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Experimental Analysis of Green Ecological Culture of Earthworm in the Farmland

Jinqing Wang[1], Hanlin Zhang[2], Shuangxi Li[2], Xiaobin Tao[2], Weizhong Li[1], Fengtao Gao[1], Jiali Feng[1]

[1]Institute of Modern Facility Fisheries, College of Biology and Oceanography, Weifang University, Weifang, China
[2]Shanghai Academy of Agricultural Sciences, Shanghai, China
Email: jinqwang@163.com

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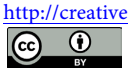


Abstract

The earthworm production in the first two years was affected by the feeding density. In the third year, the earthworm population reached equilibrium, the reproduction of the low-density population accelerated, the reproduction of the high-density population slowed down, and the density difference decreased. The annual cumulative earthworm production reached 250 kg/mu. The harvesting was carried out three times, 70 kg in April, 50% from May to June, *i.e.*, 150 kg, and 80 kg in August. The effect of earthworm culture in the Cauliflower field is better than that in the corn field, reaching 300 kg/mu per year in the Cauliflower field and 200 kg/mu per year in the corn field. The experiment found that the effect of pig manure was better than cow manure, and the effect of fresh pig manure on breeding earthworms was not obvious, but the amount of earthworms increased significantly after one month. The breeding effect of 2000 kg pig manure/mu was very obvious, and the weight of earthworms reached 300 - 400 kg.

Subject Areas

Agricultural Science

Keywords

Earthworm, Density, Pig Manure, Breeding Years, Earthworm Dung

1. Introduction

The earthworm is high-quality live bait for eel, loach and many other fish species. At the same time, it is also an important raw material of traditional Chinese medicine. It can also extract important raw materials for light industry such as

Lumbrokinase and amino acids [1]. It has broad market space in efficient breeding and industrial development. At present, the market demand is large, and carrying out large-scale earthworm breeding is in line with the current development situation. The earthworm varieties suitable for vegetable cultivation in Shanghai and with high medicinal value discussed in this paper are mainly *Pheretima vulgaris* (Chen), *Pheretima guillelmi* (Michaelsen) and *Pheretima pectinifera* (Michaelsen), belonging to the genus Pheretima of Megascolecidae, commonly known as the shanghai earth-worm [2]. This variety has the strong adaptability, a wide range of activities and a large food intake, which is 8 times larger than that of *Eisenia foetida*. At the same time, it has strong abilities of stress resistance and deep-dwelling, being suitable for loosening the underlying soil. This variety can not only increase the total breeding yield, but also better adapt to the local soil, water and climate conditions. The main purpose of this paper is to analyze the effects of stocking density and breeding years on earthworm yield under the condition of field earthworm breeding, and to analyze the effects of the dry season, rainy season and different crops on the yield of earthworm cast, which can provide reference and basic data for field earthworm breeding.

2. Materials and Methods

2.1. Materials

In recent years, earthworm composting technology, which adopts conventional composting methods and inherits and develops its advantages, has formed a new environmental protection fertility preservation technology. It makes full use of the efficient digestion and decomposition ability of earthworms, decomposes and transforms vegetable waste through the synergistic action of digestive tract and microorganisms, and produces bioactive organic fertilizer. In this study, native earthworm varieties with large individuals, high medicinal value, high vermicompost yield and strong soil turnover ability were selected as farmland breeding earthworm varieties.

Before earthworm breeding, first comprehensively improve the farmland, and fully level and loosen the farmland soil with iron rake, mainly by putting about 1000 kg/mu of organic fertilizer and 2000 kg/mu of straw back to the field. The earthworm should first adapt to the environment and fully feed, move, rest and reproduce. The first time to put in seedlings was in the plum rain season. The stocking density of earthworm species was set at three gradients of 14.5 kg, 29.5 kg and 44.5 kg.

2.2. Methods

Trapping method was used to harvest earthworms raised in the field. Before harvest, a layer of food that earthworms like to eat on the surface of the plot was placed, such as rotten fruits. After 2 - 3 days, earthworms gathered in a large number of rotten fruits. At this time, quickly take out groups of earthworms and clean up impurities through a screen. In the field, choose the feed that earth-

worms like to eat, stack it near the earthworm breeding field, and collect earthworms in the feed pile in the early morning of the next day. Small ditches with a depth of less than 10 cm along the edge of the earthworm breeding field were digged, and two earth pits with a diameter of 30 - 50 cm at both ends of the ditch was digged. Earthworms crawled along the groove at night and entered the earth pit, which were collected before dawn. In addition, after the rain, a large number of earthworms crawl on the ground surface, and earthworms were picked up by hand.

