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Araştırma

TERRESTRIAL ISOPODS DIVERSITY RELATED TO IRRIGATION AND AGRICULTURAL PRACTICES IN NORTH-EAST OF TUNISIA

M. FRAJ[1,2,*] F.C. CHEIKHROUHA[1] C.S. GROSSET[2]

[1] Université de Tunis el Manar II, Unité de Recherche de Biologie Animale et Systématique Evolutive, Campus Universitaire, 2092 Tunis, Tunisie
[2] Université de Poitiers UMR CNRS 6556, Laboratoire Ecologie, Evolution, Symbiose, 40 avenue du Recteur-Pineau, 86022 Poitiers cedex, France
***e-mail: frajmehdia@gmail.com**

Abstract: Environmental factors and land-use affect soil biological communities and their functions. Terrestrial Isopods (woodlice) are detritivorous and reliable bio indicators of habitat quality and soil capacity production. In order to evaluate the effect of different irrigation practices, woodlice richness (S), diversity indices (H' and J') and their relative abundance (A) were studied according to 3 types of irrigation (drip, surface mode and sprinkler) in 16 plots and 9 different types of cultivation: market gardening (artichoke, tomato and melon); vegetable crop (alfafa, sorghum and maize) and fruit-trees (apple, pear and olive) in the Majerda low plain (North-East Tunisia). Pitfalls were used to collect woodlice during 3 weeks (from 22nd August to 09th September 2008). Physico-chemical analyses were performed from soil sampled in each plot. According to the type of irrigation, 7 species of terrestrial Isopods were listed and their richness (S) was very important in the case of sprinkler. The mean relative abundance of *Porcellio laevis* was very important when the surface mode of irrigation was used. For both *Porcellio variabilis* and *Porcellionides sexfasciatus* it was respectively with sprinkler and drip. Both Shannon's diversity and Equitablity indices were higher with the sprinkler mode. According to the type of cultivation, species richness was higher in the alfafa and maize cultivation. *Porcellionides pruinosus, Chaetophiloscia. elongata*, *Armadillidium sulcatum* and *Leptotrichus panzeri* were the less abundant in each type of cultivation. The mean Isopods diversity revealed that their diversity was higher in the sorghum cultivation. Moreover, a relationship between the soil features and a relative abundance of terrestrial Isopods was described.
Key Words: Terrestrial isopods, Irrigation systems, Cultivation types, Soil analyses, Tunisia.

1. INTRODUCTION

The Madjerda Valley is the most important river in Tunisia. In it's a low plain where the agriculture is among the oldest practice in the country (Abbes *et al.*, 2005). In fact, 51% of the population in this site is composed of farmers. The irrigated cultivation is the major component of the evolution of agriculture in Tunisia (40% of total agricultural production). It is also the case of the low plain where most of farmers used the irrigated agriculture (21.317 ha among 29.761 ha of cultivated area) (Report of Wadi project).

In each agroecosystem, soil fauna is an important component to sustain health soil and quality for improved agricultural productions (Moron-Rios 2010). The majorities of this soil fauna are invertebrate members of the decomposer community (Herrick, 2000; Wolter, 2001). Among edaphic organisms, terrestrial Isopods are fundamental representative of soil fauna playing an important role in decomposing leaf litter and in mineralizing organic matter (Hassall & Sutton, 1978; Sutton, 1980) in agroecosystems. But some agricultural activities, such as the drainage, create habitat changes and reduce available leaf litter. Consequently, the species composition, abundance and diversity of beneficial soil species were affected (McLaughlin & Mineau, 1995; Santos *et al.*, 2006; Souty - Grosset *et al.*, 2005). It has been mentioned that the specific diversity and abundance of terrestrial Isopods were influenced by the agriculture practices such as tillage, drainage, fertilizer, pesticides (Paoletti & Hassal, 1999).

The objective of this study was to estimate the biodiversity of terrestrial Isopods related to the type of cultivation and the mode of irrigation in order to assess the effect of these two agricultural practices on their community in the North-East of Tunisia. Thus Isopods were used as bioindicators to improve the soil quality and also in order to sustain soil biodiversity enhancing the agricultural production and the protection of the environment.

2. MATERIAL AND METHODS

2.1. Study Area

The study site is an agricultural area of the Majerda low plain, located in the North-East of Tunisia (Figure 1), between the city of Bizerte and Tunis.

