

MULTI-FUNCTIONAL TIERED CULTURAL BENCH

1. Field of the Invention

The present invention relates to a tiered cultural bench and, more particularly, to a hydroponic tiered cultural bench having multiple functions to independently control light, air flow, water, nutrient solution, carbon dioxide required by the tiered cultural bench in a mass production environment.

2. Description of the Related Art

In pursuit of the concept of food safety and health, indoor hydroponic planting with or without artificial light has become one of the increasingly important plant cultivation means recently as allowing people in a dwelling environment without enough space or at any indoor environment to grow vegetables and or herbs. Moreover, a plant factory with fully artificial light can grow plants without using any pesticides and can be established on discarded/polluted lands or any floor of a building in an urban or rural area to provide mass-produced fresh vegetables and herbs to neighboring restaurants, supermarkets and or directly to the consumers.

The indoor space may be a deserted greenhouse, livestock and poultry farm, one or several stories in an office building, residential and commercial building, industrial office building, one corner at home, basement, cargo container and the like. These indoor spaces can be renovated into risk-manageable and environment-controllable spaces. With artificial light, enriched carbon dioxides and hydroponic systems, various types of plants including food crops, ornamental crops, vegetables, herbs and seedlings can be grown in such spaces.

Regardless of the land, building and scale associated with the indoor space,

a cultural bench with at least one layer of planting bed is a minimum requirement. Each layer of planting bed should be equipped with artificial light and a cultivation system. The artificial light may have multiple choices, such as fluorescent lamp, cold cathode fluorescent lamp, LED (Light-emitting Diode) tube, LED panel and the like. The cultivation system may be also based on multiple cultivation techniques, such as nutrient film technique, deep water culture, ebb and flood technique, siphon ebb and flood, aeroponics and the like.

The conventional tiered bench with artificial light and a cultivation system may be small like a desktop or a shelf unit suitable for family use. Such system normally has a nutrient solution tank at the bottom. There are also large-scale units dedicated to a mass production system assembled from multiple tiered cultural benches with desired number of planting beds placed on the respective layers of each cultural bench. For such system, a large nutrient solution tank that is centralized in or outside a cultivation area is used for storage and circulation of nutrient solution. The biggest issue of the large-scale mass production system resides in that all planting beds of all benches share the same nutrient solution. Once one planting bed is contaminated, all the planting beds in the mass production system are prone to cross-contamination. At present, regardless of how many planting beds are provided in a plant factory, there is only one nutrient solution control system. In other words, planting beds of different benches must share the nutrient solution with identical recipes.

Besides, plant growth also requires air circulation in the micro-environment around crops. Conventional small-scale planting beds usually count on fans to blow the air. For large scale operation, it is not practical to blow the air using fans.

For an environment without air circulation, it is unfavorable to plant growth as can be found in most of the large scale systems. Additionally, in systems with centralized nutrient delivery system, there is only one pH and EC (electrical conductivity) control. Briefly speaking, the nutrient control device, air-blowing device, and environment-monitoring and control device are not integrated with the cultural bench. A plant factory with more than one cultural benches still have only one tank, one control, and with no horizontal air movement. Accordingly, deficiency exists in systematic management of mass-production, and in turn the related business may be highly risky and short of flexibility in management.

An objective of the present invention is to provide a multi-functional tiered cultural bench integrating multiple functions required for cultivating and mass-producing hydroponic plants.

To achieve the foregoing objective, the multi-functional tiered cultural bench has a tiered rack, multiple artificial lighting devices, a uniform air blowing device, a nutrient solution supplying device, a monitoring and control device.

The tiered rack has multiple layers and multiple planting beds.

The multiple layers are formed in a direction parallel to the ground.

The multiple planting beds are placed on the respective layers of the tiered cultural bench.

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Each artificial lighting device is directly mounted on a portion of the tiered rack or is mounted on an external lamp-holding-frame suspended from the supporting portion of the tiered rack and is located above one of the planting

beds.

The uniform air blowing device has at least one air blower or at least one duct fan, at least one main air tube, and multiple air manifolds.

The at least one main air tube is respectively connected to the at least one air blower or duct fan.

The multiple air manifolds are respectively connected to the at least one main air tube. Each air manifold has multiple air outlets facing an upper portion of a corresponding planting bed.

The nutrient solution supplying device has at least one solution tank, at least one pump, at least one main pipe, multiple sub-pipes, at least one solution return pipe, and multiple adjustment valves.

The at least one solution tank serves to store nutrient solution.

The at least one pump is respectively connected to the at least one solution tank.

The at least one main pipe is respectively connected to the at least one pump.

The multiple sub-pipes is respectively connected to the at least one main pipe and respectively extends to the multiple planting beds.

