Metla - 80 years of forest research

KIVISUO EXPERIMENTAL FIELD

IPS FIELD TOUR

8th September 1998

Excursion guide

FINNISH FOREST RESEARCH INSTITUTE

Excursion at Kivisuo experimental field, 8. September 1998

Peatland forestry in Finland, S.Kaunisto (in the bus)
History of Kivisuo, O.Huikari (in the bus)
The Kivisuo experimental field A. Reinikainen (partly in the bus)

Point 1.(The view tower at 15,45)

1.Geology of Kivisuo, R.Korhonen (5)
2.Drainage and experiments of Kivisuo. Nutrient deficiency symptoms, A. Reinikainen (10)
3.Results of the macronutrient experiment I and micronutrient experiment II H.Veijalainen (15)
4.Results of experiment IV comparing phosphorus fertilizers, K.Silfverberg (5)
5.Leaching of fertilizer-phosphorus, M.Nieminen (10)
6. Fertizer potassium of different solubility and tree growth, S. Kaunisto (5)
7. Fertilization and ground water table, E. Ahti (5)
8. The view tower, discussion and buss to the next point (25) at 17.05

Point 2 (Buss stop**)** at 17.05

1. Natural state of Kivisuo, A.Reinikainen (20)

Point 3 (Exp.XVIII) at 17.25

1. Fertilization of birch H.Veijalainen (5)
2. Regeneration of Norway spruce S.Kaunisto (10)
3. Bus to point 4 (10)

Point 4 (Exp. 22) at 17.50

1. Fertilization of spruce stand on an old Vaccinium myrtillus peatland forest, H. Veijalainen (5)
2. Discussion (15)
3. End of the excursion at 18.10-

Some observations of the current nutritional status of tree stands at Kivisuo
Needle analysis and peat analysis (H.Veijalainen)

List of illustrations

Point 1

Point 3.

Point 4.

Tables

The Forest Ecological Experimental Field at Kivisuo. History and Research Target

Olavi Huikari

Professor emeritus in Peatland Forestry
The Finnish Forest Research Institute

In 1956 the Forest Research Institute was informed that 100 hectares of drying fields of fuel peat would become available for some other useful purpose after peat harvesting.

A forest ditching plough had been developed under the management of the Department of Peatland Forestry at the Forest Research Institute. By using the plough it was seen possible to drain, within twenty years, all the peatlands that were naturally drainable for forestry. It was also seen that the Kivisuo peat drying field would provide us with exactly the kind of information which was required for growing forests successfully in these five-million-hectare drainage areas. The area as such was a laboratory for analyzing the nutritional requirements of forest trees. Thus nature´s own resources would help bring forth healthy growth of trees and information on the needs of nutrients and micronutrients.

An agreement was made with the National Board of Forestry for using the area for this purpose.

It was agreed that

- The National Board of Forestry will receive the income from forest fellings.
- The Department of Peatland Forestry will make the reseach plans, supervise the setting up of the experiments and carry out measurements and publish the results.

This is how the world´s largest laboratory dealing with the nutrient requirements of trees was created.

The test species was pine. In six years the experimental field had 1,000 experimental plots. The plots usually measured 20 by 40 metres, each of which was separated by an open ditch or a ten-metre-wide isolating strip. Only a year after the establishment of the first series of experiments a unique demonstration field of nutrient requirements of trees and nutrient deficiency symptoms was ready. It became the target of many international excursions. The most important of them was the excursion of the Forest Fertilization Colloquium arranged by the International Potash Institute in 1966.

The Kivisuo experimental field

Antti Reinikainen

The Finnish Forest Research Institute,
Vantaa Research Centre

Originally, before the year 1945, the mire Kivisuo was an eccentric bog typical for the border zone between raised (ombrotrophic) bogs and aapa mires (minerotrophic). In 1945-47 an area of 100 hectares in the mire centre was drained for the drying of hydro-peat. The drying was very effective: the ditch spacing was 22 m and there was a vaulted ditch in the middle of each strip. The area was levelled by removing the hummocks and the living moss layer.

During 1947-53 so-called hydro-peat harvested from the deeper layers of the mire was sprayed for drying on the mire surface. Thus, the starting point for all the fertilization experiments was an even, black peat field with varying cover (5-10 cm) of more humified peat (hydro-peat residual) on the surface.

After peat harvesting had ceased the field remained almost without any plant cover for six years. The surface peat was acid (pH 4.0-4.2) and very poor in phosphorus and potassium. The content of total nitrogen varied between 0.7-1.8% according to the amount of hydro-peat residual on the raw fuscum peat.

The main climatological parameter values for Kivisuo are: annual mean temperature +3°C, annual mean precipitation 550 mm, temperature sum (treshold value +5°C) 1300°C.

Point 1.

1.1 Geological study of the Kivisuo peat deposit, Central Finland

Korhonen, Riitta
Geological Survey of Finland

Studies of the Kivisuo peat deposit were carried out by the Geological Survey of Finland in the summer of 1985. At the study sites (Fig.1) observations were made on mire types, moisture conditions of the mire types, hummock frequency, type, height and quantity of the tree stands, snag inclusions in the peat deposit (0-2 m), the degree of humification on the von Post scale (H_{1-10}), peat moisture, peat type, thickness of peat deposit, gyttja deposits underlying peat, and the type of subsoil.

Fig. 2. Degree of humification and the peat type profiles in the fertilization test area of the Kivisuo peat deposit (Riitta Korhonen, Geological Survey of Finland). *Explanations*: Site types and snag inclusions: The test area is an old Ledum-Empetrum peatland forest (VaTkg, in Finnish: varputurvekangas). The numbers below the mire type abbreviation refer to the number of snags, i.e., inclusions of wood. At site A 1700, for instance, the numbers 4/1 show that four snags were found by ten soundings at the depth of 0-1 metres and one at the depth of 1-2 metres.

Peat types: 1 Sphagnum peat, 2 Carex peat, 3 Carex-Sphagnum peat and 4 Sphagnum-Carex peat. Additional factors occurring in the peat types: 5 Eriophorum, 6 Scheuzeria, Equisetum, 8 Nanolignidi and 9 Lignidi. Types of soil underlying the peat deposit: 10 coarse detritus gyttja, 11 fine detritus gyttja, 12 till, 13 silt, 14 fine sand and 15 sand.

Radiocarbon dating show that the Kivisuo mire began to form at the turn of the Boreal and the Atlantic stages, during the late Ancylus Lake stage of the Baltic Sea, about 8060 ± 80 y.B.P. (Su 1518). The mire formed by overgrowth of the Kivijärvi lake basin and because of the way it was formed the peat deposits are underlain by coarse and fine detritus gyttja in a deposit of varying thickness (10-280 cm). The subsoil consists of till, sand, silt and fine sand. Kivijärvi was isolated from the Ancylus Lake 9400-9000 y.B.P. (Ristaniemi 1985).

The peat types of Kivisuo reflect the typical development of an overgrown basin. The gyttja was first covered by Carex peat, and then on the surface by deposits of Sphagnum peat.

1.2 Nutrient deficiency symptoms

Antti Reinikainen
The Finnish Forest Research Institute, Vantaa Research Centre

External symptoms of nutrient deficiences in the forest trees growing in Finland were not very well known before the establisment of experiment I at Kivisuo in 1959. This factorial NPK trial, including many unbalanced treatments, revealed the symptoms - often in an aggravated appearance. The symptoms were described and their occurrence against fertilization treatments analysed in the late 1960´s. The symptom frequency in young saplings (< 10 years) was in fair accordance with the variation of pine growth and yield in the experiment (see Fig.3a-b).There were no visual symptoms of nitrogen deficiency. The symptoms of phosphorus defiency - in addition to very stunted growth - were short needles, thin shoots and needle necrosis due to freezing in early spring. Necroses varied from tip burning of one year old needles to total dieback of shoots and buds. Symptom of potassium deficiency was needle tip chlorosis of very charactreristic appearance. In the very early stages of pine stand development also growth disorders due to prolific supply and imbalance of fertilizers on some NPK plots were observed. Later on the diebacks were diagnostized as boron deficiency symptoms. Symptoms analogical to those of pine were observed also in other tree species, spruce and birches as well as in the grasses and herbs of understorey vegetation. Now 40 years after the establisment of the Kivisuo experiments the symptoms do not appear as clearly as in the young saplings. This is probably due to the moderation of nutrient imbalances and refertilizations "stretching" their effect to the plots fertilized only once.

1.3 Fertilization of Scots pine

Heikki Veijalainen
The Finnish Forest Research Institute, Vantaa Research Centre

There are a number of fertilization experiments at Kivisuo mire, most of them in pine stands dating back to 1959-69. Fertilization experiments have been established also in birch and spruce stands. Most of the oldest experiments have been refertilized 10-20 years after the first treatment.

In many experiments the former hydro-peat drying ground (drained in 1945-47) was planted using 2500 transplants per hectare and fertilized very shortly after planting. Originally Kivisuo was very poor in nutrients nitrogen, phosphorus and potassium (N, P and K) forming an excellent site for macronutrient studies.

Experiment I was established in 1959. Originally it contained 64 different combinations of N, P and K at four levels in two blocks. Only Block I still exists, because growth disturbances and fungal diseases ruined the pine stand in Block II.

At the very early stage of the planted pine stands it became obvious that the order of the nutritional minimum factors was P>K>N. At first N was not significant, but now after 40 years it seems to become important (Fig.4) especially, where the hydro-peat layer was thin. The peat below the hydro-peat may have about 0,85 % total N concentration.

The levels of elemental phosphorus in experiment I were 0-29-58-86 kg/ha. Phosphorus was applied as finely ground rock phosphate (P 14,4 %, imported from Morocco, N-Africa). In

1974 each plot was divided into three different refertilization treatments with macronutrients. In 1975 each subplot was further divided into two subsubplots, for a control and a micronutrient treatment.

In 1998 it was obvious that without refertilization the highest P-level gave the best results, almost 150 m3/ha (annually almost 4 m3/ha) more than the control plot on the same strip (Fig. 5a-b). The annual mean yield after 1-2 thinnings seems to be in many cases higher than the national average for forest land (4,2 m3/ha/a). Refertilization gave proportionally the best results on the control plot and at the lowest P-level. The pines at the highest P-level did not need PK-refertilization. So the effect of double P-level (recommendation is P 43,6 kg/ha) seems to continue for 40 years (Fig. 5c).

Addition of nitrogen or potassium (NP-, PK- and NPK- fertilizations at normal levels) gave higher yields than phosphorus fertilization (Fig.3b). Especially PK-fertilization has been commonly used in our practical peatland forestry. Only on very poor sites or in cold summers in N- Finland PK-fertilizers may me ineffective.

It is not profitable to drain such peatlands as Kivisuo, if one is not prepared also to correct the nutrient deficiencies. It may be very profitable especially in the southern part of Finland, if the stand is naturally dense.

Kivisuo is a splendid place to prove that nutrient treatments may have a very favourable effect on forest vitality. Earlier micronutrient mixtures containing boron have given good results in this sense. At Kivisuo it is easy to prove that at first we must take care of macronutrients as minimum factors (Fig. 5d). This result is from *experiment VI*, where phosphorus was spread as superphosphate in 1966. The pine stand was planted and spot fertilized four years earlier using the same experimental design as in 1966. The vitality inventory dates back to 1980.

Experiment II also was established in 1959. It is a 2^4-factorial micronutrient experiment with two replications. The basic fertilization was a heavy NPK treatment. Micronutrient fertilizers were sodium borate, copper, manganese and zinc sulphates, each 50 kg/ha. In 1987 all plots received PK fertilization. In 1994 the micronutrient treatments were repeated using same compounds but different amounts. Boron and copper amounts per hectare were smaller than in 1959, but manganese and zinc amouns more than double the first application level.

Twenty years ago we were quite sure, that boron deficiency caused diebacks and other growth disturbances especially in pine stands at Kivisuo. New measurements after repetition of NPK (1987) and micronutrient treatments (1994) show that boron had no positive effect on the annual growth of the pine stand, but the other micronutrients had (Fig. 6). Observe also the high level of annual growth.

1.4 Phosphorus fertilizers

Klaus Silfverberg
The Finnish Forest Research Institute, Vantaa Research Centre

Phosphorus is, along with nitrogen and potassium, a key element in peatland forestry. Stands on drained, nutrient-poor peatlands often suffer from shortage of N, P and K and that has commonly been corrected by fertilization.

Different P-fertilizers have been tested in Finnish peatlands since the 1960's. The most important phosphorus fertilizers have been superphosphate (Psf), rock phosphate (Prf), finely ground rock phosphate (Phf) and apatite. The applied amounts of P as element have been 44 - 66 kg/ha in these experiments.

At Kivisuo ammonium metaphosphate (Paf) and Kotka-phosphate (Pkf) were studied. The phosphorus amount applied was 44 kg per hectare. In the beginning Kotka-phosphate was the best alternative at Kivisuo, but after 35 years superphosphate seems to give the best results (Fig 7a). Refertilization using NPK gave about 1.0 m3/ha/a in twenty years (Fig 7b). This means that refertilization was not necessary 15 years after differrent phosphorus treatments.

The differences in stand volume between the P-fertilizers were mostly non-significant (Fig 7c). However, the effect of superphosphate has been surprisingly strong. The effect of apatite was strong at the end of the study period. Compared to sole NK-fertilization, the effect of P was strong on very nutrient-poor pine bogs. According to foliar analyses the effect of all studied P-fertilizers studied has been long-lasting, > 20 years.

To obtain a good and long-lasting growth reaction, however fertilization with potassium and nitrogen is often demanded. In the long run potassium is often becoming a growth limiting nutrient earlier than phosphorus.

1.5 Leaching of fertilizer-phosphorus from drained peatlands

Mika Nieminen
The Finnish Forest Research Institute, Vantaa Research Centre

Phosphorus (P) deficiency is the most common nutrient deficiency on drained peatlands in Finland. On the bases of needle analyses, P-fertilizations are recommended on about 60 % of drained peatland area. However, the amounts of P-fertilizers used in practical peatland forestry are nowadays very low. One reason for low fertilization activity is the concern that fertilization might lead to enhanced leaching of fertilizer-P, thus causing eutrophication in recipient water courses. Indeed, considerable leaching losses of fertilizer-P has sometimes been observed from drained peatlands.

One of the experimental areas with very high leaching losses of fertilizer-P is located at Kivisuo (Fig. 8a). During 9.-13.3.1987, four of the basins (basins 2, 3, 5, 7) were fertilized by spreading 500 kg ha^{-1} of a commercial PK-fertilizer on the snow cover. During 19.-20.5.1987, a similar application was spread on bare ground after snowmelt (basins 1, 4, 6, 8). Runoff P data from basins 9-16 were used as control data. The average runoff P concentrations from different treatments are shown in (Fig. 8b).

Extremely high leaching losses of fertilizer-P were observed after both fertilization treatments. It should be noted, however, that the observed increases in the leaching of fertilizer-P are too high to be generalized to areas fertilized in practical peatland forestry nowadays. This is because a fertilizer including water soluble P was applied at Kivisuo (water-soluble P = 20 % of total P). A highly unreactive, water-insoluble P-fertilizer (Siilinjärvi apatite) is nowadays the primary fertilization option on drained peatlands in Finland. The rate of P-leaching from peatland areas fertilized with Siilinjärvi apatite is significantly lower than that from the areas fertilized with P-sources including water-soluble P (Fig. 8c).

The risk for enhanced leaching of fertilizer-P from drained peatlands is mainly due to low P adsorption capacity of peat. In mineral soils, fertilizer-P is tightly bound in the soil due to the ability of some soil compounds, such as Al and Fe oxides and hydrous oxides, to strongly sorb phosphate ions. Because of the low content of these elements, some peat soils have been shown to have very low P adsorption capacity. To investigate the P adsorption capacity of peat, P adsorption isotherms were determined for a range of peat soils (Fig. 8d). When increasing amounts of P are added to a series of soil suspensions, the P adsorbed can be plotted against the equilibrium P concentration. The resulting curve is called a P adsorption isotherm. Some of the peat soils in the Fig. 8d (Eutrophic pine fen, Tall-sedge pine fen) show very high P adsorption capacity, whereas some samples (Cottongrass pine bog, *Carex globularis* pine swamp) adsorbed insignificant amounts of P. The correlations between the P sorption index (PSI) values (a frequently used indicator of P adsorption) and the soil properties likely to influence P adsorption (Table 8a), indicated that the low P adsorption is mainly due to low content of Fe in peat.

1.6 Fertizer potassium of different solubility and tree growth

Seppo Kaunisto
The Finnish Forest Research Institute, Parkano Research Station

Introduction: Potassium in fertilizers has usually been given as KCI, which is completely water soluble and susceptible to leaching. On the other hand phosphorus is given as rock phosphate or apatite, which both 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. Possibilities to use different potassium amounts and sources for fertilization are based partly on experiments outside Kivisuo.

Results: Potassium fertilization with potassium chloride enhances tree growth for about 15 years. On an average, the best growth response is achieved with about 80 kg/ha of elemental potassium. However, the amount of potassium affects the duration of the growth response only slightly (Fig. 10).

Trees take up potassium from potassium chloride more readity than from phlogopite and consequently, the needle potassium concentrations rise more on the sites fertilised with potassium chloride than with phlogopite during the first years sivce fertilization (Fig.11). This is also seen in the needle putrescin concentrations. However, the situation changed to the contrary by 11-14 years after fertilization and the needle potassium concentrations were higher on the phlogopite fertilized sites than on the sites fertilized with potassium chloride. After 16-19 years the difference was even greater and the needle potassium concentrations differed significantly from those on the controls only on phlogopite fertilized sites. Consequently, the results suggest that phlogopite has a longer-lasting effect than potassium chloride on the potassium nutrition of pine trees and may form a good combination fertilizer with apatite. Phlogopite and potassium chloride fertilization resulted in similar tree growth during at least 11-14 years after fertilization.

At Kivisuo, Scots pine seems to endure very high potassium amounts and also high chloride and sulphate amounts (Fig 9a-b). There are no large differences between potassium chloride and sulphate. Potassium chloride in great amounts does not seem to be more toxic than potassium sulphate, as it was assumed.

