TENSIONFREE LYSIMTER STUDY OF THE IMPACT OF CLEAR- CUTTING TO THE SITE QUALITY

by

K. Arimitsu, Dr. and M. Kato
Forestry and Forest Products Research Institute
Kukizakimura, Ibarakiken 305, Japan

Summary

Flux of soil water and dissolved elements were measured by tensionfree lysimeters which were installed in soil solum of clearcut site and compared uncut site. Characteristics of soil water flux through tensionfree lysimeter changed yearly following clearcutting. Potassium concentration of soil water rose up markedly right after clearcutting and high concentration continued in the second year while concentration of other elements such as nitrate nitrogen, calcium and magnesium went up slightly and lowered soon. When ordinary reforestation is followed immediately after clearcutting, element flux in soil water does not increase so significantly.

Additional keywords: organic nitrogen, ammonium nitrogen, cation exchange capacity, *Chamaecyparis obtusa*, permeability

Introduction

Forest clearcutting has effects on water and nutrient cycling in various ways. The effects vary with tree species, time of cutting local precipitation patterns, topography, soil characteristics, the method of cutting and tree removal (McColl, 1978) and method of reforestation.

Comparison of effects of clearcutting in different location under different conditions of site factors should be made in order to obtain sufficient information of the effects of forest harvesting on the multiple functions of forest ecosystem. Flux of soil water and dissolved elements were measured following clearcutting of Chamaecyparis obtusa forest and compared with those of nearby uncut forest.

Site Description

The study site was located in Yaita in the Takaharayama mountains (lat. 36° 50' north, long. 139° 52' east), 150 km north of Tokyo, in Tochigiken. Mean annual temperature is 11.2°C and mean annual precipitation is 1,860 mm. The clearcut site had 27° slope, a westerly aspect and elevation of 650 m. The compared uncut 48 year old man-made Chamaecyparis obtusa stand had 25° slope, southwesterly aspect and elevation of 740 m. Mean basal area of the stand was 49.3 m^2/ha and mean height was 17.6 m.

Clearcutting of Chamaecyparis obtusa trees at the study site was carried out in March 1974 and most of slash was gathered and piled on slope contour lines with 20 - 25 m intervals for land preperation of reforestation which was done in May 1974.

Soils of the study sites were moderately moist type of Brown Forest Soils by the Japanese forest soil taxonomy and developed from volcanic ash and andesitic lava.

Method

Field sampling

Effects of clearcutting were investigated by comparison of clearcut and uncut man-made forest sites. Tensionfree lysimeters (K. Arimitsu, 1972) shown in Fig. 1 were installed in A horizon in quintuple on the same slope contour of every study site. The tensionfree lysimeter is a 12.5 x 16.0 cm hard synthetic resin trough. Capillary contact between lysimeter trough and soil was made by tightly installation of trough into a cave made in a selected horizon in the soil profile. In order to make capillary contact, the trough was filled with soil material of the soil horizon where the trough was set, and the trough was wedged against the top of the cave.

Then the cave was sealed with tamping soil and the soil pit was refilled with soil. A small amount of fiberglass was put inside the outlet of trough to prevent release of soil material. This lysimeter was considered to collect water which run freely through non-capillary cavity of soil as well as water which was retained in the soil by the tension of less than the capillary potential of soil material in the lysimeter trough.

Soil water flux was measured monthly by measuring the total volume of water collected by the lysimeter in one month period and an aliquot of 1,000 ml was sent to the laboratory for chemical analyses. The monthly measurement was done for eight months from April for four years from 1974. From December to next March, freezing and snowing prevented the lysimeter study.

Chemical analyses

Soil water samples were retained in polyethylene tanks in the field and collected every one month period. The polyethlene tanks were half buried in soil pits for minimizing the change of water quality. Potassium, calcium and magnesium were measured by atomic absorption spectrophotometry and ammonium, nitrate and organic nitrogen were by distilling method.

R e s u l t s

Water flux through tensionfree lysimeter

The curvilinear relation which had been recognized between soil water flux through A horizon and precipitation in the previous study was found again in this study (Fig. 2). The sigmoidal curvilinear relation of clearcut site changed yearly. The change was considered to be due to changes of soil physical properties through timber harvest, land preperation, reforestation and weeding practices. The change of soil physical properties was measured using the samples which were taken from the same soil pit in 1975, 1976 and 1977 The percentage of fine pores (capillary potential of fine pore is equivalent to pF value of 2.7 or 500 cm waterhead) of A horizon increased in about 80 % of total porosity which changed little in three years, while porosity and pore size composition of B horizon did not change notably (Fig. 3). The result corresponded with the yearly decrease of water permeability of A horizon (Tab. 1). Although most of water collected through tensionfree lysimeter was considered to be gravitational water which run through non-capillary pore, the yearly change of water flux shown in Fig. 2 did not entirely correspond to the change of porosity and permeability of the soil. The similar change of water flux characteristics occured even in the uncut site (Fig. 4). Water flux characteristics might be changed not only by the change of soil physical properties but by the frequency and intensity of precipitation.