A 50 cm × 50 cm quadrat was selected (n = 5) in each crop field for sampling earthworm dung, the number of earthworm holes were counted, the earthworm dung on the surface was scraped with a plastic plate, and the total amount of earthworm dung was calculated.

2.3. Data Analysis

Statistic 7.0 practical data analysis software was used to analyze statistically and plot the data. One-way ANOVA was used to analyze the effects of different years and earthworm density on earthworm yield during the experiment, and the effects of dry season, rainy season and crop types on earthworm manure yield. The experimental data are expressed by means ± S.E.

3. Results

In the first two years of this experiment, the earthworm production was obviously affected by the feeding density. In the third year, the earthworm population reached constant state, low-density population reproduced incredibly quickly and the high-density population growth slowed down, and the difference among different density populations disappeared. The annual cumulative earthworm production reached 250 kg/mu. The harvesting was carried out in three times, with 70 kg in April, 50% from May to June, *i.e.*, 150 kg, and 80 kg in August. The effect of earthworm culture in Cauliflower field is better than that in corn field, reaching 300 kg/mu per year in Cauliflower Field and 200 kg/mu per year in corn field. The experiment showed that the breeding effect of pig manure was better than cow manure, and the effect of fresh pig manure on breeding earthworms was not obvious, but the amount of earthworms increased significantly after one month. The breeding effect of 2000 kg pig manure/mu was very obvious, and the number of earthworms reached 300 - 400 kg. All kinds of vegetable wastes can be used as food sources for earthworms. Taro has high yield of stems and leaves. It is also a plant straw that earthworms like to eat. It can be used as a reserve resource for further earthworm breeding and development.

The earthworm population in Chongming vegetable field was investigated. It was found that the weight of most earthworms was about 5 g, the body length was 18 cm and the diameter was 5 mm. The population accorded with normal distribution. Earthworms in the vegetable field have strong feeding intensity, high activity ability and stronger biological farming ability (**Figure 1**).

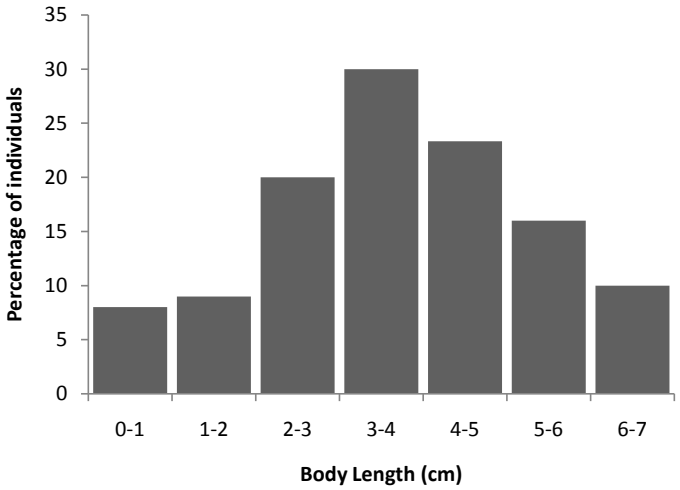


Figure 1. Proportion of individual size of earthworm population in experimental field.

The density of seedlings introduced for the first time has a significant impact on the harvest of earthworms in the first year, and the difference gradually disappears in the third year (**Figure 2**). This paper also studied the effects of shading and watering to simulate rainfall and irrigation on earthworm yield and breeding ecology, in order to screen the technical measures to improve earthworm yield under the condition of ecological planting and breeding. The results showed that moderate watering (5 kg/m^2) promoted the reproduction and growth of earthworms, and shading also had a good effect. The maximum number of earthworms could reach 100 g/m^2. This provides a reliable technical way to improve the effect of earthworm culture in the field.

In this item, it is found that the amount of soil excavated by earthworms after rain is 3075 g/m^2, and the diameter of small particles spit out by earthworms is about 2 mm. Due to the high corn stalk and good shade, earthworms have the strongest excavation ability and survival ability in the corn field (**Figure 3**). There are many earthworm tunnels in the vegetable field, with large length, loose soil surface, many horizontal pipelines, and 550 openings/m^2. On the bare ground, there are mostly vertical earthworm tunnels, with hole density of 300/m^2. The earthworm dung layer in the vegetable field is thin, but the coverage rate is high. The earthworm dung on the bare ground is thick, but the coverage area is small. The creepage marks on the ground indicated the activity frequency of earthworms, and the length of their creepage marks reached 35 m/m^2, indicating their intensive activity ability.

It is observed that the natural death season of the old individual of earthworm occurs in August. The tail of earthworm festered and decomposed in deep soil, and the new individual naturally occurred. Earthworms had active exhalation phenomenon at night in summer. Their heads was exposed to the hole and made a hissing sound, which played an important role in earthworm reproduction and courtship. **Figures 1-4** showed the population structure of earthworms in farmland.

