International Journal of Environment and Climate Change

Volume 14, Issue 12, Page 55-63, 2024; Article no.IJECC.127152
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Changes in the Soil Chemical Properties due to *Mangifera indica* (Mango) Biomass on the Soil in Western Burkina Faso

BAZONGO Pascal. [a*], TRAORÉ Karim [b], SENOU Farida Raïnatou [b] and TRAORÉ Ouola [b]

[a] *Yembila Abdoulaye TOGUYENI University (University of Fada N'Gourma), High Institute for Sustainable Development, BP: 54. Fada N'Gourma, Burkina Faso.*
[b] *Institute of Environment and Agricultural Research (INERA), Department of Natural Resources Management and Production System, Farako-Ba. Soil Water Plant Laboratory, BP 910. Bobo-Dioulasso, Burkina Faso.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/ijecc/2024/v14i124606

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/127152

Original Research Article

Received: 16/09/2024
Accepted: 18/11/2024
Published: 30/11/2024

ABSTRACT

A study on the effect of *Mangifera indica* biomass on soil chemical properties was conducted at INERA in Farako-Ba in western Burkina Faso. To do this, samples were taken from *Mangifera indica* orchards and a compost pile based on biomass from mango leaves was set up. The main objective of the study was to contribute to a better understanding of the effects of *Mangifera indica* biomass on soil chemical properties. The experimental system set up consisted of three blocks,

**Corresponding author: E-mail: bazpasco@yahoo.fr;*

Cite as: *Pascal., BAZONGO, TRAORÉ Karim, SENOU Farida Raïnatou, and TRAORÉ Ouola. 2024. "Changes in the Soil Chemical Properties Due to Mangifera Indica (Mango) Biomass on the Soil in Western Burkina Faso". International Journal of Environment and Climate Change 14 (12):55-63. https://doi.org/10.9734/ijecc/2024/v14i124606.*

each block being subdivided into two sub-plots. From the results obtained, we can conclude that the contents of soil organic matter, nitrogen, phosphorus and potassium are higher in the soil under the crown of *Mangifera indica* compared to the soil outside the crown, which is a definite advantage in the fight against the degradation of agricultural land. In the *Mangifera indica* orchard, the soil pH drops from 6.58 under the crown to 5.64 for the control soil. The organic C content obtained in the soil taken from under the crown decreases by 11% at 3 m from the crown and by 13% for the soil taken from 6 m from the crown. The same trend is observed with the nitrogen content. These litters are characterized by high levels of phosphorus (1195mg.kg-1) and potassium (1317 mg.kg-1). The results obtained have raised questions about the status of the soil under cultivation of *Magnifiera indica*, and therefore require further investigations.

Keywords: Biomass; Mangifera indica; chemical properties; composting; Burkina Faso.

1. INTRODUCTION

Burkina Faso is a landlocked Sahelian country in the heart of West Africa with an area of 274,200 km² and a population of more than 20,505,155 inhabitants (INSD, 2019). The economy is largely based on agriculture and livestock, as these sectors employ 90% of the working population and contribute 39% to the gross domestic product (Belemvire et al., 2008). However, these areas remain dependent on unfavourable pedoclimatic conditions (MAAH, 2020). Indeed, a study conducted by SP/CONEDD (2006) estimates that about 11% of the country's land is considered to be highly degraded and 34% to be moderately degraded. This land degradation has many negative ecological and socio-economic consequences. Agro-forestry parks have been recommended as one of the solutions to provide a response to the decline in soil fertility in a context of climate change. Traoré's (2019) works have shown that soils are more fertile in nutrients under the crown of Vitellaria paradoxa than outside the crown. In the South Sudanian zone and more precisely in the province of Houet, this system is very widespread and the dominant species are Vitellaria paradoxa, Parkia biglobosa, Anacardium occidentale, Magnifiera indica etc. Also, several means are used for the recovery and fertilization of degraded soils. Among these means is composting, the manufacture of organic fertilizers with biomass from certain trees, shrubs and herbaceous plants. Speaking of the biomass of certain trees, Burkina Faso, with its dry tropical climate with the alternation of a short rainy season and a long dry season, presents favourable conditions for the planting of mango trees, which produce biomass (Nacro et al., 2009). According to statistics from the MAH (2011), the sector has a production potential of more than 300,000 tonnes per year with more than 2.2 million plants spread over an area of 12,250 ha (APEX, 2021). The country accounts for between 11 and 18% of West African mango production. Mangoes are a very important economic, social and climatic issue in Burkina Faso. Indeed, the mango sector generates more than 15 billion euros in turnover per year. In addition, it contributes to food security in productive and vegetative cover areas limiting the effects of climate change (APEX, 2021). However, few studies have focused on estimating the plant's ability to produce biomass and the use of this biomass specifically the leaves in composting (in the manufacture of compost), an important factor for the fight against degradation and for the fertilization of agricultural land. It could allow the recovery and protection of soils in order to fight against food insecurity. However, knowledge related to the effect of *Magnifiera indica* biomass on soils remains limited. Given its ability to adapt to the soil of western Burkina Faso, can mango biomass positively influence soil chemistry? It is to answer this question that this study was initiated. The overall objective of this study is to contribute to a better understanding of the effects of *Magnifiera indica* biomass on soil chemical properties.

