

**Perceptions on soil macrofauna in the agricultural field**

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**Abstract summary**

In this study we have evaluated social perceptions on soil macrofauna among farmers and other stakeholders working in an agricultural context in Brazil. During the National No-Tillage Meetings of 2008 and 2018, we have interviewed a total of 171 people (87 in 2008 and 84 in 2018), where 35 percent were farmers (33 percent in 2008, and 36 percent in 2018). A questionnaire with 12 questions was used to determine the profile of interviewees, their soil management practices and perceptions regarding soil macrofauna. From a list of nine soil organisms only earthworms, spiders and centipedes, generally, were not considered pests. When asked about pest incidence, 61-73 percent of the interviewees noticed an increase, mostly related to the excessive use of pesticides (25-33 percent) and monocultures (38-55 percent) for both years. When asked about soil health indicators, more than 80 percent mentioned the presence of a large number of taxa, even including some that were considered pests earlier. The results showed a significant increase in pest incidence after 10 years, together with a decreasing trend in prevalence of good practices. This is profoundly worrisome and highlights the urgent need to foster capacity building and to stimulate more effort in dissemination of information about the importance and function of soil biodiversity, and their vast benefits to society.

*Keywords: Bioindicators, soil quality, soil macrofauna*

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**Introduction, scope and main objectives**

Soil is the habitat for several organism and holds one quarter of the world biodiversity, considered by many to function as a living organism (Harshberger, 1911, Decaëns *et al.*, 2006). The soil fauna can be divided into well-defined groups according to body size: microfauna, mesofauna and macrofauna, each providing a unique contribute to soil functioning, in particular to the food web (Swift, Heal and Anderson, 1979, Lavelle, 1996). The activity of these organisms is tightly associated with the set of ecosystem services provided, not only by directly impacting nutrient cycling, organic matter break-down, the soil structure and water retention, but also their unique role on soil trophic webs (Lavelle, 1997). The feedbacks between soil management and the functioning of soil biota are

profoundly important to promote appropriate conservation measure and stimulate a sustainable agriculture (Wolters, 2001).

Many organisms of the soil fauna are bioindicators of the environment quality and their presence/absence is directly related with how the environment and the soil are managed by man (Bianchi, Aquino and Almeida 2007; Santos *et al.*, 2019). Farmers and who work directly with soil have considered some organisms as beneficial to soil and know they assist in the agriculture productivity (Schiedeck *et al.*, 2009). Considering these associations several studies have been focusing on understanding how human action affects soil fauna and whether this information, in particular related to preservation and conservation, is disseminated to the entire society (Pulleman *et al.*, 2005; Lima *et al.*, 2016). Moreover, in assessments that aim people's perception on soil fauna, it is important to emphasize that the main idea is not evaluate people's knowledge, but to understand their points of view in relation to the subject (Bruyn and Abbey, 2003).

The aim of this study was evaluated the social perceptions concerning soil macrofauna among farmers and other stakeholders working in an agricultural context mainly in Brazil.

## Methodology

A questionnaire composed by a set of 12 questions as used (including professional activity, geographical and educational background, but also size of explored area). We have included questions about the management practices (major crops produced, livestock, soil management and crop waste residues - straw), soil macrofauna perceptions (organisms considered pests, trends in pest incidence, causes of the pest increase, but also focused on which organisms are considered beneficial to the soil and which management practices suggest increase in soil biological activity) and how the people assess the health of the soil. The questionnaire had multiple-choice questions, and most of them with an open-ended question to complement the answers and the interviewees could choose more than one answer.

The first survey was conducted in 2008 during the 11<sup>th</sup> National Meeting of No-Tillage on the Straw, held in Londrina, Paraná, Brazil, and the second was conducted in 2018 at the 16<sup>th</sup> National Meeting of No-Tillage on the Straw, held in Sorriso, Mato Grosso, Brazil. The questionnaire was included in the meeting bag and participants were free to answer.

