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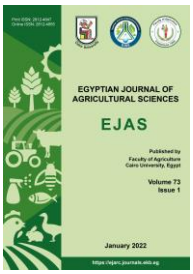

Biological Studies on Earthworm (*Eisenia Fetida)* under Egyptian Conditions

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ABSTRACT

Influence and suitability of banana peel, watermelon peel and tomato fruits on the growth and reproduction of the epigeic earthworm, *Eisenia fetida* were studied. Also, studying the effect of rearing *E. fetida* in complete darkness and normal daylight and nighttime darkness on laying cocoons by earthworm. The results showed that three tested plants feedings *i.e.*, banana peel, tomato fruits and watermelon peel were greatly differed for their effect on laying cocoons, average number of the produced earthworms in each cocoon and average weight of the mature earthworms. Watermelon peel was the superior supplement feed followed by banana peel then tomato fruits. In addition, the highest rate of cocoon laying, average number of the produced earthworms in each cocoon and average weight of the adult earthworm during the experiment was in the treatment in which banana peel + watermelon peel as well as banana peel + tomato fruits + watermelon peel was provided. There were great differences on laying cocoons, average number of the produced earthworms in each cocoon and average weight of the adult earthworms due to the amended plant and animal wastes. The production of cocoons in the growing boxes gradually increased by increasing the amount of the added earthworms from 50 to 250 g for each growing plastic box then they decreased when 500 g earthworms were added to each growing box. Meanwhile, opposite results were obtained in case of weight of one adult earthworm.

***Keywords**: Earthworm, Eisenia fetida, cocoons, fresh peel of banana fruits, hard rabbit manure.*

1. INTRODUCTION

The most promising earthworm species used for vermicomposting are *Eisenia fetida, Eisenia andrei, Eudrilus eugeniae* and *Perionyx excavatus*. However, *E.fetida* is commonly and widespread used for plant and animal wastes vermicomposting (Shetty and Birada,2023).

Eisenia fetida worm belongs to the family of lumbericidae. It, known under many common names such as red worm, brandling worm, manure worm, panfish worm, trout worm and red wiggler worm. Earthworms are widely used as bait for fishing in most parts of the world, which are a major and natural food for fish and birds. Earthworms are also considered as an important protein substance for feeding chicken chicks, and the amino acids that belong to earthworms play a major role in increasing the growth of chicks that feed on these worms. A study was also, conducted previously on the production of earthworms and their exploitation in feeding chicken chicks in Philippines (Fadaee, 2012 and Gunya and Masika, 2021).

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E.fetida not only breaks down organic wastes but also enhances the microbial population accelerating the decomposition and humification process. During the vermicomposting process, increase in microbial activity and hydrolytic enzymes indicates the biodegradation of organic wastes (Bansal and Kapoor, 2000). It also provide animal feed protein for fish and poultry industries in the form of worm biomass, which are rich in essential nutrients and minerals (Edwards, 1985).

With the gradual increase in the size of the world population and the adoption of intensive animal husbandry production, large amounts of organic waste produced all over the world are creating a serious problem and are considered as a major source of environmental pollution (Edwards and Lofty, 1977 and Edwards,1985). Therefore, nowadays using earthworm for vermicomposting these wastes become important for resolving the drastically effect of organic plant and animal wastes, which vermicompost accelerates the decomposition and humification process.

The use of chemicals for fertilization lead to the accumulation of chemicals in the soil, which affect the resulting crops. Therefore, it is necessary and important to search for highly efficient fertilization methods that do not in turn affect the resulting fruits, but rather help improve the quality of the fruits, increase soil fertility, and provide it with the important beneficial elements that the plant needs (Hernandez *et al.,* 2010). This is done by using vermicompost.

Vermicompost has proven to be more effective in terms of the number of environmental elements and nutrients that affect the resulting crop, and earthworms are used in vermicompost production (Kowalchuk *et al.*, 1999 and Mavaddati *et al.,* 2010). When the organic materials pass through the digestive system of earthworm become excreted in the form of granules called vermicasts. Vermicompost is therefore a mixture of worm secretions and organic materials including humus, live earthworms and other living organisms (Mavaddati *et al.,* 2010).