2. MATERIALS AND METHODS

2.1 Presentation of the Study Site

The study was conducted at the INERA / Farako-Bâ Research Station. The geographical coordinates are 11°06' north latitude; 4°20' west longitude. The climate is South Sudanese (Guinko, 1984) characterized by the alternation of two (2) seasons, namely a rainy season that lasts 5 to 6 months with rainfall varying between 900 mm and 1000 mm. According to Fontès & Guinko (1995), southwestern Burkina Faso is classified in the South Sudanian phytogeographical zone. There are grassy savannahs, wooded savannahs and open forests. The soils of the study site are of the tropical ferruginous type, poor in clay (7.8%) and organic matter (0.8%), which explains their low cation exchange capacity (CEC). These soils have a sandy silty texture, slightly acidic and low in nitrogen and phosphorus (Bado, 2002).

2.2 Materials

Equipment and method for composting mango biomass. The basic material for making the compost consisted of mango biomass, mainly mango leaves, and cow dung.

2.3 Methods

The composting technique is concerned with the parameters influencing the biomass decomposition process such as temperature, the amount of useful water, and the evolution of chemical quality and to evaluate the quality and nutritive quantity of the compost. The biomass and cow dung have not undergone any treatment before composting. The composting technique used in this work is inspired by the heap composting method described in the technical sheet. It is a process of aerobic degradation of organic waste. To build the pile, the organic inputs are placed in a layer in a metal mould measuring 2 m long, 1.5 m wide and 1.20 m high. The piles are made up of 80% biomass and 20% cow dung forming a compost unit. The pile receives the water, the quantity of which depends on the absorption capacity of the biomass to moisten it. The pile consists of four (04) layers. The height varies between 40 cm and 70 cm. After the layers have risen, the pile is watered until the water flows underneath and then covered with black tarpaulin. The turnaround was done every two weeks.

2.3.1 Chemical parameters of compost

The determination of chemical parameters and the determination of minerals were carried out at the Plane-Water-Soil laboratory of the Farako-Bâ research station located in the GRN/SP program for the analyses. To do this, a 0.5 kg sample was taken from different locations on the biomass heaps before composting, from the composts during turning. The pH was on the shredded grounds. To determine the pH, 10g of the shredded material was put in a beaker with 50 ml of distilled water. To determine the carbon, a previously dried sample is calcined in the oven at 550°C for 5 hours. The organic matter content is obtained by weighing the mass of the dry sample (65°C) and the mass of the calcined sample. The determination of the chemical elements was made by the method of mineralization, distillation and determination according to the KJELDAHL method for nitrogen (N). The internal temperatures of the compost piles were measured the day after the piles were assembled, using a BioTemp precision mercury thermometer, graduated from -10 to +250°C.

The plant material consisted of mango plants. The experimental set-up is made of Fisher blocks with three blocks. Each block was subdivided into two (2) sub-plots corresponding to the 2 treatments: one (01) mango plantation plot and one (1) fallow plot used as a control. In each sub-plot, three (03) plots of 400 m2 (20 m x 20 m) were demarcated for data collection. The factor studied was the effect of mango biomass on soil chemical properties relative to the distance from the mango crown soil sampling point.

