

IMPACT OF LEGUMINOUS ON THE STRUCTURE AND REPOPULATION OF SOIL ENGINEERS

ABSTRACT

In the Korhogo department, it is almost impossible to practice fallowing. The aim of this study is to determine how the *Cajanus* fallow impact the soil the biological and physical soil fertility. Macrofauna and soil samples were taken in different cropping systems (*Cajan* + maize, *Cajanus* + groundnut, *Cajanus* + maize + groundnut, *Cajanus*) and compared with the control (soil that did not contain any legume) The results show that the cropping system based on *Cajanus cajan* favoured the repopulation of the soil with *Termicidae*, *Lumbricidae* and *Formicidae* to the control. These values varied from 90 to 340 individuals/m² for *Lumbricidae* in the system based on *Cajanus*. compared to the control values lower than 5 individuals/m². The comparison of the population density according to the type of tillage also shows that flat plowing systems stimulate increase *Lumbricidae* populations more than ridged soils (325; 275; 125 individuals/m² on plowing. against 230; 100 individuals /m² on ridge) respectively on *Cajanus*+ groundnut, *Cajanus* + groundnut+ maize and pure *Cajanus*. On the other hand, the intercropping which increased the number of *Lumbricidae*, *Termicidae* and *Formicidae*, whatever the type of tillage, are, respectively, *Cajanus* + groundnut, *Cajanus* + groundnut + maize, *Cajanus* + maize and pure *Cajanus*.The introduction of *Cajanus* into intercropping systems leads to an improvement in the physical and biological fertility of the soil

Keyword: *Cajanus*, density, intercropping systems, macrofauna, Tillage

1 INTRODUCTION

Population growth increases demand for food, while land pressure increases the need for arable land [1]. With a population of 440,926 inhabitants, Korhogo is the third city in Côte d'Ivoire with a high population density [2]. As a result, fallowing as means of soil restoration became difficult in this region. However, in the past, fallowing was the only real means used by farmers to naturally restore their soil fertility [3 ;4]. Today, farmers claim that the soils are became poor and use mineral fertilizers to face to soil fertility declining [5]. Fallowing was possible because the farmers were practicing itinerant agriculture which allowed the soil to replenish itself through biological processes. Indeed, in the 1960s, Ivory Coast had sufficient arable land fallows could last for decades before being cultivated [5]. Today, the cultivable lands are insufficient compared to demand. This strong pressure on the soil has led to a profound modification of the farming system which has changed from itinerant agriculture to fixed agriculture, particularly in the dense area of Korhogo [6]. Furthermore, the sedentarization of agriculture requires the adoption of cropping systems adapted to climatic conditions which activate the biological processes of restoring soil fertility. Several research studies indicate the benefits of using leguminous. In particular, the improvement of soil fertility by the symbiotic fixation of nitrogen from the air [7; 8; 9 ;10 ;11], to produce quality fodder for animals and improve the financial income of farmers [12 ;13 ;14]. But, with the strong land and demographic pressures observed in recent years in the northern part of Côte d'Ivoire, the use of soil restoration techniques with leguminous becomes problematic. This study was initiated to study the effect of intercropping systems based on *Cajanus cajan* (shrub legume) on the density of Termicidae, Lumbricidae and Formicidae population and its effect on the soil structure.

2. MATERIAL AND METHODS

2-1. Study site

The study site was an agricultural farm with 7 ha of surface area approximately, located at Korhogo (northern Côte d'Ivoire) (09°55'28.2" N and 5°34'38 W). the most representative soil of the site are Cambisols at the top of the slope and at the mid-slope and, Gleysols in the lower slopes [15]. Within this study area, a permanent plot of 1 ha was created whose soils have a high load of coarse elements, with a sandy or sandy-clay texture in the superficial horizons (0-20 cm). The climate of the Korhogo region is Sudano-Sahelian of transitional tropical type with a rainy season (April-October) and a dry season (November-March), with annual precipitation is 1350 mm [5].

