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EFFECT OF DRYING TEMPERATURE ON THE EXTRACTABLE MACRO- AND MICRONUTRIENTS AND pH OF DIFFERENT PEAT TYPES

Kuivatuslämpötilan vaikutus eri turvelajien uuttuviin pää- ja hivenravinteisiin sekä pH-lukuun

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Increasing the drying temperature from 20 to 105°C decreased extractable iron and lowered pH but increased the extractable phosphorus. Changes in the extractability of other nutrients were negligible. The effect of drying temperature on different peat types was similar.

Keywords: Extractable nutrients, peat chemistry, soil analysis

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INTRODUCTION

Large-scale laboratory soil testing often necessitates the storage of soil samples until assay and for this purpose drying is the most common and practical means. The effect of the drying temperature on the extractability of plant nutrients and on the pH of different soils has been studied to some extent, but more work is required for a thorough understanding of the changes occurring in soil properties during drying. Such changes are not drastic, but due to recent sophistications and innovations in laboratory instrumentation and techniques they are easily and reliably detected.

Drying has generally been found to increase the extractability of nutrients and to lower pH; the higher the drying temperature the greater the changes. In some wet-incubated mineral soils subsequent oven-drying increased the levels of the DTPA-extractable micronutrients by 2 to 6 fold as compared with air-drying (Khan & Soltanpour 1978). In neutral and calcareous soils raising the drying temperature increased the levels of extractable iron and manganese, but the effect was slight on copper and zinc (Leggett & Argyle 1983). Even air-drying increased the levels of extractable cations in neutral mineral soils compared with measurements made from moist samples (Shuman 1980).

It is well known that a rise in drying temperature lowers the pH of soil samples. Drying soil samples results in changes of surface chemical properties by increasing the polarizing forces of the cations in the remaining water and then increasing their ability to donate protons (Mortland & Raman 1968). Raveh and Avnimelech (1978) attributed the increased acidity to the exposure of fresh organic matter. The pH of slightly humified *Sphagnum* peat was found to lower linearly with increased drying temperature (Saarinen & Tuittila 1983) and the pH of sedge peat was lowered by long-term air-dried storage (Sillanpää 1977).

The aim of this study was to detect a safe drying temperature region to avoid changes in pH and in the solubility of nutrients in some Finnish peat types.

MATERIAL AND METHODS

This study consists of two experiments.

Experiment 1. Peat samples were taken from two virgin bogs under the water table. The peat types were slightly humified *Sphagnum* peat (H_2, von Post) and moderately humified sedge peat (H_4) with a small amount of *Equisetum*. The samples were dried at four different temperatures: 20 (air drying), 40, 70 and 105°C and the dry peat pulverized. For both peat types there were four replicates of each temperature.

pH was determined from a peat-water suspension (1:2, 5 v/v, overnight). K, Ca, P and Mg were extracted with acid ammonium acetate, pH 4.65; extraction time was one hour and extraction ratio 1:10 v/v. Fe, Mn, Cu, Zn and Mo were extracted with AAAc-EDTA using the same extraction conditions described above. Boron was extracted with hot water. Measurements of nutrient concentrations were made using an atomic absorption spectrophotometer, P was measured colorimetrically and B by the azomethine-H method.

Experiment 2. Peat samples were collected from three sites, the third "peat type" being cultivated sedge peat taken from above the water table. Drying temperatures were 20, 30, 40, 50, 60, 70 and 80°C, with 5 replicate samples at each. Determination of pH and nutrient extractions were carried out as in Exp. 1. Boron was not extracted but Al was being extracted with AAAc-EDTA. Element contents were measured using an inductively coupled plasma emission spectrometer.

RESULTS AND DISCUSSION

pH

pH values as the function of drying temperature are presented in Figs. 1 and 2. There is little difference between the different peat types. pH values of the two lowest drying temperature did not differ significantly, but raising the drying temperature from 40 to 105°C linearly lowered pH from 3.3 to 3.0 (r = –0.84***) in *Sphagnum* peat and from 4.6 to 4.1 (r = –0.99***) in sedge peat (Fig. 1). The decline of pH in the cultivated sedge peat occurred at 70°C (Fig. 2). These results are similar to those reported by van Lierup and MacKenzie (1977) in which the average drop in pH among samples of ten Canadian organic soils was 0.5 units measured at field capacity and from air-dried samples.

