

TITLE OF THE INVENTION: SYSTEM FOR MECHANISED CROP FARMING AND METHOD THEREOF

FIELD OF THE INVENTION

[0001] Embodiments of the invention relate to mechanised crop farming system and methods which may be easily convertible to adopt different growing methods, reduce infrastructure for water and nutrient delivery, and ensure that crops receive adequate light exposure.

BACKGROUND

[0002] Urban farming is key to future food source that is efficient, sustainable and environmentally friendly. It reduces the carbon footprint through maximizing the growth of food crops within a limited land space and reduces greenhouse gas emissions. By having crops grown near consumers, it reduces transportation, storage and refrigeration.

[0003] Current farming systems typically require of fixed planting locations. Crops are planted in soil on the ground, or arranged in a fixed A-Frame shelf design (for natural light system) or a fixed multiple shelf (with lights at every layer of crops). Using such fixed crop-supporting structures, water and nutrients must be delivered to the crops. Planting and harvesting of the crops are inefficient, labour intensive and time consuming as an operator must physically be at the crops to do that. The taller the support structures, the more difficult it is to reach the crops, and hence the more labour intensive it is. Moreover, each of the farming systems is specifically designed for a specific growing method and crop type.

[0004] Certain solutions have been proposed, such as those described in US 10271485 B2, US 10694688 B2, US 20190133063 A1, and US 8533993 B2. However, these solutions are still unsatisfactory.

SUMMARY

[0005] According to a first aspect of the invention, a mechanised crop farming system comprises: a frame having a plurality of levels stacked in a vertical direction; a closed loop conveyor traversing the levels and having alternating lateral and non-lateral

conveyor paths, and a return conveyor path, wherein at least some of the lateral conveyor paths are longer than at least some of the non-lateral conveyor paths; a plurality of crop holders removably coupled to the conveyor at intervals thereof; a fluid reservoir having a fluid; a drive unit operably coupled to the conveyor and operable to cause transportation of the crop holders to a first subset of the lateral conveyor paths wherein the crop holders arranged along the first subset are within an operational reach of the fluid reservoir, and wherein the drive unit is further operable to cause transportation of the crop holders to a second subset of the lateral conveyor paths wherein the crop holders arranged along the second subset are outside the operational reach of the fluid reservoir.

[0006] In an embodiment of the first aspect, each of the crop holders which are arranged along the second subset is intermittently repositioned among a plurality of distinct positions along at least one lateral direction defined by the second subset.

[0007] In an embodiment of the first aspect, each of the crop holders includes at least one flood opening configured to receive the fluid therethrough when the crop holders are within the operational reach of the fluid reservoir, and wherein each of the crop holders includes at least one drainage opening configured to at least partially drain the fluid therefrom.

[0008] In an embodiment of the first aspect, the drive unit is further operable to cause transportation of the crop holders along the first subset to cause a movement of the crop holders through the fluid reservoir and a circulation of the fluid through the at least one flood opening and the at least one drainage opening.

[0009] In an embodiment of the first aspect, each of the crop holders includes a pair of opposed first sidewalls, a pair of opposed second sidewalls which are shorter than the first sidewalls, and a bottom wall coupled to the first sidewalls and the second sidewalls, wherein the at least one drainage opening is arranged on at least one of the second sidewalls at a distance from the bottom wall to cause retention of at least some of the fluid in each of the crop holders.

[0010] In an embodiment of the first aspect, the fluid reservoir includes at least one fluid release opening configured to release the fluid into the crop holders which are within the operational reach of the fluid reservoir.

[0011] In an embodiment of the first aspect, the drive unit is further operable to cause transportation of the crop holders to a load and/or unload station arranged along the conveyor wherein the crop holders arranged at the load and/or unload station are

within an operational reach for coupling to the conveyor or decoupling from the conveyor.

[0012] In an embodiment of the first aspect, at least some of the crop holders are replaceable by a plurality of second crop holders, wherein the at least some of the crop holders and the second crop holders are respectively configured for at least two different growing methods selected from the list consisting of soil-based farming, hydroponics and aquaponics.

[0013] In an embodiment of the first aspect, the conveyor is non-helical.

[0014] In an embodiment of the first aspect, a mechanised crop farming system may provide a closed loop zig-zag conveyor path for transporting crop holders to within an operational reach of a fluid reservoir wherein the crop holders may be moved through the fluid reservoir for providing irrigation to and/or fluid circulation within each crop holder. The zig-zag path may further transport crop holders to outside the operation reach of the fluid reservoir wherein the crop holders may be repositioned or staggered among multiple positions along lateral and/or vertical directions to ensure each crop holder receives at least a predetermined light exposure over a duration.