The earthworms of *Eisenia* sp. are annelid worms spread in many places in the world, as they tolerate varying degrees of temperature and humidity, and their life cycle shows high rates of growth and reproduction. They also, play an important role in the disposal of organic waste (Bansal and Kapoor, 2000 and Teferedegn and Ayele, 2024).

Plant, animal and kitchens wastes require large amounts of land to dispose of, which emits an ammonia odor into the air, may cause groundwater pollution and may pose a health risk and lead to structural incompatibility of the soil. The ability of some earthworms to consume a wide range of organic wastes, such as sewage sludge, animal waste, crop residues, and industrial wastes, has been confirmed in the feeding process. Earthworms break down complex wastes, enhance and increase microbial activity and rates of decomposition of organic materials and their conversion to a mineral form, which leads to the transformation into a humus-like substance is finer than compost as a result of the oxidation of complex organic materials (Hajam *et al.,* 2023 and Kavle *et al.,* 2023).

The final product, commonly called vermicompost and obtained when organic waste passes through the intestines of earthworms, is completely different from the original waste material. The presence of earthworms facilitates microbial action on the waste. This occurs because the waste is exposed to some types of bacteria and enzymes found in the earthworm's intestines, which are not available during compost preparation or other decomposition processes (Hajam *et al.*, 2023).

2. MATERIALS AND METHODS

2.1. Growing medium

Earthworms were growing in plastic boxes (40x 70x25 cm). Each box was lined by white seraan, then peatmoss (obtained from Lands and Water Inst., ARC, Giza, Egypt) was mixed with pieces of crushed cardboard (2-3 cm) at a height of 10 cm then well moistened with water. After that, the earthworms (250 g) were added to each plastic box and left until they enter inside the growing medium. The available food, either plant (banana, tomato and watermelon) or animal (hard rabbit manure) was added on top of the growing medium surface on one side (within a weight of 250 g for each plastic box), then the quantity is doubled every 30 days, so that the weight of the earthworms reached about one kg per each box after two months.

During the experiments, some of the produced cocoons were separated and placed in separate small containers to calculate the number of earthworms in each cocoon.

2.2. Effect of feeding type on the biology of the earthworm *E. fetida*

An experiment was designed to measure the effect of different plant foods (banana peel + tomato fruits and watermelon peel) either alone or in different combinations on the biology of earthworms as well as the total weight of earthworms. Three treatments were made, each treatment had three replicates (3 plastic boxes) and 50 g of earthworms were placed in each replicate. The experiment was conducted for two months between November 1, 2023, and January 1, 2024.

The cocoons were counted successively in each plastic box until the end of the experiment and the average was recorded. Earthworms inside each cocoon in each cage were counted one month after the beginning of the experiment, where 10 cocoons were taken randomly and earthworms inside them were counted, and the average was recorded. At the end of the experiment, the growing earthworms in each plastic box were weighed and the average was recorded. Also, the produced vermicompost was separated and taken.

2.3. Effect of different foods on the life cycle of earthworms as well as the total weight

An experiment was designed to measure the effect of different foods on the life cycle of earthworms as well as the total weight gain. Three treatments were made, each treatment had three replicates (3 boxes) and 50 grams of worms were placed in each replicate. The first treatment was provided only by plant waste (banana peel + watermelon peel), the second treatment provided only by animal waste (hard rabbit manure), and the third treatment provided with the mixture of plant waste and animal waste.

2.4. Effect of the number of earthworms inside the same box on the production of cocoons as well as the total weight

The experiment was designed to measure the effect of the number of earthworms inside the same box on the production of cocoons as well as the total weight gain. Four weights *i.e.*, 50,150, 250 and 500 g were used in each rearing box by a depth of 10 cm. Three weights were prepared and each weight had three replicates (3 boxes).

