

VERTICAL FARMING SYSTEM

[0001] The present application relates to a vertical farming system for growing plants, and more particularly to a portable vertical farming system having a dispensing mechanism.

[0002] Modern technologies are developed for vertical farming, such as hydroponics, aeroponics and aquaponics. However, traditional vertical farming systems require a human worker to approach to plants (known as man-to-plants) and thus are still not efficient and compact. For example, a horizontal plane growing system requires a human worker to stand in a scissor lift to serve one row of tiers and spend time moving up and down, and the scissor lift is cumbersome, expensive, dangerous and blocking access. For another example, although allowing a human worker to access any row without bulky equipment, a vertical plane growing system has a low yield per area and dollar.

[0003] Meanwhile, the traditional vertical farming systems still employ a traditional supply chain model with multiple processes, including collection of plants from vertical farms, distribution of the plants, wholesales to markets and retails to customers. After going through the multiple processes, as much as 40% would be wasted of the plants harvested from the vertical farms.

[0004] Therefore, the present application disclose a vertical farming system which on one hand solves the problems described above for the traditional vertical farming systems, and on the other hand employs a ultra-short supply chain model for saving the waste of the plants.

[0005] As a first aspect, the present application discloses a vertical farming system for growing plants. In contrast to the man-to-plant style of the traditional vertical farming, the vertical farming of the present application utilizes a plants-to-man style which makes the vertical farming system compact and efficient. The vertical farming system comprises a plurality of racks for growing plants; and an automated handling mechanism coupled to the plurality of racks for bringing the plants to an operation site and back to the plurality of racks. In particular, the plants are configured to move both along and vertically to the plurality of racks. At the operation site, multiple operations (such as inspection, irrigation,

fertilization and harvest) are conducted to the plants by either human worker to automated machineries.

[0006] The vertical farming system may further comprises a dispensing mechanism
 5 coupled to the automated handing mechanism for dispensing the plants to a customer. Due to its compact profile, the vertical farming system can be placed to a location near the customer; and the customer can directly and conveniently buy and collect the plants from the vertical farming system once the plants become mature in the vertical farming system. Therefore, an ultra-short supply chain model can be established with the vertical
 10 farming system for delivering the plants directly from the vertical farm to the customer.

[0007] The accompanying figures (Figs.) illustrate embodiments and serve to explain principles of the disclosed embodiments. It is to be understood, however, that these figures are presented for purposes of illustration only, and not for defining limits of
 15 relevant applications.

Fig. 1 illustrates a schematic view of a traditional vertical farming system;
 Fig. 2 illustrates a top view of an operation flow of the traditional vertical farming system in Fig. 1;
 Fig. 3 illustrates a schematic view of a vertical farming system of the present
 20 application according to an embodiment;
 Fig. 4 illustrates a top view of an operation flow of the vertical farming system in Fig. 3;
 Fig. 5 illustrates a side view of the operation flow of the vertical farming system in Fig. 3;
 25 Fig. 5(a) to Fig. 5(r) illustrates other operation flows of the vertical farming system in Fig. 3;
 Fig. 6 illustrates another operation flow of the vertical farming system in Fig. 3;
 Fig. 7 illustrates an internal view of a portable vertical farming system of the present application according to an embodiment;
 30 Fig. 8 illustrates a front view of the portable vertical farming system in Fig. 7;
 Fig. 9 illustrates a perspective view of the portable vertical farming system in Fig. 7;
 Fig. 10 illustrates a schematic view of operation of the portable vertical farming system in Fig. 7;

Fig. 11 illustrates an internal view of a variation of the portable vertical farming system in Fig.7;

Fig. 12 illustrates a perspective view of a plants café according to an embodiment;

Fig. 13 illustrates a schematic view of deployment of the portable vertical farming

5 system in Fig. 7 or the variation in Fig. 11 on a building roof; and

Figs. 14 to 21 illustrate the portable vertical farming system in Fig. 7.

