ALKKIA EXPERIMENTAL FOREST IN PARKANO AND KARVIA

Main topics

Edited by
Seppo Kaunisto

Finnish Forest Research Institute
Parkano Research Station
1998

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Contents

Layout: Nora Malin and Sanna Tapola

Background

Location	**62°10' N, 32°75' E**
Altitude	**150–201 m asl**
Mean temperature	
- Annual	**3.0°C**
- July	**15.0°C**
- February	**-7.9°C**
Temperature sum	**1090**
Average duration of growing season	**156 days**
Annual precipitation	**670 mm**

Climate averages for 1979–93, ©FMI

The Parkano Research Station of the Finnish Forest Research Institute was established in 1961. The total area belonging to the Resarch Station is 7582 ha. Alkkia experimental forest is located about 30 km nortwest from Parkano and covers 2690 ha., about 33 ha of which are watercources. The majority of the area is peatlands which, except for about 300 ha of peatland fields, were in their pristine state in 1961. Moderately rich or rich peatland and upland sites are very rare in the Alkkia experimental forest, consequently only few forestry problems on these site types have been investigated here.

By the end of 1970, 92 experiments had been set up, occupying a total of about 400 ha at Alkkia. The vast majority (about 90 out of the number and 97 % of the area) had been set up on mires or peatland fields. Among the most important investigations were the afforestation of nutritionally poor peatlands and peatland fields, and the problems related to basic fertilization and hydrology.

In 1971–1980, an almost equal number (90) of experiments were set up, but they were not as extensive as the previous ones and they dealt with problems both on mineral and peatland areas. The focus of experiments on mineral soil was on various regeneration problems and the rot resistance of spruce. The most important experiments on peatlands dealt with different soil preparation methods in connection with afforestation as well as refertilization of peatland stands with special reference to growth disturbances caused by boron shortage, and to the significance of nitrogen regime of the substrate for tree nutrition and growth. Furthermore, various tree genetic experiments as well as those related to growth and yield studies have had an important part in the activity of the research area.

By the end of 1997 a total of 246 different experiments, some being further divided into subexperiments, had been established in the Alkkia area. It is not possible to give the exact number of separate sample plots. The estimate is between 8,000–9,000. The total area of experiments is more than 700 ha. Although the area of the experiments is only 25 % out of the total land area, the fact is that nearly all the areas suitable for experimental activity have been utilized at least once, especially on peatlands.

By the end of 1997, more than 130 publications fully or partly based on the Alkkia experiments have been issued and several are being prepared for publication. They are concerned with several different subjects, such as afforestation methods, fertilization and refertilization (nutrient amounts and combinations, methods, nutrient sources and solubility), nitrogen mineralization, tree nutrition and its effects on the physiological condition of trees, nutritional problems of peaty farmland, hydrology, regeneration of mineral soil forests, genetics, diseases, yield and wood quality. For giving a more thorough view on the subject matter this guide contains some results also outside of Alkia.

Point 1. Effects of peatland forestry on runoff water quality

Topic 1.1 Water protection in connection with maintaining old ditches

by Samuli Joensuu

Introduction

The increased load of suspended solids into the watercourses is one of the most harmful environmental influences of peatland drainage. Today, ditch cleaning and digging supplementary ditches between the old ones are the main forms of ditching in Finland. This activity is called ditch network maintenance. In 1993, nearly 80,000 ha of drained peatlands were subject to this activity. Water protection in connection with maintaining old ditch networks has been a major concern in the late 1980's and in the 1990's. The use of sedimentation ponds is the most commonly used technical solution.

Site and treatments

The experimental site is part of a study, which was started in 1990-91 by the Finnish Forest Research Institute and the Forestry Development Centre Tapio by choosing 42 pairs of drained basins for calibration. After a calibration period of 1–2 years, ditch network maintenance was performed and sedimentation ponds constructed in one basin within each pair; the other one served as an untreated control. The general effect of ditch maintenance on the runoff waters was estimated by comparing runoff water samples from 37 catchments in 1990-1994. In 1995, 23 catchments were chosen for continued monitoring. The annual sampling was started after snowmelt in spring and continued once a week until the freezing period in late autumn. Peat type, thickness of peat layer, texture of underlying mineral soil, and other characteristics of the catchments were observed.

The study includes the testing of sedimentation basins for reducing the load of suspended solids. The environmental value of using ponds is evaluated by comparing water samples taken from the ditches entering and leaving the pond. Since 1996, 11 additional pairs of catchments have been chosen for studying the possibilities of using overland flow techniques in purifying runoff waters from forest ditch networks after their mainte-nance.

Results

During the first three-year-period after drainage maintenance, the mean concentration of suspended solids in runoff water was tenfold compared with the calibration period and the control areas, i.e. about 45 mg l^{-1} versus about 4.5 mg l^{-1} (Fig. 1.1). After drainage maintenance in the shallow-peated Alkkia study area the spring peaks of suspended solids were quite high, the highest peak exceeding 1,300 mg l^{-1} in the first spring after the maintenance.

The average concentration of dissolved organic carbon (DOC) decreased by 5 to 20 mg l^{-1} after ditch maintenance in shallow-peated areas such as Alkkia study area (Fig. 1.2). The average change in acidity after drainage maintenance in Alkkia was over 1.5 pH-units and in the whole data about 1 pH-unit (Fig. 1.3). Indications of increased concentrations of mineral nitrogen and some other elements (K, Ca, Mg, Fe, Al) after ditch maintenance could be seen in the data (Fig. 1.4).

The effectiveness of the sedimentation ponds in trapping suspended solids varied greatly both within time and between sites. As measured by 1-3 year averages, only half of the ponds actually reduced the concentration of suspended solids. The concentration of suspended solids was most clearly reduced by ponds, which received the runoff water from shallow-peated areas where the ditches had been cut into coarse-textured mineral soil.

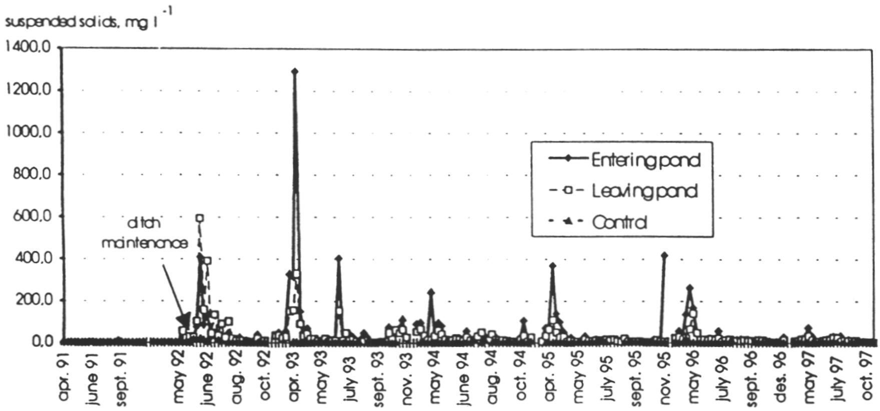


Fig 1.1. The effect of ditch maintenance and the sedimentation pond on the concentration of suspended solids in Alkkia study area.

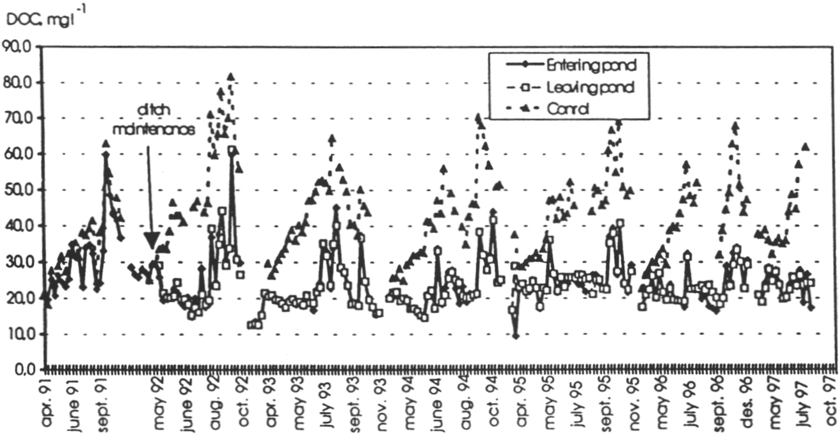


Fig 1.2. The effect of ditch maintenance and the sedimentation pond on the concentration of dissolved organic carbon (DOC) in Alkkia study area.

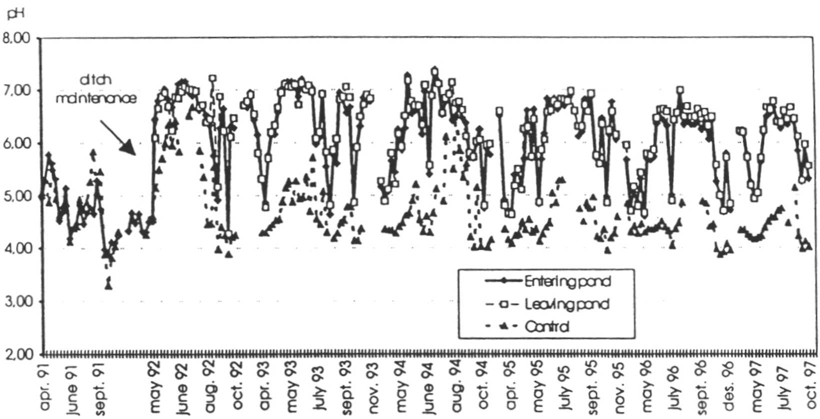


Fig 1.3. The effect of ditch maintenance and the sedimentation pond on the acidity of the discharge water in Alkkia study area.

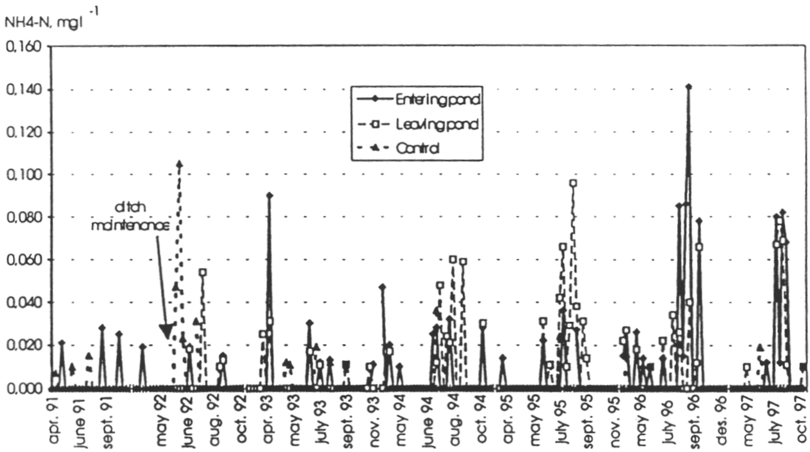


Fig 1.4. The effect of ditch maintenance and the sedimentation pond on the concentration of NH_4-N in Alkkia study area.

