UPTAKE OF PHOSPHORUS BY PLANTS IN RELATION TO CARBON DIOXIDE PRODUCTION AND ORGANIC PHOSPHORUS MINERALIZATION IN SOILS *

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Previous work with a number of soils 4 showed that after the correlation of yields of phosphorus in plants with the labile soil inorganic phosphorus had been taken into account, there was still a significant correlation between yields of phosphorus in the plants and the organic phosphorus mineralized while samples of the soils were incubated in the laboratory. From the standpoint of phosphorus nutrition of plants, this finding may be interpreted tentatively to indicate that in at least some of the soils a significant part of the phosphorus taken up by the plants was present initially in organic form and was mineralized by soil microorganisms while the plants were growing.

In the absence of direct measurements of the amount of soil organic phosphorus mineralized and absorbed, indirect evidence such as the foregoing must be used in studies of the origin of the soil phosphorus absorbed by plants. One must recognize, however, that the statistical association of yields of phosphorus in plants with organic phosphorus mineralization in soil does not provide adequate proof of a cause-and-effect relationship. In consequence, examination of other sources of evidence is in order.

As an alternative explanation for the statistical association of yields of phosphorus in plants with organic phosphorus mineralization in the soils on which the plants are grown, the suggestion has been advanced that the supposed effect of organic phosphorus is an


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indirect effect of carbon mineralization that is correlated with phosphorus mineralization. Addition of carbon dioxide to soils is known to lower the pH and to increase the solubility of inorganic phosphorus, at least where alkaline soils are concerned; and it is reasonable to suppose that an increase in uptake of inorganic phosphorus by plants follows the increase in solubility.

The purpose of the research described in this paper was to test the alternative explanation just described. Because the magnitude of the effects should be greater and more easily observed in alkaline soils than in acid soils, a group of alkaline soils was used.

MATERIALS AND METHODS

The samples employed were from a group of 36 alkaline soils from Iowa that had been used in previous work leading to a significant statistical association of organic phosphorus mineralization with uptake of soil phosphorus by plants. The soils all had pH values in the range from 7.1 to 8.3 as measured with a glass electrode pH meter on a suspension of 1 part of soil in 2.5 parts of water by weight. Many of the soils were calcareous, but none would be classed as ‘salt affected’.

Duplicate 150-g samples of these soils were placed in quart Mason jars, moistened to moisture equivalent as estimated by the method of Bouyoucos, and incubated for 3 weeks at 35°C. The jars were kept sealed except for brief periods of aeration after 1, 2, 3, 5, 7, 9, 12, 15, and 18 days.

Carbon dioxide evolved during incubation was determined by placing an open bottle containing 25 ml of a 5% solution of sodium hydroxide on the moist soil in each jar and in comparable empty jars to serve as blanks. After the incubation, the carbonate in the sodium hydroxide was precipitated with an excess of barium chloride, and the excess sodium hydroxide was titrated by standard hydrochloric acid with phenolphthalein as indicator.

Mineralization of organic phosphorus during incubation was estimated by averaging the increase in inorganic phosphorus and the decrease in organic phosphorus found by extracting the original and incubated soil with 1N hydrochloric acid and 0.5N ammonium hydroxide as described by Anderson and Black. The combined extracts were made up to volume with distilled water and were thoroughly mixed. To determine the total phosphorus extracted, a 10-ml aliquot was evaporated with 1 ml each of 6N ammonium hydroxide and 10% magnesium nitrate. The residue was then ignited, dissolved in 5 ml of 1N hydrochloric acid, and analyzed for phosphorus by the method described by Mehta et al. Inorganic phosphorus extracted was determined directly on a 5-ml aliquot of the extract as described by Mehta et al. Organic phosphorus was taken as the difference between the total and inorganic phosphorus extracted. Comparable incubated and nonincubated