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Research Article

Dynamic of soil macrofauna in organic cotton cropping under agroecological practices in the North Sudanese zone of Burkina Faso

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Abstract

Low application of organic matter on soils under cotton cultivation has a negative impact on soil macrofauna installation, a major component of soil fertility. Zaï, a soil fertility management practice, can be explored to improve soil macrofauna under organic cotton cultivation. The study's objective was to characterize the effects of zaï and ploughing on soil macrofauna in the North Sudanese zone of Burkina Faso. A completely randomized Fisher block design with seven treatments including L0 (ploughing without compost), L1 (ploughing+1 t/ha of compost), L5 (ploughing+5 t/ha of compost), Z1 (zaï+1 t/ha of compost), Z2.5 (zaï+2.5 t/ha of compost), Z3 (zaï+3 t/ha of compost), Z5 (zaï+5 t/ha of compost) was studied. Macrofauna sampling was carried out using the standard TSBF method. Results showed that macrofauna composition was dominated by Termitidae (66.3%), Formicidae (16.4%) and Octochaetidae (5.7%). Treatments L5 and Z5 showed the highest densities, with 29.1% and 28.2% of the population respectively. As for trophic groups, saprophagous represented 81.96%, compared with 7.71% geophagous, 5.69% phytophagous and 4.64% predatory. Treatment Z1 was favorable to the installation of beneficial groups (saprophagous, geophagous, predators) compared with treatments Z2.5, Z3, L1 and L0. The treatment Z1 can be vulgarized to improve the biological fertility of soils in this context of low availability of organic manure.

Keywords: *Soil macrofauna, organic cotton, compost, ploughing, zaï.*

Introduction

Cotton is the main cash crop in Burkina Faso (FAO, 2022). In recent years, cotton cultivation has been done by 283845 producers and contributed to over 4% of Gross Domestic Product (GDP) and around 14% of exportation products (MICA, 2023). Cotton production is based on intensive production systems that require the use of high amounts of chemical fertilizers and pesticides. These practices negatively affect animals and human health and the environment quality (Gomgnimbou, *et al.*, 2009). Previous studies clearly demonstrated that uncontrolled supplies of pesticides and mineral fertilizers greatly reduce the diversities and abundance of soil organisms and degrade soils if nothing is done (Gomgnimbou, *et al.*, 2009; Savadogo, *et al.*, 2017). In addition, some intensive farming practices such as regular ploughing tend to reduce the number and diversities of soil organisms by reducing soil organic matter (Traore, *et al.*, 2016). Among these soil organisms, macrofauna (termites, ants,

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earthworms, and other invertebrates) had a special place in this diversities of soil organisms (Traore, *et al.,* 2016). Indeed, macrofauna is a major component of maintaining and improving soil fertility in agrosystems through its key role in the biogeochemical cycle (Traore, 2012). They contribute to the vital function of regulating the dynamic of soil organic matter, carbon sequestration, and modification of the physical structure of the soil and increase the quantity and efficiency of nutrient uptake by plants (Ouedraogo, *et al.,* 2014 ; Ouedraogo, 2015 ; Savadogo, *et al.,* 2016 ; Sofo, *et al.,* 2020 ; Guebre, 2021).