Soil samples were taken at a depth of 0-20 cm with a 7 mm diameter auger. This depth, 0-20 cm, generally corresponds to the layer of soil worked in tropical areas (Feller, 1979; 1995). According to Girard et al. (2011), the majority of above-ground biomass that falls to the ground is concentrated at this depth. Hien et al. (2002) report that variations in carbon storage according to management methods are mainly observed in the A horizon. In each block, three mango plants corresponding to a replicate were randomly selected and soil samples were taken at three distinct points: D0 = under the crown, D1 = 3 m of the crown and D2 = 6 m of the mango crown. A total of nine (9) composite samples were collected for each plantation, including three control samples. For the three plantations, 30 soil samples were taken.

2.3.2 Determination of soil chemical parameters

The chemical elements analysed are: water pH, assimilable phosphorus, organic carbon (C), total nitrogen (N) and total potassium (K). The pH of the water was measured from a suspension of soil in water by the electrometric method with a glass electrode pH meter (AFNOR, 1999). The organic carbon content is based on the method of Walkley & Black (1934), which consists of cold oxidation of carbon with potassium dichromate (K2Cr207) 1N in the presence of concentrated sulphuric acid (H2SO4). Total nitrogen was determined by the modified Kjeldahl method (Hillebrand et al., 1953). Assimilable phosphorus The Bray-1 method (Bray & Kurtz, 1945) was used for the determination of available phosphorus. The available potassium was determined by taking 2.5 g of 2 mm sieved soil to which 25 ml of the available K extraction solution was added. After stirring for 1 h, the filtrate was measured with a flame spectrophotometer.

2.3.3 Statistical analysis

The data collected was entered into the Microsoft Office Excel 2013 spreadsheet. These data were then subjected to an analysis of variance with the Genstat edition12 version 2009 software. The treatment averages were separated by the Newman-Keuls test at the 5% probability level.

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Effect of mango biomass on soil chemical properties

Variation in pH, organic carbon and nitrogen: The results presented in Table 1 show significant differences between the soil of the control plot and that of the Mangifera indica plots with regard to pH, nitrogen and carbon contents, regardless of the distance from the soil. A drop in pH is observed as you move away from the hedge. The pH of the soil under Mangifera indica is higher compared to that of the control soil. In the Mangifera indica orchard, the soil pH drops from 6.58 under the crown to 5.64 for the control soil. The same trend can be observed for the level of organic carbon. There is a decrease in soil organic carbon as you move away from the Mangifera indica crown. Compared to the organic C value obtained in the soil taken from under the crown, this decrease is 11% for soil taken 3 m from the crown and 13% for soil taken 6 m from the crown in Mangifera indica. The same trend is observed with the nitrogen content. A decrease in the nitrogen level of the soil is observed as you move away from the crown. The decrease in the soil nitrogen rate compared to the nitrogen rate observed under a 0 m crown is 04% for soil taken at 3 m from the crown, and 14% for soil taken at 6 m from the crown.

Variation in C/N ratio, Assimilable P and Available Potassium: Table 2 shows the variation in the C/N ratio, assimilable P and available potassium. The C/N ratio of soils taken at 0 m, 3 m and 6 m from the crown of Mangifera indica shrubs are not significantly different. The C/N ratio of the control soil is equivalent to that of the soils collected under the crown of Mangifera indica. On the other hand, significant variations were observed between the levels of available phosphorus and available potassium in the soils from Mangifera indica orchards. Compared to the assimilable P content observed in the soil taken from under the crown, the content of the soil taken from 2 m from the crown increases by 12% and falls by 1% in the soil taken from 6 m. On the other hand, the available potassium content of the soil decreases by 4% for soil sampled both at 3 m and at 6 m from the crown.

Table 1. Variation in pH, organic C and nitrogen

Distances	pH	Carbon (%)	Nitrogen (%)
Control	5.64a±0.17	0.47b±0.05	0.05c±0.00
0m	6.95b±0.08	1.22a±0.16	0.12a±0.02
3m	6.76b±0.15	0.98ab±0.28	0.11b±0.02
6m	6.58b±0.14	0.94ab±0.21	0.09a±0.04
Probability	***0.018***	***0.042***	***0.045***
Signification	***S***	**S**	***S***

Legend: *Numbers with the same letters in the same column are not significantly different at the 5% probability threshold., S= significant*

Table 2. Variation in the ratio of C/N, assimilable P and available potassium

Distances	C/N	Phosphorus	Potassium
Control	9.89b±1.08	11.21b±1.10	60.84b±10.55
0m	10.82a±1.02	12.04b±1.38	231.70a±4.75
3m	10.78a±0.43	15.30a±2.02	215.41a±23.20
6m	10.54a±0.68	11.92b±1.99	215.95a±72.17
Probability	***0.140***	***0.029***	***0.018***
Signification	NS	S	S

