ORGANIC MATTER DECOMPOSITION AND MICROARTHROPOD COMMUNITY STRUCTURE IN CORN FIELDS UNDER LOW INPUT AND INTENSIVE MANAGEMENT IN GUAÍRA (SP)

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Abstract: The rate of organic matter decomposition and the structure of the communities of microarthropods were compared between two corn fields receiving contrasting agricultural management practices (low input and intensive farming). The rate of decomposition tended to be higher in the intensively managed field in the beginning of the growing season, but decreased to a level significantly lower than the observed in the low input field by the end of the growing season. This suggested that the biological community associated with the decomposition process could be negatively influenced in the intensively managed field. Analyses of the structure of microarthropod communities indicated differences between the two areas. The microarthropod populations present in the intensively managed field suffered abrupt decrease in numbers as the season progressed.
Key Words: Soil fauna, organic matter, decomposition, agroecosystems, farming systems, low-input agriculture

DECOMPOSIÇÃO DA MATÉRIA ORGÂNICA E ESTRUTURA DA COMUNIDADE DE MICROARTRÓPODES EM MILHO CULTIVADO DE FORMA INTENSIVA E COM BAIXO USO DE INSUMOS EM GUAÍRA (SP)

Resumo: A taxa de decomposição da matéria orgânica e a estrutura da comunidade de microartrópodes foram comparadas entre dois campos cultivados com milho mas recebendo manejos distintos, sendo um campo manejado intensivamente e outro com baixo uso de insumos. A taxa de decomposição foi mais alta no campo intensivamente manejado no início da cultura, mas decresceu para um nível significativamente inferior àquela observada no campo com baixo uso de insumos ao final da estação. Tal tendência sugeriu que a estrutura da comunidade dos organismos associados ao processo de decomposição poderia estar sendo negativamente influenciada no campo intensivamente manejado. Análises da estrutura das comunidades de microartrópodes indicaram que diferentes comunidades estavam presentes nos dois campos. As populações de microartrópodes presentes no campo sob manejo intensivo sofreram queda abrupta em números, sendo praticamente eliminadas já no segundo mês de desenvolvimento da cultura.
Descritores: Fauna do solo, matéria orgânica, decomposição, agroecossistemas, manejo agrícola

Introduction

The region of Guaíra, in the Northernmost part of São Paulo State, is characterized by a very intensive agriculture under rapid technological expansion, markedly with the employment of center-pivot irrigation systems. The heavy financial investment involved in such systems calls for very high yields from the irrigated areas, in order to repay the investment. Hence, allied to the high levels of mechanization, the agricultural practices normally incorporate heavy inputs of fertilizers and pesticides. However economically sound this agricultural production system may appear, an evaluation of its environmental impacts is warranted (Abreu, 1994).

A preliminary qualitative evaluation of the development of some crops in several areas under intensive irrigated management indicated problems potentially linked to unbalances in the soil - plant - soil biota relationships. Firstly, large quantities of the organic residues from previous crops were still present on the soil in an almost intact state, suggesting that the decomposition process might be slow. Secondly, in spite of the intensive control effort, root pathogens were the main agricultural problem in most crops, possibly due to a relative lack of competition from antagonistic saprophytic competitors (Chung *et al.*, 1988). Lastly, it was possible to notice signs of toxicity in weeds and even crop plants, especially those sprouting at the bottom of furrows. Possibly, this was occurring as a result of fertilizers and pesticides being washed down and accumulating on these spots, due to excessive application.

As a result of these observations it has been hypothesized that unbalances in the dynamics of organic matter decomposition and in the structure of the soil community could be involved in those problems. This hypothesis stems from the observations of Santos & Whitford (1981) that soil microarthropods are responsible for a significant control of microbial populations, and consequently on the process of decomposition. The role of microarthropods in microbial growth control is not a simple function of their numbers or abundance in the soil (which is greatly influenced by pesticide application regime), but results from a myriad of relationships among different trophic groups, spanning from saprophagous to fungivorous to nematode and mite predators (Argyropoulou *et al.*, 1993; Crossley *et al.*, 1989; Moore, 1988). As a consequence of this intricate food-web and as a result of the very action of the microarthropods on the organic matter and directly on microbial biomass, the microbial populations can be maintained in the logarithmic phase of growth, improving the process of decomposition of organic matter, release of nutrients, and biological activity in the soil (Andren *et al.*, 1988; Santos *et al.*, 1981; Schroth *et al.*, 1992).