Regarding these negative effects of conventional cotton cultivation promoting organic farming in cotton cultivation could be a sustainable alternative to reduce the abusive use of pesticides and chemical fertilizers and protect soil the diversities of macro-invertebrates. Organic cotton cultivation is farming practices that recommend the use of organic inputs (manure, compost, organic fertilizers and organic pesticides made of plant extracts). The system also requires the adoption of soil and water conservation strategies. These techniques have shown their effectiveness in improving soil fertility and crop yields (Ouedraogo, *et al.,* 2008 ; Noufe, *et al.,* 2018). Organic cotton is mostly produced by women on infertile soils, so due to financial issues it's difficult to mobilize the recommended rate of 5 t/ha of organic manure per year needed to improve cotton yield (Ouédouga, 2016). An average of 1 t/ha of organic manure is used to produce cotton in the organic system in Burkina Faso (Ouédouga, 2016). Due to this limit, it is necessary to promote effective and efficient techniques for managing water and organic manure such as the zai technique. The zaï consists of making holes very early in which organic manure is deposited and the seedlings are made after the first rains (Muchai, *et al.,* 2020). Zaï is an endogenous water and soil conservation technique used by small-scale producers in northern Burkina Faso to restore degraded soils to mitigate the effects of climate change (Yameogo, *et al.,* 2013 ; Dabre, *et al.,* 2023). It is generally accompanied by a localized application (poquet) of organic fertilizers (manure, compost, droppings, etc.) that allow reducing the amount of manure but above all about improving the soil's health in the specific areas where the manure is applied (Sawadogo, *et al.,* 2008). The local application of manure in the zaï hold could adequately respond to the preservation of soil organisms in cotton organic systems. Previous studies have shown that zaï is an effective way of improving physicochemical properties (Muchai, *et al.,* 2020 ; Barro and Koumbem, 2021) and soil biology (Dabre, *et al.,* 2016 ; Somda, *et al.,* 2022). Controlling changes in the diversities and abundance of soil macrofauna under zaï and ploughing practices in organic farming systems would help guide sustainable production options. Unfortunately, few studies have analyzed the effects of these different agricultural practices on the diversities and abundance of soil macrofauna in organic cotton production. The objective of this study is to characterize the impact of zaï and ploughing on soil macrofauna.

1. Material And Methods

1.1. Material

1.1.1. Description of Study Area

The present study was conducted in a farming environment over two cropping seasons (2021 and 2022) in the village of Tanvousse (12°20'26'' North latitude and 1°12'35'' West longitude) located in the Central Plateau region of Burkina Faso. The site is characterized by an eight-month dry season from October to May and a short wet season from June to September (Saba, *et al.,* 2017). Average annual rainfall over the last ten years has ranged between 694 mm and 855 mm isohyets (Beye, *et al.,* 2023). That demonstrated high spatio-temporal variability of rainfall. During the experiment period (2021 and 2022), cumulative rainfall was 927 and 874 mm with 52 and 49 days of rain respectively. The experimental soil is a Lixisol with low nutrient levels.

1.1.2. Plant Material

The plant material used was the variety of cotton FK64. It is a drought-tolerant variety adapted to the arid zone of Burkina Faso (CNS, 2014). The cycle from sowing to maturity is 150 days and its potential seed cotton yield is 2,6 t/ha (CNS, 2014).

1.1.3. Organic Fertilizer

The organic fertilizer used was compost from a heap composting process of cotton stem residues and manure as activators for 3 months, during which the heap was turned every two weeks until maturation. The chemical characteristics of compost used are shown in Table 1.

Table 1: Compost's chemical properties

Parameters	Value
pH	6,96
Total Carbon (%)	23
Total Nitrogen (%)	1,2
C/N	19
Total Phosphorus (g/kg)	3,4
Total Potassium (g/kg)	10.8

C-total : total carbon, N-total : total nitrogen, P-total : total phosphorus, K-total : total potassium.

1.1.4. Experimental Design

The experimental design is a completely randomized Fisher block with seven (07) treatments repeated four (04) times. It was installed in 2021 and 2022. Each elementary plot measured 10 m long by 5 m (surface area of 50 m²). In addition, each plot had seven rows with twenty-five (25) seedling pockets per row. The elementary plots and blocks were separated by a 2 m aisle. Treatments were defined as follows:

L0: Ploughing without compost ;
L1: Ploughing + spreading of 1 t/ha of compost (Farmer's practice) ;
L5: Ploughing + spreading of 5 t/ha of compost (Recommended practice) ;
Z1 : Zaï + 1 t/ha compost (32 g/zaï poquet) ;
Z2.5: Zaï + 2.5 t/ha of compost (80 g/zaï poquet) ;
Z3 : Zaï + 3 t/ha of compost (96 g/zaï poquet) ;
Z5: Zaï + 5 t/ha of compost (160 g/zaï poquet).

The application of 5 t/ha of compost represents the rate of compost recommended by agricultural research in Burkina Faso for organic cotton production (Ouedraogo, *et al.*, 2008). Applying 1 t/ha represents the average amount of organic amendment applied by farmers in organic cotton cultivation in Burkina Faso (Ouédouga, 2016).

