ARBORETUM KÓRNICKIE
Rocznik XXII — 1977

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Concentration of mineral elements in Norway spruce (*Picea abies* (L.) Karst.) wood*

INTRODUCTION

The flowering of trees and the consequent seed crop requires a considerable quantity of nutrients. Chałupka, Giertych and Królikowski (1975) indicate that for 1 kg. of dry reproductive structures there is at least 3 kg. of dry weight loss in wood production in a Norway spruce stand. In coniferous trees, where cone crops occur periodically, during a seed year the trees require mineral nutrients not only for the normal girth increment and other growth manifestations but also for the developing seeds. It has not been shown yet whether this is at the expense of growth or whether it is the result of more intensive absorption from the soil. There are indications that during a seed year the annual girth increment is somewhat below average. This was shown also for Norway spruce (Mikola, 1950; Danilov, 1953; Eklund, 1954; Holmsgaard, 1955; Hoeg, 1956; Jonsson, 1969; Chałupka, Giertych, Królikowski, 1975).

The experiment described here was aimed at establishing to what extent the differences in needs for mineral nutrients in a seed year are reflected in the mineral composition of the growth rings.

MATERIALS AND METHODS

Material for the present study has been collected in the autumn of 1971 from four forests districts in northeastern Poland, namely Borki, Sokółka, Szczebra and Serwy. In each forest district sections from mid-point on a stem of 10 mature Norway spruce trees were taken. Sectors cut along the radius were soaked in water for 2 days and the annual

* This work has been partially supported by grant FG-Po-260 from the US Department of Agriculture under PL-480.

rings were separated with the help of a scalpel and dried at 105°C in a thermostat. For chemical analyses samples of sawdust were taken. Each sample consisted of sawdust obtained from equal quantities of wood from 10 stems and four cardinal directions in each stem, the 40 wood fragments being all formed in the same year. For the analyses samples were obtained for the years from 1902 till 1971.

The content of mineral nutrients was measured by standard techniques, nitrogen by the Kieldahl method, phosphorus colorimetrically and metalic elements with the help of a flame photometer, similarily as described earlier (F o b e r, 1974).

As a result of insufficient quantities of phosphorus it proved impossible to measure the amount of this element by this technique. Some samples also did not contain measurable quantities of potassium or sodium, thus there are certain gaps in the data. The lack of data was not caused by absence of insufficient material — any amount of required sawdust could be made — but the impurities in the analytical reagents used for the digestion of the sawdust contained greater quantities of the elements than were found in the wood, making any estimates impossible. Nitrogen was analysed in samples from only two forest districts, Borki and Sokółka.

RESULTS AND DISCUSSION

The mean concentrations of the basic elements in the wood at mid-point of the stem length varied very little between studied spruce stands (Table 1).

As was indicated the quantities for K and Na are based on incomplete data and therefore are somewhat higher than in fact since the

Table 1

Concentration of mineral elements in the spruce wood

Forest District	% N	% K	% Ca	% Na	Age Years
Borki	0.088	0.020	0.087	0.006	100
Serwy	–	0.016	0.088	0.006	105
Szczebra	–	0.013	0.108	0.006	110
Sokółka	0.060	0.012	0.110	0.006	150

missing values concern lower than detectable concentrations. On the other hand in view of the method of separating growth rings used, based on soaking the wood in water, it is possible that some quantities of potassium, sodium and calcium were washed out. In spite of that, the values given in table 1 are very close to those known from literature. K r z y s i k (1974) reports the following mean values of concentrations

of mineral elements in the dry weight of pine wood: 0.03% K, 0.1% Ca and 0.007% Na.

The differences in age of the stands may be responsible for the gradients in concentration as shown in Table 1. Nitrogen and potassium concentrations appear to decline, and those of calcium increase with age.

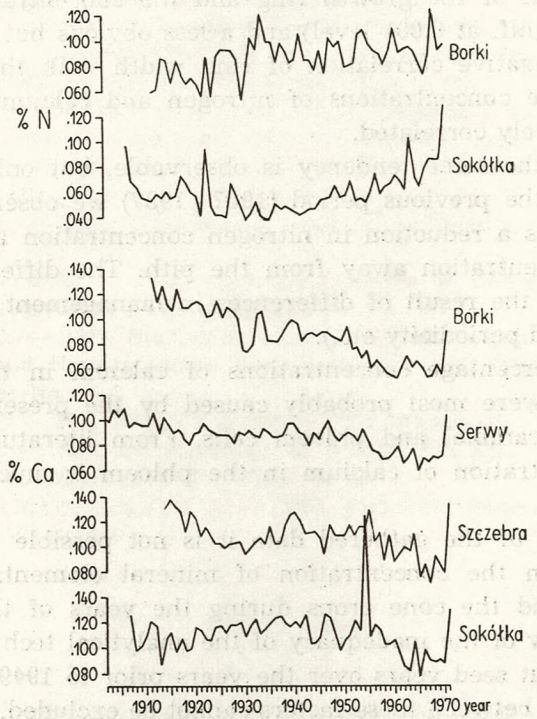

Fig. 1. Concentration of nitrogen and calcium in Norway spruce annual rings from various forest districts