In order to address the basic hypothesis that unbalances in the community structure of soil microarthropods and in the organic matter decomposition process were being caused by the intensive management in irrigated areas, a comparison between an intensively managed irrigated field and a low input field was carried out (El Titi & Ipach, 1989). This paper describes the results of such a comparison.

Material and Methods

Study site: Two neighboring farms which applied different crop management practices were selected in a single soil patch in Guaíra. Two areas (A and B, low input and intensive agricultural management, respectively) were selected, each representing an experimental treatment. By the beginning of the summer growing season, both areas were sown with corn. Area A was characterized by typical low input management, for the main economic activity of its owner was silkworm raising, and pesticides were not used in the property. Area B consisted of a plot under center-pivot, and the management involved frequent irrigation and heavy inputs of fertilizers and pesticides.

Assessment of organic matter decomposition: In each of these areas a set of 18 litter bags (20 x 20 cm, 1 mm nylon screen, containing 5 g of dry mixed-leaf litter collected in a fallow field) were laid down under approximately 5 cm of soil between the crop rows. Two additional six litter bag sets were laid in each area one and two months after the first set, in order to permit monthly estimates in addition to the cumulative estimates provided by the samples initially laid. This sampling schedule is presented in Diagram 1.

After approximately 30, 60 and 90 days, a subset of 12 litter bags were randomly collected from each area (six for the monthly and six for the cumulative estimates) and brought to the laboratory. The content of each litter bag was put into modified Berlese funnels for mesofauna extraction, being the microarthropods fixed in ethanol-glycerin 3:1 (by volume) mixture. After complete extraction (approximately 72 hours) the collected microarthropods were mounted in microscope slides, identified and counted.

After extraction, the organic material was dried at 105°C for 24 hours, weighted and incinerated at 600°C for 8 hours for the estimation of organic matter decomposition (Santos & Whitford, 1981). In this method the decomposition rate is expressed directly as percent loss of organic carbon. These percentages were normalized by arcsine transformation and the means were compared by Student's *t* tests.

Assessment of microarthropods: Microarthropod community was computed as the total number of each microarthropod order, total number of collembola and other arthropods, and total number of mites in each family. This arbitrary taxonomic subdivision was selected based on the role and importance of each group in organic matter decomposition and microflora-mesofauna relationship, and position in the soil food web (Crossley *et al.*, 1989).

The total number of organisms per period per treatment, instead of mean number per sample

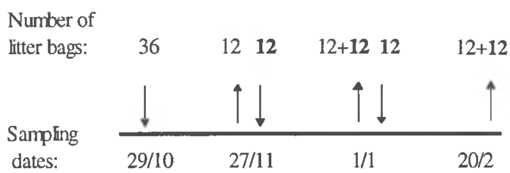

Diagram 1 - Sampling schedule for the three months experimental period. Numbers on the top line represent total litter bags laid for both areas A and B (low input and intensive management, respectively). Bold face numbers indicate samples used for the monthly estimates of decomposition, and regular face numbers represent the samples for the cumulative estimates (except for the first month, common for both estimates). Arrows indicate introduction (↓) and collection (↑) of litter bags.

unit, was computed due to the very well described patchy distribution of mesofauna in disturbed soils (Abbott & Crossley, 1982; Santos *et al.*, 1978). The resulting data consisted then of counts of total microarthropod numbers in each taxonomic category, for independent samples in relation to farm (or agricultural management), for three distinct periods of time and for two periodical analysis, monthly and cumulative. As the interest of this study lays particularly on the effects of agricultural management (low input versus intensive management), and not in the effects of time periods, the periods and periodical arrangement were studied independently, isolating only management effects in each comparison. The question to be posed in this comparison may be stated as follows:

"Are relative numbers of microarthropod in each studied taxa independent of management practices?"

It shall be noted that the question relates to relative numbers (evenness), meaning that even with accentuated drops in the total numbers (as it is likely to occur especially for the intensive management treatment, due to pesticide use) the relative proportions are sustained. This problem is typically one of comparison between observed and expected numbers, so the χ^2 test extends naturally to this situation (Snedecor & Cochran, 1967). The advantage of such a method is that it allows the construction of standardized deviations TABLES, so that each deviation (corresponding to each taxonomic category) may be assessed and discussed specifically. Statistically significant χ^2 values in these TABLES indicate the instances in which the relative proportions of microarthropods differed in a given period, between the two treatments.