[0008] Fig. 1 illustrates a schematic view of a traditional vertical farming system 100 for growing plants 102. Fig. 1(a) and Fig. 1(b) show a side view and a perspective of the
10 traditional vertical farming 100, respectively. The traditional vertical farming system 100 has a plurality of racks 110 and each rack 110 has multiple tiers 120 vertically stacked for growing the plants 102. An aisle 130 is left between two adjacent racks 110 for a human worker 104 to access to the plants 102 on the racks 110 for multiple operations such as inspection, irrigation, fertilization and harvest. Due to existence of the aisles 130,
15 the traditional vertical farming system 100 has less space for accommodating more racks 100 for growing more plants 102. In addition, if some tiers 120 of the racks 110 are stacked too high for the human worker 104 to reach, a scissor lift 140 shall be used for moving the human worker 104 up and down. The scissor lift 140 is cumbersome, expensive, dangerous and may block the human worker 104 from accessing the racks
20 110 if the aisle 130 is not wide enough. As a result, the traditional vertical farming system 100 would have even less space for growing the plants 102 and thus low yield per area and dollar.

[0009] Fig. 2 illustrates a top view of an operation of the traditional vertical farming
25 system 100 in Fig. 1. The human worker 104 gets access to the tiers 120 from either left side 112 or right side 114 of the racks 110. Arrows 150 indicate workflow directions of the operations of the human worker 104 in the traditional vertical farming system 100. Therefore, the aisle 130 is necessary for all operations (such as inspection, irrigation, fertilization and harvest) of the traditional vertical farming system 100.

30 [0010] Fig. 3 illustrates a schematic view of a vertical farming system 200 of the present application according to an embodiment. Fig. 3(a) shows a perspective view of the vertical farming system 200. Similarly, the vertical farming system 200 has a plurality of racks 210 which further have multiple tiers 220 vertically stacked for growing plants 202.

In contrast to the traditional vertical farming system 100, a human worker 204 gets access to the tiers 220 from either a front side 212 or a rear side 214 of the racks 210 in the vertical farming system 200.

5 [0011] As a result, in contrast to the traditional vertical farming system 100, the racks 210 are arranged closely to each other in the vertical farming system 200; and thus almost all space can be used for growing the plants. Therefore, the vertical farming system 200 has higher yield per area. For example, the traditional vertical farming system 100 has only four racks 110 with twenty tiers 120 as shown in Fig. 1; while for a
10 same plot of land space, the vertical farming system 200 arranges six racks 210 with thirty tiers 220 in Fig. 3. In other words, the yield per area is enhanced by 50% for the vertical farming system 200. In addition, no scissor lift 140 or similar machineries are needed; and thus the vertical farming system 200 has high yield per dollar. In summary, the vertical farming system 200 of the present application has high yield per
15 area and dollar.

[0012] Fig. 3(b) and Fig. 3(c) show a top view and a side view of the vertical farming system 200, respectively. The plants 202 are planted in separated trays which are configured to move on the tiers 220, either in a motorized manner or non-motorized
20 manner. The vertical farming system 200 has an automated handling mechanism 250 coupled to the racks 210 for moving the trays of plants 202 along each tier 220. In some implementations, the automated handling mechanism 250 has a front tray lifter and pusher 252 and a rear tray lifter and pusher 254 coupled to the racks 210 from the front side 212 and the rear side 214, respectively. Both of the front tray lifter and pusher 252
25 and the rear tray lifter and pusher 254 can move the trays of plants 202 in vertical directions (either up or down); while they also can push the trays of plants 202 along the tiers 220 to the rear side 214 and the front side 212, respectively.

[0013] Fig. 4 illustrates a top view of an operation flow of the vertical farming system 200
30 in Fig. 3. Arrows 230 indicate workflow directions of the operations of the human worker 104 in the vertical farming system 200. All operations (such as inspection, irrigation, fertilization and harvest) can be conducted on the side 212 and/or the rear side 214. As a result, the vertical farming system 200 saves spaces for the aisles 130 or similar machineries. The vertical farming system 200 further has an inlet fan 206 and an outlet

fan 208 mounted at the rear side 214 and at the front side 212 for drawing fresh air into and repelling waste air out of the vertical farming system 200, respectively.

