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Influence of Agricultural Inputs on Earthworms in kérou and Banikoara, Bénin

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Abstract:
The biological quality of soils in agriculture refers to the abundance, diversity and distribution of living organisms and their participation in soil biological activities. The present work is part of the ecotoxicological risk assessment of agricultural inputs on the earthworm community and therefore its biological quality. The work was carried out in three villages of the communes of Kérou and Banikoara in North Bénin.The methodology consisted of the enumeration of the earthworm community and the trace of elements in their flesh. Nine 1-m² plots were placed in each study field. In a second step, ecotoxicological analyzes were carried out on some earthworms taken from the different sites. After analyzing the collected data, it appears that the site 1 which is a cotton field receiving mineral and organic fertilizers has an abundance and a high ecological diversity of earthworms compared to sites 2 and 3 which receive only mineral inputs. In addition, ecotoxicological analyzes showed a high presence of nitrogen, phosphorus, potassium, nitrate and ammonium in the earthworms of sites 2 and 3 compared to site 1. It has therefore been proven in this study that the use of nitrogen fertilizer in the intense cotton crop disturbs the earthworm community.

Keywords: *Earthworm, soil quality, agricultural input, kérou, banikoara*

1. Introduction

Soil is considered as one of the most important reservoirs of biodiversity. Indeed, soil biodiversity is much higher than that observed above the soil surface (Heywood 1995). Moreover, beyond this quantitative aspect, it is now recognized that soil organisms play fundamental roles in the functioning of ecosystems, thereby making many ecosystem services (Lavelle & Spain 2001). They also participate directly or indirectly in a large number of processes such as the dynamics of organic matter (nutrient cycle), waste recycling, structure formation and maintenance, water transfer and retention of nutrients, water in soils, etc. But the abusive and uncontrolled use of fertilizers and photochemical products in agriculture, and in the almost total absence of monitoring and control structures on the use and side effects of pesticides and fertilizers on the soil poses a real monitoring problem for some soil organisms with significant roles. A large part of the compounds have influence on the soil and on the organisms they contain (Bliefert & Perraud 2001). The causes of soil pollution related to agricultural activity come mainly from the existence in the products used to fertilize or treat crops, various toxic compounds (Mazoyer 2002). Hence, it is necessary to use biological indicators to learn about the ecological status of soils. In this study, we used earthworms to assess the ecological status and the level of pollution of soils used in the cultivation of cotton in the communes of Banikoara and Kérou. Thus earthworms have significant regulations on the physical properties, the dynamics of organic matter and plant growth and therefore constitute a potential resource of great interest to the sustainability of agriculture (Lavelle et al., 1999). They act on plant production that they improve through five processes (Scheu 2003; Brown et al., 2004): (i) increasing the rate of mineralization of organic matter, thus making nutrients available to plant, (ii) pest control and plant pests, (iii) modification of soil structure, (iv) stimulation of symbiont activities, and (v) production of plant growth by stimulating microbiological activities. These organisms can, therefore, be considered as a natural resource of agronomic interest that can be used to increase agricultural production in a sustainable manner (Lee 1985; Lavelle et al., 2004).

2. Materials and Methods

2.1. Study Area

The study was conducted in three villages in the communes of Banikoara and Kérou. The climate is Sudano-Guinean and Sudano-Sahelian in some places. The climate of the study area is characterized by a rainy season, from mid-April to mid-October, and a dry season from mid-October to mid-April. It belongs to an agro-ecological zone characterized by an average rainfall of 1,000 mm of water per year and stagnant in recent years to 900 mm of water per year. The continuing decline in rainfall is a sign of increased sahelelinization following the widespread monoculture of cotton. The average temperature varies between 25 ° C in August and 31 ° C in April (Figure 1).