This site belongs to the upper semi-arid region. The climate is Mediterranean. The annual average of precipitation was 433mm, the average of temperature varied between 11 and 27°C and the relative moisture was between 65 and 80 %. The low valley of Majerda has a great economic and social importance and soil fauna was an important component of this agroecosystem. In this site, agricultural practices are not only market guarding -vegetable crop often associated with a dairy breeding- but also fruit trees, olive, cereals and other annual cultivation, particularly vegetables. In this region, the operating system was based on the water with an important activity of the irrigation. The surface system of irrigation is the most common used (Abbes *et al.*, 2005).

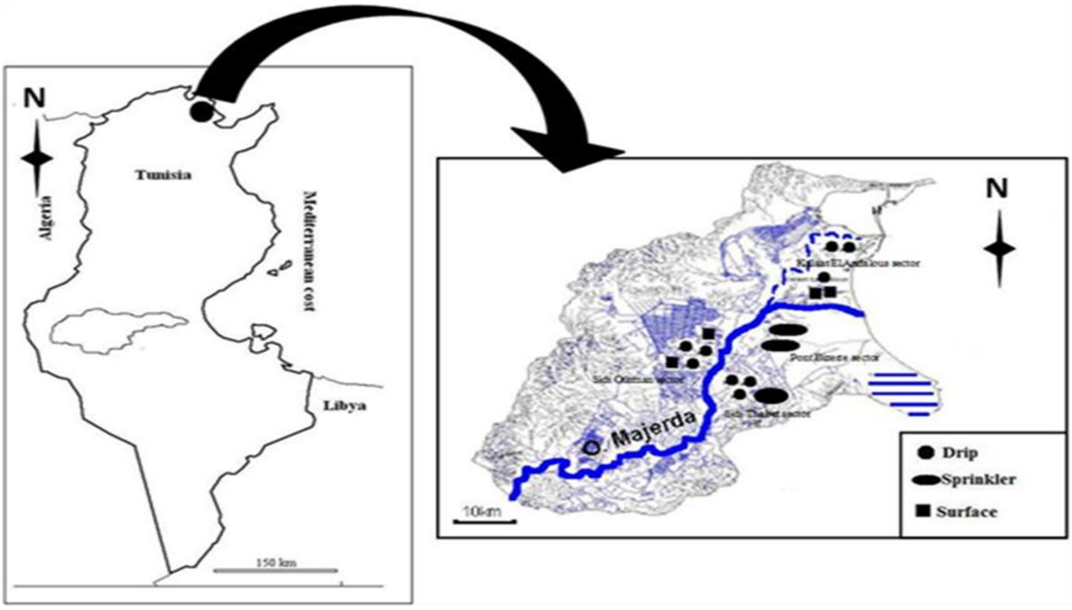

Figure 1. Study site and modes of irrigation

2.2. Methods

Sampling was performed in 16 plots and 9 different types of cultivation which were accounted: market gardening (artichoke, tomato and melon); vegetable crop (alfafa, sorghum and maize) and fruit-trees (apple, pear and olive). In the whole studied plots, 3 modes of irrigation were used: drip, surface and sprinkler mode (Table 1).

Pitfalls traps (plastic cups, 7 cm of height, 5.5 cm of diameter, 1/4 filled with ethylene glycol 70%) (Figure 2) were used to collect woodlice during 3 weeks (from 22nd August to 09th September 2008). This methodology is commonly used as a substitute of true quantitative sampling methods (Duelli *et al.*, 1999; Paoletti & Hassall, 1999; Perner & Schueler, 2004). In fact, this sampling procedure measures epigeic activity of soil-dwelling animals (Santos *et al.*, 2007; Sfenthourakis *et al.*, 2005; Zimmer et *al.*, 2000). This technique has some advantages: it is simple, economic and works continuously through day and night (terrestrial Isopods being nocturnal), allowing many samples to be taken (Lobry de Bruyn, 1999). All trapped individuals were preserved in 70% ethanol, counted and species identified under Leica MS 5 binocular microscope.

Samples of the soil were taken in every statement of the traps and mixed to obtain a composite from each plot. pH water and pH KCl were measured using pH meter EUTEH instruments (pH510). Carbon (C) and nitrogen (N) were analyzed using elemental analyzer. The C/N of soil is important to know the status of mineralization of organic matter.

