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Edaphic Fauna Associated with Areas Managed under no-till with and without Terraces

Inara de Souza Stockmann*[1]
https://orcid.org/0000-0002-6200-5339

Dinéia Tessaro[1]
https://orcid.org/0000-0002-6079-5269

Lucas da Silva Domingues[1]
https://orcid.org/0000-0001-8594-354X

Jéssica Camile da Silva[1]
https://orcid.org/0000-0001-7935-2305

Luis Felipe Wille Zarzycki[1]
https://orcid.org/0000-0002-6561-2871

Ketrin Lorhayne Kubiak[2]
https://orcid.org/0000-0003-1421-0132

Erivelto Folhato Tolfo[1]
https://orcid.org/0000-0001-6835-775X

[1]Universidade Tecnológica Federal do Paraná, Dois Vizinhos, Paraná, Brasil; [2]Centro de Investigação de Montanha, Instituto Politécnico de Bragança. Bragança, Portugal.

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*Correspondence: inarastockmann@hotmail.com; Tel.: +55-49-998104542 (I.S.S.).

HIGHLIGHTS

- The no-tillage system without terrace favors the abundance of the Collembola and Acari groups;
- The no-tillage system with terracing positively affects the order Coleoptera;
- The no-tillage system with terracing presents more promising results in terms of biological equitability.

Abstract: Conservation soil management systems can promote beneficial changes in the edaphic fauna, which is important in improving and maintaining soil quality. Hence, this study aimed to evaluate the edaphic fauna in two areas with soils managed under no-till with and without terraces for four years. The edaphic fauna was evaluated by installing 32 pitfall trapsin each experimental plot. After seven days, the traps were removed, and the sampled individuals were classified at the level of major taxonomic groups. Collembola, Acari, Formicidae, Coleoptera, and Araneae were the most abundant in both study areas. The mean abundance of the order Coleoptera stood out in the no-till system with terraces in 2021, while the orders Collembola and Acari were more abundant without terraces in 2019 and 2021, and 2021 and 2022, respectively. There was a greater abundance of organisms for both areas in 2021, with significant equitability in the no-till system with terraces. Thus, the results showed that only some groups are positively affected by mechanical erosion control.

Keywords: Conservation agriculture; soil fauna; soil management; terracing.

INTRODUCTION

Soil management is one of the greatest challenges in modern agriculture [1], demonstrating the need to adopt sustainable practices that foster ecosystem services, including support for plant growth, participation in biogeochemical cycles, provision of raw materials [2], biodiversity conservation, climate regulation, and food production [3]. In this scenario, the no-till farming system (NTS) is a sustainable alternative and the basis of conservation agriculture and sustainability [4], one of the major challenges of the 21st century as the demand for food and environmental preservation increases [5].

The NTS is an agricultural technique based on minimal soil disturbance, maintenance of soil cover, and crop rotation [6], contributing to maintaining and improving the quality of the soil's chemical, physical, and biological attributes [7].

Another major challenge to sustainable agriculture is soil loss through water erosion [8], one of Brazil's most important soil degradation processes; in fact, recent data has shown soil losses of 0.1–136.0 t ha^{-1}depending on land use and land cover [9]. In this context, adopting complementary conservation practices such as terraces is recommended for agricultural areas, as these techniques reduce water losses by surface runoff and reduce erosion processes, which negatively affect the chemical, physical, and biological attributes of the soil, causing major economic losses [10,13].

From a biological point of view, the soil is characterized as a large reservoir that shelters over a quarter of global biodiversity [14,15], which is partly represented by the edaphic fauna [16]. As a fundamental element in the soil, edaphic fauna performs essential functions in ecosystems, including nutrient cycling and mobilization, fragmentation of organic residues, with positive contribution on soil organic matter levels, aeration, and participation in biogeochemical cycles [17,20]. It positively affects soil properties and behavior due to changes caused by soil use and management, thus standing out as a possible indicator of soil quality [21,22].

The effects of production systems can promote changes in edaphic fauna [23,26]. For instance, agricultural systems with an environmental structure similar to areas with reduced anthropization tend to present a better structure of the edaphic invertebrate community [27]. Thus, the edaphic conditions promoted by NTS establish a favorable environment for soil fauna [21], which can be enhanced through mechanical erosion control practices [28,29].

The use of NTS and mechanical erosion control are widely employed in Brazil [5,30]. Despite a sharp increase in research analyzing the biological attributes of the soil and processes that may occur, long-term studies addressing soil behavior in areas managed under NTS and associated with mechanical erosion control are insipient. This questioning is valid, considering that adopting NTS without terracing has been mistakenly disseminated, in which the absence of soil preparation and permanent cover is insufficient to contain water erosion [31,33], especially during high-intensity rainfall events and in areas with long and steep slopes [32]. In these situations, surface runoff may remove straw, exacerbating the loss of water, nutrients, and organic matter and negatively impacting edaphic fauna abundance and diversity [34].

Given the above, this study sought to evaluate the influence of mechanical erosion control, through the use of terraces, over edaphic fauna of areas managed under NTS.

