Available online at http://www.journalcra.com

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

International Journal of Current Research
Vol. 12, Issue, 04, pp.11288-11293, April, 2020

DOI: https://doi.org/10.24941/ijcr.38450.04.2020

ISSN: 0975-833X

RESEARCH ARTICLE

IMPACT OF CROP ROTATIONS AND FERTILIZATION OPTIONS ON SOIL CHEMICAL AND BIOLOGICAL PROPERTIES UNDER COTTON FARMING SYSTEM IN THE SOUTH-SUDANIAN ZONE OF BURKINA FASO

Isdine Aziz Nambon, D.A.,[1,2*], Karim TRAORÉ[1], Adama TRAORÉ[1], Pascal BAZONGO[2], Ouola TRAORÉ[1] and Hassan Bismarck NACRO[3]

1Assistant Professor, Faculty of Computing and Software Engineering, Arbaminch University, Ethiopia
[2]Lecturer, Department of Computer Science, Debre Tabor University, Ethiopia
[3]Lecturer, Faculty of Computing and Software Engineering, Arbaminch University, Ethiopia

ARTICLE INFO

Article History:
Received 08th January, 2020
Received in revised form
24th February, 2020
Accepted 18th March, 2020
Published online 30th April, 2020

Key Words:
Cotton, Soil, Properties, Biological, Chemical, Crop Rotations, Fertilization, Organic.

ABSTRACT

Cotton is the main cash crop in Burkina Faso and the total cotton acreage is over1/10 of arable land. But, the overall benefit of cotton is negatively affected by decreasing yields due to constant soil degradation. The current study is a contribution to a better understanding of soil biological and chemical properties changes under cotton farming system. To do so, a study was undertaken at Farako-Bâ research stationina split-plot design with crop rotations including cotton in the main plots and fertilization options in the secondary plots. The results showed higher soil organic carbon and nitrogen in rotation "Rice-cotton" plots compared to the other rotations. The results showed also a significant increase in soil phosphorus from 68.57 to 148.76 mg/kg^1. However, the level of these nutrients was below the recommended rates to support a good crop production. The soil biological activity was better with the combined application of organic and mineral fertilizers and highest for "Rice-cotton" rotation compared to cotton monoculture. Our results show positive correlation between soil biological activities and soil organic carbon, total nitrogen and soil available phosphorus. The sustainability of the cotton farming system depends highly on suitable combination of good agricultural practices.

Citation: ***Isdine Aziz Nambon, DA, Karim TRAORÉ, Adama TRAORÉ, Pascal BAZONGO, Ouola TRAORÉ and Hassan Bismarck NACRO. 2020.*** "Impact of crop rotations and fertilization options on soil chemical and biological properties under cotton farming system in the South-sudanian zone of Burkina Faso", *International Journal of Current Research*, 12, (04), 11288-11293.

INTRODUCTION

In Burkina Faso, Cotton is the main cash crop for farmers and the major source of currency for the country. Since the 90ties, the cotton acreage has significantly increase in Burkina Faso (Schwartz, 2006). The total cotton acreage in the country was estimated to 651 294 ha in 2015 (DGESS, 2015). Indeed, cotton occupies about 10 to 15% of arable lands (MECV, 2011) and it represents 60% of the country total export earnings. Around 20% of farmers are benefiting from this crop, generating 3.5% of the Gross Domestic Product (FMI, 2014) and contributing to the mechanization of farms. Despite the importance of cotton and the potential of varieties currently planted, the yields are low due to rapid depletion in soil fertility.

***Corresponding author:** **Isdine Aziz Nambon, D.A.,[1,2*],**
1Assistant Professor, Faculty of Computing and Software Engineering, Arbaminch University, Ethiopia.
[2]Lecturer, Department of Computer Science, Debre Tabor University, Ethiopia.