2.3. Data Analysis

Relative abundance [A (%): number of individual of species i (ni)/total number of woodlice captured (N)] and species richness (S: total number of species) were calculated according to the type of irrigation and cultivation.

Diversity was measured using the Shannon–Wiener index H' and equitability J'

$$H' = -\sum_{i=1}^{S} [ni/N * \ln ni/N] \quad (1)$$

ni :meaning the number of individuals of the species *i*

N: total number of individuals of all species

S: Total number of species

$$J' = H'/\log_2 S \quad (2)$$

Difference of species richness between different type of cultivation and the different irrigation system was tested using one-way ANOVA analysis.

3. RESULTS AND DISCUSSION

Seven woodlice species belonging to three families (*Armadillidiidae*, *Porcellionidae* and *Philosciidae*) were collected in the 9 types of cultivation examined (Tab. 2A). Clear differences- species richness, abundance and diversity were noted between study plots (Table 2 (A, B) and 3, Figures, 2, 3, 4 and 5). According to the type of cultivation, *Porcellio laevis*, *Porcellio variabilis* and *Porcellionides sexfasciatus* dominanted over 50%. The others species did not exceed 10% (Figure 2).

Terrestrial Isopods in olive tree, alfafa and melon cultivation, were dominated, respectively, by *Porcellio variabilis* (A=84%), *Porcellio laevis* (A=83%) and *Porcellionides sexfasciatus* (A=82%). Whereas *Porcellionides pruinosus*, *Chaetophiloscia elongata*, *Armadillidium sulcatum* and *Leptotrichus panzeri* were less abundant in each type of cultivation. The highest average species richness was recorded in the alfafa and maize (S= 5 in one plot studied) cultivation (Tab. 3) and the lowest one in the artichoke (S=2.2±0.84). These values were not statistically different. The average diversity indices fluctuated between H'= 0.66±0.48; J'= 0. 66±0.48 in the apple tree (Tab. 3) and H'=1.46; J'=0.73 in the sorghum cultivation (in one plot studied). Differences, observed between different types of cultivation, confirms the results of Cortet *et al.* (2002) who found that some soil arthropods (collembolans) were influenced by the type of cultivation and rotation.

Related to irrigation systems, (Figure 3) the highest mean relative abundance of *P. laevis* was recorded in the surface (A=69%) and drip (A=39%) mode of irrigation. Whereas, in the sprinkler system, *P. variabilis* is the dominant species (A=49%). Mean species richness of woodlice (Figure 4) was more important in sprinkler mode of irrigation (S=4.67±1.33) than in surface (S=2.75±1.04) and drip (S=2.56±0.83) systems. In the sprinkler irrigation, richness species was significantly more important than in drip and surface systems (ANOVA test; $p<0.05$). Diversity index (H’) and Evenness (J’) were higher in sprinkler mode (H’=1.12±0.29; J’=0.52±0.18) than in surface (H’=0.72±0.33; J’=0.64±0.40) and drip (H’=0.85±0.5; J’=0.61±0.38) systems (Figure 5). Similarly, Moron-Rios *et al.* (2010) indicated the effect of irrigation on decomposers animals such as Oligochaeta, Diplopoda and Isopoda.

The influence of the irrigation system on the woodlice richness was also mentioned in previous investigations (Fraj, 2008 *unpublished*) in some oasis plots of Kebili region (S-W of Tunisia). The traditional mode favored the Isopod richness compared to the modern one. The difference of species richness related to the mode of irrigation could be explained by the fact that, in drip and surface systems, soil moisture exceeded the optimum survival of terrestrial Isopods.

