EXPLOITATION OF DIFFERENT FOOD SOURCES BY EARTHWORMS (OLIGOCHAETA: LUMBRICIDAE) IN CONDITIONS OF BANAT PLAIN

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***Abstract**: The researches presented in this paper aimed to study the way how some elements of agricultural technology (chemical and organic fertilisation) influence the earthworm abundance in soil, organisms which are great bioindicators of soil fertility. The goal of the paper was rigorously observe the changes appeared in earthworm abundance in order to enunciate the effect of different agricultural technologies in the sense of their promotion or renunciation if negatively influence the life from soil. These considerations were imposed because at worldwide level the soil fertility in continuous decrease, and on the background of conventional agriculture that was practiced during last decades, it became more and more acute the problem of soil fertility. The experiments were placed within Didactic and Experimental Station of the University of Agricultural Sciences and Veterinary Medicine of Banat Timişoara, on a cambic chernozem in oat culture. The results showed that earthworm number (individuals/m^2) and weight (g/m^2) registered higher values in the experimental plots with organic fertilization. The research methodology that was used respects the actual legislation and protocols in force. The statistic connections between the researched factors were realized by statistical methods, consisting of dispersion analysis ANOVA (Analysis of Variance). For statistical calculation, the SPSS software (Statistical Package for the Social Sciences) was used. The objectives aimed by this research were established in order to bring a series of contributions to the sustainable regeneration of soils fertility, under aspect of its physical, chemical and biological properties, by using the biological means specific to the ecological agriculture system, and with the purpose to allow the establishment of the right directions, well scientifically argued, regarding the elimination of those sequences of agricultural technologies which negatively influence the biological activity from soil, in this present case the activity of earthworms, with the consequence of soil fertility decreasing.*

***Key words:** earthworms, organic fertilization, chemical fertilization, earthworm number, earthworm weight*

INTRODUCTION

Most of the earthworms have European origin, and they were transported by human activity in many places of world. The great majority of soils from the temperate and tropical zones sustain significant populations of earthworms [DECAËNS ET AL., 2003; POMMERESCHE ET AL., 2006; ZOU ET GONZÁLEZ, 2002].

Knowing the varieties existing in a region provides important indications about the biological characteristics of that region, but, in order to enunciate considerations about the biological activity of a soil, it must obligatorily accumulate information regarding the population density. Earthworm number ranges from few hundreds to few millions per ha, meaning 90-100 kg of biomass. They play the carrier role into the soil, transporting, mixing and aerating the soil. There was found that they can transport up to 30 kg of soil [MULLER, 1968].

Earthworm populations increase with the amount of organic matter in soil and decrease with the disturbing workings of soil, like tillage and pests control [10].

Earthworm populations depends both on physical and chemical properties of soil like soil temperature, humidity, pH, salts content, aeration and texture, but also on food resources

and specie ability to reproduce and spread.

Application of chemical fertilisers, as pulverisations or powder, can have disastrous effects on earthworm populations [REINECKE AND REINECKE, 2004].

The effect of chemical fertilization with NPK on earthworm abundance biomass and quantity of coprolites excreted in the soil, comparative with organic fertilisation with cattle manure showed that sometimes, the best results are achieved when these two types of technologies (chemical and organic fertilisation) are combined. Some studies performed at the University of North-Eastern Hill from India demonstrated this fact [TIWARI, 1993].

The effect of pesticides on earthworms depends on the chemical substance that was used. Herbicides have generally a low toxicity for earthworms, but these can indirectly produce the reduction of the populations by decreasing the input of organic matter and weed removal. Also, the fungicides and fumigants are extremely toxic substances for earthworms [ABDUL RIDA AND BOUCHÉ , 1997; BOOTH AND O'HALLORAN, 2001].