2.2. Methods

2.2.1. Effect of cultural practices on macrofauna

Macrofauna samples were taken in the different cropping systems (Cajan associated with different maize and groundnut harvest residues) and compared to a control. Also, to assess the effect of the *Cajanus* population on the structure of the soil, different clods of earth were taken from different types of fallow and compared.

The non-specific method of Anderson and Ingram [16] was used to determine the abundance of soil macrofauna. Sampling was done following the TSBF (Tropical Soil Biology and Fertility) method. The targeted community was Termicidae, Lumbricidae and Formicidae. This method consists of isolating a monolith measuring 25 x 25 x 30 cm. The fauna was harvested manually after dividing the monolith into 3 strata depending on the depths (0 - 10 cm, 10 - 20 cm, 20 - 30 cm). This stratification according to these depths is linked to the fact that these macrofaunas colonize more of these horizons. In fact, by following a 7 meter-long transect, five monoliths or TSBF points were positioned per plot. Thus, 280 TSBF points were positioned along 56 transects. The fauna sampled was in 90% alcohol and identified by *Indval* method [17]. Thus, TSBF points measuring 25 cm x 25 cm side were positioned. Then using a spade manually graduated, and after the contours have been demarcated with a chisel (Figure 1a), the spade is sunk to a depth of 10 cm and a soil sample with a volume of 6250 cm³ is taken and placed on a support to serve as excavations (Figure 1b, 1c and 1d). This same process was repeated three times in order to reach thirty (30) cm depth (Figure 8i). The different individuals observed after excavation were sampled and counted by stratum (Figure 1f, 1g, and 1h).



Fig. 1. Steps for sampling soil macrofauna

a: 2 years fallow; b: soil under continuous cultivation; c: 11 months improved fallow of *Cajanus cajan*; d: soil structure of 2 years natural fallow, e: soil structure in continuous cultivation; f: soil structure from improved fallow *Cajanus cajan*; g: *Termicidae* colony; h: *Formicidae* colony; i: TSBF point of depth 30 cm,

3. RESULTS AND DISCUSSION

3.1. RESULTS

3.1.1. Effect of the association of legumes on the population density of soil macrofauna

Figures 2, 3 and 4 present, respectively, *Termicidae*, *Lumbricidae* and *Formicidae* population density taken in the different cultural practices. The analysis of variance reveals a highly significant difference between the populations of *Lumbricidae*, *Termicidae*, and *Formicidae*, resulting from the different cultural associations compared to the Control ($P < 0.05$). However, the test of the smallest significant difference LSD, at the threshold of 0.05, did not show any difference between the populations of macroinvertebrates from the groundnut + maize associations, pure groundnut culture and the control. Furthermore, differences were observed between the invertebrate populations from *Cajanus*-based systems (pure *Cajanus*; *Cajanus* + groundnut; *Cajanus* + maize and *Cajanus* + groundnut + maize) and the control. The greatest numbers of macroinvertebrates were obtained in cultural associations based on *Cajanus*. These

values varied from 90 to 340 individuals/m² for Lumbricidae at the level of Cajanus-based systems compared to values lower than 5 individuals/m² for the control.

The number of individuals obtained on the plowing system were 325; 275; 125 individuals/m² against 230; 145; 100 individuals /m² on billon respectively in Cajanus + groundnut, Cajanus + groundnut + maize and pure Cajanus associations. It was observed that the cultural associations which increased Lumbricidae, Termicidae and Formicidae population, whatever the type of tillage, were, respectively, the associations Cajanus + groundnut, Cajanus + groundnut + maize, Cajanus + maize then pure Cajanus. Termicidae were the most abundant macroinvertebrate species in all associations based Cajanus with an average oscillating between 60 and 70%, followed by Lumbricidae

