Chlorite effects compared to sulfate in combination with forms of nitrogen on yields of oat and Chinese cabbage

Avonyo K. A.
University of Lomé, Superior School of Agronomy, BP 1515, Lome (Togo)
Corresponding Author’s Email: avonyokossi@yahoo.fr

Abstract

To valorise sediments of iron mineral extraction zone of about 2500ha of coverage in Liberia, a concept of appropriate fertilizer was developed. A comparative study was carried out on two types of soil: a soil riched in organic matter called arable land and a soil formed exclusively with sediments called sediments or Tailings Pond. The results revealed that the choice of fertilizer types and forms played an important role in yield increase. Therefore, the best yields were obtained with the combination of the different forms of Nitrogen fertilizers and different forms of calcium and potassium fertilizers. The use of sawdust as supportive organic matter, from the different combinations, has increased or decreased the yields of the two types of soils.

Keywords: Sediments, sawdust, manures, oat, chinese cabbage.

INTRODUCTION

The Bong Mining Company has been mining since 1960s an iron deposit in Bong County in Liberia. The importance of this mine lies on the number of employees who are working in. Europeans settled in this mining region. In fact, this mining society has attracted many labours from different regions of the country.

Presently, a small town with 40,000 inhabitants is founded in the region. The dwellers rely on small mining related craft activities to survive. The supply of foods, such as vegetables, comes from far distance where farming system is mostly shifting cultivation. Rice in particular is imported from outside. For agricultural production, farmers of the region lack, not only knowledge, but also space for farming. It must be noticed in general that peoples settled in this region will lack, in the long term, food supply for their subsistence. In addition, the iron deposit is projected to finish in the short future; and the anticipated close of the company could occur due to the rentability challenge related to the evolution of the new iron industry. The return of this population to their different tribes of origin will not be possible with out difficulties. This problematic situation is well known of the managers of the mine.

Consequently, efforts have been put in place to finance local activities development and food supply through agricultural intensification. Mountainous aspect of the region could be an obstacle to agricultural development due to erosion challenge. The same natural factors do not favour the valorization of the zone. The goal of this project is to come out with research methods for the valorization of this swampy sediment called ‘Tailings Pond’, which covers the surface area of approximatively 2500 ha. The point of view of Sommer (1975) is against the general opinion because of the infertility of the zone. The reasons are the soil poverty in nutrients associated with the muddy and structureless status of the sediment at the one hand, and at the other hand its content in iron which is of 10%. The advantage of these surfaces is that they are piled up flattened; its proximity to the region, its exploitation by the native farmers who have a high qualified trainings killed associated with a help from an agricultural project implemented in the region since a while. The condition to succeed this research work is the elaboration of a concept of an appropriate fertilizer to this type of soil which would contribute to its valorization. The aim of this
trial is to study whether and how the anions of mineral fertilizers such as nitrate, chlorite and sulfate would influence the availability of the nutrients (sulfate in particular) in the high acid soils. It is why ammonium nitrate and calcium nitrate were chosen as nitrogen fertilizer in the program. The chloride and sulphate were applied in potassium form. The chloride and sulphate were chosen in the program because they have basic reaction in the normal conditions with the rest of the anions in soil (Villachica et al., 1974; Thung, 1975; Chien et al., 1988).

MATERIALS AND METHODS

Methods of analysis of soil samples

Experimental design
The experimental design comprised sixteen treatments with four replications of two types of soil. The soil samples were put in pots in green house according to the system of Kick-Brauchmann (1964). The treatments were arranged on the tracks that are provided each with a gauge to record the water level at each stage of plant growth. The system then enables to move the experimental device out of the green house according to the climatic hazards. These trials were carried out at the Agrochemistry Institute of the University of Bonn, in Germany.

Soil samples
All the nutrients in the soil samples were dissolved in a solution mixed with 1N HCl and 1N H2SO4 at the respective proportion of 1:3 called "Königswasser". The pH of the soils were determined after dilution of the samples in the solution described as follows: distilled water; 0.01M; CaCl2; 0.05M K2SO4 according to Jensen’s method. The carbon content was determined using the method of Lichterfeld; total nitrogen by the method of Forester (1980); the available phosphate by the method of Schachtschabel (1984); and calcium and potassium were determined by the flame photometer. The results were presented in Table I.

