International Journal of Agriculture and Environmental Research

ISSN: 2455-6939

Volume:03, Issue:02 "March-April 2017"

STUDY OF THE CHEMICAL FERTILITY OF A SANDY CLAYEY SOIL UNDER NITROGEN-FIXING (Legume) CROPS CULTIVATION IN THE SOUTH SOUDANIAN ZONE IN BURKINO FASO.

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ABSTRACT

This study was conducted in the southern Soudanian zone of Burkina Faso to assessment the effects of chemical (NPK and urea) and organo-mineral fertilizer on soil chemical parameters in trial field. An experimental design has been established in a rural area in which plant material (KVx 775-33-2G variety of cowpea) and three types of fertilization, namely T0 (fallow, control), T1 (NPK + urea) and T2 (NPK + urea + Compost) were used. The results show that the chemical parameters of the soils were influenced significantly by treatments at the threshold of 5% for all parameters except the C:N ratio. The treatment T2 at 0-10 cm depth (T2_10) provided the best values relative to T1 in terms of pH_H_2O, total carbon, total nitrogen, total phosphorus and available phosphorus that are respectively 5.91, 0.91%, 0.072%, 114.98 mg/kg and 5.11 mg/kg.

The study showed that the effects of organo-mineral fertilization on the soil are not immediate and can be better observed in the medium and long term. This experimental design should be extended to include fertilization options that can improve soil fertility and intensify cowpea production.

Keywords: NPK, Compost, Soil fertility, Cowpea

ISSN: 2455-6939

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1. INTRODUCTION

The rural sector is in Burkina Faso the basis of the population nutritional and food security and contributes more than 60% to farm household income (SCAD, 2013). Cereals (millet, sorghum, maize, rice, fonio) are the main vegetal products in Burkina Faso (PNSR, 2012). Next to that, there is the leguminous plants production such as the cowpea. The cowpea is the worldwide main food leguminous plant. It is a vital plant during food shortage (Nadjam and Touroumngaye, 2014). The cowpea is an important source of currency. In Burkina Faso, the average each five-year of its production during the last agricultural campaigns was 543,817 tons. The importance of this legume motivates producers to give it a great support in the agricultural running's, be it by cultivating it only or associating it with other plants.

In addition to its importance in diet and in the economy, the cowpea has nowadays a class one place in agronomy. Indeed, it can be used as green fertilizer, in association with other cultures or in crop rotation. In such systems, the cowpea plays an important role as a source of nitrogen for the cereal, especially in the areas known to have low fertility of soil (Dugje and al., 2009). The nitrogen balance showed that, through their capacity to use the nitrogen of the atmosphere, the leguminous plants take less nitrogen in the soil and impoverish less quick the nitrogen of the soil, favoring then the nitrogenous nutrition of the culture (N'Dayegamiye and al., 2014). Unfortunately, in a country like Burkina Faso, the agricultural practices do not go together with the will to intensify the production of the cowpea. This intensification passes through the choice of a practice of fertilization which will have a sustainable effect on the components of the cowpea income. Many studies assessed the beneficial effect of the manures on the income of the cowpea (Dugje et al., 2009; Ishikawa et al., 2013; Somé et al., 2014). It is this aim of lasting intensification that some fertilization trying were set up in the farming area. The aim of this study is to show the effect of these fertilizers on the chemical parameters of the soil under the culture of the cowpea.

2. MATERIALS AND METHODS

2.1 Area study and its characteristics

This experimentation was lead in the rural commune of Péni (10°57'North, 4°28'West). It is located at 35 km from the town Bobo-Dioulasso, region of the Hauts-Bassins in Burkina Faso. The climate is the south soudanian tropical type with two seasons: a rainy season going from May to September and a dry season going from October to April (PNGT II, 2015). In 2005, the maximum rainfall was in August (321 mm). The sum of the rainfall was 1,166mm shared into about 80 rainy days per year. The average maximum hygrometric degree was always upper to 50% and the average temperature, upper to 25°C. In average, a water quantity of 1,079.23mm

ISSN: 2455-6939

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was recorded during these last 10 years. The total quantity of the fall rain in 2015 was 1,050.9 mm shared into 64 days and in six (06) months. The maximum height of the water (284.3mm) was recorded in September.