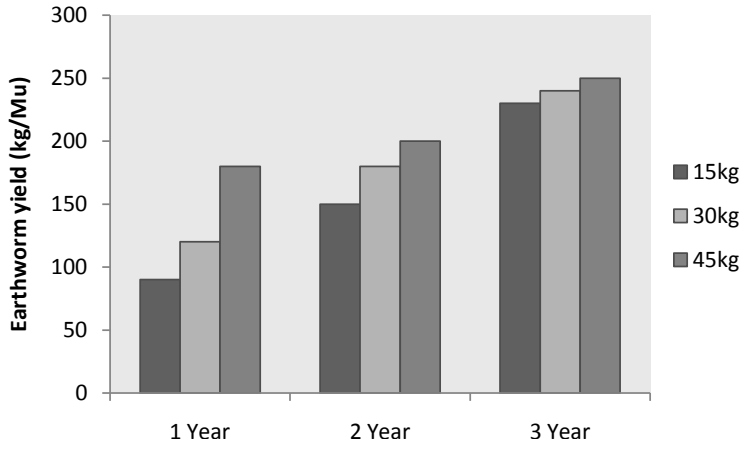


Figure 2. Effects of breeding years and earthworm species release density on earthworm yield.

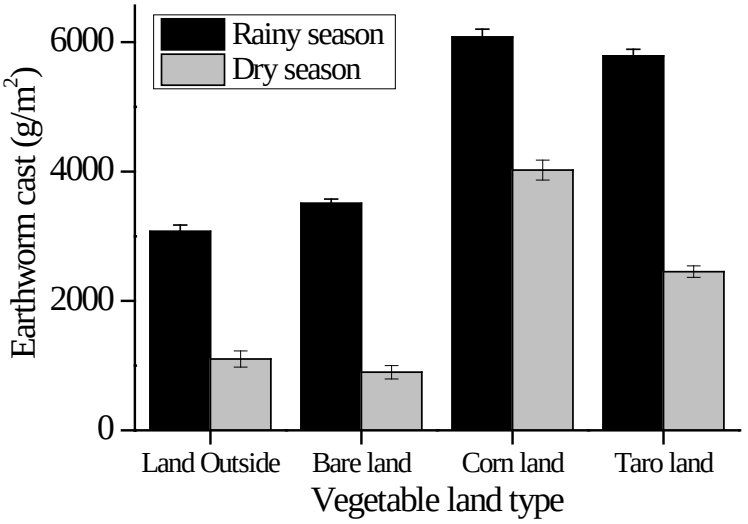
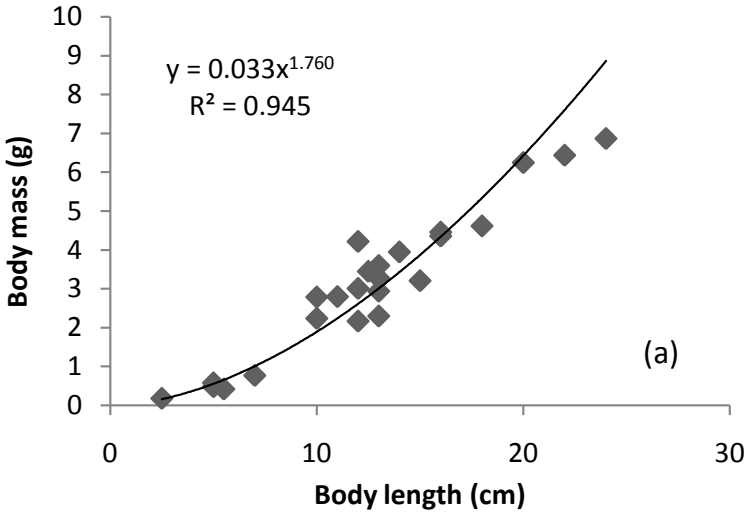


Figure 3. Excavation volume of earthworm dung.



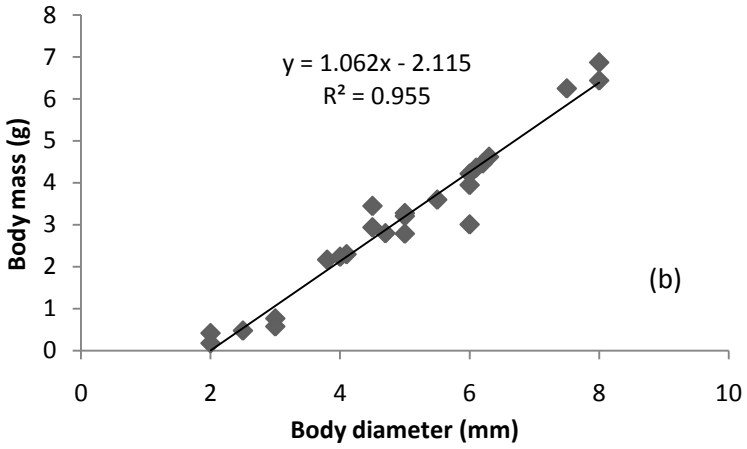


Figure 4. Relationship between body length and body mass (a), between body diameter and body mass (b) of earthworms.

