PHOSPHATE AVAILABILITY IN CALCAREOUS SOILS: A FUNCTION OF CARBON DIOXIDE AND pH

W. T. McGeorge, T. F. Buehrer, AND J. F. Breazeale

The rapidly expanding use of phosphate fertilizers in the Southwest, and in many parts of the West in general, is rather convincing evidence of the state of phosphate availability which exists in these soils. Briefly stated, the soil conditions are as follows: (a) The presence of carbonato-apatite as the dominant natural phosphate; (b) an excess of solid-phase calcium carbonate, and (c) varying amounts of free hydroxyl ions. There is no deficiency of potential phosphate reserve, as the presence of similar amounts of carbonato-apatite in non-calcareous soils would be sufficiently available to supply the phosphate needs of crops for many years. The phosphate problem of the Southwest, therefore, largely concerns an environment which depresses the ionization or breaking down of the carbonato-apatite complex. In this environment the presence or absence of carbon dioxide is a dominant factor.

The literature concerning carbon dioxide or carbonic acid in soils is very extensive and clearly portrays its importance in soil processes. This, however, is most fully appreciated by the students of alkaline-calcareous soils. There is scarcely a single undesirable soil property of alkaline soils which does not respond favorably to carbon dioxide. This applies not only to the various changes needed for alkali soil reclamation, but also to plant food availability and its absorption by plant roots. The continued observance of the importance of carbon dioxide to the fertility of southwestern soils has led us to suggest that it is the greatest growth-limiting factor in the cropping of these soil types.

The rôle of carbon dioxide in phosphate availability and its absorption by roots is an outstanding property. It functions in reducing the pH of the soil, or OH ion concentration of the soil solution, which in turn favorably influences phosphate nutrition in three ways, as follows:

1. Ion absorption by plant roots is greatly restricted by the presence of OH ions in the soil solution. Carbon dioxide neutralizes soluble hydroxides and carbonates.

2. The ratio of \( \frac{H_2PO_4^-}{HPO_4^{2-}} \) is reduced by the presence of OH ions and since plants show a preference for the \( H_2PO_4^- \) ion the rôle of carbon dioxide in increasing this ratio is self-evident.

3. The solubility of carbonato-apatite is reduced by the presence of solid-phase calcium carbonate. Carbon dioxide attacks the solid-phase calcium carbonate as well as the calcium carbonate of the

---

1. Contribution from the Department of Agricultural Chemistry and Soils, Arizona Agricultural Experiment Station, Tucson, Ariz. Also presented at the annual meeting of the Society held in Washington, D.C., November 23, 1934. Received for publication January 28, 1935.

2. Head of Department, Physical Chemist, and Research Biochemist, respectively.