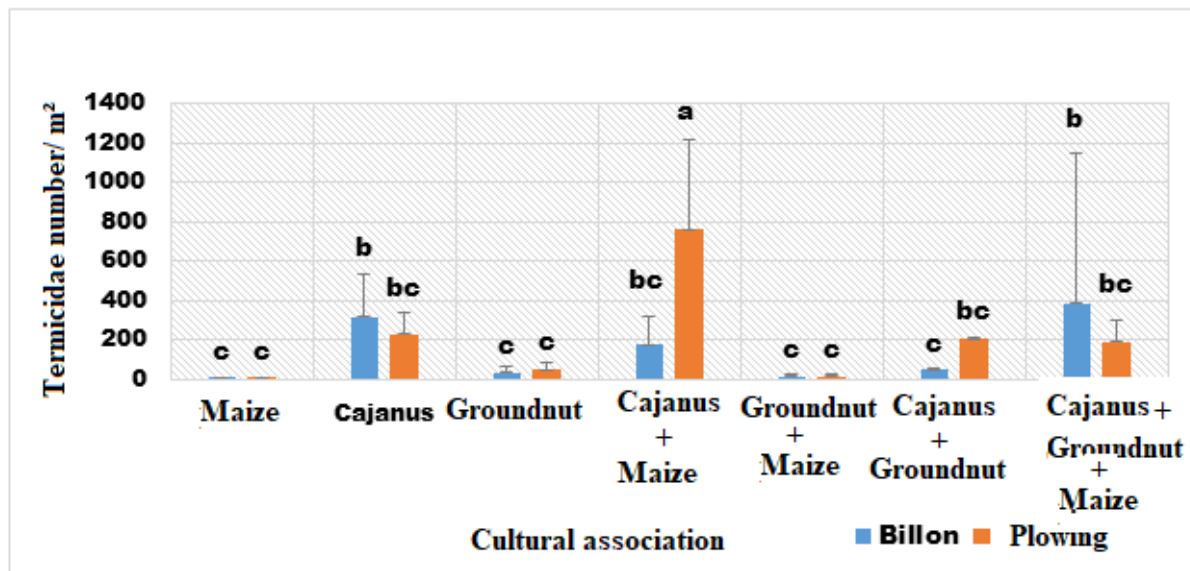


Fig. 2. Termicidae population density according to cultural associations

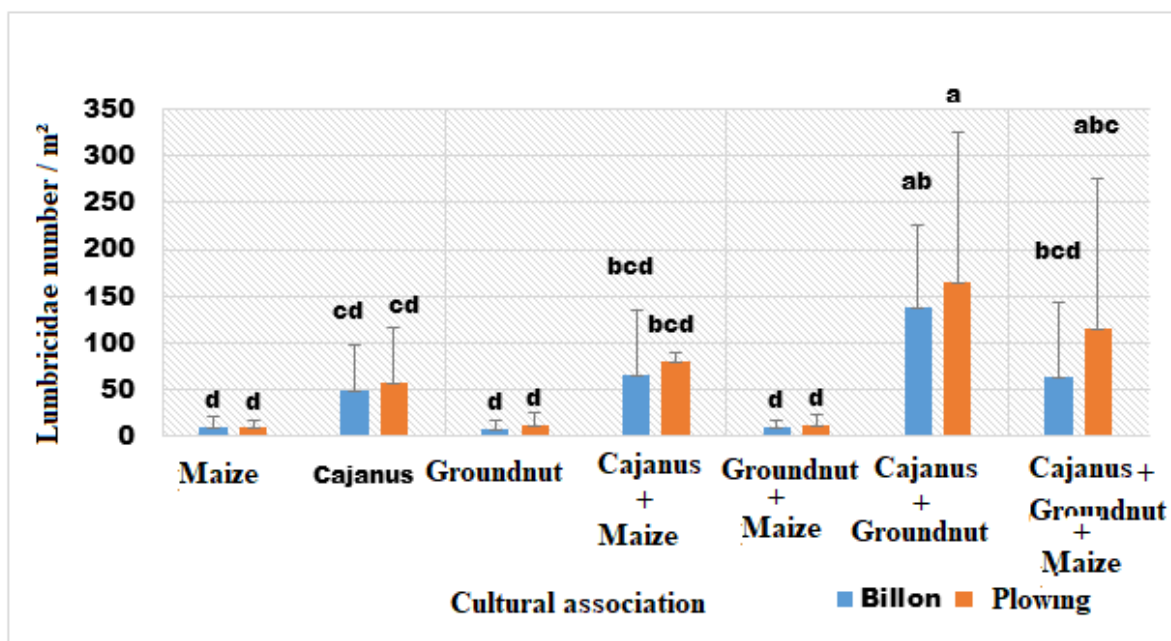


Fig. 3. Lumbricidae population density according to the plowing type and cultural association

