Design on Three-Dimensional Tidal Irrigation Pot Plant Device

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Abstract. Family gardening can improve the living environment, increase the oxygen content in the room, purify indoor pollution, and also can delight the mind, maintain mental health, and cultivate the sentiment of life and so on. In order to solve the problems of constant care of plant cultivation in family gardening and poor plant growth due to the lack of experience in cultivation and management, this paper designed a three-dimensional tidal irrigation pot plant device to realize three-dimensional cultivation of potted plants, and it has the functions of manual irrigation, automated irrigation, and remote irrigation. The device can realize the automated irrigation of plant cultivation in family gardening, and has the advantages of simple structure, easy to use, easy to maintain, safe and reliable, which is of positive significance for promoting the development of family gardening.

Keywords: Tidal Irrigation; Pot Plant Device; three-dimensional pot plant main structure ; Family gardening

1 Introduction

Gardening involves the cultivation of vegetables, fruit trees or ornamental plants within a certain area, and family gardening engages in the cultivation and decoration of horticultural plants within a spatial area such as indoors, balcony, rooftop or patio [1]. With the economic development and social progress in China, people's living standards continue to improve, people put forward higher requirements for spiritual needs [2], many want to get close to the green, return to nature, so family gardening has become increasingly popular [3].

In recent years, scholars have made many studies on gardening and health. Kristin M studied that gardening has a wide range of benefits for people's health [4]. Sirinya P conducted a study that showed that family gardening is significantly associated with happiness [5]. Leith S conducted a study showing that gardening has the potential to enhance health and well-being through increased physical activity and social connectedness [6]. Joel T studied the utility of family gardening in improving food security

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and health [7]. It can be seen that family gardening can beautify the living environment, improve the oxygen content of the living room, purify the role of indoor pollution, but also can delight the mind, to maintain mental health, cultivate the sentiment of life.

Tidal irrigation involves placing the cultivation container in a specific cultivation tank and supplying nutrient solution or water to the substrate upward through the capillarity of the cultivation substrate inside the cultivation container. When the substrate is full of water, the remaining water and fertilizer are recycled to the storage tank through the nutrient solution recycling control system [8]. Tidal irrigation can ensure that the substrate and root system in the cultivation tank fully absorb water after irrigation, and can avoid or delay the accumulation of salts on the surface of cultivation substrate, thus contributing to the improvement of water and fertilizer utilization and pest and disease prevention and control [9]. Tidal irrigation can effectively avoid the edge effect and umbrella effect produced by top sprinkler irrigation [10], and it is a humidity-reducing, water-saving, high-efficiency and labor-saving irrigation technology [11].

The three-dimensional cultivation mode provides better ornamental, can improve space utilization and increase yield [12]. There have been many research results in this field. Zhang Yuxiang studied the substrate cultivation technique of leafy vegetables in tiered racks [13]. Cong Qianqian et al. investigated the three-dimensional grid-layered shelf cultivation technology of Ganoderma lucidum [14]. Zhu Wenli et al. investigated the three-dimensional soilless cultivation technology of strawberries [15]. Guo Yi et al. researched the ring-shaped household vegetable three-dimensional cultivation device [16], the automated cultivation device for home sprouts [17], and the combined ultrasonic sprouts cultivation device [18].

In order to solve the problems of constant care of plant cultivation in family gardening and poor plant growth due to the lack of experience in cultivation and management. In addition, due to the limited planting space in general households, three-dimensional cultivation can improve the utilization of planting space and meet the ornamental needs of cultivation devices in home gardening activities. This paper designed a three-dimensional tidal irrigation pot plant device to realize three-dimensional cultivation of potted plants, and it has the functions of manual irrigation, automated irrigation, and remote irrigation. The device can realize the automated irrigation of plant cultivation in family gardening, and has the advantages of simple structure, easy to use, easy to maintain, safe and reliable, which is of positive significance for promoting the development of family gardening.

2 Design on Three-dimensional Tidal Irrigation Pot Plant Device

The three-dimensional tidal irrigation pot plant device consists of a three-dimensional pot plant main structure, a tidal irrigation system, and a control system (Figure 1). The three-dimensional pot plant main structure is used to place the plant; the tidal irrigation system is used to irrigate the plant; and the control system is used to set the working parameters of irrigation system.

2.1 Design on the Main Structure of Three-dimensional Pot Plant

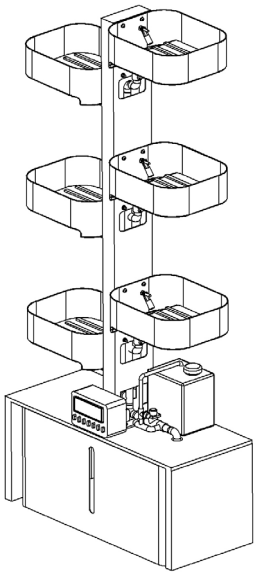

Fig. 1. Three-dimensional tidal irrigation pot plant device

The main structure of the three-dimensional pot plant consists of base, columns and sink. The base is a door-shaped structure with 6 through holes in the upper part, the largest one in the middle is used for installing the water filling port, the 4 through holes in the middle, are used for installing the column, and the other through hole is used for installing the main pipe of the irrigation and fertilization system. The column is a hollow structure with the main pipe installed in the center and the bottom is fixed by bolts connected to four through holes in the center of the base. There are four square openings on one side of the column and three square openings on the other side for installing the branch pipes. There are three L-shaped structures on each side of the column for supporting the sink. The side of the column also has a sink and level sensor mounting holes. The sink is used to place potted plants. The sink is square with an opening at the top, and has a higher depth on one side of the bottom of the sink and a smaller depth on the other side, in order that the bottom of the potted plant does not come into contact with the water after the water is returned. Through holes at the bottom of the deeper portion for mounting the outlet, and five strip-like projections at the bottom of the smaller portion for supporting the potted plants so that they can keep the air flowing through their roots during non-irrigation hours. One side of the sink has 1 level sensor mounting hole and 2 sink mounting holes. For the beauty of the device, the sink has rounded corners on all sides. The sink is bolted and fixed to the column.