In order to address which individual taxa might have suffered deviations from expected numbers, specific comparisons were performed in standardized deviations TABLES. The relative proportions of microarthropods found in each treatment in each study period were applied in 12 x 2 (taxonomic categories x treatment) R x C TABLES (note that period 1 is the same for both periodic samples). Tests of significance for each comparison were performed for the following null hypothesis:

Ho: The relative proportion of each microarthropod taxa is the same under low input and intensive agricultural management.

The TABLES were constructed under the assumption that the null hypothesis holds, considering as expected values the total number of microarthropods in each taxa for both treatments, using the following expression:

Standard deviations = Oij - Eij / SQRT Eij

where: Oij is the observed number of microarthropods in each taxa and Eij the expected number assuming Ho. For such a TABLE, a value of $\pm$ 2 is considered to be associated with meaningful deviations (Snedecor & Cochran, 1967)

Results and Discussion

The decomposition rates observed in this study for the summer growing season in cultivated corn were very high in both treatments, reaching almost 70% loss of organic carbon in one single month. Such high decomposition rates are not uncommon for straw material in tropical situations (Lekha *et al.*, 1989). As can be observed in Figure 1, the rate of decomposition was significantly higher for the intensive agricultural management (area B) in the first month. This effect was probably related to the higher water (due to irrigation) and nutrient availability in this treatment for that period (Andren

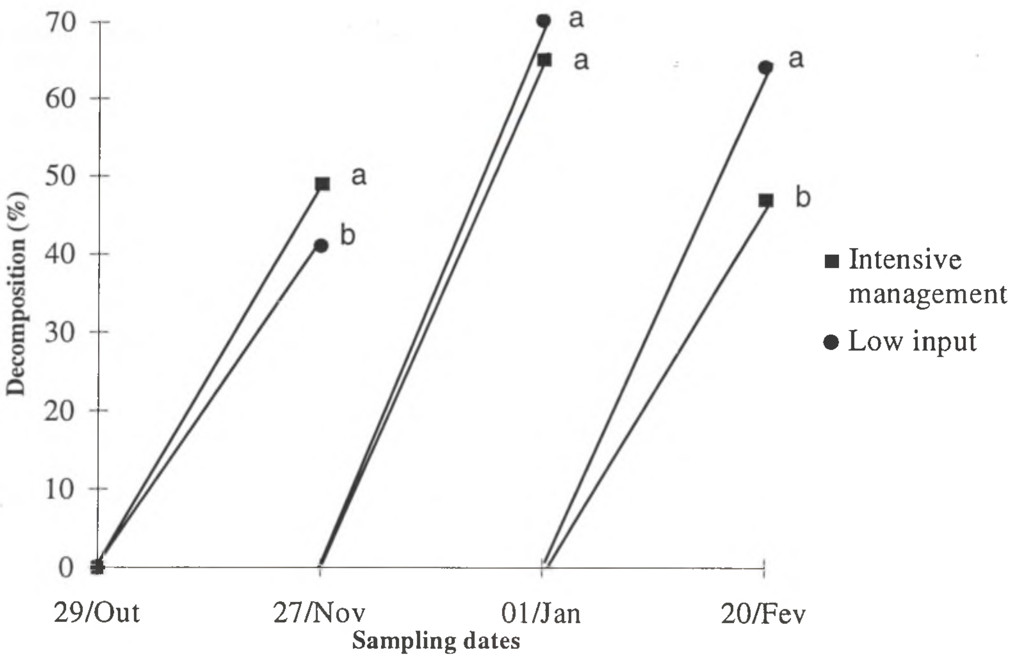

Figure 1 - Organic matter decomposition rate in corn grown under low input and intensive management. Data points in each period showing different letters are significantly different at $\alpha=0.05$.

et al., 1995). In the second monthly period the two means were no longer different, while in the third month the samples from the low input treatment (area A) showed a significantly higher decomposition rate. This result could be related to the increasing detrimental effects of the pesticides applied in the intensively managed field (Kajak, 1989). The same pattern was observed in the samples of the cumulative periods, with the rate of decomposition being higher in the intensively managed field in the beginning, reversing to a higher rate for the low input field by the end of the study period (Figure 2).