Legend: *Numbers with the same letters in the same column are not significantly different at the 5% probability threshold., S = significant, HS = highly significant, NS: not significant*

3.1.2 Evaluation of the nutrient quantity of compost based on Mangifera indica biomass

pH Variation: In general, the results presented in Fig. 1 do not show any significant difference between the different stages of compost turning with regard to pH. Nevertheless, there is an increase in the pH value as the compost matures. The pH values vary between 7.77 and 7.93. The highest pH content was observed at the M4 compost turning stage (7.93). On the other hand, the lowest value was recorded at the M1 compost turning stage (7.77).

Variation in C/N ratio: Fig. 2 shows the evolution of the C/N ratios. There is a decrease in soil C/N ratios at each stage of compost turning. The C/N ratios obtained are between 27.62 and 29.90. The C/N ratio from the M4 compost is higher at 29.90. On the other hand, the lowest C/N ratio comes from the M2 compost with 27.6.

Evolution of Organic C, Nitrogen, Phosphorus and Potassium: The results in Table 3 show some chemical characteristics of *Mangifera indica* compost. For the nitrogen content, the analysis reveals no significant difference between the compost taken at the different stages of turning. Regardless of the stage of turning, there are significant differences between the carbon, phosphorus and total potassium contents of *Mangifera indica* compost. There are high levels of carbon in the compost both in the first stage of M1Compost and in the fourth M1Compost turning with an average of 34%. Compost from *Mangifera indica* orchards contains high concentrations of P and K. These litters are characterized by high levels of phosphorus (1195mg.kg-1) and potassium (1317 mg.kg-1).

