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DIRECT ABSORPTION OF ORGANIC PHOSPHATE BY RICE AND JUTE PLANTS

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KEY WORDS

Calcium glycerophosphate Inosine-5-monophosphate Jute Lecithin Nutrient culture experiment Rice Sodium phytate

SUMMARY

Appreciable amounts of organic phosphate from calcium glycerophosphate, lecithin, sodium phytate and inosine-5-monophosphate were absorbed directly by rice plants and that from calcium glycerophosphate and lecithin by jute plants under sterile and non-sterile conditions. The plants absorbed phosphate both in organic and inorganic combinations and the deficit of one form in the media made the other 'more available' to the roots. Sterilization of jute roots with 0.1% $HgCl_2$ stopped the absorption of phosphate upto 4 days while the treatment mixture of C_2H_5OH and H_2O_2 indicates inhibitory effects on roots of neither plants.

INTRODUCTION

Soil organic phosphate comprises a significant proportion of total phosphate[1] and is of particular interest in the dynamic biological phases of phosphate cycle[7]. Organic phosphate compounds serve as good phosphate source to plants after mineralization[4,5] while a significant part of total absorption might occur directly in the organic combination[8,9]. Thus it is still to be answered and remains a key issue to unlock the true importance and relatively complete behaviour of soil organic phosphate in plant nutrition and soil fertility. An attempt was, therefore, made to study the direct absorption of calcium glycerophosphate, lecithin, sodium phytate and inosine-5-monophosphate by rice and calcium glycerophosphate and lecithin by jute plants.

MATERIALS AND METHODS

Nutrient solution

Locard's (1959) nutrient solution was used with slight modification of 41, 30, 5 and 17.2 ppm N, Ca, Fe and Cl respectively. 3.4907, 7.6923, 28.6533, 8.0972 and 12.2549 g potassium dihydrogen phos-

phate, calcium glycerophosphate, lecithin, sodium phytate and inosine-5-monophosphate containing 28.73, 13, 3.49, 12.35 and 8.16% phosphate respectively were dissolved separately in redistilled water to prepare one litre 1000 ppm phosphate solutions. Only lecithin required 2 hours of homogenization to prepare a colloidal solution. 16 ml of each of these phosphate solutions were separately diluted to 1000 ml with previously prepared nutrient solution to get a complete nutrient solution of 16 mg phosphate/litre.

Experimental technique

The experiment was designed in two sets, in one set free hydrolysis of organic phosphate compounds by root enzyme was allowed but the uptake of any form of phosphate was prevented by sterilizing the roots with 0.1% $HgCl_2$[7]. In another set, both hydrolysis and uptake were allowed, roots being sterilized with 50:50 (V:V) C_2H_5OH and H_2O_2. For comparison, however, another set of experiment was also conducted without sterilization.

Sterile water culture apparatus

The sterile-water-culture apparatus was constituted simply of a series of bottles duly filled with test solutions (each containing 250 ml solution with 4 mg phosphate) and were stoppered with rubber

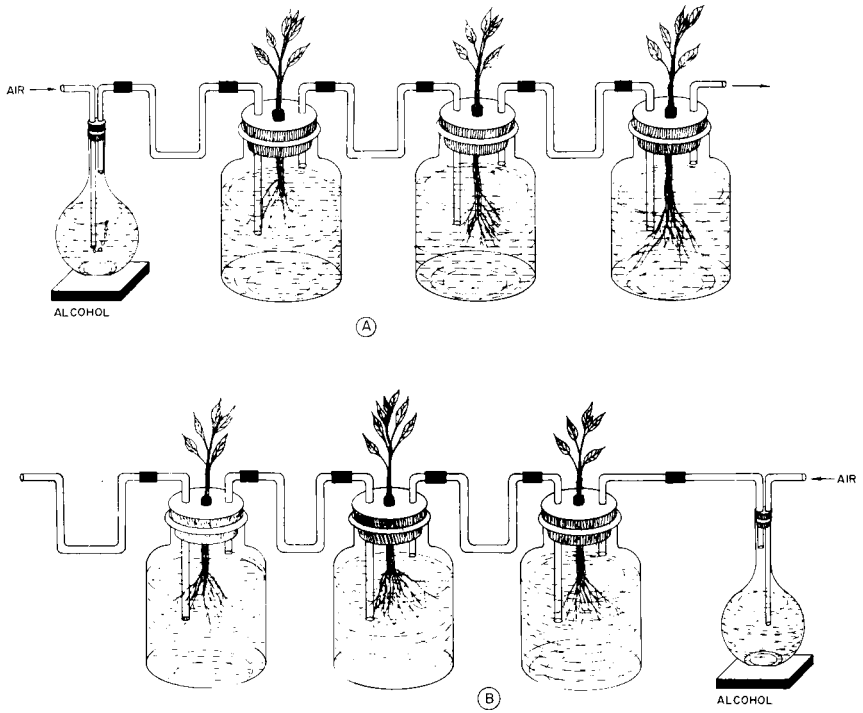

Fig. 1. The sterile water culture apparatus, (A) aerating the root media and (B) sampling of solution.

