

## Exchange of Radioactive Phosphorus $^{32}\text{P}$ between the Components of an Artificial Plant Community\*

K. ZARZYCKI <sup>1)</sup> and A. DOMNICZ <sup>2)</sup>

<sup>1)</sup> Department of Plant Ecology and Plant Geography, Institute of Botany Polish Academy of Sciences, Kraków, Poland; <sup>2)</sup> Institute of Soil Science, Agrochemistry and Microbiology, Agricultural Academy, Kraków, Poland

(Received: September 27, 1974)

### Abstract

In artificial plant communities (wooden cases with soil) the following plants were grown together for one year: case No. 1: *Betula verrucosa* Ehrh. (2 specimens) and *Carex pilosa* Scop.; cases No. 2 and 3: *Alnus incana* (L.) Mnch., *Fraxinus excelsior* L., *Padus avium* Mill., *Aegopodium podagraria* L., *Eupatorium cannabinum* L. and others.

Into the stalks or stems of one to three plants of every case  $^{32}\text{P}$  was introduced. After 3 months all the plants in every case contained radioactive phosphorus. There were great differences in  $^{32}\text{P}$  concentration (up to ten-fold) between plants grown in the same case. The concentration of  $^{32}\text{P}$  in plants into which it had not been introduced was of the range of 0.1%.

Preliminary investigations by the authors (Domnicz, Zarzycki 1970) showed that tomatoes in short-term water and soil cultures discharged into the substrate about 0.5% of the  $^{32}\text{P}$  introduced into these plants. A significant part of the phosphorus discharged (up to 70%) was then absorbed from the substrate by the roots of other specimens of the same species. Fober and Giertych (1970) observed weak emission of  $^{32}\text{P}$  in *Poa annua* L., which was markedly stronger in seedlings of *Picea abies* (L.) Karsten.

The purpose of the next experiment was to follow the course of radioactive phosphorus exchange between components of a simplified plant community in nearly natural conditions.

---

\* The investigations were financed by the Committee on Ecology of the Polish Academy of Sciences.

## MATERIAL AND INVESTIGATION METHODS

In spring 1969 six  $55 \times 40 \times 35$  cm wooden cases were filled with sandy-loamy, slightly humic garden soil. In three cases young specimens of *Betula verrucosa* 60—120 cm tall, and several specimens of *Carex pilosa* were planted; in this way a simplified model of forest community was created. In the remaining three cases young trees and herbaceous plants were planted, belonging to the composition of *Alnetum incanae* (Fig. 1). For 1 year the cases were left in the garden, the plants were watered during the dry summer period and protected against frost in winter. After one year, when the plants had well developed roots, 3 cases with abundantly and uniformly developed vegetation were selected for the proper investigations.

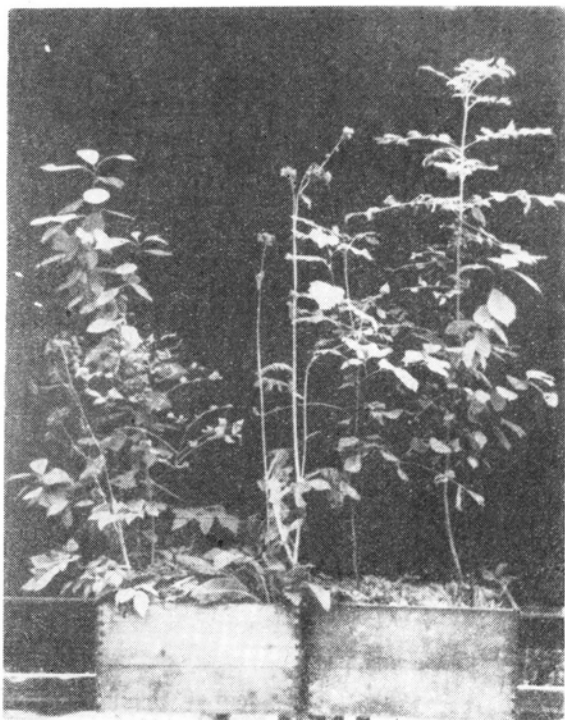


Fig. 1. Cases used in the investigations

The vegetation of case No. 1 consisted of three specimens of birch and numerous specimens of *Carex pilosa*. In case No. 2 there grew (one specimen each) *Alnus incana*, *Padus avium* and *Fraxinus excelsior*, as well as abundant herbaceous plants: *Eupatorium cannabinum*, *Asarum europaeum* L., *Carex silvatica* Huds., *Chelidonium majus* L., *Brachypodium silvaticum* (Huds.) Roem. et Schult. and *Aegopodium podagraria*. The vegetation of case No. 3 consisted of young trees of *Alnus incana*, *Padus avium* and