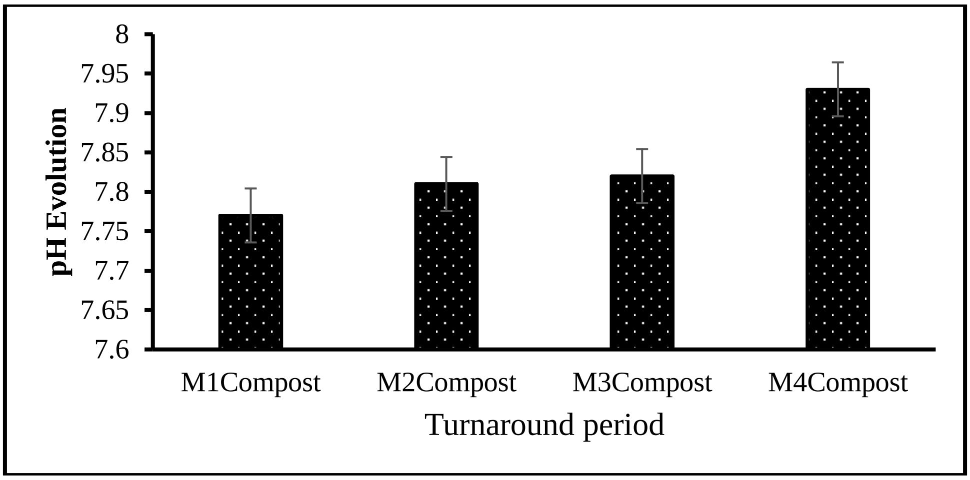

Fig. 1. pH variation

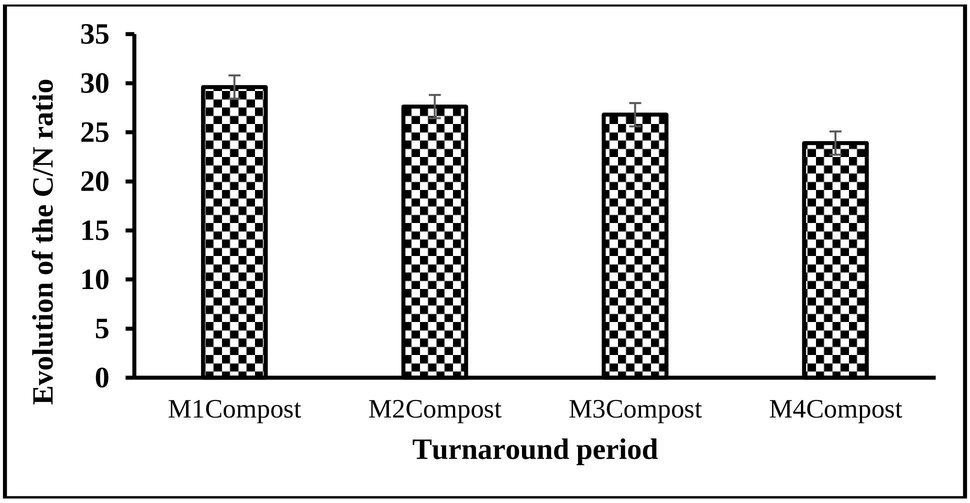

Fig. 2. Variation du rapport C/N

Table 3. Change in C, N, P, K) as a function of reversal periods

Turnaround periods	Carbon (%)	Nitrogen (%)	Phosphorus (mg/kg)	Potassium (mg/kg)
$M1_{Compost}$	34.92a±0.45	1.18±0.05	1195a±89.53	1317a±26.01
$M2_{Compost}$	31.30b±0.45	1.14±0.04	1028b±84.19	1226b±83.25
$M3_{Compost}$	33.84a±0.23	1.14±0.08	1109a±104.44	1220b±95.97
$M4_{Compost}$	34.34a±1.52	1.16±0.11	1074b±80.02	1252b±15.58
Probability	***0.003***	***0.872***	***0.019***	***0.045***
Signification	***S***	***NS***	***S***	***S***

Legend: *Numbers with the same letters in the same column are not significantly different at the 5% probability threshold. S= significant, NS: not significant*

3.2 Discussion

3.2.1 Effect of mango biomass on soil chemical properties

The statistical analysis of the results revealed that the pH of the soil is higher under the crown than outside the crown in the three plots of plantations studied. This could be due to the accumulation of certain nutrients in the epigeal plant biomass and litter or the chemical nature of the soil. These results are in agreement with those of Jonsson (1995) who reported higher pH values under *Vitellaria paradoxa* than in the control plots located in open field in Saponé in Burkina Faso. In addition, the increase in pH could be explained by the improvement in soil organic matter from Mangifera indica litter. Lompo (2009) indicates that the increase in fulvic acid contents following inputs of organic matter leads to complexation of cations, including the Al^{3+} ion, and thus to an increase in pH. Also, the decomposition of this organic matter produces many cations (Ca^{2+}, Mg^{2+}, k^{+}, etc.) that neutralize the acidity of the soil. The organic carbon content of the soils collected under the mango crown is higher than that of the control soils. This could be justified by a high accumulation of the leaf biomass of Mangifera indica. Indeed, the root exudates of old plants could be a source of organic carbon on soils (Gnoumou et al., 2017). The nitrogen content of the soils under Mangifera indica crowns is low, as well as for the control soils. This could be explained by the fact that this plant uses nutrients, especially nitrogen, for its growth but also by the leaching of nutrients. These results are similar to the conclusions of the study carried out in Torokoro and Tin by Bazongo et al. (2015) who found a degradation of nitrogen under *Jatropha curcas* L. aged 6 years. The C/N ratio characterizes the dynamics of organic matter transformation. According to Soltner (2003), C/N ratios make it possible to monitor the evolution of organic matter, to assess the richness of the humus in nitrogen and to account for mineralization. The C/N ratio is high under crown than at the control ground level. This could be explained by an accumulation of organic C in the soil under the mango crown. There could be the influence of moisture under the crown and the reduction in temperature influencing the mineralization of the litter. The same observation was made in the Sudanian zone of Burkina Faso by Bazongo (2017). The same observation was made by Ouédraogo et al. (2022). According to BUNASOLS (National Soil Bureau), the C/N ratio rate is between 10 and 15. The results of potassium contents are higher under the mango tree crown than in the control soil. The high concentration of K available under mango crowns could be explained by the fall in its biomass, which attributes fertility to decomposition. This could be related to *Mangifera indica's* ability to accumulate K in its leaves.