Land degradation in Burkina Faso is likely to jeopardize the sustainability of crop productivity in the country (Koné, 2015). Lompo (2007); Ouattara (2009) reported that cotton farming can lead at medium and long term to rapid decline in productivity due to the degradation of soil physical, chemical and biological properties. This is due to the fact that, in cotton farming systems, crop residues are burned or exported from the fields, removing important source of nutrients. For some authors the sustainable land management in cotton farming system is a major challenge due to the population growth, the expansion of cultivated areas and the low returning of mineral and organic nutrients. In such context the sustainability of cotton farming requires better guidance from scientists and extension. Most of the studies carried in the region on cotton farming are focused on soil chemical and physical properties but no result is available on both soil chemical and biological properties. The current study was initiated to contribute to a better understanding of the cotton farming system in the objective to formulate low cost and efficient cotton farming system. Specifically, our study focused on the impact of cotton cultivation on the soil biological and chemical properties.

We hypothesize that:

- The combinations of organic and inorganic fertilizations positively affect soil biological properties;
- Rotation including cotton and cereal can potentially affect soil biological properties compared to cotton mono-cropping.

MATERIALS AND METHODS

Material

Study site: The study was carried out at Farako-Bâresearchstation in the South-sudanian of Burkina Faso with rainy season from May to October and dry season from November to April. The annual rainfall ranged from 900 mm to 1200 mm. The temperatures vary between 17 °C and 37 °C during the dry season and 20 °C to 32 °C during the rainy season. Soils in the trial site are tropical ferruginous leached soils with sandy to sandy-silty texture (Bado, 2002). They have low clay and organic matter content which explains their low Cation Exchange Capacity (CEC). These soils are slightly acidic with very low content in nitrogen, available phosphorus and potassium (Koulibaly, 2011).

Planting material: The following crop varieties were used in the trials: Cotton (*Gossypium*sp.) varietyFK 37, growth cycle of 120 days and rice (*Oryza sativa)* variety FKR 45 N, growth cycle of 95 days. These improved varieties were recommended by the local agricultural extension services.

Methods

Experimental design: The experimental design was a split-plot with rotations in the main plots and fertilization options in the secondary plots. (Table and 2). The size of the main plots was 120 m^2 (15 m x 8 m) and the secondary plot 20 m^2 (4 m × 5 m).The main and secondary plots were separated by a space of 0.5 m. The whole design included 4 blocks separated by a space of1 m from each other.

Cultivation operations: The planting density was 80 cm × 40 cm for cotton and continuous planting for rice with 0.20 cm between rows. For pest management, the following insecticides were used: Avaunt 150 EC (Indoxacarb 150 g/L), then Lambdacal 212 EC (Lamdacylhathrine 12 g/L + profenofos 200 g/L) and finally Conquest 88 EC (Cyperméthrine 72 g/L+ Acétamipride 16 g/L). Those insecticide treatments were applied from 30 days after sowing and every two weeks during the rest of the growth cycle. Weed control was manually doneat15 and 30 days after sowing.
The mineral fertilizers NPK and urea were respectively applied at 15 and 30 days after sowing. The compost and "BP" were incorporated in the soil during the ploughing.

Data collection

Soil sampling and preparation: Soils samples were taken in plotsbefore plowing atdepth 0-20 cm. The samples were taken following a diagonal at three points per elementary plotwith an auger. For each plot the three samples were mixed to make a composite sample.

Then, thosecomposite samples were sun dried and oven dried at 105 °C during 48 h and sieved at 2 mm.

Lab analysis: Soil samples were tested for pH, soil organic carbon, total and available phosphorus, total nitrogen, total and available potassium at plant labof Farako-Bâresearch station:

- The pH value was testedfrom a suspension of soil and water solution ratio of1/2.5 (AFNOR, 1999)using anelectrometric pH meter.
- The organic carbon (C)was determined by Walkley and Black (1934) method.
- For total phosphorus (P_tot), total nitrogen (N_tot), total and available potassium (K_tot and K_av) determination, samples were digested in a mixture of sulfuric acid, selenium and hydrogen peroxide (H_2SO_4-H_2O_2-Se) at 450 °C for 4 h, according to the method of Walinga et *al*., (1995). N_tot, P_tot and K_tot were then determined with a spectrophotometer. Available phosphorus (P_av) was extracted using the Bray-1 method (Bray and Kurtz, 1945). Soil biological analyzes were performed in the microbiology lab of the Forestry Production Department (DPF/INERA):
- Microbial respiratory activity (CO_2-C) to assess the amount of CO_2 produced by microorganisms (summation of CO_2 daily quantity released during 21 days of soil sample incubation) was tested using the spirometry method (Dommergues and Mangenot, 1970);
- Microbial biomass (Adenosine TriPhosphate-ATP) corresponding to the total mass of living microorganisms was determined by fumigation-incubation method from Wu *et al.* (1990);
- Arbuscular Mycorrhizal Fungi (AMF) or endomycorrhizal capacity indicating the abundance of soil mycorrhizal fungi is measured by the density of extracted spores using the wet sieving and decanting method (Gerdemann and Nicolson,1963).

Statistical analysis: Data collected were recorded in Microsoft Excel 2007 and the ANOVA was done using an add-on module XLSTAT-Pro 7.5.2. The means were separated using the Newman-Keuls test at95% confidence. Pearson correlation matrix was used for correlations between soil chemical and biological components.

RESULTS AND DISCUSSION

Results

Effect of crop rotation on soil chemical properties: The results (Table 1) show that there is no significant difference between crop rotations for soil pH, soil organic carbon, total nitrogen, C/N ratio, total and available phosphorus , total and available potassium. However, the values of these nutrients are slightly higher in "Cotton-rice" rotation compared to the mono cropping of cotton. By contrast, the value of available phosphorus and total potassium and C/N ratio are lower or similar for both rotations.

Soil chemical properties changes with fertilization options: The results (Table 2) show no change in soil pH, C/N ratio and potassium (total and available) with fertilization options. But soil organic carbon, total nitrogen and phosphorus contents are different depending on the fertilization options.

In fact, soil carbon, total nitrogen and total phosphorus are highest for BP+Compost+Ureafertilization. For available phosphorus, the level is highest for NPK fertilization option and comparable for the rest of treatments. Theresults showhigher soil organic carbon and nitrogen content for fertilization options BP+Compost+Urea compared to the other options.

Effect of cotton farmingon soil biological properties

Evolution of soil CO_2 daily release based on fertilization options

The

Figure 1shows the evolution of CO_2 release based on fertilization options. The curve pattern of CO_2 release is similar for all fertilization options. In general, the CO_2 release drops significantly from day 1 to 7. The release is higher during the first days of incubation before decreasing until the 7^{th} day. CO_2 release at the 7^{th} day was 4 to 5 times less than the 1^{st} day for all fertilization options. A revival of biological activity was then observed fromday $9^{th}$to day 11^{th} before dropping andremaining stable during the last days (0.66 to 2.49 mg C-CO_2). The quantity of CO_2 is highest for BP+Compost+Ureafertilization option, followed by BP+Compost, BP+Urea, BP, NPKand control plot.

Evolution soil CO_2 daily release based on crop rotation: The Figure *2*shows the CO_2 release kinetics based on rotations. The curves show difference between the two rotations but the patternissimilar to what was reported for fertilization options. The quantity of CO_2 released is higher for cotton mono cropping compared to cotton-rice rotation.

Impact of fertilization options on the C-CO_2accumulation, microbial biomass and Arbuscular Mycorrhizal Fungi (AMF): The quantity of the accumulation of CO_2-C based on fertilization options is presented in Table 3. The data show significant difference between treatments for C-CO2 accumulations. The unfertilized plot showed significantly lower quantities (36.96mg/100g soil) compared to fertilized ones. The highest value was obtained with fertilization option BP+Ureamanure (50.23 mg/100g soil). The change in microbial biomass ranges from 21.46 mg/100 g soil to 30.94 mg/100 g and data show no significant difference between fertilization options. The results show no significant differences for AMF density.

Impact of crop rotation on the C-CO_2 accumulation, microbial biomass and Arbuscular Mycorrhizal Fungi (AMF): The results are shown in Table 4. Value are slightly higher in “Cotton-cotton” rotation for C-CO_2 accumulation and microbial biomass contrarily to density of spores. But there is no significant difference between rotations for soil biological parameters.

