Scientific Paper

Soil macrofauna as indicator of agroecological conversion of a productive system of *Moringa oleifera* Lam. in Nicaragua

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Abstract

In order to determine the diversity and functionality of soil macrofauna as biological indicator of soil health and the effect of management practices in productive systems of *Moringa oleifera* Lam., a study was conducted in areas of the National Agricultural University, Nicaragua. The essays lasted nine months, in which agroecological management and conventional management practices were implemented. The soil macrofauna was sampled through the methodology developed by the International Tropical Soil Fertility and Biology Program. Taxonomic identification at phylum, class, order and family level was performed, as well as of functional groups: detritivores, soil engineers, herbivores and predators. The non-parametric Kruskal-Wallis test was applied to determine statistical differences in the variation of density per taxon and functional group per management system. The density of individuals was statistically different (p < 0,05) between management systems at class, order and family level. Diversity was higher in agroecological conversion, and a higher equitability of families stood out. The functional groups were different between systems, with dominance of soil engineers (64,22 %) in agroecological conversion, and of detritivores (74,19 %) in conventional management. Association was found of the management practices with the density and diversity of the soil macrofauna; and the organisms from the families Formicidae and Termitidae and order Coleoptera, which interacted with *M. oleifera* in different development stages, were identified. The number of taxonomic units constituted an indicator that allowed to distinguish between the management systems, soil health and transformation dynamics of the chemical, physical and biological properties of each system.

Keywords: biodiversity, soil management, indicator organisms

Introduction

Conventional agriculture is contextualized in different studies (Nieto *et al*., 2013; Altieri *et al*., 2015; Hatt *et al*., 2016) as the causative factor of the current environmental crisis, which leads to the low sustainability of agriculture (Gliessman, 2013), soil degradation, loss of biodiversity due to simplification of the ecosystems (Hatt *et al*., 2016; Altieri *et al*., 2017) and the disturbance of the hydrological cycle; in this sense, agroecology, as science with multidisciplinary approach (Nieto *et al*., 2013), represents the resurfacing of socially, environmentally and culturally sustainable productive systems, through the promotion of ecological processes beneficial for the soil, water conservation and biodiversity management (Altieri *et al*., 2015; Altieri *et al*., 2017).

In the transition towards ecological agriculture, a predominant principle, according to the report by Blanco *et al*. (2013) and Nicholls *et al*. (2016), is the improvement in the transformation of the physical and chemical properties and in the biological functionality of the soil (Matienzo-Brito *et al*., 2015), because the capacity of a crop to withstand or tolerate the attack of pest insects and diseases is linked to the biological properties of this resource (Nicholls and Altieri, 2008).

According to Navarrete *et al*. (2011), the ability of the soil to support biological productivity should be evaluated based on its specific functionality, because it integrates the biological, chemical and physical components in certain management situations, which suggests a relation between biodiversity and productivity. These authors refer that the evaluation of soil quality allows to understand the degree to which management practices contribute to sustainability. From this approach, the soil macrofauna is an indicator for the appraisal of the efficiency of sustainable agriculture.

The soil macrofauna groups invertebrates larger than 2 mm of diameter (Cabrera-Dávila, 2012) and shows the following characteristics: sedentary habit, short-term variability in their diversity and population size (Cabrera-Dávila, 2014), a short period between generations, high density and reproduction capacity which allow intensive sampling. Such characteristics permit it to be used as monitoring and diagnosis indicator of the soil use intensity

(Díaz *et al*., 2014), its conservation or disturbance status and health (Cabrera, 2012; Vieira da Cunha *et al.,* 2012); as well as of the effect, in time, of productive practices (Socarrás and Izquierdo, 2014; Gómez *et al*., 2016), which is related to the report by Cabrera-Dávila (2014) about a higher variety and quantity of organisms in the soils with adequate management.

The objective of this study was to determine the diversity and functionality of soil macrofauna as biological indicator of soil health, in productive systems of *Moringa oleifera* Lam.

Materials and Methods

Geographical location and edaphoclimatic characteristics of the study area

The study was conducted between June, 2013, and March, 2014, in the experimental unit Santa Rosa of the National Agricultural University, geographically located in Managua, in the coordinates 12º 09' 30.65" N and 86º 10' 06.32" W, at an altitude of 50 m.a.s.l. (INETER, 2015)

The recorded historical annual mean rainfall and temperature are 1 099 mm and 27 ºC, respectively, and the relative humidity is 74 % (INETER, 2015); with predominance of two seasons defined by a dry season from November to April and a rainy season from May to October.