The number of microarthropods obtained in each treatment for each period of time is presented in Figures 3 through 6. It should be noted that the total numbers of microarthropods are very different, with remarkable decreases in the intensively managed field, again probably due to the detrimental effects of pesticides (El Titi & Ipach, 1989). The resulting values of χ^2 for the comparisons of community structures between low input and intensive agricultural management for the five experimental periods (three monthly and two cumulative) is presented in TABLE 1.

The null hypothesis is rejected for the first two monthly periods as well as for the two months cumulative samples. By the end of the crop cycle the differences in relative proportions disappear, as numbers of microarthropods diminish abruptly especially in the intensively managed field. So, we conclude that different soil microarthropod community structures were associated with low input and intensive agricultural managements during the first two-thirds of the growing season.

Although this information may be significant in agroecological terms, suggesting that impacts caused to the mesofauna by the agricultural management can influence higher processes, such as organic matter decomposition, little is available for the understanding of implicit relationships that could be explanatory. In other words, what kinds of ecological unbalances could have been caused to the structure of microarthropod communities as to result in the observed results? Which taxa were influenced the most, and how so?

These questions were addressed by the analysis of specific standardized deviations in the observed numbers of microarthropods in relation to the numbers expected if the null hypothesis held.

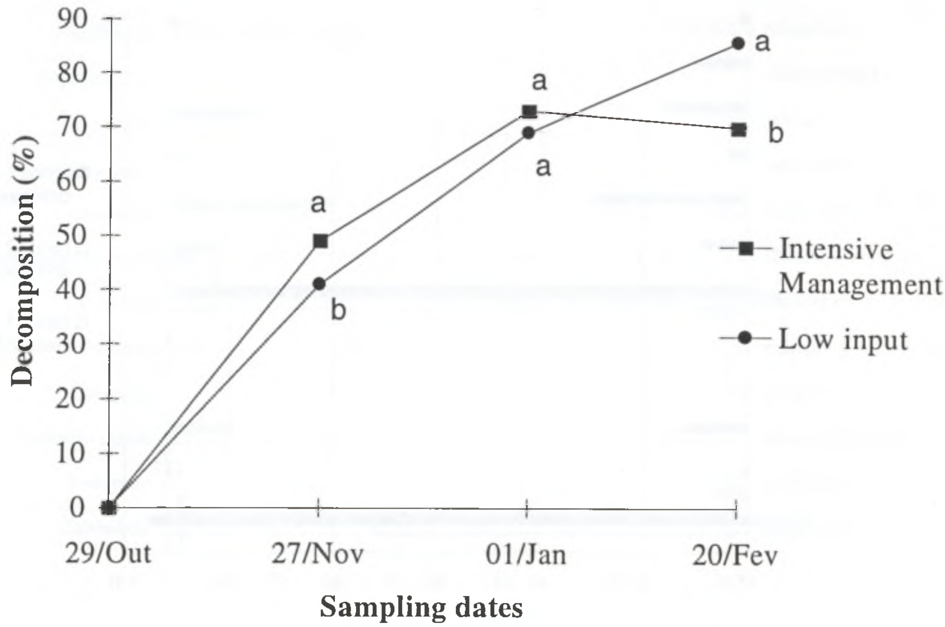

Figure 2 - Cumulative organic matter decomposition rate in corn grown under low input and intensive management. Data points in each period showing different letters are significantly different at $\alpha=0.05$.