corks and connected by glass and rubber tubings to one another (Fig. 1A, B). The entire system was autoclaved and cooled before plantation. Two seedling, roots being sterilized with 0.1% $HgCl_2$, and a mixture of C_2H_5OH and H_2O_2, were then introduced into the bottles through the corks and made air tight with sterile cotton. To aerate the root medium, air was passed through alcohol by a mechanical aspirator. Sampling of solutions was done at the interval of 2 days' of absorption and air was passed through the alternate side of the apparatus, thus pushing a little amount of solution into the bent tube connecting two adjacent bottles.

Analytical technique

Sampled solutions were divided into two portions, (a) for inorganic phosphate and (b) for total phosphate. Aliquots of (a) were used directly for colour development and that of (b) after digestion with concentrated nitric and perchloric acid. The method of Mehta *et al.*[6] was followed for determining phosphate and the difference between a and b was the amount of organic phosphate. Phosphate in plant tissue was estimated after wet ashing. The total uptake and the amount of hydrolysis were recorded from where the amount of phosphate uptake in organic form was calculated.

Inorganic phosphate absorbed = Inorganic phosphate initially present + hydrolyzed inorganic phosphate − inorganic phosphate retained in solution after absorption.

Organic phosphate absorbed = Total phosphate absorbed − inorganic phosphate absorbed.

Before sampling of solutions, to overcome the loss during transpiration sterile water was poured into the bottles to bring the volume to 250 ml for the convenience of calculation of absolute amount of phosphate. After sampling and analysing, equal amount of phosphate solution in the same concentration as removed for analysis was supplemented. The quantity of organic and inorganic phosphate in the supplementary solution was adjusted by addition of inorganic phosphate whenever necessary.

RESULTS AND DISCUSSION

Rice roots sterilized with a mixture of C_2H_5OH and H_2O_2 absorbed an appreciable amounts of phosphate from potassium dihydrogen phosphate, calcium glycerophosphate, lecithin, sodium phytate and inosine-5-monophosphate and that by jute roots from potassium dihydrogen phosphate, calcium glycerophosphate and lecithin (Fig. 2A, B, C). Phosphate absorbed by rice and jute roots from lecithin were, however, considerably lower compared to other sources. The absorption of phosphate was more rapid in the first 2 days' and then decreased gradually. Moreover, phosphate absorption from calcium glycerophosphate and potassium dihydrogen phosphate by rice roots appeared more or less parallel after 2 days' (Fig. 2A, B, C). However, microscopic study of the sampled solutions failed to detect any organisms indicating that microbial mineralization is not only responsible for making organic phosphate compounds available to plants as was noticed by other investigators[1,2,3].

Rice roots sterilized with 0.1% $HgCl_2$ absorbed no phosphate in the first 2 days' from calcium glycerophosphate and sodium phytate and that by jute root upto 4 days' from potassium dehydrogen phosphate, calcium glycerophosphate

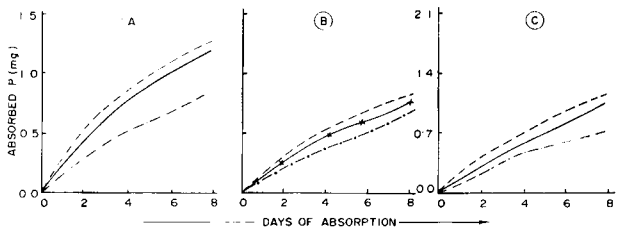

Fig. 2. Absorption of potassium dihydrogen phosphate, calcium glycerophosphate, lecithin, inosine-5-monophosphate and sodium phytate by rice (A and B) and jute (C) roots sterilized with C_2H_5OH and H_2O_2 (50:50; V:V).

Legend potassium dihydrogen phosphate, – calcium glycerophosphate, · · · lecithin, — × — × inosine-5-monophosphate, – ● ● sodium phytate.

and lecithin (Fig. 3A, B, C). This was followed by an increase in absorption with time and was probably attributed to the progressively decreasing effectiveness of inhibitory effect of $HgCl_2$. If little amount of phosphate absorbed by 0.1 per cent $HgCl_2$ treated roots is considered to occur in inorganic form, then the total decrease in organic phosphate in solution was the amount of hydrolysis. On this basis, the apparent hydrolysis of the organic phosphate compounds were estimated (Table 1).