MATERIAL AND METHOD

The described researches were developed in the field of Didactic Station of University of Agricultural Sciences and Veterinary Medicine of Banat from Timişoara (USAMVBT) and followed the effect of some elements of agricultural technologies (fertilization with bovine manure in doses of 40 t/ha and respectively 80 t/ha, fertilization with pig manure in dose of 40 t/ha, fertilization with birds manure in dose of 25 t/ha, wheat straw incorporation 3,5 t/ha, incorporation of vegetal masse (oat) and chemical fertilization with nitrogen phosphorus and potassium in dose $N_{90}P_{45}K_{45}$) on earthworms (numerical abundance and weight) within a stationary field experiment, in oat culture. The bovine manure in dose of 40 t/ha and 80 t/ha, was applied a single time at the beginning of the researches. The pig manure in dose of 40 t/ha and the bird manure in dose of 25 t/ha were applied a single time at the beginning of the researches, and the wheat straw incorporation (3,5 t/ha), green manure and chemical fertilizers ($N_{90}P_{45}K_{45}$) were annually realized.

The soil of the field experiments is a cambic chernozem, low gleyed, which also represents the characteristic soil of the Didactic Station of USAMVBT and of a large area in the region. Establishment of the pedological conditions and description of the soil profile were realized according to the Romanian System of Soils Taxonomy (SRTS 2003). The physical and chemical analyzes of the soil samples were realized in the laboratories of OSPA Timiş, according to the specific methodologies and working protocols in force.

Earthworms extraction was realized using formaldehyde solution 2%, according to the specific methodology enounced by the standard ISO 23611-1/2006 (Soil quality-Sampling of soil invertebrates, part 1: Hand-sorting and formaldehyde extraction of earthworms).

The study of the statistic connections between the studied variables was made in the basis of statistical methods, which consisted of: dispersion analysis ANOVA (Analysis of Variance); regression method (the concept of regression expresses a statistical connection, namely the mean regression regarding the behaviour of some variables); correlation method (the concept of correlation expresses reciprocal reports between certain characteristics). For statistical calculus was used the soft SPSS (Statistical Package for the Social Sciences), which assures the covering for all the methods already exposed.

RESULTS AND DISCUSSION

The soil of the field experiments is a low gleyed, cambic chernozem. The physical and chemical properties of the cambic chernozem are presented in the table 1.

Table 1

Main physical, hydro-physical, physical and chemical characteristics of the cambic chernozem, low gleyed, from Didactic Station of USAMVB Timişoara [OSPA Timiş]

PEDOLOGICAL HORIZONS	Amp	Amt	Am	A/B	Bv	B/C	Cca G_1	Cca G_3
Depth of pedological horizon (cm)	0-20	20-35	35-46	46-55	55-75	75-95	95-106	106-205
Rough sand (2.0–0.2 mm) (%)	2,0	5,0	6,0	6,0	3,0	3,0	3,0	3,0
Fine sand (international system) (0.2–0.02 mm) (%)	29,2	26,0	28,6	24,9	26,7	24,4	29,9	28,0
Dust (international system) (0.02–0.002 mm) (%)	29,7	27,3	19,7	27,8	28,1	27,3	29,9	29,8
Clay (< 0.002 mm) (%)	39,1	41,7	40,7	41,3	42,2	45,3	37,2	39,2
TEXTURE	TT	AL	AL	AL	AL	AL	TT	TT
Specific density (g/cm3)	2,42	2,56	2,58	2,54	2,56	2,55	2,52	2,51
Apparent density (g/cm3)	1,28	1,48	1,43	1,42	1,45	1,46	1,44	1,46
Total porosity (%)	47	42	44	44	43	42	42	41
Aeration porosity (%)	13,70	3,52	6,82	7,08	5,30	4,04	4,56	3,04
pH in water (pH units)	6,18	6,44	6,55	6,57	6,93	7,05	7,50	7,79
$CaCO_3$ (%)	-	-	-	-	-	-	0,16	0,25
Total organic carbon (%)	3,28	2,97	2,73	2,10	-	-	-	-
N total (%)	3,08	2,82	2,65	2,04	-	-	-	-
P mobile (ppm)	13,0	8,5	2,6	2,6	3,7	-	-	-
K mobile (ppm)	128	120	124	128	-	-	-	-
Exchangeable bases (meq/100 g soil)	25,60	26,60	26,80	26,98	27,52	-	-	-
H^+ exchangeable (meq/100 g soil)	4,75	4,21	2,84	2,62	2,43	-	-	-
Cationic exchange capacity (meq/100 g soil)	30,35	30,27	29,64	29,60	29,95	-	-	-
Base saturation (% of total)	84,34	86,09	90,41	91,16	91,88	-	-	-

In the table 2 there are presented the results regarding the numerical and weight dynamics of earthworms in different types of fertilization within the three experimental years.