Topic 1.2 Water protection in connection with fertilization

Mechanisms controlling the leaching of fertilizer-phosphorus from drained peatland forests

by Mika Nieminen

Introduction

For satisfactory tree production on drained peatlands, one or more fertilizer applications with phosphorus (P) are often needed. However, the amounts of P-fertilizers used in practical peatland forestry in Finland are nowadays very low. One reason for low fertilization activity is the concern that fertilization might lead to enhanced P outflow, thus causing eutrophication in recipient watercourses.

Indeed, long-term leaching losses of fertilizer-P from drained peatlands have been observed. However, some investigations have indicated minor changes in leaching behaviour of applied P. Achieving a capability to identify those situations where the risk for enhanced leaching of fertilizer-P is high requires information about all the mechanisms controlling the outflow of fertilizer-P from drained peatlands.

Slow-release P-fertilizers (refers to products containing water-insoluble P) have long been considered as a primary fertilization option on drained peatlands in Finland. When using slow-release P-fertilizers, and carefully avoiding the direct deposition of fertilizer granules to ditches in connection with fertilizer application, the most important mechanisms controlling the leaching of fertilizer-P include: 1) the rate of release of P from the slow-release fertilizer, 2) uptake of fertilizer-P by trees and understorey vegetation, and 3) chemical absorption of fertilizer-P by peat.

Point 2. Peat properties in deep-peat profiles

by Riitta Korhonen and Seppo Kaunisto

Introduction

Alkkianneva is a typical raised bog complex at its old, well developed phase having pools, hummock ridges (mainly occupied by Sphagnum fuscum), and with hollow formations. It is located in the area of concentric raised bogs in Finland. Alkkianneva mire was mainly formed as a result of terrestrialisation about 8100 B.P. some hundred years after the Ancylus lake retired from the area. There are gyttja layers below the peat as a residue of the former lake.

Results

The maximum depth measured in Alkkianneva was 5.6 metres. The profile presented here (Fig. 2.1) is 4.6 metres. The first 2.5 metres from the surface is Sphagnum peat with varying degrees of humification. Nitrogen concentration follows fairly well the degree of humification and is the lowest in the surface layers. The most superficial layer shows some effect of drainage having a somewhat higher nitrogen concentration and humification degree than the layer underneath. The phosphorus and especially potassium concentrations and pH in the profile are quite typical of deep peatlands.

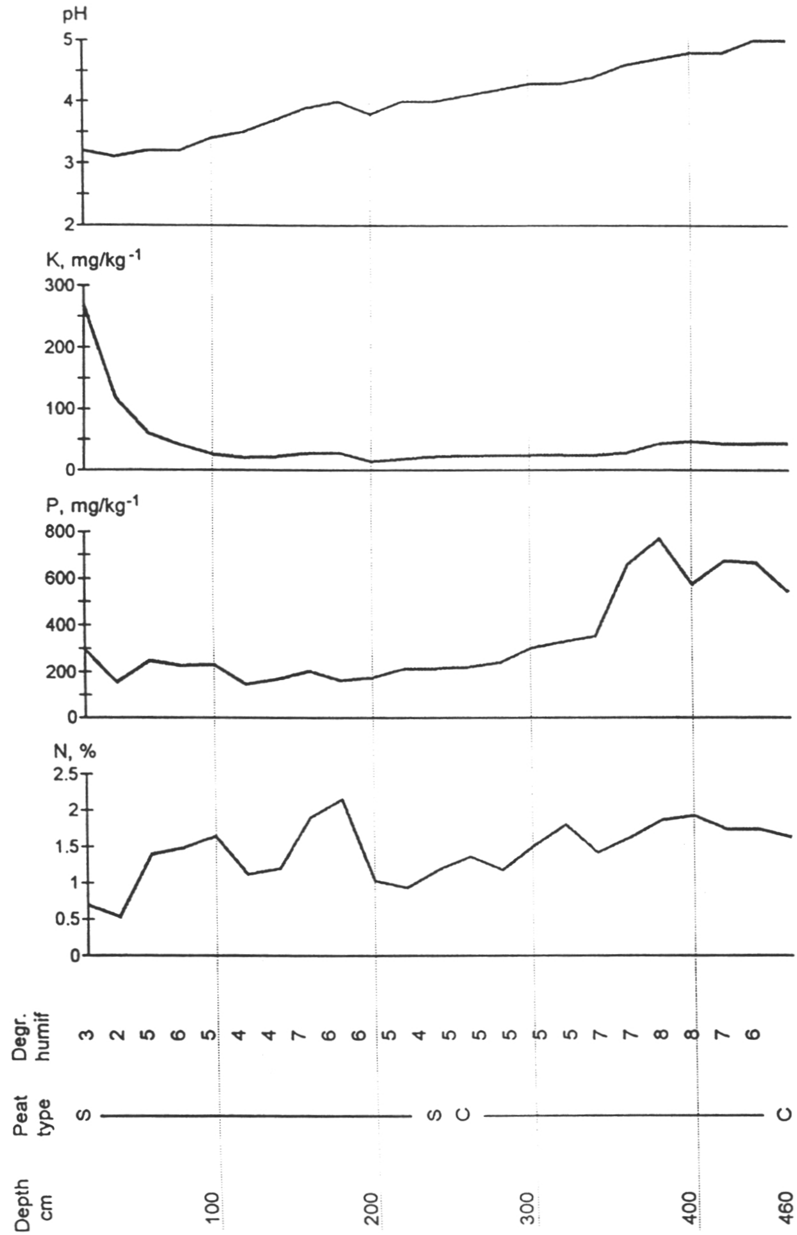


Fig. 2.1. Characteristics of the peat profile in Exp. 3 at Alkkia

Point 3. Drainage efficiency and fertilization

Alkkia, Experiment 3.

Site and treatments

Drainage intensity and fertilization. Experiment 3. in 1963, 37 ha.

Peatland site type is a Sphagnum fuscum bog with hollows. Peat depth is 1–6 m. Nitrogen content in the surface peat is 0.7–1.3 %, and at the depth of one metre 0.7–1.7 %. Drainage was carried out in 1961–1963. Ditch spacings were 5, 10, 20, 30, 40, 60, 80 and 100 m (Fig. 3.1) and ditch depths 30, 60 and 90 cm. The hydrological balance in small artificial peatland catchments with eight ditch spacings from 5 to 100 meters and three ditch depths (30, 60, and 90 cm) was studied in 1967–1981.

Basic fertilization with 400 kg/ha of Thomas phosphate (P 6.5 %), which also contains small amounts of micronutrients, was carried out in 1/1963. Pine was sown and planted in spring 1963. At the same time the plants were fertilized with NPK (10-5.2-5) 25 g/plant (0.25 m^2). Several stripwise broadcast refertilization treatments are included (partly in 1973 and 1979, completely in1989) across the strips with either PK or NPK (Fig. 3.1).

Topic 3.1. Effect of ditch depth and spacing on runoff and ground water table

by Erkki Ahti

Results

Narrow spacing and shallow ditches resulted in a rather shallow but stable level of the water table, and, correspondingly, in very sharp runoff peaks and long periods of zero runoff in between. Runoff peaks were lowered and annual runoff was decreased with increasing ditch spacing. An increase in ditch depth increased the distance to the water table and dry-period runoff, but had no effect on runoff peaks.

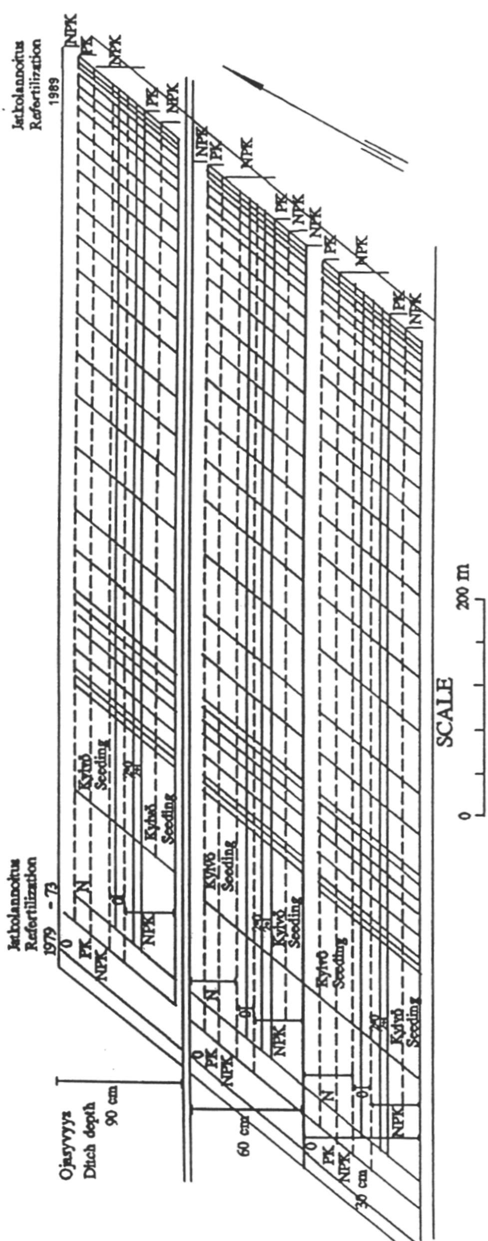


Fig 3.1. Design and treatments of Experiment 3. Hydrological experiment.

Topic 3.2. Effect of ditch depth and spacing and fertilization on tree nutrition and growth on nitrogen-poor peatlands

by Seppo Kaunisto

Introduction

Forest drainage of peatlands has mostly resulted in satisfactory wood production, but poor results have also been experienced in large areas; according to various estimates on 10–17 % of the drained area. The main reason is an insufficient nitrogen supply for trees. The effect of the ditch depth and spacing on tree nutrition, tree root penetration and tree growth is discussed as well as the drainage of too poor mires more generally.