For this study, zaï holes were 15 cm in diameter and 10-15 cm deeph. This dimension was used to reduce water stagnation in the root zone during heavy rain. The zai was hand digging using a pick on a crossed shelf prior to the actual installation of the rains. zai holes were 80 cm spaced between rows and 40 cm between poquet with a total density of 31250 holds/ha. At the beginning of each cropping season, for the conventional tillage (L1, L5), compost was uniformly applied at a dose of 1 and 5 t/ha, and then tilled by animal traction at depth of 20 cm. Compost was applied in zaï's poquet for the treatments (Z1, Z2.5, Z3, Z5) after the confection of zaï.

The cotton seedling was carried out by hand using a pick on a crossed shelf prior to the actual installation of the rains. Hole densities were 31250 holes/ha. Weed control was carried out by weeding as required, depending on weed densities. During the two years of experimentation, plant protection was provided by the biological insecticide E-CODAOLEO K from 30 to 70 after emergence at a dose of 2 l/ha, while H-N (neem oil) was applied from 80 to 110 after emergence at a rate of 5 l/ha for 200 l/ha of spray.

1.2. Methods

1.2.1. Soil macrofauna Sampling Method

The soil macrofauna was inventoried in the second year of the study in 2022 using the standard Tropical Soil Biology and Fertility (TSBF) method described by Anderson & Ingram, (1993). A metal block of 25 cm x 25 cm x 30 cm in size was quickly driven into the soil (Ayuke, *et al.*, 2009). Then a trench was dug to clear the soil to collect the monoliths (Ouedraogo, *et al.*, 2023). In each elementary plot, three monoliths were collected along the diagonal. In treatments with zaï, the monoliths were collected near the zaï holes. The inventory was carried out seventy (70) days after sowing (DAS), corresponding to the maximum flowering phase of the cotton plant. This is period when plant cover is complete and the soil macrofauna reaches its optimum development under cultivation. Sampling was carried out in the morning between 6 and 9 am.

1.2.2. Identification of Soil Macrofauna

Collected species were preserved in vials containing 70% alcohol and sent to the natural history laboratory of CNRST located in Ouagadougou (Burkina Faso) for identification. Soil macrofauna were identified and counted using a binocular and keys of identification (Traore, 2012). Identification keys were taken from several works by the following authors' : Bland and Jacques (1978), Delware and Aberlenc (1989), Staněk (1984) and Traore (2012). With the difficulties of identifying juvenile and larval stages, some groups have been identified down to the genus level.

1.2.3. Index Calculation Methods

The Shannon-Weaver Index (SI) and Piélou Equitability Index (IE) were calculated according to the formulae below:

The Shannon-Weaver Index (SI) is obtained using the formula
$SI = \sum_{i=1}^{s} pi * Log_2(pi)$,

- pi = ni/N
- ni : number of individuals of one species in the sample
- N : total number of individuals of all species in the sample

The Equitability Index (EI), was calculated according to the formula :
$EI = SI/log_2(\text{s})$.

- SI : Shannon's diversities index, and
- s: the total number of species in the stand.

1.2.4. Data Analysis

The means of soil macrofauna densities, Shannon-Weaver index and Piélou equitability index were calculated for each treatment using R software version 3.6.2 by averaging the results of the three (3) monoliths for each treatment. The Kruskal-Wallis and Mann-Whitney test for non-normality data, with a significant level of 5%, was used for multiple comparisons of the means of densities, Shannon-Weaver index and Piélou equitability index.

2. Results

2.1. Soil Macrofauna Composition

The composition of soil macrofauna in the seven treatments is displayed in Tables 2 and 3. In the seven treatments, the inventory showed a total of 1129 individuals. The soil macrofauna consists of nineteen (19) species of insects and two species of earthworms. Six orders and eight families are associated with these insects:

- order Isoptera and families Termitidae (*Microtermes upembae* (Harris, 1958)*; Odontotermes mukimbunginis* (Sjöstedt, 1924) *and Macrotermes sp*) ;
- order Hymenoptera and families Formicidae (*Pogonomyrmex sp, Monomorium pharaonis* (Linnaeus, 1758)*, Pachycondyla porcata* (Emery, 1897), *Camponotus vagus* (Scopoli, 1763) *and Pachycondyla analis* (Latreille, 1802)) ;
- order Coleoptera and families Carabidae (*Dyschirius globosus* (Herbst, 1784)), Staphylinidae (*Tachyporus hypnorum* (Fabricius, 1775)*, Philonthus marginatus* (Stroem, 1768)) and Scarabaeidae (*Scarabaeidae sp, Aphodius rufipes* (Linnaeus, 1758)) ;
- order Araneae and families Anyphaenidae (*Anyphaena sp); order Chilopodes and families Geophilidae (Geophilus flavus* (De Geer, 1778)) ;
- order Diplopodes and families Iulidae (*Iules sp*).