[0014] Fig. 5 illustrates a side view of the operation flow of the vertical farming system 200 in Fig. 3, from the rear side 214 to the front side 212; and the arrows 230 show moving directions of the plants 202 on the tiers 220. The automated handling mechanism 250 also moves the plants 102 along a ground level 240 from the front side 212 to the rear side 214; and an arrow 242 shows a moving direction of the plants 202 on the ground level 240. Meanwhile, the automated handling mechanism 250 also moves the plants 202 down vertically from the tiers 220 to the ground level 240 on the front side 212 and up vertically from the ground level 240 to the tiers 220 on the rear side 214. As a result, the automated handling mechanism 250 can move any of the plants 202 on the tiers 220 in a close loop, i.e. between the tiers 220 and an operation site, such as a front operation site 260 on the front side 212 and/or rear operation site 262 on the rear side 214. At the operation site, multiple operations (such as inspection, irrigation, fertilization and harvest) are conducted for the plants 202. Since the operation site is located on the ground level 240, the human worker 204 can conduct the operations easily and conveniently.

[0015] Fig. 7 illustrates an internal view of another portable vertical farming system 300 of the present application according to an embodiment. The portable vertical farming system 300 has a small profile and does not need a large space. In some implementations, the portable vertical farming system 300 has a size similar to a vending machine. Therefore, the portable vertical farming system 300 can be placed near a customer at various locations such as shopping malls, hawker centers, car parks, gardens, playgrounds, university campuses, as well as empty spaces downstairs in communities. Similar to the vertical farming system 200, the portable vertical farming system 300 has a plurality of racks 310 with multiple tiers 320 for growing the plants 302, and an automated handling mechanism 330 coupled to the racks 310 for moving the plants 302. It is clearly shown that the plants 302 move in a close loop inside the portable vertical farming system 300.

[0016] Different from the vertical farming system 200, the portable vertical farming system 300 has a dispensing mechanism 340 coupled to the automated handling

mechanism 250 for dispensing the plants to the customer. In other words, the portable vertical farming system 300 integrates all stages of plant farming, including seeding, cultivating and harvesting and also vending of the harvested plants 302 to the customer.

5 [0017] In particular, the portable vertical farming system 300 has a illumination mechanism 350 (such as LED) for making the plants 302 to grow at night or on cloudy or rainy days when sun light is not available. In this way, the plants 302 take less time to grow to mature in the portable vertical farming system 300. In addition, the portable vertical farming system 300 has a solar panel 360 coupled to the illumination mechanism
10 350 for converting solar energy to electrical energy in the daytime and providing the electrical energy to the illumination mechanism 350. Alternatively, or additionally to the solar panel 360, the portable vertical farming system 300 has a wind turbine 362 for harvesting wind energy to the illumination mechanism 350. The solar panel 360 and/or the wind turbine 362 may also be electrically connected to a rechargeable battery 396
15 (shown in Fig. 9) for storing the electrical energy. Furthermore, the portable vertical farming system 300 has an auto-irrigation mechanism 370 for irrigating the plants 302 automatically. In some implementations, the auto-irrigation mechanism 370 is placed at a bottom 312 of portable vertical farming system 300. When the plants 302 is moved at the bottom 312, the auto-irrigation mechanism 370 would irrigate the plants 302
20 according to a predetermined program.