Some gavel soils, clayey soils, sandy soils, silt sandy soils, clayey sandy soils, silt clayey soils as well as some lithosoils are met.

2.2 The study material

The vegetal material was made up of the cowpea, the species KVx 775-33-2G. It is a strong variety to striga and tolerant to the drought. Its sewing to maturity cycle lasts 65 days.

The used fertilizers were the following: the mineral fertilizer used was the NPK (15-15-15) and urea (46% N) and the organic fertilizer was the compost made with the crop residues (maize/corn and sorghum stems), cow dung and ashes. The chemical component of this compost is shown in the table 1.

Table 1. Chemical composition of compost used

pH-eau	C (%)	Total N (%)	C/N	Total P (mg/kg)	Total K (mg/kg)
7.36	16.84	1.044	16	1949.67	15817.64

2.3 Experimental design

The experimental design was set up during the rainy season in 2015. For the implementation of the agronomical test, we used an experimental design of farming type following Jouve's method (1990). The experimentation was done by a group of 23 producers who followed the training about the cost-effective production of the vegetal seeds (cowpea and sesame). Hence, each producer constituted a block or a repetition. The treatment brought to each farmer were as followed:

The treatment T1 having received only mineral manure (NPK+urea) on an area of 2,457.5 m² due to 50 kg of NPK and 25 kg of urea per hectare

The treatment T2 having received a organo-mineral, manure due to 50 kg of NPK plus 25 kg of urea and 7 tons of compost per hectare.

Besides, some fallows T0 were identified (no supply of fertilizers) near each plot of the farmer as a model. The figure 1 shows the elementary plot of each farmer.

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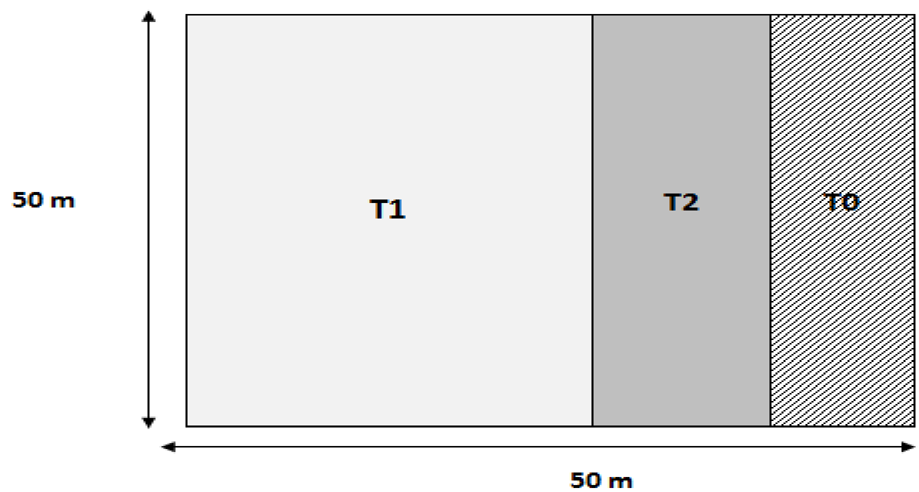

Legend: T0= Control (Fallow); T1 = NPK + urea; T2 = NPK + urea + compost

Figure 1. Elementary plot for each producer

2.4 Soil samples collected

The soil samples gathered in each depth of taking and in each treatment, were mixed up to get a composites samples. In each elementary plot of a farmer, a heterogeneous sample was got in the depth of 0-10 cm and another got in the depth of 10-20 cm for each treatment. According to the depths and the treatments, the following composites samples were obtained:

- T0_10: soil sample coming from the treatment T0 (fallow or control) in the depth 0-10 cm;
- T0_20: soil sample coming from the treatment T0 (fallow or control) in the depth 10-20 cm;
- T1_10: soil sample coming from the treatment T1 in the depth 0-10 cm;
- T1_20: soil sample coming from the treatment T1 in the depth 10-20 cm;
- T2_10: soil sample coming from the treatment T2 in the depth 0-10 cm;
- T2_20: soil sample coming from the treatment T2 in the depth 10-20 cm.