Two species of earthworm have been identified. These species belong to the order Haplotaxida, families Octochaetidae (*Dichogaster affinis* (Michaelsen, 1890)) and Acantthodrilidae (*Milsonia inermis* (Beddard 1894)).

The soil macrofauna is composed of 66.3% Termitidae, 16.4% Formicidae and 5.7% Octochaetidae. Only these three soil macrofauna families make up 88.4% of the macrofauna. The remainder of the population is composed of six families, including Carabidae, Staphylinidae, Scarabaeidae, Geophilidae, Lulidae and Anyphaenidae, and accounts for 11.6% of the total population (Tables 2 and 3).

2.2. Impact of Ploughing and zaï on the Number of Families and Soil Macrofauna Densitie

The results have shown that the highest number of families (eight families) was obtained with the zaï treatments combined with 1 and 2.5 t/ha of compost (Z1 and Z2.5), followed by the zaï treatment combined with 5 t/ha of compost (Z5) with (seven families). The zaï treatment combined with 3 t/ha of compost (Z3) and ploughing combined with 5 t/ha of compost (L5) which recorded six families. The lowest number of families (two families) was obtained with ploughing without compost (L0) (Tables 2 and 3).

Concerning soil macrofauna's densities, the highest number of individuals per m^2 was recorded in plot amended with 5 t/ha compost associated with ploughing (L5) with 328 individuals. This treatment was followed by the Z5 treatment with 318 individuals/m^2 (Tables 2 and 3). rates of 1 t/ha, 2.5 t/ha and 3 t/ha of compost in combination with zaï (Z1, Z2.5, Z3) and 1 t/ha of compost in combination with ploughing (L1) recorded 121, 117, 102 and 99 individuals/m^2 respectively. The lowest number of individuals was recorded in the control plot, ploughing without compost application (L0) with 38 individuals/m^2 (Tables 2 and 3). Analysis of variance showed that soil macrofauna densities were statistically homogeneous for all treatments (Tables 2 and 3).

Table 2: Relative abundance of soil macrofauna families according to treatments

Phylum	Class	Orders	Families	L0	L1	L5	Z1	Z2,5	Z3	Z5	Densities (individuals/m²)	RA (%)
Arthropoda	Insecta	Coleoptera	Carabidae	-	11	-	-	13	3	-	27	2.4
			Staphylinidae	-	-	-	3	3	-	5	11	1.0
			Scarabaeidae	-	-	-	8	8	-	27	43	3.8
		Isoptera	Termitidae	32	88	284	71	21	5	248	749	66.3
		Hymenoptera	Formicidae	6	3	19	24	42	75	16	185	16.4
	Myriapoda	Chilopoda	Geophilidae	-	-	3	3	3	-	3	12	1.1
		Diplopoda	Iulidae	-	-	3	3	3	3	-	12	1.1
	Arachnida	Araneae	Anyphaenidae	-	-	-	3	-	-	3	6	0.5
Annelida	Oligocheta	Haplotaxida	Octochaetidae	-	3	13	6	21	5	16	64	5.7
			Acanthodrilidae	-	-	6	-	3	11	-	20	1.8
Densities (individuals/m²)				38	105	328	121	117	102	318		100
RA (%)				3.4	9.3	29.1	10.7	10.4	9.0	28.2		

L0 : ploughing without compost ; L1 : ploughing+1 t/ha of compost ; L5 : ploughing+5 t/ha of compost ; Z1 : zaï+1 t/ha of compost (32 g/poquet) ; Z2.5 : zaï+2.5 t/ha of compost (80 g/poquet) ; Z3 : zaï+ t/ha of compost (96 g/poquet) ; Z5 : zaï+5 t/ha of compost (160 g/poquet). RA : relative abundance.