[0018] Fig. 8 illustrates a front view of the portable vertical farming system 300 in Fig. 7. The portable vertical farming system 300 may have additional mechanisms for facilitating growth of the plants 302. In some implementations, the portable vertical farming system
25 300 has an auxiliary mechanism 380 for monitoring and controlling internal environment inside the portable vertical farming system 300 and nutrients provided to the plants 302. In addition, the portable vertical farming system 300 may have an artificial intelligence (AI) mechanism 390 (such as an AI camera) for capturing and analyzing data of the portable vertical farming system 300. The AI mechanism 390 is communicatively coupled
30 to the auxiliary mechanism 380 for capturing and analyzing the data in real time. In addition, the portable vertical farming system 300 may have a transparent panel 392 (such as a piece of glass) on a front side 314 for displaying the plants to the customer.

[0019] Fig. 9 illustrates a perspective view of the portable vertical farming system 300 in Fig. 7. The portable vertical farming system 300 may further have an air-to-water mechanism 394 for obtaining water from ambient air in surrounding environment. The air-to-water mechanism 394 is coupled to the auto-irrigation mechanism 370 for providing water for irrigating the plants 302. The air-to-water mechanism 394 works very well in some tropic counties (such as Singapore) where humidity of the ambient air is above 70% throughout a year and even above 90% on rainy days. As a result, the portable vertical farming system 300 does not need to be connected to a water supply and thus can be placed at any location where water supply is not readily available. In addition, the nutrients may be feed into the air-to-water mechanism 394 according to a pre-determined program; and thus the nutrients can be solved in the water from the air-to-water mechanism 394 and then supplied to the plants 302 via the auto-irrigation mechanism 370.

[0020] Fig. 10 illustrates a schematic view of operation of the portable vertical farming system 300 in Fig. 7. In the day time, the plants 302 grow under the Sun and the illumination mechanism 350 is shut off; and meanwhile the solar panel 360 capture the solar energy from the Sun. At night, the illumination mechanism 350 shines on the plants 302 for enhancing growth of the plants 302.

[0021] Fig. 11 illustrates an internal view of a variation 400 of the portable vertical farming system 300 in Fig. 7. The variation 400 has a same structure as the portable vertical farming system 300 except that an aquaponics 410 is additionally installed to the auto-irrigation mechanism 370. Fish is raised In the aquaponics 410 for releasing nutrient-rich waste into the water and then feed to the plants 302 via the auto-irrigation mechanism 370.

[0022] Fig. 12 illustrates a perspective view of a plants café 500 according to an embodiment. The plants café 500 provides cooking apparatus and kitchen equipments (such as frypan, wok, saucepan, steamer, stockpot and double boiler) to the customer to process the plants 302; and also seats and utensils (such as chopsticks, forks and spoons) to enjoy cooked plants. The plants café 500 is preferably located near the portable vertical farming system 300 or the variation 400.

[0023] Fig. 13 illustrates a schematic view of deployment of the portable vertical farming system 300 in Fig. 7 or the variation in Fig. 11 on a building roof 600. The building is preferably around the customer, such shopping malls, hawker centers, car parks, gardens, playgrounds, university campuses whose roofs are not blocked from the Sun and are practicable for the deployment. The plants café 500 is optionally located nearby the portable vertical farming system 300 or the variation 400.

[0024] In the application, unless specified otherwise, the terms "comprising", "comprise", and grammatical variants thereof, intended to represent "open" or "inclusive" language such that they include recited elements but also permit inclusion of additional, non-explicitly recited elements.

[0025] As used herein, the term "about", in the context of concentrations of components of the formulations, typically means $\pm 5\%$ of the stated value, more typically $\pm 4\%$ of the stated value, more typically $\pm 3\%$ of the stated value, more typically, $\pm 2\%$ of the stated value, even more typically $\pm 1\%$ of the stated value, and even more typically $\pm 0.5\%$ of the stated value.

[0026] Throughout this disclosure, certain embodiments may be disclosed in a range format. The description in range format is merely for convenience and brevity and should not be construed as an inflexible limitation on the scope of the disclosed ranges. Accordingly, the description of a range should be considered to have specifically disclosed all the possible sub-ranges as well as individual numerical values within that range. For example, description of a range such as from 1 to 6 should be considered to have specifically disclosed sub-ranges such as from 1 to 3, from 1 to 4, from 1 to 5, from 2 to 4, from 2 to 6, from 3 to 6 etc., as well as individual numbers within that range, for example, 1, 2, 3, 4, 5, and 6. This applies regardless of the breadth of the range.