Because water molecules are part of the structure of humic matter, the dewatering of the system breaks down the structure and causes rearrangement of the bonds (Raveh and Avnimelech 1978, Volarovich et al. 1972). The higher the drying temperature, the more rapid the dewatering, thus allowing less time for the formation of new bonds. This breaks down new micelles revealing more active and acid groups. Another possible mechanism for

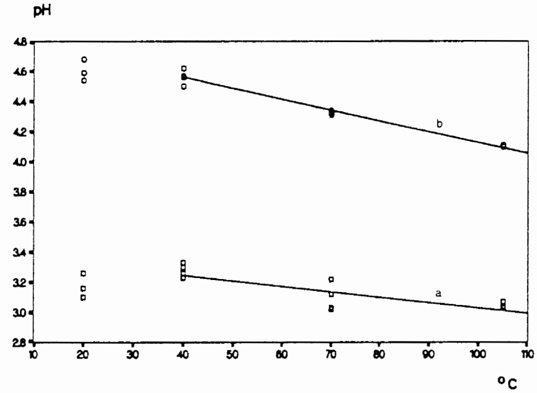

Fig. 1. Drying temperature and pH in *Sphagnum* (a) and sedge (b) peat.

Kuva 1. Kuivatuslämpötilan vaikutus rahka- (a) ja saraturpeen (b) pH-lukuun.

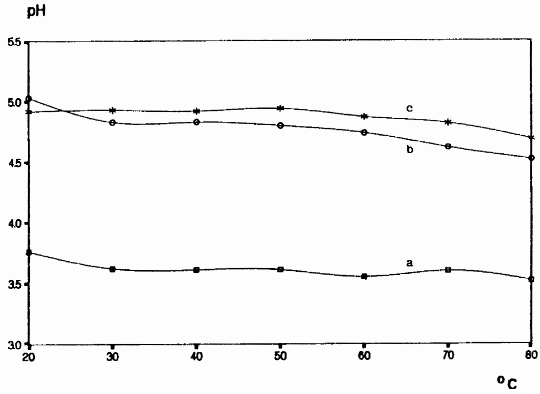

Fig. 2. Drying temperature and pH in *Sphagnum* (a), sedge (b) and cultivated sedge (c) peat (the mean of five replicates).

Kuva 2. Kuivatuslämpötilan vaikutus rahka- (a), sara- (b) ja peltosaraturpeen (c) pH-lukuun (viiden rinnakkaisnäytteen keskiarvoina).

increasing acidity is the oxidation of Fe(II) to Fe(III) at a higher drying temperature. The stability of Fe(III) chelates is greater than that of Fe(II), resulting in the release of hydrogen ions.

Macronutrients

The effect of drying temperature on the extractability of K, Ca and Mg was slight or none. In contrast the amounts of extractable P increased from 0.8 mg/l soil at 40°C to 2.2 mg at 105°C in *Sphagnum* peat and from 0.1 mg at 40°C to 1.4 mg at 105°C in sedge peat (Fig. 3). The correlation was strongly linear with correlation coefficients of r = 0.80** and r = 0.93***, respectively. There appears to be little effect at temperatures lower than 40°C (Fig. 4). The effect of the drying temperature on extractable P is most probably secondary because below pH 5.5 the protons promote dissolution of P in acetate-based solvents.

Micronutrients

Drying temperature did not have a significant effect on the extractability of B, Cu, Zn and Mo but the amount of extractable Fe decreased from 152 mg/l soil at 40°C to 107 mg at 105°C in *Sphagnum* peat and from 949 mg at 40°C to 590 mg at 105°C in sedge peat (Fig. 5). The decrease was strongly linear and the correlation coefficients were r = –0.63** and r = –0.96***, respectively. As seen even in Fig. 6, the lowest temperatures did not affect extractability, the overall decline being apparent at temperatures over 40°C.