Table 2

Dynamics of the earthworm number and weight under influence of different types of fertilization

Fertilization type	Year I		Year II		Year III	
	Earthworm number (individuals/m^2)	Earthworm weight (g/m^2)	Earthworm number (individuals/m^2)	Earthworm weight (g/m^2)	Earthworm number (individuals/m^2)	Earthworm weight (g/m^2)
Control	42,00	8,66	32,67	4,42	32,33	7,05
Green manure (oat)	80,00	12,31	50,00	10,58	12,33	1,70
$N_{90}P_{45}K_{45}$	45,00	8,33	31,00	13,93	11,00	0,97
Straws 3.5 t/ha	57,33	7,39	46,67	9,55	16,00	2,48
Bird manure 25 t/ha	83,00	6,82	57,00	6,32	30,33	4,62
Pig manure 40 t/ha	65,00	7,52	39,67	7,67	36,33	7,92
Cattle manure 40 t/ha	50,00	5,42	30,00	4,98	39,33	9,22
Cattle manure 80 t/ha	60,33	6,67	33,67	5,01	56,33	7,89

In the first year of observation it was remarked that the greatest earthworms number was identified in the variant with bird manure in dose of 25 t/ha (83 individuals/m^2), followed by the variant with oat incorporation as green manure (80 individuals/m^2), results which certify that earthworms prefer the soil enriched in these types of organic matter [IORDACHE AND BORZA, 2006]. Under weight aspect, there was found that in the first case its value was low, only 6,82 g, because mostly of earthworms were young, immature, and in the second case its value was higher, by 12,31 g/m^2, because here the earthworms were well developed, mature, which shows the preference of these organisms for this type of fertilization (figure 1).

In the second research year, there was observed a similar situation as in the first year, namely the largest number of earthworms was in the plot with bird manure fertilization in dose of 25 t/ha, followed by the plot with oat incorporation (50 individuals/m^2), although the earthworms number was much reduced comparing to the first year of researches. The lowest number (30 earthworms/m^2) was found in the plot fertilized with bovine manure in dose of 40 t/ha, much lower than in the first year of application (50 earthworms/m^2). A low earthworm

number was also identified in the plot chemically fertilized with nitrogen, phosphorus and potassium in dose of $N_{90}P_{45}K_{45}$ (figure 1).

In the third research year, the obtained data generally showed a decreasing tendency of earthworm number in almost all experimental variants comparing to the previous years. In this case, the largest number of individuals was found in the experimental plots organically fertilized with bovine manure 80 t/ha (56 individuals/m^2 comparing to 32 individuals/m^2 in the control variant). Reduction of the bovine manure dose at half (40 t/ha) has as effect the decrease of the earthworm number to 39 individuals, with a weight by 9,22 g/m^2 (figure 1).