In 2013 the annual rainfall in the area was 1 070,4 mm (fig. 1), lower compared with the historical mean; June (285,3 mm) and September (330,2) were the months with higher rainfall (INETER, 2015).

The soil belongs to the taxonomic order Andosol; due to its textural class it is sandy loam-clayey, and it has good drainage.

Description of the experiments

The essays lasted nine months, with establishment date in June, 2013, and harvest date in March, 2014, time during which agroecological management and conventional agriculture practices were applied.

The area with agroecological management corresponded to a one-hectare lot, and the agroecosystem with conventional management consisted in a plantation area, with an extension of 5 ha; in both cases an effective sampling area of 0,18 ha was used. In each system four rectangular sampling units were delimited (15 x 30 m). The defined method for sampling the soil macrofauna was systematic with monoliths separated at 15 m between them, distributed in diagonal transept within the sampling units.

Adjacent vegetation with regards to the management systems

- Agroecological conversion. The agrosystem complementary flora was composed by living fences with such tree species as *Eucalyptus camaldulensis* (Dehnh.), *Azadirachta indica* (A. Juss.), *Cordia dentata* (Poir.), *Pithecellobium dulce* (Roxb.) Benth., *Albizia saman* (Jacq.) Merr. and *Stemmadenia obovata* (Hook. & Arn.) K. Shum.; while the surrounding lots corresponded to agricultural land use with *Moringa oleifera* (Lam.) and *Sorghum bicolor* (L.).

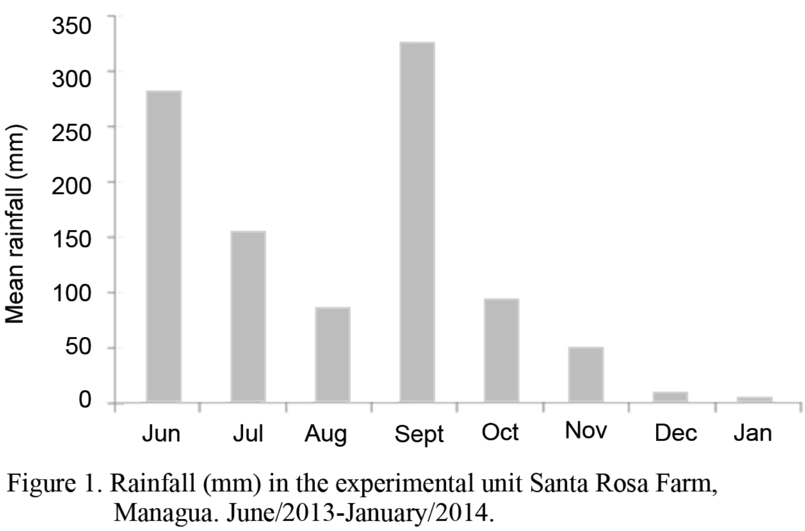

Figure 1. Rainfall (mm) in the experimental unit Santa Rosa Farm, Managua. June/2013-January/2014.

- Conventional management. The complementary flora was constituted by living fences with tree species such as *A. indica* (Neem), *Spondias* sp. and *A. saman*; while the surrounding lots corresponded to pasture production, like CT-15 and *Cynodon nlemfuensis* (Vanderyst.), in addition to such crops as *Saccharum officinarum* (L.), *M. oleifera* and *S. bicolor* (L.).

Experimental design and treatments. The design consisted in experimental units of rectangular shape, randomly selected. Each unit had plants established at a distance of 3 x 3 m, in lineal arrangement.

- Treatment 1. Conventional management, which consisted in an area of *M. oleifera* monocrop, with activities of mechanized soil preparation, mechanized and chemical weed control, inorganic fertilization and irrigation.
- Treatment 2. Agroecological conversion, whose approach was the establishment of a polycrop system, minimum tillage in soil preparation, legume rotation, organic fertilization with compost, incorporation of green manures, without irrigation, and weed control with legume cover.

Evaluations. Collections were made of the soil macrofauna before the harvest or the system exploitations. The collection period was between December, 2013, and January, 2014, at the end of the rainy season, defined from the criteria proposed by Cabrera *et al*. (2011).