The diminishing iron extractability with rising drying temperature is contrary to published results, which is probably due to the different kind of soil used in this study. Most research work has dealt with neutral or alkaline, aerobic mineral soils. The difference between peat and mineral soil is possibly due to differences in the changes of the oxidation state of ion. Increasing drying temperature oxidizes Fe(II) to Fe(III) which is less soluble. At the same time, Fe(III) forms very stable complexes with humic matter replacing some of the H-bonds and releasing protons. In neutral aerobic soils the increased solubility of iron derives from the change in the hydrous state.

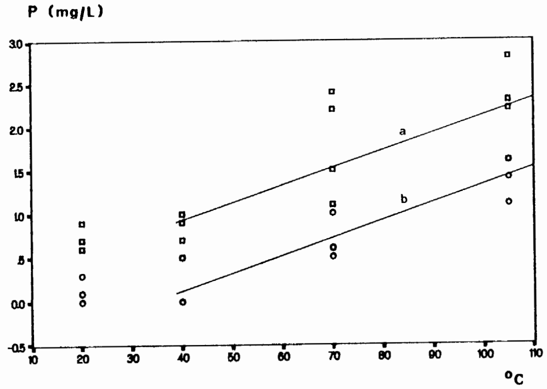

Fig. 3. Drying temperature and extractable phosphorus in *Sphagnum* (a) and sedge (b) peat.

Kuva 3. Kuivatuslämpötilan vaikutus rahka- (a) ja saraturpeen (b) uuttuvaan fosforiin.

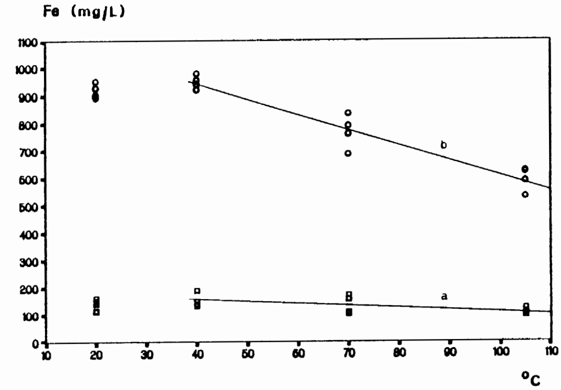

Fig. 5. Drying temperature and extractable iron in *Sphagnum* (a) and sedge (b) peat.

Kuva 5. Kuivatuslämpötilan vaikutus rahka- (a) ja saraturpeen (b) uuttuvaan rautaan.

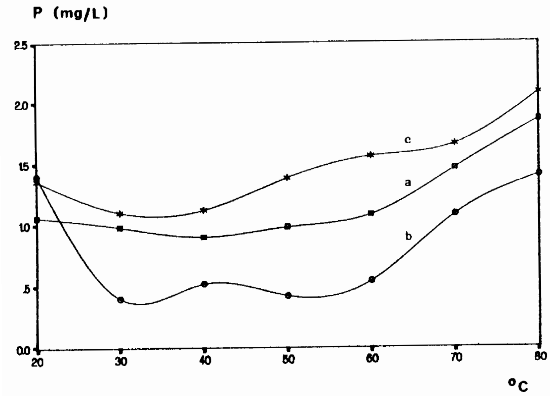

Fig. 4. Drying temperature and extractable phosphorus in *Sphagnum* (a), sedge (b) and cultivated sedge (c) peat (the means of five replicates).

Kuva 4. Kuivatuslämpötilan vaikutus rahka- (a), sara (b) ja peltosaraturpeen (c) uuttuvaan fosforiin (viiden rinnakkaisnäytteen keskiarvoina).