1.7 Fertlization, stand volume and ground water table

Erkki Ahti
The Finnish Forest Research Institute, Vantaa Research Centre

Ground water level is the most important minimum factor affecting tree growth in peatland forests in Finland. At Kivisuo ditch spacing is abnormally narrow, only 22-23 m. Almost every strip has been divided into two parts by a vaulted ditch from the very beginning. We gathered a data of ground water level at *experiment I*, where stand measurements were fairly recent. The average ground water level was not very low, on average 27-47 cm (Fig.12a). All regressions between the stand volume and ground water level were positive, and statistically significant or highly significant (Fig. 12b).
According to these regression equations we could calculate for example, how much an increment of 50 m3/ha in wood volume seemed to lower the ground water level in spring, summer and autumn (Fig. 13a). The difference seemed to be smaller in spring and in the early summer than in autumn (Fig.13b). At Kivisuo, experiment I different fertilization treatments have given rise to a vast variation in the volume of pine stand. It seems that a successful forest fertilization lowers also ground water level (Fig.14a).

Point 2. The pristine mire Kivisuo

Antti Reinikainen
The Finnish Forest Research Institute, Vantaa Research Centre

As a mire complex Kivisuo is classified as an eccentric bog. The ordinary bog, about 250 ha in area was surrounded by a mosaic of paludified forests, small pine bogs and spruce mires. The bog was an independent hydrological unit which had its highest parts in the W-NW corner sloping towards E- ESE. The peat layer was fairly deep (> 2 m) all over the bog being deepest (> 3 m) in the present experimental area. The sequence of mire site types was clear: in the proximal W-NW-margins there were dwarf-shrub and cottongrass pine bogs. Sphagnum fuscum open bogs dominated in the areas of deepest peat layer. Gradually, they changed into ombrotrophic low-sedge open bogs which occupied the southern parts of the experimental area. The only minerotrophic types, segde fens, were found in the lower lagg zone of the bog that ended in the shallow lake Kivijärvi. The lake was drained dry before the peat harvesting period.

Point 3.

3.1 Nutritional demands of Betula pubescens and B. pendula

Heikki Veijalainen
The Finnish Forest Research Institute, Vantaa Research Centre

Experiment XVIII is in reality a single block of a series of spruce and birch fertilization experiments in peatland forests. It is also a part of the hydropeat drying field, but the site has been more fertile than in the central part of the mire (Vaccinium myrtillus spruce swamp). The peat layer is 1-1,5 m, spotwise less. The Betula stand was very dense in 1979. Among B. pubescens (white birch) there were some B.pendula (silver birches). Fertilization treatments in 1979 were (2^2 -factorial, factors were N- and PK-fertilizers):

1.	Control
2.	N 110 kg/ha
3.	P 43+K 83 kg/ha
4.	NPK

The treatmens were repeated in 1988. Thinnings (1979, 1988 and 1996) have decreased the number of stems to 732 stems per hectare.
The effect of fertilization is quite modest (Fig.15 a-c) as in many older Betula stands on peat. Obviously the PK-plot has been less fertile than the other plots. Consequently it has grown less than the others all the time. Another possibility is that birches of that age need nitrogen on corresponding peatland sites.
After the very rainy summer PK plot shows yellowing of needles caused by a harmless fungal disease (Chrysomyxa ledi).
Experiment VI, not far away, gives us some interesting information of the nutrient demands of young B.pendula stands (Fig.15d). Without phosphorus fertilization almost all silver birches had vanished. There were only minor elk damage to declare the total mortality of silver birch in the empty plots.
Earlier (1981) we noticed that young silver birch in this experiment needed about 50 kg/ha more nitrogen than Scots pine. It is a well known fact that planned silver birch wins planted pine in height and radial growth in many peatland sites during the first 15-20 years.

3.2 Regeneration of forests on old drainage sites.

Markku Saarinen & Seppo Kaunisto
The Finnish Forest Research Institute, Parkano Research Station

Before and during the 1930´s about half a million hectares of peatlands were drained for forestry in Finland using manual digging. Typical sites were fertile spruce swamps. Today, an ever-increasing part of the stands on these drainage areas have grown mature or old. If pine mires are included, an estimate of 7-9 % of the now nearly 5.6 million hectares of drained peatland and paludified upland forests in Finland should be regenerated in the near future. Forest regeneration problems specific for peatlands are: fluctuations in ground water table, extreme microclimate, progressive and regressive successions of the bottom layer and nutritional problems of the substrate. As the post-drainage succession proceeds the conditions of natural regeneration are weakened.

The succession of ground vegetation after drainage is characterized by the disappearance of mire species and the establishment of upland forest species. As the *Sphagnum* mosses of the bottom layer die peat accumulation ends and instead, a raw humus layer develops that mainly consists of slowly decaying litter. This layer isolates seeds from soil moisture and hampers the establishment of advance growth. An additional problem may be a prolific ground vegetation that develops after cutting. Depending on the prevailing ground water level and the abundance of relicts of mire species, the succession of ground vegetation after cutting differs from that of upland forests.

In mixed or broadleaf dominated forest growth of ground vegetation is restricted by leaf litter, The natural regeneration of spruce succeeds fairly well if there are seed trees on the site or in its vicinity. Spruce seeds may spread to a site from the distance of a couple of hundred metres.

The natural regeneration of spruce under birch on a fairly nitrogen-rich site is quite well demonstrated in the *experiment XVIII* at Kivisuo. On the control plots there are less than 3,000 spruce plants and on the PK and NPK fertilized plots about 4,500 (Fig 16a). The normal planting density with spruce is about 2,000 seedlings/ha. All fertilization treatments have improved the height and radial growth of spruce (Fig. 16b-c), PK and NPK clearly more than pure N and NPK slightly more than PK. Similar results have been achieved also from other experiments.

-

In the beginning of the experiment XVIII PK gave rise to very dense spruce underpopulation. NPK plot had more Rubus idaeus and herbs and regeneration of spruce begann some years later. This phenomenon has been observed also in some other experiments.

Point 4.

4.1 Nutritional demands of Norway spruce, old Vaccinium myrtillus peatland forest

Heikki Veijalainen
The Finnish Forest Research Institute, Vantaa Research Centre

Experiment 22 lies outside the Kivisuo basin some two kilometers W from other experiments. It was established in 1974 as a 2^2- factorial (N100, P52K6) experiment in two blocks. The refertilization according the same design (N110, P48,K91) was done in 1985.

The site was originally a Vaccinium myrtillus spruce swamp, drained in 1962, supplementary draining in 1974. Then the peat depth was 0,8 m and ditch spacing 40 m. There are also crosswise ditches between the plots.

The spruce stand (97 % spruce, 2,7 % birch and 0,3 % pine) was naturally born. The stand volume (spruce) of the plots was 120-170 m3/ha in 1976.

The effect of the first fertilization was negative, because the stand volume on the control plots were greater than on the other plots. In S Finland (6 experiments,13 blocks) NPK increased growth by 1,2-1,3 m3/ha/a. The factorial N-effect was positive and significant ($p<0,05$), but PK-effect was negative but not significant.

In experiment 22 the result after the refertilization again seems to give strange results. Now PK and NPK have given the best volume growth, which is greater than on the control plots (Fig.17a). The factorial effect of PK is positive, but that of N negative (Fig 17b).

The order of N, PK and NPK is the same as earlier, but the growth on the control plots has decreased from 9,8 to 6,4 m3/ha/a.

Obviously the site has originally been a herb rich spruce swamp, at least partly. It is well demonstrated also by the growth estimates of the control plots. In the Finnish recommandations such sites do not need any fertilization after drainage. PK-fertilization may be profitable 20-30 years after draining. Use of nitrogen or NPK fertilization on such cases has caused increase in mortality in some stands.

Some observations of the current nutritional status of tree stands at Kivisuo

Needle and peat analysis

(H.Veijalainen)

Unfortunately the first needle samples from Kivisuo area were taken in August about 30 years ago. They showed good correlations with nutrient deficiencies, but were out of all amplitudes, when needle samples taken in winter time were analysed. Afterwards only very few samples from Kivisuo area have been taken. All they show that the central parts of the hydro-peat area do not suffer from nitrogen deficiency. Pines in control plots showed severe phsophorus deficiency and mild potassium deficiency (Table 1,exp I, P0). Obviously phosphorus deficiency will be a problem 40 years even after heavy dressing (Table 1, exp I). It is interesting that the heaviest P fertlization has lowered needle K level below all deficiency limits.

The results of experiment IV show that no of the phosphorus sources could keep the needle P above the deficiency limits. The best in this sense has been kotka phosphate (= mixture of rock phosphate and superphosphate) or ammoniummetaphosphate, which is known to be almost insoluble to water. In earlier calculations kotka phosphate (= mixture of rock phosphate and superphosphate) gave the best and ammoniummetaphosphate the smallest growth response at Kivisuo. Also in exp. IV needle K concentrations tell about deficiency.

In experiment VI no of the fertilitzers could keep needle P level above deficiency level. In this experiment wood ash 3200 kg/ha (1980) and NPK (1966) seemed to prevent potassium deficiency for years. Unfortunately we cannot rely on needle K analysis, if it gives high or normal values. The result may be an artefact.

Spruce samples were collected from undergrowth of birches at experiment XVIII. Usually needle N in spruce is lower than in pine in peatland sites. Now the very high N values show a sufficient nitrogen supply or a very good site (Table 1). On the control and N plots there seem to be mild phosphorus deficiency according to new deficiency limits for peatland spruces. The effect of fertilization is visible especially on the NPK plot, where the P is high and K a new Finnish record (earlier was 12,90).

Peat analyses from some control plots of the experiments on Kivisuo, illustrate the nutritional state in different parts of the excursion route (Table 2).

Point 2 is a pine bog in natural state showing low concentrations of all nutrients. The control plot of exp.VI is a spruce plantation, with poor or no growth, in the central parts of the hydro-peat drying field. Experiment XVIII is a birch stand with spruce undergrowth (Point 3.) and exp. XXII is the fertilization experiment outside Kivisuo (Point 4).

The increase of total N is best visible in the 0-10 cm peat layer (Fig. 18). Total phosphorus is a valid measure of great differences between sites (Fig 19). Fe concentration of peat follows better the P concentration than Ca.

Litterature about Kivisuo mire

1. Ahti, E. 1983. Fertilizer-induced leaching of phosphorus and potassium from peatlands drained for forestry. Seloste: Lannoituksen vaikutus fosforin ja kaliumin huuhtoutumiseen ojitetuilta soilta.-Commun. Inst. For. Fenn. 111. 20 p.

2. Ahti, E. 1984. Fertilizer-induced leaching of phosporous and potassium from peatlands drained for forestry.-Proceedings of the 7th International Peat Congress, June 18th-23rd, 1984, Dublin, vol 3:153-163. Dublin: 153-163.

3. Ahti, E.& Paarlahti, K. 1988. Ravinteiden huuhtoutuminen talvella lannoitetulta metsäojitusalueelta. Summary: Leaching of nutrients from a peatland area after fertilizer application on snow.-Suo 39: 19-25.

4. Huikari, O.1973. Koetuloksia metsäojitettujen soiden lannoituksesta. Summary: Results of fertilization experiments on peatlands drained for forestry. Metsäntutkimuslaitoksen suontutkimusosaston tiedonantoja 1/1973. 154 s.

5. Huikari, O. 1977. Micro-nutrient deficiencies cause growth disturbances in trees. -Silva Fennica 11(3): 251-255.

6. Kaunisto, S. 1972. Lannoituksen vaikutus istutuksen onnistumiseen ja luonnontaimien määrään rahkanevalla. Summary: Effect of fertilization on succesful planting and number of naturally born seedlings on a fuscum bog at Kivisuo experimental field.-Folia Forestalia 139. 11 s.

7. Kolari, K. K. 1979. Hivenravinteiden puute metsäpuilla ja männyn kasvuhäiriöilmiö Suomessa. Kirjallisuuskatsaus. Abstract: Micro-nutrient deficiency in forest trees and dieback of Scots pine in Finland. A review.-Folia Forestalia 389. 37 s

8. Kolari, K. K. (Ed.) 1983. Growth disturbances of forest trees. Proceedings of international workshop and excursion held in Jyväskylä and Kivisuo, Finland 10.-13-October, 1982.-Commun. Inst. For. Fenn. 116. 208 p

9. Kolari, K.K. 1979. Hivenravinteiden puute metsäpuilla ja männyn kasvuhäiriöilmiö Suomessa-kirjallisuuskatsaus: Abstract: Micro-nutrient deficiency in forest trees and dieback of Scots pine in Finland-a review.-Folia Forestalia 389. 37 s.

10. Koskela, V. 1970. Havaintoja. kuusen, männyn, rauduskoivun ja siperialaisen lehtikuusen halla- ja pakkaskuivumisvaurioista Kivisuon metsänlannoituskoekentällä. Summary: On the occurrence of various frost damages on Norway spruce, Scots pine, silver birch and Siberian larch in the forest fertilization experimental area at Kivisuo.-Folia Forestalia 78. 25 s.

11. Kurkela, T. 1965. Männyn lumikaristetaudin ja lannoituksen suhteesta Kivisuon metsänlannoitusalueella. Summary: On the relationship between the snow blight (Phacidium infestans Karst.) and fertilization in Scots pine seedlings.-Folia Forestalia 14. 8 s.

12. Kurkela, T. 1983. Fungal dieases associated with nutritional growth disturbances of Scots pine. Commun. Inst. For. Fenn. 116: 73-77.

13. Paarlahti, K.& Paavilainen, E. 1985. Turvemaiden varttuneiden kuusikoiden ja koivikoiden lannoitus. Ennakkotuloksia. Summary: The fertilization of mature spruce and birch stands on peat soils.Preliminary results.-Metsäntutkimuslaitoksen tiedonantoja 206: 4-18.

14. Paavilainen, E. 1967. Juuristoanalyysin käyttömahdollisuus suometsien lannoitustarpeen selvittelyssä. Summary: Potential use of root analysis in determining the fertilization requirements of peatland stands.-Suo 18(6): 77-80.

15. Paavilainen, E. 1968. Juuristotutkimuksia Kivisuon metsänlannoituskentällä. Summary: Root studies at the Kivisuo

forest fertilization area.-Commun. Inst. For. Fenn. 66(1). 31s.
16. Paavilainen, E. 1969. Juuristojen ja kasvualustan hivenainepitoisuuksien välisistä suhteista suometsissä. Summary: On the correlation between the contents of trace elements in roots and growth substratum in certain peatland sites.-Suo 20(2): 104-108.
17. Paavilainen, E. 1974. Die Einwirkung der Düngung auf die Wurzelverhältnisse der Kiefer auf Moorböden. II Int. Symp. Ekologie und Physiologie des Wurzelwachstums. Potsdam 1971.
18. Reinikainen, A. 1964. Kasvillisuustutkimuksia Kivisuon rahkaturvealustaisilla lannoitusaloilla. Referat: Vegetationsuntersuchungen auf dem Walddüngungsversuchfeld von Kivisuo in Mittel-Finland -Folia Forestalia 6. 17 s.
19. Reinikainen, A. 1965. Vegetationsuntersuchungen auf dem Walddüngungs-Versuchsfeld des Moores Kivisuo, Kirchsp. Leivonmäki, Mittelfinnland.-Communicationes Instituti Forestalis Fenniae 59(5). 62 p.
20. Reinikainen, A. 1967. The appearance of nutrient deficiency in plants growing in the experimental area for forest fertilization at Kivisuo. Proceedings of the 5th Colloquium on Forest Fertilization, Jyväskylä/Finland. International Potash Institute, Bern, Switzerland.
21. Reinikainen, A.& Silfverberg, K. 1983. Significance of whole-tree nutrient analysis in the diagnosis of growth disorders. Commun. Inst. For. Fenn. 116: 48-58.
22. Reinikainen, A. & Veijalainen, H. 1983. Diagnostical use of needle analyses in growth disturbed Scots pine stands.-Commun. Inst. For.Fenn.116: 44-48.
23. Silfverberg, K. 1979. Männyn kasvuhäiriön ajoittumin ja alkukehitys turvemaan boorinpuutosalueella. Abstract: Phenology and initial development of a growth disorder in Scots pine on boron deficient peatland.-Folia Forestalia 396. 19 s.
24. Veijalainen, H. 1974. Berries, mushrooms and wild life on drained peatlands. -Proceedings of the International Symposium on Forest Drainage. Jyväskylä-Oulu, Finland.
25. Veijalainen, H. 1975. Kasvuhäiriöistä ja niiden syistä metsäojitusalueilla. Summary: Dieback and fertilization on drained peatlands.-Suo 26(5): 87-92.
26. Veijalainen, H. 1976. Effect of forestry on the yields of wild berries and edible fungi. -Ecological bulletins 21:63-65.
27. Veijalainen, H. 1977. Use of needle analysis for diagnosing micronutrient deficiencies in Scots pine on drained peatlands. Seloste: Neulasanalyysi männyn mikroravinnetilanteen määrityksessä turvemailla.-Commun. Inst. For.Fenn.92 (4).32 p.
28. Veijalainen, H., Reinikainen,A. & Kolari,K. 1984. Metsäpuiden ravinneperäinen kasvuhäiriö Suomessa. Kasvuhäiriöprojektin väliraportti. Summary: Nutritional growth disturbances of forest trees in Finland. Interim report. Folia Forestalia 601. 41 s.
29. Veijalainen, H. 1981. Hivenlannoituksen vaikutus istutusmännikön kehitykseen turvemaalla. Summary: Long-term responses of Scots pine to micronutrient fertilization on acid peat soil.-Folia For. 477: 15 s.
30. Veijalainen, H. 1983. Preliminary results of micronutrient fertilization experiments in disordered Scots pine stands. -Commun Inst. For. Fenn. 116 153-159 s.