2.5 Laboratory analysis

The analyses were done in the Soil-Water-Plants laboratory of the research program of Natural Resources Management and the System of Production (GRN/SP) of the INERA/Farako-ba for the chemical analyses. Before the mixture of the chemical parameters, the taken soils were dried

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in the shade, weighted, crushed and sieved two (02) times (the first sieving at 2 mm followed by the second one at 0.5 mm).

The chemical analyses of the soils samples were done as followed:

The pH-water and pH (KCl) of the soils were measured according to the link soil/solution of 1/2.5 through a suspension of the sample respectively in a distilled water and in a KCI solution in accordance with AFNOR (1981).

The total carbon was determined through Walkley and Black's method (1934).

The total Nitrogen was determined after mineralization through KJELDAHL's method.

The mineralization to determine the total phosphorus is the same to determine the total nitrogen. The mixture was done through automatic calorimetry at the SKALAR.

The assimilable phosphorus was extracted in accordance to Bray I's method (Bray and Kurtz,1945) by a solution of ammonium fluorine (NH4F) 0.03M and hydrochloric acid 0.025 M in the extraction link soil/solution of 1/7.

The potassium was mixed by a spectrophotometer which gives out flames after the mineralization of the soils samples with a solution of dense sulfuric acid by heating in the face of a catalyst. The method of mineralization is the same as described previously.

2.6 Data statistical analysis

The gathered data were captured with the software Microsoft Office Excel 2013. The statistical analyses were done by the software XLSTAT version 2007.7.02. The partition of the averages was done through the test of Fisher on the threshold of 5%.

3. RESULTS

3.1 Effects of the treatments on the soil pH

The different variations of the pH (H_2O and KCl) according to the treatments are shown in the Figure 2. The analysis of the variance (on the threshold of 5%) reveals that the differences noted between the treatments are highly significant. However, the values of pH_H2O obtained by the treatments T0_20 and T1_10 on the one hand and those of the pH_KCl obtained by the T1_20 and T2_20 treatments on the other hand are statistically the same to the threshold of 5%.

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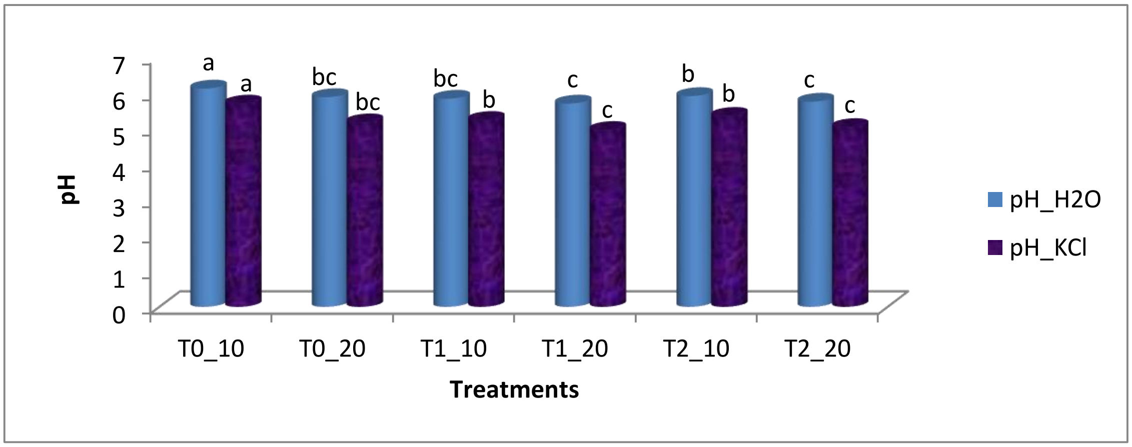