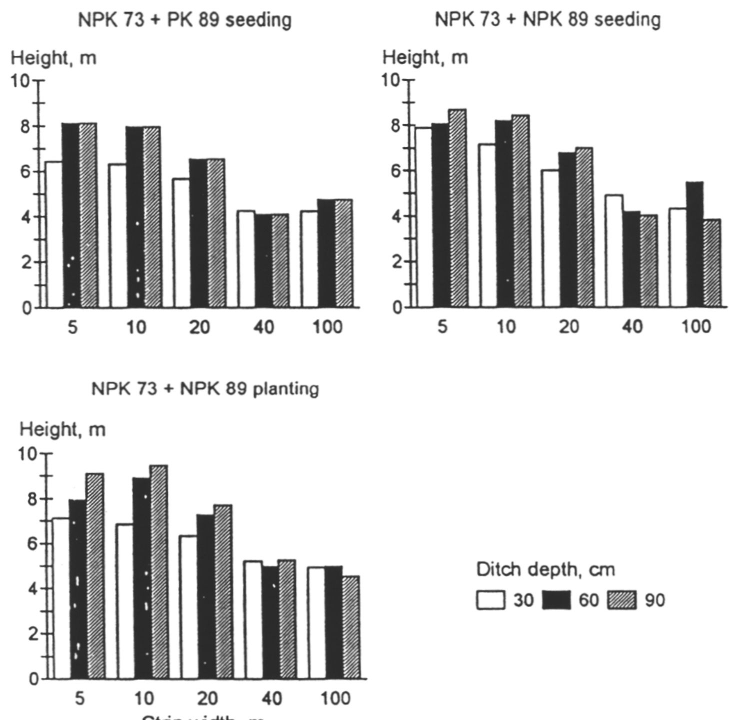


Fig. 3.2.1. Mean height of trees in Exp. 3 at Alkkia in 1990. Basic fertilization in 1963: P broadcast + NPK spot fertilization.

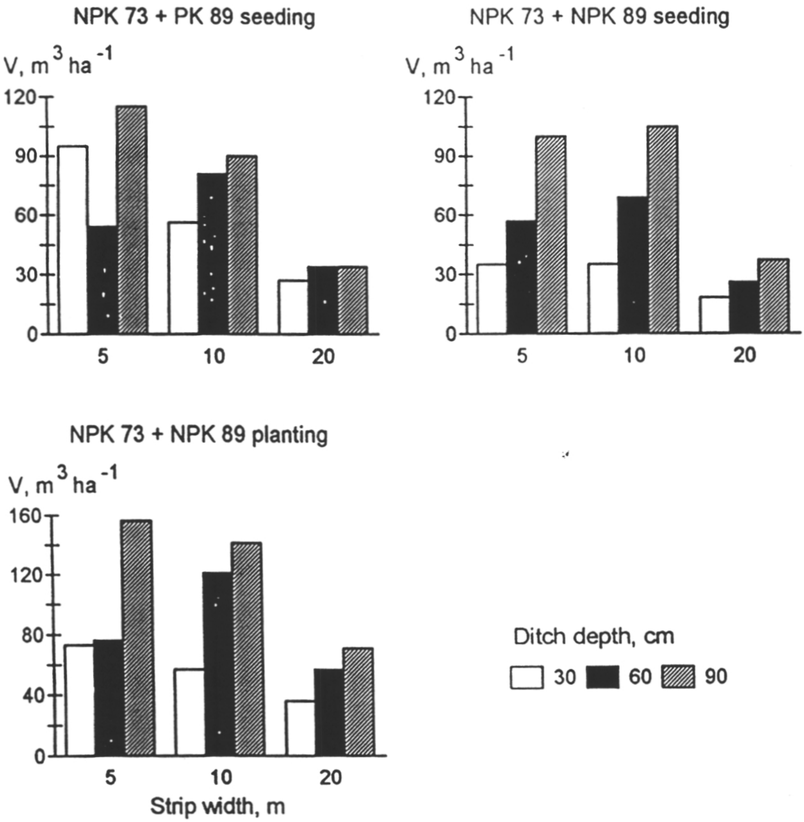


Fig. 3.2.2. Stand volume on 5, 10 and 20 m strips in Exp. 3 at Alkkia in 1990. Ditches included in the area. Basic fertilization in 1963: P broadcast and NPK spot fertilization.

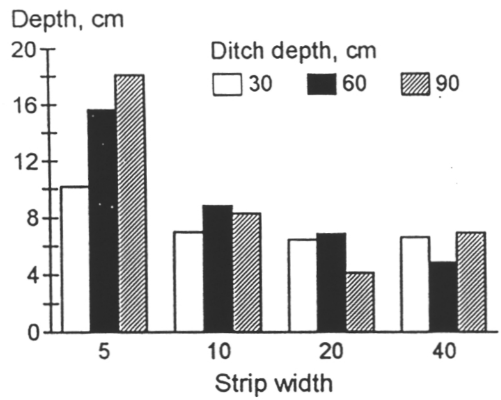


Fig. 3.2.3. Mean depth of roots < 3 mm, weighted by root dry mass in Exp. 3 at Alkkia.

Results

Height growth and stand volume enhanced along with increased drainage efficiency (Figs 3.2.1–2). Growth was the highest on the strips with 5 m ditch spacing (distance between ditch centres) and with 90 cm deep ditches. The area of ditches was included in the area when calculating stand volumes/ha. Ditch depth did not affect the strips with ditch intervals of 40 metres or more. Volume growth corresponds to growth on Calluna-Vaccinium vitis idea upland sites.

There were two basic reasons for the good growth on the narrow strips with deep ditches: better drainage resulting in better aeration that is shown by deeper root penetration (Fig. 3.2.3) and mulching effect. In connection with efficient drainage, peat with higher nitrogen concentration was lifted onto peat surface from deeper peat layers to better aeration conditions than the sites with wide ditch spacing and shallow ditches. This resulted in higher nitrogen mineralization seen in the needle nitrogen concentrations (Fig. 3.2.4).

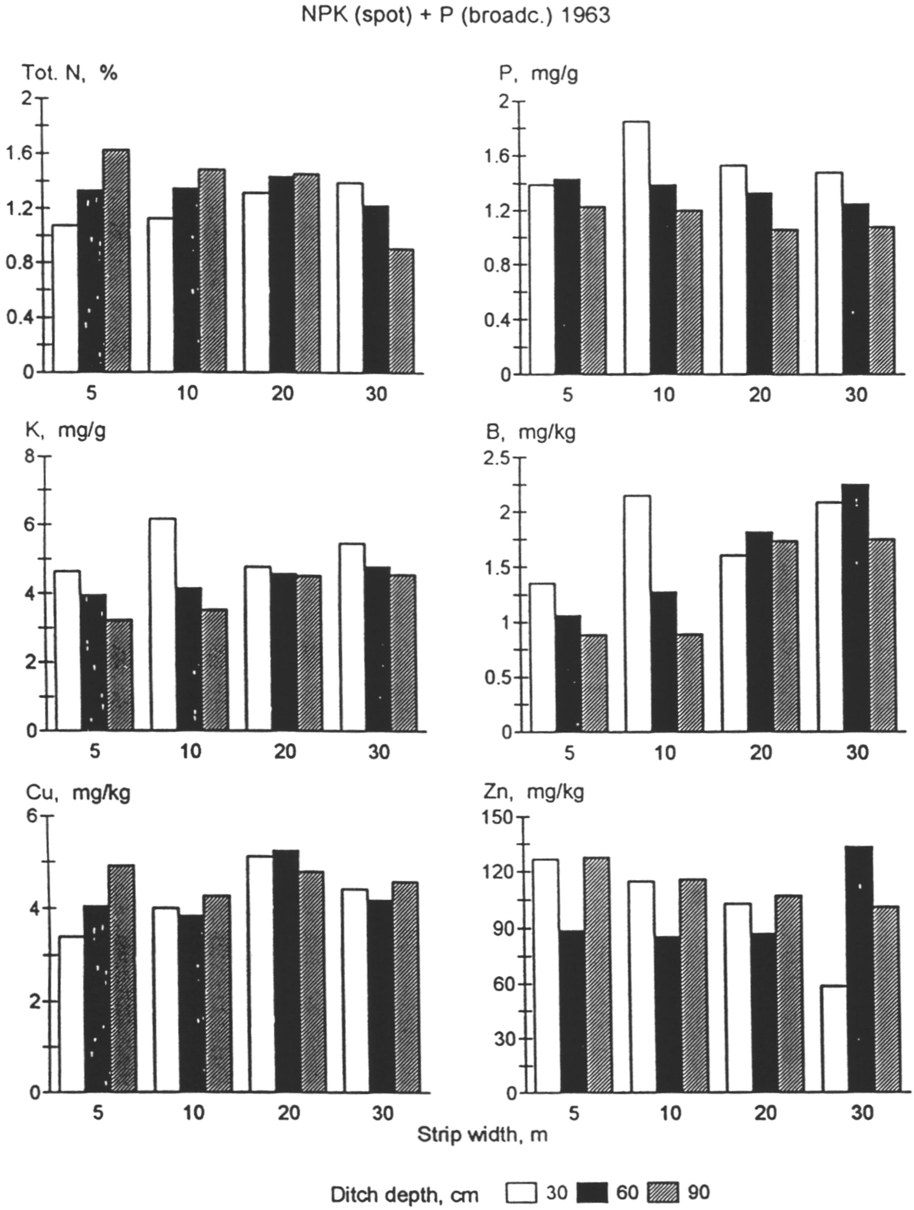


Fig. 3.2.4. Needle nutrient concentrations in Exp. 3 at Alkkia in 1988. P broadcast and NPK spot fertilization in 1963. Seeding.

Point 4. Effect of peat nitrogen on tree nutrition and growth

Alkkia 109A and B.

Site and treatments

Afforestation and fertilization experiment 109 A established in 1973. 1.7 ha.