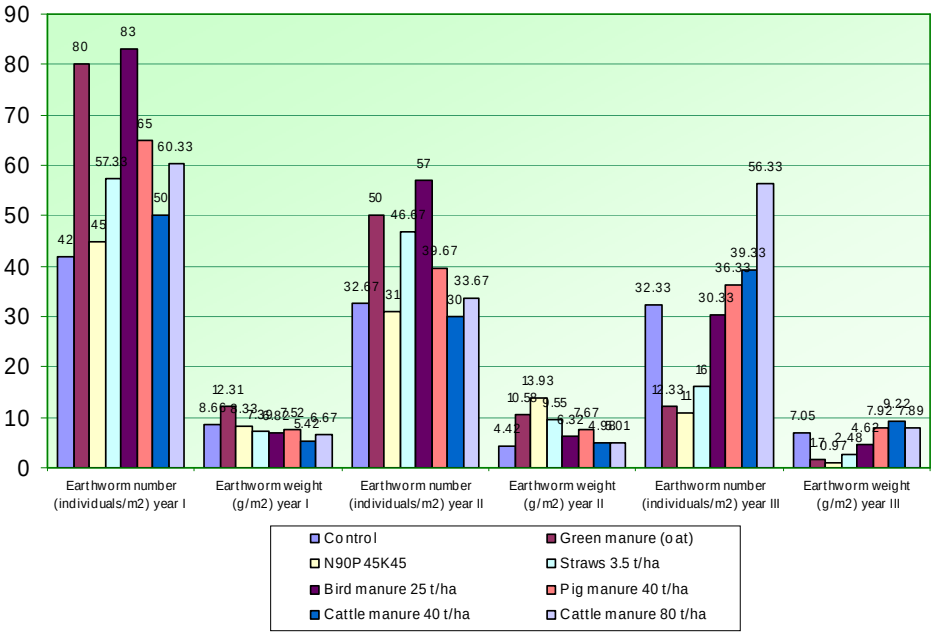

Figure 1. Mean values regarding the earthworm number and weight in different types of fertilization

The lowest earthworm number was found in the case of chemical fertilization with $N_{90}P_{45}K_{45}$ (11 individuals/m^2), lower than earthworm number from the control variant. In chemical fertilization, the earthworm number was 45,79% lower than in the variant fertilized with bird manure 25 t/ha. Significant is that earthworm weight in chemical fertilization decreased to 0,97 g/m^2.

In the table 3 are showed the comparative results of data for all experimental years.

Table 3

Comparative analyses (%) of the earthworms dynamics (individuals/m^2 and weight in g/m^2) in different types of agricultural fertilization for three research years

Fertilization type	Year I		Year II		Year III	
	Earthworm number (%)	Earthworm weight (%)	Earthworm number (%)	Earthworm weight (%)	Earthworm number (%)	Earthworm weight (%)
Control	77,79	51,04	76,97	81,40	98,95	159,50
Green manure (oat)	62,50	85,94	15,41	13,80	24,66	16,06
$N_{90}P_{45}K_{45}$	68,89	167,22	24,44	11,64	35,48	6,96
Straws 3.5 t/ha	81,41	129,22	27,90	33,55	34,28	25,96
Bird manure 25 t/ha	68,67	92,66	36,54	67,74	53,21	73,10
Pig manure 40 t/ha	61,03	101,99	55,89	105,31	91,58	103,25
Cattle manure 40 t/ha	60,00	91,88	78,66	170,11	131,10	185,14
Cattle manure 80 t/ha	55,81	75,11	93,36	118,29	167,30	157,48

It must be considered that earthworm weight recorded different values because the collected individuals had different ages, with various sizes of their bodies. Also, another factor that must be taken into account is the unfavourable conditions of soil humidity, reason why earthworms loose water out of their body, as a defence and surviving mechanism.

Is hard to explain why the lowest earthworm number was found in the variant with cattle manure fertilization in dose of 40 t/ha, where the abundance of earthworm was 8,18% lower than in the control variant. Comparing the extreme values, there was noticed a difference by 43,37% between variant organically fertilized with cattle manure 40 t/ha and the plot fertilized with bird manure in dose of 25 t/ha.

There was found that the best effect of the applied fertilizers was recorded in the firs year of researches, and then the earthworm number significantly decreased in all types of fertilization (figure 2). The numerical evolution of earthworms must be explained also by the climatic conditions during the research period. In conclusion, earthworms manifested an obvious preference for the abundant organic matter in the first year of researches.