Experimental materials

a) The soil samples
The soil samples were collected from Liberia. They were two types of soils and were as follows:
Arable land: a fertile soil of the Region.
Tailings Pond: Sediments extracted from the iron mine factory. These sediments contained 15% of iron of dark gray and powdery colour.

b) Organic and mineral manures
The nitrogen was applied in two forms at the rate of 1 g N per pot each. The treatments 1, 3, 5, 7, 8 and 16 received ammonium nitrate (NH4NO3) respectively, while the treatments 2, 4, 6, 9-15 were enriched with calcium nitrate (Ca(NO3)2). The phosphate was applied in very soluble form (KH2PO4) at 0.8g P per pot and the magnesium in form of magnesium sulfate (MgSO4) at 0.6g de Mg per pot. The potassium was applied in form of potassium chloride (KCl) for the treatments 1 to 4, 11 and 12, whilst the treatments 5 to 10 and 13 to 15 were enriched with potassium sulfate (K2SO4) at the dose of 0.99g K per pot respectively. All the treatments received each 1g K per pot due to the dose of potassium (0.1g/pot) contained in the phosphate fertilizer applied. To address magnesium deficiency often noticed in tropical soils, the magnesium was applied in form of MgSO4 at the dose of 0.6g Mg per pot. The calcium was applied in form of calcium chloride (CaCl2) to the treatments 1, 3 and 4 at the dose of 1.43 g Ca per pot; and in form of calcium sulfate (CaSO4) to the treatments 7, 9 and 14 at the dose of 1.43g Ca per pot and to the treatments 8, 10, 15 and 16 at the dose of 4.29g Ca per pot. Each treatment was enriched with micro-elements described as follows:

CuSO4: 16mg Cu/pot
MnSO4: 14.6mg Mn/pot
H3BO3: 5.0mg B/pot
ZnSO4: 16.7 mg Zn/pot
(NH4)2 MoO4: 3.3mg Mo/pot.
Finally, the treatments 11 to 16 received 60.0 g per pot of sawdust each as source of organic matter.

c) test crops
Oat (Avenae sativa) was chosen as main crop; Chinese cabbage (Brassicae ssp) and perennial Lolium were respectively selected as relay crops.

Analytic study of the samples of the test crops
To determine the yield components, the different test crop samples were dried at 105°C in stove for three days. To determine the mineral elements in the samples, the mean of the four replications of each treatment was finely grounded in a mill. The grains and straws were separately incinerated at 450 °C in an oven; then the following nutrients were determined:
Table 1: Some chemical characteristics of the soils.

| Characteristics | Arable land | Sediments | Sawdust |
|-----------------|-------------|-----------|---------|
| C Total         | 1.77        | 0.14      | 4.11    |
| N Total         | 0.12        | 0.06      | 0.09    |
| C/N             | 14.75       | 2.34      | 41.67   |
| P₂O₅ (méq/100g) | 2.50        | 2.24      | -       |
| Mg M. NaCl mg/100 | 0.72        | 0.69      | -       |
| K₂O*            | 3.32        | 2.86      | -       |
| eau             | 5.5         | 7.6       | -       |
| pH 0.01 CaCl₂   | 4.2         | 6.8       | -       |
| 0.05 M K₂SO₄    | 4.1         | 6.6       | -       |

Table 2: Yields of oat

| Treatments | Forms of N | Forms of K | Grain | Straw | Grain + Straw |
|------------|------------|------------|-------|-------|---------------|
| Arable land| NH₄NO₃     | KCl        | 101.1 | 95.2  | 195.3         |
| 2          | Ca(NO₃)₂   | KCl        | 98.4  | 79.4  | 178.0         |
| 5          | NH₄NO₃     | K₂SO₄      | 84.4  | 88.5  | 172.9         |
| 6          | Ca(NO₃)₂   | K₂SO₄      | 96.3  | 92.8  | 189.1         |
| Sediments  | NH₄NO₃     | KCl        | 75.9  | 81.6  | 157.5         |
| 2          | Ca(NO₃)₂   | KCl        | 91.0  | 79.6  | 170.6         |
| 5          | NH₄NO₃     | K₂SO₄      | 50.3  | 61.7  | 112.0         |
| 6          | Ca(NO₃)₂   | K₂SO₄      | 85.4  | 92.7  | 178.1         |
| CV5%       |            |            | 7.0   | 9.2   | 13.5          |

Table 3: Yield of dry matter (DM) of chinesecabbage

| Treatments | Forms of N | Forms of K | DM. g/pot |
|------------|------------|------------|-----------|
| Arable land| NH₄NO₃     | KCl        | 12.3      |
| 2          | Ca(NO₃)₂   | KCl        | 16.9      |
| 5          | NH₄NO₃     | K₂SO₄      | 13.7      |
| 6          | Ca(NO₃)₂   | K₂SO₄      | 18.2      |
| Sediments  | NH₄NO₃     | KCl        | 24.6      |
| 2          | Ca(NO₃)₂   | KCl        | 21.0      |
| 5          | NH₄NO₃     | K₂SO₄      | 23.7      |
| 6          | Ca(NO₃)₂   | K₂SO₄      | 28.0      |
| PPDS 5%    |            |            | 2.5       |

Phosphate through ammonium-vanadate method (Gericke et Kurmies 1952), Potassium and calcium by Gettkandt (1965) method.
Magnesium and the micro-elements with the atomic absorption spectrometry.
Nitrogen by the Kjeldahl distillation mixed with selenium of Winninger cited in Naumann et al. (1976).
The evaluation of the experiment results was done through ANOVA with three factorials of Schuster, (1978).

