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Effect of industrial wastes of the oil palm on growth and reproduction phases of earthworm, *Eisenia Andre.*

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Abstract

Eleven mixtures of oil palms industrial wastes were prepared: peels (C) and fiber (F), with cattle manure (EB) in proportions of 0, 20, 40, 60, 80 and 100%. 100% EB was used as a control. The aim of the research was to evaluate the effect of these substrates on the growth and the reproduction of the earthworm. Ten earthworms were used (51.0 ± 2.23 mg) per container of 750cc, containing 100 g of the mix in dry base. For 10 days the biomass was registered weekly plus the life's phase: Juvenile, Prechiltelleate, clitelleate and in regression, the total number of capsules/container, capsule's weight, the hatch percentage and the number of earthworms per capsule. A completely randomized design was used with four replications. Passed the fourth week clitelleate earthworms were observed. All earthworms gained weight in all mixtures until week number six. Statistical differences were found among the effects of the different substrates used, concluding that based on the analyzed variables, the best results correspond to the mixtures with fiber, that allows that the earthworms completes its life's cycle showing a good reproductive behavior. The best proportion of the mix was 60% F: 40% EB, registering the best percentage of clitelleate earthworms, 84%.

Introduction

The oil palm crop is beneficial for Venezuela for two main reasons: by its high yields of oil per hectare and by the multiple products and sub products of agricultural and industrial value; from the agronomic aspect it is much more efficient than any other oleaginous product (7). Likewise, it has an excellent adaptation to the agro climatic conditions of the country (4), facilitating the use and advantage of natural resources inside agro systems with agro ecological limitations as high rainfalls, low ph among others (7).

The production of the oil palm oscillates from 10 to 25 t bunches. ha^{-1}. Oil industry might incorporate on their processes only 25% of this amount. As

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a consequence it generates a huge quantity of wastes that have been estimated from 7.5 to 18.75 t. The characteristics of these materials, as the hardened and high contents of olive, make difficult their incorporation to the soil as «green manure», interrupting the cycle of nutrients (1).

As a consequence of mistaken policies in the handle of sub products and derivates in the industrial processing of oil palm, pollution problems in the soil and in the water are being originated. Additionally, the oil palm crop requires of huge extensions of surface and applications of fertilizers to overlook the high yields of nutrients in this specie. The handle scheme proposed for this crop has a main weaknesses a high deforestation rate, non controlled burns, alteration of the biologic equilibrium of different species and contamination of water and soils (3, 4, 19).

In Zulia, with the aim of reducing the eutrophyzation problems of the lake it is necessary to define productions programs of oil palm for reducing the applications of chemical fertilizers, as well as to advantage the huge quantity of organic wastes that are produced.

Earthworm culture is a biotechnology where the earthworm acts as a work tool for the transformation of waste into useful organic products (18), as manure that would return part of the extract nutrients without damaging the environment. The earthworm, when fed with organic wastes, transform the waste through the enzymatic mineralization process that occurs on its digestive track, in a material of easy absorption by the plant, where are incorporated an elevated bacterial charge that would facilitate the availability of nutrients for it (2). In relation to the earthworm specie used in the earthworm culture Haimi (9), refers that it is possible that most of researches done with *E. fetida* have been a mix of it with *E. Andrei*, since it is difficult to find populations of *E. fétida*; García *et al*. (8), refer that there is few explicit documentation about the biology of *E. Andrei* and its production capacity of humus, due to many authors do not differentiate *E. fetida* from *E. Andrei* since are morphologically indisputable, even though each specie has a different color pattern, *E. fetida* has red dots alternated with yellow bands, and *E. Andrei* is completely red (23). Haimi (9), indicates that *E. Andrei* is more numerous in the mixes of population.

Recent researches have demonstrated the feasibility of employing on animal alimentation, wastes coming from the processing of oil palm, substituting the energetic sources. An advantage of this alternative is that resources are employed that might be produced in tropical areas, reducing the dependency of external consumption (1, 3, 21).

It has been proved that the industrialization sub products of oil palm may be used in the earthworm culture since these allow the maintaining of the biomass and the reproduction (22), but it is unknown how it influences in other biologic

parameters, therefore, the aim of this research was to evaluate the mixes of these wastes: husk and fiber of the fruit, with one of the common alimentation substrate of the earthworm, as it is the cattle manure on the growth phases and reproductive behavior of the red worm *Eisenia andrei.*

Materials and methods

The organic wastes, husk and oil palm fiber employed in this research were given by the industrial complex Palmeras Diana, Jesús María Semprúm municipality, Zulia state, while the cattle manure came from the production unit located in an area classified as Tropical Dry Forest, in this worms were also found.