3.9.1998

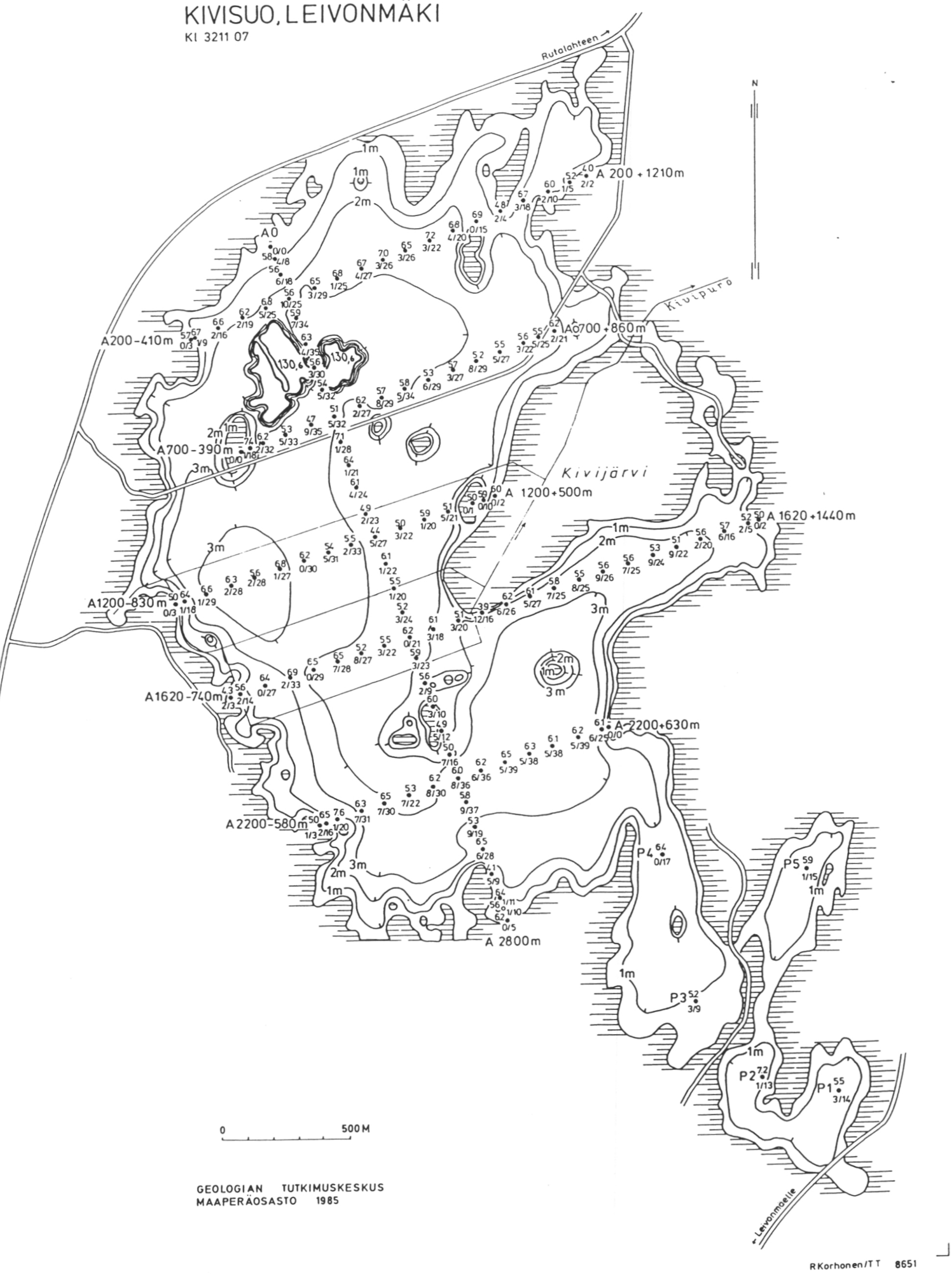


Fig. 1. Transect lines and peat depth at Kivisuo mire. The experimental field lies between the main ditches W from Kivijärvi (a peat covered lake). The ponds N from the experimental field were born as a result of hydro-peat excavation 1947-53.

Fig.2.

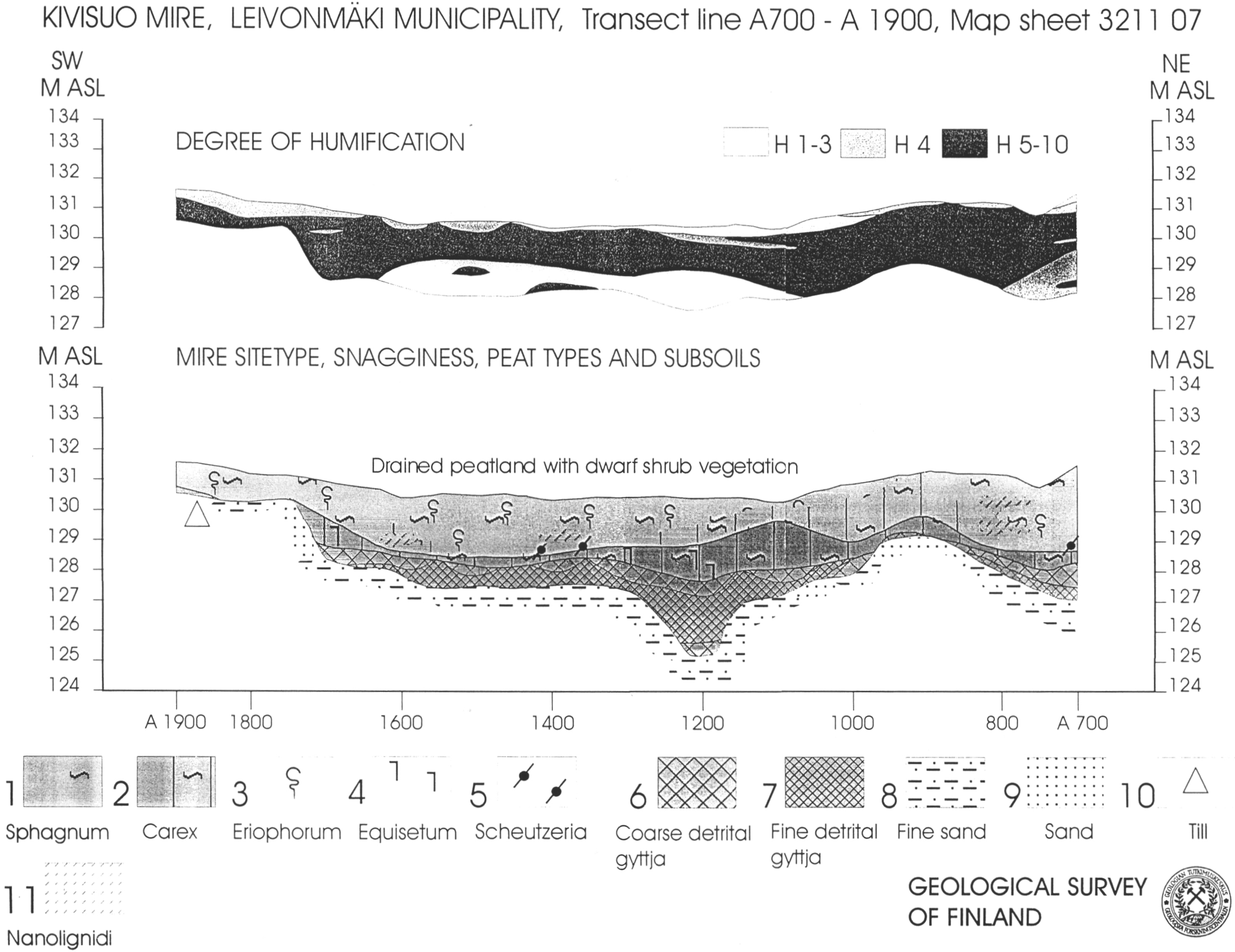

KIVISUO MIRE, LEIVONMÄKI MUNICIPALITY, Transect line A700 - A 1900, Map sheet 3211 07
SW
M ASL
NE
M ASL
DEGREE OF HUMIFICATION
H 1-3
H 4
H 5-10
134
133
132
131
130
129
128
127
M ASL
MIRE SITETYPE, SNAGGINESS, PEAT TYPES AND SUBSOILS
Drained peatland with dwarf shrub vegetation
124
125
126
A 1900
1800
1600
1400
1200
1000
800
A 700
1 Sphagnum
2 Carex
3 Eriophorum
4 Equisetum
5 Scheutzeria
6 Coarse detrital gyttja
7 Fine detrital gyttja
8 Fine sand
9 Sand
10 Till
11 Nanolignidi
GEOLOGICAL SURVEY OF FINLAND

Fig.3 a. Effect of fertilizers and their combinations on the total yield of Scots pine (1959-87), Kivisuo I-1

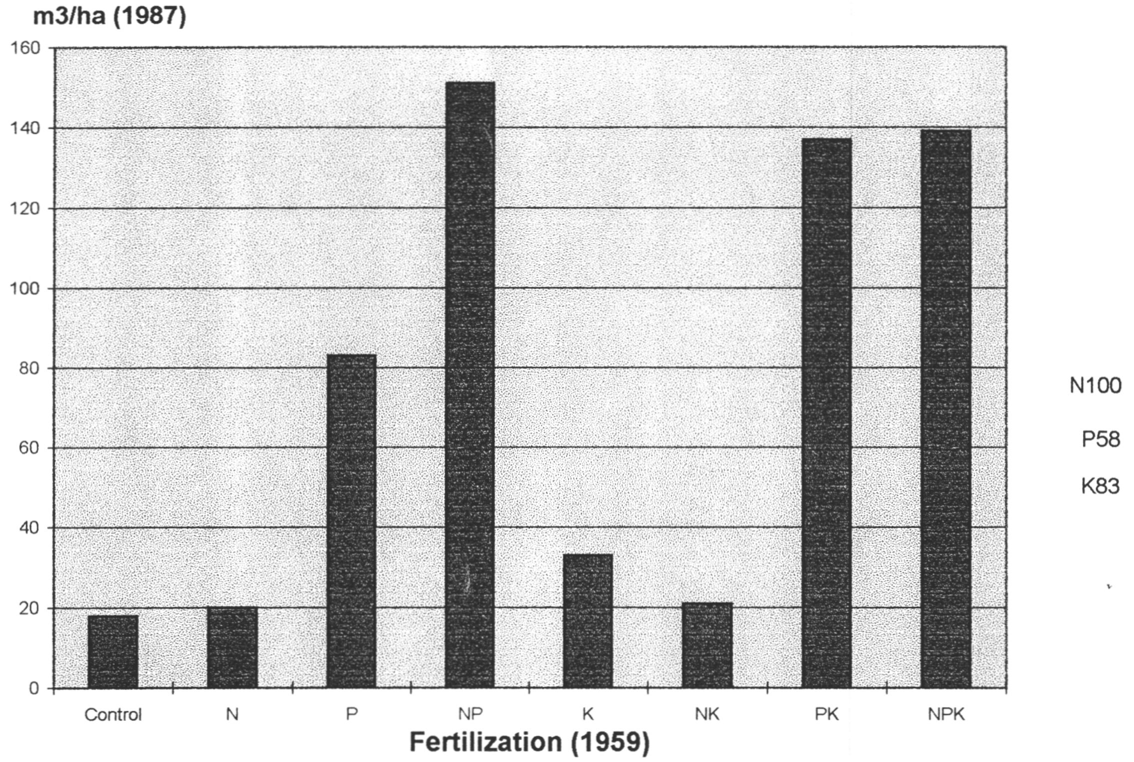


Fig.3b. Total yield of Scots pine (m3/ha) on some of the unrefertilized plots, Kivisuo I, 1959-98

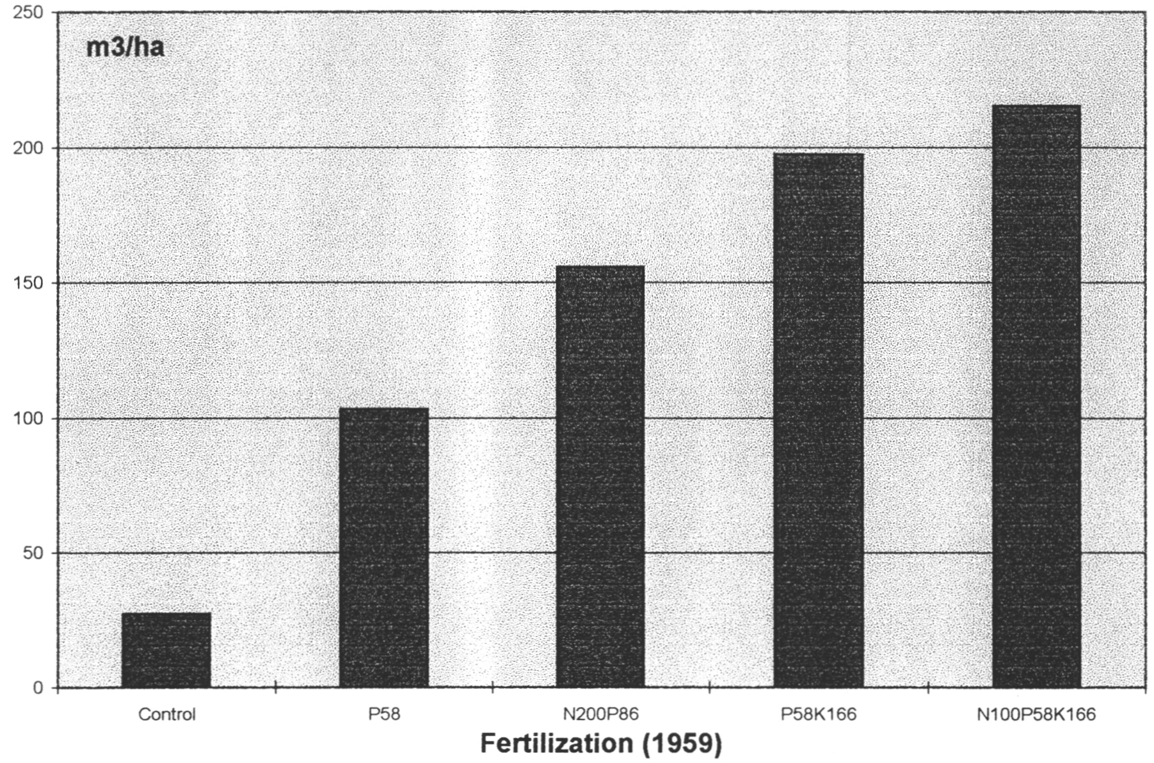


Fig.4. An example:Factorial effects of fertilizers containing N100, P58 and K 83, Kivisuo I-1

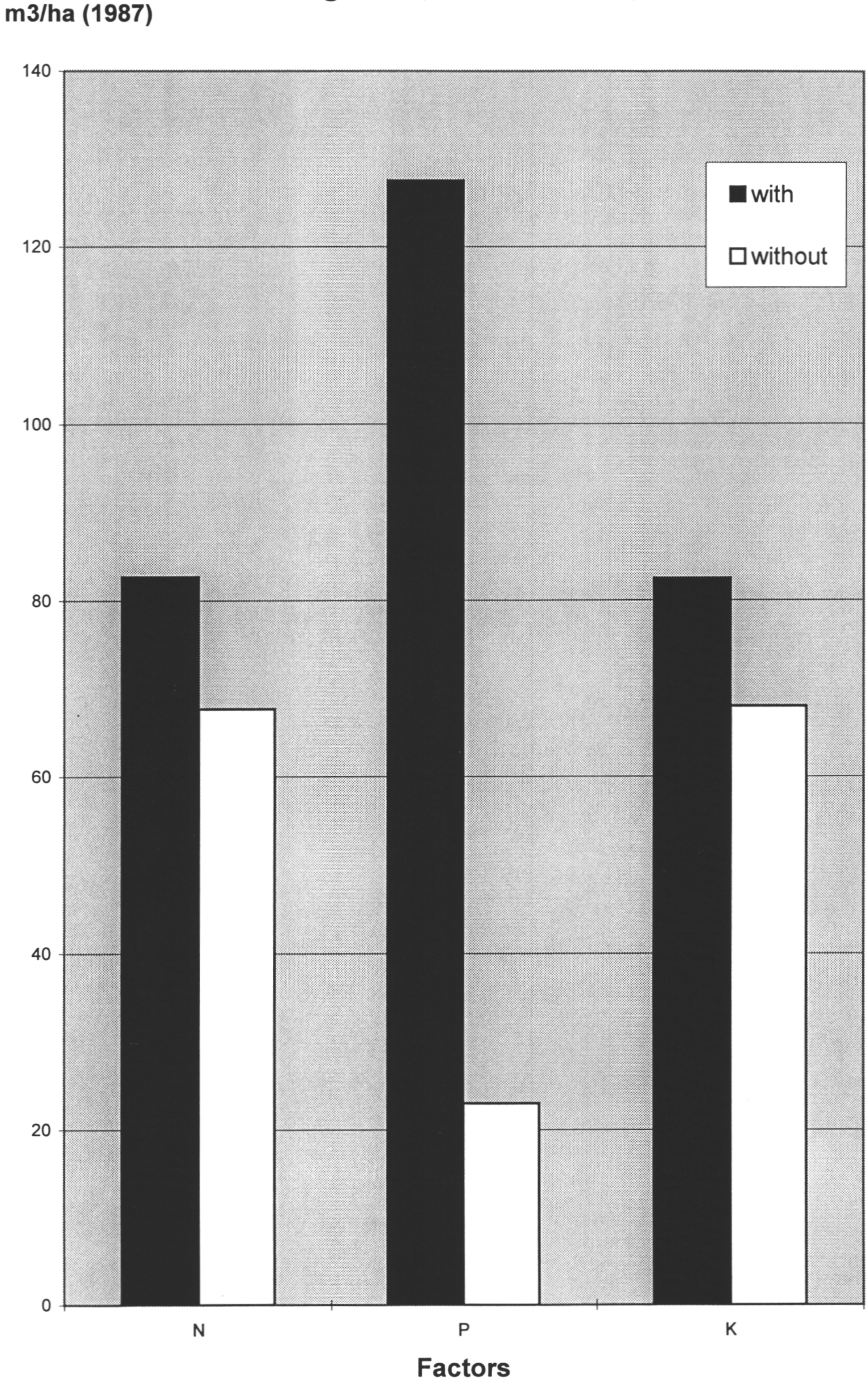


Fig.5a. **Total yield of Scots pine at different phosphorus levels, Kivisuo I, 1959-1998**

