculture, Unioninkatu 40 B, SF-00170 Helsinki 17.

YLI-VAKKURI, PAAVO and PELKONEN, PAAVO O.D.C. 161.4: 164.5
Pinus silvestris

1976. Rooting of Scots pine needle fascicles with different growth substances and media. — SILVA FENNICA Vol. 10, No. 4, 5. p. Helsinki.

Needle fascicles of Scots pine *(Pinus sylvestris* L.*)* were rooted in a standard Jacobsen's germination apparatus. The apparatus was found to be suitable for rooting at least on a laboratory scale. The best rooting substrate was living *Sphagnum*, which remained sufficiently moist in the germination containers throughout the experiments. In a comparison of various growth substance treatments, the best result was obtained with a combination of IAA (100 mg/l) and thiamine (5 mg/l). The rooting percentage using these growth substances with *Sphagnum* as the rooting medium was in the first experiment 30 and in the second 48.

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O.D.C. 905.2 (480)

1976. Timber report 1976. — Finland's roundwood, industrial residue and forest residue balances by 1980 as well as the wood raw material situation of Finnish forest industries by the year 2000. — SILVA FENNICA Vol. 10, No. 4, 23 p. Helsinki.

This study was carried out on behalf of the Central Association of Finnish Forest Industries in order to obtain information about the wood raw material situation, to serve, in turn, as a basis for the forest industries' long-term planning. The study deals with the potential supply of roundwood, industrial residue and forest residue by the year 2000 by five wood-supply areas. Examination of the situation during the period 1972—80 is based on available balances and that concerning the period 1985—2000 in the estimated quantities available for industrial use.

The study was carried out on behalf of the Central Association of Finnish Forest Industries. The address: Eteläesplanadi 2, SF-00130 Helsinki 13, Finland.

KIRJOITUSTEN LAATIMISOHJEET

Silva Fennica-sarjassa julkaistaan lyhyitä metsätieteellisiä tutkimuksia ja kirjoituksia koti maisilla kielillä tai jollakin suurella tieteellisellä kielellä. Julkaistavaksi tarkoitettu käsikirjoitus on jätettävä Seuran sihteerille painatuskelpoisessa asussa. Seuran hallitus ratkaisee asiantuntijoita kuultuaan, hyväksytäänkö kirjoitus painettavaksi.

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Kuvien ja piirrosten viivapaksuudet ja tekstikoko on valittava siten, että ne sallivat painatuksen vaatiman pienennyksen. Kuvien ja piirrosten painatuskoosta on syytä neuvotella etukäteen toimittajan kanssa, sillä tarpeettomia kustannuksia aiheuttavaa painatuskokoa ei sallita. Valokuvien tulee olla teknisesti moitteettomia ja kiiltävälle valkealle paperille suurennettuja. Värikuvia ei yleensä hyväksytä painettavaksi. Kuvat ja taulukot numeroidaan kummatkin erikseen juoksevasti, ja niiden otsikoista laaditaan erillinen luettelo kirjapainoa varten.

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ILVESSALO, Y. 1952. Metsikön kasvun ja poistuman välisestä suhteesta. Summary: On the relation between growth and removal in forest stands. — Commun. Inst. For. Fenn. 40.1.

WILCOX, W. W., PONG, W. Y. & PARMETER, J. R. 1973. Effects of mistletoe and other defects on lumber quality in white fir. Wood & Fiber 4 (4): 272—277.

Englanninkielisen lyhennelmän ja mahdollisten kuva- ja taulukkotekstien käännättämisestä ja pätevän kieliasiantuntijan tekemästä tarkastamisesta huolehtii kirjoittaja. Seura voi maksaa kustannukset valtiovarainministeriön antamien ohjeiden mukaan. Jos kääntäjän lasku on ohjeiden edellyttämää tasoa korkeampi, kirjoittaja vastaa ylittävästä osuudesta.
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