The peatland site type was a tallsedge fen with flarks. Drainage took place in 1970, ditch spacing was 30 m and ditch depth 80 cm. The peat nitrogen content was 1.99 % on average in the 5–10 cm layer in 1978 (varying between 1.59–2.96 %). Planting and mechanical row seeding was carried out in 1973. Altogether four experiments were established at the same time. The total peat nitrogen content varied between 0.59– 2.96 %. in the 5–10 cm peat layer. The trials include different site preparation treatments, unfertilized controls and broadcast fertilization with PK or NPK at the time of establish-ment. The experiments were broadcast fertilized again in 1989. The experiment also includes limed and unlimed treatments and several combinations of soil preparation, fertilization and liming.

Topic 4.1. Nitrogen mineralization in peat and tree growth

by Marjut Karsisto and Seppo Kaunisto

Introduction

Nitrogen is the key element for good tree growth on peatlands typical of the boreal forest zone. It is needed more than any other critical nutrient in various organic structures of plants. This means that it is organically bound in plant residues and converted into a form available to trees only by microbiological processes. Nitrogen mineralization is highly dependent on the peat nitrogen concentration (C/N ratio), and possibly also on peat composition, both of which are affected by drainage and temperature conditions. Higher peat total nitrogen levels are needed to supply similar tree stands with sufficient nitrogen in a cold than in a warm climate. Nitrogen mineralization processes and the relationship between peat total nitrogen and nitrogen nutrition and growth of trees are discussed.

Results

Height growth of trees enhanced along with the increasing peat total nitrogen concentration, but the needle dry weight levelled at 1,3-1.5 % of peat total nitrogen and so did the needle nitrogen concentration (Fig. 4.1.1). The needle phosphorus concentration was

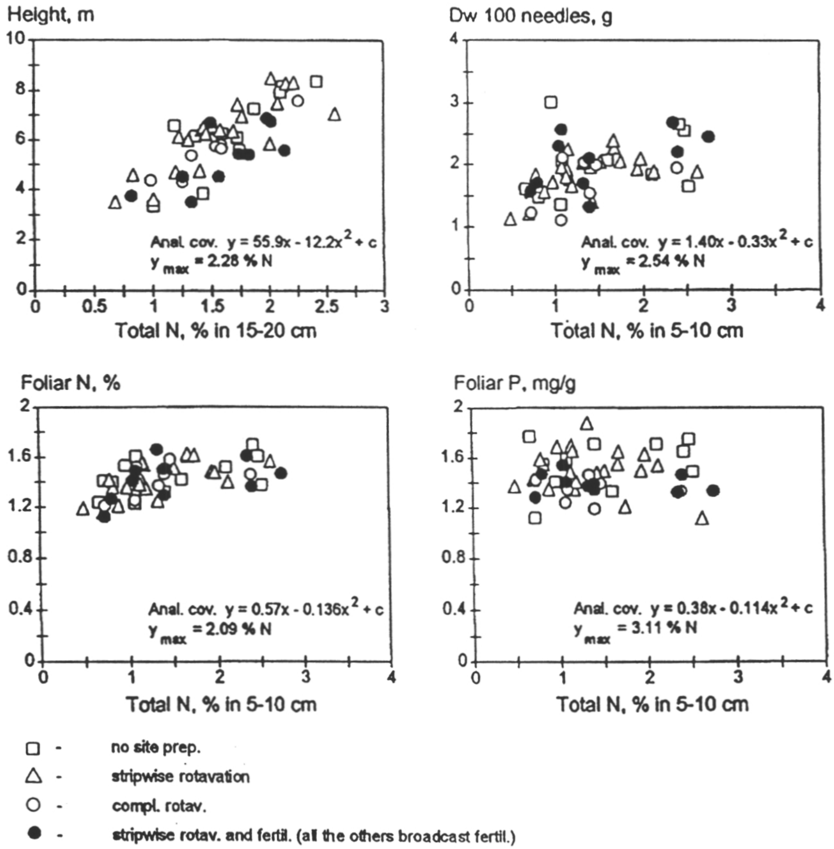


Fig. 4.1.1. Dependence of tree height, 100 needle dw and foliar N and P concentrations on the peat total nitrogen content at Alkkia Exp. 109. Fertilized with PK or NPK in 1973 and with boron in 1978, and with PK or NPK again in 1982.

unaffected by the peat total nitrogen concentration. The needle potassium, boron, copper and zinc concentrations decreased along with the increasing peat nitrogen concentration (Fig.4.1.2). Figures show the results from PK and NPK fertilized plots. Similar results have been obtained also from other corresponding sites in eastern Finland. The nitrogen concentration in surface peat increased considerably during 17 years from 1978 till 1995 (Fig. 4.1.3)

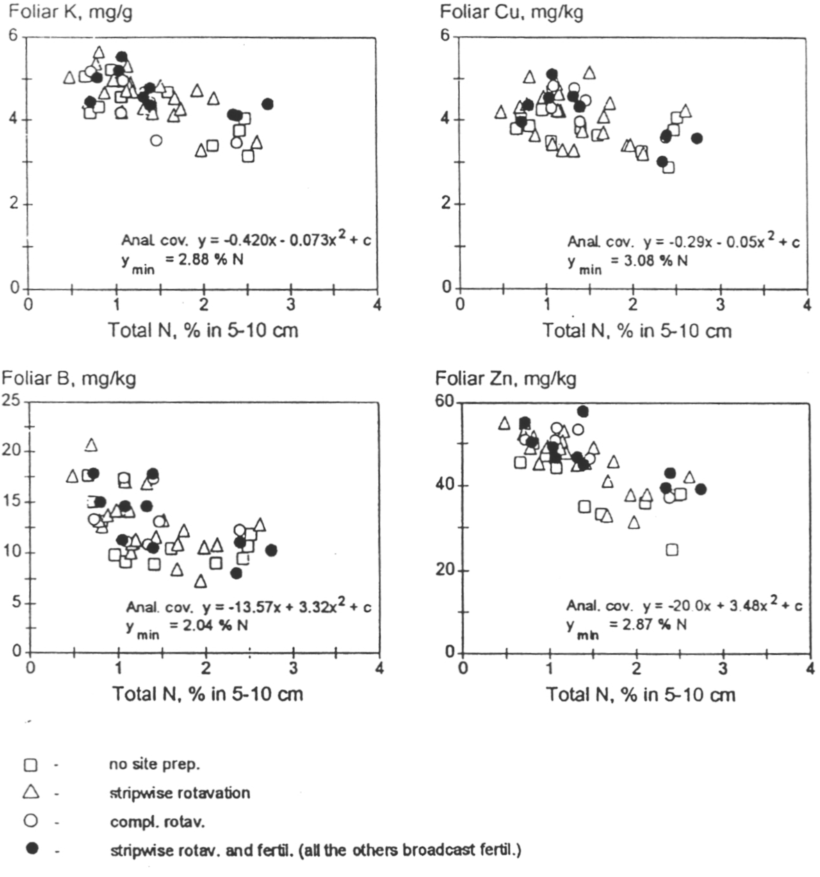


Fig. 4.1.2. Dependence of foliar K, Cu, B and Zn concentrations on the peat total nitrogen contents at Alkkia Exp. 109. Fertilized with PK or NPK in 1973 and with boron in 1978, and with PK or NPK again in 1982.

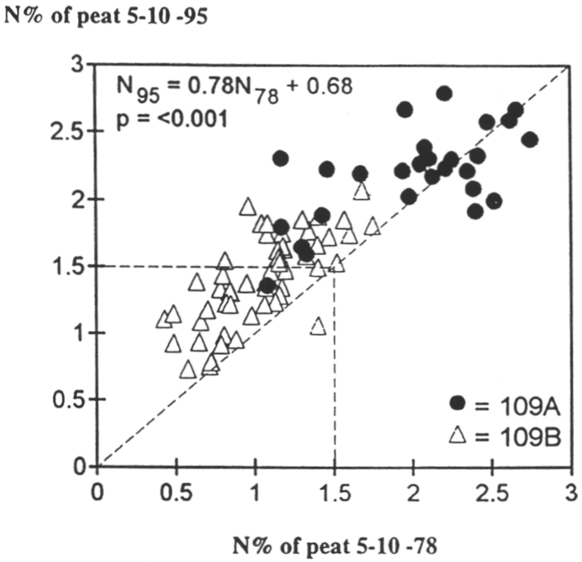


Fig 4.1.3. Nitrogen concentration in 5-10 cm peat layer in 1978 and 1995. Alkkia 109A and B.

Topic 4.2. Effects of excessive nitrogen

by Seppo Kaunisto and Pekka Pietiläinen

Introduction

Nitrogen mineralisation is usually high enough on drained tall-sedge and herb-rich pine fens and spruce swamps. However, if these are originally wet and sparsely stocked they may begin to suffer from potassium deficiency some decades after drainage. In addition, altogether about 0.4 million ha of open mires have been drained, and about 250,000 ha of them afforested. Nitrogen mineralization is mostly at a sufficient level on drained open mires, but tree growth is almost always dependent on phosphorus, potassium and boron fertilization. In high nitrogen mineralization conditions shortage of mineral nutrients as such, and unfavourable ratios between nitrogen and other nutrients may cause problems, which can be seen both at the physiological processes and tree growth.

Ammonium, either absorbed or evolved from the reduction of nitrate, is assimilated into glutamine via glutamine synthetase (GS; EC 6.3.1.2.) and into glutamate via glutamate synthase (Fd-GOGAT; EC 1.4.1.14) in the roots. The same enzymes or isoenzymes are involved in the N-assimilation in foliage. The production of glutamine and glutamate is dependent on the transport and production of metabolites and reductants in and into the roots. Glutamine (2N/5C) and asparagine (2N/4C), are considered to be the main nitrogenous compounds that participate in the xylem transport of N from the roots to the foliage. In the foliage, glutamine is further assimilated in the various metabolic processes according to the needs of the foliage. One of the assimilation products is arginine (4N/6C). Arginine is a normal component of the proteins and it serves as a N storage compound buffering excess N and responds to a variety of environmental and nutritional factors. High excess arginine may seriously disturb the protein synthesis in Scots pine.