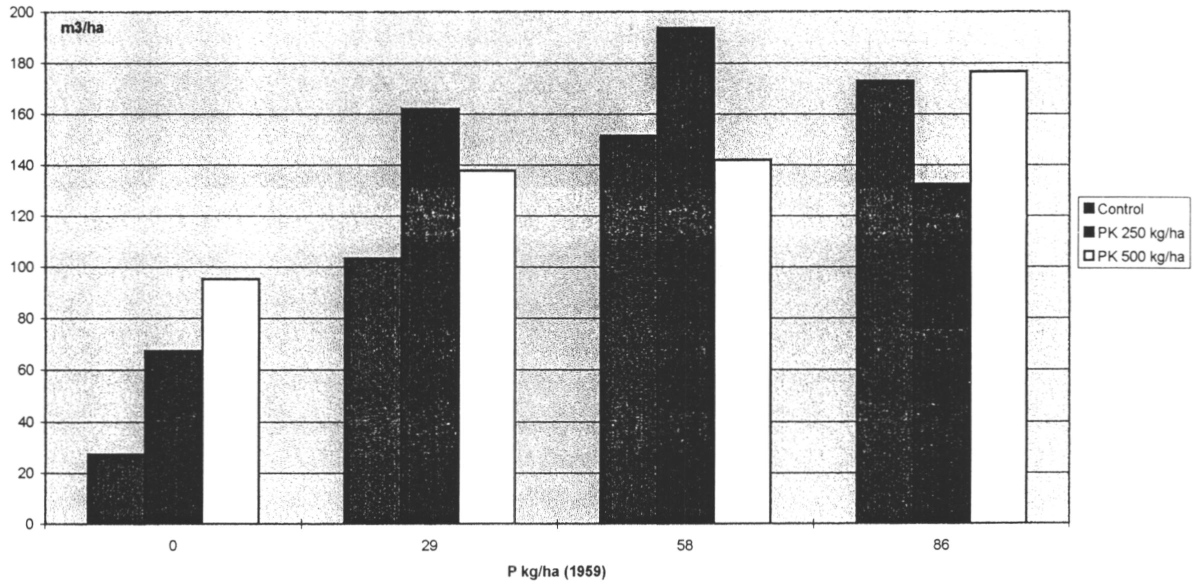


Fig.5b. **Annual mean yield of Scots pine at ascending phosphorus levels and different refertilizations (1974), Kivisuo I, 1959-98**

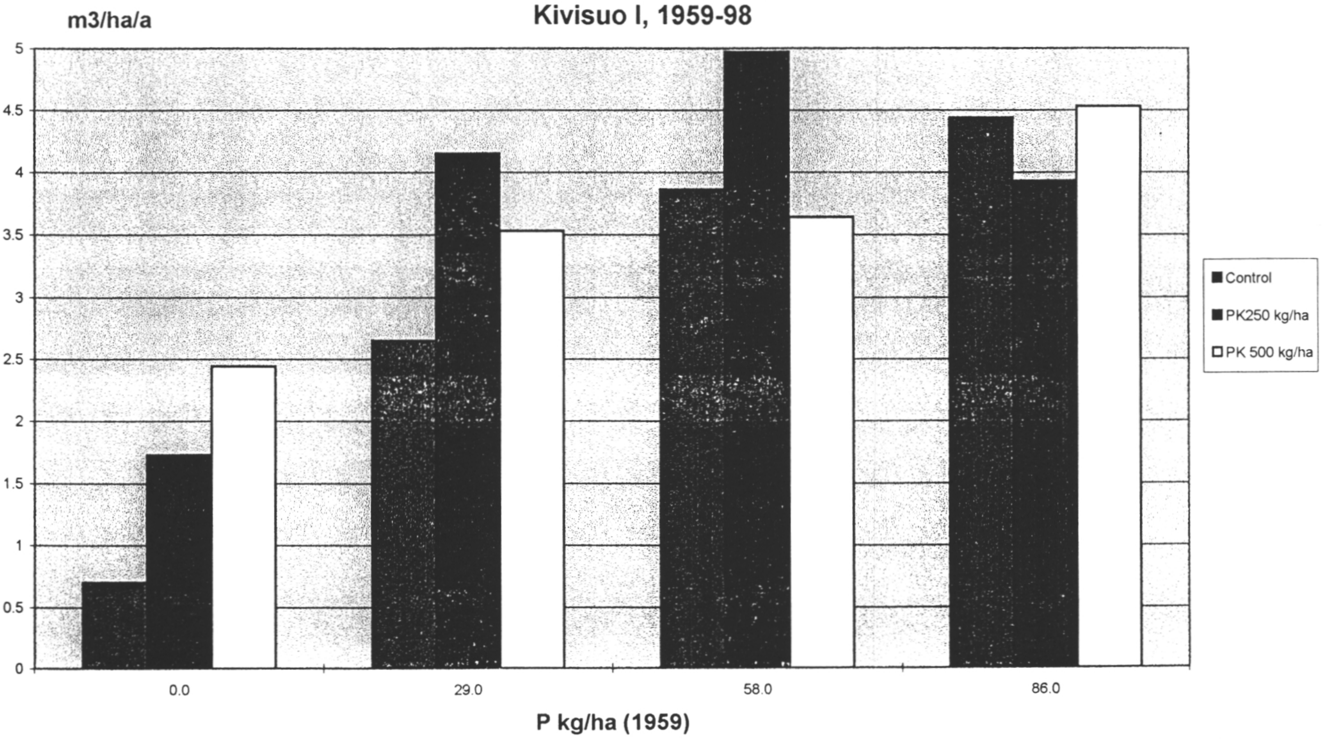


Fig. 5c. Effect of phosphorus level on the P concentration of pine needles,Kivisuo I, plots 62-65, March 1998

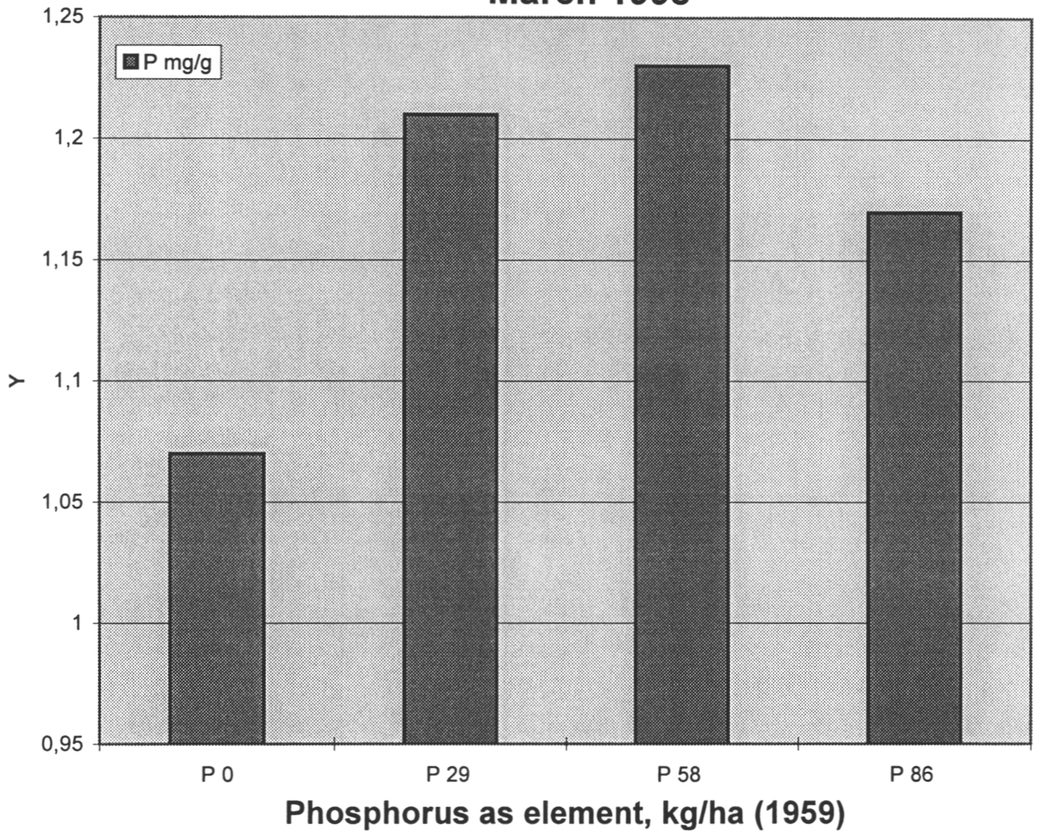


Fig 5d. Effect of fertilization (P=superphosphate) on the vitality of Scots pine, Kivisuo VI

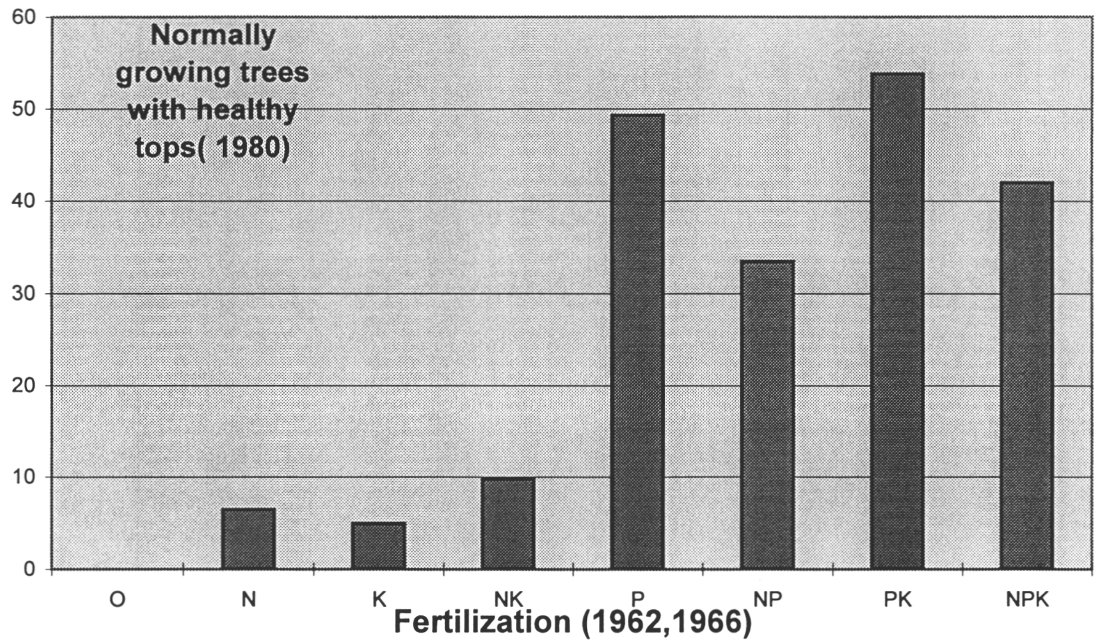


Fig.6. Factorial mean effects of micronutrient fertilization on the annual growth after 2nd treatment, Kivisuo II

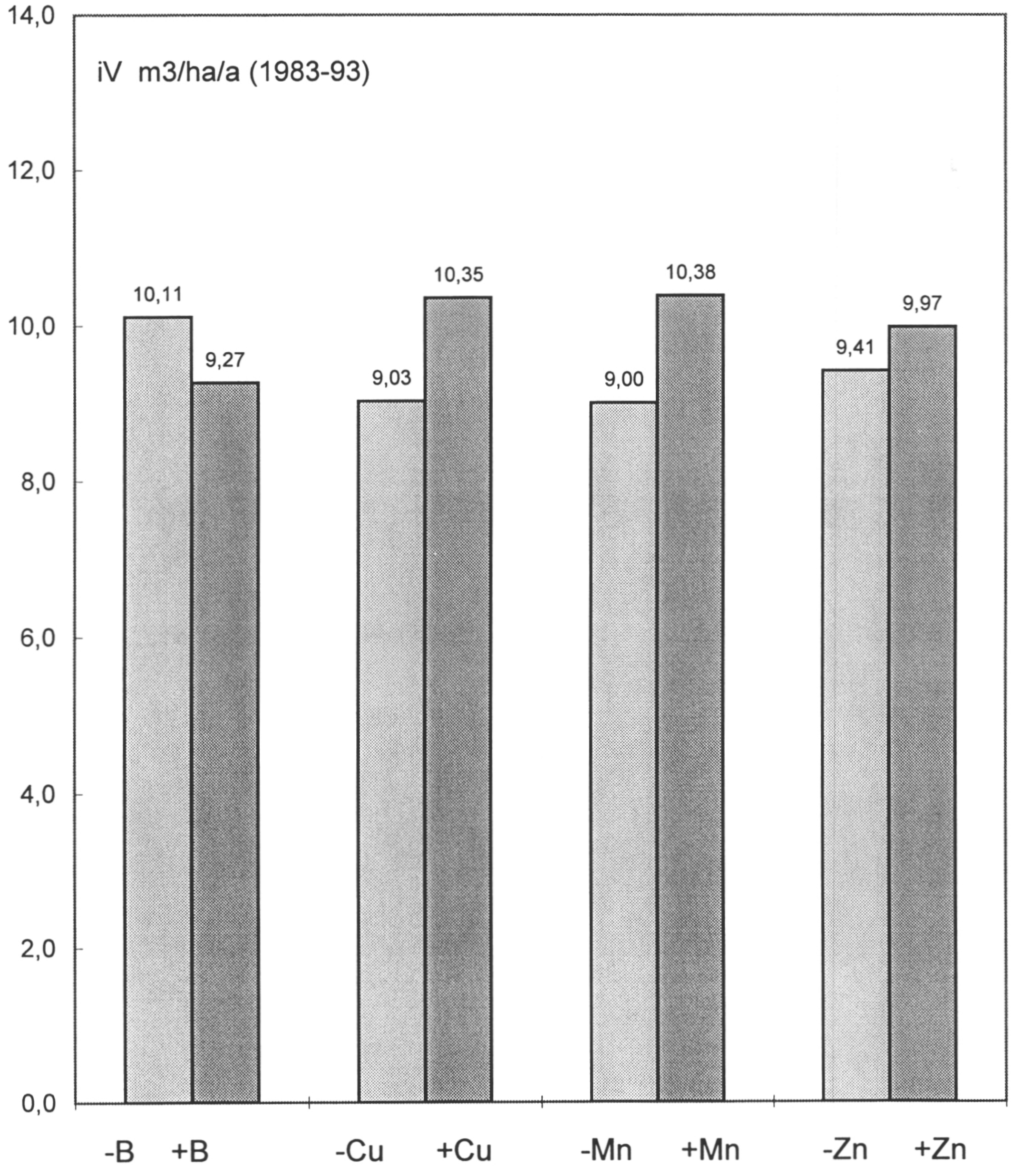


Fig.7a. Effect of different P-fertilizers on the yield of Scots pine, Kivisuo IV (no refertilization)

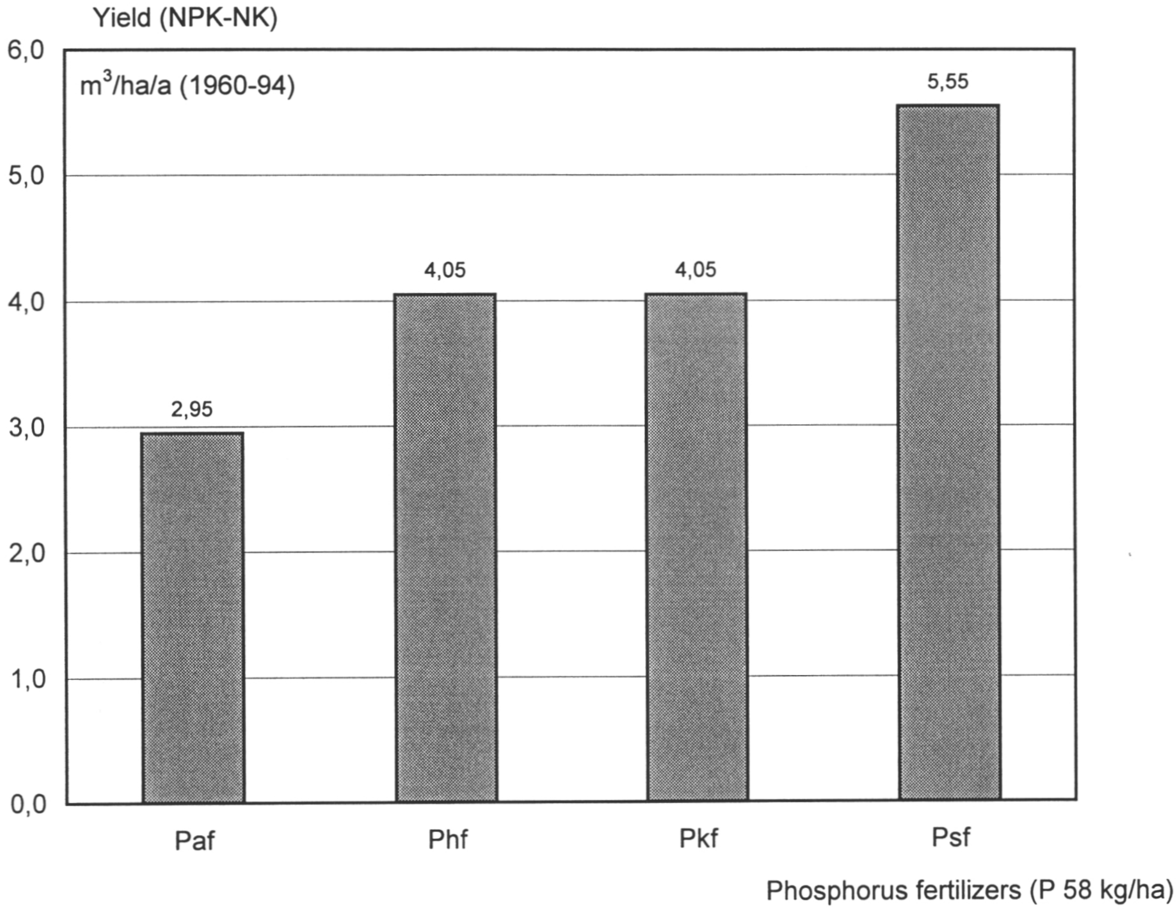
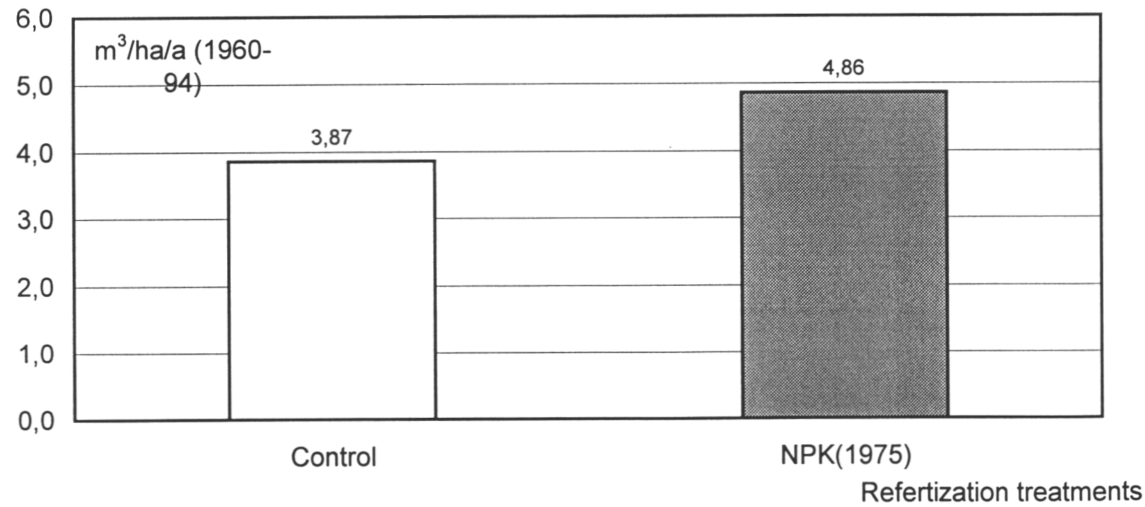