In Fig. 1 variability of concentrations of mineral elements in growth rings from various years are presented. The differences between years are rather great, but they most probably represent inaccuracies of the measurements since we were operating at the lower limit of detectability. Generally there is a tendency for the concentration of nitrogen and potassium to increase and for the concentration of calcium to decrease from the pith towards the cambium. This is very distinct in the stand from Borki. Thus there is agreement in the data. Both in older trees and in the earlier formed growth rings we observe a higher concentration of calcium and a lower concentration of nitrogen and potassium. This can be readily explained. Calcium is an ion that does not migrate readily (Nowotny-Mieczyńska, 1965). It accumulates in a natural manner in the wood during processes of growth and nutrition and becomes fixed there. Thus with age its content in the tissues

is on the increase relative to dry weight. On the other hand nitrogen and potassium belong to elements that easily migrate to younger tissues more active metabolically at a given time.

As always the width of the annual rings declines from the pith to the circumference. Thus there was a very clear positive correlation between the width of the growth ring and the concentration of calcium in the wood (signif. at 0.001 level) and a less obvious but still significant at 0.05 level negative correlation of ring width with the concentration of nitrogen. The concentrations of nitrogen and calcium are of course strongly negatively correlated.

In Sokółka the same tendency is observable, but only in the years 1937 - 1971. In the previous period (1907 - 1937) we observe an opposite tendency, that is a reduction in nitrogen concentration and an increase in calcium concentration away from the pith. The differences between stands could be the result of differences in management history (thinning intensity and periodicity etc.).

The high percentage concentrations of calcium in the last growth ring, for 1971, were most probably caused by the presence in the material of some cambial and phloem cells. From literature it is known that the concentration of calcium in the phloem is much greater than in the wood.

On the basis of the gathered data it is not possible to observe any relation between the concentration of mineral elements in individual growth rings and the cone crops during the years of their formation. However in view of the inadequacy of the analytical techniques, and the uncertainty about seed years over the years prior to 1949 the possibility of some relation between these factors cannot be excluded.

SUMMARY

From spruce stands of 4 Forest Districts in northeastern Poland wood samples were taken in order to determine the content of the basic macroelements in individual annual rings from 1902 till 1971.

Differences in the mean concentrations of the elements did not differ much between the Forest Districts. The concentration of nitrogen and potassium decline and that of calcium is on the increase with increase in stand age. There is also an increase in nitrogen and a decline in calcium concentration from the pith towards the cambium, parallel with the decline in radial increments. No correlations between the concentrations of mineral elements in wood and the cone crop of a given year were observed.

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Stężenie składników mineralnych w drewnie świerka pospolitego

Streszczenie

Z drzewostanów świerkowych 4 nadleśnictw z północno-wschodniej Polski pobrano próbki drewna, w celu oznaczenia zawartości podstawowych makroelementów w rocznych słojach z lat 1902 - 1971.

Różnice w średniej zawartości pierwiastków między nadleśnictwami są nieznaczne. Stężenie azotu i potasu zmniejsza się, a wapnia rośnie wraz z wiekiem drzewostanów.

Zaznacza się tendencja do zwiększania się stężenia azotu, a zmniejszania się stężenia wapnia w kierunku od rdzenia do miazgi. W tym samym kierunku zmniejsza się szerokość rocznych przyrostów, stąd istotna pozytywna korelacja między szerokością przyrostu a stężeniem wapnia, i negatywna, między szerokością przyrostu a stężeniem azotu.

Na podstawie uzyskanych wyników nie można stwierdzić czy istnieje zależność między stężeniem makroelementów w poszczególnych rocznych przyrostach a urodzajem szyszek w latach formowania się tych przyrostów.

ХЕНРЫК ФОБЕР

Содержание минеральных элементов в древесине ели обыкновенной

Резюме

В еловых древостоях четырех надлесничеств северо-восточной Польши взяты образцы древесины с целью определения содержания основных макроэлементов в годичных кольцах за 1902 - 1971 гг.

Различия в среднем содержании элементов между надлесничествами несущественны. Содержание азота и калия падает с возрастом древостоев, содержание кальция растет.

Обнаруживается тенденция к увеличению содержания азота и к уменьшению содержания кальция в направлении от сердцевины к камбию. В этом же направлении уменьшается толщина годичного прироста. Следовательно, существует положительная корреляция между толщиной годичных колец и содержанием кальция, а между содержанием азота и толщиной колец — отрицательная.

На основе полученных результатов нельзя утверждать — существует ли зависимость между содержанием макроэлементов в отдельных годичных кольцах и урожаем шишек в году их формирования.