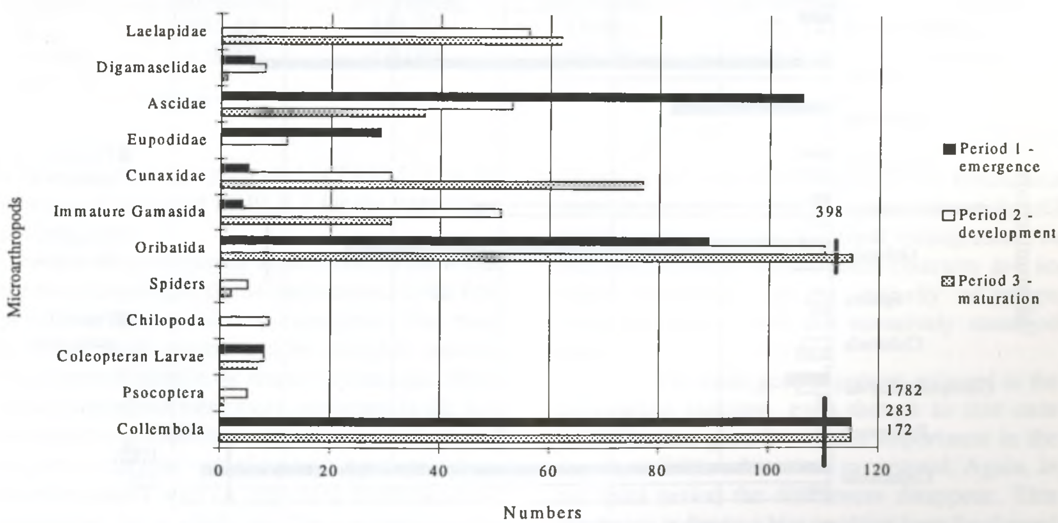

Figure 3 - Microarthropod community structure for three monthly periods in a corn field under low input management.

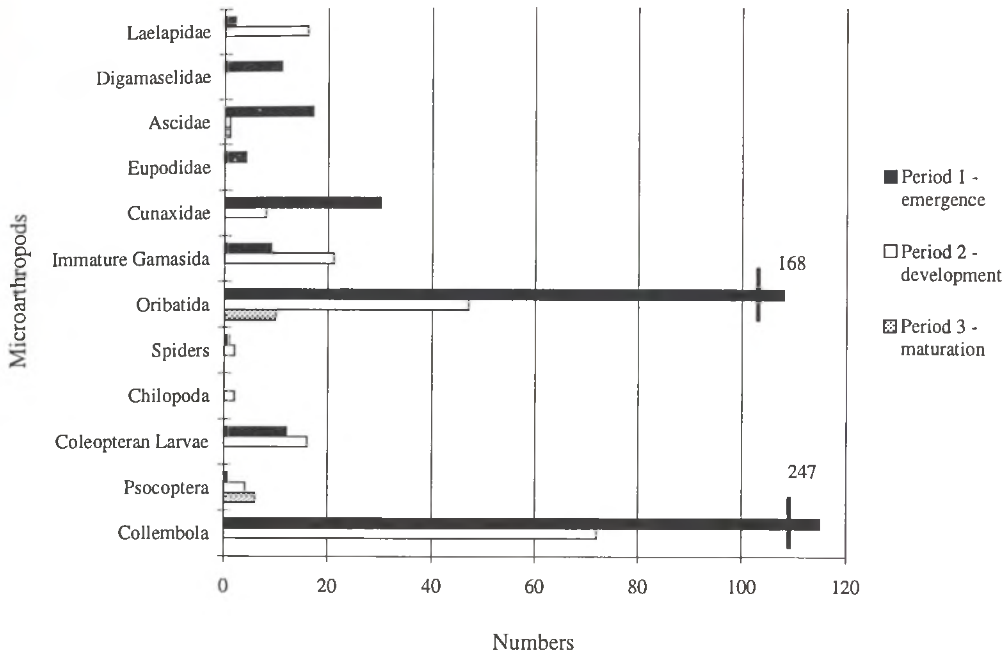

Figure 4 - Microarthropod community structure for three monthly periods in a corn field under intensive management.