Only limited discussion can be made by the monthly data of soil water flux and precipitation in the present study. Further detail analysis will be done in another report in the future using the data of every event of water flux and precipitation which were recorded by a self-recording device.

Element concentration

Chemical analyses were carried out for four years from April 1974 right after clearcutting and the results are shown in Fig. 5 - Fig. 10. The concentration is shown as weighted mean value of quintuple samples.

Notable increases in concentrations of the elements were not observed after clearcutting. Nitrate nitrogen concentration of soil water of clearcut site kept markedly lower level than that of uncut site through the study period with initial slight increase in the first year (Fig. 5). Ammonium nitrogen concentrations of both clearcut and uncut sites were similarly low with seasonal fluctuations (Fig. 6). Organic nitrogen concentration of clearcut site did not decrease as nitrate nitrogen and continued similar level as that of uncut site with sharp fluctuations (Fig. 7). Calcium and magnesium concentrations of clearcut site were slightly higher than that of uncut site in three or four consecutive months after clearcutting and then became lower than uncut site throughout the study period (Fig. 8, 9). Potassium concentration of clearcut site rose up notably in the first year after clearcutting and the higher trend kept in the second year, then the difference of concentration became obscure in the following years(Fig.10).

These results mentioned above are inconsistent with the results of the watershed study in which various increases in nutrient concentrations in drainage water were observed after clearcutting (Likens et al., 1970). In their study, revegetation of the clearcut area was inhibited by herbicides and slash was left on the ground. The high nutrient concentration in drainage water was attributed to these conditions.

The results of the present study are rather corresponding with the soil solution study in which concentrations of potassium, calcium, magnesium and nitrate nitrogen decreased following clearcutting (McColl, 1978). Some of the conditions of the present study were similar to those of McColl's study. For example, the soil condition of the present study was clay loam with higher cation exchange capacity of 46.86 meq/100g (27.76 meq/100g Ca and 3.08 meq/100g Mg) and rapid revegetation after clearcutting was not inhibited by herbicides. The released nutrients were taken up by revegetated plants or held in the soil in these conditions. Nitrogen held in revegetated plants in another clearcut site near the study site was 29 kg/ha (Authors' unpublished data). The nutrient release from decomposing slash and litter was minimal in this condition and revegetated plants had significant role in the nutrient cycling in clearcut site.

One of the differences in the conditions of both McColl's study and the present study was that most of the slash was removed and original litter layer was disturbed in the former while slash was left and piled in lines on the slope in the latter. The nutrient release from decomposing litter and slash contributed somewhat to the fluctuation of element concentration of soil water in the present study.

In ordinary reforestation practice, slash and litter are not removed, revegetation is not inhibited by herbicides, and trees are planted again. When the ordinary reforestation is followed immediately after clearcutting, the element flux in the soil water does not increase so significantly.

Conclusions

1) Soil water flux through tensionfree lysimeter changed yearly following clearcutting. The results are not fully corresponding with the change of soil physical properties. Further detail study is required to explain the results.

2) Notable increase in concentrations of nitrate nitrogen, ammonium nitrogen, organic nitrogen, calcium and magnesium in the soil water were not observed after clearcutting. Factors contributing to the results were considered to be the uptake of nutrients by revegetated plants and the relatively high cation exchange capacity of the soil.

3) The concentration of potassium of soil water was notably high for about two years after clearcutting. Slash and litter remained in the clearcut site contributed to the result.

4) When the ordinary reforestation is followed immediately after clearcutting, the element flux in soil water does not increase so significantly.

Literature Cited

Arimitsu, K., 1977: Tension and tensionfree lysimeter study of soil water in the Shigayama IBP study area. JIBP Synthesis, Vol. 15. 15-24.

Likens, G. E. et al., 1970: Effects of forest cutting and herbicides treatment on nutrient budget in the Hubbard Brook watershed ecosystem. Ecol. Monogr. Vol. 40, 43-47

McColl, G. J., 1978: Ionic composition of forest soil solutions and effects of clearcutting. Soil Sci. Soc. Jour., Vol. 42, 358-363.

Table 1-Yearly change of saturated permeability.

Year	Horizon	Permeability cm/sec
1975	A	1.4×10^{-1}
	B_1	3.2×10^{-2}
1976	A	3.4×10^{-2}
	B_1	1.1×10^{-2}
1977	A	7.6×10^{-3}
	B_1	9.9×10^{-3}