Originally, mixes of worm were obtained of the *E. fetida* and *E. Andrei* species, which were lately selected in function of the color, employing for the investigation earthworms belonging to *E. Andrei.*, characterized by having a uniform red color without bands.

The experiment was carried out in a small scale at the Ecology laboratory of the Agronomy Faculty of LUZ, with an average temperature of 27ºC (maximum 31ºC and minimum 24ºC). At the greenhouse of the Agronomy Faculty of LUZ, the organic materials to be evaluated were ground and mixed in proportions of 0, 20, 40, 60, 80 and 100% in a v/v relation. 11 mixes were obtained, 5 of them corresponding to husk-manure, 5 to fiber-manure and a witness, represented by 100% of manure. Mixes were composted for 20 days; doing survival test every week, putting a pair of earthworms in a container with a sample of the substrate to be evaluated. If earthworms gained weight of put capsules, the substrate was able to be employed.

A randomized experimental design was used with ten replications, for a total of 110 observations. The experimental unit was formed by a container of 750 cm^3 of mix capacity, where 10 hatching earthworms were put, with an average weight of 51.0 ± 2.23; in a mix quantity of 100 g in dry base.

Weekly, for 10 weeks, the biomass was measured in mg/ earthworm and four phases of its life cycle were determined, juvenile (from the birth to the incipient development of the clitellum), Preclitelleate (incipient development of the clitellum), clitelleate (well developed clitellum) and regression (lost of the clitellum). To determine the regression status of worms, none new food was put.

For evaluating the reproductive behavior of earthworms that reached this capacity, the number of total capsules put by 10 worms during five weeks was evaluated, determining the number of capsules/worm/day. For the weigh of capsules, were weighted individually in an analytic balance all capsules put in the second week of have reached the reproduction capacity. The hatch percentage was evaluated on the total of capsules put,

and the number of worms per capsule was determined on capsules that were weighted.

The information was analyzed statistically with the statistical software Statistix for Windows 6.0

Results and discussion

The variance analysis results showed statistically significant differences between the substrates effects used for all the measured variables. The best substrate was the fruit's fiber of the oil palm, which produced the highest percentage of clitelleate worms 84%; in husk 82% of worms never reached to form clitellum in the period of 10 weeks of evaluation. Likewise, 100 g of the fiber substrate maintained worms for a longer period of time in the reproduction phase. The highest percentage of worms that lost their reproduction capacity was registered in the cattle manure with 70% (figure 1).

The first adult worms were observed at the fourth development week, with 32%, 20% and 0% of clitelleate worms, and with a reproduction capacity for the fiber substrates, manure and husk respectively, with significant differences of the fiber effects and the manure in relation to the husk effect. On this same week, mixes that had the highest percentage of clitellate worms were 80 and 60% of fiber with 56 and 52% of adults' worms. Of these results it can be considered that at the time that increased the percentage of oil palm waste (fiber or husk of the palm fruit) in the mix with the

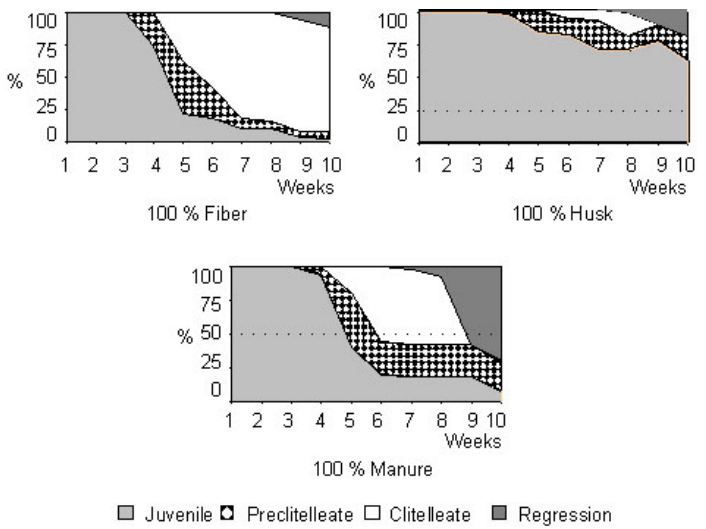

Figure 1. Industrialization waste effect of oil palm and manure on the earthworm's maturity phase of (*Eisenia andrei*).

manure, the behavior of the worm improved (figures 2 and 3).

