

Design of Family Sprouting Vegetables Cultivation Equipment

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Abstract: In order to adapt to the promotion of household sprouting vegetables cultivation techniques, a family-type sprouting vegetable cultivation equipment was designed, which consisted of main structure, cultivation trough, water circulation system, fill light system and control system. The cultivation space is saved by the 3D cultivation mode; the water requirement of the sprouting vegetable is ensured by the water circulation system, and the light demand of the sprouting vegetable is ensured by the fill light system; the automatic water supply and the fill light are realized by the control system. The equipment has the advantages of simple structure, low production cost and convenient use, and can meet the needs of the household environment for the cultivation of sprouting vegetables, and is easy to be popularized and applied, which has certain reference value for related designs.

1. Introduction

With the rapid development of society, environmental problems have become increasingly prominent, and people have higher requirements for living environment while being satisfied with the economy. Many families hope to create a warm and comfortable living environment by planting green plants [1]. Balcony agriculture refers to the mainly apply soilless cultivation method. Residents can use indoor, balcony, courtyard and other spaces for agricultural production of household horticultural plant cultivation or decoration. Balconies and roofs cultivation in Japan, as well as developed countries in the in Europe and America have been very mature. Horticultural planting has become one of the most popular leisure sports for adults [2]. Sprouting vegetables are a new type of "live vegetables" that grow edible young buds, seedlings, stems, etc. by using various kinds of beans, cereals, trees and other plant seeds or other vegetative organs under various suitable conditions. Sprouting vegetables are rich in nutrients and are alkaline foods. Some sprouting vegetables have certain medicinal or health care value themselves. Because they do not involve chemical fertilizers or pesticides in their production, and mainly using hydroponic, so they are considered as a kind of new unpolluted, edible-safe vegetable [4]. Sprouting vegetables are especially suitable for home planting due to their simple cultivation techniques.

In recent years, there have been many related studies on cultivation equipment. Xiaowen Zhang et al. designed a 3D cultivation equipment system for leafy vegetables [5]. Zaihe Shen et al. designed a new 3D aerosol cultivation equipment [6]. Jing Zhao et al. have developed an automatic conveying 3D culture bed system [7]. Zhihao Zhu et al. designed a smart green cultivation device [8]. Zongqun Zhang designed a water-fertilizer integrating smart irrigation system with relatively closed cultivation environment [9].

Although there are many studies on cultivation equipment, the cultivation of household sprouting vegetables are still rare to be adapted. In order to solve this problem, this paper designs a family-type sprouting vegetable cultivation equipment. The equipment has the advantages of simple structure, low production cost and convenient use, and can meet the needs of the household environment for the cultivation of sprouting vegetables, and is easy to be popularized and applied, which has certain reference value for related designs.

2. Overall Design

The family-type sprouting vegetable cultivation equipment is composed of a main structure, a cultivation trough, a water circulation system, a fill light system, a control system. The main structure consists of a cultivation frame and a box. The cultivation frame is used to install the cultivation trough. The trough is used to support the cultivation frame, and the water tank, water pump, filter and control system of the water circulation system which are installed inside. The cultivation trough consisted of a water tank and a cultivation board. The water tank is used to hold a certain amount of irrigation water to ensure the water supply of the sprouting vegetables; the cultivation board is used to cultivate the sprouting vegetables. The water circulation system is used to offer water to the cultivation trough and return the excess water to the water tank. The fill light system is used to replenish the cultivated sprouting vegetables so that they can grow normally even under insufficient light. The control system is used to control the timing on and off of the water circulation system and the fill light system.

3. Parts Design

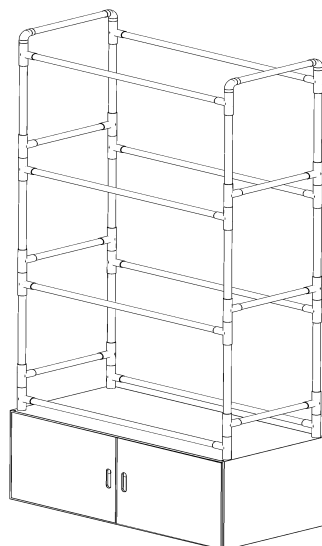


Figure. 1 Main structure

3.1 The Design of the Main Structure.

The main structure is composed of a cultivation frame and a box body (Figure 1). The cultivation frame is made of PVC pipe and tee, and its length, width and height are determined according to the number of cultivation layers, the number and the size of cultivation troughs. In this design example, the number of cultivation layers is 3, and the number of cultivation troughs is 3. The cultivation trough has a length of 60 cm and a width of 30 cm. In order to meet the light needs of the growth of sprouting vegetables, the layer spacing is designed to be 35 cm. The length and width of the box are determined by the size of the cultivation frame, which is used to install the water tank, water pump, filter and control system of the water circulation system, and is designed to be 40 cm in height.

3.2 Design of Cultivation Trough.

The cultivation trough is composed of a water tank and a cultivation board (Figure 2). The water tank is a cuboid with an upper opening, which is made of PVC sheets and has a height of about 5 cm. One side of the water tank has a hole 1 cm from the upper edge, which is a water inlet hole for inserting the water inlet pipe. When the water supply system works, water enters the cultivation trough through the water inlet. The other side of the water trough also has a through hole 2 cm away from the bottom surface, which is a backwater hole, and a backwater pipe is installed thereon. When the water level in the cultivation trough reaches the position of the backwater pipe orifice, it

flows back to the water trough through the backwater pipe. The cultivation board is made of PVC board with sieve meshes. When cultivated, the roots of the sprouting vegetables can pass through the sieve meshes and grow downward to absorb the moisture in the water trough. There is a frame at the bottom for support so that the cultivation board is 4 cm from the bottom of the water tank. The advantage of this design is that, in use, the water surface in the water tank kept 2 cm in height, and the space between the cultivation board and the water surface is 2 cm in height, which contains air that can meet the water and air needs of the sprouting vegetables root.