For the collection the methodology proposed by the International Tropical Soil Biology and Fertility Program (Lavelle *et al*., 2003) was used. From each management system 12 soil monoliths of 25 x 25 cm were extracted, up to a depth of 30 cm.

The collected specimens were deposited in vials with alcohol at 70 %, and were later identified at phylum, class, order and family level, through the use of keys developed by Roldan (1988) and Castner (2000), in the biology laboratory of the School of Natural Resources and Environment.

The macrofauna was classified into detritivores, herbivores, soil engineers and predators, according to the functional groups proposed by Cabrera *et al*. (2011).

The results corresponded to the indicators: density (individuals per m^2) of each identified taxon and functional group, and diversity per management system; diversity and composition at family level were analyzed as indicators related to the soil health, according to Rendón *et al*. (2011), and their interaction to the *M. oleifera* crop.

For the evaluation of management systems, from the set of monoliths two samples were collected composed by 2 kg of soil and the chemical and physical properties were determined in the soil and water laboratory (LABSA) of the National Agricultural University (table 1).

Experimental procedure. The composition of the area with agroecological management was constituted by a *M. oleifera* plantation with density of 1 111 plants, managed in polycrop with rotations of *Canavalia ensiformis* (L.), *Canavalia brasiliensis* (Mart. ex Benth.), *Cajanus cajan* (L.) Millsp., and *Vigna unguiculata* (L.) Walp.

The establishment and management consisted in minimum tillage, manual weed control, organic fertilization with compost (N: 35 %; P: 0,22 ppm; K: 0,86 meq/100 g of soil; Cu: 96 ppm, and humidity: 32,07 %); 0,03 kg were applied to each plant at the moment of sowing and six months later, for a total application of 33,3 kg/ha, incorporation of legumes and harvest and weed residues, and weed and insect management through legume cover.

The conventional system corresponded to a *M. oleifera* plantation in monocrop with density of 1 111 plants/ha. The establishment and management were defined by a set of practices, such as mechanized

Table 1. Chemical and physical properties of the soil in two management systems of *M. oleifera* Lam.

Soil property	Conventional management	Agroecological conversion
pH	6,54	6,58
OM (%)	3,11	4,40
N (%)	0,14-0,16	0,16-0,22
P (ppm)	35,70	ND
Humidity (%)	48,60	43,87
Textural class	Sandy loam	Sandy loam clay

ND: not detected, pH: soil-water ratio 1:25, Hester (1930) en AOAC (1980). OM: humid combustion of Walkey and Black (1934), in AOAC (1980). N: Kjendalh (1883) in AOAC (1980). P: OLSEN (1954) in AOAC (1980). Texture: Bouyoucos hydrometer (AOAC, 1980). Humidity: drying in oven and weight difference AOAC (1980).

tillage in the soil preparation (weed control with weeder); soil turning, which consisted in three harrow activities; and soil breakup between 20 and 30 cm of depth for furrow elaboration, with mechanical sub-soil plow.

Inorganic fertilization was applied (N:15-P: 30-K:10 at a rate of 50 kg/ha) at the moment of sowing and after one year of establishment of the agrosystem; besides, sprinkler irrigation, pruning practices, pest control through inorganic chemicals (Cypermethrin 100) were used and weed control with weeder, with a frequency from two to three times during the essay, in addition to chemical control (herbicide 2-4-D and glyphosate).

Statistical processing. Non-parametric statistics (Kruskal-Wallis) was used to determine differences in the variation of density per taxon and functional group per management system. As part of the macrofauna diversity, at management system level for the taxa, classes and orders, the dominance index of the community (D) was determined through the method proposed by Turner and Garner (1991), with t-Student comparisons in the PAST program version 1.29.

A diversity analysis was made by the cluster method, to determine the probability of similarity of families per management system and Jaccard index. This index expresses the degree in which two or more samples are similar due to the species present in them, and it was used for the family level.

Results and Discussion

The system agroecological conversion recorded the highest taxonomic diversity of the soil macrofauna, with three phyla, five classes, nine orders and 19 families; compared with a phylum, three classes, two orders and four families identified in the conventional system (table 2).