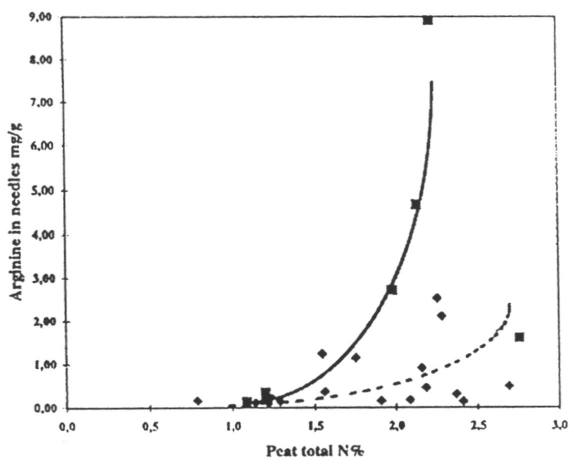


Fig. 4.2.1 The effect of PK-fertilization on arginine content of Scots pine needles growing on peat with different nitrogen concentrations (solid line = unfertilized; dash line = fertilized).

Results

In high nitrogen mineralization conditions, shortage of P, K and B as such and unfavorable ratios between nitrogen and these nutrients cause an increase in the arginine concentration in the needles of Scots pine (Fig. 4.2.1). PK-fertilization decreases the foliar arginine content by converting the N-flow from arginine into balanced protein synthesis prevailing under optimal nutrition. The nutrients responsible for the switch in the N-flow in the needles are P and K (Fig. 4.2.2 and Table 4.2.1)

Table 4.2.1. simple correlation between the foliar arginine and the foliar nutrients (N, P, K, Ca, Mg, Zn, Cu and B) 13 years after fertilization on two tall-sedge fens in Central Finland

	Vesikkosuo	Köhisevä
Arginine - N	0.61*	0.68*
Arginine - P	-0.50*	0.50*
Arginine - K	-0.86*	0.62*
Arginine - Ca	-0.13	-0.25
Arginine - Mg	-0.09	0.38
Arginine - Zn	-0.19	0.54*
Arginine - Cu	-0.23	-0.34
Arginine - B	-0.62*	-0.41

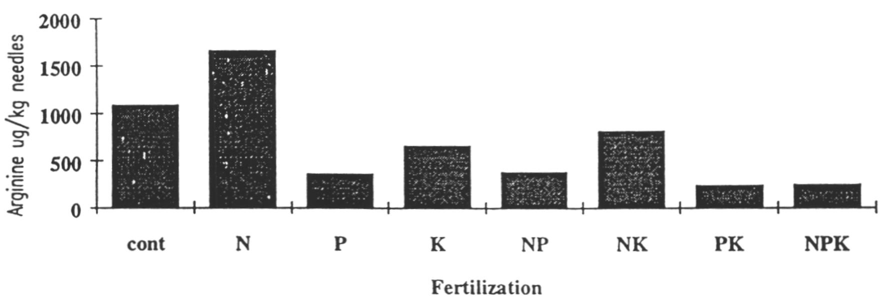


Fig. 4.2.2. The effect of fertilization on the foliar arginine concentration in Scots pine growing on a tall sedge pine fen 3 years after fertilization.

Topic 4.3. Micronutrients in peatland forests

by Heikki Veijalainen

Introduction

The first reports of growth disturbances as well as the first micronutrient experiments in peatland forests in Finland date back to the early 1950´s. The hypothesis was that micronutrient deficiencies were the causal agents of dieback. At the end of the 1970´s more than 100,000 ha of forest land, which was about 2 % of the drained area at that time, had been affected by different visible growth disturbances,.

According to needle analyses, pine stands with visible disorders had higher N, P and K contents but lower boron contents than stands with no disorders. Boron addition to PK-fertilizer for peatland forests, which has been done since 1976, seems to be a proper measure to prevent growth disturbances. Later on micronutrient experiments have shown that about 80 % of the growth disturbances, corresponding to at least 800 g/ha., can be cured by fertilizers containing boron

Low boron concentrations in pine needles seem to be quite common in young stands growing on fertile peatland sites, but also on many afforested, limed and fertilized peatland fields. Copper deficiency can also inhibit tree growth and cause dieback on peatland sites.

Point 5. Comparison of different potassium sources

Experiment 231

Site and treatments

Fertilization trial with different potassium sources. 1989. 0.24 ha.

The site was an ombrotrophic open bog, which was sown and originally fertilized in 1965 - 67 (25 g/sowing spot of NPK fertilizer N10 - P5.2 - K5 %). The peat total nitrogen content varied between 0.75 and 1.49 in the 0 - 10 cm peat layer. The ditch spacing is 20 m and the ditch depth 70 cm. The potassium fertilization trial was established in 1989. Flogopite, KCl, K_2CO_3, KPO_3 and a mixture of flogopite and KCl were used. Altogether three similar experiments were established at the same time.

Topic 5.1. Polyamines as indicators of potassium nutrition of trees

by Tytti Sarjala

Introduction

Visual symptoms of a

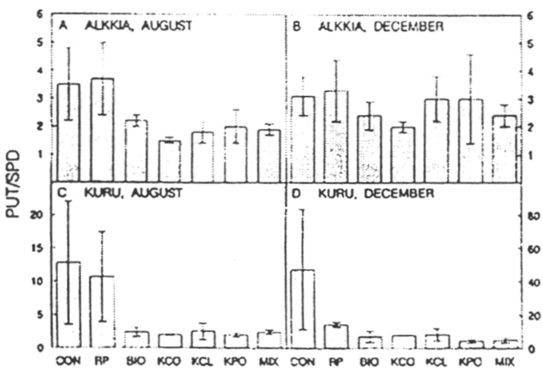


Fig. 5.1.1. Needle potassium and putrescine concentrations in Alkkia and Kuru experimental plots in August and December. CON=control, RP=rock phosphate, BIO= biotite, KCO=K2CO3, MIX=biotite and KCl. Vertical bars represent SE. Tree Phys. 13:87-96. 1993.

nutrient deficiency develop usually so late that tree growth is already reduced. Therefore foliar nutrient analysis has been traditionally used to estimate the nutrient status of trees during the dormant season. Biochemical changes have been shown to initiate well above the concentrations generally considered as potassium deficiency. Putrescine, one of the most common polyamines in plants, has a strong negative correlation with the potassium concentrations of needles and this relationship has been used to define critical limits for potassium nutrition in Scots pine and Norway spruce. This kind of study is also going on with birch. During the growing season, needle potassium concentrations vary a lot, which means that the estimation of nutrient status is difficult to interpret. However, the accumulation of putrescine reflects potassium deficiency very well also during the growing season.

Results

The potassium concentrations were lower and the putrescine concentrations higher on the non-fertilized control and rock phosphate plots (Fig.5.1.1). More severe potassium deficiency was found in Kuru than in Alkkia. It led to very high putrescine levels (> 1000 nmol/gFW) in the needles on the control plots. The accumulation of putrescine indicated severe K deficiency in Scots pine with the needle K level less than 3.5-4.0 mg/gDW and in Norway spruce less than 4.2-4.6 mg/gDW (Fig. 5.1.2).

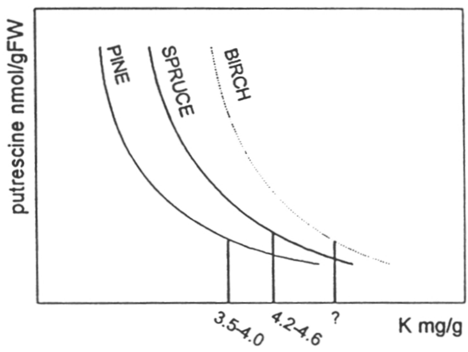


Fig. 5.1.2. Critical limits for potassium indicated by accumulation of putrescine.

Topic 5.2. Fertilizer potassium of different solubility and tree growth

by Seppo Kaunisto

Introduction

Potassium in fertilizers has usually been given as KCl which is completely water soluble and susceptible to leaching. On the other hand, phosphorus is given as rock phosphate or apatite, both of which are insoluble to water. This creates some discrepancy in the nutrition of trees because the duration of the fertilization effect depends on the solubility of the nutrient source. Efforts have been made to solve this problem by increasing the amount of fertilizer. In some new fertilizers potassium is as slowly soluble biotite or phlogopite. Discussion on possibilities to use different potassium amounts and sources for fertilization is partly based on experiments outside Alkkia.

Results

Potassium fertilization with potassium chloride enhances tree growth for about 15 years on average (Fig. 5.2.1). The best growth response is achieved with about 80 kg/ha of elemental potassium on average. However, the amount of potassium affects the duration of the growth response only slightly.

Trees take up potassium from potassium chloride, potassium metaphosphate and potassium carbonate more readily than from biotite and consequently the needle potassium concentrations rise more during the first years. This was also shown in the needle putrescin concentrations (Fig. 5.1.1). In some other ex-periments needle potassium concentrations were higher on the phlogopite fertilized sites than on the sites fertilized with potassium chloride after 11-14 years (Figs 5.2.2-3), although tree growth was the same. After 16-19 years the difference was even greater and needle potassium concentrations differed from those on the controls only on phlogopite fertilized sites.

Phlogopite and potassium chloride fertilization resulted in similar tree growth (Figs 5.2.4-5).

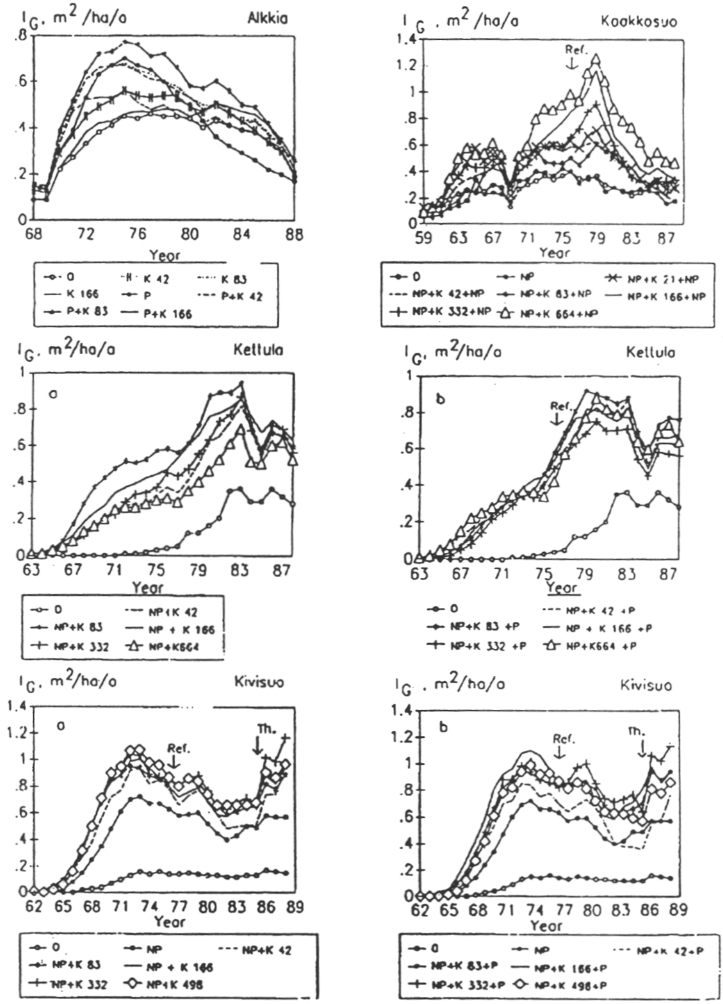


Fig. 5.2.1. (Right) Effect of the fertilizer rate on the annual basal area increment. The fertilization year was 1969 in Alkkia, 1961 in Kettula and Kaakkosuo and in Kivisuo. Refertilization (Ref.) in 1976 in Kaakkosuo, Kettula and Kivisuo. In Kettula Fig. a includes the unrefertilized and b the refertilized parts of the plots. In Kivisuo Figure a includes all the plots, but Fig. b only the plots that have received P at refertilization. In Kettula and Kivisuo refertilized plots may have also N, micornutrients or both. Th. = thinning in winter 1984-85. Suo 43(2)/1992.

