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INVESTIGATIONS ON THE UTILIZATION OF PHOSPHORUS
FROM FERTILIZERS AND INSOLUBLE PHOSPHORUS
COMPOUNDS BY YOUNG PLANTS OF COMMON PINE

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INTRODUCTION

The recognition of the influence of environmental factors on the uptake of phosphorus from its different compounds by common pine is of importance for a correct fertilization ensuring a higher wood mass increment.

The most part of soil phosphorus compounds occurs as insoluble forms, viz.: of aluminium phosphate $AlPO_4$ and ferrous phosphate $FePO_4$ [2, 7, 8, 9]. The investigations on transformations of fertilizer phosphorus including high amounts of $AlPO_4$ and $FePO_4$ [3, 5, 6, 7, 8, 9, 11]. These the soil medium result in the formation of many compounds in soil, including high amounts of $AlPO_4$ and $FePO_4$ [3, 5, 6, 7, 8, 9, 11]. These phosphorus compounds are regarded as unavailable to most plants. However, the investigations carried out by Mullette [10] have proved that the eucalyptus seedlings can utilize phosphorus from $AlPO_4$ and $FePO_4$. On the other hand, Ballard and Pritchett [11], basing on their investigations, prove that $AlPO_4$ is a bad phosphorus source for *Pinus elliotti*. Our investigations on the influence of soluble aluminium on the phosphorus uptake [4] have shown that the common pine plants are taking up and utilizing phosphorus necessary for their growth from insoluble aluminium phosphate $AlPO_4$.

The aim of the present work was to study in pot experiments possibilities of the phosphorus uptake by the common pine (*Pinus silvestris* L.) plants from different fertilizers and compounds of phosphorus.

Method of the experiments

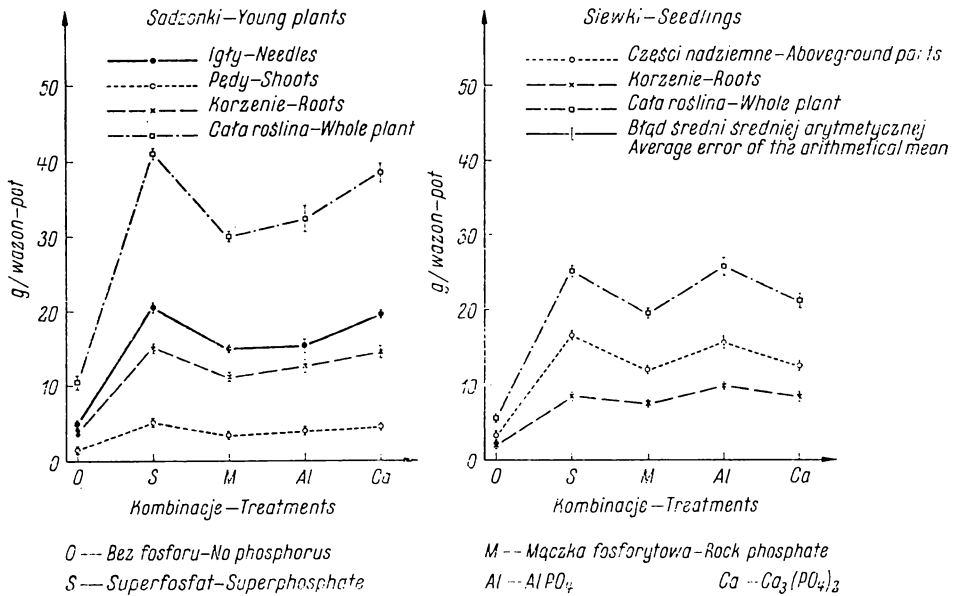
The pot experiments on sand were carried out in the greenhouse of

the Department of Soil Science and Fertilization, Forestry Research Institute in Warszawa-Sękocin. The technique of the experiments has been described in the paper by Gawliński [4].

In the first year of investigations (1974) the experiment with seedlings and 1-year old common pine plants was established. It comprised five treatments: (1) no phosphorus, (2) superphosphate — 18% P_2O_5 , (3) Morocco rock phosphate — 30% P_2O_5 , (4) $AlPO_4$ pure, (5) $Ca_3(PO_4)_2$ pure. The plants were harvested on September 26, 1974, in 3 replications.

In the next year (1975) another experiment with 1-year old pine plants was established. It comprised 6 treatments, including 5 like in the previous year and the 6th with $FePO_4$ pure, in 9 replications. The plants tested were divided into three series: in the I st series the plants grew on a sandy substrate with pH 6.5; in the II nd series pH was lowered to about 5.0 by addition of sulphuric acid; in the III rd series triplicate phosphorus rate was applied at an unchanged pH value, amounting to about 6.5. During the growth (May 31) all plants were additionally fed with 1/2 nitrogen rate. The plants were harvested on September 25, 1975 in each series, by 3 replications.