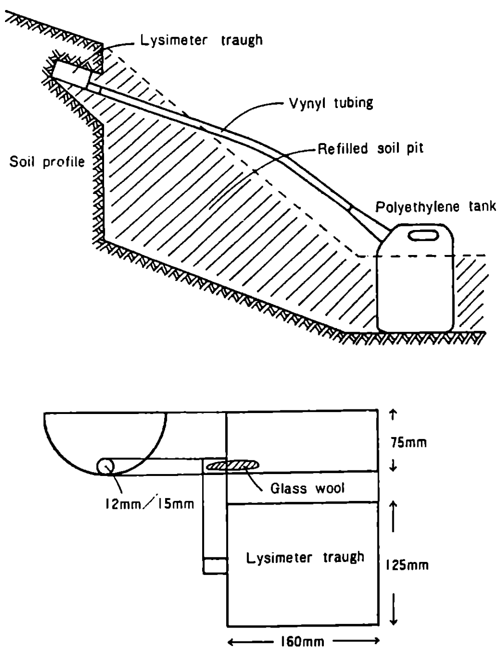

Fig. 1-Tensionfree lysimeter apparatus

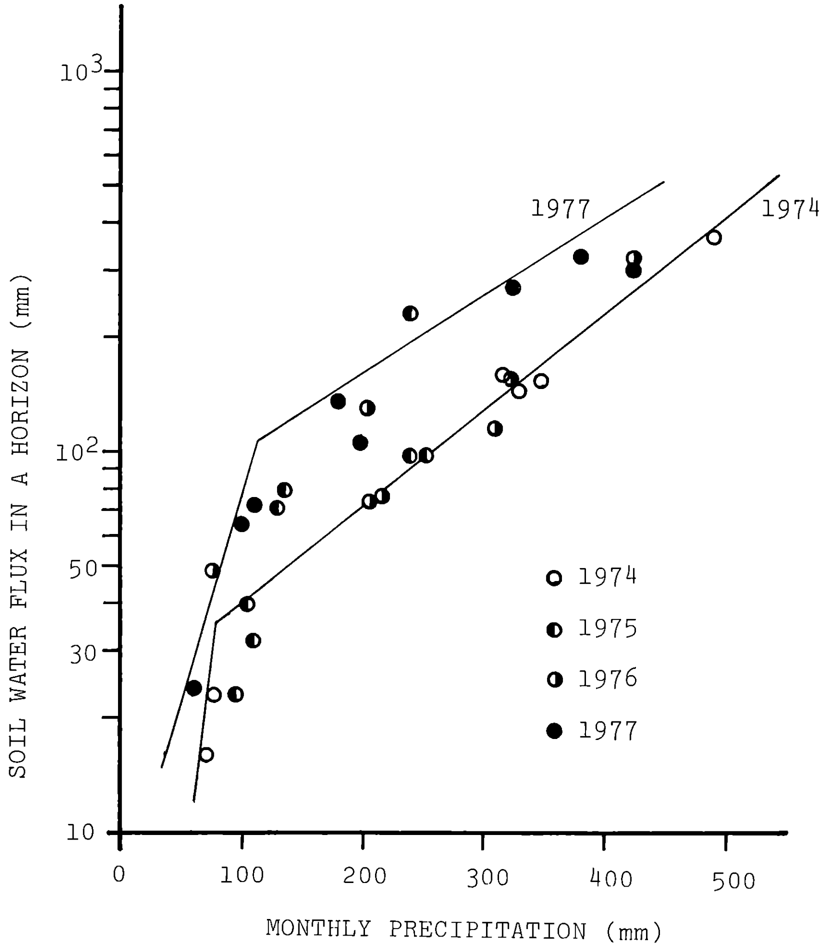

Fig. 2- Relation between monthly soil water flux and precipitation in clearcut site.

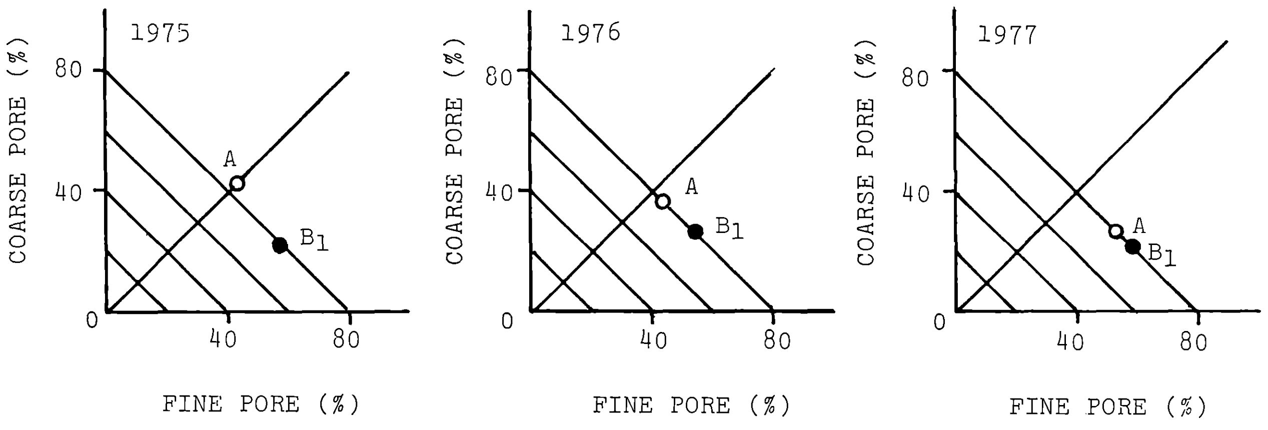

Fig. 3- Yearly change of soil porosity in clearcut site.