## Results

In 2008, the National No-Tillage on the Straw Meeting had 600 participants and 87 answered the questionnaire, and in 2018 had 570 participants and 84 answered, about 20 percent of the participants in both events, totalling 171 answered questionnaires.

**Table 1: Profile of the interviewees**

Question	Responses (%)		
	2008	2018	
	n=87	n=84	
Education	Agronomist	61	50
	Other formation	11	13

	Agricultural technician	7	20
	Collage	11	14
	High School	7	8
	Middle School	2	1
Profession <sup>1</sup>	Farmer	33	31
	Researcher	14	11
	Professor	2	8
	Autonomous/Consultant	4	11
	Extensionist	9	0
	Technical Assistance	20	14
	Other	18	24
Country of origin	Brazil	93	100
	Paraguay	7	0
Region of origin in Brazil <sup>2</sup>	North	1	10
	Northeast	0	4
	Midwest	20	78
	Southeast	19	8
	South	60	0
Size of the management area <sup>3</sup>	< 20 ha	13	8
	21 to 50 ha	9	0
	51 to 100 ha	5	4
	101 to 500 ha	28	10
	501 to 1000 ha	6	10
	1001 to 2000 ha	3	7
	> 2001 ha	36	61

<sup>1</sup> Various interviewees answered more than one option; <sup>2</sup> n=78 for both years; n=64 in 2008 and n=71 in 2018.

In 2008, 33 percent of the interviewees were farmers, 20 percent technical assistance. In 2008, 36 percent of the interviewees managed an area larger than 2001 ha and 21 percent areas 101 to 500 ha. In 2018, farmers were the larger proportion of interviewees (31 percent). Regarding the size of the exploration area, 51 percent had managed areas larger than 2000 ha (Table 1).

From the list of nine organisms (Oligochaeta - earthworms, Hemiptera - stinkbugs, Formicidae - ants, Diplopoda - centipedes, Araneae - spiders, Isoptera - termites, Coleoptera - beetles, Chilopoda - millipedes and Gastropoda - slugs), only earthworms, spiders and centipedes were, generally not considered pests (Table 2). When asked if they observed an increase in pest incidence, 61 percent of the interviewees noticed an increase in 2008 and 73 percent in 2018. This increase was related mostly to the excessive use of pesticides (25 percent) and monocultures (38 percent) for both years, though the number of people relating these practices increased in 2018 (31 percent and 52 percent, respectively). When asked what kind of management was used for pest control, the chemical, mechanical and fallow practices were the most cited in both years, but the fallow decreased almost the half and other options, like biological and alternative managements and the Integrated Pest Management (IMP) increased from 0 to 3 percent in 2008 to 17 percent to 32 percent in 2018 (Table 2).

**Table 2: Responses about organisms considered to be pests, their control and management practices**

Question	Responses (%)
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		2008	2018
		n=87	n=84
Organisms considered pests	Oligochaeta	1	2
	Hemiptera	52	62
	Formicidae	41	33
	Diplopoda	33	14
	Araneae	2	7
	Isoptera	55	38
	Coleoptera	62	43
	Chilopoda	6	8
	Gastropoda	37	38
	Others	17	20
Increase in plagues/pests	Sim	61	73
	No	39	27
Reason for the increase of plagues/pests	Pesticides	25	31
	Monocultures	38	52
	Pest/plague resistance	21	13
	Other	16	3
Management used for pest control	Chemical <sup>1</sup>	40	49
	Biological <sup>2</sup>	0	17
	Mechanical <sup>3</sup>	33	39
	Alternatives <sup>4</sup>	3	17
	IPM <sup>5</sup>	3	32
	Fallow	94	48
	Nothing	3	4

<sup>1</sup> Use of traditional pesticides; <sup>2</sup> Use of viruses, bacteria, parasites, etc.; <sup>3</sup> plowing, harrowing, etc.; <sup>4</sup> Homeopathy, herbal medicine, etc.; <sup>5</sup> Integrated pest management.

