Design of a Vermiculture Device with the Separation Function

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Abstract. To address problems of high labor intensity, low efficiency and poor effect in separating earthworms from vermicompost manually, a vermiculture device with the separation function has been proposed. This box-structure device is divided into the culture tank and the transit tank by a partition board with through holes. Its front and rear sides are designed with doors that can be opened and closed. Inside the culture tank and the transit tank are heaters, which are arranged at the same interval from left to right. The heater, the culture tank door and the transit tank door are controlled by the control cabinet, which turns on heaters at different positions to create a high temperature environment to force earthworms move to the place with heaters not started after passing the through holes on the partition boards. In this way, earthworms are separated from their vermicompost. After that, the doors of the culture tank and the transit tank can be opened for cleaning the vermicompost. This device can be used for either outdoor or indoor vermiculture, and is able to automatically separate earthworms from vermicompost, which thus has greatly reduced the workload, lowered labor cost, elevated efficiency while producing a better separation effect. More than that, it has a simple structure, a low manufacturing cost and is easy to operate, hence presenting a high popularization value for vermiculture.

Keywords: Vermiculture Device; Separation Function; Heating System; Culture Tank; Transit Tank.

1. Introduction

More and more attention has been paid to the treatment of waste by earthworms. For this reason, a professional term has been formed: vermicomposting, which refers to the processing by which various wastes are eaten by earthworms and converted into body components and wormcasts[1-2, 5-7]. No matter the waste generated from plants [3-4,6,8], such as fallen leaves, tail vegetables, rice husks and straw, or the waste excreted by animals [3-6,11], such as feces, can become the food of earthworms after fermentation treatment, so that earthworms can grow and reproduce and produce wormcasts. Moreover, worms and wormcasts are good things. Earthworms, in addition to free and fertilize soil [9], can also be used as raw materials for lumbrokinase extraction, protein feed for cultured animals, and bait for fishing [19]. Wormcasts can be directly used as plant fertilizer [13,16], as a cultivation medium in facility agriculture such as greenhouses [14,18], and as bedding for livestock and poultry houses [19]. That agricultural wastes treated by earthworms is in accordance with the laws of nature. In nature, earthworms live in the ground and eat organic matters, which are mainly the mixture of decomposed feces and leaves, as well as branches. One of the purposes of earthworms traveling through the land is to find these foods, thereby indirectly loosening the soil and producing wormcasts to nourish the ground. Many studies have shown that there are more earthworms in areas with rich soil. Experiments show that one of the measures for land restoration and improvement is to apply organic fertilizer and inoculate earthworms [13]. Secondly, the technology of earthworm treatment of agricultural waste is simple and easy to learn, less investment, quick effect,

and obvious economic and ecological benefits [12-14]. Plant waste is rich in carbon, and animal manure has a high content of nitrogen. The two are mixed in an appropriate proportion for fermentation (i.e. composting), and the fermentation products can become food for earthworms [14-15,17]. These composts are stacked into a "breeding bed", where the worms are inoculated, and then the daily work is to add water and feed, to extirpate weeds, as well as to separate the worms from wormcasts[10]. The products of this processing are earthworms and wormcasts, which are beneficial to human beings, and there is no useless or harmful by-products. Moreover, recycling agriculture can be constructed with the treatment of agricultural waste by earthworms [8,19]. Generally, plant materials should be properly added in the composting process of livestock and poultry manure to adjust the appropriate carbon and nitrogen ratio, which is conducive to shortening the fermentation time and improving the maturity of fermentation products. The products of wormcast and earthworm can be used back to the crop farming and animal husbandry, so as to form a cycle, thereby reducing the waste output of the entire agricultural system and ensuring the sustainable development of the agricultural system fundamentally.

Currently, vermiculture is generally carried out outdoors. In practice, the breeding materials are piled up into bars, where earthworms are raised. After a period of time, the earthworms will convert the breeding materials into vermicompost and be separated, so that new breeding materials will be refilled. The separation process is generally completed manually, featuring high workload, low efficiency but poor effect.

To deal with the foregoing problems, a vermiculture device with the separation function has been proposed. This device can be used for either outdoor or indoor vermiculture, and is able to automatically separate earthworms from vermicompost, which thus has greatly reduced the workload, lowered labor cost, elevated efficiency while producing a better separation effect. More than that, it has a simple structure, a low manufacturing cost and is easy to operate, hence presenting a high popularization value for vermiculture.