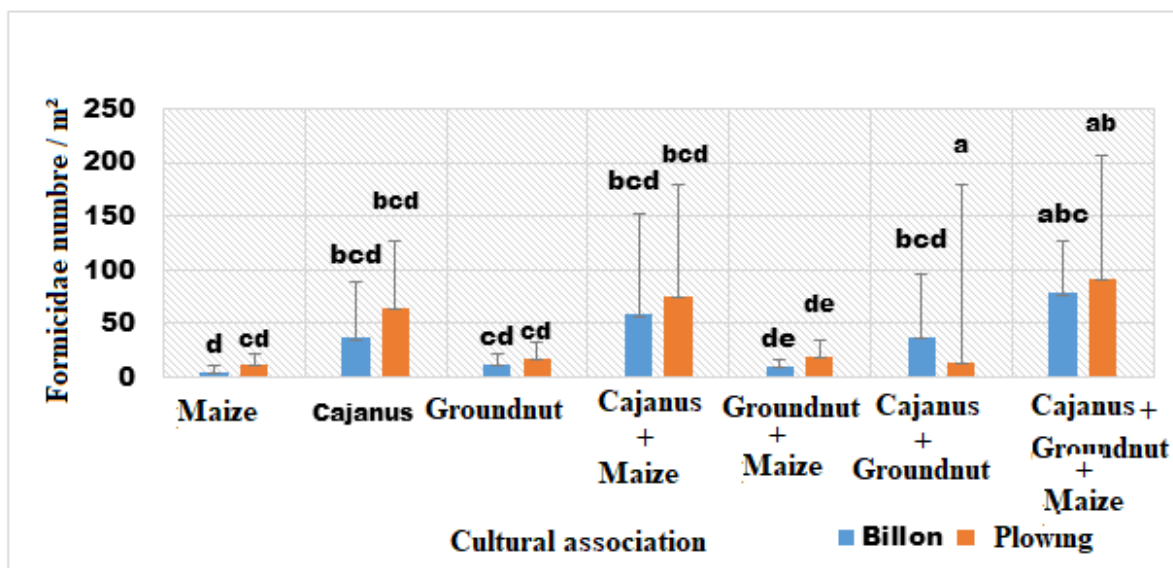


Fig. 4. Formicidae population density according to cultural association

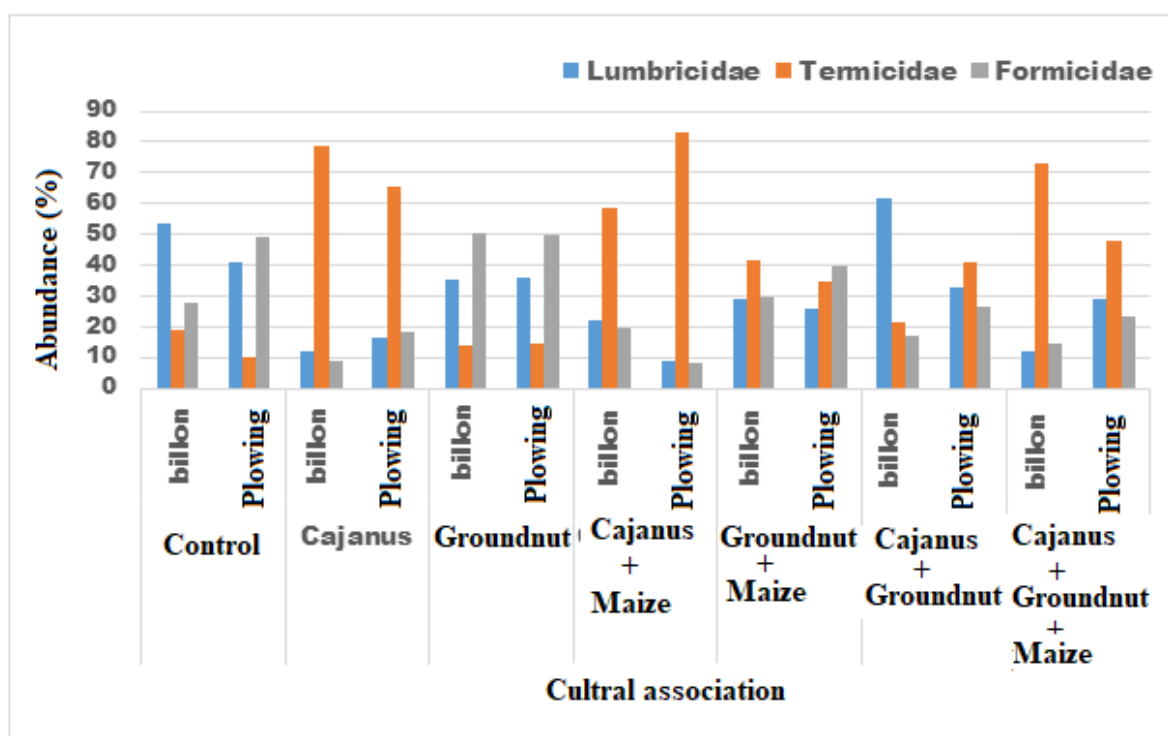


Fig. 5. Abundance of macrofauna population according cultural association

3.1.2. Effect of different fallows on soil structure

The textures observed in the different cropping systems are presented as follows. The particle structure under continuous cultivation (Figure 6 b), the polyhedral structure in the 2 years old improved fallows (Figure 6 d) and the lumpy structure in the improved fallow of 11 months old Cajanus (Figure 6c).



Fig. 6. Types of fallows and associated soil structures

a: fallow for 2 years; b: soil under continuous cultivation; c: Improved fallow of *Cajanus cajan* aged 11 months; d: soil structure of natural fallow for 2 years, e: soil structure in continuous cultivation; f: soil structure from improved fallow *Cajanus cajan*)

3.2. DISCUSSION

The supply of exogenous organic matter, represented in this study by combinations of leguminous – maize and different mulches, stimulated the growth of populations of *Termicidae*, *Lumbricidae* and *Formicidae* compared to controls (without leguminous and without mulch). These results are similar to those observed in many previous works [18; 19]. The presence of *Termicidae* in the soil modifies the environment by the rise of particles from the subsoil to the surface [20; 19]. Thus, a soil with a particle structure on the surface and rich in clay in the depth horizons can have its texture modified on the surface, under the action of *Termicidae*, like the soils of *Termicidae* mounds which have a higher clay content than the rest of the soil.

surrounding ground. The agricultural practices implemented had a positive impact on the enrichment of clay soils in the context of this study, which would be linked, in part, to the action of termites through their ability to bring clay up from the depths to the surface.

Indeed, the ground cover with straw constitutes a food source for Termitidae which attracts them to the surface of the soil. By consuming the straw, the Termitidae will begin the process of decomposition of organic matter. Which would place them at the forefront in the decomposition of organic matter even before the action of soil microorganisms. The richness of the cellulose straw from cultural associations would attract Termitidae. In fact, the cellulose content of the straw amounts to 46% compared to 8% for manure [21]. This high density of the Termitidae population could therefore be explained by the abundance of food (cellulose) contained in the straw. they occupy an important place in tropical ecosystems; They participate in numerous ecosystem services such as the decomposition of organic matter and the evolution of soil structure [22; 23].