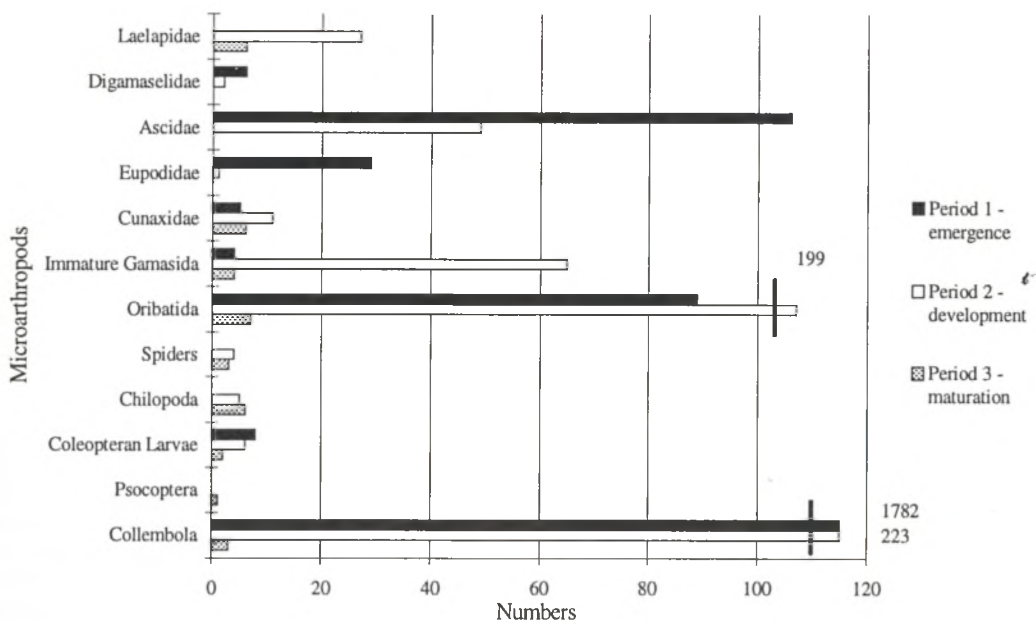

Figure 5 - Microarthropod community structure for three cumulative periods in a corn field under low input management.

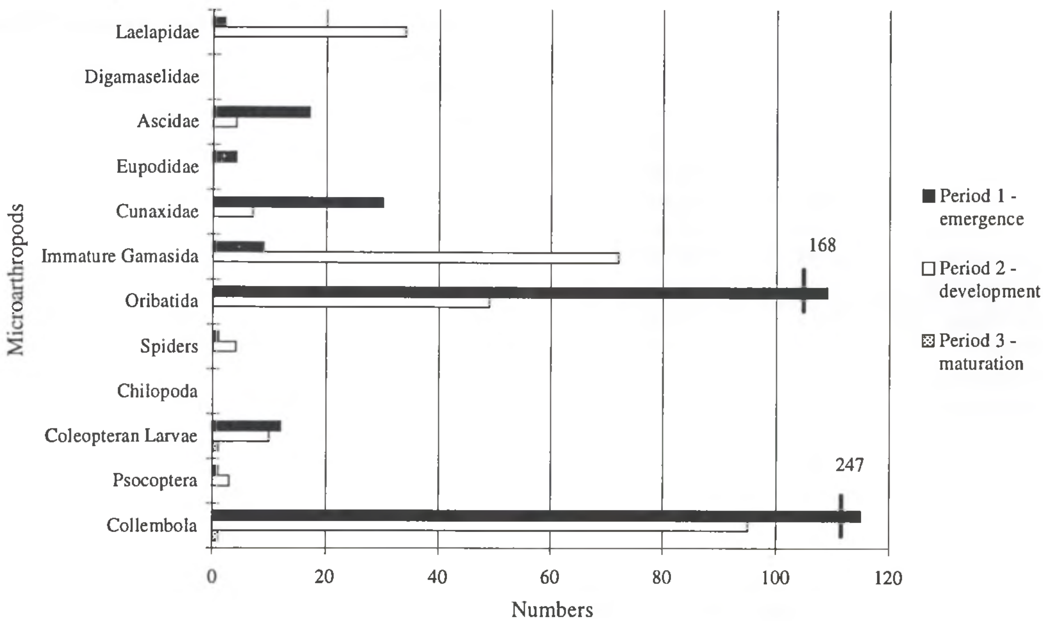

Figure 6 - Microarthropod community structure for three cumulative periods in a corn field under intensive management.

TABLE 1 - Results of the five χ^2 tests of significance performed for microarthropod community structure comparison between low input and intensive farming.

	monthly			cumulative	
Period	1st month	2nd month	3rd month	2 months	3 months
$\chi^2_{calc.}$	585.52	157.79	13.00	171.17	8.195
p-value	<0.005	<0.005	>0.25	<0.005	>0.5
df = 11					

These deviations are presented in TABLE 2 for the monthly periods and TABLE 3 for the cumulative periods.