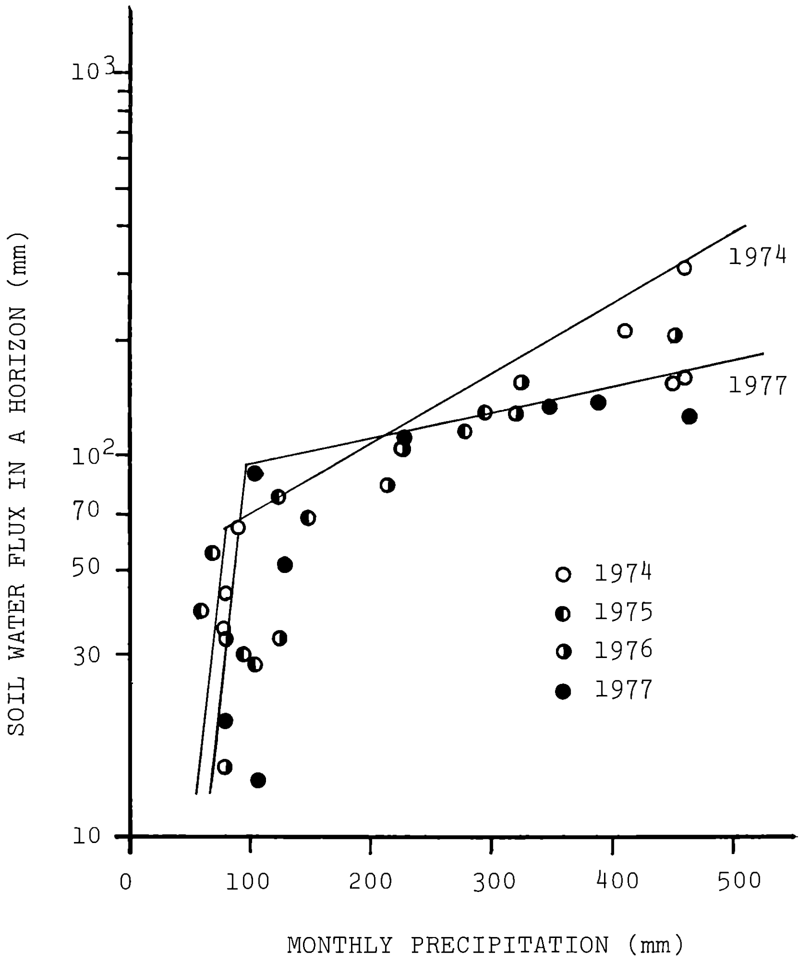

Fig. 4- Relation between soil water flux and
precipitation in uncut site

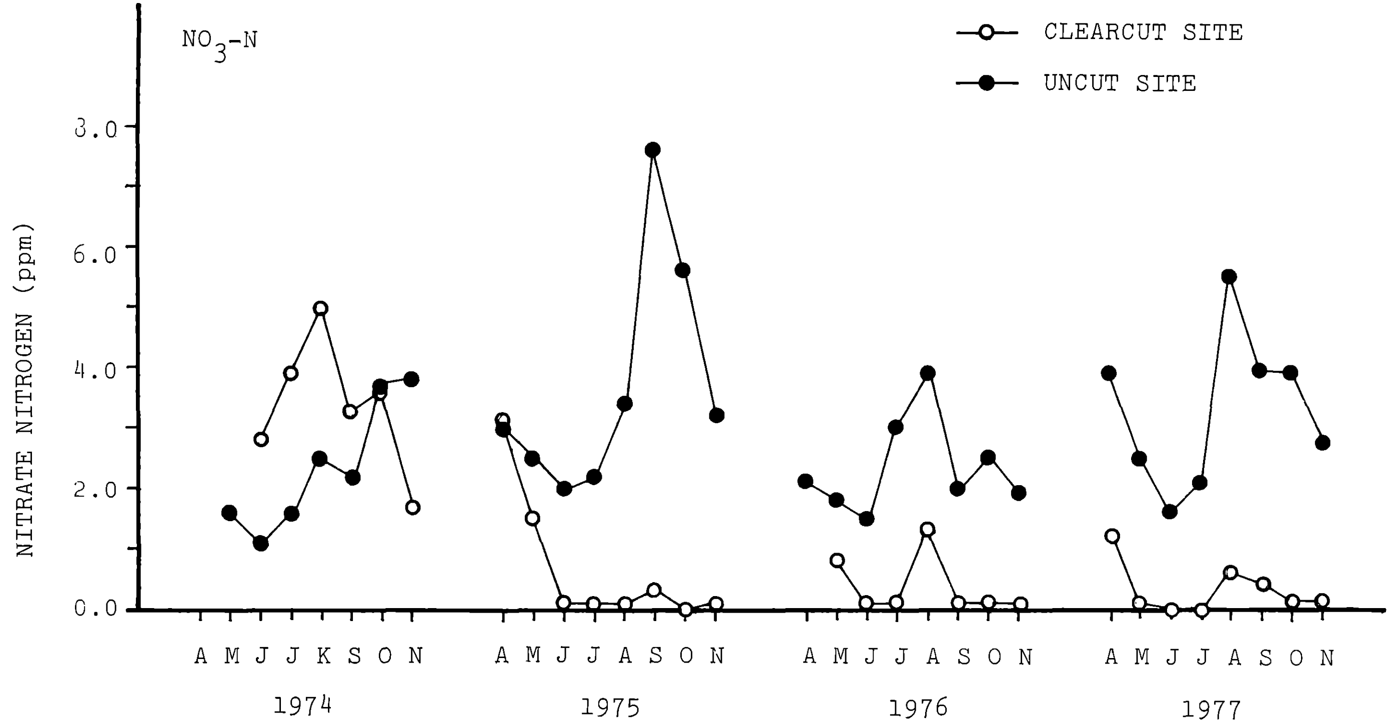