2.5. The effect of darkness on the number of cocoons laid by red earthworm and their locations

An experiment was conducted to measure the effect of darkness on the reproduction rate of worms with the feeding fixed on a mixture of fresh peel of banana fruits with hard rabbit manure wastes. A piece of black tarpaulin was placed over the growing medium to prevent light from reaching. Also, the sides of the boxes were covered with black tarpaulin, while the other boxes (plastic boxes) did not use black tarpaulin but used white tarpaulin. The experiment was conducted for a month from April 2,2024 to May 2,2024. During this period, the number of cocoons and their placement locations were recorded. The experiment was conducted by performing 3 replicates for each treatment.

2.6. Statistical analysis

All the obtained data were statistically processed by split design (Snedecor and Cochran, 1980) and the analysis of variance and by determining the significance threshold using Duncan's test (Duncan, 1955).

3. RESULTS

3.1. Effect of feeding type on the biology of the earthworm *E.fetida*

The results in Table (1) reveal that the three tested plants feedings *i.e.*, banana peel, tomato fruits and watermelon peel were greatly differed in their effect on laying cocoons, average number of the produced earthworms in each cocoon and average weight of the mature earthworms. In this regard, watermelon peel was the superior supplement feed, being 268.67 cocoons, 6.33 earthworms and adult earthworms weight of 200.0g followed by banana peel, being 264.67 cocoons, 5.33 earthworms and 194.67 g and tomato fruits, being 262.00 cocoons, 3.37 earthworm and adult earthworm weight of 188.33 g, respectively. In addition, the highest rate of cocoon laying, average number of produced earthworms in each cocoon and average weight of the mature earthworm (g) during the experiment, were in the treatment in which banana peel + watermelon peel was provided, being 270.00 cocoon, 6.67 earthworm in each cocoon and adult earthworm weight of 210.33 g. The treatment in which watermelon peel was added ranked second in case of cocoon laying and average number of the produced earthworms in each cocoon, being 268.67 cocoons and 6.33 earthworms in each cocoon.

Meanwhile, the treatment in which banana peel + watermelon peel + tomato fruits were added recorded 268.33 cocoons, 5.57 earthworms in each cocoon and adult earthworm weight of 202.67 g. The lowest figures of cocoons production, the produced earthworms in each cocoon and adult earthworm weight was the treatment in which only tomato fruits were added for feeding, being 262.00 cocoon, 3.67 earthworm in each cocoon and adult earthworm weight of 188.33 g. The results also showed that adding tomato fruits to either banana peel or watermelon peel negatively affected the rate of cocoons laying, the number of worms inside the cocoons and weight of adult earth worms.

watermelon peel produced the highest number of the produced cocoons, being 270.67 cocoon followed by hard rabbit manure, being 272.67 cocoon then banana peel + tomato fruits+ watermelon peel, being 267.67 cocoon. The number of the produced earthworms inside each cocoon was not greatly differed due to the feeding type (6.67-7.0 cocoon). The highest weight of the adult earthworms at the end of the experiment (g) was obtained in case of feeding on banana peel + tomato fruits+ watermelon peel, being 249.67 g followed by hard rabbit manure, being 213.33 then banana peel + watermelon peel, being 210.33 g.

Table (1): Effect of feeding on three plant kinds and there in combinations on the biology of the earthworm *E. fetida*.

type Feeding	Average number of the produced cocoons	Average number of the produced earthworms in each cocoon	Average weight of the earth-worms at the end of the experiment (g)*
Banana peel (BP)	264.33 ^{b}	5.33 ^{a}	194.67 ^{c}
Watermelon peel (WP)	268.67 ^{a}	6.33 ^{a}	200.00 ^{b}
Tomato fruits (TF)	262.00 ^{b}	3.67 ^{b}	188.33 ^{d}
BP+WP	270.00^{a}	6.67 ^{a}	210.33 ^{a}
BP+TF	263.33 ^{b}	4.67 ^{b}	192.67 ^{c}
WP+TF	264.67 ^{b}	4.67 ^{b}	194.00 ^{c}
BP+WP+TF	268.33^{a}	5.67 ^{a}	202. 67 ^{b}

***Only mature worms were weighed, not young or newly hatched earthworms.**

Means with the same letter are not significantly different. a,b,c,d values in the same column with different superscripts differed significantly.