MATERIALS AND METHODS

Study area and experimental design

This study was developed at Universidade Tecnológica Federal do Paraná in Dois Vizinhos, southwestern Paraná State (southern Brazil). The soil is classified as Nitossolo [63] and the climate is classified as subtropical humid mesothermal (Cfa) according to the Köppen classification, with average temperatures below 18 ºC in the winter and above 22 ºC in the summer, without defined dry season, and an average of 2000 mm per year for precipitation [35].

The accumulated annual rainfall during the study period was acquired from the National Institute of Meteorology (INMET) weather station in Dois Vizinhos (Figure 1) [36].

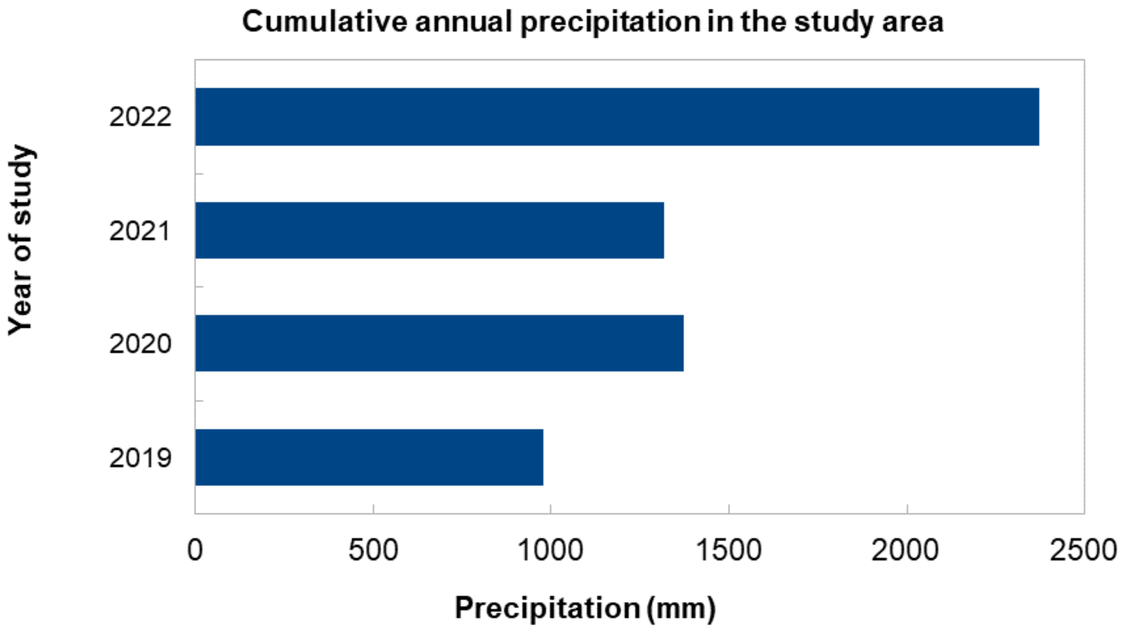


Figure 1. Accumulated annual precipitation (in millimeters) from 2019 to 2022 in the study area in Dois Vizinhos (Paraná State).

The experiment began in 2019 in two 1.9-ha experimental plots, one managed under no-till with mechanical erosion control (NTC) and the other area managed under no-till without erosion control (NTW) (Figure 2A). Conservation practices (e.g., NT and terracing) are used in the area for over 20 years, being that NTW had the terraces removed in 2019 to conduct the experiment. During the study, corn, soybeans, wheat, oats, rye and beans crops were grown. The NTC plot has an average slope of 8.98%, while the NTW plot has 8.62%.

In order to evaluate the effect of the position in the landscape and its interaction with the terrace system, the experimental area was divided into four subplots of two lines each along the plot, characterizing a 4x2 bifactorial design (2 systems and 4 positions in the landscape) (Figure 2B).