*Fraxinus excelsior*, as well as the herbaceous plants *Eupatorium cannabinum*, *Carex silvatica*, *Brachypodium silvaticum* and *Aegopodium podagraria*.

An injection of  $^{32}\text{P}$  in the form of  $\text{NaH}_2\text{PO}_4$  was given on May 18th, 1970, during exuberant growth of the plants. In case No. 1 the radioactive substance was introduced into the stems of two birch trees; the holes of c. 2 mm diameter were directed at a slant downwards to a depth of c. 10 mm, and c. 1 mci of  $^{32}\text{P}$  was introduced into each (Fig. 2). The places of injection were protected against ambient contamination by wood-wool and sealing tape. In case No. 2 about 2 mci of  $^{32}\text{P}$  were introduced into the stalk of *Aegopodium podagraria*, and in case No. 3 about 1 mci of the same into 3 shoots of the same plant.

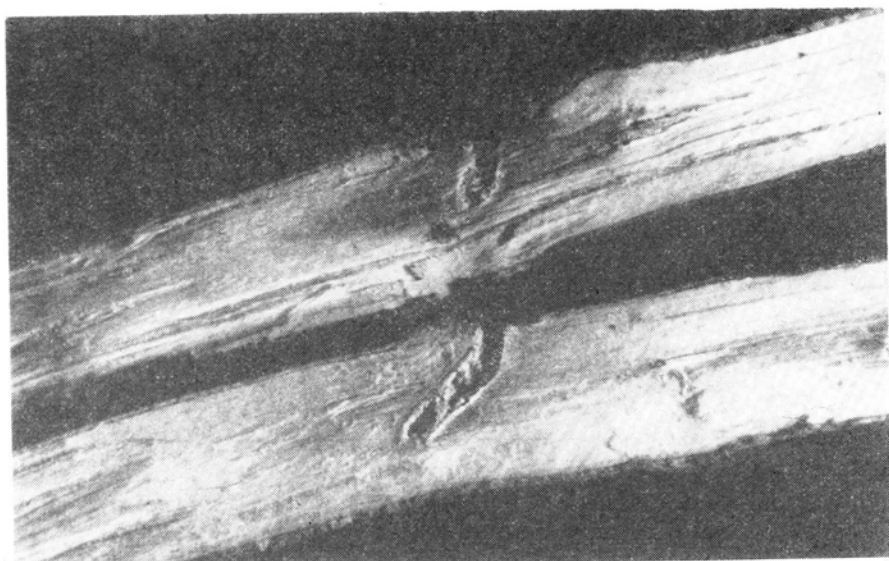


Fig. 2. Cross-section of young birch stem with a hole for introducing  $^{32}\text{P}$

The rate of distribution of radioactive phosphorus in plants into which it had been introduced was checked in the leaves of birch trees in the upper, central and lower part of the crown. In the case of *Aegopodium podagraria* circles of 5-mm diameter were cut from young, older and intermediate leaves. Collection of the material was begun as early as 1/2 hour after the injection.

Three months after introduction of  $^{32}\text{P}$  (i.e. on August 18th, 1970) the plants from the individual cases were harvested, divided into leaves and stalks, or, in the case of trees, into leaves, branches and stems, and then dried, weighed and burned. In the ash total phosphorus content was colorimetrically determined (Domnicz, Gorlach 1970), and total radioactivity in the manner described in the preceeding paper (Domnicz, Zarzycki 1970).

Considerable methodical difficulties were encountered in the separation of small roots and root hairs from the soil. Therefore, determination of the  $^{32}\text{P}$  content in underground part of plant and soil was omitted.