Fig. 7 b. Effect of refertilization on the yield of Scots pine, Kivisuo IV P



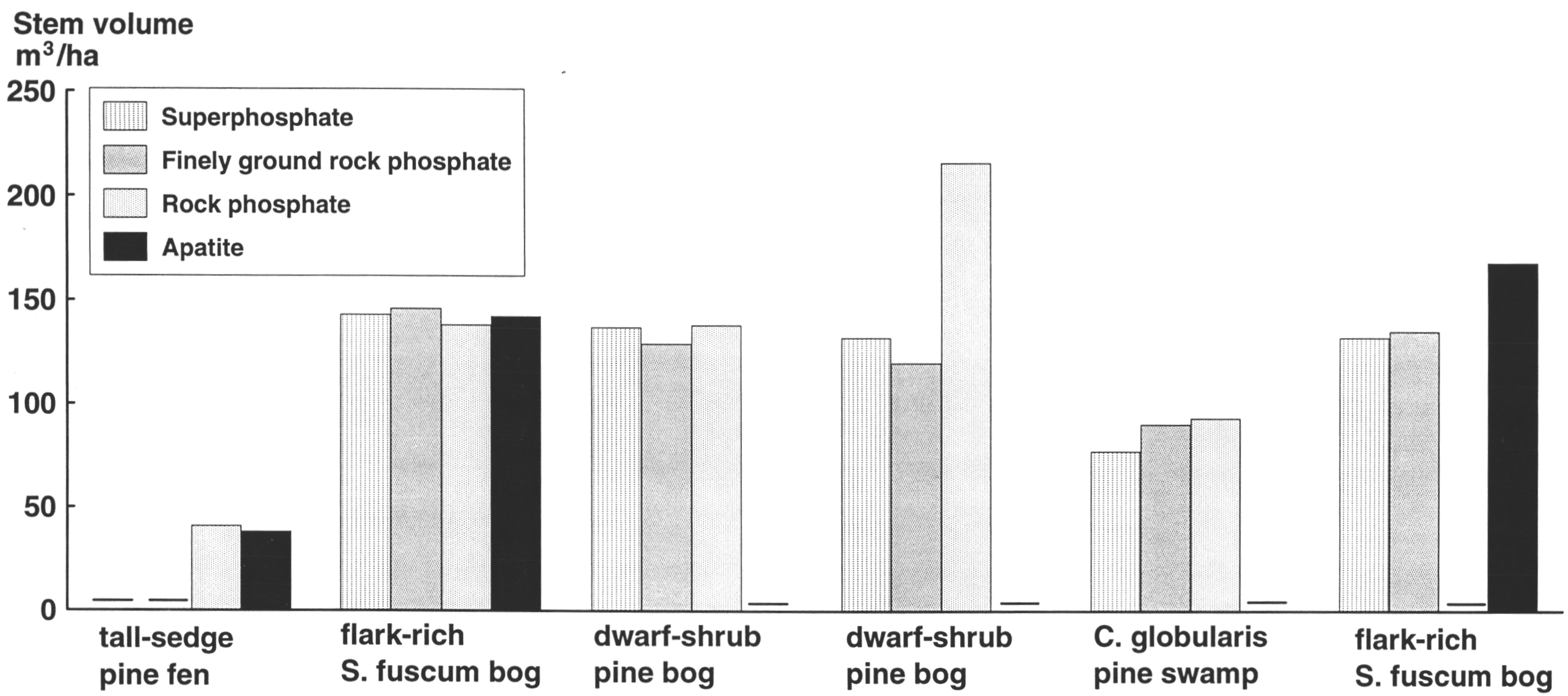


Figure 7c. Stem volumes for different P-fertilizer (P 44-66 kg/ha) treatments. In the individual experiments the amounts of N, P and K are the same. Years since fertilization 15-32 years.

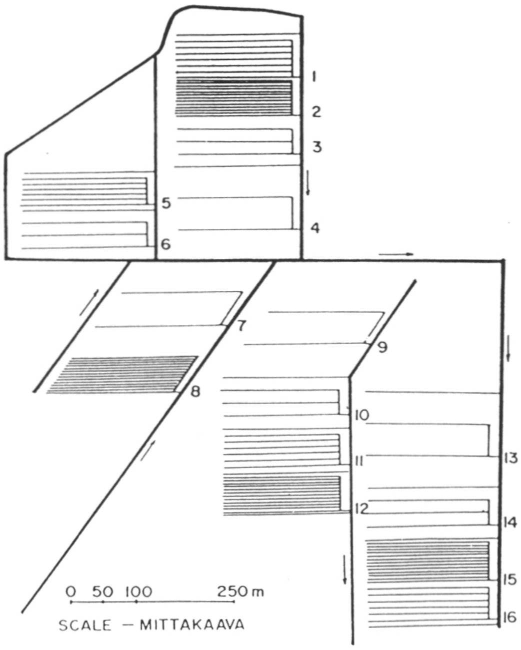


Fig. 8a. The experimental layout at Kivisuo. Areas 1-16. Fertilization: Areas 2, 3, 5 and 7; application on snow 9. - 13.3.1987, areas 1, 4, 6 and 8; application on bare ground 19. - 20.5.1987. Areas 9-16 not fertilized. Ditch spacing: 5, 10, 20 or 50 meters. Ditch depth: areas 1-4 and 13-16 0.8 meters; areas 5-12 0.4 meters.

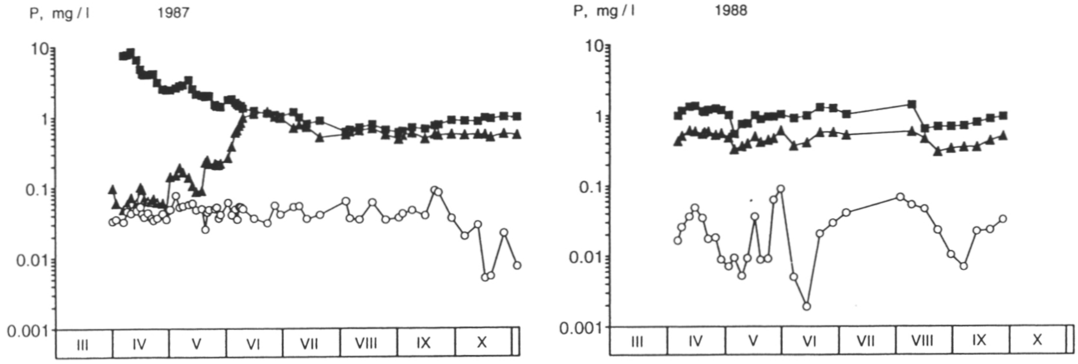


Fig. 8b. P concentration of runoff water in 1987 and 1988 in Kivisuo. Logarithmic scale. Fertilization: 9. - 13.3.1987 (■) and 19. - 20.5.1987 (▲). Control (○).

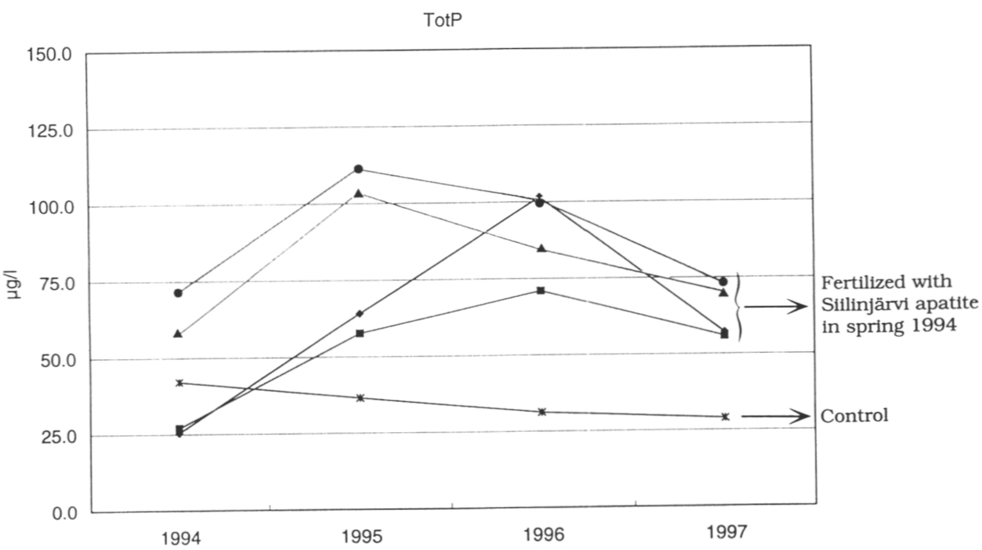


Fig. 8c. Runoff P concentrations in 1994 - 1997 in Liesineva.

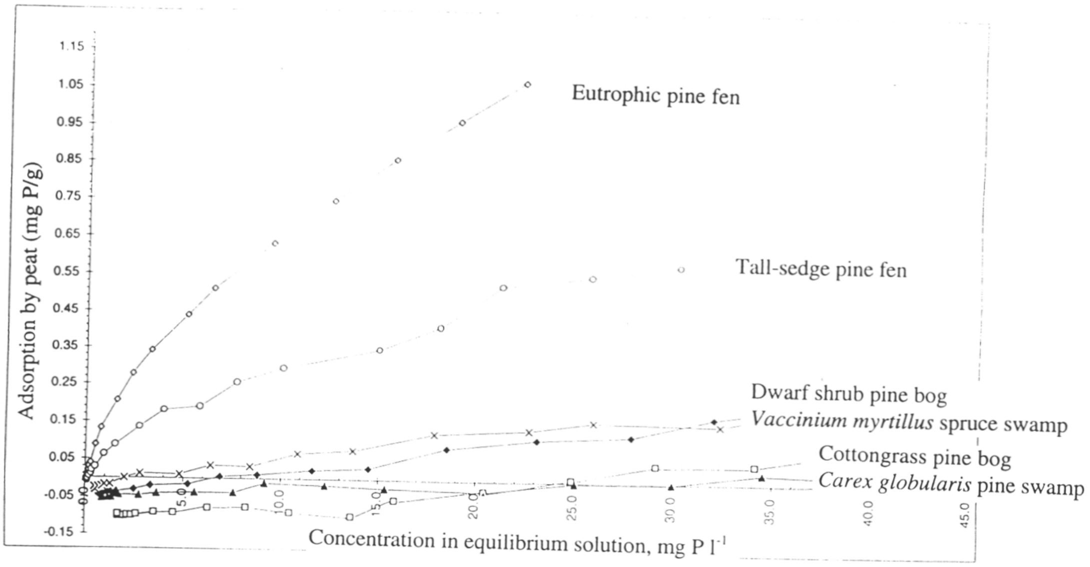


Fig. 8d. Phosphorus adsorption isotherms for some peat soils.

Significance level: $^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$

	PSI	
	0–15 cm	15–30 cm
Site quality index	0.216	0.363
pH	0.486*	0.561**
Ash content	0.413	0.292
Fe_{tot}	0.859***	0.935***
Fe_{ox}	0.901***	0.901***
Al_{tot}	0.197	0.297
Al_{ox}	0.233	0.193
Ca_{tot}	−0.117	0.009
Mg_{tot}	−0.211	−0.049

Table 8a. Correlation coefficients between phosphorus adsorption index (PSI) values and site quality index and some peat properties for the 0-15 cm and 15-30 cm peat layers (n = 20)

Fig. 9a. Effect of two potassium sources on the yield of Scots pine, Kivisuo IV. Basic fertilization: N100+P58 kg/ha (1961). Refertilization (1976) had no significant effects.

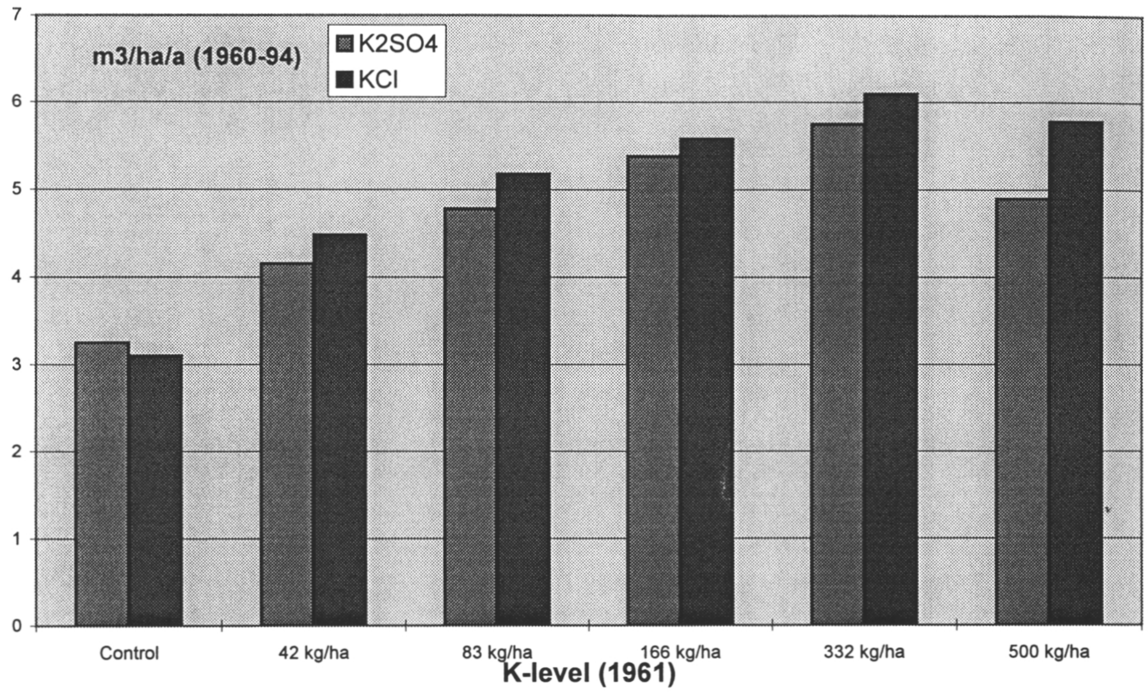
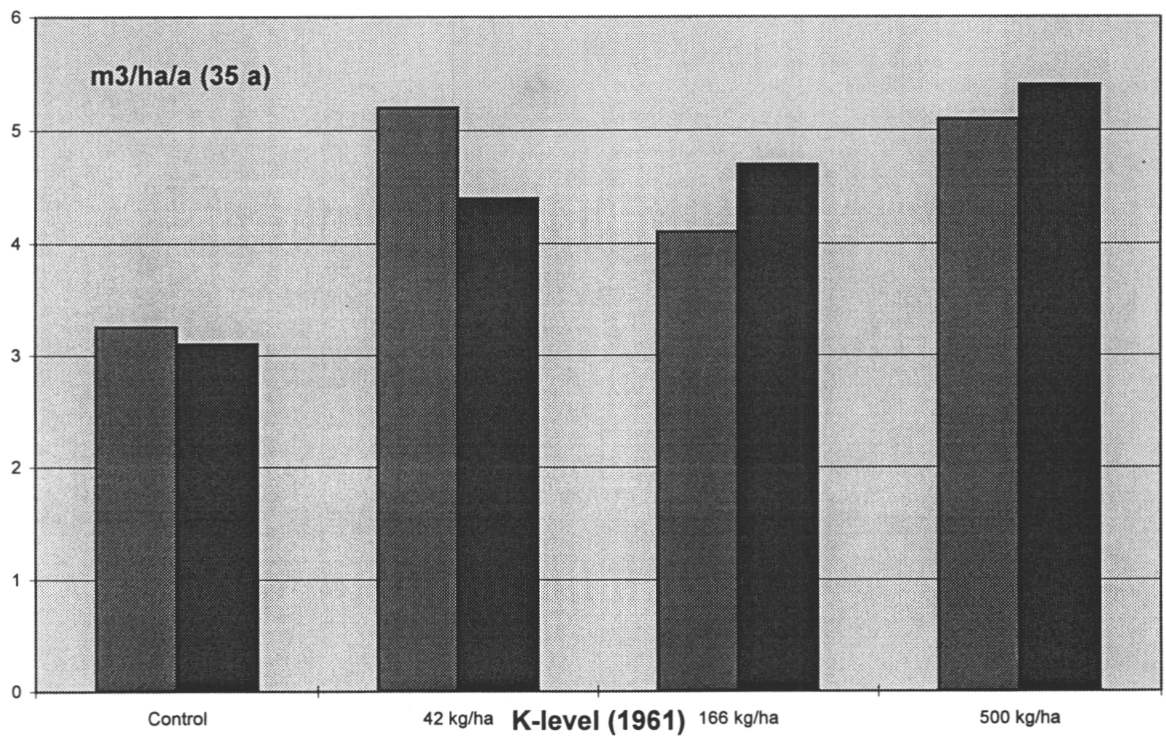