After the harvest the young plants were divided into needles, shoots and roots, the seedlings — into aboveground parts and roots. The weight of air-dry matter of plants was determined and standart error of the



Rys. 1. Sucha masa młodych roślin sosny zwyczajnej w zależności od formy nawozu i związku fosforowego (1974)

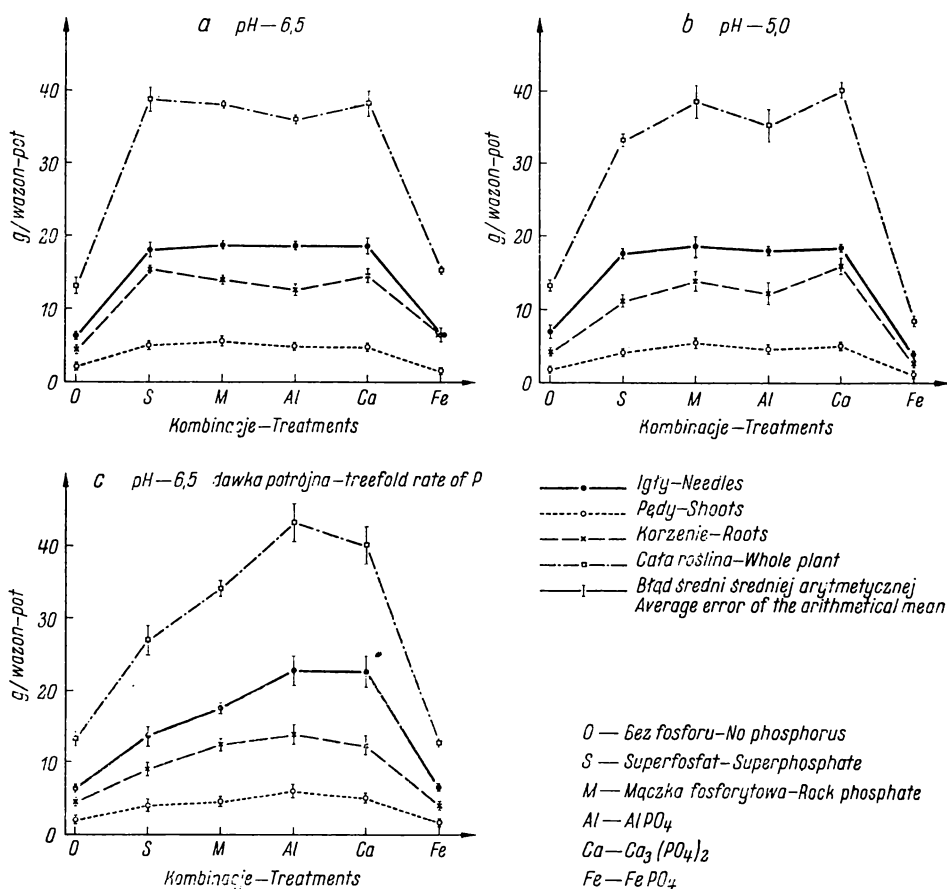
Dry matter of young plants of common pine depending on the phosphorus fertilizer form or the phosphorus compound kind (1974)

arithmetical mean was calculated. The plant matter was burnt wet with the mixture of the HNO_3 and HClO_4 acids. Total phosphorus was determined in the solution by the vanarium method.

Discussion of the results

The growth of 1-year old plants and seedlings of common pine was by about 3–4 times better in all treatments with phosphorus as compared to plants in the treatment without phosphorus, what is clearly evident from the dry matter yield (Fig. 1). Although the dry matter yield of young plants grown on the rock phosphate and on AlPO_4 was about 20–30% lower as compared to the plants grown on superphosphate, it was nevertheless several times higher than that of plants without phosphorus.