Correlation coefficients (Pearson r) between chemical and biological parameters: The correlations between some soil chemical and biological parameters are presented in Table 5.The results show positive and very low correlation between soil microbial biomass and soil chemical parameters pH(r^2 = -0.365). At opposite, the results show negative and significant correlation between the density of spores, pH (r^2 = -0.528) and available potassium (r^2 = -0.584).

DISCUSSION

Effect of fertilization options and crop rotation on soil chemical properties: Crop rotation alone affected less soil chemical properties. This shows that necessity to combine many farming systems to get a sustainable production. Depending on the fertilization options, the results show trial site soil pHvaluesbetween5.47 and6.21, meaning acidic to slightly acidic soil. These acidity levels are similar to those reported by Bado (2002)for the region. Organic manure application can help to improve soil chemical characteristics, mainly the levels of soil organic carbon and total nitrogen. These results are in line with those reported by Bado (2002) and Coulibaly *et al*., (2012).Despite this increase, the soil organic carbon(0.32 to 0.46%) and nitrogen (0.032 to 0.047%) remain below the appropriate values indicated by National Soil Bureau-BUNASOLS (0.58 to1.16% for C and 0.06 to 0.1% for N_tot). With respect to the C/N ratio, the average value is 10 regardless of the crop rotation and the type of fertilization. This shows a rapid organic matter mineralization of the soil organic matter. This is probably due to the low level of organic matter in the soil and high soil biological activities. These results are in agreement with those obtained by Koulibaly et *al*., (2015). Our study showed that available phosphorus and total phosphorus contents are very low and this varies with fertilization options. Fertilization including mineral fertilizers containing P have not necessarily higher P availability. This result shows that important quantities of P from the soil is fixed by the soil and not available to the crops. The availability of P in acidic soils was reported by many other scientists (Andrianambinina, 2013; Plassard *et al*., 2015) under the same conditions. To increase the P availability, the use of inorganic fertilizer will be a key for those soils. As reported by Coulibaly et *al*., (2012) the application of organic manure to soil has a significant impact on the availability of phosphorus in the soil. Our results showed low quantities of both total potassium (≤ 600mg/kg) and available potassium (≤ 100 mg), compared to the level recommended by BUNASOL (K_tot≥1000 mg/kg and K_av≥100 mg/kg). Potassium deficiency was also reported by Bado (2002) under the same conditions. P and K are the most limiting nutrients in those soils and this should be taken up when proposing any fertilization option for the region.

Effect of crop rotation and fertilization on soil biological properties: Soil biological activity is a good indicator of soil fertility, since it allows to monitor the dynamics of the process of decomposition and transformation of organic matter. Fertilization options containing compost showed higher increase of CO_2 released from soil due to increase in organic matter. Such results have been reported by De Shorn et *al*. (2019). The quantity of CO_2 released obtained from our experiment are in agreement with those obtained by Zombré (2006) which showed that the CO_2released depends on the soil content of nutrients. The pattern ofCO_2released is in line with the results reported by Haro (2011). This author also reported intense release of CO_2 observed during the first days of incubation and the decline in microbial activity during last days due to depletion of food reserves for the microorganisms of the soil. Our results showed no significant difference between rotations and fertilization options for microbial biomass, even with compost application. Overall, low microbial biomass is noted for all fertilizers.

Table 1. Crop rotation used in the trials

	Trials Years				
Rotation pattern	2011	2012	2013	2014	2015
R1	Cotton	Rice	Cotton	Rice	Cotton
R2	Cotton	Cotton	Cotton	Cotton	Cotton

Table 2. Fertilization options

Plot designation	Manuring options
F1	Control – Unfertilized plot
F2	NPK (200 kg/ha) + Urea (100 kg/ha)
F3	BP (500 kg/ha)
F4	BP (500 kg/ha) + Urea (100 kg/ha)
F5	BP (500 kg/ha) + Compost (5 t/ha)
F6	BP (500 kg/ha) + Compost (5 t/ha) + Urea (100 kg/ha)