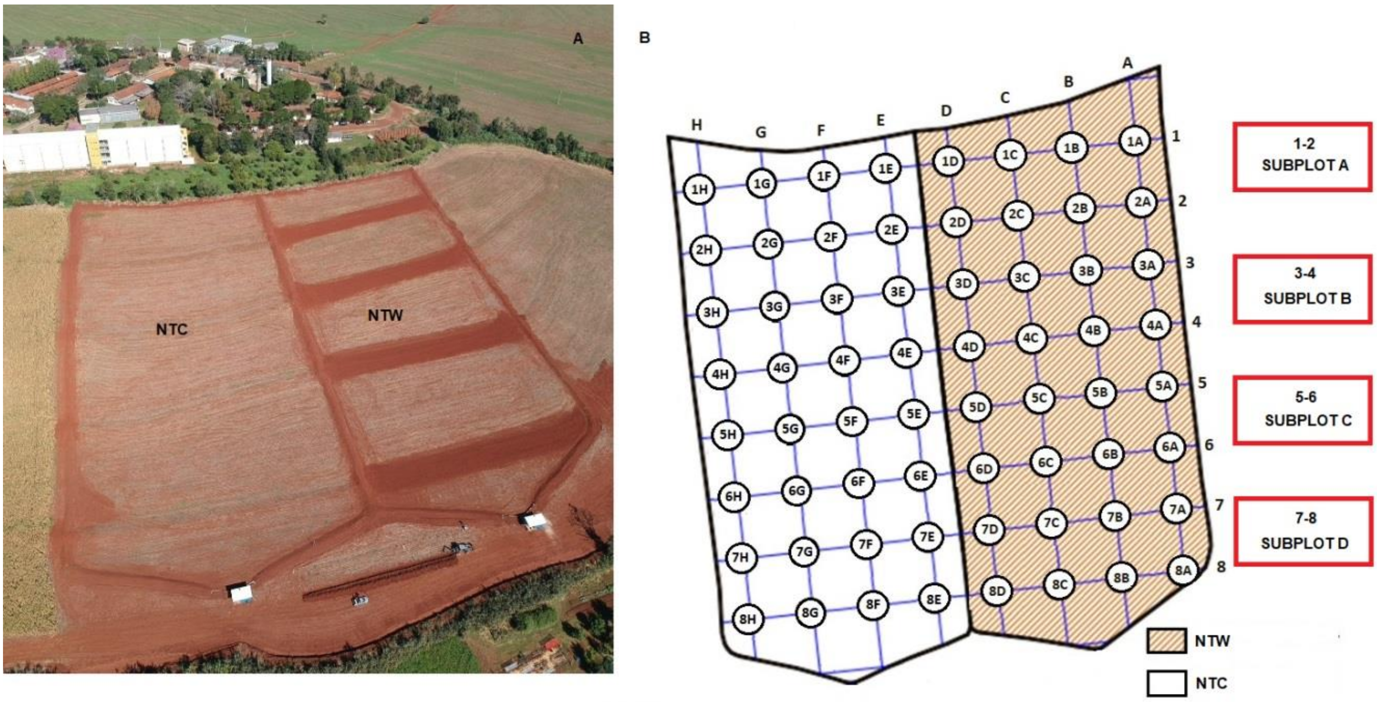


Figure 2. A) Aerial view of the area managed under no-till with (NTC) and without terraces (NTW). B) Sampling grid to collect edaphic fauna using pitfall traps, according to the position in the landscape (subplot). Source: Soil Science Research Group UTFPR-DV.

Edaphic fauna sampling and classification

Edaphic fauna was sampled once a year in October from 2019 to 2022 preceding the planting of annual crops, totaling four samplings; 32 pitfall traps were placed and spaced 25 m between points and 25 m between lines in each experimental plot (Figure 2B). Each trap contained a 250 mL plastic container partially filled (1/3) with a 4% formaldehyde preservative solution [64,65]. The traps were placed using a Dutch auger by opening a hole in the soil with sufficient width and depth to place the plastic containers so that the edge was at the same level as the soil surface. To avoid the entry of rainwater and not jeopardize sample quality, the traps were covered with plastic plates fixed with small wooden sticks, forming a cover.

Seven days later, the traps were removed from the experimental area, individually washed with using a 270-mesh sieve and stored in containers with 70% ethyl alcohol solution. The sampled organisms were classified to the lowest possible taxonomic level with a stereoscopic microscope and dichotomous classification keys to estimate the taxa (richness) and abundance of organisms in each taxon [37].

Data analysis

After classifying and counting the organisms captured, the relative frequency and mean abundance per taxonomic group were calculated. For abundance data, the Shapiro-Wilk normality test was applied. As the assumptions for normality were not met, the data were transformed by √(x) or log (x+1), followed by a comparison of means using the Tukey test at 5% probability in the Rbio software [38]. To compare the areas in terms of diversity, the ecological indices of Shannon-Wiener diversity (H’) (Equation 1) and Pielou evenness (J’) (Equation 2) were calculated using the Past software (version 4.03) [39].

$$H' = -\Sigma pi.\log Pi \qquad \text{(Equation 1)}$$

Where: Pi = ni/N; ni = density of each specie or group; N = total number of individuals

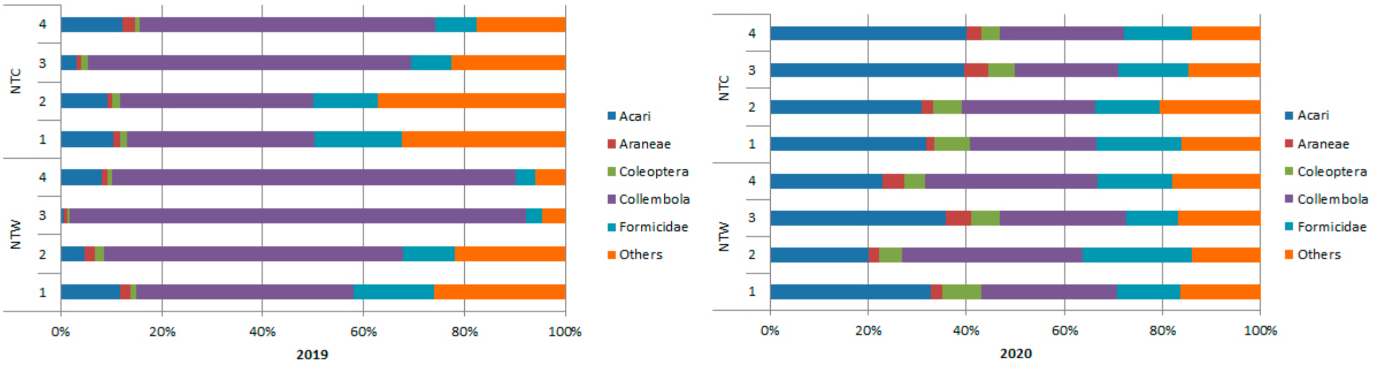
$$J' = H/ \log S \qquad \text{(Equation 2)}$$

Where: H’ = Shannon-Wiener index; S = number of species or groups

In order to better visualize the distribution of organisms and differentiation between treatments, a principal component analysis (PCA) was also performed using the Past software (version 4.03).

