Assessment of the mineralization of compost and the availability of the fertilizing elements in two soils in Niger

Abstract

The work aims to study the mineralization of compost in soils and the availability of the fertilizing elements to plants. A silty sandy soil S_1 and a sandy soil S_2 have been used to study the elaborated compost mineralization. Soils-compost mixture (100 :1) are incubated to 2/3 the humidity of field capacity during 30 days to follow-up the mineralization of the organic matter and during 30 days for the availability of soil fertilizing elements and the temperature to 28°C. Results in a first incubation showed curve of mineralization a slope at beginning and offers to be constant after 20 to 30 days of incubation. Then, the incorporation of compost to soils, leads to an increase of the mineral nitrogen of soil at the end of 28 days of incubation. The analysis of the physico-chemical parameters from the beginning to the end of the incubation, revealed an increase of the content in available phosphorus of 120.6 mg/kg for S_1C, and 128.4 mg/kg for S_2C. The content of the assimilated phosphorus in soils (control) is 10, 65 mg/kg for S_1 and 9, 21 mg/kg for S_2. The contents in assimilated phosphorus didn't vary meaningfully during 28 days in soils without composts. During this incubation, the values of pH for the control soil are lower than those of mixture soils + compost; the pH at the end of the incubation period is lower compared to one at the beginning. This organic contribution improved the cation- exchange capacity of soils of more than 96.33% for the treatments with S_2C and more than 92.24% with S_1C. The sum of the three cations (K^+, Ca^{2+}, Mg2+) measured out is higher in treated soils with compost than soils without compost.

Key words: organic amendment, organic matter, fertilizing elements, availability, soils, mineralization, incubation.

1. Introduction

Niger is classified among the countries " to agricultural vocation" because of the importance of its poor farming population and the role of agriculture as main activity of growth (46% of the GDP between 2005 and 2008) that uses close to 80% of the active population [1]. Of this fact the conditions of agriculture exercise are difficult because of the insufficiency and the irregularity of the precipitations and also of the poor soil conditions. In these conditions, the outputs of the rainy crops, dominant to Niger (sorghum, cowpea and peanut), are generally weak, and the possibilities of extension of these cultures appear limited whereas at the same time the population is in full growth [2].

In addition, the land degradation is the cause of the poor agricultural productivity, the food insecurity and poverty. Thus, more than 200.000 ha of arable land are degraded every year because of the climatic variability or interventions by man [3]. Facing these deterioration of the arable land, some researchers recommended the use of compost as amendment of the soil .The application of this compost to soil improves its fertility while bringing to the plants most of the nourishing elements while modifying the physico- chemical and biological structures of soil,

It is therefore at the heart of this preoccupation that survey was carried out Survey of the mineralization of composts and the availability of the fertilizing elements in two soils of Niger.

Compost containing several nutrients elements enriches soil and improves its structure, facilitates the work of soil, limits the erosion and the deterioration of soil and permits the plant to resist drought. It is organic manure applied locally by hill or in free spreading and sampled soil before the seedling or the recording of the plantations [4]. It is what contributes to the mineralization. The mineralization is the decomposition of the organic matter to mineral matter. It allows the availability of the carbon and other elements under inorganic form and therefore again accessible to plants [5].

The general objective is the assessment of the compost effect on two soils of Niger.

2. Material and Methods

Soils were collected in the botanical garden of the faculty of sciences and techniques of the University Abdou Moumouni of Niamey. For the S_1 soil, the site of soil sampling is located at 13°50'27 " and 2°10'05 ". For the S_2 site, the site is located at 13°50'19 " and 2°09'95 ". The sampling was done in December 2017. Soils samples for analysis were collected with the help of a manual auger. The auger has been driven until the short of soil to be filled completely in the hole to get homogeneous samples to 30 cm depth. The different samples were thoroughly mixed, before being put in labeled plastic bags. Samples were ground and sieved to 2 mm.

Chemical analyses have been achieved in the chemistry laboratory of National institute of Agronomic Research of Niger (INRAN) of Niamey and in the laboratory of pedology of the faculty of agronomy of the University of Niamey.