3.2.2 Evaluation of the nutrient quantity of compost based on *Mangifera indica* biomass

The pH water values show a change in pH at the beginning of composting. These results confirm those of Steger et al. (2006), who recorded an increase in pH from 5.4 to 8.5 after 57 weeks of composting green waste mixed with household waste and concluded that the composting process is always accompanied by an alkalinization phenomenon. Francou (2003) and Bokobana et al. (2017) justified this increase in pH from the second week onwards according to the composition of the base substrate by the neutralization of acidic substances by the ammonia thus generated during the degradation of amines and the decomposition of organic acids. Albrecht (2007) suggests that the pH of mature composts varies between 7 and 9, while that of immature composts is acidic. On the basis of these results, the composts studied would be considered mature. The C/N ratio of compost varies between 23.62 and 29.90. These results confirm those of Soudi (2001) who showed that if the C/N ratio is too high, the time required for degradation becomes longer and if it is low, most of the nitrogen is lost as ammonia through volatilization. Compost from the Mangifera indica orchard is characterized by high levels of carbon, nitrogen, phosphorus and potassium. This could be related to the plant's ability to accumulate C, N, P, and K in their leaves. Work conducted by Leye et al. (2009) has shown that the mycorrhization of *Jatropha curcas* L. with fungi of the genus Glomus, improves the level of mineral elements (C, N, P, K) in the leaves of the plant. These results confirm those of Larsen & McCartney (2000) who showed that microorganisms in compost require nutrients.

4. CONCLUSION

The objective of our study was to contribute to a better understanding of the effects of Mangifera indica biomass. L on the chemical properties of soils. From the results obtained, we can conclude that the contents of soil organic matter, nitrogen, phosphorus and potassium are higher in the soil under the crown of Mangifera indica compared to the soil outside the crown, which is a definite advantage in the fight against the degradation of agricultural land. Nutrient levels are higher in Mangifera indica orchards compared to fallow (controls). *Magnifiera indica* leaves could help improve land management and combat land degradation and deforestation. From our results, it appears that compost from *Magnifiera indica* is a source of nutrients for the soil. Compost made from the biomass of *Magnifiera indica* improves the chemical properties of the soil. The results obtained have raised questions about the status of the soil under cultivation of *Magnifiera indica*, and therefore require further investigations.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

AFNOR. (1999). *Determination of pH* (French Standardization Association) NF ISO103 90, AFNOR Soil Quality, Paris. 339–348 p.

Albrecht, R. (2007). *Co-composting of sewage sludge and green waste: New methodology for monitoring organic matter transformations* (Thesis for the award of the degree of Doctor in Environmental Biosciences).

APEX. (2021). *Sector sheet: Mango of Burkina Faso*. 3–5 p.

Bado, B. V. (2002). *Role of legumes on the fertility of tropical ferruginous soils in the Guinean and Sudanese zones of Burkina Faso* (Doctoral thesis, Université Laval, Quebec). 145 p.

Bazongo, P. (2017). *Study of the contribution of Jatropha curcas L. to ecosystem functions and the productivity of associated crops in farms in the South Sudanese zone of Burkina Faso* (Doctoral thesis, Single doctorate in Rural Development). Polytechnic University of Bobo-Dioulasso, Burkina Faso. 137 p.

Bazongo, P., Traore, K., Sanon, K. B., Yelemou, B., Traore, O., Nacro, B. H., Bacye, B., Belem, M., Traore, M., Hien, V., & Sedego, M. P. (2015). Impact of *Jatropha* plantation on soil chemical and biological properties in the South Sudanian region in Burkina Faso. *International Journal of Biological and Chemical Sciences, 9*(4), 762–778.

Belemvire, A., Maiga, A., Sawadogo, H., & Savadogo, M. (2008). *Assessment of the socio-economic biophysical impacts of investments in natural resource management actions in the north of the central plateau of Burkina Faso* (Summary report: Sahel Burkina Faso study). 8 p.

Bokobana, A., Toundou, O., Kolani, L., Amouzouvi, K. A. A., Koledzi, E., Tozo, K., & Gado, T. (2017). Treatment of household waste by co-composting with the legume *Cassia occidentalis L.* and some local adjuvants to improve the agronomic quality of composts. *Waste Sciences and Techniques*, No. 73, 13 p.

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

Feller, C. (1979). A method of granulometric fractionation of organic matter in soils: Application to tropical soils with coarse textures, very poor in humus. *Cahiers ORSTOM, Série Pédologie, 17*, 339–346.

Feller, C. (1995). *Organic matter in tropical clay soils 1:1. Search for functional compartments. A granulometric approach*. TDM Collection, Vol. 144. ORSTOM, Paris, France. 393 p.

Fontès, J., & Guinko, S. (1995). *Vegetation and land use map of Burkina Faso*. In French Ministry of Cooperation: Explanatory note. Toulouse, France. 67 p.

