The Relation of Potassium Fixation to Ammonium Fixation

GEORGE STANFORD AND W. H. PIERRE

Potassium fixation has been studied extensively during the past decade. It now is known that many soils and certain of the clay minerals fix large amounts of potassium when the materials are dried following the addition of potassium salt. Less information is available concerning the fixation of potassium under moist conditions, although certain soils possess this ability to a marked extent (1, 7).

Fixation of ammonium by the inorganic constituents of soils has received some attention. Generally, however, the studies which have been reported concerning this problem are quite limited in scope. As early as 1917, McBeth (9) reported that he was unable to recover more than 81% of the ammonium salt added to a California soil even after prolonged extraction with 10% HCl.

Other evidence that certain soils may possess the ability to fix ammonium is reported in the early literature on methods for determining exchangeable ammonium in soils (2, 8, 10). It then was believed that a suitable method for exchangeable ammonium should allow complete recovery of added ammonium salt. Such a method, proposed by Olsen (10) in 1929, employs a HCl-KCl extractant, a solution that would extract some of the non-exchangeable as well as the exchangeable ammonium from soils.

In 1936, Chaminade and Drouneau (4) presented evidence that non-exchangeable ammonium accumulated in soils which had received several applications of ammonium fertilizer over a period of years. They found that more ammonium nitrogen was released from a fertilized soil than from the corresponding unfertilized soil during prolonged grinding in a ball mill. In a later study, Chaminade (3) presented further evidence of ammonium accumulation in a soil as a result of fixation, and reported that this cation fixed by the clay fraction of soils could be liberated by ball-milling or treatment with hydrofluoric acid. These workers measured fixation after the soil or colloid had been in contact with a salt solution for a suitable period (1). It appeared that the underlying causes for fixation under moist conditions are quite unlike those involved in the type of fixation reported by Volk (13). Accordingly, studies were begun in 1942 to investigate the nature of this fixation which occurs without drying. During the course of these investigations, it was found that certain soils which fixed potassium in appreciable amounts were capable of fixing ammonium.

Preliminary results concerning the nature of this fixation which occurs without drying are reported briefly in this paper. The primary objective of this study, however, was to determine quantitatively the relationship between the fixation of potassium and ammonium, with a view toward establishing whether or not these cations are rendered non-exchangeable through the same mechanism.

MATERIALS AND METHODS

The soils used in this investigation were obtained from outlying field plots used in fertilizer experiments during the period 1939 to 1944. Each sample represents the plow layer to a depth of 6 inches. The Webster silty clay loams 25A and BL1, on which the most extensive studies were carried out, were taken from two areas quite deficient in available potassium. Other soils of a similar nature from very potassium-deficient areas are 32AH and 29A of the Webster soils included in this study, namely, 28A, 34A, 26A, and BL6, supported a good crop during the season in which the sampling was made. These soils are members of the Wiesenboden Great Soil Group. The Fayette silt loam and Clinton silt loam included in the study are members of the Gray-Brown Podzolic Group. The Clarion and Carrington loams belong to the Group.

All fixation studies were carried out after mixing the soil with the salt solution. In the studies on potassium fixation, exchangeable and water-soluble potassium were extracted from 10-gram samples of soil with 250 ml of a 1% normal ammonium acetate (pH 6.8). Removal of exchangeable and added ammonium was effected with normal HCl solution. Extraction with this reagent was continued until the leachate no longer gave a test for ammonium with Nessler's reagent. Usually 250 ml of the extractant was used. The leachate was filtered to remove exchangeable and water-soluble ammonium from 10-gram samples. The leachates were adjusted to a suitable volume and ammonium was determined by an aliquot using a Nessler method (12) modified to include the use of gum arabic. Potassium was determined according to the method reported by Lawton (5). The procedures used in the individual studies are described in the discussion of the experiment. An Evelyn photoelectric colorimeter was used in the colorimetric determination of ammonium and potassium.