Neuhauser *et al*. (20) suggest that the availability of food determines the time to reach the sexual maturity indicating that the development of the clitellum varies in a direct relation to the abundance of nutrients. Nogales *et a*l. (21) evaluating the sub products of the extraction of olive oil registered adults worms in the fifth week; however, when these were mixed with cattle manure the sexual maturation was observed in the third week, being this the shortest time referred in the literature; the longest time is of 90 days (2, 25).

The type of food offered will affect the weight gain (20). Different authors refer the use of crops' wastes as sources of carbon (5, 8, 12, 13, 21). When vegetal wastes are employed as substrates for worms, it is affected the availability of nutrients and the physical chemical characteristics of the substrate improve (8). Another benefit of employing vegetal organic matter, is that a better C:N relation is obtained in the substrate, since C is supplied and N losses are prevented by volatilization of ammonium (5).

When substrates are obtained as a result of employing materials with high N contents and materials with high C content, the nutrients balance and the structure of the substrate that is offered to worms improve. An additional benefit of these combinations is the inoculum of

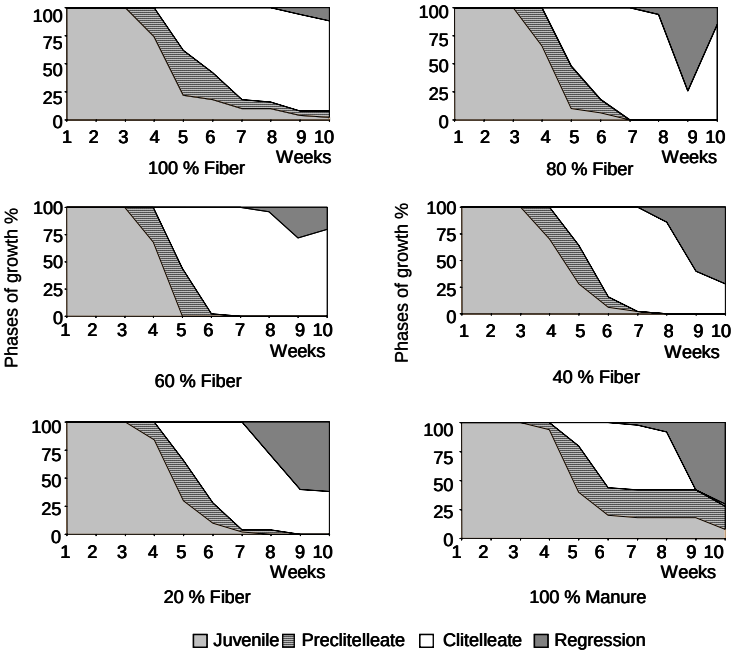

Figure 2. Mixes effect of fruit's fiber wastes of oil palm and manure on the maturation phase of the red earthworm (*Eisenia andrei*).

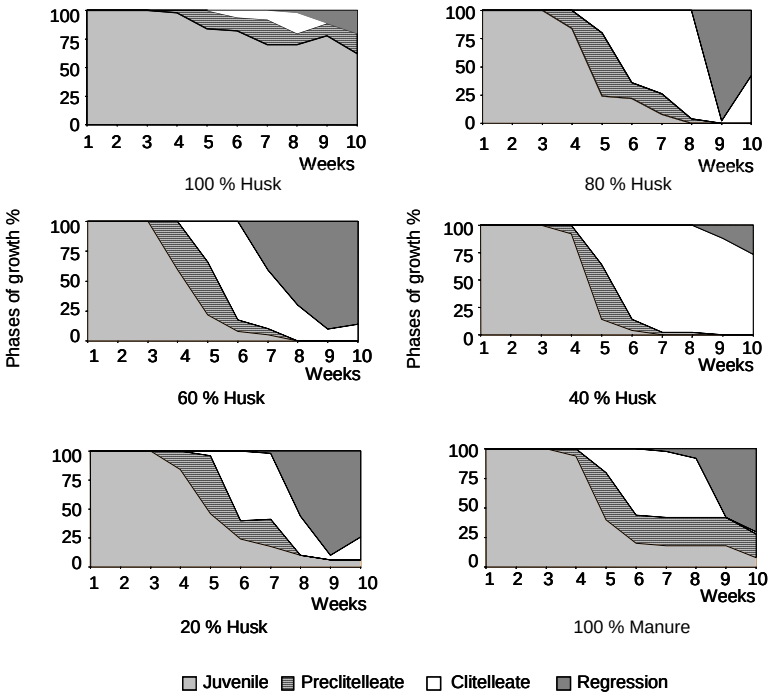

Figure 3. Mixes effect of the fruit's husk of oil palm and manure in the maturation phase of the red earthworm (*Eisenia andrei*)

microorganisms that proportion these materials (6).