RESULTS

A total of 107,287 organisms were sampled, 59,078 individuals in 2019, 18,321 in 2020, 21,286 in 2021, and 8,602 in 2022; they were grouped into 20 taxonomic groups: Acari, Araneae, Blattodea, Chilopoda, Coleoptera, Collembola, Dermaptera, Diplopoda, Diptera, Formicidae, Hemiptera, Hymenoptera, Isopoda, Isoptera, Lepidoptera, Orthoptera, Thysanoptera, Thysanura, larvae, and nymphs. The most found groups in the four years and both experimental areas were Collembola, Acari, Formicidae, Araneae, and Coleoptera, and the least common groups were grouped into the “Others” category, which justifies their high frequency in all samplings and both study areas (Figure 3). In 2019 and 2022, the Collembola class was the most frequent, whereas there was a high frequency of the order Acari in 2020 and 2021 in both study areas, distributed significantly in the subplots. Notably, there was a high frequency of the order Thysanoptera in 2021, which was not representative of the other samplings, and a high frequency of the order Coleoptera in 2022.



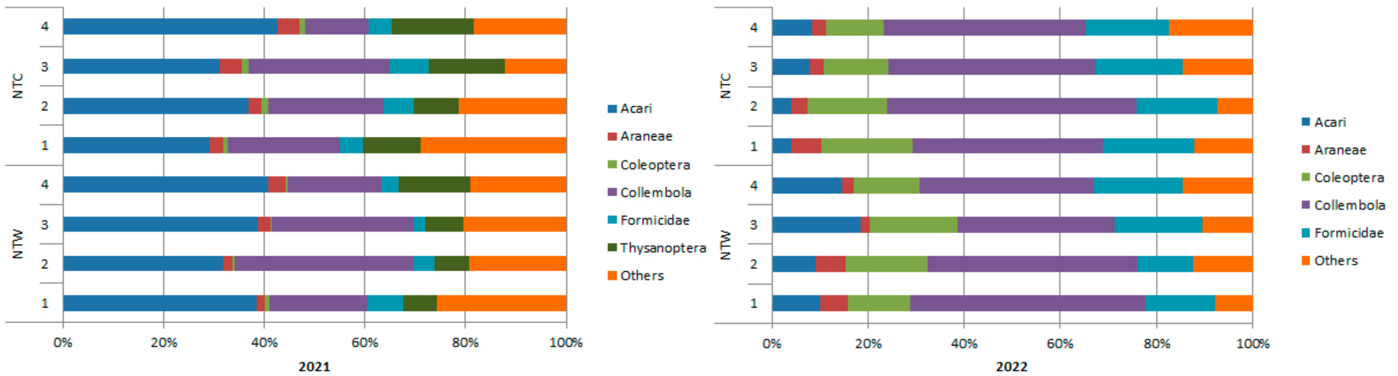


Figure 3. Relative frequency of taxonomic groups in the no-till areas with and without mechanical erosion control.

As for the test of means, no interactions were observed between NT systems with and without terraces and the subplots from the bifactorial analysis therefore, the observed effects are independent of the factors (Table 1). The mean abundance of edaphic organisms did not interact, although significant differences were observed between the NTC and NTW areas for some groups. In 2019, Collembola showed a significant difference between the NTW and NTC areas. The highest mean for the “Others” group was found for NTC. No significant differences were observed between the areas for any edaphic group in 2020. In 2021, Acari and Collembola showed significantly higher abundance in NTW, while Coleoptera presented significantly higher abundance in the NTC area. In 2022, only Acari differed significantly between areas, with a higher mean abundance in the NTW.

Table 1. Mean abundance of edaphic organisms per taxonomic group for the edaphic fauna associated with no-till areas with and without terraces.

2019

	Acari[2]	Araneae[2]	Coleoptera[2]	Collembola[1]	Formicidae[1]	Others[2]
NTW	53.41^{ns}	14.31^{ns}	9.59^{ns}	810.56^{a}	66.09^{ns}	115.75^{b}
NTC	66.75	11.00	9.88	394.5^{b}	85.25	209.09^{a}
Mean	60.08	12.66	9.73	602.53	75.67	162.42
CV1(%)	77.66	29.38	28.44	44.43	35.5	17.51
Subplot A	59.94^{ab}	9.56^{b}	6.5^{b}	218.5^{c}	91.13^{ns}	158.94^{ns}
Subplot B	56.88^{ab}	11.5^{ab}	13.38^{a}	382.75^{bc}	91.81	239.88
Subplot C	17.5^{b}	10.19^{b}	9.94^{ab}	1025^{a}	59.31	135.19
Subplot D	106.00^{a}	19.38^{a}	9.13^{ab}	783.88^{ab}	60.44	115.69
Mean	61.75	14.78	9.53	904.44	59.88	125.44
CV2(%)	62.12	25.65	33.73	41.56	32.05	18.97