Table 3: Composition and densities of soil macrofauna according to treatments

Treatment	Orders	Families	Genera and species	Densities (individuals /m²)	Trophic groups
L0	Isoptera	Termitidae	*Microtermes upembae* (Harris, 1958)	32	Saprophagous
	Hymenoptera	Formicidae	*Pogonomyrmex sp*	3	Saprophagous
			Monomorium pharaonis (Linnaeus, 1758)	3	Saprophagous
L1	Coleoptera	Carabidae	*Dyschirius globosus* (Herbst, 1784)	11	Predator
	Isoptera	Termitidae	*Microtermes upembae* (Harris, 1958)	88	Saprophagous
	Hymenoptera	Formicidae	*Monomorium pharaonis* (Linnaeus, 1758)	3	Saprophagous
	Haplotaxida	Octochaetidae	*Dichogaster affinis* (Michaelsen, *1890*)	3	Geophagous
L5	Haplotaxida	Octochaetidae	*Dichogaster affinis* (Michaelsen, 1890)	13	Geophagous
		Acanthodrilidae	*Milsonia inermis* (Beddard, 1894)	6	Geophagous
	Chilopoda	Geophilidae	*Geophilus flavus* (De Geer, 1778)	3	Predator
	Isoptera	Termitidae	*Microtermes upembae* (Harris, 1958)	283	Saprophagous
	Diplopoda	Lulidae	*Lules sp*	3	Phytophagous
	Hymenoptera	Formicidae	*Monomorium pharaonis* (Linnaeus, 1758)	19	Saprophagous
Z1	Haplotaxida	Octochaetidae	*Dichogaster affinis* (Michaelsen, 1890)	6	Geophagous
	Coleoptera	Scarabaeidae	*Aphodius rufipes* (Linnaeus, 1758)	8	Phytophagous
		Staphylinidae	*Larve*	3	Predator
	Chilopoda	Geophilidae	*Geophilus flavus* (De Geer, 1778)	3	Predator
	Diplopoda	Lulidae	*Lules sp*	3	Phytophagous
	Hymenoptera	Formicidae	*Monomorium pharaonis* (Linnaeus, 1758)	8	Saprophagous
			Pogonomyrmex sp	16	Saprophagous
	Araneae	Anyphaenidae	*Anyphaena sp*	3	Predator
	Isoptera	Termitidae	*Microtermes upembae* (Harris,	71	Saprophag

			1958)		ous
Z2,5	Haplotaxida	Octochaetidae	*Dichogaster affinis* (Michaelsen, 1890)	24	Geophagous
	Coleoptera	Carabidae	*Dyschirius globosus* (Herbst, 1784)	13	Predator
		Staphylinidae	*Tachyporus hypnorum* (Fabricius, 1775)	3	Predator
		Scarabaeidae	*Larve (Scarabéiforme)*	8	Phytophagous
	Isoptera	Termitidae	*Microtermes upembae* (Harris, 1958)	21	Saprophagous
	chilopodes	Geophilidae	*Geophilus flavus* (De Geer, 1778)	3	Predator
	Hymenoptera	Formicidae	*Pachycondyla porcata* (Emery, 1897)	42	Saprophagous
	Diplopodes	Lulidae	*Lules sp*	3	Phytophagous
Z3	Haplotaxida	Acanthodrilidae	*Milsonia inermis* (Beddard, 1894)	11	Geophagous
		Octochaetidae	*Dichogaster affinis (épigé)* (Michaelsen, 1890)	5	Geophagous
	Isoptera	Termitidae	*Odontotermes mukimbunginis* (Sjöstedt, 1924)	5	Saprophagous
	Diplopoda	Lulidae	*Lules sp*	7	Phytophagous
	Coleoptera	Scarabaeidae	*Larve (Scarabéiforme)*	3	Phytophagous
	Hymenoptera	Formicidae	*Camponotus vagus* (Scopoli, 1763)	75	Saprophagous
Z5	Coleoptera	Scarabidae	*Dyschirius globosus* (Herbst, 1784)	27	Phytophagous
		Staphylinidae	*Philonthus marginatus* (Stroem, 1768)	5	Predator
	Haplotaxida	Octochaetidae	*Dichogaster affinis* (Michaelsen, 1890)	16	Geophagous
	Hymenoptera	Formicidae	*Pachycondyla analis* (Latreille, 1802)	16	Saprophagous
	Isoptera	Termitidae	*Macrotermes sp*	248	Saprophagous
	Araneae	Anyphaenidae	*Anyphaena sp*	3	Predator
	Chilopoda	Geophilidae	*Geophilus flavus* (De Geer, 1778)	3	Predator

