Effect of the Co-ion of sulphate, chloride, and carbonate on the decomposition of organic matter in soil

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With 2 figures

Summary

The influence of salts as divided into different cations, combined with certain anionic forms, on the decomposition of non-humic plant substances (maize and cotton stalks) was studied on clay loam soil.

Series of sulphate, chloride, and carbonate of calcium, magnesium, potassium, and sodium at the concentration of 15 meq./100 g. soil, and organic materials at the rate of 2% were added in a powdered form to the soil and mixed thoroughly. The water content was 55% w.b.e. Mineralized nitrogen, total nitrogen, and organic carbon were estimated.

Among the anions examined, sulphates supported the degradation of the plant residues, carbonates were somewhat inhibiting, whilst chlorides showed the highest depressing action.

Cations of the same anion acted according to the necessity of the cation for the microbial activity, such as the highest stimulatory effect of potassium sulphate. Sodium was the most inhibitory. Calcium and magnesium acted at different levels.

Maize stalks were more decomposable than the cotton stalks throughout the experiments.

Introduction

Most of the non-humic substances could be attacked by soil microbes. Hence, these organic materials are considered to be the seat of most of the microbial activities in soil, as they represent an important source of energy and nutrient elements for the growth and the activity of soil micro-organisms. Many reports have stated the interaction between the soil microflora and the added plant residues. The results showed a correlation between the C/N ratio of the supplied additives and both the nitrogen fixation and the cellulose decomposition, especially in presence of calcium phosphate (ISHAC 1958, EL-HADDY 1960, DHAR 1962).

Salts were found to affect the microbial activities in soil, such as the bacterial counts, the nitrification rate, and the evolution of carbon dioxide. The consequent influence differed according to the nature of salt and its concentration (LIPMAN 1909, PATHAK and JAIN 1965, RANKOV 1965, SINGH et al. 1969).

The present work was undertaken to clear up the influence of salts as divided into different cations, combined with certain anionic forms, on the composition of non-humic plant substances, presented as maize and cotton stalks in soil.

Material and Methods

Samples of one type of clay loam soil — Nile alluvium — were taken from the 0—15 cm. horizon from the experimental farm of the Department of Agriculture at Giza. The soil samples were air-dried and ground to pass a 2 mm. sieve. The soil was again mixed thoroughly. Some physical and chemical properties of the soil used are presented in Table 1.

Series of sulphates, chlorides, and carbonates of calcium, magnesium, potassium, and sodium were finely ground. The organic additives comprised maize and cotton stalks, and they were milled. Data for organic carbon and total nitrogen of these additives appear in Table 2.
Salts at the concentration of 15 meq. per 100 g. air-dry soil and organic materials at the rate of 2% were added to the soil and mixed thoroughly. The treatments — in duplicate — were carried out in polyethylene pots with 2 kg. treated soil crumbs.

The water content was adjusted to 65% of the water holding capacity of the soil, and the evaporation losses were made up periodically during the experimental period by addition of distilled water. The experiments were undertaken up to 8 months.

Quantitative estimates for mineral nitrogen by the steam distillation technique, total nitrogen by the macro-Kjeldahl method, and organic carbon by means of the Walkley-Black method was carried out (Black et al. 1965).

<table>
<thead>
<tr>
<th>Texture grade</th>
<th>Water holding capacity %</th>
<th>pH (1:2.5)</th>
<th>Organic carbon %</th>
<th>Total nitrogen %</th>
<th>Total soluble salts (1:5) %</th>
<th>CaCO₃ %</th>
<th>P₂O₅ %</th>
<th>Soluble ions meq./100 g.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay loam</td>
<td>58.4</td>
<td>8.1</td>
<td>1.84</td>
<td>0.1490</td>
<td>0.39</td>
<td>7.20</td>
<td>0.05</td>
<td>Ca⁺⁺⁺ 1.87 Mg⁺⁺ 1.25 Na⁺ 7.50 CO₃⁻⁻ 0.00 Cl⁻ 1.15 SO₄⁻⁻ 9.16</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Property</th>
<th>Maize stalks</th>
<th>Cotton stalks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic carbon %</td>
<td>44.2</td>
<td>47.9</td>
</tr>
<tr>
<td>Total nitrogen %</td>
<td>0.80</td>
<td>0.71</td>
</tr>
<tr>
<td>C/N ratio</td>
<td>55.2</td>
<td>67.4</td>
</tr>
</tbody>
</table>

Results and Discussion

Data are calculated on the oven-dry weight of soil basis, and the means (of two replicates) are shown in Figures 1 and 2. The amounts of organic nitrogen are calculated by the difference between total and soluble nitrogen, and presented in Table 3.