Fig. 5- Monthly change of nitrate nitrogen concentration in soil water.

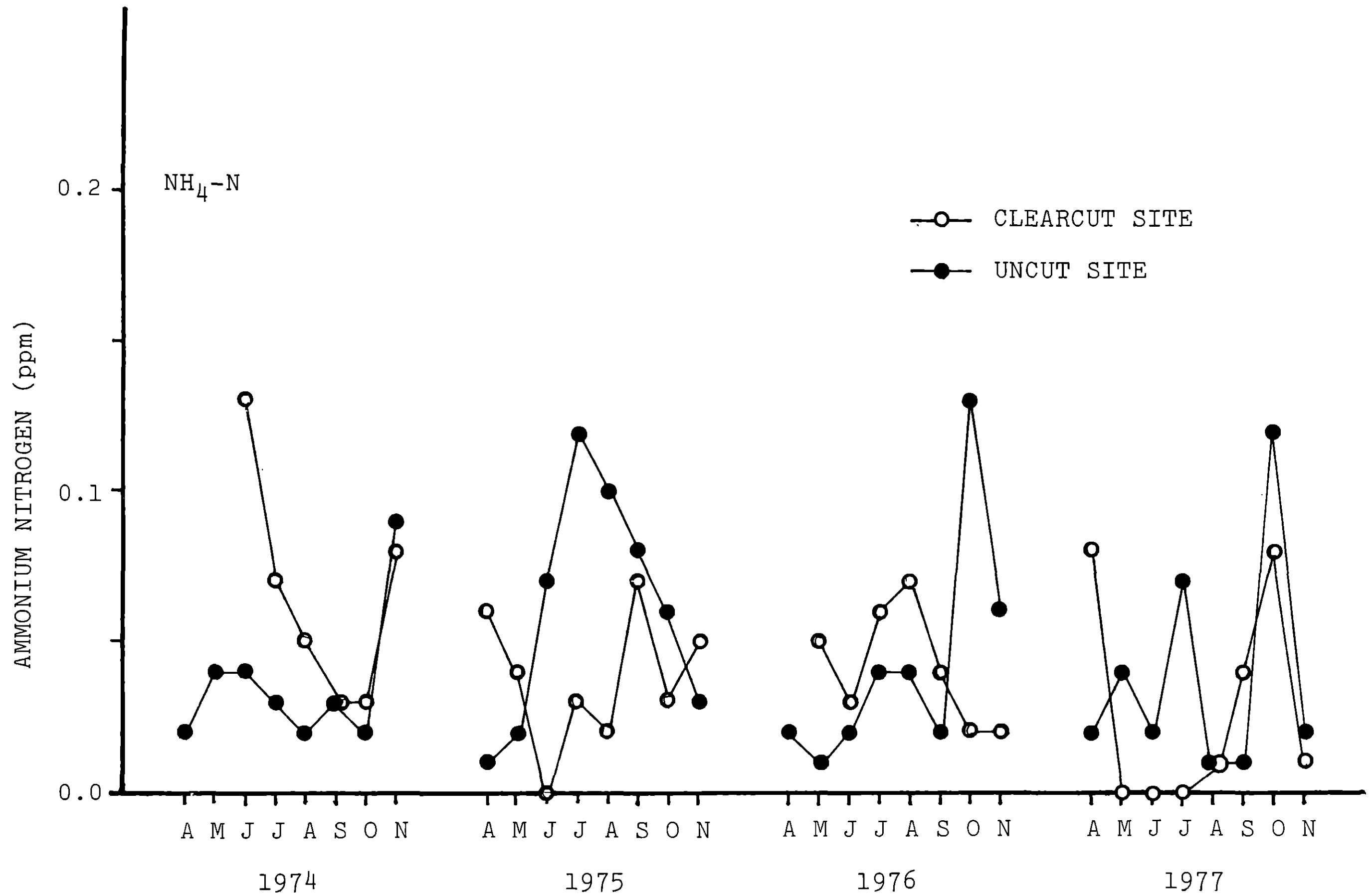

Fig. 6-Monthly change of ammonium nitrogen concentration in soil water.