BP: Burkina Faso rock Phosphate of (25.5% P_2O_5)
NPK: compound mineral fertilizer (14N-23P-14K)
Urea: simple mineral fertilizer (46% nitrogen)
Compost: organic manure (33.9% Organic matter and C/N of 14.6)

Table 1: Effect of crop rotation on soil chemical parameters

Crop rotation	pH	C (%)	N_tot (%)	C/N	P_tot	P_av	K_tot	K_av
						(mg/kg soil)		
Cotton-Rice	6.19±0.33a	0.34± 0.07a	0.035±0.006a	10±0.35a	112.36±65a	3.45±0.81a	726±41.39a	100±40a
Cotton-Cotton	6.06±0.23a	0.32±0.05a	0.032±0.003a	10±1.08a	77.70±8a	4.46±1.67a	759±125.30a	89±30a
Probability (Pr> F)	*0.282*	*0.809*	*0.747*	*0.874*	*0.494*	*0.211*	*0.107*	*0.729*
Signification	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*

Values with the same letter are not significantly different at statistical significance of 5%. *NS* = Not Significant C = organic carbone, N_tot = total nitrogen, Ptot = total phosphorus, P_av = available phosphorus, K_tot = total potassium, K_av = availablepotassium.

Table 2: Change in soil chemical properties with fertilizer options

Treatments	pH	C (%)	N_tot (%)	C/N	P_tot	P_av	K_tot	K_av
						(mg/kg soil)		
Unfertilized plot	5.87±0.3a	0.31±0.02b	0.031±0.004b	10±0.6a	68.57±19.1ab	2.49±0.15b	613±113.18a	75±9.64a
NPK	5.47±0.4a	0.35±0.1ab	0.036±0.0ab	10±0.9a	62.22±14.4ab	7.05±1.88a	41.51±513a	80±45.09a
BP	6.21±0.3a	0.35±0.0ab	0.036±0.0ab	10±0.8a	147.82±46.5a	3.11±0.8ab	19.82±560a	96±45.03a
BP+Urea	5.79±0.5a	0.36±0.0ab	0.034±0.0ab	10±0.7a	67.78±32ab	4.12±0.7ab	50.41±566a	60±30.03a
BP+Compost	6.14±0.8a	0.42±0.07ab	0.041±0.0ab	10±0.8a	110.46±31.9b	3.91±0.6ab	666±174.4a	61.99±101a
BP+Compost+Urea	6.03±0.3a	0.46±0.08a	0.047±0.006a	10±0.71a	148.76±43.82a	5.19±2.97ab	680±216.12a	99±40.73a
Probability	*0.470*	*0.065*	*0.051*	*0.717*	*0.016*	*0.038*	*0.565*	*0.810*
Significance	*NS*	*S*	*S*	*NS*	*S*	*S*	*NS*	*NS*

Values with the same letter are not significantly different at statistical significance of 5%. *S* = Significant, *NS* = Not Significant

Table 3. Evolution of the C-CO_2accumulation, microbial biomass and density of spores with fertilizer options

Treatments	C-CO_2 accumulation	Microbial biomass (mg/100 g soil)	Density spores (mg/100 g soil)
Control	36.96±7.11ab	28.44±5.37a	1549.33±630.23a
NPK	46.64±4.52a	21.46±0.81a	1553.33±494a
BP	47.74±0.89a	24.5±1.61a	1972.66±991.89a
BP+Urea	50.23±0.01a	28.61±6.98a	1903.33±298.59a
BP+Compost	48.20±0.22a	30.94±2.14a	2224±114.94a
BP+Compost+Urea	48.91±1.58a	25.75±2.16a	1897.33±932.22a
Probability (Pr> F)	*0.0047*	*0.109*	*0.895*
Meaning	*S*	*NS*	*NS*

Values with the same letter are not significantly different at statistical significance of 5%.*S* = Significant, *NS* = Not Significant

Table 4. Evolution of the C-CO_2 accumulation, microbial biomass and density of spores with crop rotation