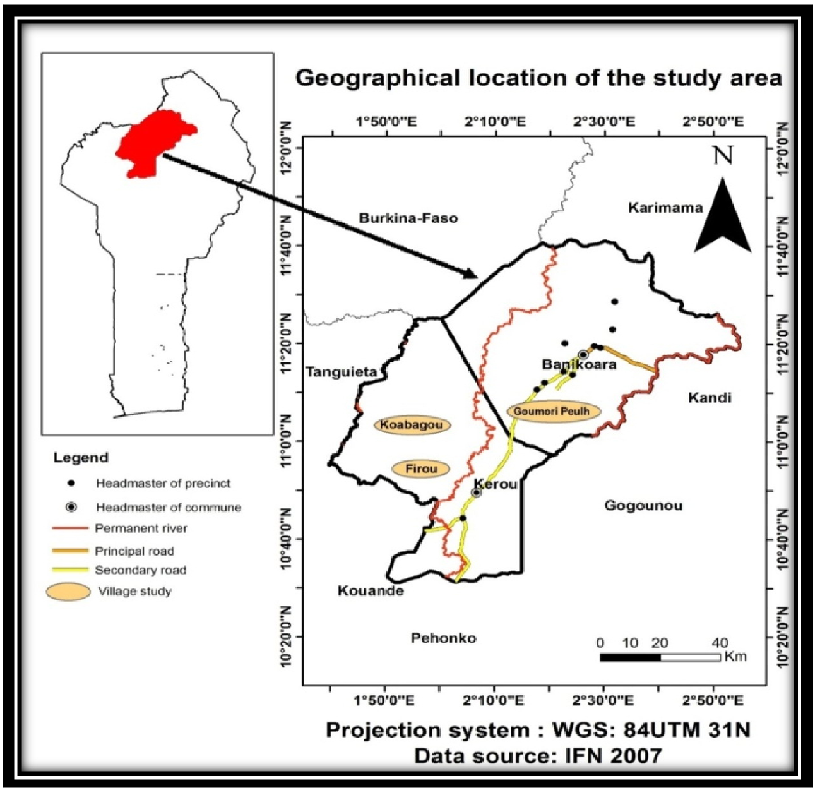

Figure 1: Geographical Location of Study Area

2.2. Experimentation

The trial was conducted at three sites, two sites in the commune of Kérou and one in the commune of Banikoara. The three different sites are fields that have received different treatments. The plots of 1m² were installed in the fields of different villages hosting the test. The earthworm community was counted in the different sites. The earthworms were collected according to the method of Bouché (1972) and the norm ISO 23611-1 adapted to the agropedoclimatic context (Cluzeau et al., 1994 and 2012): Three doses of formalin solution (3 x 10 L concentrations 0.25%, 0.25%, 0.4%) were applied on 1m², 15 minutes apart. Earthworms, adopting an escape behavior in response to the stinging properties of formalin, are taken at the soil surface. A superficial scraping (1 cm of depth) is then carried out to recover the unharvested individuals. This step was completed by a physical sample: a block of soil (0.25 x 0.25 x 0.20 m deep) is extracted within 1m² and sorted manually. Then, earthworms taken from the various sites were analyzed to determine the presence or absence of mineral elements in their flesh. Specifically, we have:

- Make an inventory on a plot of 1 m² and compare the numbers of earthworms enumerated in the different sites.
- Evaluated the presence or not and the dose of nitrate, ammonium, total nitrogen, total phosphorus and total potassium in the flesh of the earthworms used after their exposures in different treated cotton fields

Table 1 summarizes the characteristics of the different study sites.

	Site 1	**Site 2**	**Site 3**
Speculation	Cotton	Cotton	Cotton
Treatments	Urea : 50kg/ha NPK : 200kg/ha Compost : 2T/ha	Urea : 50kg/ha NPK : 200kg/ha	Urea : 50kg/ha NPK : 200kg/ha
Cultural antecedents	2 years of intensive cotton production with the same treatments	3 years of intensive cotton production	2 years of intensive cotton production

Table 1: Characteristics of Different Sites

2.3. Interpretation of Data

Some indices were used to interpret the data.

Shannon-Wiener diversity index (H ') and Pioulou's equitability index (J')

These indices are used in this case to measure not only the number of functional groups but also the distribution of individuals within functional groups

Shannon-Wiener diversity index (H '):

Its formula is.

$$\boxed{H' = -\sum pi}$$

pi = proportional abundance or percentage of importance of the species: pi = ni/N;
ni =number of individuals of a species in the sample:

After application, we have: **H'1=0,43; H'2=0,39; H'3=0,35**

Pioulou's equitability index (J')

Où H'max=log S (S= total number of species)

$$\boxed{J' = H'/H'max}$$

After application, we have: **J'1=0,91; J'2=0,82; J'3=0,74**

3. Results

3.1. Mineralogical Composition of the Different Sites of Experimentation (G/Kg Of Sol)

Table 2 presents the mineralogical composition of the sites 1, 2 and 3.