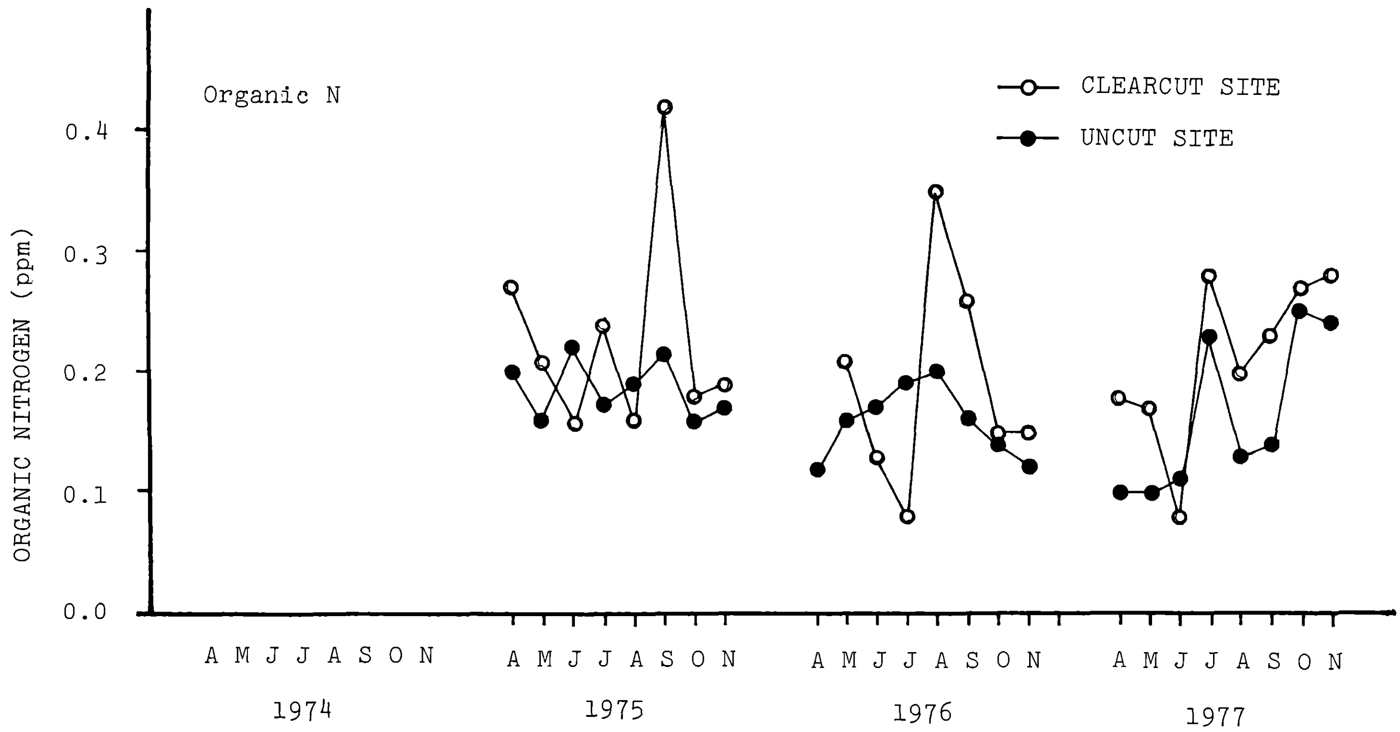

Fig. 7- Monthly change of organic nitrogen concentration in soil water.
Data were not obtained in 1974.