3.2. Effect of different foods on the life cycle of earthworms as well as the total weight

Results presented in Table (2) show that there were great differences in laying cocoons, average number of the produced earthworms in each cocoon and average weight of the adult earthworms due to amending with plant and animal wastes. In addition, banana peel +

3.3. Effect of the number of earthworms inside the same box on the production of cocoons as well as the total weight

Data shown in Table (3) indicate that the produced cocoons, being 22.33, 87.67 and 136.0 cocoons, gradually increased significantly by increasing the amount of the added earthworms to each growing plastic box, being 50,150 and 250 g, respectively then they decreased to 122.33

Table (2): Effect of feeding on two plant wastes together and hard rabbit manure, each alone or in combination on the biology of earthworm *E. fetida*.

type Feeding	Average number of the produced cocoons	Average number of earthworms inside the cocoon after (days)	Average weight of the adult earthworms at the end of the experiment (g)*
Banana peel (BP)+ watermelon peel (WP)	272.67^{a}	6.7 ^{a}	210.33 ^{b}
Hard rabbit manure (HRD)	267.67 ^{b}	7.0 ^{a}	213.33 ^{b}
BP+WP+HRD	270.67 ^{a}	7.0 ^{a}	249.67 ^{a}

***Only mature worms were weighed, not young or newly hatched worms.**

Means with the same letter are not significantly different. a,b values in the same column with different superscripts differed significantly

cocoons when 500 g earthworms were added to each growing box. On the other hand, the weight of one adult earthworm (g) was gradually decreased by increasing the amount of the added earthworms under study to each growing plastic box, being 0.63, 0.56, 0.54 and 0.37 g, respectively.

Meanwhile, in case of normal daylight and nighttime darkness earthworms were distributed throughout most of the growing medium, which may reduce the mating process.

It was found during the experiment that the new pupae take on a light yellow or golden color, and as time progresses, they begin to take on a dark red then brown color as the worms emerge from them.

Table (3): Effect of earthworm *E. fetida*. numbers in the same growing area (plastic box) on cocoons production and weight of one adult earthworm (g).

Weight (g) of the added earthworms to each plastic growing box	Average number of the produced cocoons	Average weight of one adult earthworm (g)*
50	22.33 [d]	0.63 [a]
150	87.67 [c]	0.56 [a]
250	136.00 [a]	0.54 [a]
500	122.33 [b]	0.37 [b]

Means with the same letter are not significantly different. a,b,c,d values in the same column with different superscripts differed significantly.

3.4. Effect of darkness on the number of cocoons laid by earthworm

Table (4) shows that complete darkness was more favorable for mating and producing a higher number of cocoons than normal daylight and nighttime darkness, being 148.33 and 129.67 cocoon, respectively.

When examining the earthworms in complete darkness, it was noted that they were constantly present in the surface layer of the growing medium in clusters, which increases the chance of the earthworms meeting and mating (Fig.1).

Table (4): The effect of darkness on the number of cocoons lay by earthworm *E. fetida*.

Lighting	Average number of the produced cocoons
Complete darkness	[a]148.33
Normal daylight and nighttime darkness	[b]129.67

Means with the same letter are not significantly different. a,b values in the same column with different superscripts differed significantly.

Fig.1. (1): Earthworms grow on the growing medium, (2): Mating of earthworms, (3): Cocoon of earthworms (white color) and (4): New emerged earthworms.

4. DISCUSSION

Red wiggler worms (*Eisenia fetida*) are amongst the most popular worm species in worms composting organic wastes. Earthworms have large coelomic cavities containing Coelomocytes, a closed vascular system with at least one dorsal and a ventral trunk and a ventral nerve cord. The alimentary canal is basically an anterior - posterior tube with excretion through the anus or specialized organs called nephridia; respiration is mainly cuticular.