Crop rotation	C-CO_2 Accumulation	Microbial biomass (mg/100 g soil)	Density of spores (mg/100 g soil)
Cotton-rice	35.49±4.32a	19,13a±2.98	2408.66±191.31a
Cotton-cotton	41.94±2.31a	28,89a±3.51	2084±180.23a
Probability (Pr> F)	*0.296*	*0.231*	*0.099*
Meaning	*NS*	*NS*	*NS*

Values with the same letter are not significantly different at statistical significance of 5%. *NS* = Not Significant

Table 5. Correlation coefficient between some soil chemical and biological parameters

Biologicalparameters	Microbialbiomass	Density of spores	C-CO_2 accumulation
Chemical parameters			
pH	0.365	-0.528	0.056
N_tot	0.032	-0.258	0.319
C	0.025	-0.335	0.291
C/N	0.036	0.289	0.045
P_tot	-0.143	-0.155	0.201
P_av	-0.263	0.275	0.228
K_tot	0.161	-0.184	-0.037
K_av	0.009	-0.584	0.103

Value in bolt are significantly correlated at statistical significance of 5%. C = organic carbone, N_tot = total nitrogen, Ptot = total phosphorus, P_av = available phosphorus, K_tot = total potassium, K_av = available potassium.

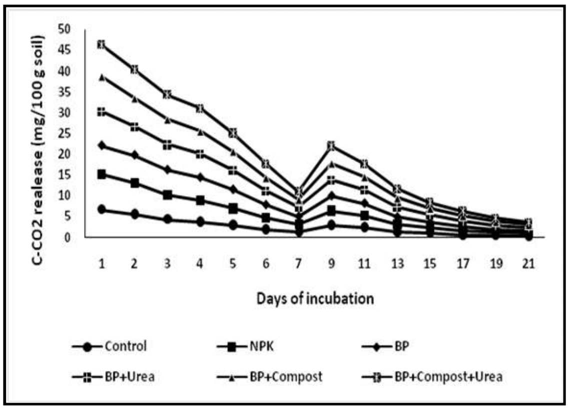

Figure 1. Evolution of the soil CO_2 daily release with fertilizer options

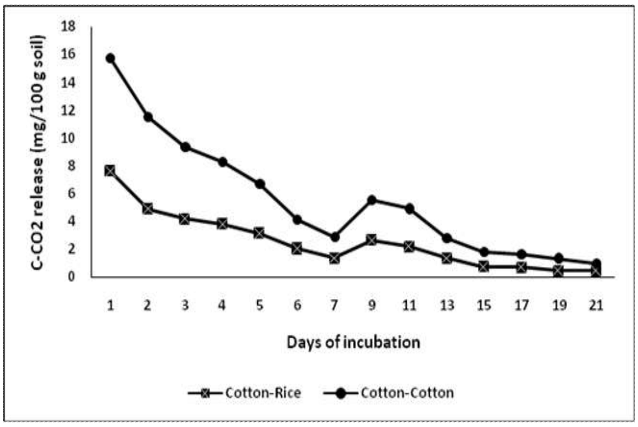

Figure 2. Evolution of the daily release of CO_2 from soils-based rotations

It can be related to the low organic carbon levels in the studied soil because the microbial biomass would be dependent on carbon content which is showed by the positive correlation between them. These results are in line with those reported by Bilgo et *al*., (2006) and Traore et *al*., (2007) which showed a positive correlation between organic matter and microbial biomass. According to our results there is a higher density of spores with crop rotations than with fertilizer options. However, the mycorrhizal power of the two rotations and manure are considered acceptable (> 1500 propagule.kg^{-1}) according to ITAB (2002). This parameter is a good organic soil condition indicator. In addition, the analysis of our results shows that level of spores is negatively and significantly correlated with pH and potassium values. Similar results were reported by Asimi (2009) and Haro (2011). But we might not support that the density of spores decreases according to those parameters since Rousk et *al*. (2009) showed that the trend of fungal growth depends on a broad range of pHs and other chemical parameter ratios. This variable can be used to assess the overall good health of the soils