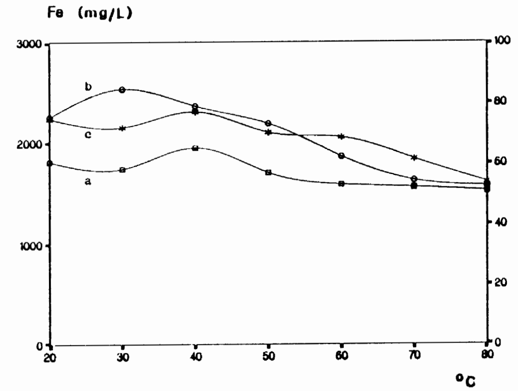

Fig. 6. Drying temperature and extractable iron in *Sphagnum* (a), sedge (b) and cultivated sedge (c) peat (the means of five replicates, *Sphagnum* on right hand scale).

Kuva 6. Kuivatuslämpötilan vaikutus rahka- (a), sara- (b) ja peltosaraturpeen (c) uuttuvaan rautaan (viiden rinnakkaisnäytteen keskiarvoina, rahkaturve oikeanpuoleisella asteikkolla).

In sedge peat, there was a slight decrease in the extractability of manganese but the statistical significance was only fair.

CONCLUSIONS

Drying temperature affects both pH and the extractability of some nutrients similarly in all three peat types.

The effect on the extractability of nutrients can depend on the oxidation state (Fe) or related to pH changes (P).

Drying temperatures between 20 and 40°C, where changes in pH and nutrient extractability are slight, are recommended.

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TIIVISTELMÄ:

KUIVATUSLÄMPÖTILAN VAIKUTUS ERI TURVELAJIEN UUTTUVIIN PÄÄ- JA HIVENRAVINTEISIIN SEKÄ pH-LUKUUN

Kuivatuslämpötilan vaikutusta eri turvelajien uuttuviin ravinteisiin sekä pH-lukuun tutkittiin kahdessa kokeessa. Kokeessa 1 rahka- ja saraturvenäytteet kuivattiin neljässä lämpötilassa: 20 (ilmakuivatus), 40, 70 ja 105°C. Kuivista näytteistä määritettiin K, Ca, Mg ja P (hapan ammoniumasetaattiuutto, pH 4,65), Fe, Mn, Cu, Zn ja Mo (AmAc-EDTA-uutto), B (kuumavesiuutto) ja pH (vesi).

Kahdessa alimmassa kuivatuslämpötilassa tulokset pysyttelivät samalla tasolla, mutta lämpötilan nosto 40°:sta 105°:en alensi pH-lukua 3,3:sta 3,0:an ($r = -0,84^{**}$) rahkaturpeella ja 4,6:sta 4,1:en ($r = -0,99^{***}$) saraturpeella. Fosforin uuttuminen lisääntyi 0,8 mg:sta/l maata 2,2 mg:an rahkaturpeella ja 0,1 mg:sta 1,4 mg:an saraturpeella. Uuttuvan raudan määrä taas vähentyi 152 mg:sta/l maata 107 mg:an rahkaturpeella ja 949 mg:sta 590 mg:an saraturpeella. Muutokset olivat lineaarisia korrelaatiokertoimien ollessa fosforilla $r = 0,80^{**}$ ja $r = 0,93^{***}$ ja raudalla $r = -0.63^{**}$ ja $r = -0,96^{***}$. Vaikka uuttuvien ravinteiden määrät ja pH-luku erosivat eri turvelajeilla, muutosten suunnat ja luonne olivat hyvin samankaltaisia. Kuivatuslämpötilan vaikutus muihin kuin yllämainittuihin ravinteisiin oli vähäinen.

Kokeessa 2 oli kolme turvelajia, rahka-, sara- ja viljelty saraturve ja kuivatuslämpötilat olivat 20°:sta (ilmakuivatus) 80°C:en kymmenen asteen välein. Boorin sijasta analysoitiin alumiini. Mitään jyrkkiä muutoksia uuttuvuudessa tai pH-luvussa lämpötilan kohotessa ei esiintynyt, vaan tulokset noudattelivat kaikilla turvelajeilla kokeen 1 suuntaviivoja. Turvallisin kuivatuslämpötila näyttäisi ravinneanalyysien suhteen olevan 20–40°C.

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