The density of individuals was statistically different ($p < 0,05$) between management systems; 7 424 ind/m^2 were recorded in agroecological conversion, compared with 1 984 ind/m^2 in conventional management (table 2). This result coincides with the ones reported by Díaz-Porres *et al.* (2014) and Matienzo-Brito *et al.* (2015), who reported differences in the density and diversity of the soil macrofauna between diverse systems and simplified animal husbandry systems, with regards to intensive cropping systems, as consequence of the complexity and management of the systems. These authors found that with higher diversification there was higher biological activity, and this applies in this study to the agroecological conversion system.

At class level, the diversity components showed higher total density in agroecological conversion, associated to the dominance of specimens of the taxonomic group Insecta, which was expressed in significant differences ($p < 0,05$) in the community dominance index (D = 0,68); the dominance of the class Insecta was also observed in conventional management (D = 0,59, table 3).

Rendón *et al.* (2011), when analyzing the dominance of the phylum Arthropoda, and within it of the class Insecta, explained that its reproductive, feeding habits and its distribution and ecological intervention at soil level make it useful as biological indicator of the status of such resource.

The richness of classes was higher in agroecological conversion (five classes), compared with conventional management and, thus, low similarity probability was determined (J = 0,16) between the management systems.

Sheibani and Gholamalizadeh (2013) reported that the soil turning during tillage has effects on the physical-chemical indicators that promote the functional diversity of the macrofauna; while Ayuke *et al.* (2009) and Díaz-Porres *et al.* (2014) associated the low diversity of the soil macrofauna to such management practices as the use of agrochemicals and the modification (simplification) of the habitat when establishing *M. oleifera* in monocrop, elements which allow to explain the low equity values recorded.

The lower diversity in agroecological conversion, compared with the results reported by Ayuke *et al.* (2009), was ascribed to the age of the system. In this regard, Nicholls *et al.* (2016) stated that productivity based on the functional diversity tends to be low during the first three to five years in diversification schemes, compared with conventional management, to be later increased due to efficient designs regarding facilitation relations among crops, which contributes not only to the increase of diversity, but also to its functionality in favor of the system.

The above-explained fact is an indicator of the progressive increase in the diversity values as part of the evolution of the system, according to Nicholls *et al.* (2016), who recorded decrease of diversity after a few years of starting the practices based on organic inputs, crop rotation and incorporation of legumes.

In this sense, it is stated that biodiversity in agriculture differs among agroecosystems, which in turn differ in indicators relative to establishment time, constitution of the species and sustainable practices.

Table 2. Taxonomic classification, trophic groups and diversity of soil macrofauna organisms in two management systems.

Management system	Phylum	Class	Order	Family	Density (ind/m^2)	Relative density (%)	Trophic group
Agroecological conversion	Anellida	Oligochaeta	Haploxida	Lumbricidae	352	4,74	Engineer
	Arthropoda	Malacostraca	Isopoda	Armadillidiidae	432	5,81	Detritivore
	Arthropoda	Diplopoda	Julida	Julidae	96	1,29	Detritivore
		Insecta	Coleoptera	Elmidae	176	2,37	Detritivore
				Chrysomelidae	16	0,22	Engineer
				Curculionidae	16	0,22	Engineer
				Dermestidae	16	0,22	Detritivore
				Scarabaeidae	576	7,76	Herbivore
				Hydrophilidae	16	0,22	Detritivore
				Ptilodactylidae	448	6,03	Detritivore
			Diptera	Drosophilidae	16	0,22	Detritivore
				Noctuidae	16	0,22	Herbivore
			Hymenoptera	Formicidae	784	10.55	Engineer
				Vespidae	32	0,43	Herbivore
			Isoptera	Termitidae	3 600	48,49	Engineer
	Mollusca	Gastropoda	Mesogastropoda	Physidae	16	0,22	Detritivore
				Planorbidae	16	0,22	Detritivore
				Thiaridae	352	4,74	Detritivore
		Gastropoda	Littorinimorpha	Hydrobiidae	448	6,03	Detritívoro
				D = 0,21a H' = 1,86a J = 0	∑7424a	∑100	64,22 % SE 27,37 % Det 8,41 % Her
Conventional	Arthropoda	Arachnida	-	Salticidae	464	23,39	Predator
		Chilopoda	Scolopendromorpha	Scolopendridae	48	2,42	Predator
		Insecta	Trichoptera	Hydropsychidae	272	13,71	Detritivore
				Leptoceridae	1 200	60,48	Detritivore
				D = 0,43b J= 0	∑1 984b	∑100	74,19 % Det 25,81 % Pre

D: dominance index at community level, J: Jaccard index, H': Shannon-Wiener index
SE: soil engineer, Det: detritivore, Her: herbivore, Pre: predator

Table 3. Density and diversity of classes and orders of the soil macrofauna in two management systems.