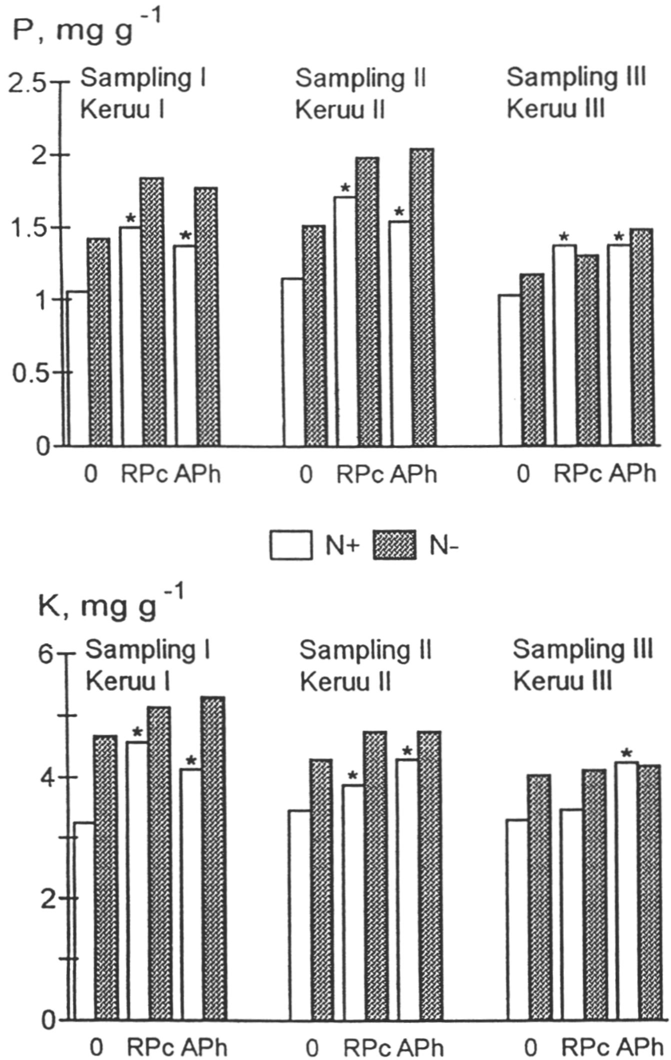


Fig. 5.2.2. Effect of different phosphorus and potassium sources on the needle phosphorus and potassium concentrations. Sampling I=5–7, II=11–14 and III=16–19 years after fertiization.

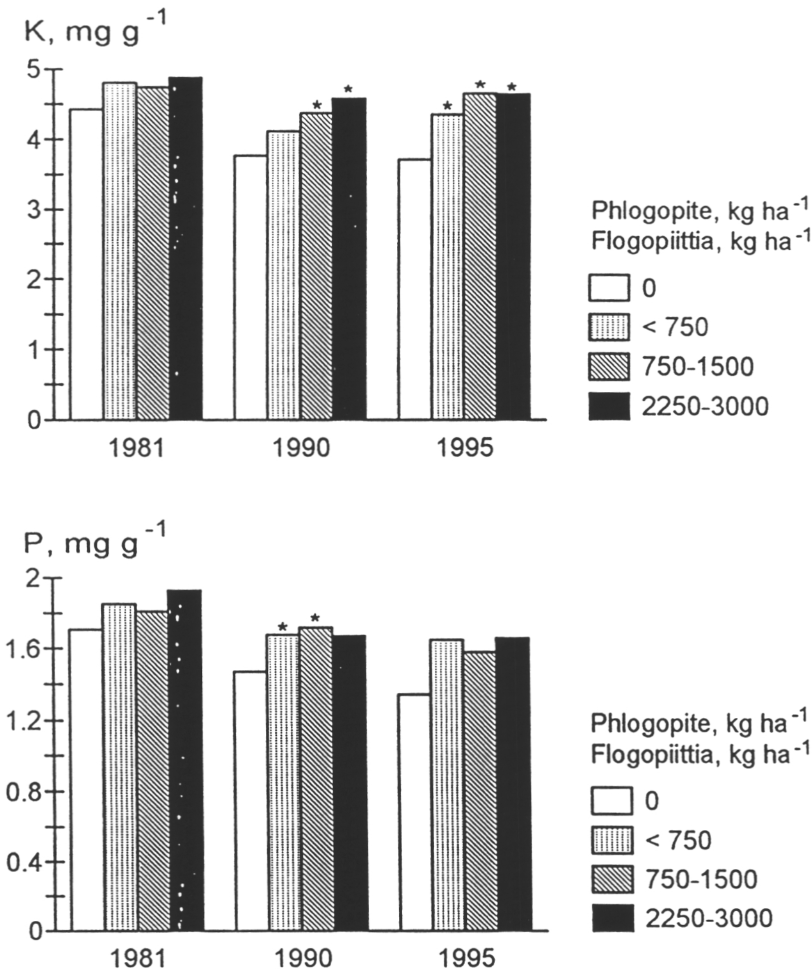


Fig. 5.2.3. Effect of the phlogopite rate on the needle phosphorus and potassium concentrations.

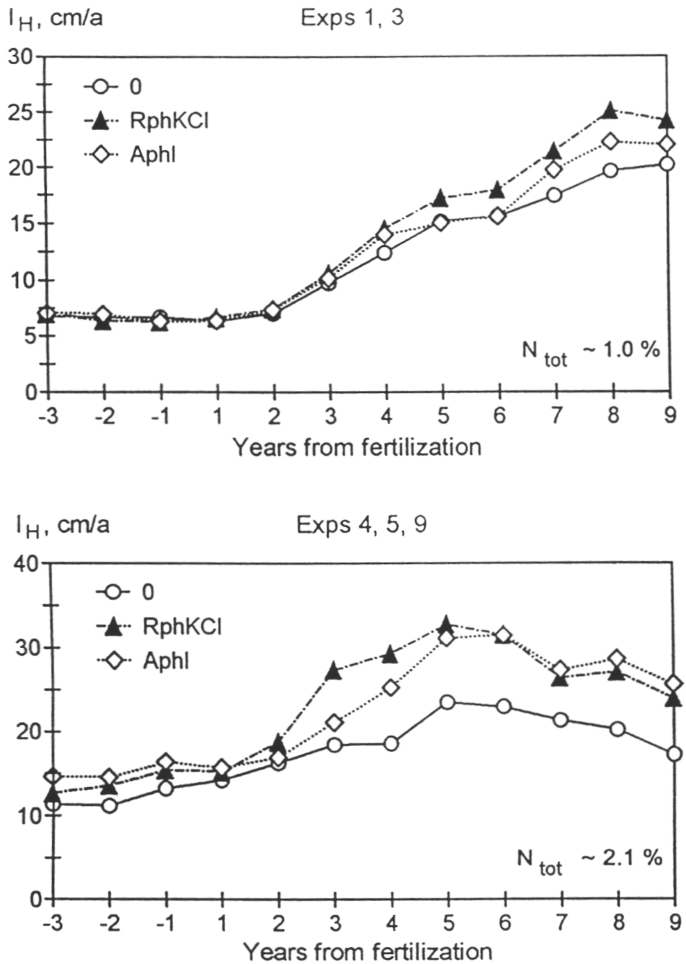
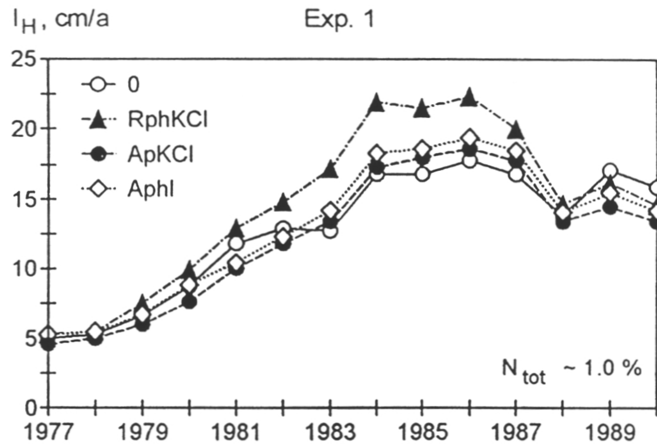


Fig. 5.2.4. Pine growth after phosphorus and potassium fertilization. RphKCl = rock phosphate + potassium chloride, Aphl = apatite + phlogopite. Folia Forest. 810.



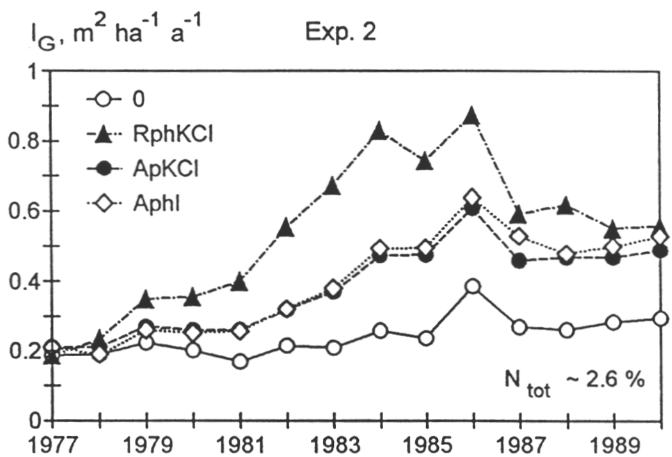


Fig. 5.2.5. Pine growth after phosphorus and potassium fertilization. Rock phosphate, apatite, phlogopite, potassium chloride. Folia Forest. 810.

