A STUDY OF THE MECHANISM OF
SOIL-PHOSPHATE UPTAKE IN RELATION TO
PLANT SPECIES

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INTRODUCTION

In the classical investigations that have been made into the ability of different plant species to utilise sparingly soluble soil phosphates or applied phosphates, the criterion by which a plant's performance has been judged has been its total uptake of phosphorus or its increased yield when an insoluble fertilizer was applied. Marais 11 has reviewed early work on this subject and Thomas 23, Smith 25 and Lyness 10 have reported that different species or even varieties of plants vary in the efficiency with which they are able to extract from the soil the less readily available forms of soil phosphorus. Russell 18 in a discussion of the subject mentions lupins as one of the strongest extractors of phosphate among farm crops and quotes Schander 23 who suggests that they solubilize less readily available phosphate by excreting an organic acid from the roots. It is also known that plants vary greatly in their uptake of phosphorus from added sparingly soluble phosphates such as basic calcium phosphate or iron and aluminium phosphates (see reviews by Fried and Dean 5 and Kurtz 8). In general it has been found that the Leguminosae and Cruciferae can use sparingly soluble phosphates to a greater extent than the Gramineae or Solanaceae. Among the beneficial effects attributed to green manure crops such as lupins or sweet clover is their partial effectiveness in using the less soluble soil phosphates and returning them to the soil through their leaves in a more soluble form.

The question of the phosphorus-extracting efficiency of different
species is of special interest in the study of humid tropical soils. Fertility in most of these soils is restored by the natural resting fallow. The ‘available’ phosphate status of many of these soils as measured by conventional chemical extractants is often extraordinarily low and thus the possibility of finding a plant species which is particularly effective in utilising relatively insoluble phosphates and releasing them through the litter in a more available form is of considerable agricultural interest.

It is clear that differences between the phosphate content of plants grown under identical conditions could be due to differences in the area of their root absorbing surfaces or to differences in the efficiency of the plant in extracting the phosphate from the soil. It is impossible to measure the root absorbing surfaces of plants growing in soil, partly because it is very difficult to recover all the fine roots, and partly because it is not known what portion of the root is actually absorbing. Differences in the efficiency of plants in extracting the different forms of phosphate from the soil have been attributed to the production of carbon dioxide (Parker 17), and the effects of the rhizosphere population (Dalton 2).

It was considered that further understanding could be obtained about the differences in the extracting efficiency of plants by growing a range of plant species under identical conditions in pots containing soil into which carrier-free $^{32}$P had been thoroughly mixed. It seemed that the measurement of the ratio of $^{32}$P/$^{31}$P in the plant might indicate whether the different species were all using the same forms of soil phosphorus. For example, a plant that was able to feed on a very insoluble form of soil phosphate might be expected to have a higher proportion of $^{31}$P : $^{32}$P (i.e. a lower specific activity) than a plant unable to use such forms. The results for two of the soils used have been briefly reported (Nye and Foster 16).

Since there was no information on the effect of radiation on plant growth and phosphate uptake under conditions in which the $^{32}$P is intimately mixed with the whole soil, studies to determine the importance of such effects were also made.