Prepared samples were subjected to physico-chemical analyses, to know: the granulometry, the pH, the cation- exchange capacity and exchangeable bases. Also, total organic carbon, Kjeldahl nitrogen as well as available phosphorus,

The follow-up of the evolution of the mineral nitrogen and the one of the mineralization of the carbon makes themselves independently but simultaneously and in the same conditions, during incubations in controlled conditions of soils-compost mixture.

For assessing mineralization of the carbon, the method of [6, 7] has been used and atmospheric CO_2 has been quantified [8].

For showing evidence of the availability of the fertilizing elements, an appropriate method has been used [9]. In this study, four treatments are compared: two treatments of soil without amendment (S_1 and S_2) that are the control and two treatments of soil with organic amendment: S_1C, S_2C.

Furthermore, phosphorus, nitrogen, pH, exchangeable bases and the cation- exchange capacity of soils were determined [8].

Granulométrie was done by the Method of Bouyoucos, The measure of the pH is done after ten (10) minutes of homogenization and thirty (30) minutes of rest to ambient temperature with the help of HANNA type pH meter.

The organic carbon determination and dosage of the carbon mineralized by [6].

Determination of the Kjeldahl nitrogen and dosage of the available phosphorus according to the method of Bray 1

Dosage of exchangeable bases by suitable procedure [10]

The determination of cation-exchange capacity by the method of Metson. [11]

Results and Discussions

The characteristic physico-chemical two soils used to study the elaborate compost mineralization are shown at Table 1

Table 1: Physico-chemical caracteristics of soils

	Sol S_1	**Sol S_2**
pH eau	7.54	7.58
pH KCl		
org C (%)	0.27	0.14
org M (%)	0.47	0.24
Nitrogen (%)	0.092	0.021
Avail P (ppm)	31.81	33.18
Exchangeables Cations (mg/Kg)		
K	93.84	86.02
Ca	390	280
Mg	221.312	97.28
CEC(cmol+/Kg)	4.38	2.72
	Granulometry (%)	
Sand	41.88	60.23
Fine Sand	38.57	33.77
Silt	9.29	3.43
Cley	7.73	2.65

Table 2: physico-chemical characteristic of compost

Compost	pH	C	N	C/N	Pt	Pass	K	Ca	Mg	Na	Cl
		%			mg/kg						
C	7.83	16.57	1.62	10.83	15275	695.8	1313.30	64000	16346.47	110.4	108.27

3.1. Mineralization of the organic carbon of compost in soils

The quantification of the CO_2 cleared during the incubation of soils and soil-composts mixture (100:1) to the laboratory during 28 days. Data are shown as evolved CO_2 during the incubation period.

Table 3: The quantification of the CO_2 cleared during the incubation of soils and soils-compost mixture

	C-CO_2 (mg)			
Temps (days)	**S_1**	**S_1C**	**S_2**	**S_2C**
1	52.8	70.4	17.6	79.2 ?
3	79.2	114.4	26.4	88
7	125.6	149.6	35.2	96.8
14	158.4	195.2	52.8	101.8
28	184.8	237.6	113.2	140.8
30	210.9	250.2	125.3	150.8

Abbreviations: S_1=Silt Sand soil; S_1C= Silt Sand soil amended with compost; S_2= Sand soil; S_2C= Sand soil amended with compost.

Whatever is the nature of mixture soil + compost, the speeds of mineralization are maximal at beginning of the incubation. They are more important in mixture soil + compost than pure soil. In these last, the mineralization of the carbon has the tendency to be constant after 20 to 30 days of incubation, in contrast to the other mixture that continue toundergo mineralization even after 90 days of incubation.

The contents accumulated of the mineralized Carbon, presented on the face, were significantly different to all periods of incubations. Strongest contents have been gotten with mixture soils + compost and weakest with the two check soils.

