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Full Length Research Paper

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

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Abstract

To valorise sediments of iron mineral extraction zone of about 2500ha of coverage in Liberia, a concept of appropiate 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 dercreased 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 socieity 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 relyon 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 paticular is imported from outside. For agricultural production, farmers of the region lack, not only knowledge, but also space for farming. It must benoticed in general that peoples settled in this region will lack,in the long term, food supply for their subsitence. 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.

Consequeently, efforts have been putin 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 associeted with the muddy and strucutreless status of the sediment at the one hand, and at the other hand its content in ironwhichis of 10%. The adavantage 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 associeted 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 appropiate 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 guage 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 Agrochemestry Institute of the University of Bonn, in Germany.

Soil samples

All the nutrients in the soil samples were disolved in a solution mixed with 1N HCl and 1N H_2SO_4at 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 ; $CaCl_2$; 0.05M K_2SO_4 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 treatments1, 3, 5, 7, 8 and 16 received ammonium nitrate (NH_4NO_3) respectively, while the treatments 2, 4, 6, 9-15 were enriched with calcium nitrate ($Ca(NO_3)_2$). The phosphate was applied in very soluble form (KH_2PO_4) at 0.8g P per pot and the magnesium in form of magnesium sulfate($MgSO_4$) 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 15wereenrichedwith potassium sulfate (K_2SO_4) 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 fertilizerapplied. To address magnesium deficiency often noticed in tropical soils, the magnesium was applied in form of $MgSO_4$ at the dose of 0.6g Mg per pot. The calcium was applied in form of calcium chloride ($CaCl_2$) to the treatments 1, 3 and 4 at the dose of 1.43 g Ca per pot ; and in form of calcium sulfate ($CaSO_4$) to the treatments 7, 9 and14 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 :

$CuSO_{4:}$ 16mg Cu/pot
$MnSO_{4:}$ 14.6mg Mn/pot
H_3BO_3 : 5.0mg B/pot
$ZnSO_4$: 16.7 mg Zn/pot
$(NH_4)_2$ MoO_4 : 3.3mg Mo/pot.
Finally, the treatments 11 to16 received 60.0 g per pot of sawdusteach as source of organicmatter.

c) test crops

Oat (Avenae sativa) waschosen as main crop ; chinesecabbage (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 I : 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
P_2O_5 (méq/100g)	2.50	2.24	-
Mg M. NaCl) mg/100	0.72	0.69	-
K_2O*	3.32	2.86	-
eau	5.5	7.6	-
pH 0.01 $CaCl_2$	4.2	6.8	-
0.05 M K_2SO_4	4.1	6.6	-

Table 2 : Yields of oat

Treatments	Forms of N	Forms of K	Rendements en g / pot		
			Grain	Straw	Grain + Straw
Arable land					
1	NH_4NO_3	KCl	l01.1	95.2	195.3
2	$Ca(NO_3)_2$	KCl	98.4	79.4	178.0
5	NH_4NO_3	K_2SO_4	84.4	88.5	172.9
6	$Ca(NO_3)_2$	K_2SO_4	96.3	92.8	189.1
Sediments					
1	NH_4NO_3	KCl	75.9	81.6	157.5
2	$Ca(NO_3)_2$	KCl	91.0	79.6	170.6
5	NH_4NO_3	K_2SO_4	50.3	61.7	112.0
6	$Ca(NO_3)_2$	K_2SO_4	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			
1	NH_4NO_3	KCl	12.3
2	$Ca(NO_3)_2$	KCl	16.9
5	NH_4NO_3	K_2SO_4	13.7
6	$Ca(NO_3)_2$	K_2SO_4	18.2
Sediments			
1	NH_4NO_3	KCl	24.6
2	$Ca(NO_3)_2$	KCl	21.0
5	NH_4NO_3	K_2SO_4	23.7
6	$Ca(NO_3)_2$	K_2SO_4	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 adecrease of yields for the treatment 5 for the twosoil types. Independently to the form of the nitrogen applied, treatments enriched with

Table 4: Nitrogen content and quantity exported from oat

	Content inN (%)				Quantity of Nexported (mg/pot)						Average (%) N	
	Grain		Staw		Grain		Straw		Total			
Treatments.	a.l	sed	a.l	sed	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	1602	1240	80	62
2	2.02	1.32	0.48	0.14	2094	1203	388	123	2482	1326	124	66
5	2.03	1.31	0.53	0.19	1717	661	477	118	2194	779	109	38
6	1.90	1.25	0.50	0.19	1834	1074	463	184	2297	1258	114	63

Table 5. Phosphorus content and quantity exported from aot.

	Content in P (%)				Quantity of P exported (g/ pot)					
	Grain		Straw		Grain		Straw		Total	
Treatements:	a.l	sed	a.l	sed	a.l	sed	a.l	sed	a.l	sed
1	0.83	0.92	0.10	0.13	830	70	102	106	932	807
2	0.82	0.83	0.09	0.07	849	757	78	65	927	822
5	0.96	0.93	0.14	0.11	810	446	130	70	940	538
6	0.88	0.93	0.11	0.10	846	791	108	92	954	883

a.l : arable land
sed : sediments

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

	Content in K (%)				Quantity of K exported (g/pot)					
	Grain		Straw		Grain		Straw		Total	
Treatments	a.l	sed	a.l	sed	a.l	sed	a.l	sed	a.l.	sed
1	1.03	1.23	2.52	3.31	1039	935	2397	2700	3436	3635
2	1.09	0.94	2.91	3.31	1135	856	2320	2768	3455	3624
5	1.10	1.14	2.52	2.67	933	575	2230	1646	3163	2221
6	1.12	1.17	2.52	3.31	1083	1000	2337	3067	3420	4070

a.l : arable land
sed : sediments

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

	Content in Mg (%)				Quantity of Mg exported (mg/ pot)					
Grain	Straw		Grain		Straw		Total			
Treatments.	a.l	sed	a.l	sed	a.l	sed	a.l	sed	a.l	sed
1	0.97	0.91	0.12	0.05	978	697	115	46	1094	743
2	0.83	0.98	0.16	0.04	867	894	129	35	996	929
5	0.69	0.76	0.15	0.03	589	385	132	19	722	404
6	0.26	0.88	0.14	0.04	257	755	129	45	87	800

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, clacium content was

Table 8. Content andquantity of Ca exportedfrom oat**.**

	Content in Ca (%)				Quantity of Caexported(mg/pot)					
	Grain		Straw		Grain		Straw		Total	
Treatments.	a.l	sed	a.l.	sed	a.l	sed	a.l	sed	a.l	sed
1	0.60	0.55	2.89	1.45	60	42	274	118	335	160
2	0.55	0.45	4.18	1.75	57	41	333	146	390	187
5	0.50	0.45	2.79	1.00	42	22	247	61	289	84
6	0.75	0.40	3.78	1.20	72	34	351	116	424	150

a.l : arable land ;
sed : sediments

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

	Mn (mg/kg)				Zn (mg/kg)				Fe (mg/kg)			
	Grain		Straw		Grain		Straw		Grain		Straw	
Treatments.	a.l.	sed	a.l	sed	a.l	sed	a.l	sed	a.l	sed	a.l	sed
1	72	59	71	82	54	27	47	15	189	193	133	149
2	52	42	52	54	52	9	35	14	136	126	93	90
5	56	60	56	77	55	22	23	14	146	129	246	100
6	81	54	81	45	47	19	27	12	216	123	133	80

low at the flowering stage of oat.

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