Conclusion

The objective of this study was to evaluate the impact of crop rotation and fertilization options on soil biological and chemical properties in the south Sudanianzone of Burkina Faso. Our results show significant impact of fertilizer options on soil chemical and biological properties. An increase in the content of certain parameters such pH, total nitrogen, total phosphorus and organic matter was found in the plots fertilized with compost compared to the control. Our results show that both rotations and fertilizer application does not have a major influence on the availability of phosphorus in the soil. From these results it appears that application of mineral source of phosphorus is a must for potential productivity of the crops in this environment. Also, the potassium availability seems to be a major constraint also for the studied soils. Fertilization applied had no significant impact on soil acidity but the application organic matter seems to increase the pH.Our results show a positive impact of fertilizer on soil biological activities. It seems necessary, for a good management to apply both organic and inorganic fertilizer. This study should continuous because of evaluation was limited to 2 crop cycles. The properties will probably change when many cycles of crops

Acknowledgment

The authors are grateful to the Natural Resources Management and Farming System Program of Institute of Environment and Agricultural Researches (INERA) Farako-Bâ research center for its multiform support to the achievement of this study.

REFERENCES

AFNOR., 1999. Détermination du pH. (Association Française de Normalisation) NF ISO103 90, AFNOR Qualité des sols, Paris, pp. 339-348.

Andrianambinina F. V., 2013. Dynamique et disponibilité de l'azote et du phosphore sous association riz-haricot soumise à différentes doses croissantes de fertilisation minérale azotée et phosphatée-Essai en pot sous serre sur sol ferrallitique de Tanety de Lazaina. Mémoire de fin d'études d'Ingénieur Agronome. Université d'Antananarivo, Ecole supérieure des sciences agronomiques. Madagascar. 71p.

Asimi S., 2009. Influence des modes de gestion de la fertilité des sols sur l'activité microbienne dans un système de cultures de longue durée au Burkina Faso. Thèse de Doctorat d'état ès-sciences naturelles, Institut du

Développement Rural/ Université Polytechnique de Bobo-Dioulasso, Burkina Faso. 177 p.

Bado B. V., 2002. Rôle des légumineuses sur la fertilité des sols ferrugineux tropicaux des zones guinéenne et soudanienne du Burkina Faso, Thèse de doctorat troisième cycle, Université de Laval du Québec, 148 p.

Bilgo A, Masse D, Sall S, Serpantié G, Chotte J.L, Hien V., 2006. Chemical and microbial properties of semi-arid tropical soils of short-turn fallows in Burkina Faso, West Africa. *Biology and Fertility of Soils*. 43, 313-320.

Bray R.H, Kurtz L.T., 1945. Determination of total, organic, and available forms of phosphorus in soils. *Soil Science*59, 39-45.

Bunasols. 1990. Manuel pour l'évaluation des terres. Document technique n°6. Ouagadougou, 181 p.

Coulibaly, K., Vall, E., Autfray, P., Nacro, H.B. et Sedogo, M.P. 2012. Effets de la culture permanente coton-maïs sur l'évolution d'indicateurs de fertilité des sols de l'Ouest du Burkina Faso. *International Journal of Biological and Chemical Sciences*, 6, 1069–1080.

DGESS, 2015. Bilan de la campagne,2016/2017. Rapport d'Activité Agricole.

Dommergues Y. &Mangenot F. (1970). Ecologie microbienne du sol. Paris, France, Masson. 796 pages.

De Shorn E. B., Gregory A., Gouveia and Ravindra R., 2019.Organic Residues and Ammonium Effects on CO2 Emissions and Soil Quality Indicators in Limed Acid Tropical Soils. SoilSyst. 2019, 3, 16; doi:10.3390/soilsystems3010016

FMI.,2014. Burkina Faso: Questions Générales. Rapport No. 14/230 de juillet 2014.

Gerdemann, J.W., & Nicolson, T.H. 1963.Spores of mycorrhizal Endogone species extracted from soil by wet sieving and decanting. *Trans.Br. Mycol.Soc. 46, pp 235-244*.