[0027] It will be apparent that various other modifications and adaptations of the application will be apparent to the person skilled in the art after reading the foregoing disclosure without departing from the spirit and scope of the application and it is intended that all such modifications and adaptations come within the scope of the appended claims.

Reference Numerals

	100	traditional vertical farming system;
	102	plants;
5	104	human worker;
	110	rack;
	112	left side;
	114	right side;
	120	tier;
10	130	aisle;
	140	scissor lift;
	150	arrow;
	200	vertical farming system of the present application;
	202	plants;
15	204	human worker;
	206	inlet fan;
	208	outlet fan;
	210	rack;
	212	front side;
20	214	rear side;
	220	tier;
	222	top tier;
	230	arrow;
	240	ground level;
25	242	arrow;
	250	automated handling mechanism;
	252	front tray lifter and pusher;
	254	rear tray lifter and pusher;
	260	front operation site;
30	262	rear operation site;
	300	portable vertical farming system of the present application;
	302	plants;
	310	rack;
	312	bottom;

- 314 front side;
- 320 tier;
- 330 automated handling mechanism;
- 340 dispensing mechanism;
- 5 350 illumination mechanism;
- 360 solar panel;
- 362 wind turbine;
- 370 auto-irrigation mechanism;
- 380 auxiliary mechanism;
- 10 390 AI mechanism;
- 392 transparent panel;
- 394 air-to-water mechanism
- 396 rechargeable battery;
- 400 vertical farming system of the present application;
- 15 410 aquaponics;
- 500 plants café;
- 600 building roof.

Claims

1. A vertical farming system comprising:
 - a plurality of racks for growing plants; and
 - 5 • an automated handling mechanism coupled to the plurality of racks for bringing the plants to an operation site and back to the plurality of racks, wherein the plants are configured to move both along and vertically to the plurality of racks.
- 10 2. The vertical farming system of claim 1, further comprising:
a versatile system that is configured to be deployed for various vertical farming methods, Hydroponic, Aeroponic, Aquaponic and/or Geoponic.
- 15 3. The vertical farming system of claim 1, further comprising:
one single point of workstation per lifter for centralized seeding, plotting, irrigation, fertigation, inspection, harvesting and maintenance reducing automation and labor cost.
- 20 4. The vertical farming system of claim 1, further comprising:
a planting tray of Full Tray for higher throughput versus Slat Tray for compact lifters design.
- 25 5. The vertical farming system of claim 1, further comprising:
a plotting tray with Tray-Mounted-Rollers and Track-Mounted-Rollers.
6. The vertical farming system of claim 1, further comprising:
an automated modular irrigation tray for spraying up and/or spraying down.
- 30 7. The vertical farming system of claim 1, further comprising:
a modular LED tray.
8. The vertical farming system of claim 1, further comprising:
an IoT tray, intelligent measurement, monitoring, vision inspection, data analysis and recovery action system.

9. The vertical farming system of claim 1, further comprising
a CO₂ emission controller for neutralizing or reusing CO₂ in order to reduce carbon
footprint.

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10. The vertical farming system of claim 1, further comprising:
an integration system with solar thermal (e.g. molten salt) renewable energy system
for greener vertical farming.

10 11. The vertical farming system of claim 1, further comprising:
a fully sanitize/sterile/hygienic plot/container device to prevent contamination or
bleeding of pest during loading and unloading.

12. The vertical farming system of claim 1 further comprising:
15 a dispensing mechanism coupled to the automated handing mechanism for
dispensing the plants to a customer.

13. The vertical farming system of claim 1, further comprising:
an integrated system that permits selection, ordering and delivery platform for
20 purchasing of the vegetable.

14. A vertical farming system substantially as described with reference to the drawings.