Most respondents considered earthworms (93-100 percent) and spiders (45-64 percent), to be beneficial animals. The management practices considered to enhance soil biodiversity were mainly green manures, crop rotation, integrated pest management and the use of no-tillage (all >65 percent in 2008), although the number of responses including these practices decreased slightly 10 years later. In 2008 <40 percent of the respondents considered that maintaining native vegetation fragments was important to improve soil biodiversity, but in 2018 only 29 percent considered this option. When asked about soil health indicators, >80 percent mentioned the presence of many organisms (although most animals had been considered by many respondents to be pests earlier), while roughly half mentioned the presence of increased number of earthworms and soil aggregation.

**Table 3: Responses on soil macrofauna as beneficial organisms, good management practices and soil health**

Question		Responses (%)	
		2008	2018
		n=87	n=84
Organisms considered beneficial	Oligochaeta	93	100
	Hemiptera	7	7
	Formicidae	22	23
	Diplopoda	18	23
	Araneae	64	45
	Isoptera	10	15
	Coleoptera	26	18

	Chilopoda	17	13
	Gastropoda	5	10
	Others	7	5
Management to favor soil biodiversity	Green manure	90	77
	Crop rotation	91	89
	Native forest fragments	40	29
	IPM	15	65
	Terracing	22	19
	Subsoiling <sup>1</sup>	5	6
	No-Tillage System	90	82
	Minimum tillage	11	17
	Other	3	0
Destination of the straw on soil	Left on the soil	93	88
	Burned	2	0
	Incorporated in soil	7	11
	Animal feeding	6	7
	Silage	1	4
	Other	3	1
How assess soil health	Many organisms	80	85
	Many earthworms	51	45
	Soil color	20	37
	Texture	15	45
	Soil aggregation	49	46
	Plants as indicator	21	0
	Other	22	0

<sup>1</sup> Mechanical practice using equipment (subsoiler or rippers) to break up soil compacted layers (30 to 50 cm depth).

## Discussion

The social perception, especially from farmers and other stakeholders working in agriculture, concerning the functions, importance and benefits promoted by soil macrofauna, is still lacking. Generally, farmers recognize that organisms are capable of modify soil structure, the dynamic of organic matter and nutrients and balance of the food web, but few are aware about how these activities can assist water infiltration, aeration, improve soil fertility and plant growth, reflecting directly the soil health.

A review was conducted by Pauli *et al.* (2016) on the studies performed and the knowledge of farmers regarding the use of soil macrofauna. Across continents, the authors observed that most of the studies are focused mainly in one taxonomic group and this inclination happens according to the location and the importance or how strong negative impacts were observed (Pauli *et al.*, 2016).

In Brazil, throughout the different regions, is possible to observe some knowledge regarding the benefits of the macrofauna for the soil, mostly for earthworms, as several farmers emphasize that a soil with earthworms is a healthy soil with better fertility and helping with crop production (Schiedeck *et al.*, 2009; Van Groenigen *et al.*, 2014; Schiavon *et al.*, 2015). In some regions, where the dissemination of

information is more difficult and most farmers use agriculture for subsistence, there is almost nothing regarding the knowledge about soil macrofauna or how to classify a healthy soil (Lima *et al.*, 2016).

Talking directly to farmers in situ and enquiring about their actions towards a sudden increased amount of organisms (insects, bugs, millipedes, crickets, etc.) in their crop fields, they spontaneously answered: "I apply pesticides!" (personal observation M.L.C. Bartz). There is a major misunderstanding concerning the function and importance of the soil biodiversity that embodies the perceptions of farmers, technical workers and other professionals linked to agriculture. We suggest that these patterns are associated with market and consumer perceptions, especially shaped by the ones that sell products for farming, and that are not well prepared to work with a biodiverse environment. Moreover, in Brazil and probably elsewhere, there is a profound gap between the academic community with those that directly work in agriculture.

## **Conclusions**

In this study, the fact that most soil macrofauna were not perceived as beneficial and that the number of responses showed an increase in pest, together a decreasing trend in the application of good practices after 10 years is worrisome, and highlights the need to foster capacity building and to stimulate dissemination of evidence regarding the importance and function of soil biodiversity to society.

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