2020

	Acari[1]	Araneae[2]	Coleoptera[2]	Collembola[2]	Formicidae[2]	Others[2]
NTW	76.81^{ns}	9.69^{ns}	15.75^{ns}	91.03^{ns}	44.88^{ns}	46.22^{ns}
NTC	103.31	8.78	15.91	71.09	41.72	47.34
Mean	90.06	9.23	15.83	81.06	43.3	46.78
CV1(%)	49.1	32.62	21.27	13.91	16.66	9.98
Subplot A	78.25^{ns}	4.56^{ns}	18.50^{ns}	64.38^{ns}	36.38^{ns}	39.19^{ns}
Subplot B	81.63	7.00	17.19	103.56	57.56	55.38
Subplot C	103.06	13.56	15.38	62.81	34.25	42.69
Subplot D	97.31	11.81	12.25	93.5	45	49.88
Mean	100.19	12.69	13.81	78.16	39.63	46.28
CV2(%)	47.43	40.11	24.33	14.84	16.9	11.27

Cont. Table 1

2021							
	Acari[2]	Araneae[2]	Coleoptera[1]	Collembola[2]	Formicidae[2]	Thysanoptera[2]	Others[1]
NTW	135.72^{a}	8.47^{ns}	1.75^{b}	97.47^{a}	15.41^{ns}	31.72^{ns}	76.75^{ns}
NTC	102.75^{b}	10.25	3.69^{a}	65.09^{b}	17.19	38.38	60.56
Mean	119.23	9.36	2.72	81.28	16.3	35.05	68.66
CV1(%)	15.35	27.57	25.81	27.35	40.85	23.46	40.01
Subplot A	106.38^{ns}	6.94^{ns}	2.88^{ns}	66.13^{ab}	18.56^{ns}	28.81^{ns}	86.25^{a}
Subplot B	129.5	8.06	2.94	117.75^{a}	18.31	29.63	77.25^{a}
Subplot C	118.19	11.00	3.00	93.94^{ab}	16.44	37.31	55.43^{b}
Subplot D	122.88	11.44	2.06	47.31^{b}	11.88	44.44	55.68^{b}
Mean	120.53	11.22	2.53	70.63	14.16	40.88	55.56
CV2(%)	18.48	27.07	31.27	28.51	37.82	25.57	26.58

2022						
	Acari[2]	Araneae[2]	Coleoptera[2]	Collembola[2]	Formicidae[2]	Others[2]
NTW	17.84^{a}	5.44^{ns}	20.97^{ns}	55.25^{ns}	21.41^{ns}	15.25^{ns}
NTC	7.63^{b}	5.16	20.59	59.88	23.53	15.88
Mean	12.73	5.3	20.78	57.56	22.47	15.56
CV1(%)	55.88	35.05	24.78	15.25	20.38	24.82
Subplot A	10.06^{ns}	8.13^{a}	21.56^{ns}	61.25^{ns}	22.56^{ns}	13.63^{ns}
Subplot B	9.88	7.19^{ab}	26.44	77.19	23.44	14.94
Subplot C	16.94	2.81^{c}	19.88	46.31	22.63	15.25
Subplot D	14.06	3.06^{bc}	15.25	45.5	21.25	18.44
Mean	15.5	2.94	17.56	45.91	21.94	16.84
CV2(%)	58.73	33.98	23.7	16.26	22.59	15.69

[1]Data transformed √(x); [2]Data transformed to log (x+1); NTW: no-till without terraces; NTC: no-till with terraces; CV1: Coefficient of variation refers to the main plots; CV2: Coefficient of variation refers to the subplots; Means followed by different letters in the column differ significantly by the Tukey test at 5% probability; ns means not significant at 5% probability by the Tukey test.

Regarding the subplots, significant differences were observed due to independent variables. In 2019, the order Acari presented the highest mean in subplot D, while the lowest mean for the group was found in subplot C. Subplots A and B did not differ from C and D. For the order Araneae, subplot D presented the highest mean for the group, and differed from subplots A and C. The order Coleoptera, for its part, presented a higher average in subplot B, which differs from subplot A, while subplots C and D do not differ from each other and are the same as the others. The Collembola group presented a statistically significant difference for subplot C, which differs from the others, while subplot A presented the lowest average. Subplots B and D differ from each other, but are the same as subplot C and A, respectively.

In 2020, no statistically significant differences were observed for the subplots. In 2021, differences were noted for the Collembola group presented the highest average for subplot B, followed by subplots A and C, which do not differ from each other. Subplot D presented the lowest average for the group. For the "Others" category, subplots A and B are equal to each other and differed from C and D. For 2022, only the order Araneae differed between the subplots, in which the highest average is associated with subplot A, which differs from the others, while subplot C presents the lowest average.

Regarding the ecological indices of diversity, it is observed that in 2020 there was no significant difference for any of the evaluated indices. Generally speaking, the differences found in the other years are mainly associated with the total abundance and the Shannon diversity and Pielou uniformity indices, as shown in Table 2. The total richness of groups showed a statistical difference only in the year 2021, in which the subplots A and B presented the highest averages for both areas, while the lowest average was observed in Subplot C, for the NTC area.