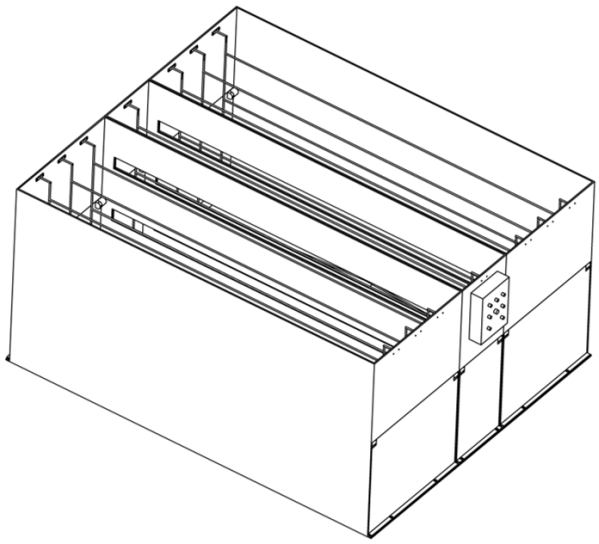


Fig 1. Vermiculture device with the separation function

2. Overall Structure and Working Principles

The device has a box structure, which is divided into the left, middle and right parts by the partition board that has through holes on it. Its left and right parts are the culture tank, and the middle part is the transit tank. On the front and rear sides of the three parts are doors that can be opened and closed. The bottom surface is two inclined planes leading to the front and rear direction, to facilitate centralized cleaning of vermicompost. Inside the culture tank and the transit tank are heaters that are made of heating pipes supported by a bracket and set at equal intervals along the left and right directions. The heaters are controlled by a control cabinet.

To separate earthworms in the transit tank, heaters inside will be started, so that earthworms will move to the culture tank through the through holes on the two partition boards under the high temperature. After a period of time, after all earthworms have reached the culture tank, vermicompost in the transit tank can be cleaned. Similarly, to separate earthworms in the culture tank, heaters inside will be started, so that earthworms will move to the transit tank through the through holes on the two partition boards under the high temperature. After a period of time, after all earthworms have reached the transit tank, vermicompost in the culture tank can be cleaned accordingly.

3. Structural Design

3.1 Design of the Culture Tank

The culture tank is a rectangular box with an opening at the top and is divided into the left, center and right parts by two parallel partition boards set vertically. The left and right parts are the wider culture tanks made of steel plate for breeding earthworms, while the middle part is the smaller transit tank. On the two identical partition boards are four symmetrical bar-type openings from top to bottom, for earthworms to enter into the transit tank.

At the bottom of the culture tank, the center is high and the two sides are low, forming symmetrical inclined surfaces facing the front and rear directions. In the lower part of the front and rear sides of the culture tank, rectangular openings are designed and hinged with the door of the culture tank. Vermicompost falls from the two inclined planes of the culture tank and gathers to the culture tank doors on the front and rear sides. Then, the culture tank door will be opened, so that vermicompost can be discharged out of the culture tank from the opening. If vermicompost needs to be taken out, the culture tank door will be opened, but it should be closed in other cases. At the bottom of the front and rear sides of the transit tank, the same rectangular openings are also designed and hinged with the transit tank. Doors of the culture tank and the transit door are all opened and closed by the linear actuator.

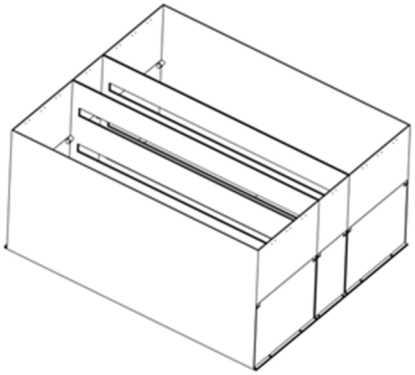


Fig 2. Culture tank

3.2 Design of the Heating System

The heating system compromises of the heating pipe and the heating pipe support. The heating pipe is divided into the culture tank heating pipe and the transit tank heating pipe. Since the culture tank is wider than the transit tank, so it has been equipped with three groups of heating pipes along its left and right to ensure uniform heating, while in the transit tank are two groups of heating pipes along the left and right to ensure uniform heating as well. Both the culture tank and the transit tank are provided with multiple heating pipes vertically. The heating pipes are arranged along the front and rear directions, with both ends fixedly mounted on both sides of the U-shaped heating pipe support, whose both sides are bolted to the front and rear side walls of the culture tank and the transit tank. Since the preferred temperature for earthworms is 15~25℃, when the heating pipe heats up the culture tank to above 25℃, the earthworms will move to the place with a lower temperature, thereby to realize a complete separation process. Taking account of the heat absorption by the breeding