Taxonomic group	Management system			
	Agroecological conversion		Conventional management	
Class	Density (ind/m²)	Diversity	Density (ind/m²)	Diversity
Malacostraca	432	Dominance index D = 0,68[a]	NR	Dominance index D = 0,59[b]
Insecta	5 712		1 472	
Diplopoda	96		NR	
Chilopoda	NR	Similarity index J = 0,16	48	Similarity index J = 0,16
Gastropoda	832		NR	
Arachnida	NR		464	
Oligochaeta	352		NR	
Order		Dominance index		Dominance index
Haploxida	352	D = 0,33[a]	NR	D = 0,93[b]
Isopoda	432		NR	
Julida	96		NR	
Isoptera	3 600			
Coleoptera	1 264		NR	
Diptera	32		NR	
Hymenoptera	816	Similarity index	NR	Similarity index
****	NR		464	
Mesogastropoda	384	J = 0	NR	J = 0
Littorinimorpha	448		NR	
Scolopendromorpha	NR		48	
Trichoptera	NR		1 472	

Equal letters in the rows indicate not significant differences in the index value.

NR: not recorded, **** unidentified Arachnida order.

The class Insecta recorded the orders with higher representativeness, in which Isoptera (3 600 ind/m²), Coleoptera (1 264 ind/m²) and Hymenoptera (816 ind/m²) stood out for their high density in the agroecological conversion management. These orders, according to Ayuke *et al.* (2009), occupy an important proportion at soil macrofauna level, which confers a good transformation dynamics of soil properties in this management system; in contrast, in conventional management Trichoptera (1 472 ind/m²) showed the highest density.

Due to the higher density of Trichoptera, the dominance index of the community recorded a higher value (D = 0,93) in conventional management, compared with agroecological conversion (D = 0,33), with significant differences ($p < 0,05$) between the systems; there was no probability of similarity between management practices, because they did not show common orders (table 3). The low value of the dominance index in agroecological conversion proved that the structure with different strata, low-impact management and, thus, habitat diversity and quality promote equity in the distribution of the soil macrofauna and high potential of interactions within the system.

The diversity of families was different between systems. In that sense, the community dominance (D = 0,43) was approximately double in conventional management, compared with agroecological conversion (D = 0,21); for which, in the latter management system, equity in the density of individuals per family was higher (H' = 1,86 *vs.* 1,0; $p < 0,05$).

From the 19 identified families in agroecological conversion, eight represented 94,15 % of the population of the soil macrofauna (table 2); among which Termitidae (48,49 %), Formicidae (10,55 %) and Scarabaeidae (7,76 %) stood out. The dominance of these families was reported by Ayuke *et al.* (2009) and Cabrera *et al.* (2011), with representatives that perform important functions within the agrosystems, from the point of view of participation in the regulation of the physical-biological dynamics of the soil, as well as in their interaction with the crops, mainly as pest organisms.

In conventional management, from the four identified families, Leptoceridae represented 60,48 % of the macrofauna population, followed by Salticidae (23,39 %) and Hydropsychidae (13,71 %); while Scolopendridae was the family with lower proportion of individuals.

Different authors, among them Díaz-Porres *et al.* (2014), proved that the incorporation of harvest waste, especially when they have high nitrogen content (legumes), promotes an increase in the density of individuals. On the contrary, when in the system there is high cover of pastures, which frequently have high C/N ratio (Díaz-Porres *et al.,* 2014), the density is lower. The results of this study coincide with the above-presented report, because in agroecological conversion periodical incorporations to the soil of legumes and pruning waste from *M. oleifera*, whose leaves have high nitrogen content (2 g in 100 g of fresh matter) were made; while in conventional management, the soil cover was mainly star grass (*C. nlemfuensis*).

The distribution of families per functional group was different between management systems with predominance of soil engineers (64,22 %) and detritivores (27,37 %) in agroecological conversion; and of detritivores (74,19 %) and predators (25,81 %) in conventional management (fig. 2).