Legend: *T0_10 = Control at 0-10 cm depth; T0_20 = control at 10-20 cm depth; T1_10 = NPK + urea, 0-10 cm depth; T1_20 = NPK + urea, 10-20 cm depth; T2_10 = NPK + urea + compost, 0-10 cm depth; T2_20 = NPK + urea + compost, 10-20 cm depth.*
The letters a> b> c indicate for each treatment the mean values significantly different from the 5% threshold (ANOVA, Fisher's test). Each histogram is the average of 23 values.

Figure 2. Effects of the treatments on soil pH

3.2 Treatments effects on the content of the mineral components

The effects of the different treatments on the content in the mineral components are shown in the table 2. According to the statistical analyses, there is a significant difference between the treatments on the threshold of 5% for the carbon (C) and the nitrogen (N). The analysis of variance showed that all the values of the C:N ration are statistically the same on the threshold of 5%. As far as the contents in the total phosphorus (Total P) are concerned, the lowest average values (74.93 mg/kg) and the highest ones (114.98 mg/kg) were obtained respectively by the treatments T0_20 and T2_10. The statistical analyses show that there is a significant difference between the treatments on the threshold of 5% for the assimilable phosphorus (Ass_P). The results showed that the highest content in the assimilable phosphorus (5.11 mg/kg) was obtained by T2_10 and the lowest content (1.67 mg/kg) by T0_20. The analysis of variance (ANOVA) on the threshold of 5% revealed that the differences noted between the treatments are highly significant for the total potassium (Total K) with a highest content recorded by the treatment T2_20.

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Table 2. Effects of the treatments on fertilizers elements content

Treatments	C (%)	N (%)	C/N	Total P	Ass_P	Total K
					mg/kg	
T0_10	0,52 bc	0,044bc	11,83a	84,30b	3,95ab	886b
T0_20	0,36c	0,031c	11,30a	74,93b	1,67b	983ab
T1_10	0,74ab	0,057ab	12,92a	88,87ab	4,78a	824b
T1_20	0,57bc	0,043bc	12,06a	87,97b	2,83b	891b
T2_10	0,91a	0,072a	13,12a	114,98a	5,11a	981ab
T2_20	0,67bc	0,050bc	13,08a	100,25ab	3,05b	1092a
SD	0,38	0,028	2,14	45,49	2,92	318
P	< 0,001	< 0,001	> 0,05	< 0,05	< 0,001	< 0,001
Mean	HS	HS	NS	S	HS	HS

Legend: *T0_10 = Control at 0-10 cm depth; T0_20 = control at 10-20 cm depth; T1_10 = NPK + urea, 0-10 cm depth; T1_20 = NPK + urea, 10-20 cm depth; T2_10 = NPK + urea + compost, 0-10 cm depth; T2_20 = NPK + urea + compost, 10-20 cm depth; P=Probability.*
Total P = Total phosphorus; Ass_P = Assimilable phosphorus; Total K= Total potassium.
The letters a> b> c indicate for each treatment the mean values significantly different from the 5% threshold (ANOVA, Fisher's test). Each histogram is the average of 23 values.

4. DISCUSSION

Our results show that in the whole, the chemical parameters developed positively in the depth 0-10 cm. This could be explained by the beneficial effect of the addition of the compost to the mineral fertilizer (NPK+ urea). The ANOVA shows that the differences noted between the treatments at the level of the pH values are highly significant. In comparison to the fallow (control), we noted a slight tendency to acidification. Generally speaking, the soils analyzed after the harvest were fairly acid according to the BUNASOLS (1990). However, the tendency to acidification was more reduced in the depth 0-10 cm for the treatment T2_10. This could be explained by the beneficial effect of the compost supplied. These results sustain those of other authors (Houot et al., 2009; Santos et al., 2011; Arrouays et al., 2012; Konaté and al., 2012; Miranda and al., 2014; and Sikuzani et al., 2014). According to them, the supply of compost allows to raise and keep the pH of the soils. This raising would be due to the buffer effect of the organic material, to the basic cations (essentially Ca and Mg), to the presence of some filament microorganisms which originate in the organic supplies and to the complexation of the aluminum. Indeed, soils acidity has a great influence on the concentration of the toxic, nutritional elements of the solution of the soil (Sikuzani et al., 2014).

