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UPTAKE AND UTILIZATION OF FERTILIZER PHOSPHORUS BY RICE FROM SOME RICE SOILS OF CEYLON AS DETERMINED BY RADIOACTIVE PHOSPHORUS P^{32}

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INTRODUCTION

FERTILIZER trials carried out over the last few years have demonstrated the important role of phosphorus in the fertilization of rice soils of Ceylon. A recent soil fertility survey (1) of the Island's rice fields have indicated that the majority of the island's rice fields are poorly supplied with phosphorus. It is quite likely, that besides the inherently poor phosphorus levels in the soils, the exclusive use of nitrogenous fertilizer may also have contributed towards an enhanced depletion of soil phosphorus. However, even in soils having adequate supplies of 'available' phosphorus, plants seem to respond to small applications of readily absorbable phosphorus during their early stages of growth.

A knowledge of the uptake and utilization of both fertilizer and soil phosphorus would therefore be extremely useful in understanding the uptake pattern by rice when it is grown on soils of different phosphorus levels. Before the advent of radioisotopes, the uptake and utilization of phosphorus was determined by subtracting the amount of phosphorus in plants of the unfertilized pot from the amount of phosphorus in plants of the fertilized pot (2). Subsequent work revealed that such a simplified approach had several limitations (3, 4). Today, the radioactive tracer technique affords the best means of estimating the uptake and utilization of applied phosphorus by plants.

The radioactive isotope of phosphorus P^{32} , which is used in these studies is readily available, emits beta rays with a maximum energy

of 1.7 MeV and has a conveniently short half-life of 14.3 days. On the other hand, uptake studies with nitrogen and potassium have been difficult because of the non-availability of suitable radioisotopes of nitrogen and potassium. The radioactive isotope of potassium K^{42} , emits both beta and gamma rays and has a half-life of 12.4 hours, while that of nitrogen has a half-life of only 9 minutes. In these instances, stable (non-radioactive) isotopes are used but detection and estimation involve the use of more complex techniques of mass-spectrography. The detection and estimation of radioisotopes on the other hand, is simple and rapid.

This paper presents some preliminary data on the uptake and utilization of fertilizer phosphorus by rice when grown on six different soils under greenhouse conditions. In addition, the 'A' values of these six soils were determined according to the method of Fried and Deani (5). The experiments were conducted at the Radioisotope Centre, University of Ceylon, Colombo.

MATERIALS AND METHODS

The rice soils used in this study were from Kundasale, Ambalan-tota, Polonnaruwa, Karapincha, Mirigama and Bibile. The general characteristics of these soils are given in table I.

The experiment was conducted in procelain pots containing 10 lb. of soil per pot. The soils were treated with basal dressings of 20 lb. N per acre which was supplied in the form of ammonium sulphate; 100 lb. K_2O per acre which was supplied in the form of muriate of potash (35 lb. K_2O) and potassium dihydrogen phosphate (65 lb. K_2O) and 100 lb. P_2O_5 per acre which was supplied in the form of 'tagged' potassium dihydrogen phosphate at the rate of 0.55mc P^{32} per g. P_2O_5 . The P^{32} in the form of phosphoric acid was obtained from the Radiochemical Centre, Amersham, Buckinghamshire. Soils were transferred into a triple-shell dry blender and thoroughly mixed with the 'tagged' phosphorus. Rice seeds of the H-4 variety were initially germinated on a moist filter paper and two three-day old seedlings were planted per pot. Soils were kept inundated with 2 inches of standing water during the growth of the plants. A top dressing of 10 lb. N. per acre in the form of ammonium sulphate was given to all pots at three weeks after planting. The plants were harvested after 38 days growth and dry yields recorded. The dry plants were crushed, dry-ashed and the P^{32} content was estimated by the technique of solution counting of Clayton-Mcauliffe (6) using

a 10 ml. organic-quenched Geiger-Müller tube. Counting was conducted under standard conditions and the usual corrections for background, resolution and decay were made. Total phosphorus was determined colorimetrically by the molybdivanadophosphoric acid method of Kitson and Mellon (7).

RESULTS AND DISCUSSION

The data on yield, uptake and utilization of fertilizer phosphorus are indicated in table II.

The amount of fertilizer phosphorus utilized by the plants during their five weeks growth varied from 0.52 to 2.26 %. The low fertilizer phosphorus utilization may be attributed in some degree to the following procedures adopted in this experiment: Firstly, to avoid complications that would arise from the seeds not germinating, three-day old rice seedlings were planted instead of sowing the seeds in the pots. Hence, any exchange between the phosphorus of the seed and the 'tagged' fertilizer phosphorus has been excluded. Some workers, however, have shown that the phosphorus of the seed exchanges with the phosphorus of a labelled nutrient solution in sand culture to more than 80% within the first few weeks of growth (8). Secondly, when the plants were harvested, the roots were discarded as it was difficult to remove the soil particles clinging on to the roots. Washing of roots was not attempted as this procedure is known to leach out soluble phosphorus from the roots (9). Despite these limitations the low utilization of fertilizer phosphorus by rice clearly reflects the benefits of both residual and cumulative effects of phosphorus fertilization. Low utilization of fertilizer phosphorus by crops have been reported by several workers (10, 11, 12, 13, 14). Fixation of added phosphorus by iron, aluminium and calcium compounds could also have contributed towards a reduced uptake and utilization.