Table 2. The richness of taxonomic groups, total abundance, Shannon-Wiener diversity index (H'), and Pielou equitability (J') for the edaphic fauna in no-till areas with and without terraces.

	NTW				NTC			
Subplots	A	B	C	D	A	B	C	D
2019								
Total richness	12 n.s.	12	12	11	11	11	13	14
Total abundance	4360b	5929ab	13315a	10627a	4353 b	6810a	6799a	6885a
(H')	1.566a	1.347a	0.470b	0.807b	1.570a	1.546a	1.175b	1.358ab
(J')	0.630ab	0.542ab	0.189b	0.337b	0.655a	0.645a	0.458b	0.515ab
2020								
Total richness	10n.s.	11	12	14	10	9	11	13
Total abundance	2053n.s.	2656	1881	2510	1807	2501	2467	2446
(H')	1.655n.s.	1.618	1.710	1.711	1.702	1.692	1.681	1.667
(J')	0.719n.s.	0.675	0.688	0.648	0.739	0.770	0.701	0.650
2021								
Total richness	15a	15a	14ab	14ab	16a	15a	12b	14ab
Total abundance	2488bc	3726a	2874ab	2665b	2567b	2409bc	2491bc	2066c
(H')	1.733 n.s.	1.598	1.602	1.669	1.792	1.730	1.796	1.734
(J')	0.640 n.s.	0.590	0.607	0.632	0.646	0.639	0.723	0.657
2022								
Total richness	13 n.s.	13	12	14	13	13	12	14
Total abundance	1167 n.s.	1032	1074	1084	1028	1513	907	797
(H')	1.568a	1.678a	1.778a	1.797a	1.682a	1.458b	1.731a	1.799a
(J')	0.611b	0.654ab	0.716a	0.681a	0.656a	0.569b	0.697a	0.682a

NTW: no-till without terraces; NTC: no-till with terraces. Means followed by different letters in the line differ significantly by the Tukey test at 5% probability; ns means not significant at 5% probability by the Tukey test.

The principal component analysis (PCA) allowed to better comprehend the edaphic fauna distribution in the studied plots over four years. The first principal component (PC1) of 2019 explained 49,4% and the second (PC2) explained 24,44%, totalizing 73,8% of the data variability (Figure 4A). This period presented association of groups Araneae and Collembola with NTW, while Formicidae and Coleoptera associated with NTC. In 2020, the PCA explained 65,9% of the data variability, being 37,4% explained by PC1 and 28,2% explained by PC2 (Figure 4B), showing association between NTW and both groups Collembola and Formicidae, while NTC associated with NTC. On the third year of study, 2021, the PC1 explained 45,6% while PC2 explained 27,6% totalizing 73,2% of the data variability (Figure 4C). This year Acari, Collembola and 'Others' associated with NTW and NTC associated with Araneae, Thysanoptera, Coleoptera and Formicidae. In 2022, PCA explained 71,8% of the data variability, being 47,5% explained by PC1 and 24,3% by PC2 (Figure 4D). Acari and 'Others' showed association with NTW, while Coleoptera and Formicidae with NTC.