	Site 1	**Site 2**	**Site 3**
Total azote	18.5	28.4	23
Total Phosphorus	7	9	9.6
Total Potassium	0.13	0.489	0.42
NHO_3^-	4.27	12.08	11
NH_4^+	2.9	6.31	5.57
% of organic matter	2.7%	0.78%	0.56%

Table 2: Mineralogical Composition of Different Experimentation Sites

3.2. Assessment of the Abundance of Earthworms in the Different Sites

The enumeration of earthworms at the three sites shows a high abundance in Site 1 compared to Sites 2 and 3 where the number of earthworms per m² is relatively low. In fact, the average number of earthworm is 11, 3.44 and 1.22 per m² respectively in site 1, 2 and 3 (Figure 2 and 3).

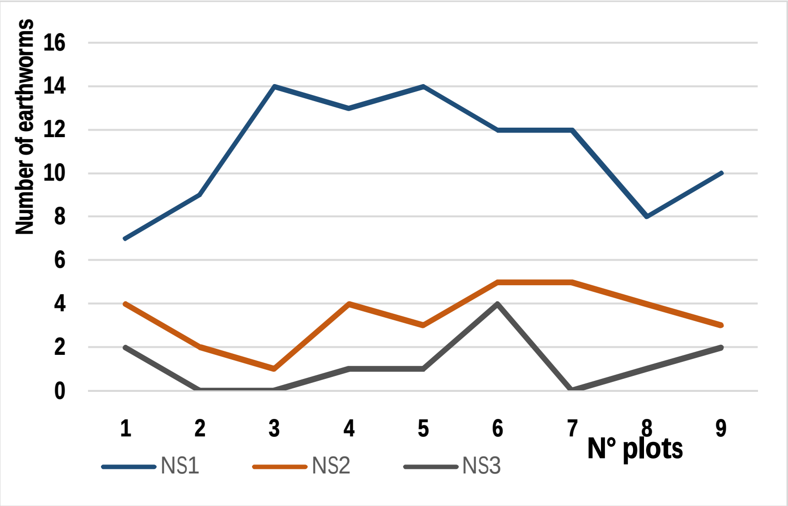

Figure 2: Evolution of the Number of Earthworms According To the Site

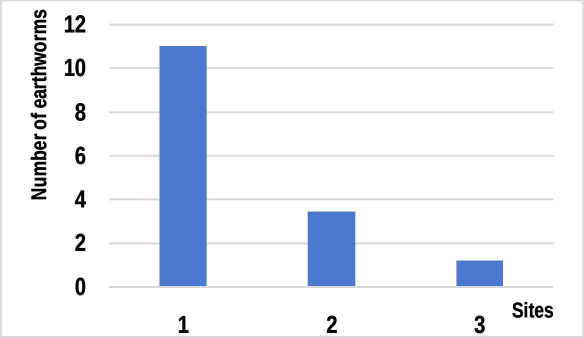

Figure 3: Average Number of Earthworms per Site

The low abundance of earthworms in sites 2 and 3 may be due to the mineralogical composition of the soil, especially its low percentage of organic matter. The site 1 regularly receiving compost is favorable to biological activities and therefore to the development of earthworms because of the organic matter that is abundant there. The site 3 presents the average number of the lowest earthworms in view of its cultural antecedent and its composition also. The three years of intensive cotton cultivation with mineral fertilizer alone have therefore directly influenced the development of earthworms.

3.3. Evaluation of the Functional Groups of Earthworms Present In the Different Sites

Figures 4 and 5 show respectively the different functional groups of earthworms enumerated in the different experimental sites and the percentage of their contribution to the total counted number.The enumeration at the three sites yielded varying proportions of functional groups from one site to another.Indeed, Epigeic, species of small size and dark color (red and brown) and endogenic species of variable size between 0 and 20 cm and very slightly colored and pigmented (gray, pink) are found in three experiment sites with notably substantially equal proportions. Anecic species, large species and color ranging from red to brown with commonly required color gradients of the head to the tail very necessary in the fragmentation of dead organic matter and very responsive to changes in temperature and humidity are totally absent in the site 3.From the analysis of the indices of diversity and equitability, it appears that the sites 1 and 2 have the highest specific richness and only the site 1 has a highest index of equitability in view of the relative importance of the different functional groups. Overall, the different indices of equitability are less than 0.5. The three sites therefore have low ecological diversity in earthworms. However, site 1 has an index approaching the average of ecological diversity because of the organic manure it receives