The results could be concluded as follows:

Generally, sharp decreases in soluble nitrogen occurred within the first three months, and then the N-mineralization began. This is due to the augmentation of the biomass in soil, following the application of organic substances and suitable moisture, as indicated by the organic nitrogen values of the controls.

Maize stalks were faster decomposable than the cotton stalks throughout the experiments, as shown in the mineralization of nitrogen and oxidation of carbon, which is attributed to the narrower C/N ratio and lower lignin content of the former stalks (Waksman 1952, Anton 1970).
1. Sulphates

Potassium favoured the microbial growth and activity, as shown by the higher quantities of soluble nitrogen, consumed within the first three months. Higher mineralization occurred by the fourth month and beyond, on one hand, and lower organic carbon percentages, on the other hand. Magnesium followed potassium in favouring...
Table 3

Organic nitrogen in the different treated soil samples (p.p.m.)

<table>
<thead>
<tr>
<th>Time (month)</th>
<th>Control¹)</th>
<th>Anions</th>
<th>Ca</th>
<th>Mg</th>
<th>K</th>
<th>Na</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>T</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1578</td>
<td>1563</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1563</td>
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</tr>
<tr>
<td>3</td>
<td>1603</td>
<td>1582</td>
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<tr>
<td></td>
<td>1591</td>
<td></td>
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<td></td>
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<tr>
<td>5</td>
<td>1584</td>
<td>1575</td>
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<td></td>
<td></td>
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<tr>
<td></td>
<td>1553</td>
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<td></td>
</tr>
<tr>
<td>8</td>
<td>1463</td>
<td>1496</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>1392</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹) without salt, M = Maize stalks, T = Cotton stalks.

— Organic nitrogen content was 1548 and 1523 p.p.m. in soil samples treated with maize and cotton stalks, respectively, at time 0.
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the decomposition course. Calcium showed different effects with regard to the studied microbial processes and the organic supplements. No definite trend could be stated. Sodium was inhibiting for the soil micro-organisms, as indicated by the least and longest consumption of mineral nitrogen and the lower oxidation rate of organic carbon.

These results might be interpreted by the action of the sulphate salts on soil properties such as pH which is affected by the solubility of salts. Sulphates improve the pH of the arid soils. The higher the portion of the salts dissolved, the more proper the soil pH. In this respect we find Mg > Na > K > Ca (HODGOMAN et al. 1955). Consequently, the stimulatory effects of K and Mg might be referred to the direct necessity of K for the micro-organisms, and the indirect action of Mg by its higher solubility, affecting the soil pH. The lowest solubility of Ca explains its different actions. The inhibition showed by Na could be referred to the own nature of the cation, hindering the microbial growth (EL-SHINNAWI 1970). It must be also noted that the used soil contained initially a somewhat high percentage of soluble sodium.

II. Chlorides

It was evident that the chloride salts inhibited largely the studied microbial processes as shown by the least and longest consumption of soluble nitrogen. No mineralization took place during the experimental period. The inhibition of the N-mineralization process was in the order Ca > Mg > Na > K, whilst it was Na > K > Mg > Ca for the oxidation of organic carbon.

The observed effect of chlorides is referred to their own toxicity, confirming the earlier findings by BROADBENT (1965), SINDHU and CORNFELD (1967), and SINGH et al. (1969) that chlorides inhibit the ammonium nitrogen release even at low concentrations. The different effects of the cations on the mineralization of nitrogen and oxidation of organic carbon could be elucidated by the different action of the cations on the specific microbial groups, such as ammonifying bacteria and Azotobacter.

III. Carbonates

Series of the carbonate salts inhibited — somewhat — the mineralization of nitrogen and the oxidation of organic carbon of the used non-humic materials. No definite trend was clearly observed among the inhibiting cations, except the higher inhibition by sodium in all cases.

The effect of carbonates is actually correlated with the rise in pH, following their application to soil. High pH value causes the loss of soil nitrogen by the volatilization of ammonia, which in turn affects the decomposition course by the lower nitrogen supply for acting micro-organisms, as indicated by the data of organic nitrogen.

Zusammenfassung

Es wurde der Einfluß von Ca-, Mg-, K- und Na-Ionen als Kationen von Sulfaten, Chloriden und Karbonaten in einer Konzentration von 15 mval/100 g Boden auf die Zersetzung von organischen Stoffen (Mais- und Baumwollstengel, Zusatz 2%, fein gemahlen) untersucht.


Das Maisstroh wurde schneller abgebaut als die Baumwollstengel.

Literature


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