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Table 1. Characteristics of studied plots

Number	Locations	Code plots	Latitude/Longitude	Cultivation	area (ha)	Irrigation
1	Kalaat El Andalous	Art KA1	N37°06’4.26’’ E010°09’16.9’’	Artichoke	0,75 ha	Drip
2	Kalaat El Andalous	Art KA2		Artichoke	1ha	Drip
5	Kalaat El Andalous	Art KA3	N37°04’42.4’’ E 010°07’50.4’’	Artichoke	1ha	Drip
6	Kalaat El Andalous	Pea KA4		Pear tree	2,5ha	Surface
7	Kalaat El Andalous	App KA5		Apple tree	2,5ha	Surface
8	Sidi Thabet	Alf ST1	N36°56’07.6’’ E 010°02’35.1’’	Alfafa	1 ha	Sprinkler
9	Sidi Thabet	Art ST2	N36°57’07.7’’ E010°01’46.6’’	Artichoke	1,5ha	Drip
10	Sidi Thabet	Mel ST3		Melon	3ha	Drip
11	Sidi Thabet	Tom ST4		Tomato	1,5ha	Drip
12	Sidi Othman	Art SO1	N36°56’04.0’’ E 009°53’59.3’’	Artichoke	15ha	Drip
13	Sidi Othman	App SO2		Apple tree	5ha	Surface
14	Sidi Othman	Oli SO3		Olive tree	6ha	Drip
15	Sidi Othman	Pea SO4		Pear tree	3ha	Surface
16	Sidi Othman	Tom SO5		Tomato	7ha	Drip
15	Pont Bizerte	Sor PB1	N36°58’58.4’’ E 10°03’53.6’’	Sorghum	3ha	Sprinkler
16	Pont Bizerte	Mai PB2		Maize	1ha	Sprinkler

Table 2. The relationship between pH, C/N soil and relative abundance of terrestrial Isopods

		Art KA1	Art KA2	Art KA3	Pea KA4	App KA5	Alf ST1	Art ST2	Mel ST3	Tom ST4	Art SO1	App SO2	Oli SO3	Pea SO4	Tom SO5	Sor PB1	Mai PB2
(A)	*P. laev*	98%	100%	50%	40%	94%	83%	25%	8%	0%	16%	50%	0%	90%	50%	23%	8%
	P. vari	0%	0%	0%	0%	0%	3%	17%	8%	25%	76%	50%	84%	7%	50%	63%	82%
	Ps. prui	0%	0%	0%	0%	0%	1%	0%	0%	25%	0%	0%	2%	1%	0%	0%	6%
	Ps. Sexf	2%	0%	50%	60%	6%	10%	58%	83%	50%	8%	0%	10%	1%	0%	10%	2%
	C. elon	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	5%	2%
	A. sulc	0%	0%	0%	0%	0%	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	L. panz	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	4%	1%	0%	0%	0%
(B)	pH water	7,68	7,96	7,92	7,9	7,68	7,67	7,74	7,9	7,84	7,75	7,85	7,73	7,9	7,87	7,67	8,01
	pH KCl	7,29	7,46	7,58	7,58	7,53	7,4	7,61	7,52	7,75	7,67	7,65	7,58	7,63	7,61	7,58	7,38
	C/N	0,00	7,35	9,39	7,87	8,06	7,87	8,14	12,21	7,77	8,78	9,12	0,00	8,13	10,38	8,02	7,73

A: Average of relative abundance of terrestrial Isopods
B: pH water, pH KCl and C/N of soil

Table 3. Average species richness (S), diversity (H') and evenness (J') related to the type of cultivation, (± standard deviation)

	S	H'	J'
	2,2±0,84	0,70±0,61	0,52±0,44
Artichoke	3,5±1,24	0,77±0,44	0,61±0,37
Pear tree	2,5±0,7	1,25±0,35	0,97±0,97
Tomato	2	0,66±0,48	0,66±0,48
Apple tree	4	0,84	0,42
Olive tree	5	0,92	0,40
Alfafa	4	1,46	0,73
Sorghum	5	0,99	0,43
Maize	3	0,82	0,52