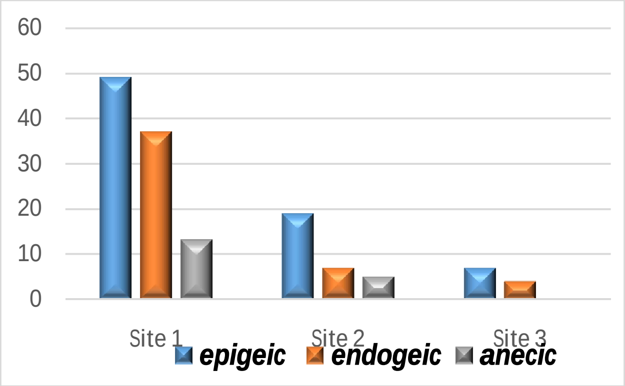

Figure 4: FunctionalGroups of Earthworms Counted Per Site

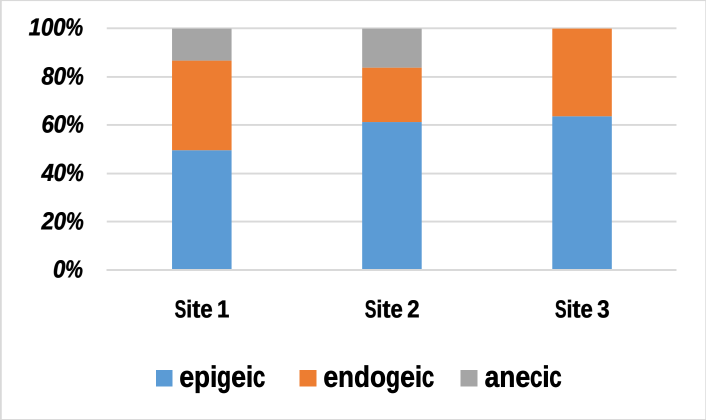

Figure 5: Contribution of Each Category of Earthworms to the Total Number Counted

3.4. Ecotoxicological Tests Performed On the Earthworms of the Three Sites

The analyzes carried out on the earthworms collected from the sites 1, 2 and 3 show a presence of the different minerals and chemical elements in the flesh of the majority of earthworms of the sites 2 and 3. The earthworms of these sites are heavily contaminated by the elements and minerals tested. This is justified by the treatment (integral mineral input) received by these two sites.Total Nitrogen, Nitrate and Phosphorus have virtually no trace in the flesh of earthworms at Site 1 (Table 3). Thus, we can best understand the difference in abundance in number and functional group from the community enumeration earthworms performed.

	Total azote	**Total Phosphorus**	**Total Potassium**	**Nitrate**	**Ammonium**
Site 1	- -	±	+	±	+
Site 2	+ +	+ +	+ +	+ +	+ +
Site 3	+ +	+ ±	+ +	+ +	+ +

Table 3: Result of Ecotoxicologic Analyses Carried Out On Earthworms of Three Sites
+ Means Presence. The Intensity of Presence of Dosed Element Is Expressed By the Number of Sign + By Spectrometer

4. Discussion

The different results as presented show an abundance of earthworms higher in the site sheltering a cotton field receiving organic elements and thus having a high percentage of organic matter. In fact, the use of integral and successive nitrogen mineral inputs in cotton fields has an impact on the earthworm community and compromises its participation in soil biological activities. In addition, the application of organic matter on cultivated soils mitigates the negative effects of soil acidification linked to a limitation of liming and the use of mineral fertilization. According to Cluzeau et al., (1994), contributions of urban composts over 12 years, in an experimental vineyard of the Interprofessional Committee for champagne wines, lead to a 30 percent increase in the earthworm biomass, anecic in particular. A supply of organic matter then has consequences on the development of earthworm activities and therefore on porosity, water retention and microbial activities. Curry et al.,(2002) and Anderson et al., (1983) showed that slurry or manure additions rapidly increased worm populations. However, some manures may have adverse effects related to the presence of ammonia (Curry et al., 2002). Authors as Potter et al., (1985) or Hansen and Engelstad (1999) found, as in the present work, a decrease in the density and biomass of earthworms after a nitrogen supply that caused soil acidification. Braham and Mansour (2017) also showed the toxicity of a Decis pesticide with the active ingredient Deltamethrin on the earthworms *Aporrectodea caliginosa* in Algeria. In fact, the intensification of agricultural practices, as in the case of cotton fields in northern Benin, has led to a change in communities following a decline in abundance, biomass and earthworm richness (Paoletti et al., 1998; Curry et al., 2002). Edwards & Lofty (1972); Lee(1985); Pelosi et al., (2014) have shown that some practice as pesticide usage have had a significant impact on the environment. The present work and its methodology is therefore a reasonable approach to measure the ecotoxicological risks of contaminated soils and the impacts on soil biological activities.

5. Acknowledgements

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6. Conflict of interest

The authors declare that they have no conflict of interest.

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