Topic 5.3 Fertilizer phosphorus of different solubility and tree growth

by Klaus Silfverberg, Markus Hartman and Seppo Kaunisto

Introduction

While N/P/K ratios are 100/10-13/32-39 in pine trees, they may in the corresponding drained surface peats be 100/3/1. Up to 95 % of the phosphorus in peat may be in an organic form, from which it can be released only by microbial activity. Organically bound nitrogen and phosphorus are released by microbes in the same ratio as they exist in the organic matter. Thus there is generally shortage of available phosphorus in Finnish peat soils compared with the need of trees. Phosphorus is the most important element causing eutrophication of waters. Therefore fertilizer industry has changed from water soluble phophorus fertilizers into water insoluble ones. The effects of different phosphorus fertilizers on tree growth and phosphorus nutrition are discussed.

Site and treatments

Peatland site type is a S. fuscum bog with flarks and peat depth exceeding 150 cm. The nitrogen content in the surface peat is slightly higher in Alkkia 66 than in Alkkia 2 (1,4 % and 1,2 respectively). Nowadays sites like these are classified as non-drainable. The first drainage was carried out in 1940 and the present ditch spacing is 20 meters. The elevation is 157 a.s.l. and the mean temperature sum 1119 dd°C. The tree stand was dominated by Scots pine (Pinus sylvestris). Experiment Alkkia 2 was fertilized in 1961 using NPK. The P-fertilizers were apatite, rock phosphate, finely ground rock phosphate and super-phosphate. The levels of phosphorus were 22, 44 and 66 kg/ha. Experiment 66 was fertilized in 1968 with NPK the P-fertilizers being the same as in Alkkia 2, excluding rock phosphate. The amount of P was 52 kg/ha. There were 12 replications in this experiment.

Results

The growth-increasing effect of phosphorus is clearly seen in comparison with the sole NK-fertilization (Alkkia 2). Between the P-fertilizers there were only insignificant differences in both experiments. Even the growth development for apatite and superphosphate seemed to be very similar. The higher growth rate in Alkkia 66 is probably due to higher nitrogen resources in peat and higher P-dose given in fertilization.

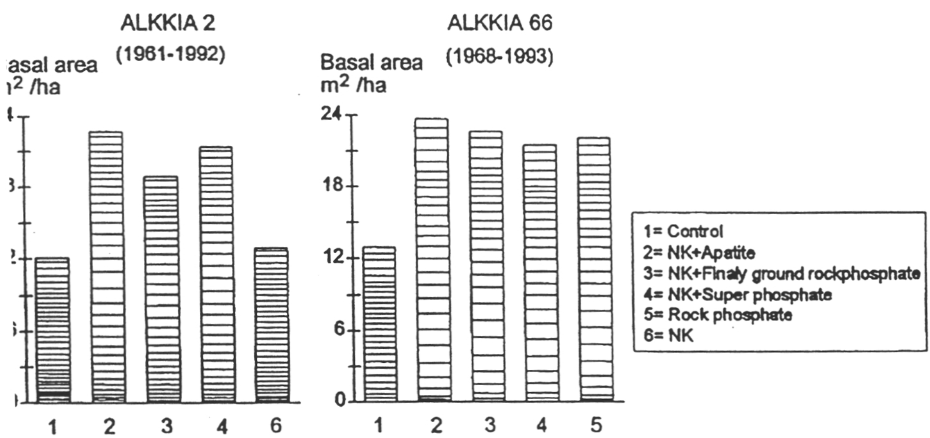


Fig. 5.3.1. Effect of different phosphorus sources on the basal area 26 (Alkkia 66) and 31 (Alkkia 2) years after fertilization.

Point 6. Afforestation of abandoned peat farmlands

Experiments 36,42, 43 and 161.

by Jyrki Hytönen and Seppo Kaunisto

Introduction

About 200,000 ha of Finnish farmlands have been afforested since the 1960's. Because of the over-production of agricultural products still about 1/4 out of the remaining 2.2 million ha will be left out from farming and are planned to be afforested. Peatland fields form a large group among these, but the exact area is not known.

Abandoned peatland fields are nutritionally a very complicated group of peat soils having high nitrogen mineralization activity and varying mineral nutrient contents due to fertilization and the application of mineral soil during farming. Amelioration treatments during farming may interfere with the availability of some nutrients.

Abandoned peat farmlands are generally covered by luxurious ground vegetation that severely affects the development of planted tree plants and may cause substantial mortality among them. Therefore, methods have to be developed for hindering its detrimental effects. Quite often ploughing has been used for helping tree plants for the first years. On the other hand, by forming continuous ridges of better temperature, moisture and nutrient conditions with a furrow on one side, ploughing may cause asymmetric root growth and susceptibility to wind fall.

Site and treatments

Afforestation and fertilization experiment 42. 1967. 2.4 ha.

The site was originally either an open bog or sparsely tree-covered pine bog, poor in nitrogen. It was reclaimed for farming in the 1930's. Various amounts of mineral soil from adjacent uplands were mixed in the tilled layer. Farming was discontinued in the late 1950's.

Ditch spacing is 20 m and peat depth more than 2.0 m. Soil preparation was carried out with a double mouldboard plough making a 15-20 cm deep furrow. Pine was planted in 1967. The transplants were spot-fertilized with P, PK or NPK.

Results

***Properties of the substratum*:** The bulk density was considerably higher and the organic matter content lower in the tilled 0-10 cm than in the untouched 30-40 cm layer indicating that mineral soil had been used as a soil improvement agent in the fields (Fig. 6.1.1). Except boron, the amounts of the total nutrients correlated positively with the bulk density (Fig. 6.1.2-4). Accordingly there were more nutrients in the surface layer than in the 30-40 cm layer, although very small amounts of boron were even in the surface layer. Thus mineral soil application had greatly changed the surface substrate but only slightly affected the nutrient regime of the 30-40 cm layer. Nitrogen contents in the

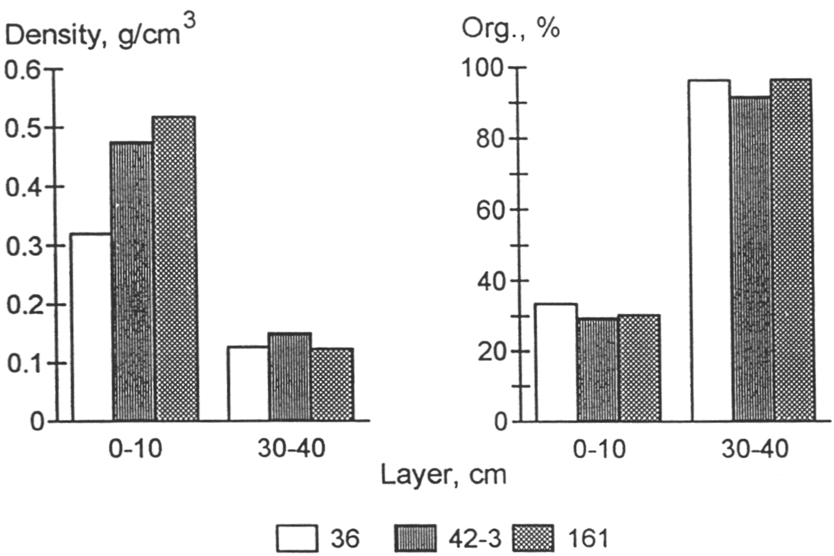


Fig. 6.1.1. The mean bulk density and organic matter content in different soil layers in different experiments (36, 42-3, 161). Folia Forest. 778.

30-40 cm layer were low indicating an originally poor peatland site type. The needle nitrogen and phosphorus concentrations correlated generally best with the corresponding soil nutrients calculated as mg/g or kg/ha, but the needle potassium concentrations correlated only weakly with the soil properties. The total soil nitrogen and phosphorus contents correlated as well as or better than the soluble fractions

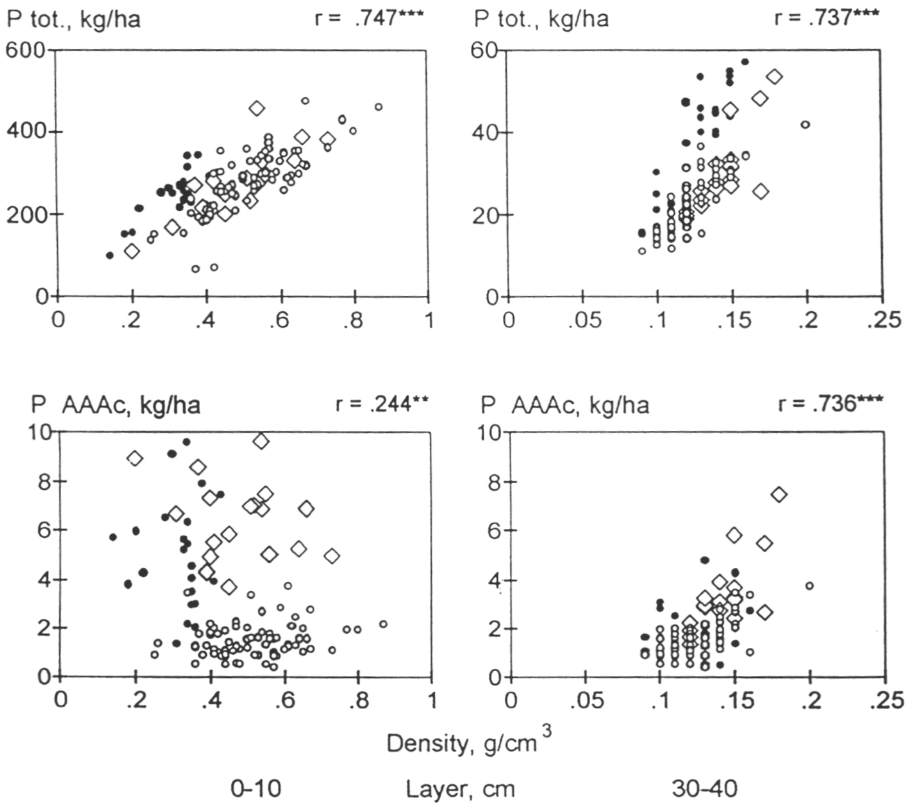


Fig. 6.1.2. Dependence of the amounts of the total and ammoniumacetate (AAAc) extractable phosphorus on soil bulk density at different depths. Folia Forest. 778.