materials, in order to accelerate the separation process, the designed temperature for the heating pipe is set to 40-50℃.

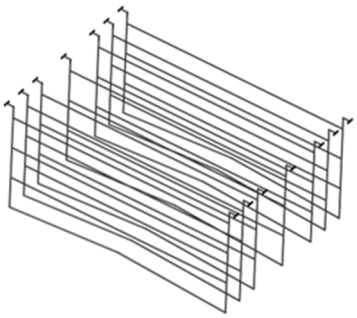


Fig 3. Heating system

3.3 Design of the Control System

The control system is installed in the control cabinet on the external wall of the culture tank and consists of the transit tank heating pipe switch, the culture tank heating pipe switch, the transit tank door switch, the culture tank door switch and the main switch. Specifically, the transit tank switch is connected to the transit tank heating pipe through a wire and is used to control the start and stop of its heating. The culture tank switch is connected to the culture tank heating pipe through a wire and is used to control the start and stop of its heating. The transit tank door switch is used to control the opening and closing of the door, which is the same case for the culture tank door switch. The main switch is used to control the connection and disconnection of the power supply of the control cabinet.

4. Application Method

4.1 Earthworm Separation Method

To separate the earthworms, firstly, put vermiculture materials into the culture tank and the transit tank together with the earthworms. After a period of time, when the breeding materials in the transit tank are converted to vermicompost by the earthworms, open the heating switch of the transit tank to start the heater to heat up the inside of the transit tank. In this case, the earthworms can feel the high temperature and will move to the culture tanks on the left and on the right from the bar opening on the two partition boards. After a period, when the earthworms have completely moved into the culture tanks, turn off the heating switch of the transit tank to stop the heater. At the same time, open the transit tank door to take out vermicompost that has been converted from the breeding materials by the earthworms. Again, after a period, when the breeding materials in the culture tank have been fully converted into vermicompost, put new breeding materials to the transit tank. Then, turn on the left and right culture tank heating switches to start the heaters to heat up the left and right culture tanks. In this case, the earthworms in the culture tank can feel the high temperature and will move to the transit tank from the bar opening on the two partition boards. When the earthworms have completely moved in to the transit tank, turn off the left and right culture tank heating switches, open the culture tank door to take out vermicompost that has been converted from the breeding materials by the earthworms. Again, after a period, when the breeding materials in the transit tank have been fully converted into vermicompost, put new breeding materials to the culture tank. Start the transit tank heating switches and repeat the above steps to make earthworms move to the culture tank. In this way, earthworms will be separated from vermicompost.

4.2 Vermicompost Cleaning Method

To clean vermicompost in the transit tank, open the transit tank doors on both sides and take out vermicompost with tools like shovels (Fig. 4). Likewise, To clean vermicompost in the culture tank, firstly, open the culture tank doors on the front and rear sides and take out vermicompost with tools like shovels (Fig. 5).

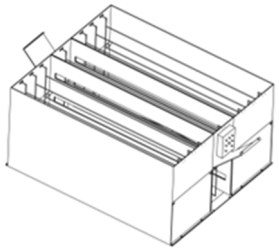


Fig 4. Transit tank door open state

4.3 Method for Filling the Breeding Materials

To fill the breeding materials to the culture tank, close the culture tank doors on the front and rear sides and fill in the breeding materials from the top. Similarly, to fill the breeding materials to the transit tank, close the transit tank doors on both sides and fill in the breeding materials from the top.

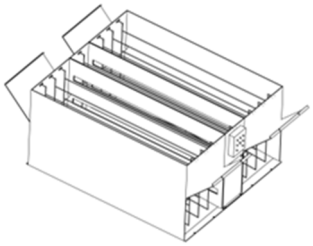


Fig 5. Culture tank doors open state

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