ACTA SACIETATIS
BOTANICORUM POLONIAE
vol. XXXIX — nr 1
1970

The uptake of ^{32}P by spruce seedlings (*Picea abies* (L.) Karst.) growing in competition with grass

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INTRODUCTION

The problem of competition between grass and small seedlings of trees in nurseries or on young plantations is of considerable economic importance. Many authors have pointed out that fertilization can help weeds more than it does help trees (McClurkin 1961; Berg 1958; Faulkner 1966). In greenhouse experiments it has been shown (Fober and Giertych 1968) that grass competition has on the average lowered the dry weight of spruce seedlings sixfold and under extreme condtions even eightfold. In these conditions an improvement of nitrogen nutrition has resulted in a decline of the spruce dry weight. A similar effect has been obtained by improving phosphorous supply (Giertych 1969). In a field experiment (Pobedov 1963) radioactive phosphorous supplied to pine transplants has been picked up by grass roots as far as 25 cm away from the point of application.

In view of the above the authors have decided to study in greater detail the competition between grass and spruce seedlings for phosphorous. The amount of absorbed phosphorous as well as its distribution in the plants has been studied after 1 and 7 days of absorption. Furthermore a supplementary study was made or phosphorous exudation by the plant roots.

MATERIALS AND METHODS

For the experiment one year old spruce seedlings *Picea abies* (L.) Karst. have been raised from seeds of 15 different Polish provenances. The seedlings were grown in the greenhouse in small clay pots, lined with paraffin wax, and filled with white technical sand washed several times. In each pot 5 spruce seedlings and 5 plants of the grass *Poa annua* L. have been raised (Fig. 1).

The whole experiment included 30 pots. Twice weekly the plants were watered with a mineral solution completely deficient in phosphorous. On the remaining days the watering was done with distilled water.

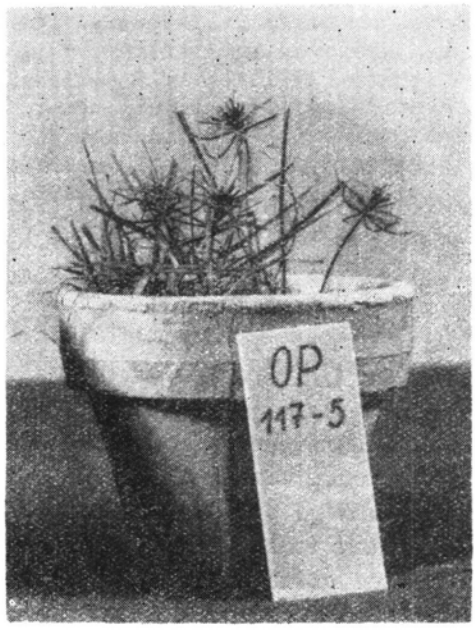

Fig. 1. A pot with spruce seedlings and grass growing together after one year of culturing on a P deficient medium.

A small sample of $Na_2H^{32}PO_4$ has been added to 200 ml of a phosphate solution 1 ml of which contained 0.062 mg of pure phosphorous. Into each pot 5 ml of the labelled solution has been applied. In 15 pots the absorption was permitted for 24 hours and in the remainder for 7 days. After these times the pots were taken out of the greenhouse, the sand was washed out under running tap water for exactly three minutes, the grass was separated from the spruce and the roots were severed from the aerial plant parts. After drying the plants for 24 hours at 105°C the dry weight was estimated as well as the radioactivity of individual samples. The radiocativity was measured in a GM counter the results being corrected for self absorption by the dry plant tissue. From these data the amount of phosphorous in the plants, in mg and as percentage of dry weight have been calculated.

In a further experiment radioactive phosphorous was applied to a few pots with spruce and grass raised as before. After 24 hrs the plants were taken out of the pots washed first in tap and then in distilled water, the grass and spruce separated from each other and their roots immersed in a nutrient solution containing cold phosphorous. After 9 days radioactivity was measured in the plants and in the nutrient solutions in which they stood.

RESULTS AND DISCUSSION

As was mentioned in the introduction, an increase in supply of phosphorous leads to a reduction of dry weight of spruce seedlings growing in competition with grass, which has been demonstrated on material grown parallel with the present experiment and under identical conditions but with different levels of phosphorous supply (Fig. 2).