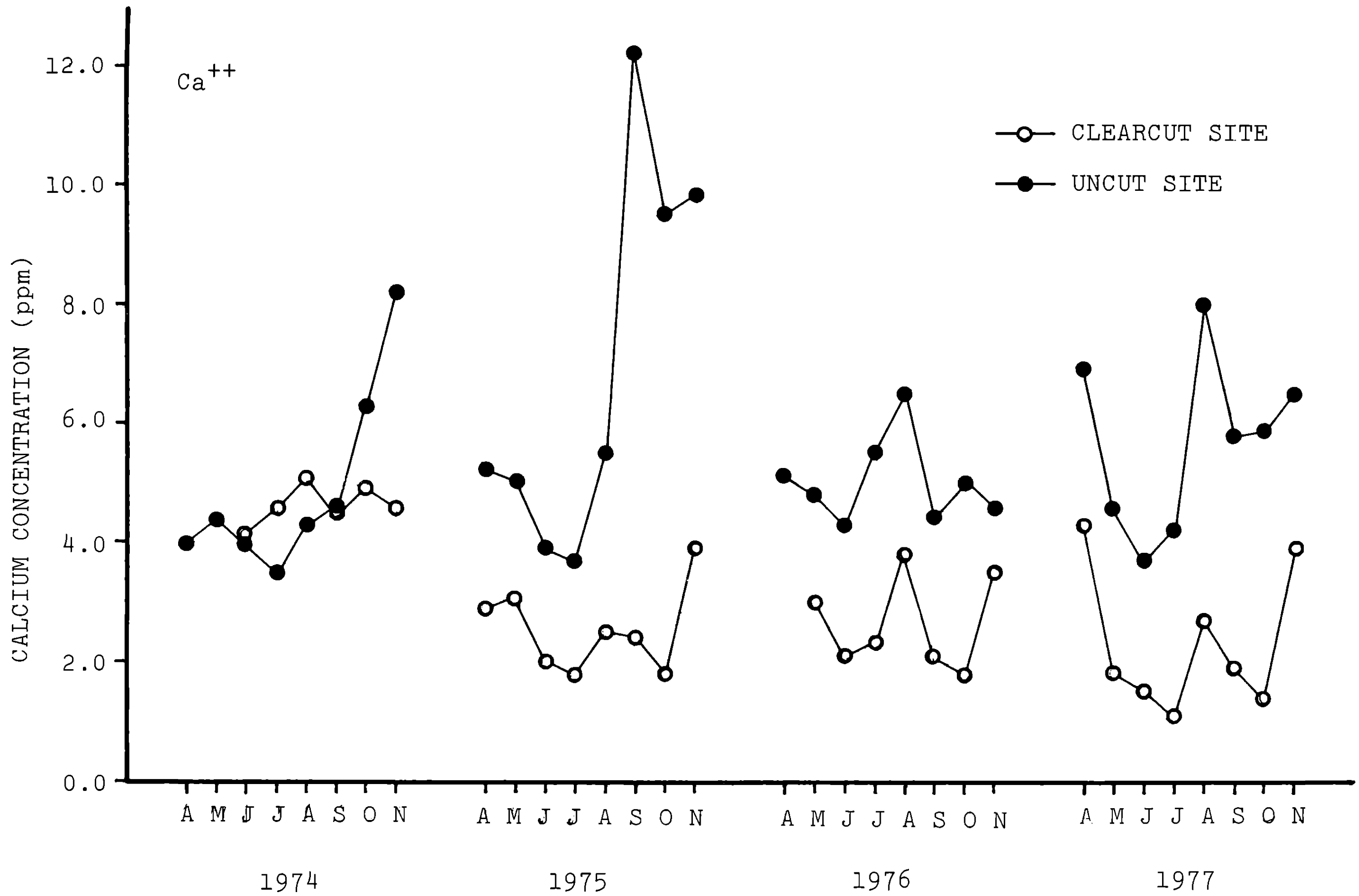

Fig. 8-Monthly change of calcium concentration in soil water.