The obtained data revealed that the three tested plants feedings *i.e.*, banana peel, tomato fruits and watermelon peel were greatly differed for their effect on laying cocoons, average number of the produced earthworms in each cocoon and average weight of the mature earthworms(g), where watermelon peel was the superior supplement feed followed by banana peel then tomato fruits. In addition, the highest rate of cocoon laying, average number of the produced earthworms in each cocoon and average weight of the mature earthworm (g) during the experiment, were in the treatments in which banana peel + watermelon peel as well as banana peel + tomato fruits + watermelon peel were provided. The highest rate of cocoon laying, average number of the produced earthworms in each cocoon and average weight of the adult earthworm (g) during the experiment, were in the treatment in which banana peel + watermelon peel , banana peel + watermelon peel+ watermelon peel and watermelon peel. The lowest figures of cocoons production, the produced earthworms in each cocoon and adult earthworm weight was the treatment in which only tomato fruits were added for feeding. The results also, showed that adding tomato fruits to both banana peel and watermelon peel negatively affected the rate of cocoon laying, the number of worms inside the cocoons and weight of adult earth worms.

The obtained results revealed that there were great differences in laying cocoons, average number of the produced earthworms in each cocoon and average weight of the adult earthworms due to amending with plant and animal wastes. The number of the produced earthworms inside each cocoon was not greatly differed due to the feeding type. Moreover, banana peel + watermelon peel produced the highest number of the produced cocoons followed by hard rabbit manure then banana peel + tomato fruits+ watermelon peel. The number of the produced earthworms inside each cocoon was not greatly differed due to the feeding type (6.67-7.0 cocoons). The highest weight of the adult earthworms at the end of the experiment (g) was obtained in case of feeding on banana peel + tomato fruits+ watermelon peel followed by hard rabbit manure then banana peel + watermelon peel.

There were, to somewhat, no differences in the number of earthworms inside the cocoons due to feeding on the mixture of plant feed (banana peel + watermelon peel), hard rabbit manure and the mixture of both feeding. The obtained data are in accordance with obtained data of Chauhan and Singh (2012 and 2013) and Unuofin and Mnkeni, (2014).

E. fetida, plays a major role in vermicom-posting and environmental preservation by its voracity for organic matter, rapid reproduction, and high-quality vermicompost production makes it an invaluable ally. In India, domestic waste is mostly of organic nature and contributes 70- 80% to the total solid urban waste. However, it can be used as a potential resource for transformation from expensive disposal problems to stabilized vermicompost production for sustainable land restoration practices. Some epigeic earthworms: *Lumbricus terrestris, Eisenia fetida, E. andrei, Eudrilus eugeniae* and *Perionyx excavatus* have been appeared as key sources to combat the problems of organic waste disposal on a low-input basis (Elvira, *et al.*, 1998; Dominguez, *et al.*, 2001; Garg and Kaushik, 2006 and Suthar, 2006).

The increase in the number of cocoons in the case of plant feed may be due to the accumulation of earthworms on the plant parts, which increases the chance of their meeting and thus mating and cocoon production.

It has been found that the produced cocoons were gradually increased significantly by increasing the amount of the added earthworms to each growing plastic box from 50 to 250 g then they decreased when 500 g earthworms were added to each growing box. On the other hand, the weight of one adult earthworm (g) was gradually decreased by increasing the amount of the added earthworms under study to each growing plastic box.

Data revealed that complete darkness was more favorable for mating and producing a higher number of cocoons than normal daylight and nighttime darkness.