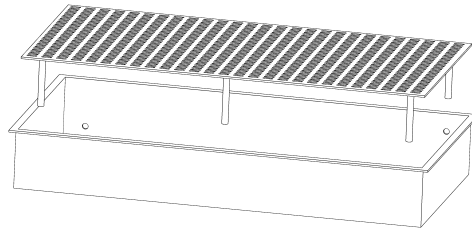


Figure 2. Cultivation trough

3.3 The Design of Water Circulation System.

The water circulation system includes a water supply system and a backwater system (Figure 3). The water supply system consists of a water trough, a water pump, a filter, a main water supply pipe, a water supply branch pipe, and a water dropper. The water trough is used to store a certain amount of irrigation water, and is connected to the water pump through a pipe. After the water pump is pressurized from the water trough, the water filters out the impurities when flowing through the filter, and is transported through the main water supply pipe and then transported to the water trough through the water supply branch pipe. Irrigation water flows into the cultivation trough by using a water dropper connected to the end of the water supply branch pipe. In order to ensure the water supply pressure, a self-priming pump is used. To ensure that the filter effect, a laminated filter is used. In order to simplify installation and save production costs, PE hoses were used as main pipe and branch pipes. In order to alleviate the pressure difference between the water supply layers and ensure uniform water supply to the cultivation trough, a pressure-compensated water dropper is adopted. The backwater system consists of a joint, a backwater branch pipe, and a backwater main pipe. The joint is connected to the backwater hole of the water tank. When the water level in the water tank is higher than the backwater hole, the water flows into the backwater main pipe through the backwater branch pipe, and then flows into the water pipe. The water tank is kept at a certain water level in this way, and excess water can flow back to the water tank. In order to simplify installation and save production costs, PE pipes are also used for the main and branch pipes of the backwater.

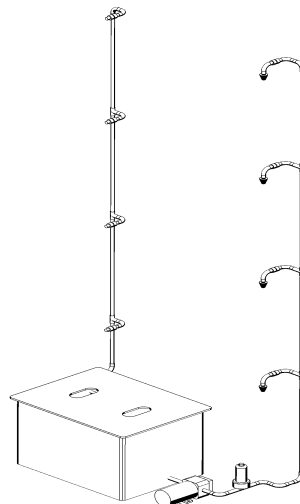


Figure. 3 Water circulation system

3.4 Design of Fill Light System.

In recent years, research on the use of artificial light sources to supplement the light required for plant growth has received increasing attention. The artificial light sources used for plant growth mainly include LED lamps, incandescent lamps, fluorescent lamps, metal halide lamps, high-pressure sodium lamps and daylight lamps [10]. LED light quality has the advantages of convenient spectral energy modulation, energy saving and environmental protection, and low calorific value, which has become an important artificial light source for plant growth [11].

The fill light system is mainly composed of fill light and wire. This design is mainly used for the cultivation of sprouting vegetables in the household environment. Due to insufficient indoor lighting, the fill light system is installed to supplement the light of the cultivated sprouting vegetables to meet the needs for illumination during the growth of the sprouting vegetables. The fill light lamp is an LED plant growth lamp with a red-blue ratio of 3:1. The fill light lamp is installed above the cultivation troughs of each layer, connected to the power source through wires, and controlled by the control system to achieve timing fill light.

3.5 Design of Control System.

The control system consists of the main control chip, LCD screen, electric relay, button, power supply and so on. The main control chip is a single-chip microcomputer, and the on and off control of the electric relay is realized through a program. The irrigation time and the fill light time are set by the button, so that the cultivation equipment can automatically perform water circulation and fill light according to the set time. The power supply is used to power the water pump and fill light lamp.

4. Design of Total Assembly Part

After the design of the parts is completed, the assembly function of the SolidWorks is used to assemble the parts. After interference checking and determining that the parts are not interfered, the design of the total assembly part of the family-type sprouting vegetable cultivation equipment is completed (Figure 4).

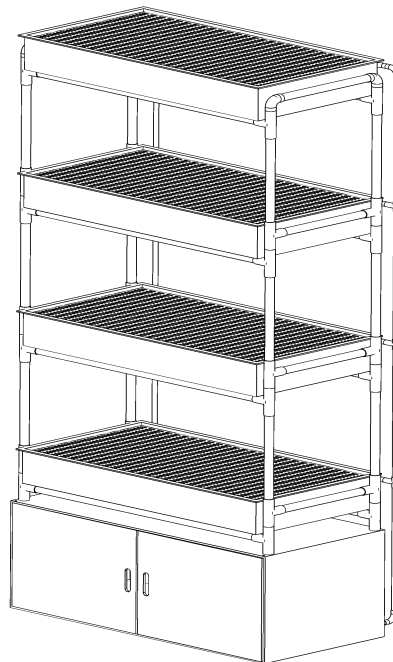


Figure. 4 Family-type sprouting vegetable cultivation equipment

5. Conclusion

In order to adapt to the promotion of household sprouting vegetables cultivation techniques, a

family-type sprouting vegetable cultivation equipment was designed, which consisted of main structure, cultivation trough, water circulation system, fill light system and control system. The cultivation space is saved by the 3D cultivation mode; the water requirement of the sprouting vegetable is ensured by the water circulation system, and the light demand of the sprouting vegetable is ensured by the fill light system; the automatic water supply and the fill light are realized by the control system. The equipment has the advantages of simple structure, low production cost and convenient use, and can meet the needs of the household environment for the cultivation of sprouting vegetables, and is easy to be popularized and applied, which has certain reference value for related designs.

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