Fig.9b. Effect of two potassium fertilizers on the yield of Scots pine, Kivisuo IV. Basic fertilization: N100+ P58 kg/ha. No refertilizations, no replications (except for control plots n=2)



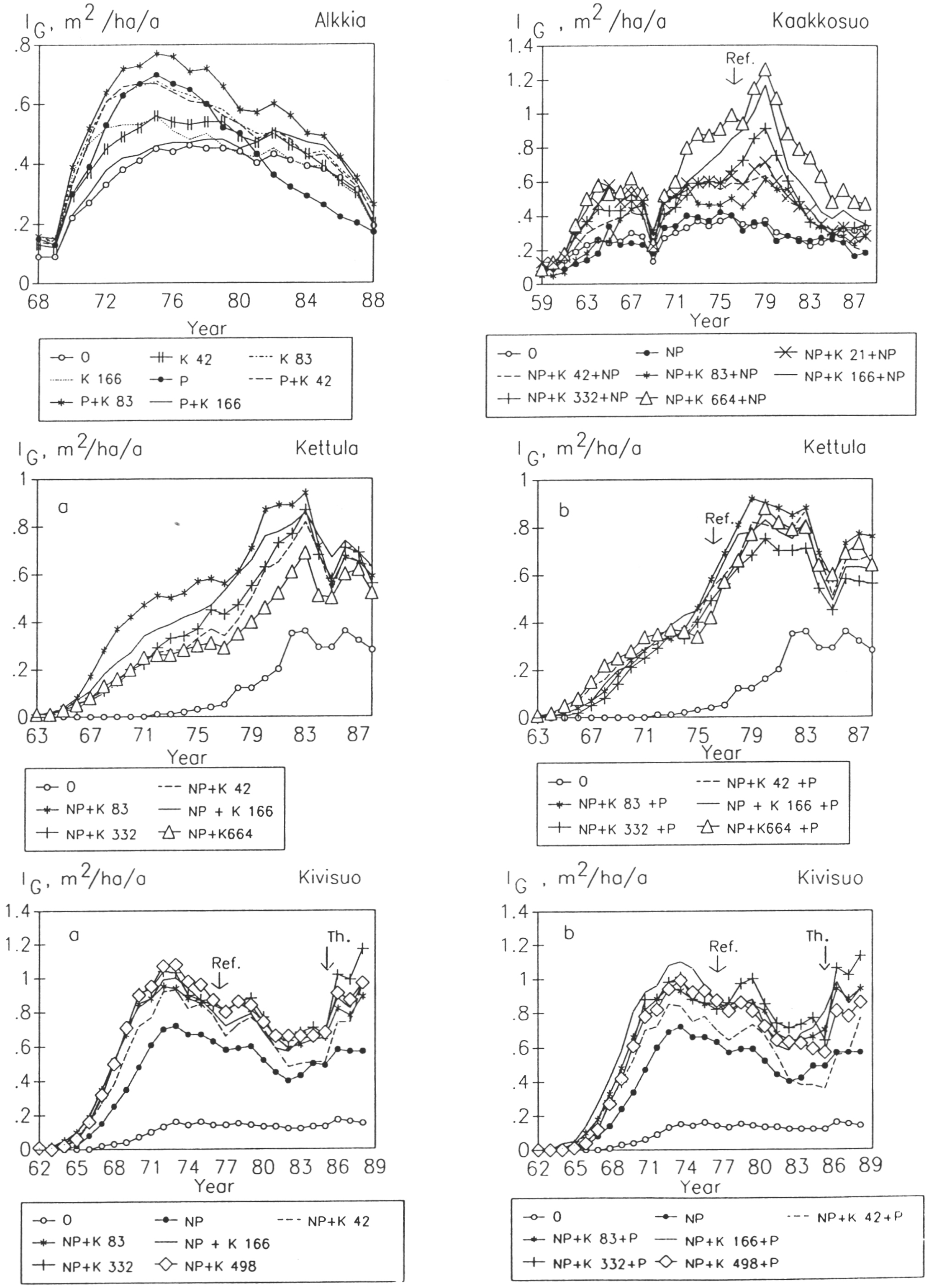


Fig.10. (Right) Effect of the fertilizer rate on the annual basal area increment in the experiments. The fertilization year was 1969 in Alkkia, 1961 in Kettula and Kaakkosuo and 1960 in Kivisuo. Refertilization (Ref.) in 1976 in Kaakkosuo, Kettula and Kivisuo. In Kettula Fig. a includes the unrefertilized 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 or micronutrients or both. Th. = thinning in winter 1984–85. [redacted]

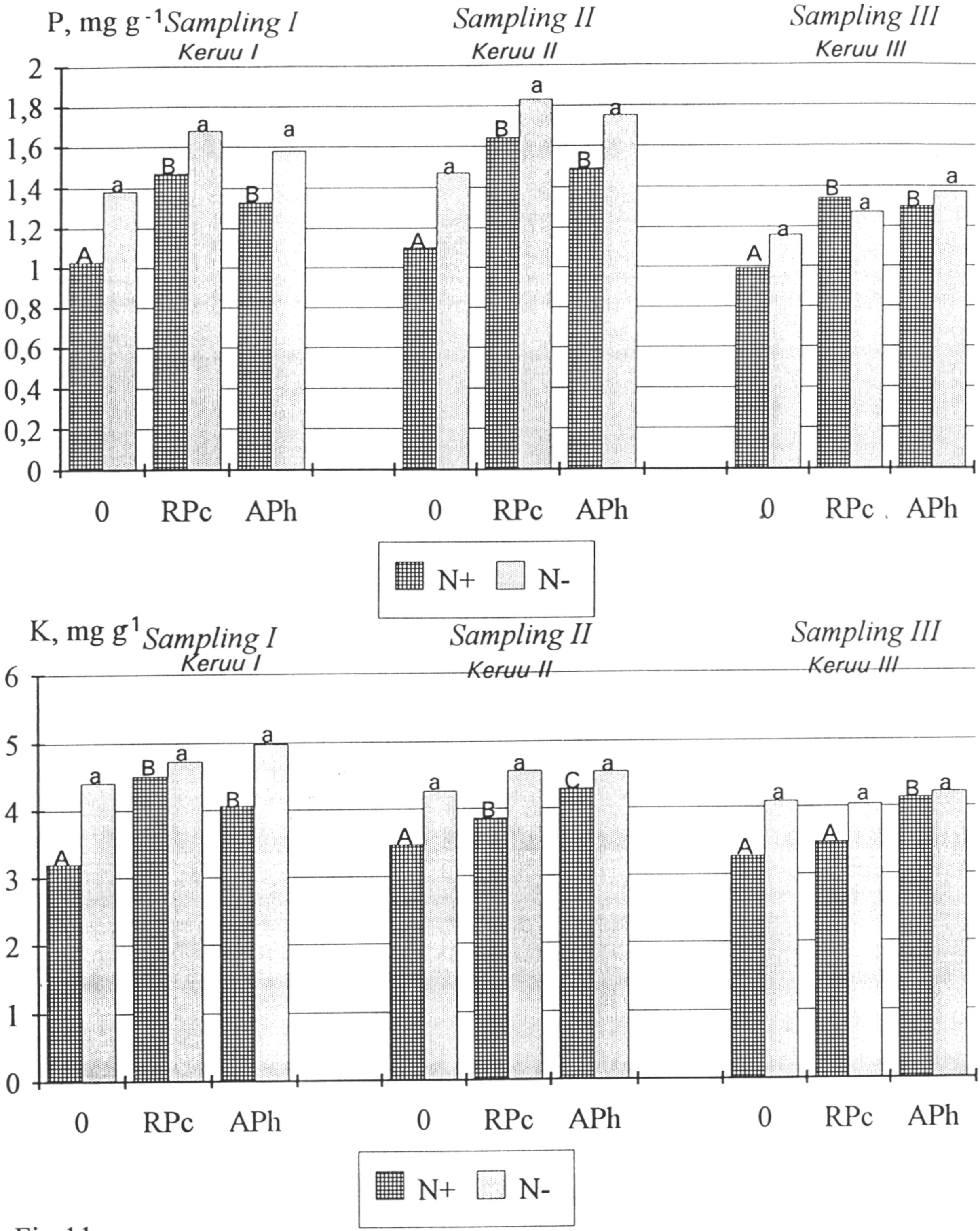


Fig.11.

Phosphorus and potassium concentrations in pine needles by collecting times and fertilization treatments. Means of the experiments. Sampling I = 5-7 years, Sampling II = 11 - 14 years, Sampling III = 16 - 19 years after fertilization. N+ = nitrogen-rich site types (Exps 2, 4 and 9; n=27), N- = nitrogen-poor site types (Exps 1 and 3; n=21). 0 = control, R= rock phosphate, A = apatite, Pc = potassium chloride, Ph = phlogopite. The columns indicated with the same letter do not differ from each others within the same group and sampling time (Bonferron, p-value > 0.05).

Fig.12a. Mean ground water level at Kivisuo I (n= 208)

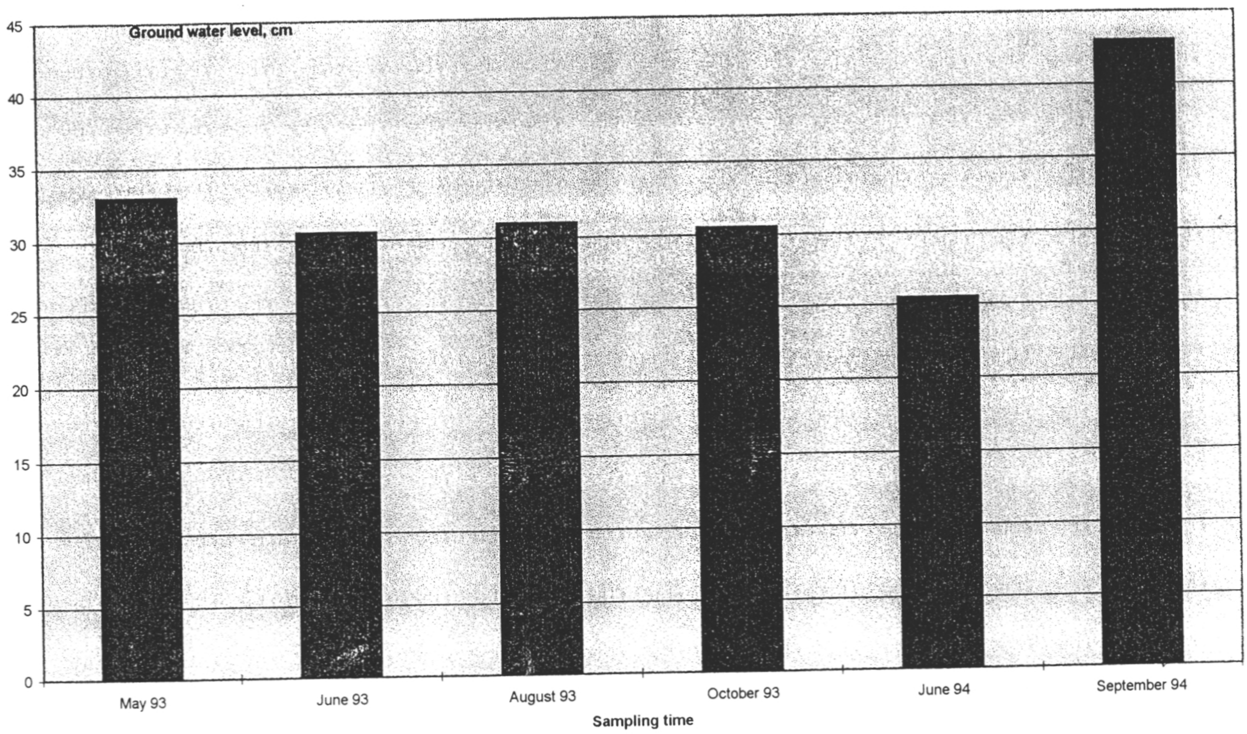


Fig12b. Regression between ground water level (Sept. 1994) and stand volume (1993), Kivisuo exp. I,

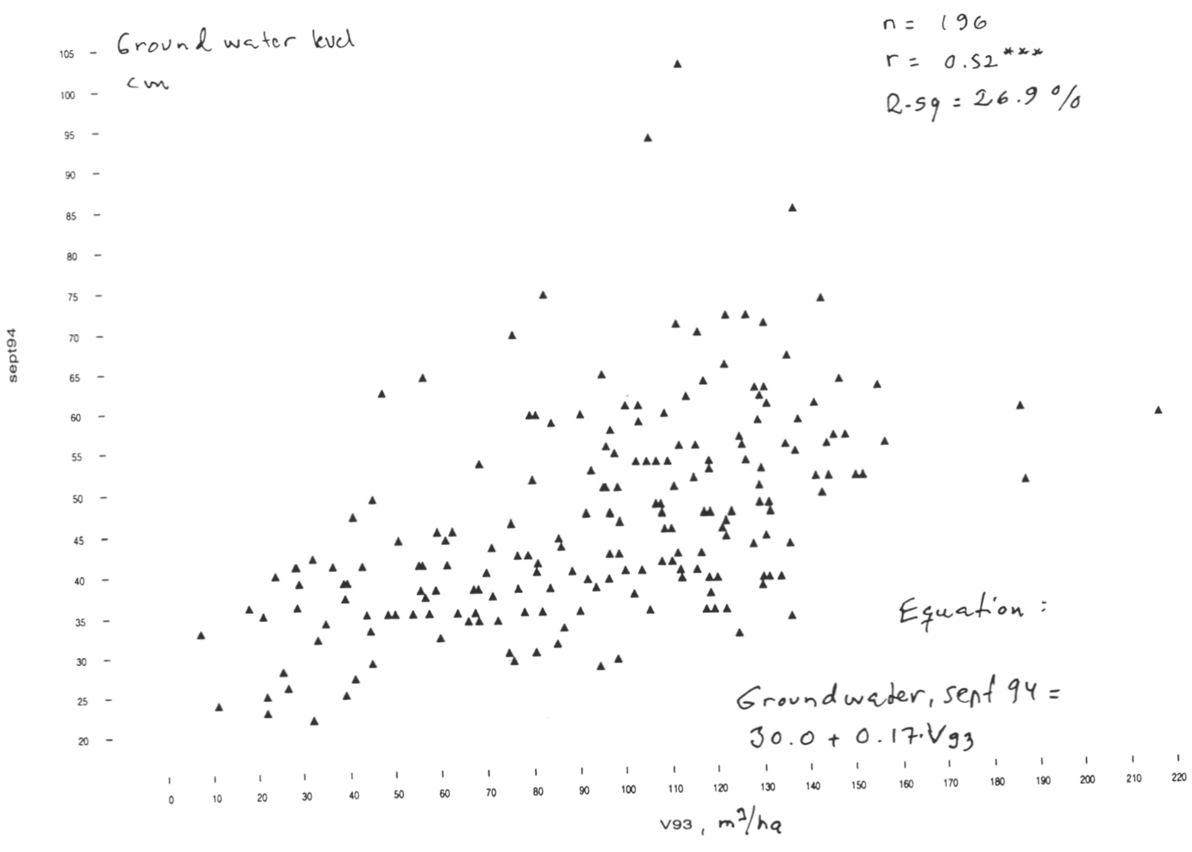


Fig.13a. Lowering of ground water level, when the volume of pine stand increases from 50 to 100 m3/ha, Leivonmäki, Kivisuo, Exp.I

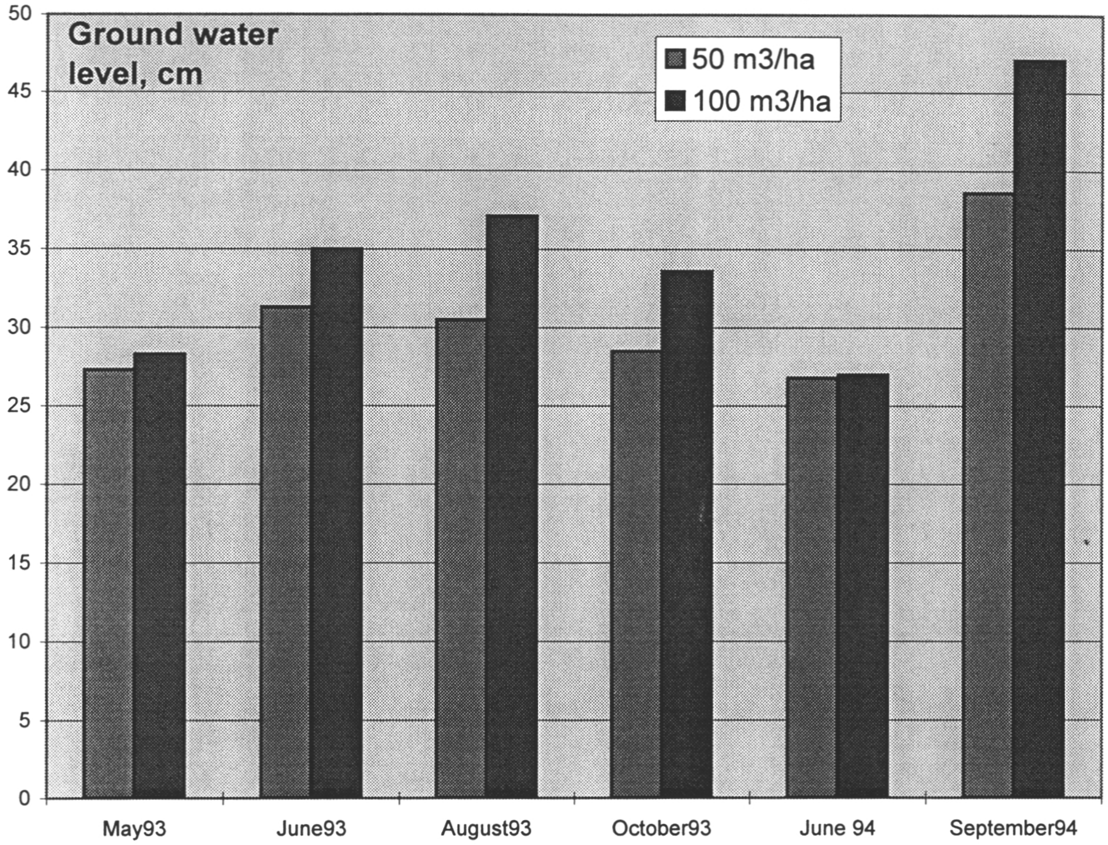


Fig. 13 b. Lowering of ground water level, when pine stand increases from 50 to 100 m3/ha, Leivonmäki, Kivisuo, Exp.I

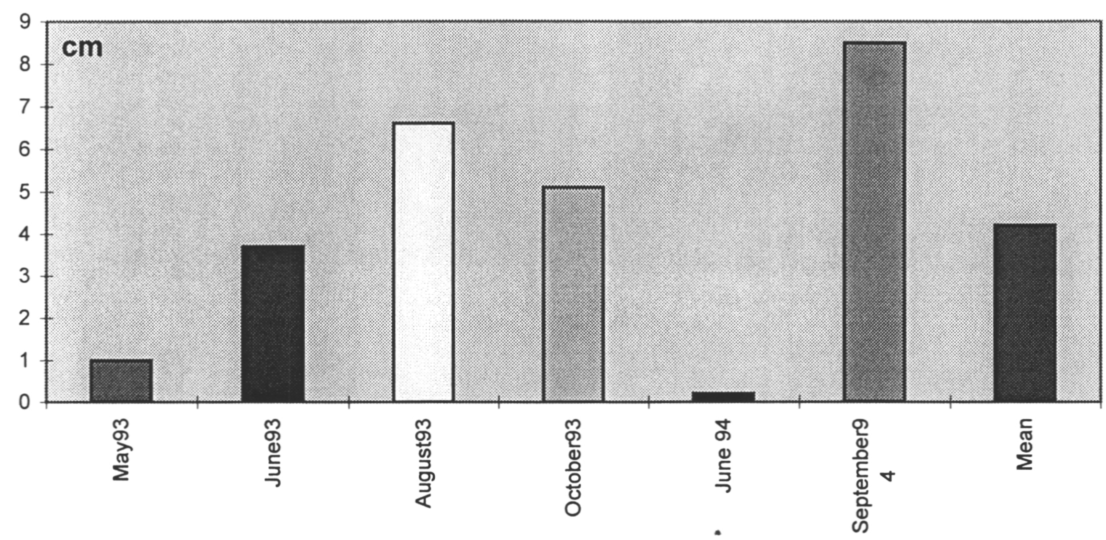


Fig. 14a. Effect of fertilization on the ground water level?