As expected, an inverse relationship between the percentage of phosphorus in rice plants derived from the fertilizer, and the Olsen's 'available' phosphorus (15) values of soils can be observed, except for Karapincha soil.

Fried and Dean (5) considered the plant as the best judge of nutrient availability and put forward a simple hypothesis to measure 'available' phosphorus in soils. They assumed that a plant confronted with two sources of phosphorus, namely the soil and the fertilizer,

will utilize them in direct proportion to the availability of the phosphorus in each. This leads to the equation

$$A = \frac{B(1-y)}{y}$$

where A is the amount of the soil phosphorus supply,

B, the amount of the fertilizer phosphorus supply, and

y, the fraction of the phosphorus in the plant derived from the fertilizer.

Since the procedure adopted in this experiment conformed to the requirements of Fried and Dean, the 'A' values of these soils were calculated using the above formula. These are given in Table II.

It can be observed that the calculated 'A' values range from 25 to 434 lb. P_2O_5 per acre. These values are considerably higher than the values of 'available' phosphorus as obtained by Olsen's bicarbonate extraction method. However, such a comparison has little meaning because there is yet no satisfactory method of measuring the absolute value of 'plant available' nutrient in a soil. Yet it can be seen from the results of Table II that there is a marked parallelism between the calculated 'A' values and the 'available' phosphorus values as estimated by the Olsen's method.

Furthermore, it should be realized that the added fertilizer phosphorus when mixed uniformly with the soil, would be liable to undergo changes and may not be as accessible to the plants as the soil phosphorus. This would be in direct conflict with the basic assumptions of Fried and Dean and thus probably result in an over-estimation of the 'A' values. A recent investigation has indicated that band placement of fertilizer phosphorus gives 'A' values substantially lower than that obtained with mixed placement of fertilizer phosphorus (16).

Although such marked variation in the 'A' values could result from different methods of mixing or placing the 'tagged' fertilizer, the foregoing results provide a valuable starting point for more refined investigations.

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TABLE I

Soil Characteristics

<i>Soil</i>	<i>pH</i>	<i>Texture</i>	<i>C.E.C. me/100g. Soil</i>	<i>T.E.B. me/100g. Soil</i>	<i>Base saturation percentage</i>	<i>Olsen's 'available' P₂O₅ lb. per acre</i>	<i>Carbon percentage</i>	<i>Nitrogen percentage</i>	<i>Carbon Nitrogen ratio (C/N)</i>
Kundasale	.. 6.6	.. S.C.L.	.. 13.0	.. 9.8	.. 75.4	.. 50.2	.. 0.8	.. 0.09	9
Ambalantota	.. 6.4	.. Clay	.. 26.7	.. 15.7	.. 58.8	.. 63.8	.. 2.4	.. 0.19	13
Polonnaruwa	.. 7.3	.. S.C.L.	.. 14.5	.. 10.5	.. 72.4	.. 63.8	.. 1.3	.. 0.11	12
Karapincha	.. 5.1	.. S.L.	.. 6.2	.. 1.7	.. 27.4	.. 13.7	.. 1.8	.. 0.12	15
Mirigama	.. 4.7	.. S.C.L.	.. 9.1	.. 1.9	.. 20.9	.. 11.4	.. 1.9	.. 0.17	11
Isibile	.. 5.7	.. S.L.	.. 5.0	.. 2.8	.. 56.0	.. 13.7	.. 0.6	.. 0.07	8.5

TABLE II

Data on Uptake and Utilization of Fertilizer Phosphorus and 'A' Values

Soil	Applied phosphorus/ pot mg. P	Yield/pot g.	Phosphorus absorbed from fertilizer mg. P	Total phosphorus in plant mg. P	Percentage phosphorus in plant derived from fertilizer	Percentage fertilizer phosphorus utilized	mg. P/g. plant material	'A' values lb. P_2O_5 / acre
Kundasale	.. 100.3	.. 4.33	.. 2.27	.. 12.55	.. 18.10	.. 2.26	.. 2.90	.. 434
Ambalantota	.. 100.3	.. 3.27	.. 1.70	.. 7.40	.. 23.05	.. 1.70	.. 2.27	.. 334
Polonnaruwa	.. 100.3	.. 1.98	.. 1.73	.. 7.40	.. 23.36	.. 1.72	.. 3.74	.. 328
Karapinoha	.. 100.3	.. 1.39	.. 0.55	.. 1.90	.. 29.00	.. 0.55	.. 1.37	.. 245
Mirigama	.. 100.3	.. 1.26	.. 1.57	.. 2.05	.. 76.34	.. 1.56	.. 1.63	.. 31
Bibile	.. 100.3	.. 0.37	.. 0.52	.. 0.65	.. 80.00	.. 0.52	.. 1.76	.. 25