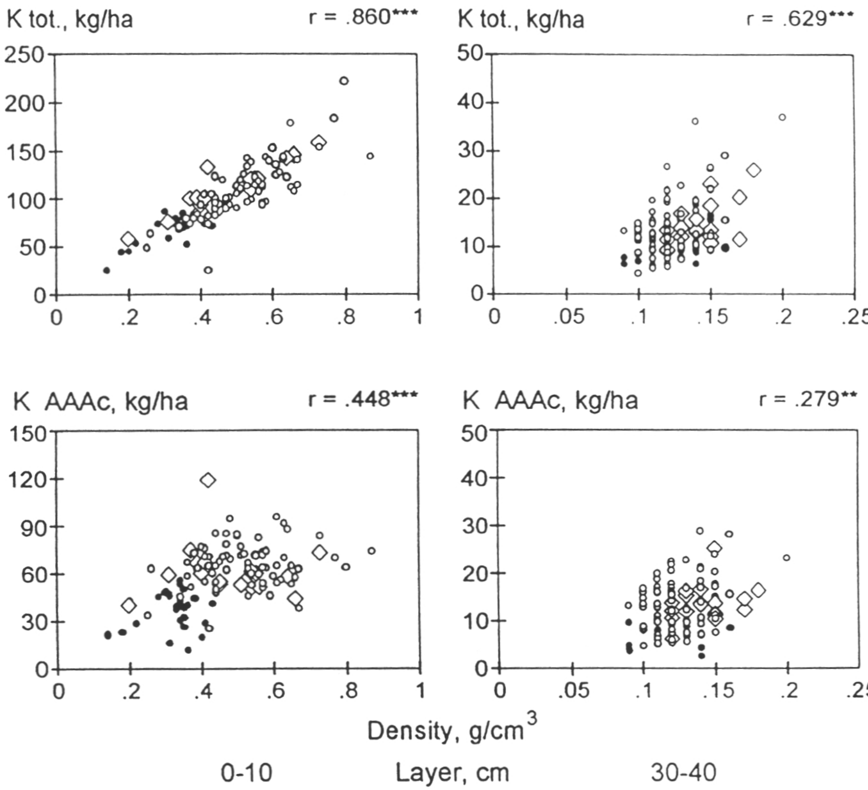


Fig. 6.1.3. Dependence of the amounts of the total and ammoniumacetate (AAAc) extractable potassium on soil bulk density at different depths. Folia Forest. 778.

with the corresponding needle nutrient concentrations. It is cbvious that analyses both from the tilled layer and deeper layers are needed in order to estimate the quality of the substrate for wood production on peatland fields and that at least the following analyses are necessary: bulk density, organic matter content, total N, P, K, Ca, B and exchangeable K. The volumetric results should be expressed per volume *in situ*.

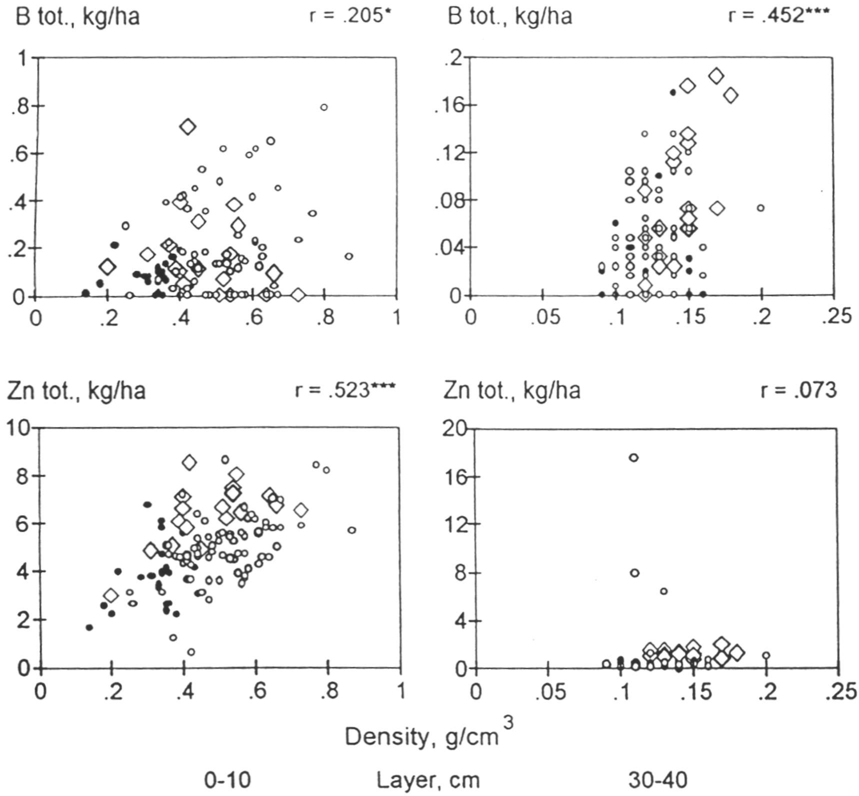


Fig. 6.1.4. Dependence of the total boron and zinc amounts on the soil bulk density at different depths. Folia Forest. 778.

Survival and growth: The survival was very good on plough ridges but manual weeding was needed even then. The survival was clearly lower on untouched surfaces. In the inventories carried out on practical afforestation sites, the survival rate has generally been quite poor (Fig. 6.1.5). Moose browsing and fungus diseases were the most frequent causes of damage. Also growth disorders caused by boron deficiency (Fig. 6.1.6) were quite frequent.

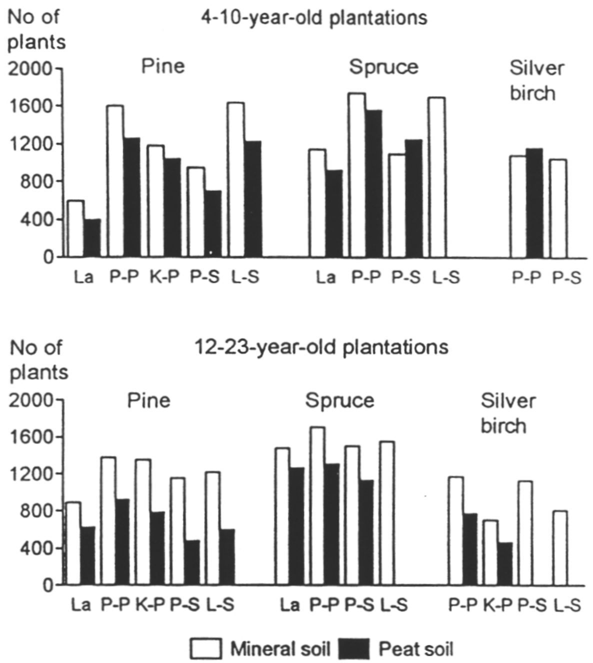


Fig. 6.1.5. The number of transplants in young and old plantations on peat and mineral soil and in different localities.

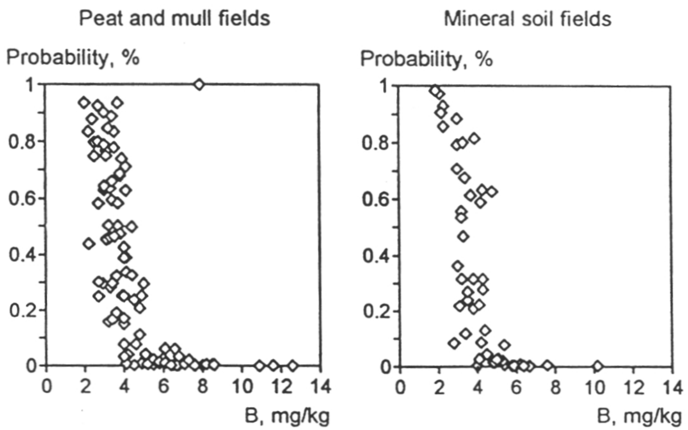


Fig. 6.1.6. Correlation between the predicted probability of growth disturbances and foliar boron concentrations. Folia Forest. 882

Root development

Root development was the greatest in the ridges but fairly good also in the level, untouched side of the ridge (Fig. 6.1.7). Originally about 20-cm-deep, but at the time of the study only about 15-cm-deep furrows, hindered root growth quite effectively and only few roots grew below the furrows.

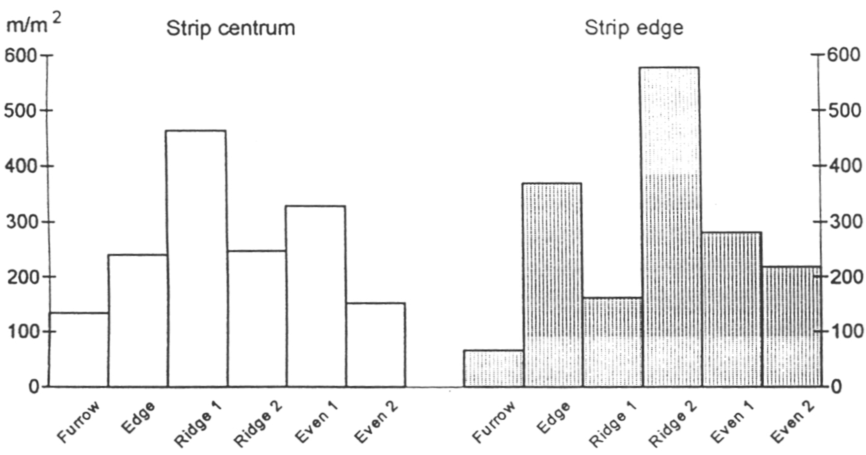


Fig. 6.1.7. Total lengths of roots < 1 mm in diameter. Edge = between furrow and ridge, even = untouched surface, 1~50 cm, 2~100 cm from the tree. Metsäntutkimuslaitoksen tiedonantoja 581.