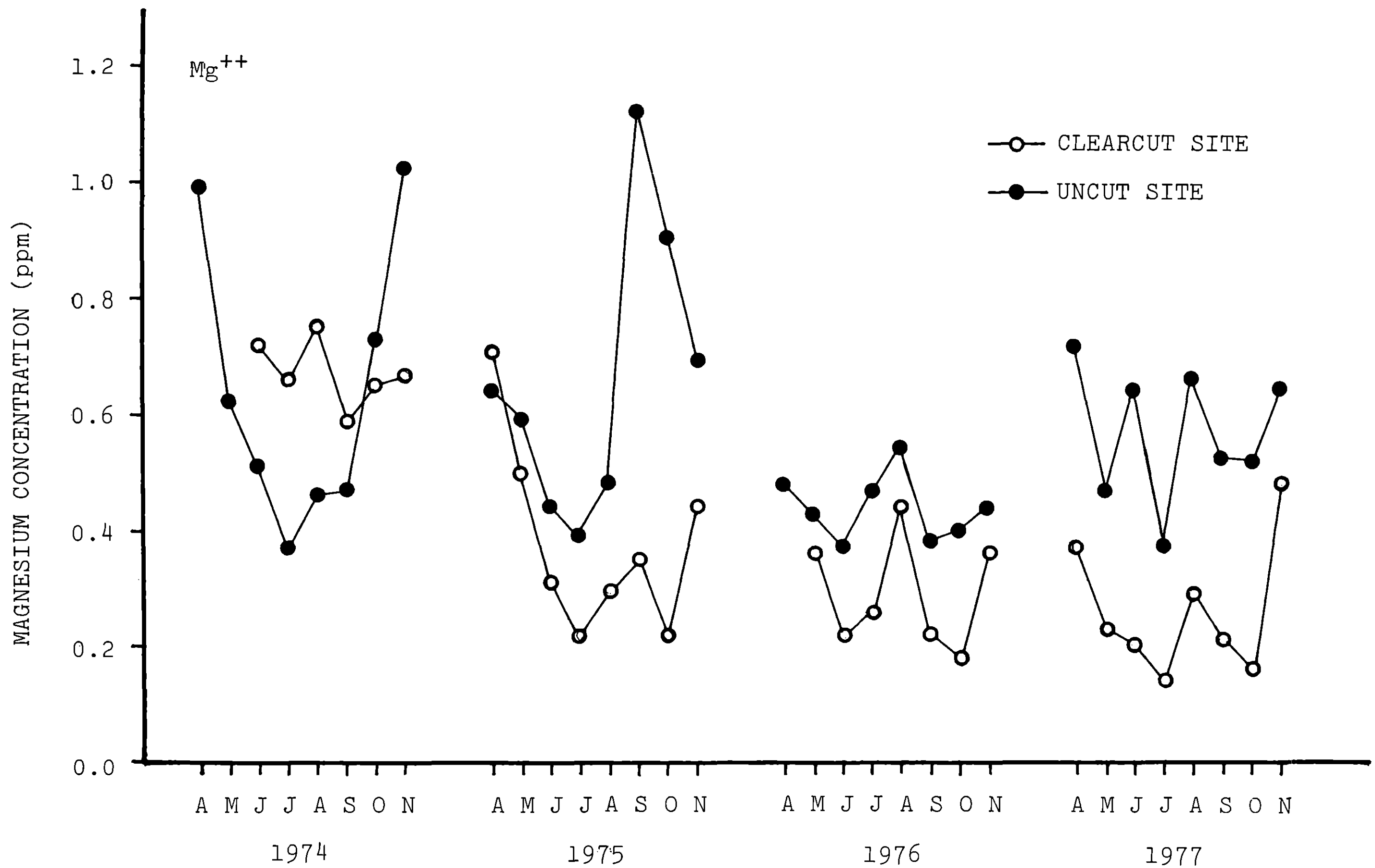

Fig. 9- Monthly change of magnesium concentration in soil water.

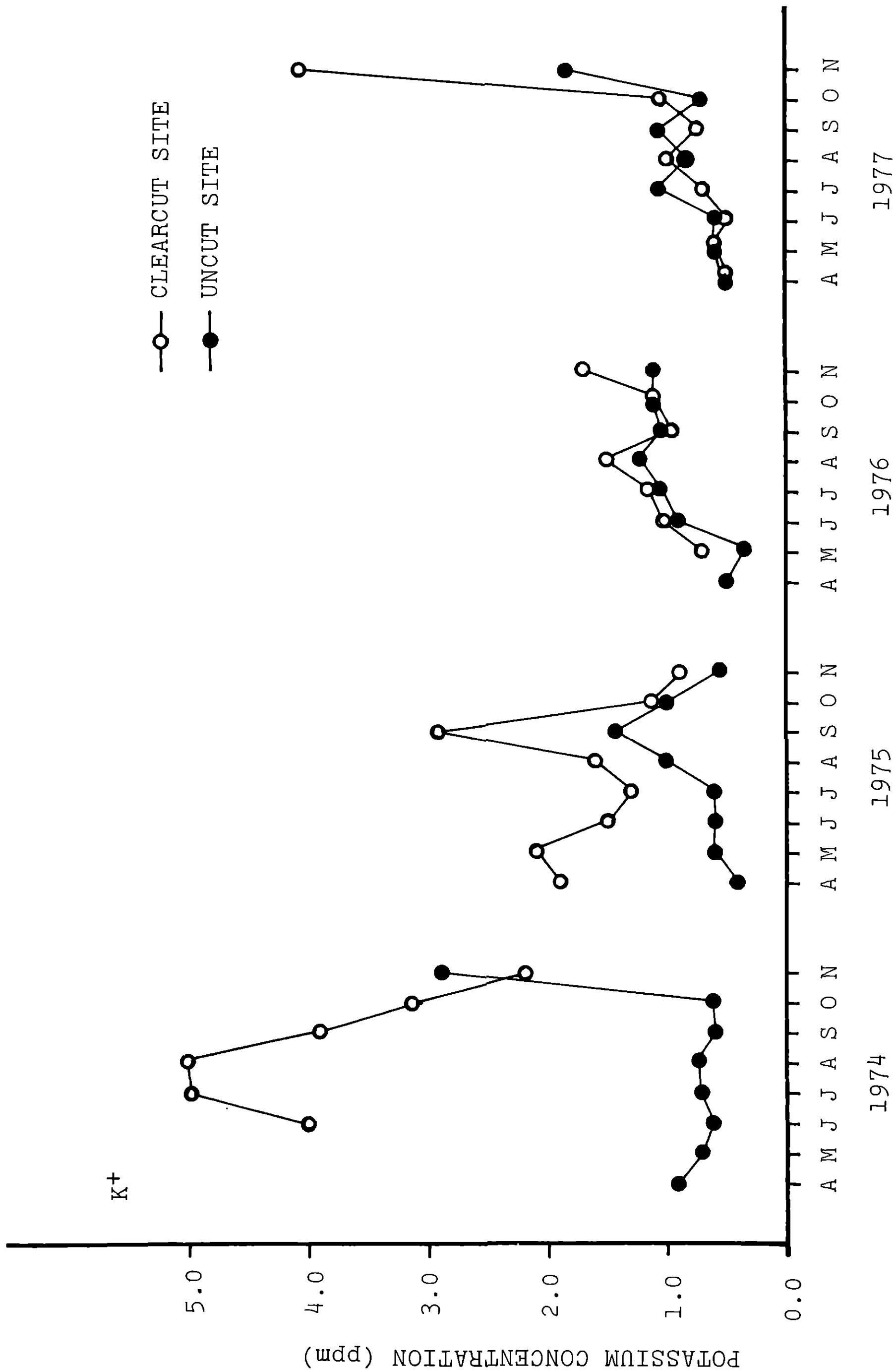

Fig. 10- Monthly change of potassium concentration in soil water.