Hydrolysis of lecithin by both rice and jute roots was extremely low compared to calcium glycerophosphate while that of inosine-5-monophosphate by rice roots was slightly higher than sodium phytate (Table 1). This was probably because of greater susceptibility of calcium glycerophosphate to hydrolysis. Rice roots absorbed more phosphate from inosine-5-monophosphate than sodium phytate probably in the same manner. However, enzymes of rice and jute roots caused hydrolysis of all the organic phosphate compounds used.

Both rice and jute roots absorbed considerable amount of phosphate in organic form after 2, 4, 6 and 8 days' of growth in the culture solution (Table 2). They absorbed more phosphate from calcium glycerophosphate but the amount in organic combination was comparatively more from lecithin. After 8 days' of

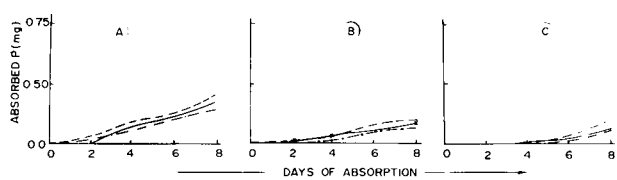

Fig. 3. Absorption of potassium dihydrogen phosphate, calcium glycerophosphate, lecithin, inosine-5-monophosphate and sodium phytate by rice (A and B) and jute (C) roots sterilized with 0.1% $HgCl_2$ solution. Legends see Fig. 2.

Table 1. 'Apparent hydrolysis' of organic phosphate compounds by rice and jute roots

Days of absorption	Apparent hydrolysis in mg					
	Calcium glycerophosphate		Lecithin		Sodium phytate	Inosine-5-mono-phosphate
	Rice	Jute	Rice	Jute	Rice	Rice
2	0.598	0.352	0.044	0.006	0.108	0.117
4	1.054	0.761	0.138	0.053	0.043	0.435
6	1.522	1.040	0.207	0.091	0.639	0.684
8	2.005	1.506	0.278	0.143	0.825	0.844

Remarks: The amount of hydrolysis of all the compounds was calculated on the basis of total decrease in the organic phosphate content in the sets of experiments with 0.1% $HgCl_2$ treated plants, assuming that the uptake though negligible, might have occurred in the inorganic form. Therefore, the term 'apparent hydrolysis' was used.

absorption, rice roots absorbed 32 and 74% phosphate of the total absorption in organic form from calcium glycerophosphate and lecithin respectively while that for jute roots amounted to 50 and 80% respectively. The higher amount of organic phosphate absorption from lecithin by both roots was probably due to scarcity of inorganic phosphate in the media. However, the reverse was true for

Table 2. Absorption of phosphate from organic phosphate compounds in the organic form by rice and jute roots sterilized with C_2H_5OH and H_2O_2

Source of organic phosphate	Days of absorption							
	2		4		6		8	
	mg	%*	mg	%*	mg	%*	mg	%*
Rice								
Calcium glycerophosphate	"0.215	44	0.234	29	0.283	28	0.383	32
Lecithin	0.272	88	0.430	79	0.516	75	0.628	74
Sodium phytate	0.220	71	0.325	61	0.472	66	0.684	73
Inosine-5-monophosphate	0.280	66	0.355	51	0.371	44	0.508	49
Jute								
Calcium glycerophosphate	0.095	40	0.175	42	0.233	39	0.374	50
Lecithin	0.171	91	0.296	86	0.382	84	0.433	80

* Total absorption.

calcium glycerophosphate due to abundance of inorganic phosphate produced during hydrolysis. The rate of hydrolysis of sodium phytate and inosine-5-monophosphate by rice roots did not vary appreciably but 73 and 49% phosphate was absorbed in organic form from the respective compounds after 8 days' of growth. This variation in the rate of absorbtion was probably the result of the differences in the molecular complexities of the two compounds. Moreover, the study revealed that (i) the enzyme system of both rice and jute roots caused hydrolysis of the organic phosphate compounds; (ii) when grown in a medium containing both organic and inorganic phosphate, rice and jute roots absorbed phosphate from both the combinations, the deficit of one in the media increased the absorption of the other, and (iii) the hydrolyzing action of root enzymes of these plants were as important as the participation of microorganisms in making organic phosphate 'more available' to them.

Absence of any appreciable variation in phosphate absorption from potassium dihydrogen phosphate by non-sterilized, and sterilized roots with a mixture of C_2H_5OH and H_2O_2 indicates no inhibitory effect of these sterilizing agents on roots. However, the slight increase in phosphate absorption from organic compounds by non-sterilized roots was due to microbial decomposition of the compounds.

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