### INVESTIGATION RESULTS AND DISCUSSION

The radioactive phosphorus from the stems or stalks of herbaceous plants was very quickly distributed within all the plant. Ten hours after injection the  $^{32}\text{P}$  content in birch leaves reached its maximal level (Fig. 3).

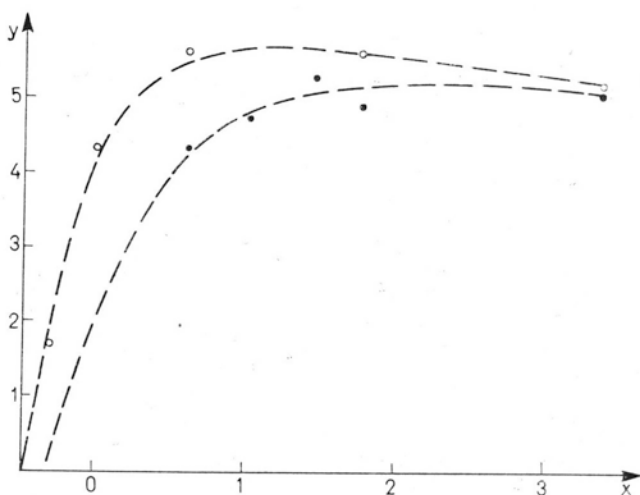


Fig. 3. The rate of distribution of  $^{32}\text{P}$  to leaves from upper and lower part of crown of *Betula verrucosa* into which stem it had been introduced

Y-axis — log activity in imp./min./100 mg dry matter of leaves; X-axis — log time in hours after injection of  $^{32}\text{P}$

After 3 months from the injection  $^{32}\text{P}$  radioactive phosphorus was found in all plants growing together in one case. If in plants which had been injected with  $^{32}\text{P}$  (plants "R") activity reached, or even surpassed,  $10^6$  imp./min./100 g dry matter, then in adjacent recipient plants this activity did not exceed as a rule  $10^3$  imp./min./100 g dry matter. If the  $^{32}\text{P}$  content in leaves of "R" plants was assumed at 100%, the content of this element in leaves of "O" plants was between 0.1 and 1.4%. The high activity found in one of the specimens of *Aegopodium podagraria* from case No. 2 (plant No. 6) was probably caused by an underground connection with the "R" plant. The amounts of  $^{32}\text{P}$  in other species do not show such wide differences when compared with one another (Figs 4, 5 and 6).

The authors' investigations show that the components of one plant community exchange between each other, although to an insignificant

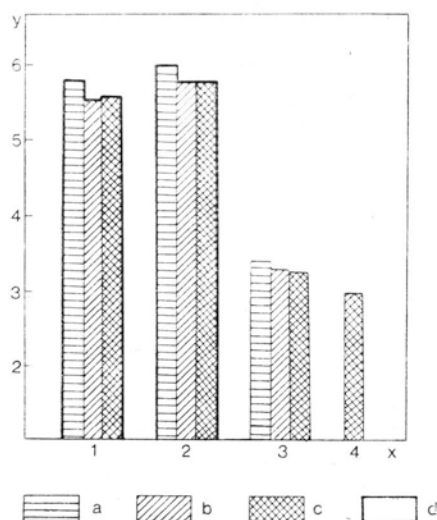


Fig. 4. Radioactivity of plants (case No. 1) months after the injection of  $^{32}\text{P}$  into two stems of young birches

Y-axis — log activity in imp./min. per mg P; a — stems, b — branches, c — leaves, d — plants which had been injected with  $^{32}\text{P}$

X-axis — plant species: 1, 2 — *Betula verrucosa* (plants injected with  $^{32}\text{P}$ ), 3 — *Betula verrucosa* (without injection), 4 — *Carex pilosa*