The mineralization of the total organic carbon under the incubation is often used like an indicator of the global microbial activity. This one is stimulated easily by contributions of organic matters degradation, characterized by coefficients of speed of elevated decomposition [12, 13]. Compost would have to therefore greatly to stimulate the microbial activity of soil. All curves present a strong slope to the departure of the incubation and, that softened progressively so that the curve stretches toward a landing at the end of the experience. It confirms the slowing of the speed of the mineralization of the carbon observed by the reduction of the daily production of C-CO_2.

The tests breathing permitted to put in evidence the effect of compost on the evolution of the organic matter of soil. The clearing of CO_2 translates the biologic answer to a modification of the middle. The incorporation of compost of agro food garbage increased and stimulated the microbial biomass of soil, compared to sand alone.

3.2. Mineralization of the ammonia

The NH_4^+ is the end product of the mineralization of the organic nitrogen of soils. The transformation of the soil nitrogen is assured by the micro-organisms. The organic nitrogen is mineralized in NH_4^+ by ammonification. The ammonification is achieved by bacteria. The decomposition of the nitrogenous organic matter can be translated by the following reaction:

$$\textbf{Nitrogen from organic matter} + \textbf{Microorganisms(bacteria)} \rightarrow \mathbf{NH_4^+}$$

The incubation is done to a dose of 1 g of compost for 100 g of soil. It is noted that the incorporation of compost to soils entailed an increase of the mineral nitrogen of soil at the end of 28 days of incubation. These results are in agreements with works of (Amlinger and al., 2003). It is noticed that the proportions of the mineral shapes are relatively more elevated in the S_2C miscellanies. It is due to the C/N reports that are of 6.67 in the S_2 soil against 2.93 in the S_1 soil.

Table *4*: Content of it % of nitrogen ammoniacal according to the time of the different soils-compost treatments.

	% Nitrogen			
Period (days)	S_1	S_1C	S_2	S_2C
0	0.45	0.85	0.32	1.63
3	0.4	1.35	0.33	1.95
7	0.38	1.65	0.3	2.2
14	0.34	1.73	0.32	2.45
28	0.3	1.85	0.32	2.65

3.3. Availability of phosphorus from compost soils mixture

The phosphor is absorbed by the plants as anions mono or dihydrogen phosphates ($H_2PO_4^-$ and HPO_4^{2-}) present in the solution of soil. These mineral structures of the phosphorus can enter into combinations with the calcium from alkali environment, and aluminum and iron in the acidic soils and can become unavailable to the plants [8].

3.3.1. Available phosphorus according to Olsen method

The assimilated phosphor of Olsen is extracted with the alkali solution of sodium bicarbonate. The results are consigned in the table 5. The content of the assimilated phosphor in soils (check) is de10. 65 mg/kg for S1et 9. 21 mg/kg for S2. One can note that the incorporation of compost improves the content in assimilated phosphor of soils. The contents in assimilated phosphor didn't vary meaningfully during 28 days in soils without composts. In soils-compost treatments we notice a meaningful increase of the content on the other hand in assimilated phosphor, result of the mineralization of the organic phosphor of compost.

This phenomenon, qualified of retrogression, is the fixing of the assimilated phosphor on the colloids of soil.

The effect of compost on the availability of phosphorus in the two soils, from the beginning and the end of the incubation was observed. (Table 5).

Table 5: Rate of increase of available phosphorus

	Soil	**Soil + Compost**
	mg/kg	
Sol S_1	**-5.6**	**120.6**
Sol S_2	**9**	**128.6**

In the two soils the rate of increase of available phosphorus between the beginning and the end of the incubation is noticed more in the treatments of soils with compost.