L0 : ploughing without compost ; L1 : ploughing+1 t/ha of compost ; L5 : ploughing+5 t/ha of compost ; Z1 : zaï+1 t/ha of compost (32 g/poquet) ; Z2.5 : zaï+2.5 t/ha of compost (80 g/poquet) ; Z3 : zaï+3 t/ha of compost (96 g/poquet); Z5 : zaï+5 t/ha of compost (160 g/poquet

Impact of Ploughing and Zaï on Soil Macrofauna Diversities

The Shannon-Weaver Diversities and Piélou Equitability indices are shown in Table 4. Analysis of variance showed that the Shannon-Weaver diversities index and Piélou equitability index were statically homogeneous for all treatments (P= 0.854;

P=0.96). For the Shannon diversities index (SI), treatments Z1 and Z2.5 are the most diverse than the control, with values of 2.61 and 2.71 respectively. Analysis of Piélou's equitability index showed that there is no linear evolution with IS values.

Table 4: Shannon-Weaver Index (SI) and Equitability Index (EI) by treatment

Treatment	SI (means ± SD)	EI (means ± SD)
L0	0.79±0.02	0.79±0.24
L1	1.19±0.84	0.74±0,39
L5	0.85±1.38	0.68±0.42
Z1	2.61±0.83	0.70±0.43
Z2,5	2.71±1.31	0.96±0.06
Z3	1.12±1.46	0.57±0.63
Z5	1.24±1.14	0.33±0.35
P>Fr	0.85	0.96
Significance	ns	ns

L0 : ploughing without compost ; L1 : ploughing+1 t/ha of compost ; L5 : ploughing+5 t/ha of compost ; Z1: zaï+1 t/ha of compost (32 g/poquet) ; Z2.5: zaï+2.5 t/ha of compost (80 g/poquet) ; Z3: zaï+3 t/ha of compost (96 g/poquet); Z5: zaï+5 t/ha of compost (160 g/poquet). SI: Shannon-Weaver index, EI: Piélou equitability index. ns= not significant. Values followed by the even letter in each column are not statistically different at the 5% threshold.

2.3. Impact of Ploughing and Zaï on Trophic Groups

Table 5 shows the densities of soil macrofauna trophic groups. Four trophic groups were identified according to the applied treatments. These are saprophagous, geophagouss, predators and phytophagous. Saprophagous composed by of termites (*Microtermes upembae, Odontotermes mukimbunginis, Macrotermes sp*) and ants (*Monomorium pharaonis, Pogonomyrmex sp, Pachycondyla analis, Pachycondyla porcata, Camponotus vagus*), were the most abundant (936 individuals). The highest number (302 individuals/m^2) was recorded in the ploughing combined with 5 t/ha of compost (L5). This was followed by 5 t/ha of compost combined with zaï (Z5), with 264 individuals/m^2. The lowest number (38 individuals/m^2) was recorded in ploughing without compost (L0). Geophagous (*Dichogaster affinis and Milsonia inermis*) was the second most abundant group, with 88 individuals recorded per m^2. Geophagous beetles were completely absent from the ploughing plot without compost application (L0). In the zaï system, the highest numbers were recorded in the Z2.5 treatment (24 individuals/m^2), followed by the L5 treatment (18 individuals/m^2). Finally, phytophagous (*Lules sp, Aphodius rufipes* and *Dyschirius globosus*) and predators (*Geophilus flavus, Dyschirius globosus, Anyphaena sp, Tachyporus hypnorum and Philonthus marginatus*) were the least abundant, with 65 and 53 individuals/m^2 respectively. Analysis of variance showed that saprophagous, predators, geophagous and phytophagous densities were statistically homogeneous for all treatments (P=0.561, P=0.05, P=0.137, P=0.059).