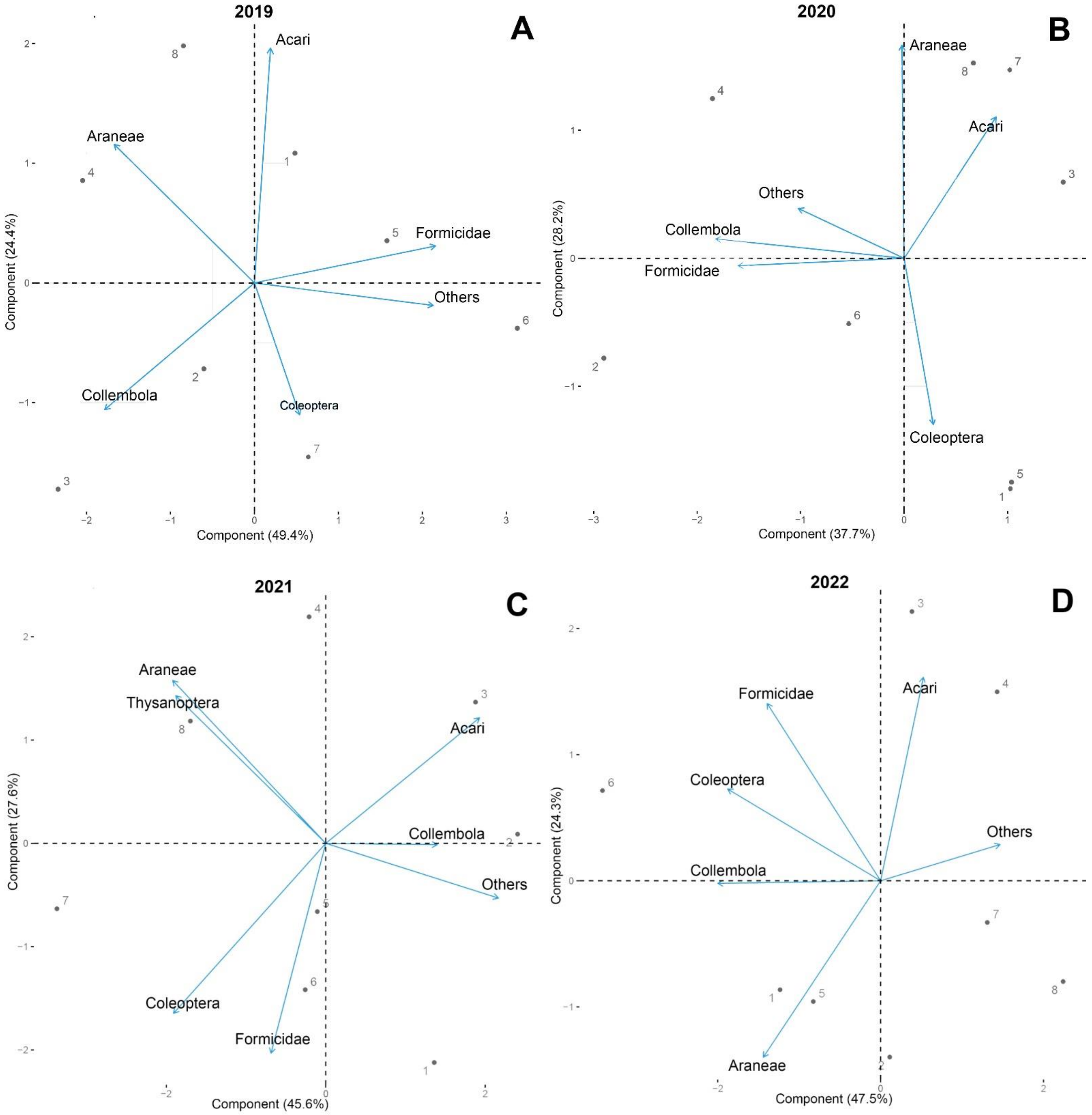


Figure 4. Relationship between principal components 1 and 2 explaining the groups of edaphic fauna associated with no-till areas with and without terraces. A: 2019; B: 2020; C: 2021; D: 2022; 1- 4 are NTW and 5- 8 are NTC.

DISCUSSION

Considering the organisms frequency in each plot and year of the study (Figure 2), the presence of the most frequent groups (Collembola, Acari, Formicidae, Araneae and Coleoptera) is possibly related to soil characteristics promoted by NTS used in both plots. Da Silva and coauthors [16] reported that the contribution of organic residues added to the soil, influenced by the NTS, positively affects the development of some edaphic groups, including those mentioned herein. The authors also described that the abundance and frequency of certain organisms are altered by the type of cultivation system adopted, modifying its composition when there is litter maintenance and biomass production of the aerial part and the root system. De Melo [40] reported that these findings are based on the hypothesis that systems that guarantee adequate organic carbon levels in the soil and rhizospheric environment favor edaphic fauna diversity and environmental quality.

In 2019 and 2022, both studied areas had a high abundance of Collembola, corroborating the literature [41], as one study reported a higher abundance of Collembola, Hymenoptera, and mites in ryegrass/soybean crops and pasture areas. In another study [42], high frequencies of the Collembola in crop rotation and succession systems were reported, in which there was a greater quantity and variety of plant cover, indicating that the maintenance of the edaphic community relies on vegetation and litter quality. It should be noted that until 2019 (the first year of the study), the areas came from a conservation system consisting of no-till and terracing, with crop rotations, which favors the high occurrence of some groups. The second most representative group was the order Acari, which was more frequent in 2020 and 2021; its high frequency may be linked to the quantity and quality of plant biomass in these areas, considering that many species of this group are phytophagous [43].

The order Coleoptera was also representative throughout the study, especially in 2022. This result may be related to the characteristics of the group that occupies different trophic levels [44], as established by the history of the area, and due to the predatory behavior of some families as they help control insect populations, which are usually found in large numbers in agricultural areas [45]. The higher frequency of the order Araneae in 2022 may be linked to the time of conducting the study, in which the straw provided by the NT contributed to a more consolidated composition of elements in the agroecosystem, providing suitable habitats for these insects' reproduction and creating shelters [16]. Indeed, spiders are predatory organisms that help regulate the populations of other groups in such areas and maintain the balance of ecosystems [46].

The family Formicidae, in turn, was more frequent in 2020 and 2022, more notably in areas with litter [46]. In the soil, they act by redistributing particles of organic matter, which improves water infiltration and increases soil porosity and aeration [47,48]. In isolation, the order Thysanoptera proved to be a representative group in the year 2021. Changes in litter and especially plant composition interfere with the dynamics of this group [46]. The lack of rainfall in the initial years may have affected plant dynamics, reducing the contribution of organic material to the soil and, consequently, a more pronounced occurrence of the group due to this disturbance. In fact, evidence has shown that the presence of certain species of this group may be associated with environmental disturbances, in addition to temperature and precipitation being related factors [49].