Each one of the at least one solution return pipe is connected between the respective planting beds and one of the at least one solution tank.

The multiple adjustment valves are respectively mounted on the sub-pipes.

The monitoring and control device has a control module and a sensing and actuating module.

The control module has a central controller, and a power control unit and a

display unit electrically connected to the central controller.

The sensing and actuating module has a sensing unit and an actuating unit.

The sensing unit is electrically connected to the central controller, and serves to detect chemical and physical properties of air and the nutrient solution in the cultural bench and to transmit detected electronic signals to the central controller.

The actuating unit is electrically connected to the power control unit, the artificial lighting devices, the at least one air blower or the at least one duct fan and the at least one pump.

A procedure built in the central controller activates the power control unit and controls operation modes of the artificial lighting devices, the at least one air blower or the at least one duct fan and the at least one pump through the actuating unit, and the values of the detected chemical and physical properties and control parameters of a human-machine-interface are displayed through the display unit.

Given the foregoing multi-functional tiered cultural bench, one type of nutrient solution can be supplied to all plants on the same bench. Different cultural benches can be supplied with different nutrient solutions generated according to different recipes. The planting beds of each cultural bench share the nutrient solution made by a same recipe as the nutrient solution is only circulated within the planting bed by a pump. All cultural benches in a plant factory can be independent from each other, such that cross-contaminations among different cultural benches can be avoided. Besides, the artificial lighting devices and the uniform air blowing device deliver sufficient and adequate light, carbon dioxide

and enriched air, which is required for plant growth, at right timing according to environmental conditions and chemical/physical properties measured by the monitoring and control device. As the artificial lighting devices, the uniform air blowing device, the nutrient solution supplying device and the monitoring and control device are integrated with the cultural bench to facilitate systematic management and risk reduction.

Other objectives, advantages and novel features of the invention will become more apparent from the following detailed description when taken in conjunction with the accompanying drawings.

IN THE DRAWINGS

Fig. 1 is a perspective view of a multi-functional tiered cultural bench in accordance with the present invention;

Fig. 2A is a schematic side view illustrating supply of water and uniform air to a multi-functional tiered cultural bench in accordance with the present invention;

Fig. 2B is a schematic side view illustrating a nutrient solution return mechanism of a multi-functional tiered cultural bench in accordance with the present invention;

Fig. 3 is a perspective view of a multi-functional tiered cultural bench in accordance with the present invention having two planting beds assembled in a row; and

Fig. 4 is a functional block diagram of a monitoring and control device of a multi-functional tiered cultural bench in accordance with the present invention.

With reference to Figs. 1 and 2A, a multi-functional tiered cultural bench in

accordance with the present invention has a tiered rack 1, multiple artificial lighting devices 2, a uniform air blowing device 3, a nutrient solution supplying device 4 and a monitoring and control device 5.

The tiered rack 1 is assembled from various types of structuring materials such as iron, steel, aluminum, wood and plastic. Each layer of the tiered rack 1 has a planting bed 11 placed thereon. As can be seen from Fig. 3, there are multiple planting beds 11 that are placed on the respective layers of the tiered rack 1 and are arranged to be parallel to the ground.

Each artificial lighting device 2 is mounted on a portion of the tiered rack 1 and is located above one of the planting beds 11 to provide light required for plant growth. The artificial lighting device 2 can be directly mounted on the tiered rack 1 or is mounted on an external lamp-holding-frame suspended from the tiered rack 1 to facilitate subsequent manual or automatic adjustment of a mounting height of a light unit on the artificial lighting device 2. The light unit includes multiple light elements 21, such as LED tubes, LED panels, fluorescent tubes, light bulbs and the like.

When the light element 21 employs light tube, the multiple light tubes may be arranged to be parallel to a lateral direction of the tiered rack 1 as illustrated by the light elements 21 on a top layer of the planting bed in Fig. 1, or arranged to be parallel to a longitudinal direction of the tiered rack 1 as illustrated by the light elements 21 on the third layer starting from the top layer of the tiered rack 1 in Fig. 1. When employing a light bulb or a LED chip, the light elements 21 may be arranged in a matrix form as illustrated by the light elements 21 on the second layer starting from the top layer of the tiered rack 1 in Fig. 1.