In the next year of the experiments, at a very good feeding of plants



Rys. 2. Sucha masa sadzonek sosny w zależności od źródła fosforu i warunków środowiska (1975)

Dry matter of young plants of pine depending on the phosphorus source and the environmental conditions (1975)

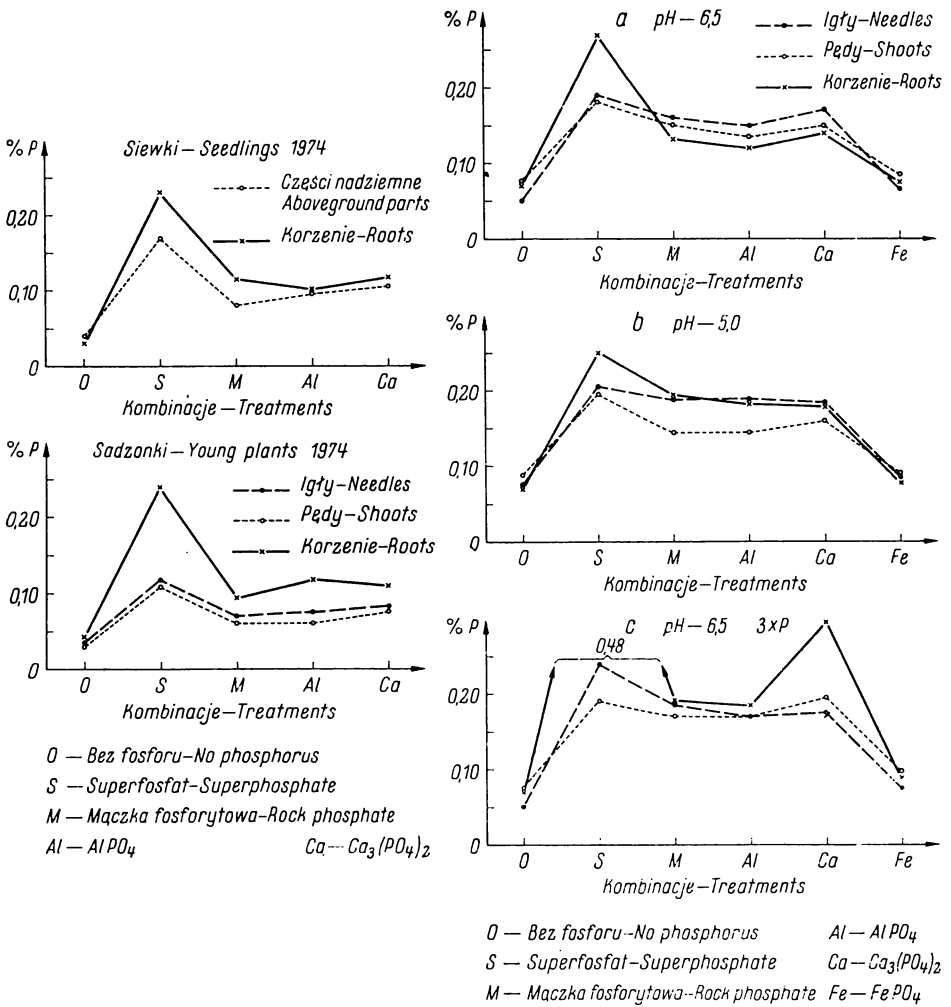
with nitrogen, the dry matter yield on superphosphate, rock phosphate, AlPO_4 and $\text{Ca}_3(\text{PO}_4)_2$ was similar, at the reaction of the medium amounting both to pH 6.5 and to about 5.0, and varied from about 35 to 40 g per pot (Fig. 2a, b). At the threefold phosphorus rate the growth of the plants on superphosphate was worse than in the treatments with rock phosphate, AlPO_4 or $\text{Ca}_3(\text{PO}_4)_2$. The result with the threefold superphosphate rate proves a relatively high sensitivity of pine plants to higher phosphorus concentration in the medium (Fig. 2c). On the other hand, it was phosphorus from ferrous phosphate FePO_4 , which proved to be completely unavailable to plants. The dry matter volume in this treatment was similar to that without phosphorus, irrespective of the phosphorus level, whereas at a lowered pH it was even less than that in the treatment without P, amounting to about 13 g per pot.

The mass of needles constituted the highest percentage in the total mass of young pine plants, amounting to about 50% (Figs. 1 and 2). Somewhat less was the percentage of roots, which amounted to about 37%, and the least that of shoots — to about 13%. This relation did not undergo any significant changes with regard to the differentiated feeding and was similar both at bad and very good growth of plants, giving accordingly only 10 g or 40 g of dry matter per pot.

The content of phosphorus in young plants and seedlings of common pine (Fig. 3) was the highest in plants from the treatment with superphosphate, in needles, shoots and roots alike. The plants, on the phosphorus source of which were insoluble phosphorus fertilizers and compounds, like rock phosphate, AlPO_4 and $\text{Ca}_3(\text{PO}_4)_2$ showed a lowered phosphorus content as compared to plants with superphosphate; nevertheless the above values were much higher as compared to plants in the control treatment, without phosphorus. In the next year of the experiments (Fig. 4) relations in the content of phosphorus were similar to previous ones, but in plants with FePO_4 this value approximated to that in plants without phosphorus. This last result bears evidence of unavailability of phosphorus from FePO_4 to pine plants.