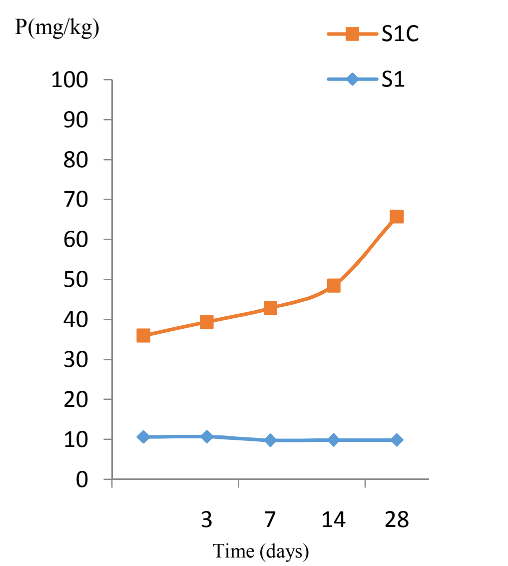

Figure 1.1 : Development of available P in S_1-compost samples

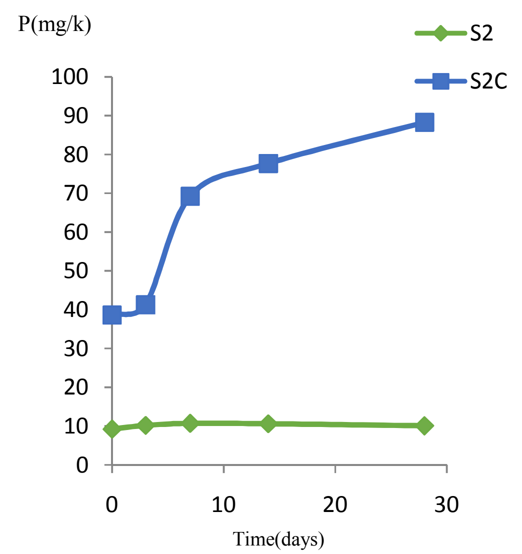

Figure 1.2 : Development of available P in S_2-compost samples

Figures 1.1 and 1.2 Development of available P in two combination of soil-compost samples

3.4. Effects of compost on the pH, the CEC and EC of soil

3.4.1. PH

The figures (2.1and 2.2,) return in the beginning account of the compost effect on the variation of the pH and the end of the incubation. One recalls that the S1 soil has a pH water of 7.54 and the S2 soil, a pH of 7.58. The C compost has a pH of 7.83 (figure 2.1 et 2.2). In the S_1 soil and the S_2 soil, the C compost has an acidic effect. The acidic character of C compost is responsible for reduction of the pH. The H+ protons of soil are transferred toward the functional sites of the organic matter of compost.

During this incubation, the values of pH for the control soils are lower to those of the mixture sols +compost. The organic amendments brought to soils affect the variation of the pH of these soils (figures 2.1 and 2.2). These results are in agreements with the works of Tchégueni and Aziables [7]. However, the reduction of the pH of the different treatments at the end of the incubation could be due to the mineralization of the organic matter with accumulation of the CO_2 in the serving jar of the experimental device.

That it is in the S_1 soil or S_2; the pH at the end of the incubation is lower to the one of the beginning. The mineralization of the organic matter with the liberation of the CO_2 would be at the origin of the reduction of the pH of the treatments with compost noted after 1 month of incubation. [8]

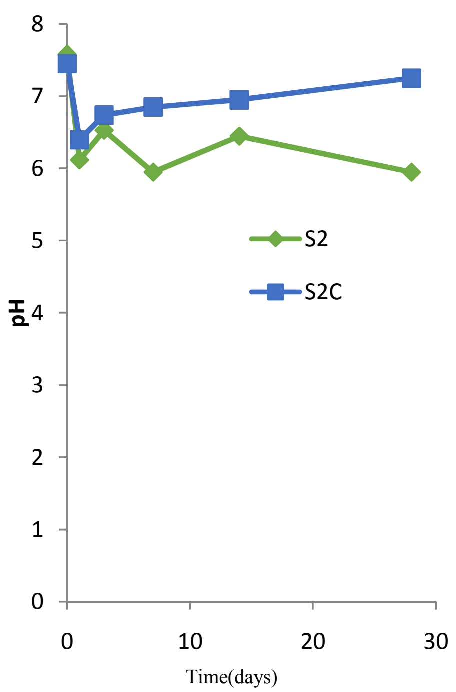

Figure 2.1 :P^H development in time with water as solvent in S2, S_2-Compost samples