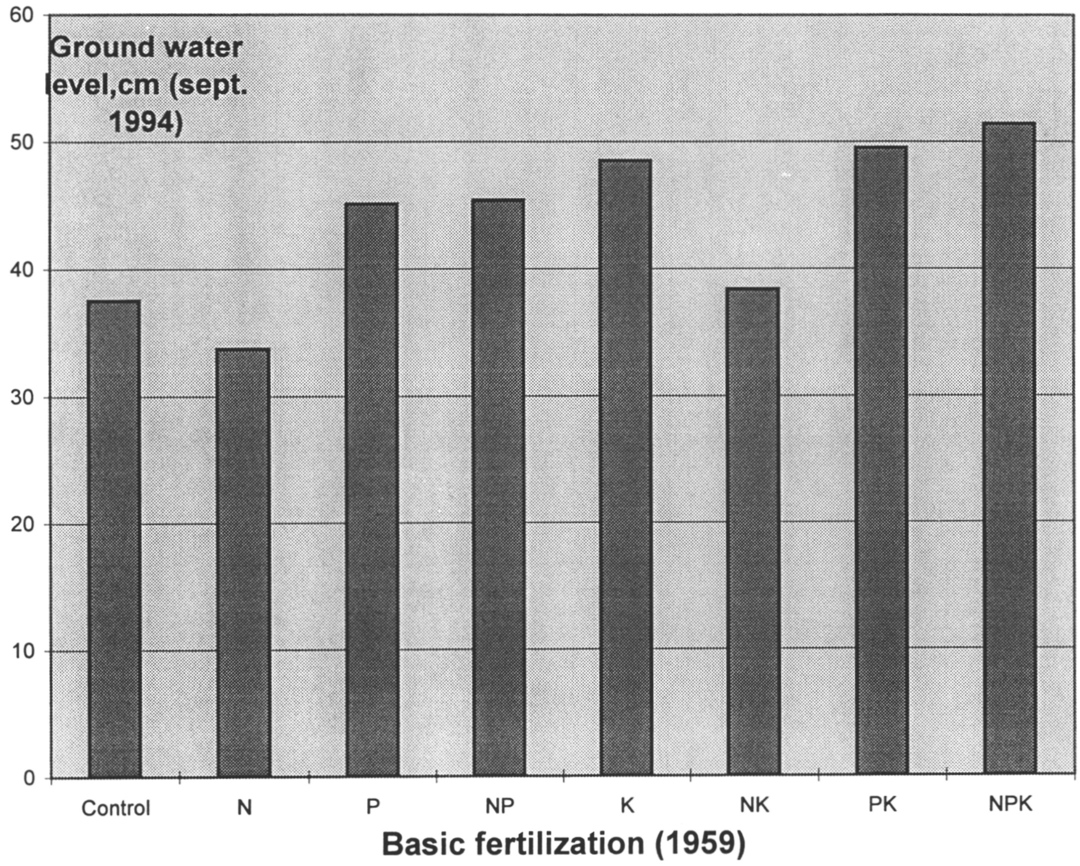
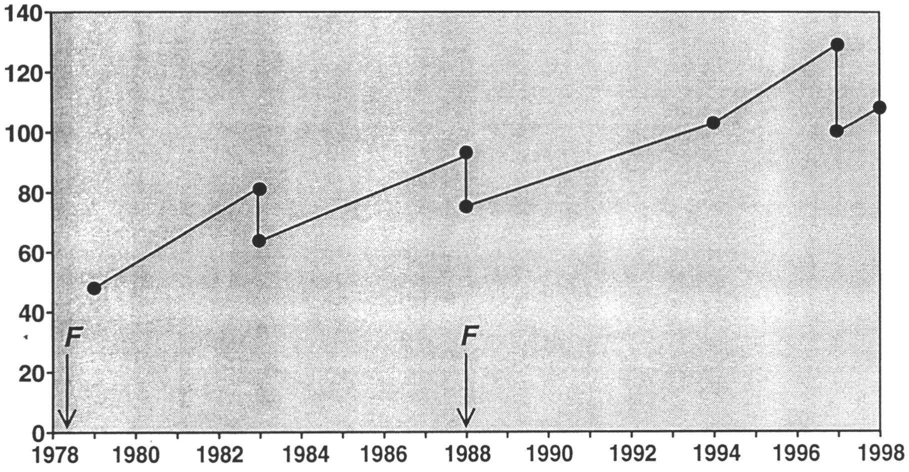


Fig.15 a-c. ***KIVISUO, Exp. XVIII***

- **Birch stand (mostly B. pubescens), naturally regenerated, age 42 years.**
  Mean volume increament (iV) = 4,2 m^3/ha/a

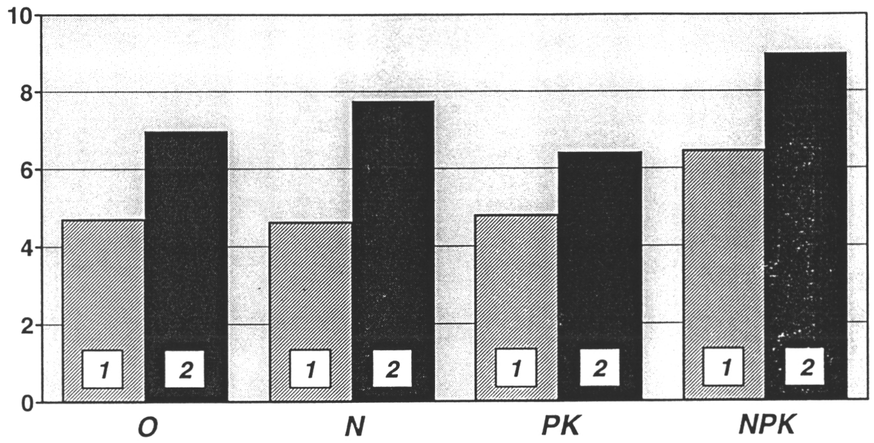
a. DEVELOPMENT OF THE STAND (MEAN OF THE PLOTS) AND THINNINGS



SITE: Mtkg II (Old Vaccinium myrtillus peatland forest)
PEAT LAYER: 1,0 - 1,3 m
DRAINAGE IN 1945 -47
THE AIM OF THE EXPERIMENT:
- Fertilization of young B. pubescens stand
- Natural regeneration of spruce

TOTAL STAND VOLUME 1997					REMOVAL			STAND LEFT				
PLOT	N	G	V1	iV 1994-97	N	G	Vr	N	G	V2	H,dom	D 1,3
		m2/ha	m3/ha	m3/ha/a		m2/ha	m3/ha		m2/ha	m3/ha	m	cm
2. O	732	15,7	131,0	7,0	213	3,5	28,0	518	12,3	103,1	19,7	18,2
4. N	732	14,8	124,7	7,8	220	3,6	28,3	512	11,2	96,4	19,9	17,2
1. PK	732	14,2	111,1	6,4	207	3,1	22,8	524	11,1	88,3	18,4	17,0
3. NPK	732	14,8	124,6	7,8	220	3,6	28,3	512	11,2	96,4	19,9	17,2

b. MEAN GROWTH 0-6 YEARS (1) AND 7-9 YEARS (2) AFTER REFERTILIZATION TREATMENT



c. TOTAL YIELD, REMOVAL AND THE STAND VOLUME IN 1997

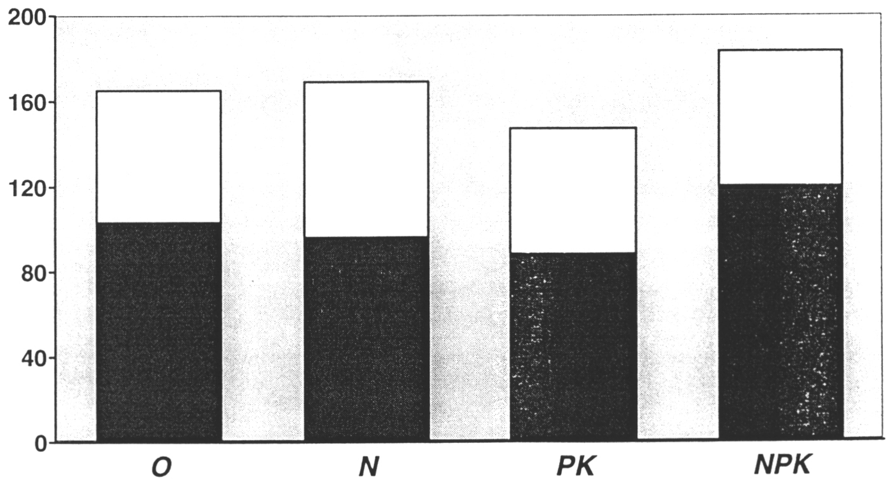


Fig. 15d. Effect of N, P and K fertilization on the volume growth of silver birch, Kivisuo VI

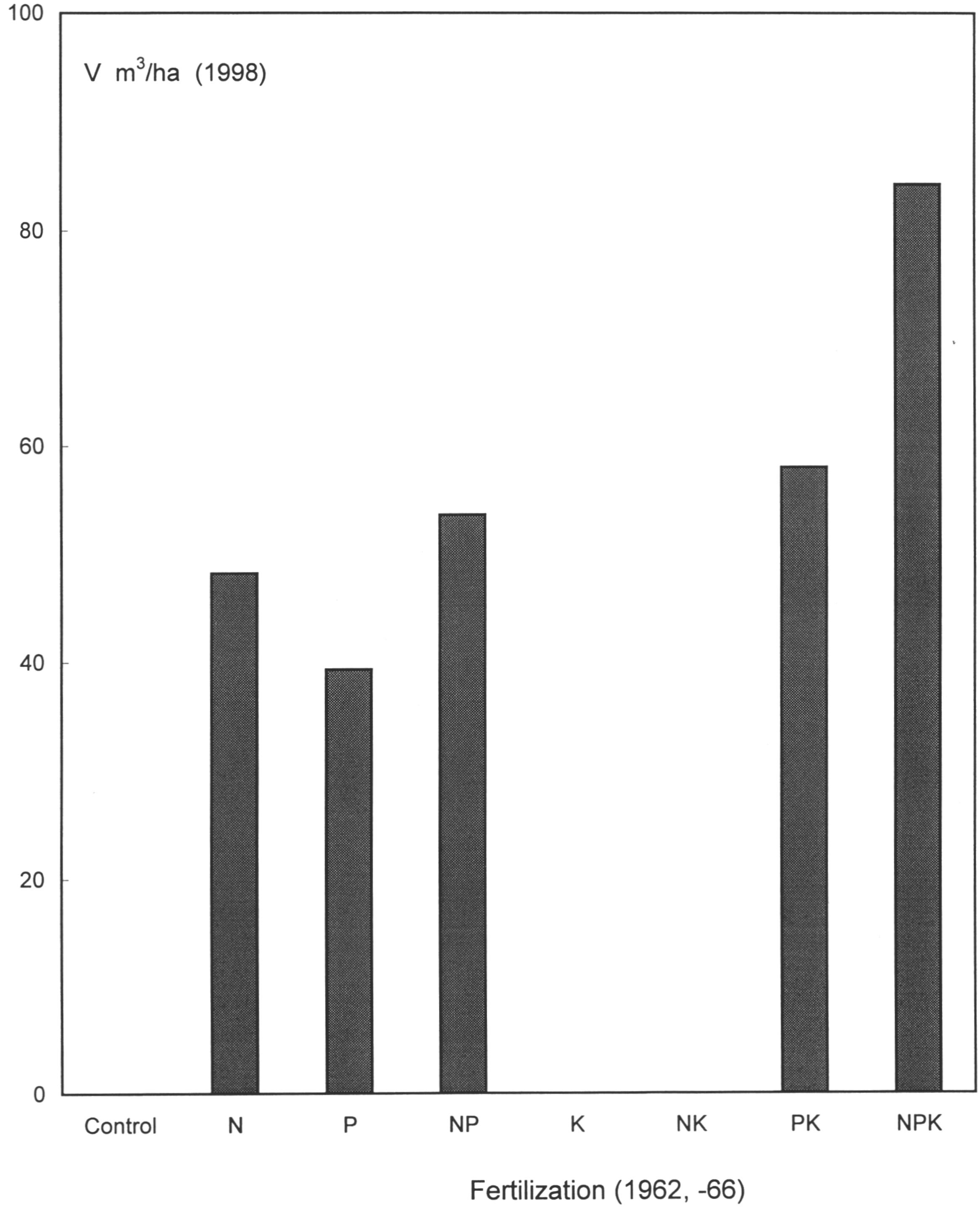


Fig. 16a-c. Effect of fertilization treatments on the number,height and diameter of spruce seedlings under birch stand, Kivisuo XVIII (1998)

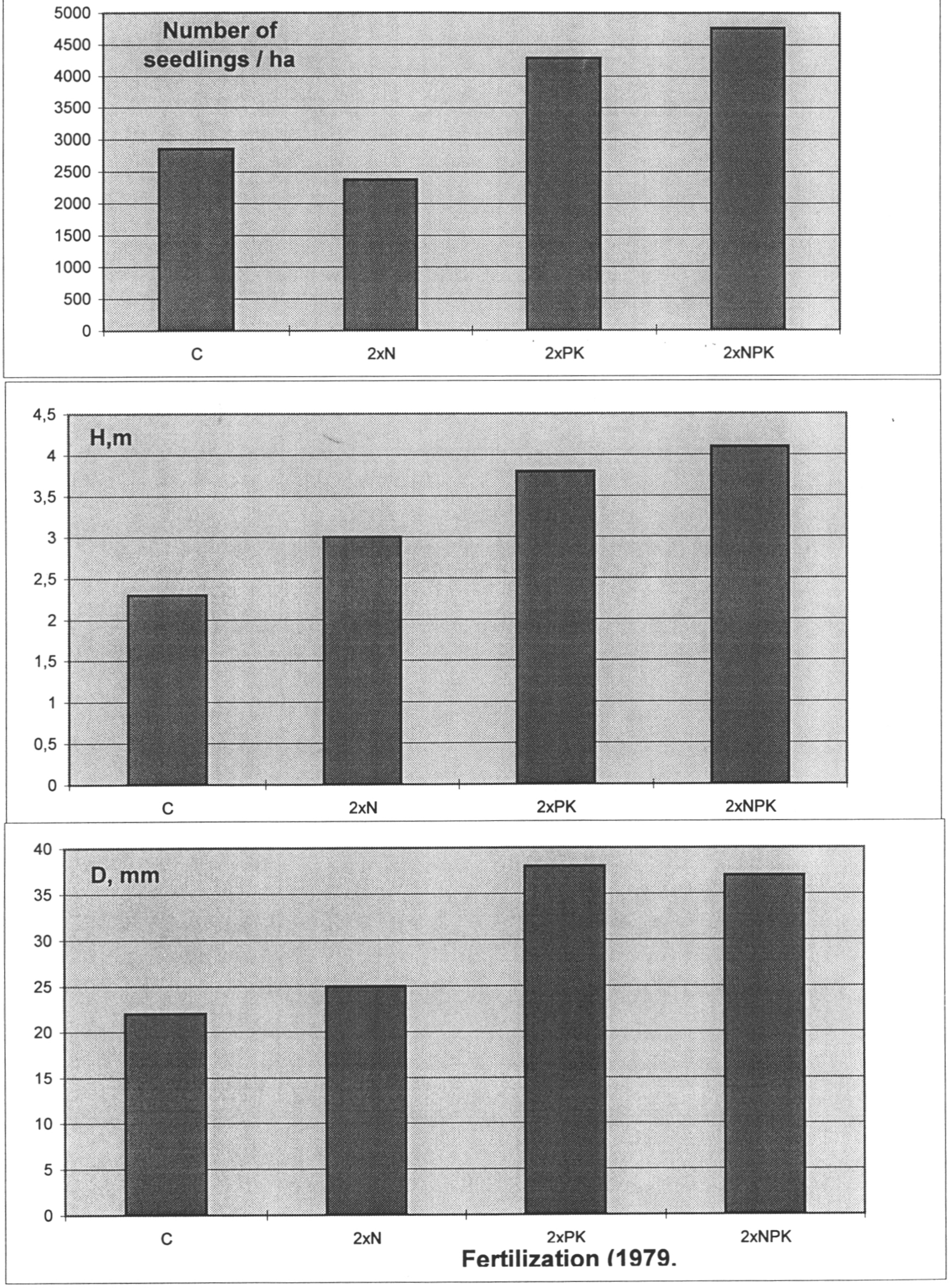


Fig.17a. Effect of two fertilizations on the volume growth of an old spruce stand, Kivisuo 22