Table 5: Soil macrofaunal trophic group densities by treatment (individuals/m²)

Treatment	Saprophagous	Geophagous	Predators	Phytophagous
L0	38	0	0	0
L1	91	3	11	3
L5	302	18	3	3
Z1	95	11	9	11
Z2,5	66	24	19	11
Z3	80	16	0	10
Z5	264	16	11	27
RA (%)	81.96	7.71	4.64	5.69
P>Fr	0.561	0.137	0.05	0.059
Significance	ns	ns	ns	ns

L0 : ploughing without compost ; L1 : ploughing+1 t/ha of compost ; L5 : ploughing+5 t/ha of compost ; Z1 : zaï+1 t/ha of compost (32 g/poquet) ; Z2.5 : zaï+2.5 t/ha of compost (80 g/poquet) ; Z3 : zaï+3 t/ha of compost (96 g/poquet) ; Z5 : zaï+5 t/ha of compost (160 g/poquet). ns = not significant. Values followed by the Even letter in each column are not statistically different at the 5% threshold.

Discussion

The results showed that Isoptera, Hymenoptera and Haplotaxida represented by Termitidae, Formidate and earthworms (Acanthodrilidae and Octochaetidae) constituted the dominant soil macrofauna with 92.4%. These communities are considered soil engineers (Jones, *et al.*, 2014) because they are deeply involved in soil decomposition and play a key role as soil crushers and decomposers. Their interactions contribute to soil fertility restoration (Sofo, *et al.*, 2020). These types of soil macrofauna are well known to be highly populated in tropical, subtropical and semi-arid regions (Traore, *et al.*, 2012 ; Tamsire, *et al.*, 2017). Their abundance in tropical regions is explained by their ability to adapt to diverse ecosystems (Traore, *et al.*, 2012 ; Tamsire, *et al.*, 2017). The obtained results are similar to those of Traore, *et al.* (2016),Savadogo, *et al.* (2016), Somda, *et al.* (2022) and Beye, *et al.* (2023) in Burkina Faso, which demonstrated that isoptera, hymenoptera and Haplotaxida were dominant in the tropical soils of Burkina Faso.

In general, the ploughing (L1, L5) and zaï (Z1, Z2.5, Z3 and Z5) treatments amended with compost showed higher densities than the control without compost (L0). Indeed, applying compost contributes to inoculating soil with billions of living and diverse organisms that increase its biodiversities (Savadogo, *et al.*, 2017). Compost also promotes the development of soil macrofauna due to the various nutrients it contains (Traore, *et al.*, 2012 ; Savadogo, *et al.*, 2017 ; Ouedraogo, *et al.*, 2017). These results are similar to those obtained by Traore (2012), Savadogo, *et al.* (2017), Ouedraogo, *et al.* (2017) and Nare, *et al.* (2017) who obtained higher densities in compost-amended plots than in plots without organic amendments. In addition, densities of soil engineers (Termitidae, Formitidae, Acanthodrilidae and Octochaetidae) were higher in zaï associated with 1 t/ha of compost (Z1) compared with treatments L1, Z2.5, Z3 and L0. This result could be explained by the fact that the Z1 treatment was beneficial for the establishment of a high number of macrofauna compared to the combined Zaï treatments at 2.5 and 3 t/ha of compost (Z2.5 and Z3), ploughing combined with 1 t/ha of compost (L1) and ploughing without compost (L0). The high abundance of soil engineers (Termitidae, formitidae, Acanthodrilidae and Octochaetidae) with the 5 t/ha rate of compost in association with ploughing (L5) and zaï (Z5) is due to the high concentration of lignin and cellulose contained in the organic matter supplied, all of which Termitidae, formitidae, Acanthodrilidae and Octochaetidae prefer (Ilboudo, *et al.*, 2023).

Furthermore, Türkmen and Kazanci (2010) mentioned that Shannon-Weaver diversities index values greater than or equal to three (3) would reflect good diversities and a stable, balanced soil macrofauna structure. Values of less than one (1), on the other hand, would indicate a deterioration in the structure of the soil macrofauna habitat. In our case, only the ploughing treatments combined with 5 t/ha of compost (L5) and the control without compost application (L0) had low index (<1), indicating a state of soil degradation (Türkmen and Kazanci, 2010). However, the zaï treatments combined with compost (Z1, Z2.5, Z3 and Z5) and ploughing combined with 1 t/ha of compost applied (L1) have recorded high indices (>1 but lower than 3), that indicated moderately degraded structures (Türkmen and Kazanci, 2010). On the other hand, high diversities indices (2.61 and 2.71) were obtained by zaï treatments combined with 1 and 2.5 t/ha of compost (Z1 and Z2.5). This shows that these treatments are beneficial for the diversified settlement of soil macrofauna and play a full part in improving soil quality (Türkmen and Kazanci, 2010).