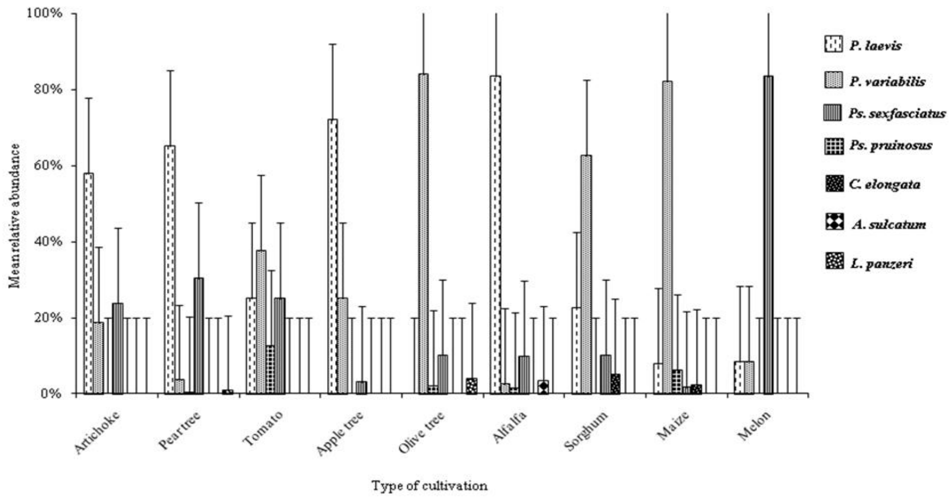

Figure 2. Mean relative abundance of terrestrial Isopods related to cultivation type