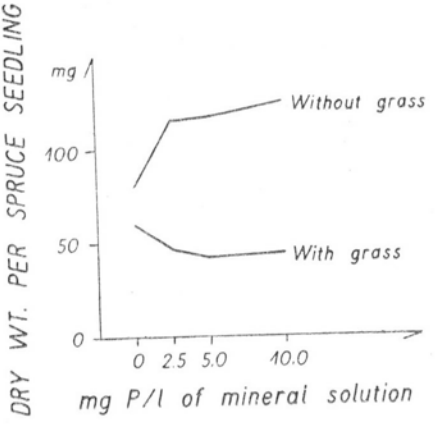

Fig. 2. The influence of phosphorous supply and grass competition on the dry weight of spruce seedlings.

The plants grown on phosphate deficient cultures have demonstrated distinct symptoms of the deficiency. The spruce seedlings have set terminal buds and ceased to grow. After 4 months the seedlings have reached an average height of 4 cm which was maintained for the remaining 8 months of the experiment. Also the growth of the grass was arrested, and almost throughout the duration of the experiment numerous necroses and wilted leaves have been observed. External appearance of grass indicated that it was more affected by the deficiency than spruce.

The amounts of absorbed phosphorous as well as its distribution between the roots and the aerial parts of spruce seedlings and grass are presented in table 1 as averages per one pot.

With the labelled phosphate solution 0.31 mg of phosphorous was applied to each pot. After 24 hours grass and spruce have jointly absorbed 49.2% of the label supplied. Of this amount 80% was taken up by grass and 20% by the spruce seedlings. Similarily after 7 days the plants have jointly absorbed 46% of the label supplied of which 74% was in the grass and 26% in the spruce. Grass has absorbed four times as much phosphorous in absolute values in spite of weighing less than half as much as spruce (in dry weight). This is presumably the result of the grass

Table 1

Absorption of labelled phosphorous by spruce seedlings and grass growing together in pots, following a long period of P deficiency. The values are averages over 15 provenances in units per one pot

Units	Absorption time in days	Grass			Spruce		
		Aerial part	Root	Total	Aerial part	Root	Total
Dry weight in mg	1	91.1	66.6	157.7	227.8	165.5	393.3
	7	95.5	54.9	150.4	229.4	173.9	403.3
P absorbed in µg	1	97.9	27.7	125.5	5.7	24.0	29.7
	7	83.7	22.4	106.1	11.1	27.1	38.2
P absorbed as ‰ of dry weight	1	1.20	0.55	0.80	0.03	0.15	0.08
	7	1.02	0.46	0.71	0.05	0.15	0.10
P absorbed as ‰ of root dry wt.	1			0.19			0.02
	7			0.19			0.02
^{32}P in shoot	1			3.54			0.24
^{32}P in root	7			3.74			0.41

root system having a greater absorption surface, on its numerous small and thin rootlets. The roots of grass weigh about 1/3 as much as the roots of spruce and therefore have a more favourable ratio of the absorptive surface to dry weight. Thus they are more efficient in absorbing phosphorous. In relation to root dry weight grass has absorbed 10 times as much phosphorous as spruce. This of course results in that the percentage content of absorbed phosphorous in the grass plants was considerably higher then in the spruce seedlings. Grass was quick to react when phosphorous was supplied in spite of the fact that it exhibited more serious pathological symptoms of phosphorous deficiency in the from of necroses and wilted leaves. Already after 24 hours the grass plants have absorbed a maximal quantity of the element needed for one week. In fact over the following 7 days there was even a tendency of the internal phosphorous content to decline. This may appear to be the result of lower total root weight of grass plants in the pots used for the experiment with longer absorption time, on the other hand however the percentage content of absorbed phosphorous is lower, both in the roots and in the aerial parts, which rather indicates exudation. Seedlings of spruce absorb less phosphorous than grass and do so very slowly, thus an extension of the absorption time has increased the content of this element in the plants, both in absolute and percentage values.

The transport of phosphorous from roots to the aerial plant parts is

very different in grass and spruce. In the former it is rapid and already after 24 hours the aerial parts contain the maximal amount of phosphorous. In spruce on the other hand this process is very slow so that after 7 days the content of phosphorous in the aerial parts is double that observed after 24 hours and still well below that in the roots.

In grass the aerial plant part contains the bulk of the absorbed phosphorous, twice as much as roots in percentage values. In spruce the opposite is true, even after 7 days.