Haro H., 2011.Effets d'inoculum de champignons mycorhiziensarbusculaires sur la productivité du *NiebéVignaunguiculata* (L.) Walp. Mémoire de DEA, Université de Ouagadougou. 63 p.

ITAB., 2002. Activités biologiques et fertilité des sols: Intérêts et limites des methodes analytiques disponibles, 25 p.

Koné S., 2015. Diagnostic des effets de la fertilisation sur les nuisibles et sur la fertilité des sols dans les zones cotonnières du Burkina Faso. Mémoire de fin de cycle d'ingénieur d'Agriculture, CAP/M, BF, 59p

Koulibaly, B., Dakuo, D., Ouattara, A., Traoré, O., Lompo, F., Zombré, P.N. et Kouamé, A.Y., 2015. Effets de l'association du compost et de la fumure minérale sur la productivité d'un système de culture à base de cotonnier et de maïs au Burkina Faso. *Tropicultura*, 33, 125–134.

Koulibaly, B., 2011. Caractérisation de l'acidification des sols et gestion de la fertilité des agrosystèmes cotonniers au Burkina Faso. Ouagadougou, Université de Ouagadougou, thèse de doctorat en Sciences appliquées, spécialité agro-pédologie, 155 p.

Lompo D.J.P., 2007. Impact des résidus de pesticides sur les microorganismes des sols dans les agrosystèmes cotonniers du Burkina Faso. Mémoire de Diplôme d'Etudes Approfondies, Université Polytechnique de Bobo-Dioulasso/ Institut du Développement Rural, Burkina Faso. 46 p.

MECV., 2011. Programme d'action national d'adaptation à la variabilité et aux changements climatiques. Rapport d'activité. Burkina Faso, 76 p.

Ouattara B., 2009. Analyse-diagnostic du statut organique et de l'état structural des sols des agro-systèmes cotonniers de l'Ouest du Burkina Faso (terroir de Bondoukui). Thèse de doctorat d'Etat, Université Polytechnique de Bobo-Dioulasso, 186 p.

Plassard C., Robin A., Le Cadre E., Marsden C., Trap J., Herrmann L., Waithaisong K., Lesueur D., Blanchart E., Chapuis-Lardy L., Hinsinger P., 2015. Améliorer la biodisponibilité du phosphore : comment valoriser les compétences des plantes et les mécanismes biologiques du sol ? Innovations Agronomiques 43 (2015), 115-138

Rousk J., Philip C., Brookes and Bååth E., 2009. Contrasting soil pH effects on fungal and bacterial growth suggest functional redundancy in carbon mineralization.Applied and Environmental Microbiology, Mar. 2009, p. 1589–1596. Vol. 75, No. 6

Schwartz, A., 2006. Les grands repères de l'histoire de la culture du coton au Burkina Faso. Communication à l'atelier de clôture du projet GERICO, Bobo-Dioulasso, 8-9.

Traoré O., Somé N.A., Traoré K., Somda K., 2007 a. Effect of land use change on some important soil properties in cotton-based farming system in Burkina Faso. Int. J. Biol. Chem. Sci. 1(1), pp. 7-14.tropicales. Maisonneuve et Larose, Paris, France, 502 p. *Univ. Natio. de Côte d'Ivoire,* 249 p.

Walinga I, van der Lee J.J, Houba V.J.G, van Vark, W, Novozamsky I., 1995. Plant Analysis Manual. Kluwer Academic, Dordrecht, the Netherlands. p 11.

Walkley A, Black R.N., 1934. An examination of the method Dedtjareff for determining soil organic matter and to proposed modification of the chromic acid titration method. *Soil Science*, 37: 29-38.

Wu J, Joergensen R.G, Pom B.R, Chaussod P.C, Brookes., 1990. Measurement of soil microbial biomass C by fumigation - extraction - An automated procedure. *SoilBiol. Biochem*; 22: 1167-1169.

Zombré N.P., 2006. Variation de l'activité biologique dans les zipella (sols nus) en zone subsahélienne du Burkina Faso et impact de la technique du zaï (techniques des poquets). *Biotechnol. Agron. Soc. Environ*., 10 (2) : 139 – 148.

****