The uniform air blowing device 3 serves to dissipate heat generated by the artificial lighting devices 2, provides circulation of air in favor of an optimal cultivation environment for plants, such as uniform distribution of air temperature, humidity and carbon dioxide concentration, and includes at least one air blower or at least one duct fan 31, at least one main air tube 32 and multiple air manifolds 33. The at least one main air tube 32 is respectively connected to the at least one air blower or the at least one duct fan 31. The multiple air manifolds 33 are respectively connected to the at least one main air tube 32. Each air manifold 33 is located in one of the layers of the tiered rack 1, and has multiple evenly spaced air outlets 331 facing an upper portion of the planting bed 11 in the layer. With reference to Fig. 2A, one of the at least one main air tube 32 extends from a corresponding air blower 31 in a bottom portion of the tiered rack 1 to pass through all the layers of the tiered rack 1 in an upward direction. The location of the air blower can be either at the bottom or at the top of the bench. Each air manifold 33 extends from a portion of a corresponding main air tube 32 adjacent to a corresponding layer of the tiered rack 1 in a horizontal direction and is approximately located in the middle of a height of the corresponding layer, such that all the air outlets 331 of the air manifold 33 faces the upper portion of a corresponding planting bed 11. Thus, when the corresponding air blower or duct fan 31 is operated, air can be blown to the upper portion of the corresponding planting bed 11 through the corresponding main air tube 32, air manifold 33 and air outlet 331.

With further reference to Figs. 1, 2A and 2B, the nutrient solution supplying device 4 serves to supply nutrition and water required for plant growth, and has

at least one solution tank 41, at least one pump 42, at least one main pipe 43, multiple sub-pipes 44, at least one solution return pipe 45, and multiple adjustment valves 46. The at least one solution tank 41 serves to store nutrient solution. Options of a large-size solution tank placed or mounted at the bottom portion of the tiered rack 1 or multiple small-size solution tanks placed or mounted at the bottom portion of the tiered rack 1 and connected in series with each other are available. The at least one pump 42 is respectively connected to the at least one solution tank 41. The at least one main pipe 43 is respectively connected to the at least one pump 42. The multiple sub-pipes 44 are respectively connected to the at least one main pipe 43 and respectively extend to the multiple planting beds 11 on the respective layers of the tiered rack 1. Each one of the at least one solution return pipe 45 is connected between the respective planting beds 11 and one of the at least one solution tank 41. Each solution return pipe 45 has multiple return manifolds 451. Each return manifold 451 is connected to a bottom portion of a corresponding planting bed 11. The multiple adjustment valves 46 are respectively mounted on the sub-pipes 44 for adjusting the amount of nutrient solution flowing into the respective planting beds 11.

With further reference to Fig. 2A, the multiple sub-pipes 44 are connected in parallel to the at least one main pipe 43. With further reference to Fig. 2B, the multiple return manifolds 45 are connected in parallel to a corresponding solution return pipe 44. When the at least one pump 42 is operated, the nutrient solution inside the at least one solution tank 41 is drawn to flow into the planting beds 11 through the at least main pipe 43 and the sub-pipes 44. The residual nutrient solution in the planting beds 11 returns to the at least one solution tank

11 respectively through the return manifolds 451 and the at least one solution return pipe 45 to be drawn and circulated by the at least one pump 42 again. The ways of connection between the at least one main pipe 43 and/or the multiple sub-pipes 44 and between the solution return pipe 44 and the planting beds 11 can be chosen from series connection only or a combination of series connection and parallel connection.

The artificial lighting devices 2, the uniform air blowing device 3 and the nutrient solution supplying device 4 are automatically monitored and controlled by the monitoring and control device 5. With reference to Fig. 4, the monitoring and control device 5 has a control module 51 and a sensing and actuating module 52. The control module 51 has a central controller 510 and a power control unit 511 and a display unit 512 electrically connected to the central controller 510. The sensing and actuating module 52 has a sensing unit 521 electrically connected to the central controller 510 and an actuating unit 522 electrically connected to the power control unit 511. The sensing unit 521 includes a sensing device 521a for detecting temperature, humidity and carbon dioxide mounted at appropriate locations of the tiered rack 1 as shown in Fig. 1, and a sensing device 521b for detecting power of hydrogen (pH) value and electrical conductivity of the nutrient solution as shown in Fig. 2A. The actuating unit 522 is electrically connected to the artificial lighting devices 2, the at least one air blower or the at least one duct fan 31 and the pump 42, and has a nutrient solution control and actuating unit 522b as shown in Fig. 2A.

The central controller 510 may use a single chip, a programmable logic controller (PLC) or a microprocessor as a core for independent operation.

Alternatively, multiple central controllers 510 may be jointly or independently operated. When jointly operated, the multiple central controllers 510 may monitor and control cultivation conditions in one or more cultivation areas in collaboration a centralized monitoring and control system through the Internet.