Matienzo-Brito *et al.* (2015) stated that the number of functional groups differs due to the complexity in the composition of the ecosystems, with advantage for the diversified systems with management of axillary biota; this allows to explain the presence of groups with functions of biomass accumulation and transformation, such as soil engineers and detritivores. In that sense, Díaz-Porres *et al.* (2014) concluded that the conditions with higher influence on the diversity and functionality of the soil macrofauna groups are the organic matter content and the carbon/nitrogen ration contained in the soil.

Association has been reported between the predominance of detritivores and the little intensive soil use and, thus, with good organic matter content (fig. 2), contributes complementarily to the function of soil engineers, and confirms that the difference in the composition of functional groups was associated to the habitat conditions.

The proportion of detritivores confirmed the organic matter content recorded in the soil analysis (table 1) for both systems, as well as its quality regarding the N content and decomposition status, because representative species of the families Hydrobiidae, Hydrophilidae and Physidae are indicators of sites with decomposing sediments (manure, snail excreta and decomposing plant material).

Soil humidity (table 1) was a condition which, according to Cabrera *et al.* (2011) and Matienzo-Brito *et al.* (2015), influenced the presence of certain organisms. This factor was assumed due to the presence of snail families, such as Hydrophilidae, Planorbidae and Leptoceridae, in conventional management (table 2); and of water coleopterans, like Elmidae, in agroecological conversion (table 2). Some

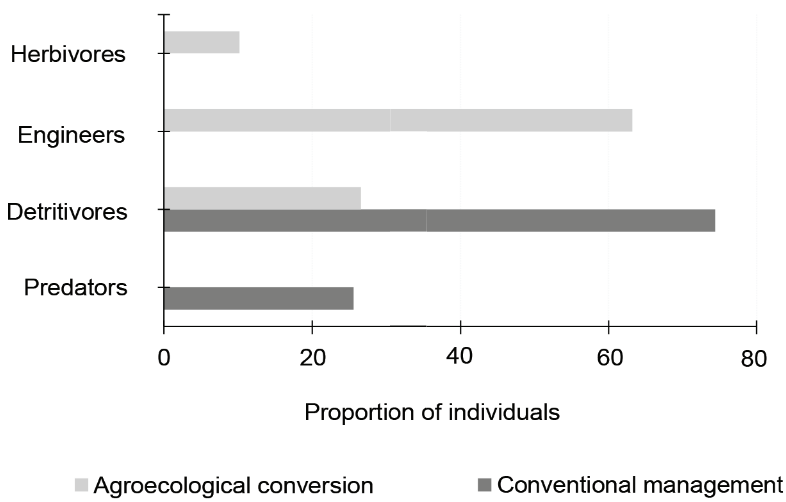

Figure 2. Proportion of individuals per functional group, recorded in two management systems of *M. oleifera*.

species show a distribution associated to flooded sites or in water without current and to humid environments; for which they are useful as indicators of soil humidity, of the decomposition degree of organic matter and, thus, of the available nutrients in the system.

The effect of a high presence of detritivores is related to their feeding activities, because, as part of the trophic network in agrosystems, this functional group increases the efficiency of the mobility and acquisition of nutrients by the plants; this influences indirectly the presence of leaf-eating insects and crop pests (Altieri and Nicholls, 2003), condition that is not desirable from the point of view of crop health and productivity.

In practical sense, detritivores make efficient the concentration of resources expressed in biomass, organic matter and, thus, available nutrients for the plants, for which the concentration of resources attracts more potential pest organisms; however, the activities of diversification, crop rotation and promotion of natural enemies contribute to the decrease of pests and, thus, to the productive sustainability of the systems.

Silva *et al.* (2012) concluded that the diversity of predators, which in this study was composed mainly by the classes Arachnida (Fam. Salticidae, 23,39 %), Arthropoda (family Formicidae, 10, 55 %) and Chilopoda (family Scolopendridae, 2,42 %), indicates availability of prey. Due to their epigeal habit, they functionally contribute to the regulation of populations of potential pest species, condition which was also reported by Díaz-Porres *et al.* (2014) in agricultural systems, compared with naturalized systems.

An important population of tailless whip scorpions was recorded in the agroecological conversion system, as well as predators of the family Formicidae, which influenced a high proportion of herbivores, in spite of the existence of a high concentration of resources (diversity of legumes and weeds, among others). This allows to prove that the reduction of pest populations in agroecological systems is a consequence of the nutritional changes induced in the crop by organic fertilization, as well as of the increase of natural pest controls (Altieri and Nicholls, 2003).