The results obtained suggested that grass exuded some of the phosphorous absorbed in excess during the time immediately following application. The supplementary experiment on exudation has shown that labelled phosphorous is returned to the medium both by grass and by spruce. After 9 days grass has returned 3.5% of the phosphorous absorbed during the first 24 hours and spruce has returned 11%. During these 9 days grass has grown markedly in size while spruce did not alter its dimensions. From other studies we know that the content of phosphorous in spruce seedlings growing in competition with grass on a phoshorous deficient medium was 1.20‰ and on a full medium 3.10‰. The application of labelled phoshporous has after 24 hours increased the internal concentration of the element in spruce seedlings to about 1.28‰ and therefore very slightly in comparison with the optimal value. In spite of that however even this amount proved temporarily excessive since 11% of the label was returned to a cold medium. During the following 7 days spruce, as contrasted to grass, continued to absorb phosphorous, labelled in the main experiment and cold in the experiment on exudation. It appears that plants after a long period of phosphorous deficiency when given the element absorb it rapidly and in exeess of what they are capable of metabolising immediately. In the following days some of this phoshporous is exuded back through the roots, though in the case of spruce it is soon reabsorbed again.

Results of these studies indicate how grass competes with spruce seedlings in relation to mineral nutrition. The growth inhibition caused by phosphorous deficiency is more permanent in spruce than in grass. The more absorptive root system of grass, the ability of the plants to transport the phosphorous immediately to the aerial plant parts and in particular the rapidity with which the deficient plants are capable of responding to an improvement of nutrient conditions results in the rapid growth of grass leading to domination in the pot, and restriction of the growth of spruce. This explains why fertilization in the presence of weeds can bring more harm than benefit to tree seedlings. The better are the nutritional conditions in the soil, the more serious is the problem of grass competition for spruce. Fertilization must therefore be always coupled with effective control of weeds.

SUMMARY

One year old spruce seedlings have been raised in the greenhouse on phosphorous deficient sand cultures with grass in the pots. After application of a full nutrient solution labelled with ^{32}P the plants jointly absorbed 49% of the supplied phosphorous after 24 hours and 46% after 7 days. Grass has absorbed four times as much phosphorous as spruce and in a short time the label was transported to the aerial plant part. Extending the time allowed for absorption sevenfold did not alter substancially the distribution of labelled phosphorous in the grass and its overall amount somewhat declined. In spruce the phosphorous was more slowly transported to the aerial plant part, where after 7 days its content increased substancially, however even then most of the label was still in the roots.

A supplementary experiment has shown that phosphorous is also returned to the substratum by the plants. Of the amount absorbed in the first 24 hours within 9 days 11% and 3.5% were returned by spruce and grass respectively to a cold full nutrient medium.

The authors wish to thank Doc. M. Tomaszewski for his help with the measurement of radioactivity.

This work has been partially supported by grant FG-Po-174 from US Department of Agriculture, under US Public Law 480.

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(Entered: April 3, 1969)

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Doświadczenia nad pobieraniem ^{32}P przez siewki świerka Picea abies (L.) Karst rosnące w konkurencji z trawą

Streszczenie

W cieplarni wyhodowano w doniczkach jednoroczne siewki świerka z trawą na pożywce mineralnej bez fosforu. Jednorazowo podano pożywkę pełną znakowaną przez ^{32}P. Po 24 godzinach razem w roślinach stwierdzono 49% podanego fosforu, a po 7 dniach 46%. Trawa pobrała cztery razy więcej fosforu niż świerk i w krótkim czasie został on przetransportowany do części nadziemnej. 7-krotne zwiększenie czasu absorbcji nie wprowadziło znaczących zmian w rozmieszczeniu tego pierwiastka w trawie, a jego ilość ogólnie nieco zmalała. U świerka fosfor był wolniej przemieszczany do części nadziemnej, gdzie jego ilość wzrosła znacząco po 7 dniach, ale główna jego część nadal znajdowała się jeszcze w korzeniach.

Doświadczenie uzupełniające wykazało przechodzenie jonów fosforowych do podłoża. Z fosforu pobranego w pierwszych 24 godzinach, w ciągu 9 dni świerk oddał lub wymienił 11% fosforu, a trawa 3,5%.

Szkodliwość nawożenia w warunkach zachwaszczenia tłumaczyć więc można szybszą reakcją trawy niż świerka na poprawę warunków odżywczych.