Reciprocal Effects of Magnesium and Potassium as Shown by Their Cationic Activities in Four Clays

E. O. McLEAN

Previous work from this laboratory has indicated the feasibility of measuring the cationic activities of a monovalent and a divalent cation in the same system by means of the clay membrane technique, and literature dealing with the mutual effects of exchange cations was briefly summarized (4). The results indicated that interactions of the calcium and potassium cations were striking in montmorillonite clay. Further work on these two cations is being reported by Marshall and Barber (1). The present paper deals with the reciprocal effects of potassium and magnesium in four different clay systems. That magnesium ion activities may be measured in homionic systems by means of clay membranes has been shown by Marshall and Eime (3).

The ultimate aim of all these studies is to throw light upon the environment to which the plant root is subjected in extracting its inorganic sustenance from the soil. Idealistically one would like to add a certain active nutrient to the system and then stand back and by remote control observe how it affects the plant as well as the other nutrients already present. So far the mechanics of measuring these active substances collectively have proved difficult. A decade ago there were no tools for making any direct measurements on such a system. Today we have the clay membrane technique for measuring cationic activities. When only one cation is present the determination is simple; with two (besides hydrogen which may be determined by the glass electrode) it is more complicated; with three such a measurement of individual activities is difficult if not impossible in most cases. Even though with present techniques the individual activities of the several cations in a complete soil cannot be measured, yet the fact that the activities of bionic systems can be measured offers a possibility for breaking up complex systems into the different parts for detailed study. Then it is hoped that these parts may be integrated into the complete picture of the plant root environment in its proper perspective with respect to composition and function.

TECHNIQUE

The clay systems used were prepared from electrodialyzed pure clays—montmorillonite (Wyoming bentonite) 1% suspensions < .2 microns; beidellite (Putnam) 2½% suspensions < .2 microns; halloysite 10% suspensions 2–2.2 microns; and grundite illite 5% suspensions < 2 microns. Increasing amounts of potassium hydroxide and magnesium oxide were added to the respective series for homionic systems. Otherwise exactly the same technique was employed as described previously (4). The standard used was MgCl₂ of 0.0009. In making measurements the series with the high K-low Mg to the low K-high Mg sequence of difficulties in determining accurate mobility ratios. It was found that when the activity of the magnesium became equal to or greater than that of the potassium the KCl side of the membrane should be replaced by standard MgCl₂. The standard used was MgCl₂ of 0.0009. This situation was easily affected since membranes soaking in MgCl₂ are already available for measuring the magnesium activity in homionic systems. Otherwise exactly the same technique was employed as described previously (4).

DISCUSSION OF RESULTS

In general the maximum accuracy for measurements of potassium occurs in the range A⁺⁺ = 10⁻². For this reason it is felt that in dealing with magnesium the general shape of the curves resulting from the data is of more significance than the absolute activity concentration for any given system.

The complete data for the homionic and polyionic clays are summarized in Tables 1 and 2. So far it is not available for graphing or even detailed discussion of the data. However, since interactions of potassium and magnesium in the montmorillonite are distinct from the other three clays, it was felt that a representative of the latter group, illite, should be graphically with the montmorillonite so that differences might be better detected and understood. Activities expressed in moles per liter of the several cations are the determiners of the plant root environment, yet these are regulated by the amount of exchangeable cations present. Hence the fraction of total which is active, i.e., the ratio of the activity to the total present for any given determination is important.