It should be stressed that at a good supply of the pine plants with readily available phosphorus (superphosphate), the content of phosphorus in roots was distinctly higher than in needles or shoots. On the other hand, in case of sparingly available phosphorus forms (except for $\text{Ca}_3(\text{PO}_4)_2$ at the threefold P rate) the above values in needles, shoots and roots were similar.

Also the phosphorus uptake by plants was the highest in the treatment with superphosphate, being much lower in case of other phosphorus fertilizers or compounds (Fig. 5). However, in 1975 (Fig. 6), at a lowered pH of the medium, almost equal amounts of phosphorus were taken up by plants from all phosphorus compounds tested, except for ferrous phosphate FePO_4 . No phosphorus from the latter compound (FePO_4) was



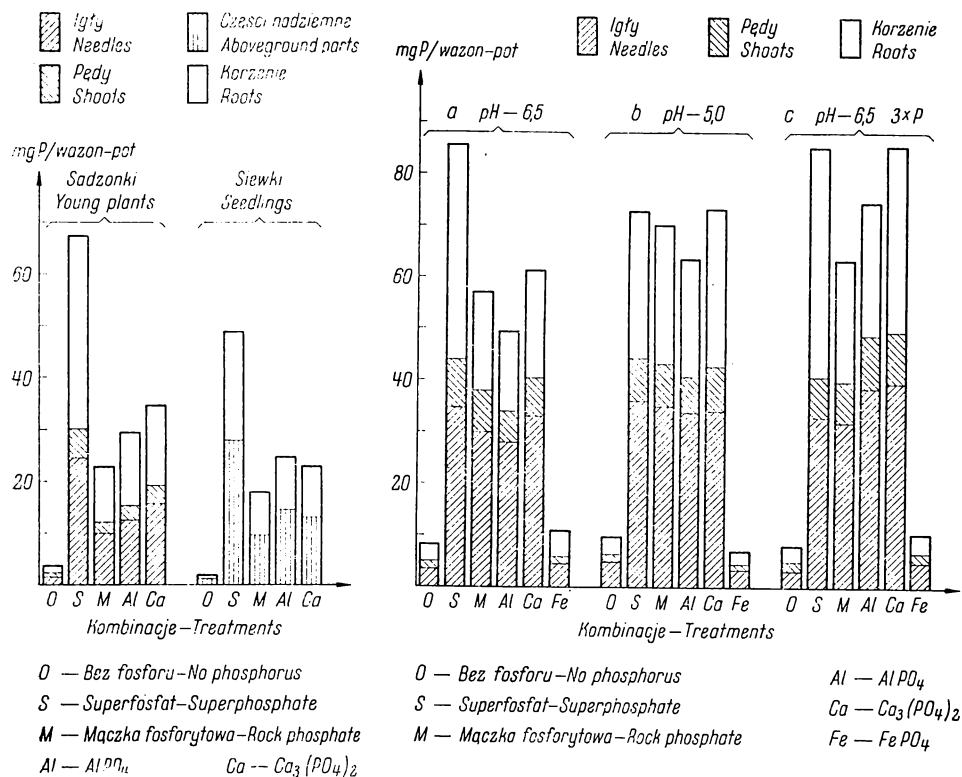
Rys. 3. Procentowa zawartość fosforu w siewkach i sadzonkach sosny zwyczajnej w zależności od źródła fosforu

Percentual content of phosphorus in seedling and young plants of common pine depending on the phosphorus source

Rys. 4. Procentowa zawartość fosforu w sadzonkach sosny w zależności od źródła fosforu i warunków siedliska (1975)

Percentual content of phosphorus in young plants of pine depending on the phosphorus source and the environmental conditions (1975)

taken up by plants, its amounts being similar as in plants of the control treatment, without phosphorus, irrespective of the nitrogen feeding level, reaction of the medium or triplication of the rate of the compounds tested.



Rys. 5. Pobranie fosforu przez młode rośliny sosny zwyczajnej z kilku nawozów i związków fosforowych

Phosphorus uptake by young plants of common pine from several phosphorus fertilizers and compounds

Rys. 6. Pobranie fosforu przez sadzonki sosny z kilku nawozów i związków fosforowych

Phosphorus uptake by young plants of common pine from several phosphorus fertilizers and compounds

The results obtained concerning growth of plants, content of phosphorus and amounts of phosphorus taken up by the common pine plants, bear evidence of the availability of phosphorus from rock phosphate and/or insoluble phosphorus compounds, like $AlPO_4$ or $Ca_3(PO_4)_2$. These compounds can constitute a source of phosphorus for the common pine plants. Phosphorus from the above insoluble compounds is, to be true, taken up slower by the pine plants, of which a lower content of phosphorus in these plants can bear evidence; nevertheless they can cover totally the phosphorus requirements of plants, enabling thus their appropriate growth, if the plants will be at the same time supplied satisfac-

torily with other nutrients and other factors will approximate to their optimal arrangement for the growth of plants.