The analyses of these TABLES show that the most meaningful deviations occurred in the first period, at the time of crop emergence. The main contrasts were represented by a higher relative abundance of mites in the intensively managed field, while collembola were more important in the low input farming. Note that oribatid mites represented the prey in the food web of the high input agriculture (most probably with an important contribution of nematodes, not studied), and that predacious mites (laelapidae, digamaselidae, cunaxidae, and immature gamasida) were proportionally more important. In the second monthly period, however, this pattern changed, with total numbers dropping bluntly in the intensively managed field. Predacious mites become rare in this field, and collembola still more important in the low input management. In the third monthly period most contrasts are no longer important, as the majority of groups were eliminated from the intensively managed field.

The same general pattern occurred in the cumulative samples, even though in this case oribatid mites grew in relative importance in the low input field as the season progressed. Again, in the third period the differences disappear. This result may in fact be a bias resulting from the skewed character in the data, caused by the extirpation of organisms in the later periods of the intensive agricultural management treatment, causing the expected values to be closer to zero.

TABLE 2 - Standardized deviations for microarthropod community structure relative to expected independence from agricultural management for three monthly periods.

Microarthropod	Period 1		Period 2		Period 3	
group	Low input	Intensive	Low input	Intensive	Low input	Intensive
Laelapidae	-1.26	**2.52**	0.08	-0.14	0.17	-1.28
Digamaselidae	**-2.06**	**4.15**	0.74	-1.36	0.02	-0.14
Ascidae	0.74	-1.49	1.77	**-3.24**	-0.03	0.22
Eupodidae	0.49	-0.99	0.91	-1.66	0	0
Cunaxidae	**-4.35**	**8.75**	0.18	-0.33	0.18	-1.27
I. Gamasida	-1.99	**3.99**	-0.59	1.08	0.12	-0.80
Oribatida	**-8.15**	**16.40**	-0.98	1.80	-0.07	0.47
Spiders	-0.89	1.80	-0.17	0.31	0.04	-0.20
Chilopoda	0	0	1.85	-0.30	0	0
Coleoptera L.	**-2.01**	**4.04**	**-2.44**	**4.45**	0.06	-0.38
Psocoptera	-0.89	1.80	-0.73	1.33	**-2.24**	**15.21**
Collembola	**3.84**	**-7.73**	**10.13**	-1.09	0.28	-1.91

(significant deviations are evidenced in bold face numbers).

TABLE 3 - Standardized deviations for microarthropod community structure relative to expected independence from agricultural management for cumulative periods.

Microarthropod	Period 1		Period 2		Period 3	
group	Low input	Intensive	Low input	Intensive	Low input	Intensive
Laelapidae	-1.26	**2.52**	**-2.20**	**3.28**	0.15	-0.59
Digamaselidae	**-2.06**	**4.15**	0.54	-0.80	0	0
Ascidae	0.74	-1.49	**2.15**	**-3.14**	0	0
Eupodidae	0.49	-0.99	0.38	-0.56	0	0
Cunaxidae	**-4.35**	**8.75**	-0.35	0.52	0.15	-0.59
I. Gamasida	-1.99	**3.99**	**-2.92**	**3.90**	0.12	-0.48
Oribatida	**-8.15**	**16.40**	**9.80**	-0.24	0.16	-0.64
Spiders	-0.89	1.80	-0.62	0.90	0.10	-0.42
Chilopoda	0	0	0.87	-1.86	0	0
Coleoptera L.	**-2.01**	**4.04**	-1.48	**2.16**	-0.48	1.96
Psocoptera	0.89	1.80	-1.43	**2.08**	0.06	-0.24
Collembola	**3.84**	**-7.73**	0.45	-0.65	-0.39	1.57

(significant deviations are evidenced in bold face numbers)

These results show that while all groups were affected in the intensively managed field, the organisms closer to the base of the food web (especially collembola and oribatid mites) suffered the most. As it would be expected, with the elimination of the base of the trophic pyramid the whole community failed.

Even though the results obtained in this work permit only the drawing of conclusions in terms of association and not causation, since the data are essentially observational, the objectives proposed were achieved. The method was sufficiently malleable to allow the assessment of specific relationships, with clear visualization of direction and degree of deviation, besides testing the hypothesis proposed. Finally, it was possible to obtain some insights for the design of further experiments to be conducted in order to show relationships of causation in soil microarthropod community structure and agricultural management. Two important conclusions can be obtained from this analysis:

1 - Manipulative and replicated experiments are needed to permit inferences about causation relationships for agricultural management and microarthropod community changes in general, not only for the studied situation.