When examining the earthworms in complete darkness, it was noted that they were constantly present in the surface layer of the growing medium in clusters, which increases the chance of the earthworms meeting and mating. Meanwhile, in case of normal daylight and nighttime darkness earthworms were distributed throughout most of the growing medium, which may reduce the mating process. Therefore, there was a much variation in biomass, growth rate and cocoon production by this earthworm in different organic wastes. The obtained results are accordance with the obtained results by Loh *et al.* (2004) and Nagannawar *et al.* (2021). In addition earthworms in complete darkness were constantly present in the surface layer of the growing medium in clusters, which increases the chance of the earthworms meeting and mating. Meanwhile, in case of normal daylight and nighttime darkness earthworms were distributed throughout most of the growing medium, which may reduce the mating process. Similar results were obtained by Pulikeshi and Amoji (2003)

Overcrowding within the rearing environment leads to a decrease in the weight of the worms, a noticeable development of the gonads, and an increase in the production of cocoons (Unuofin and Mnkeni, 2014).

Comprehending the growth and reproductive capabilities of vermicomposting the earthworm, *E.fetida* across diverse wastes from banana peel, tomato fruits and watermelon peel and their combination are crucial for the effective utilization of earthworms in sustainable waste management systems. Earthworm farming is an important way to get rid of plant and animal wastes in a way that recycles them and produce vermicompost, which is used as an organic fertilizer instead of chemical fertilizers to produce organic food free of chemicals. *E. fetida* is ideal for vermicomposting. It quickly degrades organic matter, creating high-quality vermicompost in a short time. Its rapid reproduction ensures a healthy population, promoting continuous processing.

The experiments, also, proved the importance of rearing earthworms in a dark environment, as it helped in accelerating growth and laying a greater number of cocoons due to the frequent meeting of worms during the dark on the surface of the soil.

Conclusion

Based on the results of this research, we recommend that farmers expand the cultivation of earthworms to produce vermicompost as a good organic fertilizer to increase soil fertility, as cultivating earthworms does not require high costs and plant waste and food leftovers can be used to produce vermicompost to produce high-quality agricultural products free of chemical fertilizers and hence it is considered to be a potent organic fertilizer for sustainable agricultural practices.

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Conflict of interest

The authors declare that they do not have any actual or potential conflict of interest.

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دراسات بيولوجية على دودة الأرض(*Eisenia fetida*) تحت الظروف المصرية

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[2] قسم الإنتاج الحيوانى- كلية الزراعة- جامعة القاهرة- الجيزة

ملخص

تم دراسة تأثير وملاءمة قشر الموز وقشر البطيخ وثمار الطماطم على نمو وتكاثر دودة الأرض *Eisenia fetida* .كما تم دراسة تأثير تربية *E. fetida* في الظلام وضوء النهار الطبيعي على وضع شرانق دودة الأرض .أظهرت النتائج أن التغذية النباتية وهي قشر الموز وثمار الطماطم وقشر البطيخ كانت مختلفة بشكل كبير من حيث تأثيرها على وضع الشرانق ومتوسط عدد ديدان الأرض المنتجة في كل شرنقة ومتوسط وزن ديدان الأرض الناضجة . أيضا كان قشر البطيخ هو المكمل الغذائي الأفضل يليه قشر الموز ثم ثمار الطماطم . بالإضافة إلى ذلك، كان أعلى معدل لوضع الشرانق ومتوسط عدد ديدان الأرض المنتجة في كل شرنقة ومتوسط وزن دودة الأرض البالغة أثناء التجربة في المعاملة التي تم فيها استخدام قشر الموز + قشر البطيخ وكذلك قشر الموز + ثمار الطماطم + قشر البطيخ .وقد كانت هناك فروق كبيرة في وضع الشرانق ومتوسط عدد الديدان المنتجة في كل شرنقة ومتوسط وزن الديدان البالغة وذلك بسبب إضافة المخلفات النباتية والحيوانية، وقد زاد إنتاج الشرانق في صناديق النمو تدريجياً بزيادة كمية الديدان المضافة من 50 إلى 250 جرام لكل صندوق بلاستيكي ثم انخفضت عند إضافة 500 جرام من الديدان لكل صندوق، بينما تم الحصول على نتائج عكسية في حالة وزن دودة الأرض البالغة الواحدة.