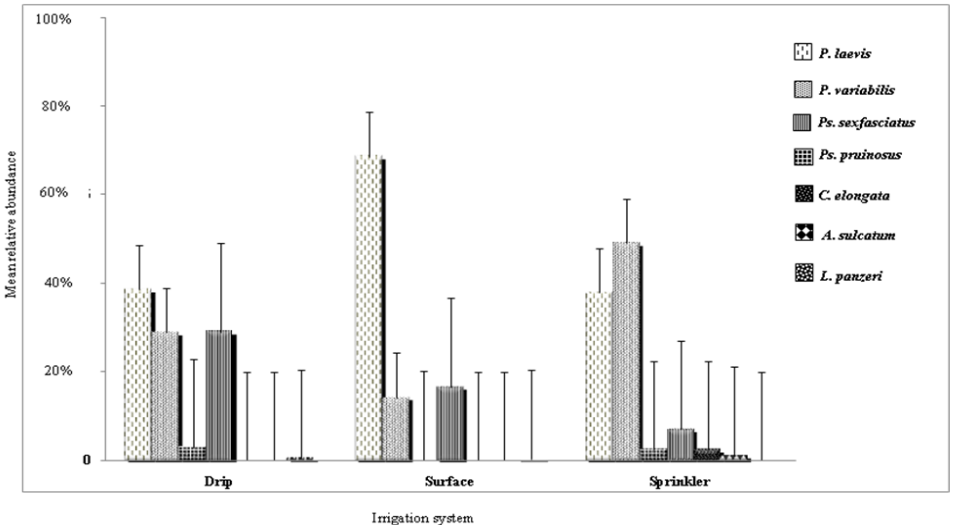

Figure 3. Mean relative abundance related to irrigation system

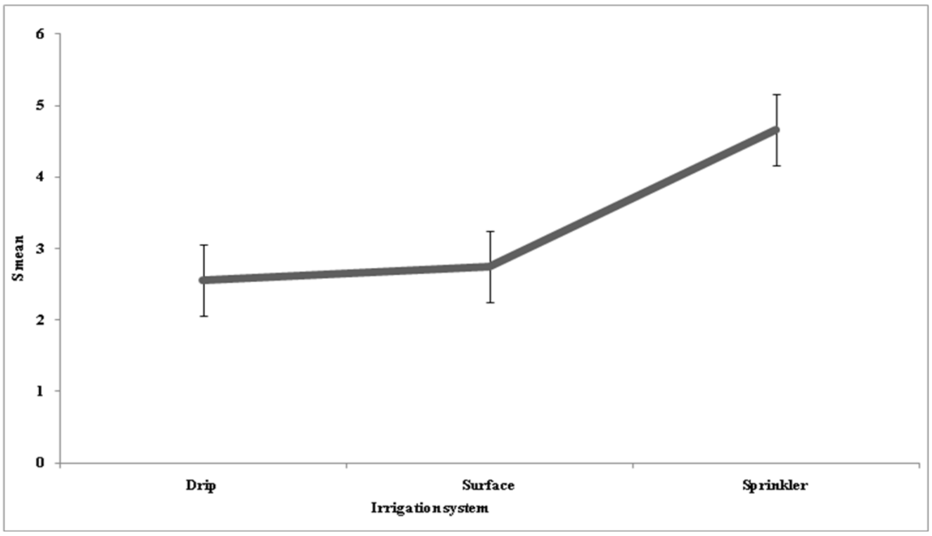

Figure 4. Mean species richness related to irrigation system

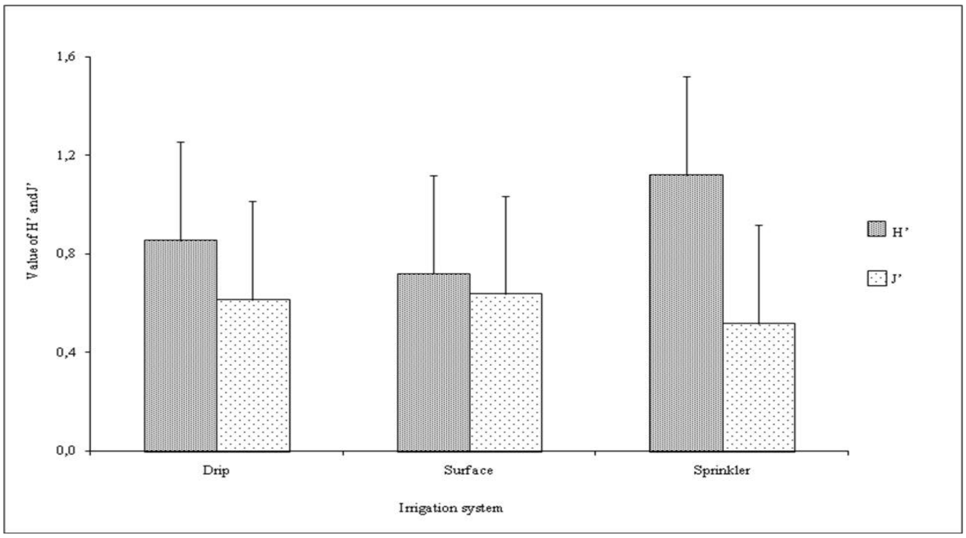

Figure 5. Shannon and equitability indices related to irrigation system

Moreover, the nature and the physicochemical properties of soil were also very important factors. Hassall *et al.* (2006) indicated that pH of soil was the only environmental variable for which the number of terrestrial Isopods per plot was relatively significant. In the present study, a relationship between the soil features and a relative abundance of terrestrial Isopods was detected. pH water and pH KCl varied within studied plots. *P. variablis* was a very abundant species in maize (Maize PB1: pH water=8.01) and artichoke (Art SO1: pH KCl=7.67) (Tab. 2B). Compared to *Oniscus asellus*, which is an acidophil species (Van Straalen & Verhoef, 1997), *P. variabilis* will be considered as an alkaline species. *P. laevis* was the most abundant species in the Alf ST1 and Sor PB1 plots with low values of pH water (7.67) and pH KCl (7.29). Contrary to Carabidae, Isopods have been shown to react to variations in pH water and pH KCl (Souty- Grosset *et al.*, 2005).

Our results showed that *Ps. sexfasciatus* was the most abundant species in the plot with the highest value of C/N (Mel ST3: 12.21). However, *P. laevis* and *P. variabilis* were abundant in the soil with C/N equal to 0. For cultivated soil, the C/N was about 9 when the mineralization was good. But, for a report value equal or greater than 12, mineralization process was bad (Baize, 2000). In the melon cultivation where *Ps. sexfasciatus* was very abundant, the mineralization process was very bad. In the artichoke and olive cultivation, the C/N reveals good mineralization. According to these preliminary results, the two species, *P. laevis* and *P. variabilis* will be considered as bioindicators and a useful tool to determine the soil quality.

4. CONCLUSION

Our results showed that agricultural practices influenced diversity of terrestrial Isopods in the Madjerda low plain. The mode of irrigation has an effect on the abundance and distribution of woodlice at different types of cultivation. The sprinkler irrigation may be considered a good system to Isopods diversity conservation. Thus, our study also shows that cultivation type affected woodlice community. Indeed, differences in Isopods richness, abundance and diversity were observed between market gardening, vegetable crop and fruit-trees cultivation. This study underscores that woodlice community of agricultural area constitutes a useful tool to sustain the soil health and quality. These data provide to the scientists the necessary information to evaluate the impact of some agricultural activities on soil fauna and will aid farmers to adapt the appropriate practices inducing a more sustainable agricultural production. In order to confirm these results, works are in progress by studying other types of cultivation and other systems of irrigation.

5. ACKNOWLEDGEMENT

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