Slejska (24) indicates that worms obtain their food from the micro organisms that develop inside the organic material, and refers that laboratory studies have proved that microbial groups with nutritive value for worms in decreasing order are: fungi, protozoo, algae, bacteria, and actinomycetes.

The effect of the alimentation substrate on the number of capsules produced by 10 worms followed the same tendency observed for the growth phases of earthworm. In figure 4 it is observed that in 100% of the fiber were a total of 101 capsules in a period of 5 weeks, presenting significant differences with the manure substrate with 4.2 capsules, and with the husk, where capsules were not registered, the result differed to the observed in the prior evaluation done by Hernández *et al.* (12), where in 100% of husk, were registered 3.23 capsules/partner/week; this might be due to the decomposition status that is achieved on the compost process, since this determined the abundance and diversity of the microbial groups (17) that form the food for worms (24).

The earthworms behavior in 100% of manure in this research resulted to be atypical, because in other evaluations under similar

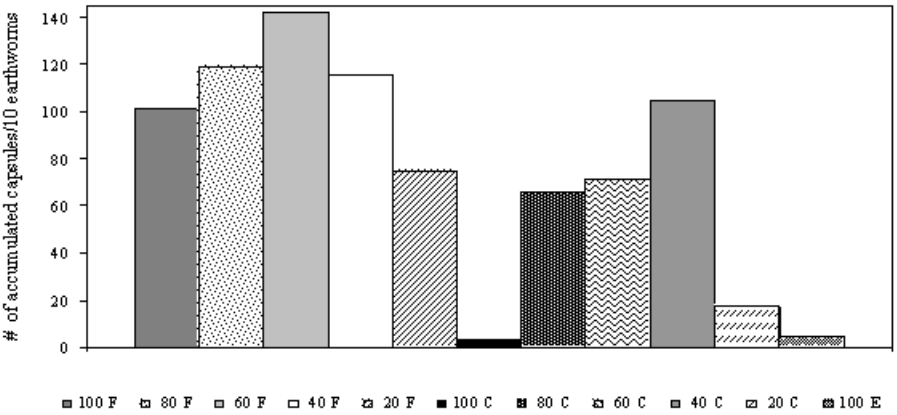

Figure 4. Effect of fiber and husk mixes of the oil palm on the number of accumulated capsules in five weeks in the earthworm (*Eisenia andrei*).

research conditions, the number of capsules per worms has been higher (14, 15, 16), in non published information more than 1 capsule per worm/day has been registered. However, this same manure when is mixed with the rest of the palm had a better behavior (figure 4). Nogales et al. (21) indicate that even though cattle manure is considered as an excellent substrate for worms, this is improved when it is mixed with rest of olive, a sub product used in the extraction of oil. Hernández et al. (10, 11) also observed that mixing the horse and cattle manure with composted leafs of neem, worms showed better growth and reproduction parameters in the mixed substrate rather than in manures without been mixed.

In table 1 are observed the reproductive variables evaluated, the highest values were registered with the substrate 60% of fiber with 0.41 cap/worm/d, with a capsule's weight of 15.5 mg, a hatch percentage of 98% and 3 worms/cap; Nogales *et al.* (21) evaluating extraction wastes of oil palm registered 0.43 cap/worm/d, 80% of hatch and 2.86 worm/cap.

The proportions of the cattle manure mixes with wastes of the crop affected significantly the growth phases of the red earthworm (*Eisenia andrei*), the best proportion was 60% wastes of palm (RP), without presenting statistical significant differences with the 40% proportion. In 60% of RP, earthworms started to reproduce within the fourth week with 45% of adults worms, within the seventh week, 100% of the population were capable to reproduce (figure 5).

For all proportions, earthworms gained weight until week six, after the seventh they started to lose weight (figure 6), which indicates that independently of the mix proportion and the nutritional quality of 100 g of

Table 1. Effect of the industrialization sub products of oil palm (husk and fiber of the fruit) mixed with cattle manure

Treatments	Capsules/ worm/day	Weight of capsules (mg)	% Hatching	# Worms/ capsules
100 F	0.24^{bc}	9.6^{b}	95^{a}	3.2^{a}
80 F	0.34^{ab}	11.54^{a}	92^{a}	2.7^{a}
60 F	0.41^{a}	15.4^{a}	98^{a}	3^{a}
40 F	0.30^{ab}	14.74^{a}	90^{a}	2.5^{a}
20 F	0.20^{c}	13.84^{a}	90^{a}	2^{a}
100 C	-	-	-	-
80 C	0.17^{c}	10.12^{a}	89^{a}	1.9^{b}
60 C	0.18^{c}	10.22^{a}	91^{a}	2^{a}
40 C	0.28^{abc}	13.72^{a}	90^{a}	2.3^{a}
20 C	0.05^{d}	9.12^{b}	89^{a}	2^{a}
100 E	0.01^{d}	10.87^{b}	95^{a}	3.1^{a}