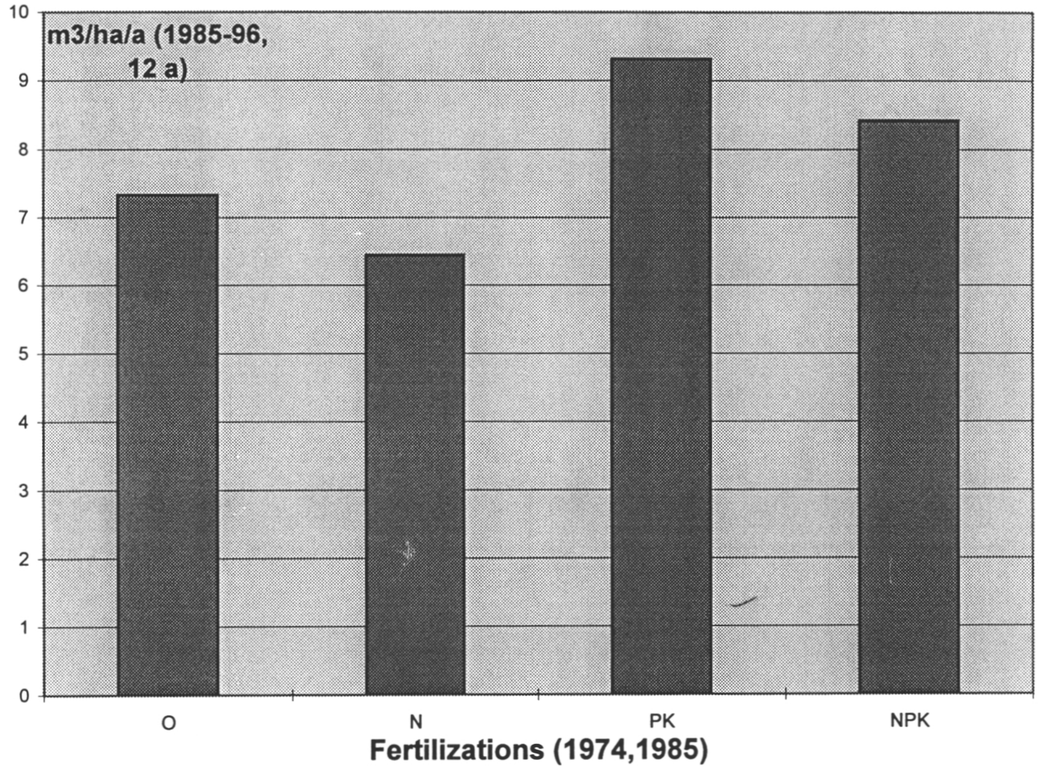


Fig. 17b. Comparison of factorial mean effects of N and PK on the spruce growth, Kivisuo 22

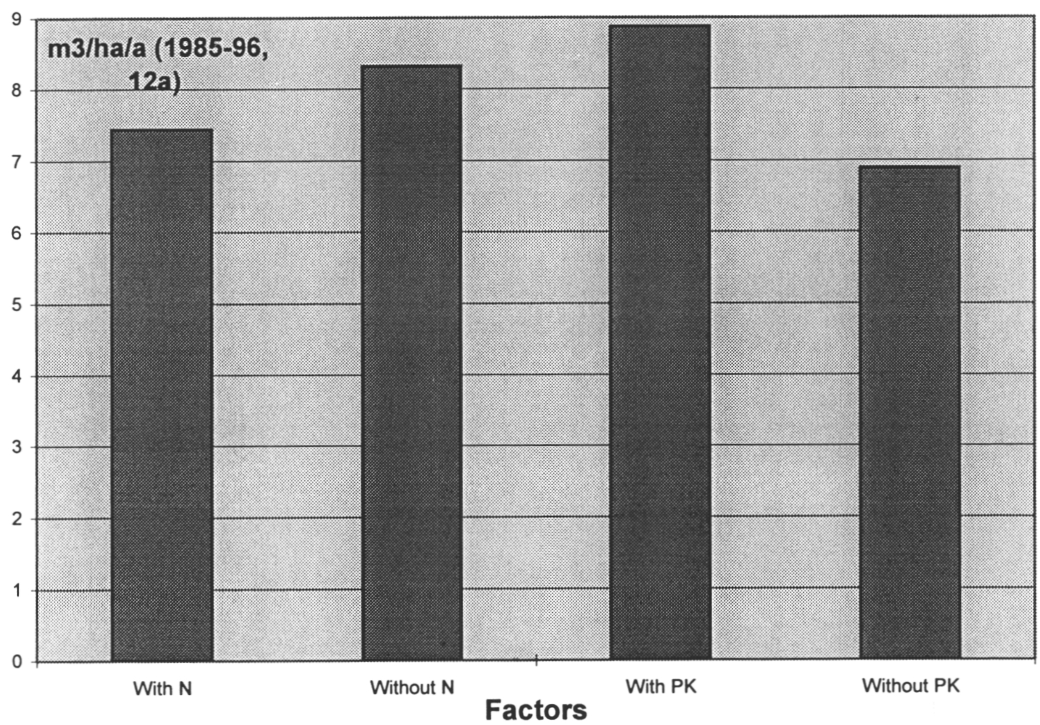


Fig.18. Ntot in the peat of control plots at some experiments,Kivisuo 1996 and 1998 (Point 2), surface humus

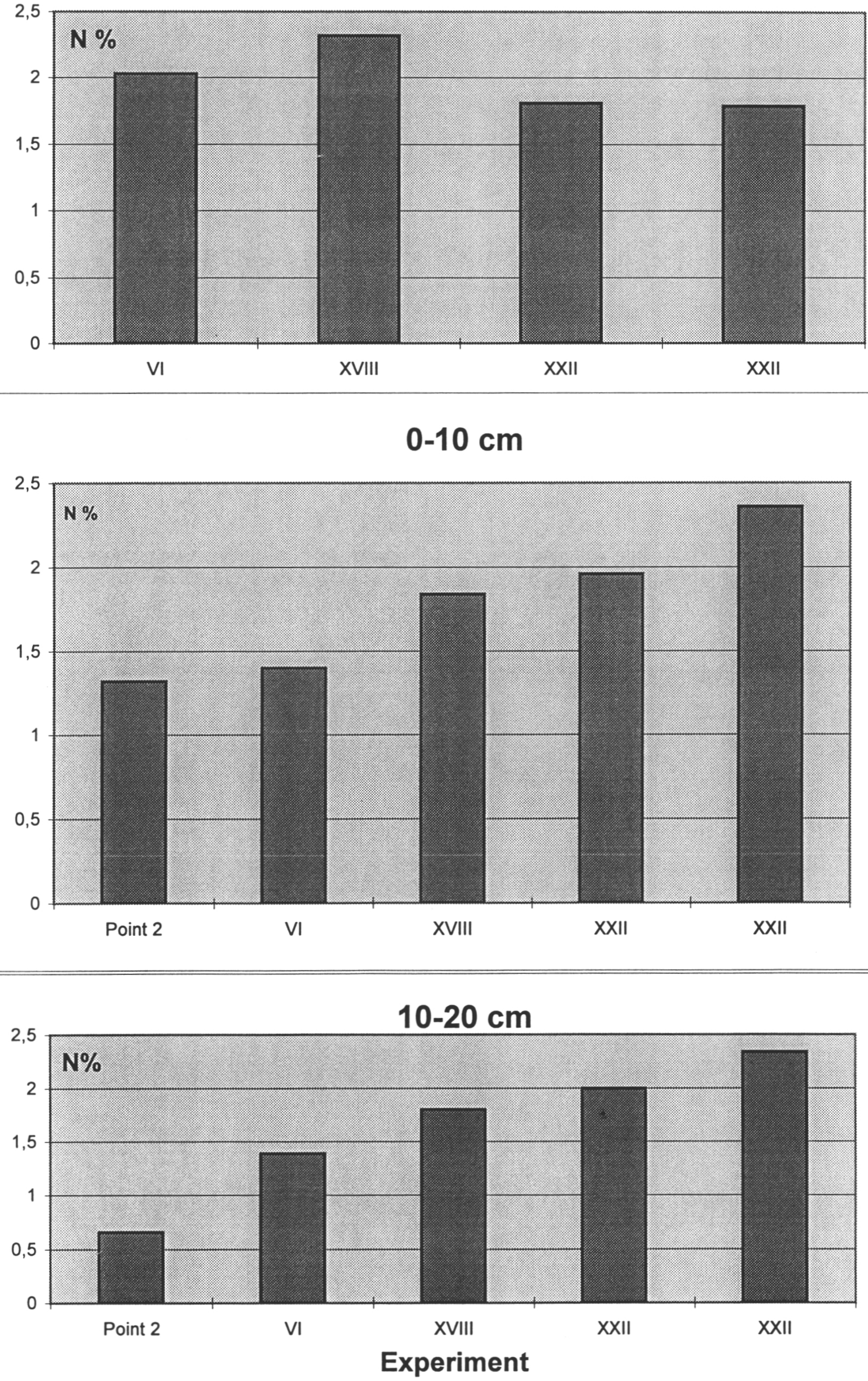


Fig19.Total phosphorus,calcium and iron concentrations in the peat (0-10 cm) of some control plots, Kivisuo experiments

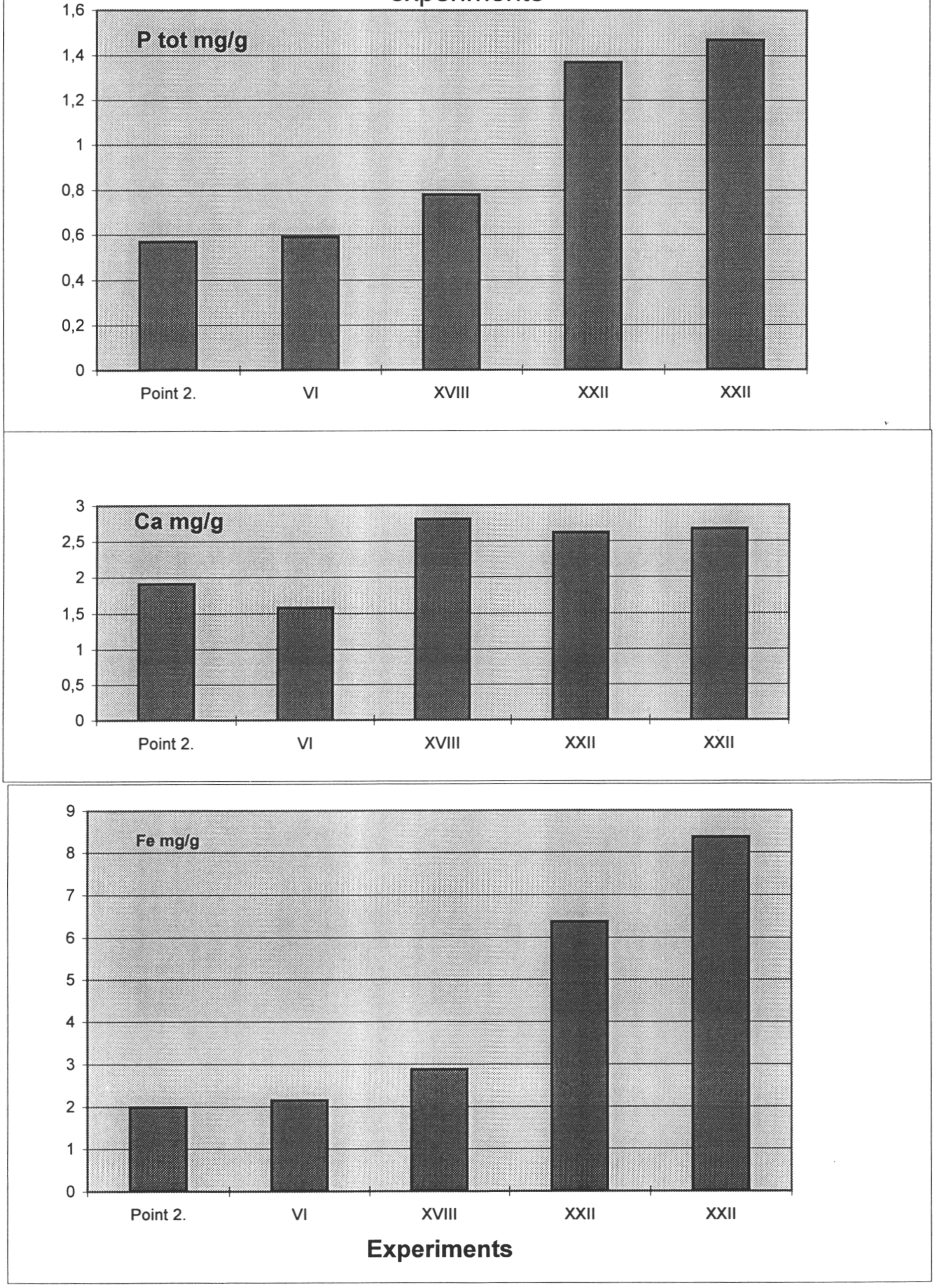


Table 1. Some macronutrient concentrations of pine and spruce needles,
Kivisuo, March 1998

Experiment	Treatments	N %	P mg/g	K mg/g	DM mg/needle	Tree sp.
I	P 0	1,46	1,07 •	4,45 ∘	20,4	Pine
I	P 29 kg/ha	1,61	1,21 •	4,23 ∘	27,8	Pine
I	P 58 kg/ha	1,85 +	1,23 •	4,37 ∘	20,9	Pine
I	P 86 kg/ha	1,49	1,17 •	2,87•	18,2	Pine
IV	NK+Psf	1,96 +	1,10 •	3,39 •	21,4	Pine
IV	NK+Phf	1,45	1,03 •	3,59 ∘	17,5	Pine
IV	NK+Pkf	1,71	1,36 ∘	3,99 ∘	21,3	Pine
IV	NK+Paf	1,39	1,13 •	2,80 •	17,6	Pine
IV	NK+Paf	1,61	1,00 •	3,77 ∘	24,6	Pine
IV	Psf	1,39	1,08 •	3,41 •	22,2	Pine
IV	Phf	1,54	1,22 •	2,84 •	16,2	Pine
IV	Phf	1,43	1,13 •	2,80 •	14,2 –	Pine
IV	Pkf	1,68	1,20 •	4,06 ∘	27,7	Pine
IV	Pkf	1,41	1,14 •	3,54 ∘	13,0 –	Pine
IV	Paf	1,43	1,43 ∘	3,45 •	24,2	Pine
IV	Paf	1,45	1,28 •	3,02 •	16,3	Pine
VI	Control	1,43	0,97 •	4,18 ∘	11,5 –	Pine
VI	Control+ wood ash	1,63	1,33 ∘	4,73	27,7	Pine
VI	Psf 350	1,32	1,19 •	3,33 •	18,5	Pine
VI	Psf 350+ wood ash	1,50	1,36 ∘	4,39 ∘	21,1	Pine
VI	NK+Psf 700	1,48	1,41 ∘	4,63	22,6	Pine
VI	NK+Psf 700+Ca	1,37	1,30 ∘	3,28 •	22,8	Pine
XVIII	Control	1,63	2,09 ∘	9,75	3,52	Spruce
XVIII	N+N	1,46	2,04∘	11,04	3,98	Spruce
XVIII	PK+PK	1,64	3,19	12,78	4,32	Spruce
XVIII	NPK+NPK	1,78	3,46	12,98	4,08	Spruce

<u>**Interpretation and treatments:**</u>

• = Severe deficiency ∘ = Mild deficiency
– = Low + = High

Experiment	1 st treatment (year)	2nd treatment (year)	3rd treatment
I	Phf -levels *(1959)	-	-
IV	P- species *(1961)	-	-
VI	Spot fertilization (1963)	Broadcast fert.(1966)	Wood ash (1980)
XVIII	N110-P35-K83 (1978)	N110-P50-K94 (1988)	-

Phosphorus species , all P 58 kg/ha (water solubility decreases downwards in the list):
Psf = Superphosphate
Pkf= "Kotka-phosphate", a mixture of Psf and Phf)
Phf= Finely ground raw phosphate (N- Africa)
Paf= Ammoniummetaphosphate

Table 2. Peat analysis results from some control plots of Kivisuo experiments

Exp.	plot	dom.tr.sp.	Layer	pH	N %	Pmg/g	K mg/g	Ca mg/g	Mg mg/g	Fe mg/g
VI	630	spruce	0	3,79	2,03	0,77	0,86	2,75	0,55	0,98
XVIII	2	birch	0	3,99	2,32	0,95	0,67	4,23	0,76	1,14
XXII	4	spruce	0	4,07	1,81	0,95	0,86	5,44	0,56	1,2
XXII	6	spruce	0	4,24	1,79	1,06	0,69	5,52	0,52	2,65
Point 2.		pine	1	3,83	1,32	0,57	0,42	1,91	0,36	1,99
VI	630	spruce	1	3,9	1,4	0,59	0,28	1,58	0,34	2,15
XVIII	2	birch	1	3,91	1,84	0,78	0,14	2,81	0,39	2,88
XXII	4	spruce	1	3,9	1,96	1,37	0,4	2,62	0,31	6,38
XXII	6	spruce	1	4,06	2,36	1,47	0,33	2,67	0,32	8,37
Point 2.		pine	2	3,87	0,66	0,27	0,47	0,83	0,36	1,07
VI	630	spruce	2	3,83	1,39	0,38	0,1	1,69	0,29	0,74
XVIII	2	birch	2	3,86	1,8	0,61	0,15	2,95	0,29	2,62
XXII	4	spruce	2	4,31	2	1,26	0,22	3,2	0,3	7,6
XXII	6	spruce	2	4,32	2,34	1,3	0,17	3,67	0,33	6,4