As for the population of Lumbricidae, the systems stimulated more their to the controls. This enrichment of soils with Lumbricidae would partly result from the humidity produced by cultural practices, and their permanent enrichment with organic matter through the constant deposition of dead leaves. Indeed, the study revealed an enrichment of soils with organic matter under the agricultural practices implemented. Furthermore, the evolution of the quantity of organic matter under different cultural systems would more attract Lumbricidae [19]. Lumbricidae, thanks to their bioturbative activity, ingest organic matter to form more stable aggregates with the clay fraction, under different populations of *Cajanus cajan* [24; 25]. The evolution of soil structure under different cultivation practices is an illustration of this. The presence of these organisms in an environment accelerates the restoration of the soil and the establishment of a functional ecosystem. In fact, they constitute a source of food for many predators, or even the recycling of organic waste; likewise, they improve primary production and provide numerous ecosystem services such as improving soil fertility at surface horizon level [26; 27].

4. Conclusion

The study showed the highlight changes induced by *Cajanus Cajan* on the repopulation of Termitidae, Formicidae and Lumbricidae in the soils of Kafigué. The greatest numbers of macrofauna were observed in plowed soil. As for the structure of the soil, the *Cajanus* favoured the structuring of the soil. It appears from this study that leguminous associations accelerated soil repopulation by Termitidae, Lumbricidae and Formicidae.

References

- 1 MOUSSA K M. Impact of land dynamics in the fight against land insecurity and women's poverty in the Tahoua region of Niger (PhD thesis). University of Liège-Gembloux Agro-Bio Tech, Belgium. 2014; 249 p. French.
- 2 General Population and Housing Census (RGPH). Number of Ivorians and non-Ivorians by sex by sub-prefecture Overall results. 2021; 12 p
- 3 Koulibaly B, Traoré O, Dakuo D, Zombré P N, Bondé D. Effects of crop residue management on yields and crop balances of a cotton-maize-sorghum rotation in Burkina Faso. *Tropicultura*. 2010; 28(3):184-189. French.
- 4 N'Guessan KA., Kouakou KE, Alui KA, Yao-kouamé A. Peasant strategies and practices for sustainable soil fertility management in the Korhogo department in northern Côte d'Ivoire. *Afrique SCIENCE*. 2019;15(4): 245 - 258. French.
- 5 Kouakou KE. Resilient crop practices in the face of soil degradation in the dense area of Korhogo in northern Côte d'Ivoire. Single thesis, Félix Houphouët Boigny University. 2021;144p. French.