Conclusions

1. Young plants of common pine can take up and utilize for their growth phosphorus from insoluble phosphorus fertilizers and compounds, like rock phosphate, AlPO_4 or $\text{Ca}_3(\text{PO}_4)_2$.

2. The utilization of phosphorus from insoluble compounds increases under conditions of a good supply of plants with other nutrient elements, at an appropriate reaction of the medium and at existence of other factors necessary for the growth of plants.

3. At the present stage of the investigations there are no grounds to prove that phosphorus from insoluble ferrous phosphate FePO_4 could be taken up by the common pine plants.

4. The diagnostics of the phosphorus fertilization requirements of pine ought to take into consideration the content of insoluble phosphorus compounds — AlPO_4 and $\text{Ca}_3(\text{PO}_4)_2$, in soil.

5. Excessive amounts of readily soluble phosphorus from superphosphate lead to a decrease of the growth rate of the common pine plants.

6. It would be necessary to intensify the investigations on utilization of phosphorus from different phosphorus fertilizers and compounds by the common pine plants, since the respective results would constitute a basis for the optimization of the phosphorus fertilization of pine.

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С. ГАВЛИНСКИ

ИССЛЕДОВАНИЯ ПО ИСПОЛЬЗОВАНИЮ ФОСФОРА МОЛОДЫМИ
РАСТЕНИЯМИ СОСНЫ ОБЫКНОВЕННОЙ ИЗ ТРУДНО РАСТВОРИМЫХ
ФОСФОРНЫХ УДОБРЕНИЙ И СОЕДИНЕНИЙ

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Резюме

В годах 1974-1975 проводились вегетационные опыты на песке по выяснению усвояемости фосфора из трудно растворимых удобрений и фосфорных соединений для молодых растений сосны обыкновенной (*Pinus silvestris* L.). Полученные результаты показывают, что растения сосны могут усвоить и использовать фосфор таких труднорастворимых веществ как: фосфоритная мука фосфат, алюминия $AlPO_4$ и трехкальцевый фосфат $Ca_3(PO_4)_2$. Растения эти имеют однако пониженное на 10-50% содержание фосфора а их рост и урожай массы бывает немного меньшим или таким-же как и растений на суперфосфате. Зато фосфат железа $FePO_4$ оказался плохим источником фосфора для сосны и развитие ее на этом соединении было также-же растений без фосфора.

Повышенные количества легко растворимого фосфора (суперфосфат) вызывают угнетения роста растений сосны обыкновенной по сравнению с растениями гравильно питаемыми.

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BADANIA NAD WYKORZYSTANIEM FOSFORU
PRZEZ MŁODE ROŚLINY SOSNY ZWYCZAJNEJ
Z TRUDNO ROZPUSZCZALNYCH NAWOZÓW I ZWIĄZKÓW FOSFOROWYCH

Zakład Gleboznawstwa i Nawożenia Instytutu Badawczego Leśnictwa,
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Streszczenie

W latach 1974-1975 prowadzono doświadczenia wazonowe na piasku nad przyswajalnością fosforu z trudno rozpuszczalnych nawozów i związków fosforowych przez młode rośliny sosny zwyczajnej *Pinus silvestris* L. Uzyskane wyniki wskazują, że rośliny sosny mogą pobierać i wykorzystywać fosfor z trudno rozpuszczalnych nawozów i związków, jak mączka fosforytowa, fosforan glinowy $AlPO_4$ i fosforan wapniowy trójzasadowy $Ca_3(PO_4)_2$. Rośliny te jednak mają obniżoną zawartość fosforu od 10 do 50%, ale ich wzrost i plon masy jest nieco mniejszy lub podobny jak u roślin na superfosfacie. Natomiast fosforan żelazowy $FePO_4$ jest złym źródłem fosforu dla sosny i wzrost roślin na nim rosnących jest podobny jak roślin bez fosforu.

Większe ilości łatwo rozpuszczalnego fosforu (superfosfat) powodują zahamowanie wzrostu roślin sosny zwyczajnej w porównaniu do roślin prawidłowo żywnych.

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