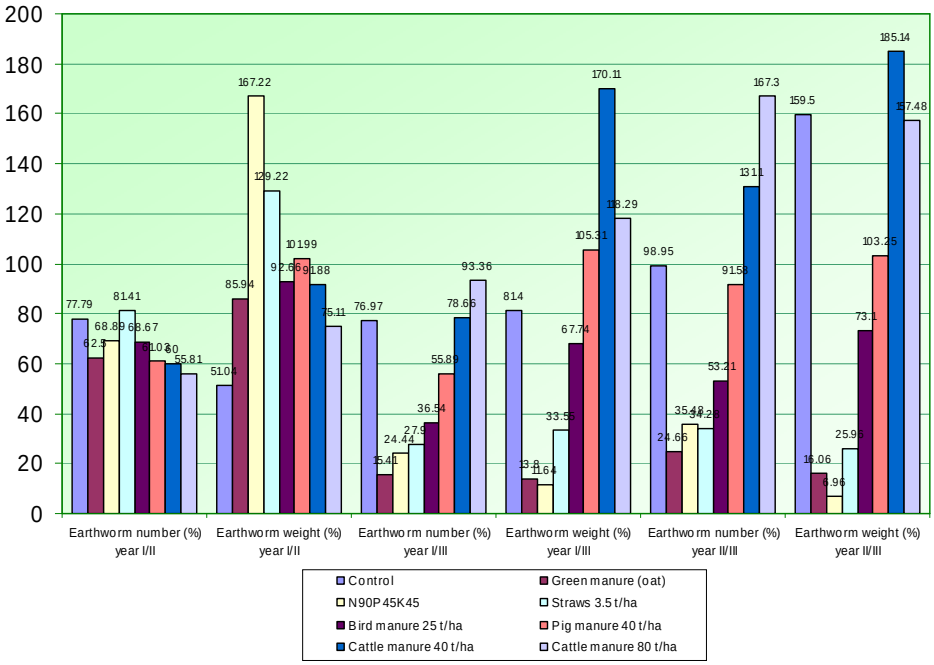

Figure 2. Comparative analyses (%) of earthworms dynamics (individuals/m^2 and weight in g/m^2) in different types of agricultural fertilization for three research years

Referring to the earthworm tolerance for the chemical fertilization there was noticed after two consecutive years a dramatically decrease, both as number and weight. Thus, in the second year of chemical fertilization a decrease with 31,11% of earthworm number was recorded, and in the third year a decrease with 75,56% comparative with the first year. These results demonstrated once again the low tolerance of these organisms to the chemical fertilization. The obtained results showed that application of pig manure in dose of 40 t/ha does not favour earthworm number, which decreased from a year to another (with 38,97% in the second year comparative to the first year and with 44,11% in the third year comparative to the first year). The oat was valuated in small measure by earthworms since from the first year. For this type of fertilization the earthworm number decreased in the third year with 84,59%

comparative to the first year, this being the most significant decrease of earthworm number from a year to another. The straws stimulated the earthworm activity, but not in the same measure as the cattle manure. In the third year a drastic decrease of earthworm number has been recorded, with 72,10% less earthworms than in the first year. The most interesting evolution of earthworm numerical abundance was recorded in the plots fertilized with bird manure in dose of 25 t/ha. Thus, for this type of fertilisation, in the second year the earthworm number decreased with 31,33% comparative to the first year.

CONCLUSIONS

The performed researches showed that earthworm number into a soil depends on: quantity and type of the organic matter introduced in soil, chemical substances (fertilizers, pesticides) and tillage system, but also on the values of some physical and chemical indices of soil, natural or modified by agricultural systems. Concluding, earthworms manifested an obvious preference for the abundant organic matter in the first research year.

In the first year of researches, the best effect on earthworm was manifested by the organic matter in the form of bird manure 25t/ha, and the most unfavourable influence on earthworm number was exerted by the chemical fertilization with $N_{90}P_{45}K_{45}$.

In the second experimental year, comparative to the first year, the most favourable effect on earthworm number was exerted by the vegetable rest as wheat straws, and the most unfavourable effect was manifested by the chemical fertilizers.

In the third year related to the first year there was observed that the largest increase of earthworm number was in the variants fertilized with cattle manure 80 t/ha, unlike the second year when was found the lowest earthworm number comparative to the first research year.

The best valuation of the organic fertilizers under earthworm number aspect, was found in the first year of application, for all types of organic fertilisers.

The most unfavourable influence on earthworm number was observed at the end of the third year, in the case of oat incorporation, followed by the chemical fertilization.

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