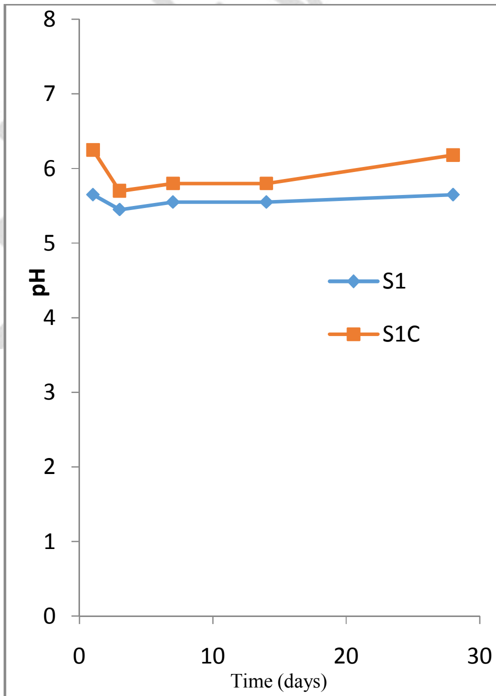

Figure 2.2: P^H development in time with KCl as solvent in S1, S_1-Compost samples

3.4.2. Cation- Exchange Capacity

We can note that there is not a significant difference between the two soils with regard to their contribution to the cation-exchange capacity. The values in CEC of the treatments determined sols+compost after 28 days incubations are consigned in the Table 6.

This organic contribution improved (Table 6) the CEC of soils of more than 96.33% for the treatments with S_2C and more of 92.24% with S1C. The observation of this results watch that the contents pressed some exchangeable of the treatments sols+compost and the control (soil) varied meaningfully.

Compost brought to soils, increased the cation exchange capacity (CEC) and improved the content of some exchangeable cations of soils. Compost increases the CEC of soils therefore increases their capacity to keep the plant nutrients.

The humic substances forms with the mineral, colloids of the soil i.e complex negatively loaded named cley-humic complex. These complex improve the soil cation- exchange capacity. They fix EC and act therefore like reservoirs of plants' nutrients. To the level of the anions, among others the nitrates and the phosphates, they can also be fixed by the ion of positive sites in periphery of the cley-humic complex.

Table 6: CEC Contents, in meq /100g, in soils and soil-composts mixture after 28 days of incubation.

	S1	**S1C**	**S2**	**S2C**
		méq /100g		
CEC	10	21.25	10	30

3.4.3. Exchangeable Cations

Table 7: Content, in mg/kg, of exchangeable cations (K^+, Ca^{2+}, Mg^{2+}) of the different samples, after 28 days of incubation

	S_1	**S_1C**	**S_2**	**S_2C**
		meq /100g		
K^+	**62.56**	**70.38**	**58.65**	**140.76**
Ca^{2+}	**1000**	**1400**	**1000**	**2000**
Mg^{2+}	**316.16**	**1459.2**	**304**	**2188.8**

"exchangeable" cations since capable to participate in a reversible exchange process (adsorption and desorption) once in the solution of soil. These exchangeable cations are available for plants. The contents in potassium, calcium and magnesium exchangeable in soils dealt with compost after 28 days of incubation.

The sum of the three pressed measured out is raised more in soils treated with composts than the soils without composts. Compost contributed more in the two soils for potassium, magnesium and calcium. This difference can be due to organic matter content in the compost.

Conclusion

In the two soils, amended with compost has a rate of mineralization of carbon and the more elevated nitrogen content. In the same way the two soils dealt with this compost have an effect on the pH and on the CEC of soils. This effect is more considerable on the availability of the phosphorus and on exchangeable cations (EC) of soils. The pH, CEC and EC of the amended soils are more improved by the treatments with the compost than soils without organic matter contribution.

It has been indicated with the study that the availability of the phosphorus of the treatments with compost presented an intense mineralization phase during the incubation that corresponded to the flux of the mineralization.

It is obvious that contribution of compost to a positive impact on the biologic activity of soil while bringing also some nutriments for plant use.

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