4. Discussions and Conclusions

4.1. Analysis on the Breeding Methods of Earthworms

In view of the important application value of earthworms in fish breeding bait and the development of traditional Chinese medicine, the future work should focus on improving the research on earthworm reproduction and proliferation technology, and provide abundant earthworm provenance through the implementation of a series of technologies suitable for earthworm incubation and cultivation, such as the temperature, humidity and pH adjustment of the breeding bed. Li He *et al.* (2020) reported that the suitable temperature and humidity for earthworm breeding are 20˚C - 25˚C and 55% - 60%. The feed with the volume ratio of cow dung and vegetable straw of 1:1 is the most suitable for earthworm feeding and utilization [3]. Earthworms with bright color, strong development and swollen reproductive zone are selected as breeding earthworms. After mating and spawning for 2 - 3 months, they should be replaced with new breeding earthworms. They should be kept sparsely during the breeding period. In the peak breeding season (April to July, September to October every year), cocoons are taken once a week, the feeding bed is loosened to improve air permeability, and the feed is changed every two weeks. Earthworm diets are supplemented with nutritious feeds such as wheat bran, cow dung, melons and fruits. The mixture of earthworm eggs and earthworm dung is used as the hatching base material, with a thickness of 20 cm, and the humidity is adjusted to 60% - 70%. It is placed in the breeding bed for hatching, and covered with grass curtain to keep warm and moist. When most earthworm cocoons hatch young earthworms for more than 1 month (about 2 cm long), collect the young earthworms into the vegetable field for breeding. Earthworm dung is a good natural organic fertilizer, which is rich in nutrient elements, mineral elements and beneficial microorganisms. It has uniform texture, natural soil smell and good ability to absorb and maintain nutrients [4]. Earthworm biological fertilizer with application rate higher than 500 kg/667m^2 can significantly in-

crease the content of VC and protein in Chinese cabbage and improve the yield of Chinese Cabbage [4]. Li Chao *et al.* (2021) found that the earthworm density of winter fallow, winter milkvetch and winter rape was 10.8 - 36.3/m^2; the yield of earthworm is 373 - 1364 kg/hm^2; the yield of earthworm dung is 2652 - 11,535 kg/hm^2 [1]. Similar results were obtained in this study.

4.2. Analysis of Feeding Substrate Types of Earthworms

Earthworm breeding can utilize agricultural waste as a resource. Crop straw has been successfully applied. Gu Yongfen *et al.* (2012) successfully cultured earthworms after adding 10% rape straw, corn straw, pepper straw and rice straw and fresh cow dung fermentation [5]. Studies have shown that there is a lack of relationship between the nitrogen content of feed bed and the growth or reproduction of earthworms [6], and lignin and polyphenols in feed matrix may inhibit factors [7]. Some studies have shown that polyphenols and lignin:nitrogen ratio (L:N) is negatively correlated with the yield of earthworm population [8]. Under the treatment with or without sawdust, the content of polyphenols and related substances in plant leaves is high, and some substrates have smell, which will cause the death of earthworms [9]. Lu *et al.* (2019) measured the weight gain of earthworms, the number of cocoons, the number of increased pieces and the length of earthworms to screen the best proportion of mixed matrix of cow dung, pig dung and sheep dung, and determined that the best mass proportion is cow dung:sheep dung:pig dung = 80:10:10 as the most suitable combination [10]. Therefore, the matching of substrates for earthworm breeding and reproduction, the proportion of raw materials, physical and chemical properties and the elimination of harmful substances are the focus of the preliminary work of earthworm breeding.

Earthworm culture between ridges in vegetable fields could make full use of the straw waste in vegetable fields, which was converted into organic fertilizer available for crops, so as to improving the soil aggregate structure. In case of rainfall, earthworms can escape on the ridge for cultivating farmland and feeding. In case of drought, earthworms crawled into the ring ditch and became the live bait of freshwater fish *Monopterus albus*. The feeding effect of *Monopterus albus* also regulated the number of earthworm population. Earthworms were most afraid of flooding. During heavy rain, a large number of earthworms were found crawling on the cement pavement and sand pile to avoid flooding, which was very unfavorable to the growth and survival of earthworms. Special earthworm breeding measures should be established for the problem of rain and waterlogging.

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Conflicts of Interest

The authors declare no conflicts of interest.

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