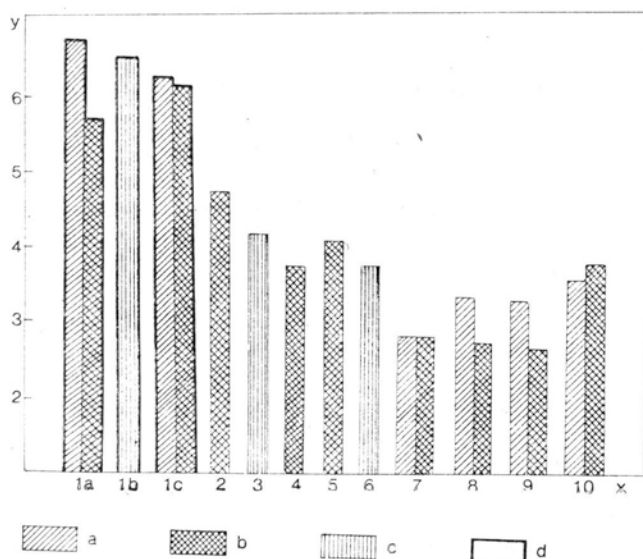


Fig. 5. Radioactivity of plants (case No. 3) 3 months after the injection of  $^{32}\text{P}$  into 3 stalks of *Aegopodium podagraria*

Y-axis — log activity in imp./min./mg P; X-axis — plant species:

1a, 1b, 1c — *Aegopodium podagraria* (plants injected with  $^{32}\text{P}$ ), 2, 3 — *Aegopodium podagraria* (without injection), 4 — *Brachypodium silvaticum*, 5 — *Carex silvatica*, 6 — *Eupatorium cannabinum*, 7, 8 — *Fraxinus excelsior*, 9 — *Alnus incana*, 10 — *Padus avium*;

a — stalks, branches, stems, b — leaves, c — all plant, d — plants injected with  $^{32}\text{P}$

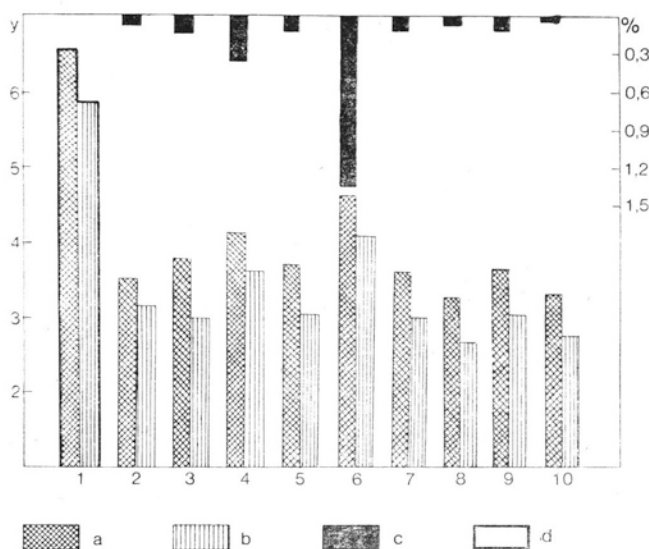


Fig. 6. Radioactivity of plants (case No. 2) 3 months after the injection of  $^{32}\text{P}$  into one stalk of *Aegopodium podagraria*

Y-axis — log activity in imp./min. per mg P of leaves (a) or per 100 mg dry matter (b), c — percentage of radioactivity in non-injected plants (100% = radioactivity of plant injected with  $^{32}\text{P}$  — d); X-axis — plant species:

1 — *Aegopodium podagraria* (plant injected with  $^{32}\text{P}$ ), 2 — *Padus avium*, 3 — *Fraxinus excelsior*, 4 — *Eupatorium cannabinum*, 5, 6 — *Aegopodium podagraria*, 7 — *Asarum europaeum*, 8 — *Chelidonium majus*, 9 — *Carex silvatica*, 10 — *Brachypodium silvaticum*

degree only, phosphorus compounds *in vivo*. This exchange, in conditions of the experiment performed, is not of significant importance as regards plant nutrition but it indicates the existence of a feeding connection between such plants. Part of the phosphorus diffused in inorganic form is probably intercepted also by microorganisms.

#### REFERENCES

- Domnicz A., Gorlach K., 1970. Przewodnik do ćwiczeń z chemii rolnej (Guide to exercises in agricultural chemistry), Kraków.
- Domnicz A., Zarzycki K., 1970. Exchange of radioactive phosphorus between specimens of *Solanum lycopersicum* L. in water and soil cultures, Bull. Acad. Pol. Sc., Cl. 2, 18: 297—300.
- Fober H., Giertych M., 1970. The uptake of  $^{32}\text{P}$  by spruce seedlings (*Picea abies* (L.) Karst.) growing in competition with grass, Acta Soc. Bot. Pol. 39: 115—121.
- Zarzycki K., Domnicz A., 1971. The exchange of radioactive phosphorus  $^{32}\text{P}$  between various components of an artificial plant community, IV Polish-Yugoslav Symposium on the Application of Radioisotopes and Ionizing Radiations in Agriculture, Veterinary Science and Forestry, 4—5 June, 1971, Abstracts, p. 58, Kraków.