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The contents in the total C had significantly varied. The highest content (0.91%) in the depth 0-10cm of the treatment T2_10 shows the beneficial effect of the compost. This result is in accordance with those of Houot and al. (2009) and Sizukani and al. (2014).

The highest content in total nitrogen (0.072%) noted after the harvest in the depth 0-10 cm of the treatment T2_10, would be due to the addition of compost. It was 0.044% in the depth 0-10 cm of the model T0_10. The mineralization slow and progressive of the compost would have allowed to raise the content thanks to the release of the mineral nitrogen. According to Adibi and al. (2008), the nitrogen which is essentially in organic shape in the compost is mineralized (ammonification and nitrification) slowly to be available to the plants which would use it mainly in nitrate shape.

The C:N ration varied from 11.30 to 13.12 respectively in the depths 10-20cm of the treatment T0_20 and 10-20 cm of the treatment T2_10 . This variation noted was due to the decomposition of the compost which brought more organic elements to the soil. The optimum of the C:N ratio was between 9 and 12. The nearest ratio to 12 was obtained in the depth 10-20 cm of the treatment T1_20. This could be explained by the effect of the compost which would have improved the supply of the nitrogen through a better stimulation of the biological activity. The study of Segda and al. (2001) showed that the addition of the urea to the organic substrates allows to speed the decomposition; this made the value of the C:N ratio decrease.

In the depths 0-10 cm and 10-20 cm of the treatments T2_10 and T2_20, the highest contents in total phosphorus were recorded, which are respectively 114.98 mg/kg and 100.25 mg/kg. Moreover, only the treatment T2_10 in the depth 0-10 cm allowed to have a low content of easy assimilated phosphorus; the other contents were known to be the lowest. About the total potassium, the content obtained in the depth 10-20 cm of T2_20 was the average; the other ones were known to be low. The differences noted between the contents (total phosphorus, assimilable phosphorus, total potassium) would due to the beneficial effect of the beginning of mineralization of the compost. According to Sikuzani and al. (2014), the supply with compost has a significant effect on the content in the phosphorus and the potassium of the soil. However, when the contents in the potassium and those of the initial situation of the soil are compared, we noticed that, generally speaking, there was not a development enough remarkable between them, mainly in the depth 0-10 cm of T2_10. This sustains the one obtained by Arrouays and al. (2012). According to these latter's, the agricultural soils do not show a measurable fall of the contents in potassium, despites an important reduction of external mineral supplies.

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5. CONCLUSION

This study had as aim to assess the effect of two (02) types of fertilization on the chemical parameters of the soils. The soil analyzed were fairly acid. This tendency to acidification was low following the application of the treatment T2 in the depth 0-10 cm (T2_10), which allowed to record the best values of the pH_H_2O (5.91) and of the pH_KCl (5.35) The same treatment in the same depth favored to obtain the high contents in total carbon, total nitrogen, total phosphorus and in easy assimilated phosphorus which are respectively 0.91%; 0.072%; 114.98 mg/kg and 5.11 mg/kg. It was assessed that the addition of the compost to the mineral manure had a significant effect on the chemical parameters of the soil.

Given that the compost is progressively mineralized, its beneficial effect could be grasped better in the medium and long terms. Hence the beneficial effects noted at the level of the chemical parameters of the soil.

ACKNOWLEDGMENTS

We thank the Circle of Assistance, and Environmental Consultancy (CACE) for the support given to this study.

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