Conversion of Nonexchangeable Potassium to Exchangeable Forms in a Hawaiian Soil

A. S. Ayres, M. Takahashi, and Y. Kanehiro

Some Hawaiian soils, like many soils of other regions, are capable of releasing nonexchangeable potassium to exchangeable forms rapidly enough to be of economic importance. Thus, Horner (6), in 1930, studying the composition of pineapple plants grown on an Oahu soil, found that the mature plants contained substantially more potassium than was initially present in the soil in exchangeable form, even where potassium fertilizer was not added. Abel and Magistad (1), in a subsequent pot study of pineapple soils from the islands of Maui, Oahu, Kauai, and Lanai, observed annual release of from 75 to 100 pounds of nonexchangeable potassium per acre-foot of soil, depending upon treatment. Ayres (2), in 1944, reported the conversion of 375 pounds of nonexchangeable potassium per acre-foot of soil to the exchangeable and water-soluble forms, in the case of an Oahu soil, as a result of intensive leaching with distilled water and the consequent removal of a large portion of the exchangeable potassium. Besides this there is field observational evidence which strongly suggests the release of potassium in some Hawaiian soils.

In 1941 an experiment was initiated by the Department of Agronomy of the Hawaii Agricultural Experiment Station, the purpose of which was to determine the influence of various fertilizer treatments on the yield and forage properties of Napier grass, Pennisetum purpureum. Mineral analysis of the first two crops to be studied, together with the yield data, indicated the removal of unusually large quantities of potassium from the soil (as much as 400 pounds K₂O per acre per crop) even where potassium fertilizer was not added. The rate of removal of potassium by crops being a matter of considerable practical importance, it was decided to continue these measurements for a period of several years and at the same time to determine, at intervals, the levels of exchangeable potassium in the soil as well as the potassium content of the irrigation water in an effort to determine the source of the absorbed potassium. The resulting observations, covering a period of 4½ years from 1941-45, together with the results of electrodialysis of the soil, form the basis of this report. Although complete in itself, the present paper is essentially a preliminary report of a more intensive study of the potassium-supplying power of Hawaiian soils in general.

EXPERIMENTAL

The experiment was located at the Poamoho substation, experimental area of the Ppamoho substation, derived from Koolau basaltic lavas. It was in sugar cane for many years prior to its acquisition by the Experiment Station. Some of the chemical properties of this soil are indicated in Table 1.

Since rainfall at Poamoho amounts to only about 45 inches annually, irrigation was frequently necessary. For this purpose a low salt content mountain water was employed. Fertilizer was applied at the rates of 100 pounds N (ammonium sulfate), 100 pounds P₂O₅ (as superphosphate), and 100 pounds K₂O (as potassium sulfate) per acre per crop. For purposes of analysis, the plant material from similar treatments was combined after weighing. Further compositing resulted in a single sample per year for each of the treatments. The material in these samples was divided and stems, and the two fractions analyzed separately.

One of the check plots, two of the N plots, and two of the NP plots were studied. The soils of the N plots were sampled immediately following the harvest of the seventh crop, and the intact soil was sampled and the results of the subsequent analysis used as a check on the estimate of the levels of exchangeable potassium in the cropped soils prior to planting.

Exchangeable potassium was extracted from the soil by means of N — ammonium acetate adjusted to pH 7.0. Analysis of soil extracts and plant materials for potassium were performed in part by the cobaltinitrite method and in part by a colorimetric modification of the Lindo-Gladding method.

Table 1—Some properties of the Poamoho soil

<table>
<thead>
<tr>
<th>Depth, inches</th>
<th>Total N, %</th>
<th>Total K, %</th>
<th>Exch. Ca, m.e. per 100 grams</th>
<th>Exch. K, m.e. per 100 grams</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-12</td>
<td>0.18</td>
<td>1.40</td>
<td>3.96</td>
<td>0.50</td>
<td>5.3</td>
</tr>
<tr>
<td>12-24</td>
<td>0.076</td>
<td>1.04</td>
<td>4.30</td>
<td>0.25</td>
<td>6.3</td>
</tr>
</tbody>
</table>