2 - Sample units should be individualized so that tests of significance are not biased by the skewed character of the data set.

In conclusion, this work indicated that distinct microarthropod community structures (represented by relative proportions among taxa, or evenness) are associated with different agricultural management, and that an unbalanced community structure reflects negatively in the process of organic matter decomposition (El Titi & Ipach, 1989). Furthermore, we suggest that the rate of organic matter decomposition and analysis of microarthropod communities are good indicator parameters for the assessment of the environmental impacts in agriculture.

REFERENCES

ABBOTT, D.T.; CROSSLEY, D.A.J. Woody litter decomposition following clear-cutting. **Ecology,** v.63, n.1, p.35-42, 1982.

ABREU, L.S.B. **Impactos Sociais e Ambientais na Agricultura:** uma abordagem historica de um estudo de caso. Brasilia: SPI/EMBRAPA, 1994. 149p.

ANDREN, O.; BENGTSSON, J.; CLARHOLM, M.; COLLINS, H.P.; ROBERTSON, G.P.; KLUG, M.J. Biodiversity and species redundancy among litter decomposers. **In: The significance and regulation of soil biodiversity**, East Lansing, 1995. v.3-6, p.141-151.

ANDREN, O.; PAUSTIAN, K.; ROSSWALL, T. Soil biotic interactions in the functioning of agroecosystems. **Agriculture, Ecosystems and Environment,** v.24, p.57-67, 1988.

ARGYROPOULOU, M.D.; ASIKIDIS, M.D.; IATROU, G.D.; STAMOU, G.P. Colonization patterns of decomposing litter in a maquis ecosystem. **European Journal of Soil Biology,** v.29, n.3-4, p.183-191, 1993.

CHUNG, Y.R.; HOITINK, H.A.H.; LIPPS, P.E. Interactions between organic-matter decomposition level and soilborne disease severity. **Agriculture, Ecosystems and Environment,** v.24, p.183-193, 1988.

CROSSLEY, D.A.J.; COLEMAN, D.C.; HENDRIX, P.F. The importance of the fauna in agricultural soils: research approaches and perspectives. **Agriculture, Ecosystems and Environment,** v.27, p.47-55, 1989.

EL TITI, A.; IPACH, U. Soil fauna in sustainable agriculture: results of an integrated farming system at Lautenbach, F.R.G. **Agriculture, Ecosystems and Environment,** v.27, p.561-572, 1989.

KAJAK, A. Can fauna impoverishment affect humus content in cultivated soils? **Wiadomosci Ekologiczne,** v.35, n.3-4, p.235-249, 1989.

LEKHA, A.; CHOPRA, G.; GUPTA, S.R. Role of soil fauna in decomposition of rice and sorghum straw. **Proceedings of the Indian Academy of Sciences, Animal Sciences,** v.98, n.4, p.275-284, 1989.

MOORE, J.C. The influence of microarthropods on symbiotic and non-symbiotic mutualism in detrital-based below-ground food webs. **Agriculture, Ecosystems and Environment,** v.24, p.147-159, 1988.

SANTOS, P.F.; DePREE, E.; WHITFORD, W.G. Spatial distribution of litter and microarthropods in a Chihuahuan desert ecosystem. **Journal of Arid Environments,** v.1, p.41-48, 1978.

SANTOS, P.F.; PHILLIPS, J.; WHITFORD, W.G. The role of mites and nematodes in early stages of buried litter decomposition in a desert. **Ecology,** v.62, n.3, p.664-669, 1981.

SANTOS, P.F.; WHITFORD, W.G. The effects of microarthropods on litter decomposition in a Chihuahuan desert ecosystem. **Ecology,** v.62, n.3, p.654-663, 1981.

SCHROTH, G.; ZECH, W.; HEIMAN, G. Mulch decomposition under agroforestry conditions in a sub-humid tropical savanna: processes and influence of perennial plants. **Plant and Soil,** v.147, n.1, p.1-11, 1992.

SNEDECOR, G.W.; COCHRAN, W.G. **Statistical Methods.** Ames: Iowa State University Press, 1967. 593p.

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