Trophic group composition revealed that saprophagous are the most abundant trophic group (82.8%) in terms of densities. They are mainly composed of wood-eating termites (*Microtermes upembae, Odontotermes mukimbunginis*), mushroom-eating termites (*Macrotermes sp*) and ants (*Monomorium pharaonis, Pogonomyrmex sp, Pachycondyla analis, Pachycondyla cordata, Camponotus vagus*). High doses of compost (5 t/ha) in association with ploughing (L5) and zaï (Z5) harboured the highest densities of saprophagous because organic matter is favorable to the development of saprophagous. (Somda, *et al*., 2022). Saprophagous feed on litter, dead roots and decomposing wood (Traore, 2012 ; Rakotomanga, *et al*., 2016 ; Traore, *et al*., 2023). They accelerate the speed of decomposition and mineralization of organic matter leading to the release of nutrients for plant nutrition (Rabemanantsoa, 2010 ; Somda, *et al*., 2022). Similar results were obtained by Somda, *et al*. (2022) who inventoried significant numbers of saprophagous under zaï and ploughing treatments combined with organic manure. Geophagous represent the second most abundant group Due to their essential role in soil made up of the *Dichogaster affinis* which feeds mainly on the soil in the upper horizon 0-10 cm and the *Millsonia inermis* which feeds on organic debris at depths of 0-30 cm (Traore, 2012 ; Ilboudo, 2022). They are present only in treatments amended with compost and more abundant in treatments with zaï. These results are similar to those of Traore (2012) and Rakotomanga, *et al*. (2016) who had shown that geophagous were significantly present in significant numbers in plots with minimum tillage combined with organic fertilization, but less in with ploughing plots. Traore (2012) and Bouthier, *et al*. (2014) have demonstrated that ploughing soil without applying organic matter is unfavorable to the development of soil macrofauna communities and could lead to the disappearance of earthworms, and consequently accelerate land degradation. However, geophagous group plays a beneficial role in soil fertility improvement through the structuring and formation of soil aggregates (Ilboudo-Tapsoba, *et al*., 2011). Their disappearance is an indicator of soil fertility degradation (Ilboudo-Tapsoba, *et al*., 2011). Regarding low densities the predators (*Geophilus flavus, Dyschirius globosus, Anyphaena sp, Tachyporus hypnorum and Philonthus marginatus*) and phytophages (*Lules sp, Aphodius rufipes and Dyschirius globosus*) in all treatments concluded that their population growth are limited by the shortage of food sources availability due to their specific food regime (Somda, *et al*., 2022). Predators play an important role in regulating pests abundance in soil such as caterpillars, aphids and jassids (Rakotomanga, *et al*., 2016). Phytophagous feed on the aerial organs of plants (Rakotomanga, *et al*., 2016) and are generally harmful to cotton (Coulibaly, *et al*., 2019). In conclusion, high doses of compost (5 t/ha) in combination with ploughing (L5) and zaï (Z5) were more beneficial for the establishment of saprophagous, geophagous and soil predators. These treatments were followed by 1 t/ha of compost.

Conclusion

The impacts of agroecological practices on soil macrofauna under organic cotton cultivation were investigated in the second year of our study.

Compost inputs were more favorable to maintain soil macrofauna. High doses of compost (5 t/ha) in combination with ploughing (L5) and zaï (Z5) were more beneficial for the establishment of saprophagous, geophagous and soil predators. These treatments were followed by 1 t/ha of compost. Ploughing without applying organic fertilizer negatively affects soil macrofauna activity and therefore the preservation of the biological fertility of farmland. The soil macrofauna was dominated by specific groups belonging to the Termitidae, Formicidae and Octochaetidae families which had a good effect on soil physical and chemical properties. Zaï treatments with 2.5 and 3 t/ha of compost application resulted in diversifying development of macrofauna groups. In the context of low organic manure availability, zaï combined with the 1 t/ha compost dose (Z1) would be a beneficial farming practice to establish good soil macrofauna and consequently improve the biological fertility of soils under organic cotton cultivation.

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