Same letters do not differ statistically (P<0.05). Tukey's mean test

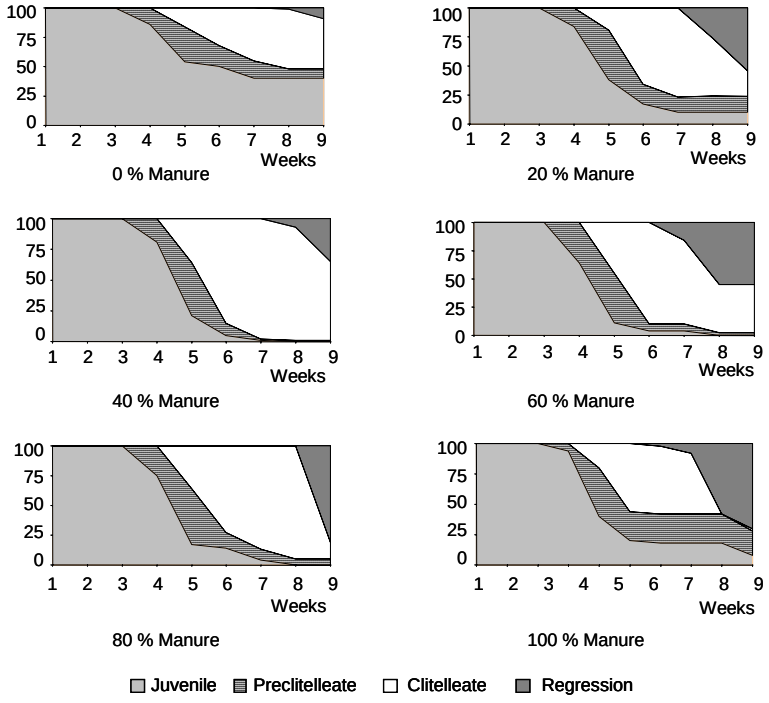

Figure 5. Manure content effect in the industrialization wastes mixes of oil palm on the maturation phase of the red earthworm (*Eisenia andrei*)

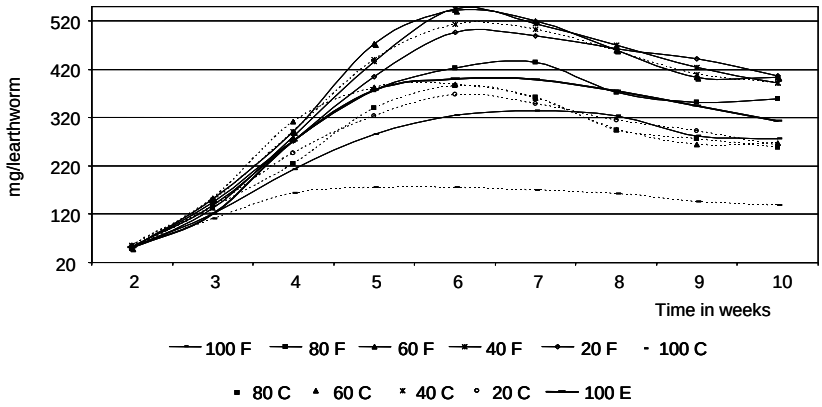

Figure 6. Effect of the fiber and husk mixes of the oil palm fruit on the earthworm growth (*Eisenia andrei*.)

the alimentation substrates' dry matter, these support the biomass until the sixth week; in this research may be inferred that the lost may be due to the lack of food, since here food was not restored, however, Domínguez *et al*. (5), observed a similar behavior even though they did feed them weekly, they tested seven mixes of substrates and for all, the gain of weight was kept until the fourth week, ins spite that significant differences were found among these; it can be deduce that physiologically, the earthworm had a continuous growth and then, independently of the food quality the gain of weight decreases.

Conclusions

Of the two substrates coming from the industrialization of Oil palm, husk and fiber of the fruit, this last is the one that gives the red worm *E. Andrei* the necessary nutriments for completing its life's cycle and showing adequate reproductive parameters. The best mix proportion was 60% of fiber and 40% of cattle manure.

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