Francou, C. (2003). *Stabilization of organic matter during composting of urban waste: Influence of the nature of the waste and the composting process - Search for relevant indicators* (Doctoral thesis). National Institute of Agronomy Paris-Grignon. 289 p.

Girard, M.-C., Walter, C., Rémy, J.-C., Berthelin, J., & Morel, J.-L. (2011). *Soils and environment* (2nd ed.). Malakoff: Dunod.

Gnoumou, X. N., Yameogo, J. T., Traore, M., Bazongo, G., & Bazongo, P. (2017). Adaptation to climate change in sub-Saharan Africa: Impact of zaï and improved seeds on sorghum yield in the villages of Loaga and Sika (Bam Province), Burkina Faso. *International Journal of Innovation and Applied Studies, 19*(1), 166–174. https://doi.org/10.1016/j.gloplacha.2007.09.005

Guinko, S. (1984). *Vegetation of Upper Volta* (Doctoral thesis, State, in Natural Sciences). University of Bordeaux III, France. 364 p.

Hien, E., Ganry, F., Hien, V., & Olivier, R. (2002). Carbon dynamics in a savannah soil of South-West Burkina under the effect of cultivation and cultural practices. In Jamin, J. Y., Seiny, B. L., & Floret, C. (Eds.), *African savannas: Changing spaces, actors facing new challenges* (Proceedings of the conference, May 2002, Garoua, Cameroon). 11 p.

Hillebrand, W. F., Lundell, G. E. F., Bright, H. A., & Hoffman, J. I. (1953). *Applied inorganic analysis* (2nd ed.). John Wiley & Sons, Inc. 1034 p.

INSD. (2019). *Statistical yearbook*. Burkina Faso. 355 p.

Jonsson, K. (1995). *Agroforestry in dry savanna areas in Africa: Interactions between trees, soils, and crops* (Ph.D. dissertation, Swedish University of Agricultural Science, Umea, Sweden). 92 p.

Larsen, K. L., & McCartney, D. M. (2000). Effect of C/N ratio on microbial activity and N retention: Bench-scale study using pulp and paper biosolids. *Compost Science & Utilization, 8*(2), 147–159.

Leye, E. H. M., Ndiaye, M., Ndiaye, F., Diallo, B., Sarr, A. S., Diouf, M., & Diop, T. (2009). Effect of mycorrhization on the growth and development of *Jatropha curcas L. Tropicultura, 12*(2), 269–278.

Lompo, F. (2009). *Induced effects of fertility management methods on phosphorus status and solubilization of natural phosphates in two acid soils of Burkina* (State doctoral thesis). University of Cocody, Abidjan, Ivory Coast. 219 p. + annexes.

MAAH. (2020). *Agricultural statistics yearbook*. Burkina Faso. 437 p.

MAH. (2011). *General report of the rainfed module: Central office of the general census of agriculture*. Phase 2, RGA 2008. Burkina Faso. 322 p.

Nacro, S., Nadie, A. K., Zongo, A., Kabre, E., Kabore, C., Ouedraogo, S., & Guira, M. (2009). *Participatory training manual on organic mango production through school orchards in Burkina Faso*. 9 p.

Ouédraogo, A., Kaboré, F., & Kaboré, O. (2022). Perception of soil fertility and adaptation strategies of agricultural producers in Samandéni (Burkina Faso). *International Journal of Biological and Chemical Sciences, 16*(4), 1536–1553. https://doi.org/10.4314/ijbcs.v16i4.15

Soltner, D. (2003). *The basics of crop production: Volume I: The soil and its improvement* (23rd ed.). Agricultural Sciences and Techniques Collection, Paris. 472 p.

Soudi, B. (2001). *Composting household waste and compost recovery: Case of small and medium-sized municipalities in Morocco* (Proceedings edition). 102 p.

SP/CONEDD. (2006). *Assessment of vulnerability and adaptation to climate change in Burkina Faso: Water resources component*. 44 p.

Steger, M. F., Frazier, P., Oishi, S., & Kaler, M. (2006). The Meaning of Life Questionnaire: Assessing the presence of and search for meaning in life. *Journal of Counseling Psychology, 53*, 80–93.

Traoré, S. A. (2019). *Study on the economics of land degradation in Burkina Faso: Neutrality gains and economic gains generated by sustainable soil and land management in three provinces of Burkina*

Faso. ELD, GIZ, German Cooperation. Burkina Faso. 76 p.

Walkley, A., & Black, R. N. (1934). An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Science, 37*, 29–38.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/127152