Given the sensing device 521a for detecting temperature, humidity and carbon dioxide and the sensing device 521b for detecting pH value and electrical conductivity of the nutrient solution, the sensing unit 521 detects chemical and/or physical properties, such as temperature, humidity, concentration of carbon dioxide and the like of the air, pH value, electrical conductivity, dissolved oxygen and the like of the nutrient solution, in the planting environment, even detects operation conditions of entire or partial system, such as the on or off of the light elements 21, the at least one pump 42, a water level switch and the like, and then transmits detected electronic signals to the central controllers 510, such that a procedure built in the central controllers 10 activates the power control unit 511 and further controls operation modes of the artificial lighting devices 2 and the at least one air blower or the at least one duct fan 31, such as activation or deactivation, luminance adjustment by ascending or descending lamp-holding-frame relative to the planting bed associated with the artificial lighting devices, and activation or deactivation and setting of operation speed and operation time associated with the at least one air blower or the at least one duct fan 31, and controls activation or deactivation and setting of operation time of the pump 42 according to the measured pH value and the electrical conductivity of the nutrient solution detected through the nutrient solution control and actuating unit 522b to adjust the nutrient solution to an preset

condition. The detected values of the chemical and physical properties and control parameters on a human machine interface can be displayed through the display unit 512.

In sum, the multi-functional tiered cultural bench in accordance with the present invention is an independent hydroponic plant cultivation system including multiple planting beds and integrating the artificial lighting device, the uniform air blowing device, the nutrient solution supplying device and the monitoring and control device with the multiple planting beds only, making it ideal for systematic management in mass plantation and flexible in terms of quantity and combination of all the foregoing devices based on an actual demand. Moreover, due to independent supply of nutrient solution, the risk of cross-contamination arising from multiple cultural benches sharing a common nutrient solution supplying device can be avoided.

Even though numerous characteristics and advantages of the present invention have been set forth in the foregoing description, together with details of the structure and function of the invention, the disclosure is illustrative only. Changes may be made in detail, especially in matters of shape, size, and arrangement of parts within the principles of the invention to the full extent indicated by the broad general meaning of the terms in which the appended claims are expressed.

CLAIMS:

1. A multi-functional tiered cultural bench, comprising:
 - a tiered rack (1) having:
 - multiple layers formed in a direction parallel to the ground; and
 - multiple planting beds (11) placed on the respective layers of the tiered cultural bench;
 - multiple artificial lighting devices (2), each artificial lighting device (2) directly mounted on a portion of the tiered rack (1) and located above one of the planting beds (11) or mounted on an external lamp-holding-frame before the lamp holding frame is fastened on or suspended from the supporting portion of the tiered rack (1);
 - a uniform air blowing device (3) having:
 - at least one air blower or at least one duct fan (31);
 - at least one main air tube (32) respectively connected to the at least one air blower or the at least one duct fan (31); and
 - multiple air manifolds (33) respectively connected to the at least one main air tube (32), each air manifold (33) having multiple air outlets (331) facing an upper portion of a corresponding planting bed (11);
 - a nutrient solution supplying device (4) having:
 - at least one solution tank (41) for storing nutrient solution;
 - at least one pump (42) respectively connected to the at least one solution tank (41);

at least one main pipe (43) respectively connected to the at least one pump (42);

multiple sub-pipes (44) respectively connected to the at least one main pipe (43) and respectively extending to the multiple planting beds (11);

at least one solution return pipe (45), each one of the at least one solution return pipe (45) connected between the respective planting beds (11) and one of the at least one solution tank (41); and

multiple adjustment valves (46) respectively mounted on the sub-pipes (44); and

a monitoring and control device (5) having:

a control module (51) having a central controller (510), and a power control unit (511) and a display unit (512) electrically connected to the central controller (510); and

a sensing and actuating module (52) having:

a sensing unit (521) electrically connected to the central controller (510), and serving to detect chemical and physical properties of air and the nutrient solution in the cultural bench and to transmit detected electronic signals to the central controller (510); and

an actuating unit (522) electrically connected to the power control unit (511), the artificial lighting devices (2), the at least one air blower or the at least one duct fan (31) and the at least one pump (42);

wherein a procedure built in the central controller (510) activates the power control unit (511) and controls operation modes of the artificial lighting devices (2), the at least one air blower or the at least one duct fan (31) and the at

least one pump (42) through the actuating unit (522), and the values of the detected chemical and physical properties and control parameters on a human-machine-interface are displayed through the display unit (512).

2. The multi-functional tiered cultural bench as claimed in claim 1, wherein the operation modes of the artificial lighting devices (2) include activation or deactivation of the artificial lighting devices (2), and ascending or descending the artificial lighting devices (2) relative to the corresponding planting beds (11).

3. The multi-functional tiered cultural bench as claimed in claim 2, wherein the operation modes of the at least one air blower or duct fan (31) include activation or deactivation and setting of operation speed and operation time of the at least one air blower or the at least one duct fan (31).

4. The multi-functional tiered cultural bench as claimed in claim 3, wherein the operation modes of the at least one pump (42) include activation or deactivation and setting of operation time of the at least one pump (42).