RESULT AND DISCUSSION

Table 2 showed that the application of potassic fertilizer in form of chlorite produced the best yields for all the treatments. 1 and 5 compared to the treatments 2 and 6 which were enriched with calcium nitrate and potassium sulfate. In addition, it was noticed a decrease of yields for the treatment 5 for the two soil types. Independently to the form of the nitrogen applied, treatments enriched with
Table 4: Nitrogen content and quantity exported from oat

| Treatments | Grain N (%) | Quantity of N exported (mg/pot) | Average N (%) |
|------------|-------------|---------------------------------|---------------|
|            | Grain       | Straw                           |               |
|            | a.l | sed | a.l | sed | a.l | sed | a.l | sed |
| 1          | 1.18 | 1.38 | 0.44 | 0.23 | 1181 | 1052 | 421 | 188 |
| 2          | 2.02 | 1.32 | 0.48 | 0.14 | 2094 | 1203 | 388 | 123 |
| 5          | 2.03 | 1.31 | 0.53 | 0.19 | 1717 | 661  | 477 | 118 |
| 6          | 1.90 | 1.25 | 0.50 | 0.19 | 1834 | 1074 | 463 | 184 |

Table 5. Phosphorus content and quantity exported from oat.

| Treatments | Content in P (%) | Quantity of P exported (g/pot) |   |
|------------|------------------|---------------------------------|---|
|            | Grain            | Straw                           |   |
|            | a.l | sed | a.l | sed | a.l | sed |
| 1          | 0.83 | 0.92 | 0.10 | 0.13 | 830 | 70  |
| 2          | 0.82 | 0.83 | 0.09 | 0.07 | 849 | 757 |
| 5          | 0.96 | 0.93 | 0.14 | 0.11 | 810 | 446 |
| 6          | 0.88 | 0.93 | 0.11 | 0.10 | 846 | 791 |

a.l: arable land; sed: sediments

Table 6. Content and quantity of K exported from oat.

| Treatments | Content in K (%) | Quantity of K exported (g/pot) |   |
|------------|------------------|---------------------------------|---|
|            | Grain            | Straw                           |   |
|            | a.l | sed | a.l | sed | a.l | sed |
| 1          | 1.03 | 1.23 | 2.52 | 3.31 | 1039 | 935 |
| 2          | 1.09 | 0.94 | 2.91 | 3.31 | 1135 | 856 |
| 5          | 1.10 | 1.14 | 2.52 | 2.67 | 933  | 575 |
| 6          | 1.12 | 1.17 | 2.52 | 3.31 | 1083 | 1000|

a.l: arable land; sed: sediments

Table 7. Content and quantity of Mg exported from oat.

| Treatments | Content in Mg (%) | Quantity of Mg exported (mg/pot) |   |
|------------|------------------|---------------------------------|---|
|            | Grain            | Straw                           |   |
|            | a.l | sed | a.l | sed | a.l | sed |
| 1          | 0.97 | 0.91 | 0.12 | 0.05 | 978 | 697 |
| 2          | 0.83 | 0.98 | 0.16 | 0.04 | 867 | 894 |
| 5          | 0.69 | 0.76 | 0.15 | 0.03 | 589 | 385 |
| 6          | 0.26 | 0.88 | 0.14 | 0.04 | 257 | 755 |

a.l: arable land; sed: sediments

chlorite had a higher yields compared to those enriched with sulfate. Arable land favoured yields than sediments. There were interactions between soil types and the forms of nitrogen and potassium. Besides, calcium content was
Table 8. Content and quantity of Ca exported from oat.

| Treatments | Grain a.l. | Straw a.l. | Grain sed | Straw sed | Total a.l. | Total sed |
|------------|------------|------------|-----------|-----------|-----------|-----------|
| 1          | 0.60       | 2.89       | 0.55      | 1.45      | 60        | 42        |
| 2          | 0.55       | 4.18       | 0.45      | 1.75      | 57        | 41        |
| 3          | 0.50       | 2.79       | 0.45      | 1.00      | 42        | 22        |
| 4          | 0.75       | 3.78       | 0.40      | 1.20      | 72        | 34        |

a.l : arable land ;
sed : sediments

Table 9: Content in micro-éléments Zn and Fe for oat

| Treatments | Mn (mg/kg) Grain a.l. | Straw a.l. | Zn (mg/kg) Grain a.l. | Straw a.l. | Fe (mg/kg) Grain a.l. | Straw a.l. |
|------------|-----------------------|------------|-----------------------|------------|-----------------------|------------|
| 1          | 72                    | 59         | 54                    | 27         | 189                   | 193        |
| 2          | 52                    | 42         | 52                    | 54         | 136                   | 126        |
| 3          | 56                    | 60         | 55                    | 23         | 146                   | 129        |
| 4          | 81                    | 54         | 47                    | 19         | 216                   | 123        |

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低在开花阶段的小麦。

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