## Authors' addresses:

Prof. dr Kazimierz Zarzycki  
Department of Plant Ecology and Plant Geography,  
Institute of Botany, Polish Academy of Sciences,  
ul. Lubicz 46; 31-512 Cracow; Poland

Dr Antoni Domnicz  
Institute of Soil Science, Agrochemistry and Microbiology,  
Agricultural Academy of Cracow  
Al. Mickiewicza 21; 31-120 Cracow; Poland

*Wymiana radioaktywnego fosforu  $^{32}\text{P}$  pomiędzy komponentami sztucznej  
asocjacji roślinnej*

## Streszczenie

Wstępne badania autorów wykazały (Domnicz, Zarzycki 1970), że pomidory w krótkotrwałych kulturach wodnych i glebowych wydzielają do podłoża około 0,5‰ wprowadzonego do nich radioaktywnego fosforu. Znaczna część wydzielonego  $^{32}\text{P}$  (do 70‰) została następnie pobrana z podłoża przez inne osobniki tego samego gatunku. W następnym doświadczeniu prześledzono jak przebiega wymiana radioaktywnego fosforu pomiędzy komponentami uproszczonego zbiorowiska roślinnego w warunkach zbliżonych do naturalnych.

Do 6 skrzyń napełnionych glebą ogrodową wysadzono wiosną 1969 r. młode okazy drzew i roślin zielnych, które rosły w nich przez okres 1 roku (ryc. 1). Gdy rośliny dobrze się ukorzeniły wytypowano do właściwych badań 3 skrzynie. W skrzyni nr 1 rosły 2 młode brzozy brodawkowate i liczne okazy *Carex pilosa* (odpowiednik spotykanego czasami w przyrodzie lasu brzozowego, który powstał po wycięciu drzewostanu grądowego). W skrzyniach nr 2 i 3 uformowano model olszynki karpackiej (*Alnetum incanae*); rosły w nich m.in. *Alnus incana*, *Fraxinus excelsior*, *Padus avium* do 1,2 m wysokie oraz z roślin zielnych *Aegopodium podagraria*, *Brachypodium silvaticum*, *Carex silvatica* i in.

Do pni brzoź lub pędów podagrycznika w obrębie każdej skrzyni w dniu 18 maja 1970 r. wprowadzono  $^{32}\text{P}$  (ryc. 2), który szybko został rozprowadzony po roślinie (ryc. 3). Po 3 miesiącach (18 sierpnia 1970) od wprowadzenia  $^{32}\text{P}$  we wszystkich roślinach rosnących razem w jednej skrzyni znaleziono radioaktywny fosfor. Gdy w roślinach, do których wprowadzono  $^{32}\text{P}$  drogą iniekcji (rośliny "R"), aktywność dochodziła lub nawet przekraczała  $10^6$  imp./min./100 mg suchej masy, to w sąsiadujących z nimi roślinach (rośliny "O") nie przekraczała z reguły aktywności  $10^3$  imp./min./100 mg suchej masy (ryc. 4, 5, 6).

Niniejsze badania wykazują, że komponenty jednego zbiorowiska roślinnego wymieniają między sobą, w niewielkim zresztą stopniu, związki fosforowe „na żywo”. Wymiana ta, w warunkach przeprowadzonego doświadczenia, nie ma większego znaczenia dla odżywiania roślin, ale wskazuje na istnienie między nimi więzi pokarmowej. Część fosforu, który wydzielany jest w formie nieorganicznej, przechwytywana jest najprawdopodobniej także przez mikroorganizmy.

*Instytut Botaniki PAN  
Zakład Ekologii i Geografii Roślin  
Instytut Gleboznawstwa, Chemii Rolnej  
i Mikrobiologii Akademii Rolniczej.  
Kraków*