- 6 Bigot. Y. Cash corn in the far north of Côte d'Ivoire: production opportunities, marketing problems. Communication at the seminar: Food crops, a strategic element of Ivorian agricultural development, organized by CIRES, Abidjan, multigr. 1982;15 p. French.
- 7 Barro A, Sangaré M, Coulibaly K, Koutou M, Diallo MA. Study of the modalities of maize/cowpea association in the villages of Koumbia and Gombêlêdougou in the cotton-growing area of western Burkina Faso. International Symposium on Science and Technology. Natural Sciences and Agronomy. 2016; 2:151-163. French.
- 8 Coulibaly K, Gomgnimbou APK, Traoré, M. Effects of maize-legume associations on maize (*Zea mays* L.) yield and the fertility of a tropical ferruginous soil in western Burkina Faso. *Afrique SCIENCE*.2017;13(6):226-235. French
- 9 Gbakatchetche H, Sanogo S, Camara M, Bonet A, Keli JZ Effect of mulching with angola pea residues (*Cajanus cajan* L.) on the yield of rainfed rice (*Oryza sativa*) in the forest zone of Côte d'Ivoire. *African Agronomy*. 2010;22(2):131-137. French
- 10 Kouassi NJ, Tonessia DC, Seu JG, Soko DF, Ayolie K.. Influence of the staggered sowing of maize (*Zea mays* L.) and voandzou (*Vigna subterranea* (L.) Verdc.) on their production in the savannah zone of Côte d'Ivoire. *J. Appl. Biosci*. 2016;102:9745–9755. French
- 11 Myriam H.. Use of perennial pigeon pea (*Cajanus cajan*) in agroforestry systems for better soil conservation in Lalouère (4th communal section of St Marc, Haiti) under peanut (*Arachis hypogea*) cultivation. 2017;84 p. French
- 12 Bambara D, Zoundi JS, Tiendrébéogo JP. Cereal/legume association and agriculture-livestock integration in the Sudano-Sahelian zone. *Cahiers Agricultures*. 2008;17(3):297–301. English
- 13 Bloukounon GYA, Saïdou A, Babatoundé S, Balogoun I, Arakogne S, Kassavi E, Adegbi A. Effects of NPK manures and small ruminant droppings on the productivity and fodder value of maize and peanuts in southern Benin. *Annales des Sciences Agronomiques*. 2015; 19 (2): 213-238. English
- 14 Ido EJ. Study of the development cycle, biomass production, fodder quality and effect on soil fertility of some fodder legumes. End of cycle thesis, 2016; 54p. English
- 15 WRB, USS Working Group, (2014). World reference base for soil resource 2014. International soil classification system for naming soils and creating legends for soil maps, FAO Rome Update 2015, 106 p. English
- 16 Anderson JM, Ingram JSI. Tropical Soil Biology and Fertility. A handbook of methods. CAB International, 1993; 221 p. English
- 17 Dufrene M, Legendre P. (1997). Species Assemblages and Indicator Species: The Need for a Flexible Asymmetrical Approach. *Ecological Monographs*. Ecology society of America. 67(3):345-366.
- 18 Mboukou-Kimbatsa IMC. Soil macroinvertebrates under different agricultural systems in Congo: A special case of two traditional agricultural systems (slash and burn and slash-and-burn) in the Niari Valley. Doctoral thesis, Pierre and Marie Curie University, Paris, France. 1997; 163 p. English
- 19 Traoré M, Lompo F, Ayuke F, Ouattara B, Ouattara K., Sedogo M.). Influence of agricultural practices on soil macrofauna: case of straw and manure burial. *International Journal of Biological and Chemical Sciences*. 2012; 6(4):1761-1773. French
- 20 Zaremski A, Fouquet D, Louppe, D. Termites in the world. Editions Quae. 2009. 93p.

- 21 Hien E. Carbon dynamics in a ferric Acrisol of Central West Burkina: Influence of cultural practices on the stock and quality of organic matter (Doctoral dissertation, École nationale supérieure agronomique (Montpellier) 2004; 138 P. French
- 22 Rakotomanga D, Blanchart E, RabaryB, Randriamanantsoa R, Razafindrakoto M. AutfrayP. (Diversity of soil macrofaunas cultivés sur les Hautes-Terres de Madagascar. BASE, 2016 ; 20(4): 495-507. French
- 23 Verma, Sandeep Kumar, Mukesh Kumar, Vivek, PK. Singh SP, Singh, Bhim Singh, Aparna Verma, and Shalini Roy. Effect of Foliar Application of Nano Fertilizers on Soil Properties of Rice (*Oryza Sativa* L.) Under Western UP, India”. International Journal of Plant & Soil Science. 2024; 36 (9):973-79. <https://doi.org/10.9734/ijpss/2024/v36i95048>
- 24 Ratsiatosika, H, O. 2018 Vers de terre et services ecosystemiques en riziculture pluviale a madagascar. connaissances des processus et propositions d’innovations agricoles Thèse Unique, 193P. French
- 25 Frouz J, Prach K, Pižl V, Háněl L, StarýJ, Tajovský K, Řehounková K. Interactions between soil development, vegetation and soil fauna during spontaneous succession in post mining sites. European journal of soil biology. 2008; 44(1): 109-121.
- 26 Boyer S, Wratten SD. The potential of earthworms to restore ecosystem services after opencast mining. A review, Basic and applied ecology. 2010; 11: 19 -203.
- 27 Villeneuve, C. Étude des effets d'une invasion de vers de terre exotiques sur la dénitrification dans les sols d'érablières au Québec (Doctoral dissertation, Université de Sherbrooke). (2023). French