The high frequency of the "Others" category in all sampling periods is directly linked to the high occurrence of adult individuals of the order Diptera, which, despite being considered non-edaphic in the adult stage, are abundant in various agroecosystems, as some families deposit their larvae in areas with high concentrations of decomposing organic matter[50]. Their high occurrence may be linked to the saprophagous habit of the group, which acts on plant materials and favors organic matter decomposition and nutrient cycling [51].

Regarding the mean abundance of organisms (Table 1), the absence of interaction between the factors evaluated may be associated with the low rainfall rates in the first three years of the study (Figure 1). This observation is important when considering that water erosion is one of the leading sources of soil degradation, causing problems in agricultural soils by removing the most superficial layers of the soil and negatively affecting soil fauna [29,52]. Hence, combining conservation practices of soil cover associated with mechanical practices to control surface water runoff (i.e., terracing) is paramount to control erosion processes. In this context, Sbaraini and coauthors [28] employed NT with terracing and reported no visible signs of soil erosion; the authors emphasized that in spite of the misconception that one practice 'cancels' the other one out, their findings demonstrate the opposite.

Considering the results obtained for both systems (Table 1), the NTC area stood out in relation to the "Others" group in 2019 and Coleoptera in 2021. Coleoptera are sensitive to soil preparation, and their populations may decrease in crop areas [41], meaning possible soil losses from erosion could negatively impact this group. The benefits associated with the NTS contribute to these findings and corroborate the literature [53], as conservation activities are the basis for balance in edaphic ecosystems.

Furthermore, the orders Collembola in 2019 and 2021 and Acari in 2021 and 2022 significantly differed for the NTW area compared to the NTC, and removing the terraces in 2019 may have been a determining factor; anthropized areas have a higher occurrence of these groups [54,55,56]. Mites have a close relationship with the physical attributes of the soil (e.g., porosity, aeration, water infiltration, and biological functioning), making their presence in NTW areas during high rainfall periods possibly contribute to recovering possible impacts [41]. Additionally, spatially unpredictable resources can easily affect their occurrence, such as adding residues to the soil that support their communities, causing population peaks [57].

Although there are variables that do not show significant differences over the years, which may be due to similarities between the areas since both adopt conservation practices, the differences reported herein for just four years of research demonstrate the benefits of combining NTS and terracing practices for some edaphic groups. Nevertheless, there are still limitations from the scientific point of view, as only a handful of studies have simultaneously evaluated both practices.

Considering the differences observed for the subplots, several groups may have excelled over others in relation to their position on the landscape due to their habits or characteristics. Given the lack of interaction of the position in the landscape with the presence or absence of terraces, the differences found seem to be associated with favorable conditions in these sites, considering that the balance of abundance between the functional groups contributes to the strengthening against adverse abiotic factors [58]. The balance of the abundance of organisms can be an interference variable for some groups, and in 2019, the order Acari presented the highest average in subplot D. Evidence has shown that this group is commonly associated with the occurrence of predator groups, coinciding with the abundance of spiders in subplot D [16,59]. Feeding habits may also be associated with the abundance of Collembola in 2019 and 2021, considering that the group feeds mainly on organic matter added to the soil by the production systems. In none of the years mentioned did this group of organisms stand out in subplot A, that is, the beginning of the farming area, where there may be greater influence of mechanized management and consequently changes in soil characteristics [60]. In this same vein, the difference for the Coleoptera order only in 2019 may be a reflection of the high occurrence of other groups, such as Acari and Collembola, as some beetle families are predators of these groups [67,68].

As for ecological indices (Table 2), for total richness, a greater number of associated groups were found in 2021, for both areas, which responded in a similar way, with greater richness in subplots A and B. Richness indicates the variability of groups of organisms present in each area, and studies indicate that agroecological or conservation-based systems, which promote internal regulation, present an increase in their diversity have shown that agroecology or conservation- based systems, which promote internal regulation, present greater diversity in the same period [61]. Pielou's uniformity varied throughout the study, although it showed more promising results in the NTC area. Considering the association of Collembola with anthropic areas [54], its high frequency associated with the NTW area, especially in 2019, contributed to reducing uniformity. In 2022, the similarity between areas for the Pielou index may be associated with heavy rains during the collection period, affecting the dynamics and abundance of organisms.

As for the PCA, comparable results were observed elsewhere [16], as groups such as Araneae and Coleoptera were dissimilar in areas managed under conservation systems [51,66], suggesting that certain plant compositions promote the abundance of predators, ecosystem engineers, decomposers, and herbivores. The characteristics promoted by adopting the NTS delimit the occurrence of certain groups, including predators, in areas with habitat provision for high trophic levels and the high biomass that shelters these organisms [59]. Therefore, ecosystem engineers and litter transformers benefit from soil structuring by helping other groups establish themselves in the ecosystem [40,62].

These findings emphasize the importance of considering the effects of conservation practices, with emphasis on NTS on the biological component of the soil represented by the edaphic fauna, considering the crucial role of edaphic fauna as an essential element of ecosystem functioning and its ability to indicate environmental quality.

CONCLUSIONS

The results showed no interaction between no-till farming system with and without terrace and the position in the landscape, although some groups have been positively affected by terraces, while the Collembola and Acari groups presented greater abundance associated with the area without terraces. Furthermore, no-tillage system with terracing presents more promising results in terms of biological equitability.

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