2.2 Design on Tidal Irrigation and Fertilization System

The tidal irrigation and fertilization system consists of head unit, fertilization unit, piping unit, liquid level control unit. It is used to supply water or water-fertilizer mixture to each cultivation tank, and to make the water in the cultivation tank return to the water tank after irrigation (Figure 2).

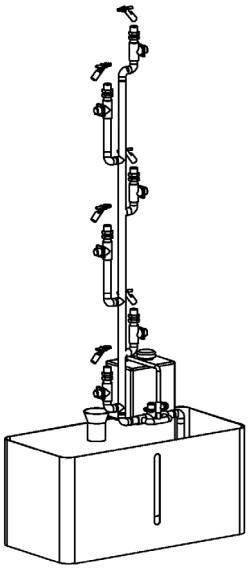

Fig. 2. Tidal irrigation and fertilization system

The head unit consists of a water tank and a water pump. The water tank is installed inside the base for storing irrigation water. The water tank consists of a box, a water tank cover, a water filling port, and an inspection window. The box is square and the upper opening is fitted with a water tank cover. The tank cover has two through holes, one of which corresponds to the through hole in the base for the water filler, and the other for the main line to pass through it. The water filling port is funnel-shaped and is mounted on the tank cover, through which water can be added to the tank from the outside. The inspection window is made of transparent material to check the water level in the water tank, and when the water is in a low level, irrigation water can be replenished to the water tank through the water filling port. The water pump is a submersible pump, installed at the bottom of the tank, the outlet of the pump is connected to the main pipeline through a connector, and there is a strainer at the inlet of the pump for filtering impurities in the water.

Fertilizer device consists of fertilizer tank, fertilizer injector, main pipe solenoid valve and fertilizer solenoid valve. Fertilizer tank is mounted on the upper part of the base for storing liquid fertilizer, and there is a cover on the upper part, which can add liquid fertilizer to the fertilizer tank. There is a fertilizer injector connected to the transverse side of the main pipe, which uses Venturi injector. The working principle of Venturi injector is to use the liquid flow through the pipeline when the overflow area

suddenly becomes smaller, generating a local negative pressure, the fertilizer from the external container will be sucked through the fertilizer pipe into the main pipe. Venturi injector has the characteristics of simple structure, low cost, simple use and easy to realize automatic control. Fertilizer tank is connected to the fertilizer injector through the fertilizer pipe, and there is a fertilizer solenoid valve at the connection between the fertilizer pipe and the fertilizer injector. The main pipe solenoid valve is used to control the water supply and fertilization.

The pipe unit consists of main pipe, branch pipe, sink solenoid valve, and water outlet. The main pipe consists of water pump connecting pipe, cross pipe and vertical pipe, the water pump connecting pipe is connected to the water pump through a connector, the fertilizer injector is installed at the cross pipe, the vertical pipe is installed inside the column, and the vertical pipe is connected to 6 branch pipes, which correspond to 6 water tanks. The branch pipe is connected to the main pipe through a connector and to the sink through an outlet, and a sink solenoid valve is installed on each branch pipe. The sink solenoid valve opens when water needs to be supplied to the sink; it closes when the water level in the sink needs to be maintained; and it opens when water needs to be returned. The outlet is installed at the bottom of the sink for supplying and returning water to the sink.

The level control device consists of a level sensor and a relay. The liquid level sensor is used to sense the height of the liquid level in the tank. Adopting duckbill type float sensor, the buoyancy of the liquid can be used to realize the switch control, when the liquid level rises, the float rises accordingly, and similarly when the liquid level falls, the float falls accordingly. In this design, when the water level in the sink rises to a height limited by the sensor, a signal is sent to the relay, which controls the closure of the sink solenoid valve and stops the water supply to the sink. When the control system opens the sink solenoid valve, the water in the sink returns and the level sensor drops with it.

2.3 Design on Control System

The control system is used to set the working parameters for irrigation and fertilization. The controller is mounted on the upper part of the bottom acne and is connected to an external power supply through a wire to supply power to the controller. The control system has three modes of use: manual control, automatic control and network control. Users can realize irrigation and fertilization by manual control without time limitation; under automatic control, users can set the irrigation time and fertilization time through the controller, and the controller will irrigate and fertilize automatically at regular intervals; under the network control mode, users can set the irrigation and fertilization time through the cell phone APP, so as to achieve timed irrigation and fertilization or anytime irrigation and fertilization.

3 Conclusion

In order to solve the problems of constant care of plant cultivation in family gardening and poor plant growth due to the lack of experience in cultivation and management, this paper designed a three-dimensional tidal irrigation pot plant device to realize three-dimensional cultivation of potted plants, and it has the functions of manual irrigation, automated irrigation, and remote irrigation. The device can realize the automated irrigation of plant cultivation in family gardening, and has the advantages of simple structure, easy to use, easy to maintain, safe and reliable, which is of positive significance for promoting the development of family gardening.

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