The remarkable incidence of individuals of the family Formicidae in agroecological conversion was due to the presence of *M. oleifera*, legumes and flowering weeds; this group, called soil engineers, indicates particular conditions, such as the degree of disturbance of the ecosystem and, in turn, the potential interaction between crops and organisms.

Chávez *et al.* (2016) stated that Formicidae individuals are organisms of remarkable specific diversity, because they are commonly found in high density and constitute useful indicators, because they experience fast responses to different agricultural practices.

On the other hand, Castro *et al.* (2008) reported that high densities of Formicidae (leaf-cutter ants) can move the same quantity of soil as earthworms, this explains the fact that, in the management systems *Solenopsis* sp. and *Camponotus* sp. transported detritus originated by the decomposition of *M. oleifera* and the legumes into the soil.

Regarding the interaction of *M. oleifera* with Formicidae representative organisms, the plant phenology, manifested in two profuse annual flowerings, guaranteed the presence and functionality of this family; which was shown in activities such as defoliation, which had higher incidence on young plants, and the foraging of flowers in adult plants, mainly in the dry season. The predation of individuals of the Formicidae family by small spiders of the family Salticidae was also observed, with which one of the population regulation mechanisms was identified.

As part of the functional group soil engineers, the density of Termitidae in agroecological conversion shows the conditions under which this system was originated, regarding the predominance of shrubby vegetation of forestry fallow, leading to the concentration of branches and other organic material, favorable for the proliferation of these organisms.

The interaction of organisms from the Termitidae family with *M. oleifera* was negative, because Termitidae constituted a pest that quickly weakened the plants of different ages and led to the dry rot of branches and stems. Associated to the parasitism of Termitidae on *M. oleifera*, Lepidoptera larvae appeared which exerted herbivory, in addition to Hydrobiidae that acted as detritivore.

The incorporation and continuous existence of litter in the soil in the form of harvest wastes increased the density of some Formicidae orders, which transported them into the soil; and in the process predation of other macrofauna organisms, such as Termitidae and Coleoptera larvae, occurred. Other predators, like Julidae and Scolopendridae, used the galleries to exert their function, the former in the comminution of plant remains (Chávez *et al.*, 2016).

Contrary to the report by Leyva-Rodríguez *et al.* (2012) and Cabrera (2012), humidity did not influence the presence of Oligochaeta, although low abundance of earthworm was observed in agroecological conversion; this coincides with the values reported by Matienzo-Brito *et al*. (2015) in diversified plots, in systems of soil use conversion from conventional to agroforestry, which showed low density at first and an evident increase 10 years after conversion. Individuals from this functional group were not recorded in the conventional management system.

Chávez *et al*. (2016) stated that the presence of Coleoptera is important, because it participates in the comminution of plant wastes, for which it is an indicator of biomass and organic matter accumulation. The presence of herbivores, mainly Coleoptera larvae (family Scarabaeidae, *Phyllophaga* ssp.), was associated to different agricultural soil uses and, according to Leyva-Rodríguez *et al*. (2012), to the incorporation of wastes and to litter quality, as a product of the presence of trees and shrubs with high protein levels in the systems.

The interaction between Scarabaeidae larvae and adults with *M. oleifera* in conventional management and with *M. oleifera* plus legumes in agroecological conversion was different between the growth stages, because in larval stage they fed from the roots of young plants; while in adult stage the species *Cotinis mutabilis* fed from the nectar of *M. oleifera* and of the legumes, which contributed to the pollination process.

Noctuidae, for being represented by larvae or caterpillars that live on the soil and feed from leaves, flowers, fruits and sometimes from seeds, represented affectation risks for the *M. oleifera* crop in the initial growth stage, but, on the other hand, some species in adult stage participate in the pollination processes of companion tree species and, thus, attract pollinators to the system.

Conclusions

The number of taxonomic units, soil macrofauna density and diversity constituted indicators that allowed to distinguish between the agroecological management and conventional agriculture of *M. oleifera*.

Likewise, the high proportion of individuals from the functional groups soil engineers and detritivores in agroecological conversion was an indicator of good soil health, as well as of a remarkable dynamics of physical-biological transformation.

In systems with conventional management, the lack of individuals from the functional group soil engineers originated a slow physical-biological transformation, in spite of the high organic matter decomposition made by the dominance of detritivores.

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