[0015] According to a second aspect of the invention, a method for mechanised crop farming comprises: removably coupling a plurality of crop holders to a closed loop conveyor at intervals thereof, the conveyor having alternating lateral and non-lateral conveyor paths, and a return conveyor path, wherein at least some of the lateral conveyor paths are longer than at least some of the non-lateral conveyor paths, wherein the conveyor traverses a plurality of layers of a frame which are stacked in a vertical direction; transporting the crop holders to a first subset of the lateral conveyor paths, thereby arranging the crop holders within an operational reach of a fluid reservoir having a fluid; receiving, by the crop holders which are within the operational reach of a fluid reservoir, the fluid from the fluid reservoir; and transporting the crop holders to a second subset of the lateral conveyor paths, thereby arranging the crop holders outside the operational reach of the fluid reservoir.

[0016] In an embodiment of the second aspect, the method further comprises: intermittently repositioning each of the crop holders, which are arranged at the second subset, among a plurality of distinct positions along at least one lateral direction defined by the second subset.

[0017] In an embodiment of the second aspect, the step of receiving, by the crop holders which are within the operational reach of the fluid reservoir, the fluid from the

fluid reservoir, includes: receiving the fluid through at least one flood opening of each of the crop holders, wherein the method further comprises: at least partially draining the fluid through at least one drainage opening of each of the crop holders.

[0018] In an embodiment of the second aspect, the step of receiving, by the crop holders which are within the operational reach of the fluid reservoir, the fluid from the fluid reservoir, includes: transporting the crop holders along the first subset, the transporting including moving the crop holders through the fluid reservoir and causing the fluid to circulate through the at least one flood opening and the at least one drainage opening of each of the crop holders.

[0019] In an embodiment of the second aspect, each of the crop holders includes a pair of opposed first sidewalls, a pair of opposed second sidewalls which are shorter than the first sidewalls, and a bottom wall coupled to the first sidewalls and the second sidewalls, wherein the at least one drainage opening is arranged on at least one of the second sidewalls at a distance from the bottom wall to cause retention of at least some of the fluid in each of the crop holders.

[0020] In an embodiment of the second aspect, the step of receiving, by the crop holders which are within the operational reach of the fluid reservoir, the fluid from the fluid reservoir, includes: releasing the fluid, through at least one fluid release opening of the fluid reservoir, into the crop holders which are within the operational reach of the fluid reservoir.

[0021] In an embodiment of the second aspect, the method further comprises: transporting the crop holders to a load and/or unload station arranged along the conveyor; and decoupling the crop holders from the conveyor.

[0022] In an embodiment of the second aspect, the method further comprises: interchanging at least some of the crop holders with a plurality of second crop holders, wherein the at least some of the crop holders and the second crop holders are respectively configured for at least two different growing methods selected from the list consisting of soil-based farming, hydroponics and aquaponics.

[0023] In an embodiment of the second aspect, the conveyor is non-helical.

BRIEF DESCRIPTION OF DRAWINGS

[0024] Embodiments of the invention will be described in detail with reference to the accompanying drawings, in which:

[0025] Figure 1A is a perspective view of a mechanised crop farming system according to some embodiments;

[0026] Figure 1B is a front view of Figure 1A;

[0027] Figure 1C is a partial close-up view of Figure 1A and shows crop holders at a first subset of the lateral conveyor paths;

[0028] Figure 1D is a partial close-up view of Figure 1 and shows crop holders at a second subset of the lateral conveyor paths;

[0029] Figure 2A shows a crop holder according to some examples;

[0030] Figure 2B shows a receptacle of the crop holder of Figure 2A;

[0031] Figure 2C shows an engagement mechanism of the crop holder of Figure 2A; and

[0032] Figure 3 is a flow chart which describes a method for mechanised crop farming according to some embodiments.

DETAILED DESCRIPTION

[0033] In the following description, numerous specific details are set forth in order to provide a thorough understanding of various illustrative embodiments of the invention. It will be understood, however, to one skilled in the art, that embodiments of the invention may be practiced without some or all of these specific details. It is understood that the terminology used herein is for the purpose of describing particular embodiments only, and is not intended to limit the scope of the invention. In the drawings, like reference labels or numerals refer to same or similar functionalities or features throughout the several views.

[0034] Embodiments described in the context of one of the devices or methods are analogously valid for the other devices or methods. Similarly, embodiments described in the context of a device are analogously valid for a method, and vice versa.

[0035] Features that are described in the context of an embodiment may correspondingly be applicable to the same or similar features in the other embodiments. Features that are described in the context of an embodiment may correspondingly be applicable to the other embodiments, even if not explicitly described in these other embodiments. Furthermore, additions and/or combinations and/or alternatives as described for a feature in the context of an embodiment may correspondingly be applicable to the same or similar feature in the other embodiments.

[0036] It should be understood that the articles "a", "an" and "the" as used with regard to a feature or element include a reference to one or more of the features or elements. The term "and/or" includes any and all combinations of one or more of the associated feature or element. The terms "comprising", "including", "having", and any of their related terms, as used in description and claims, are intended to be open-ended and mean that there may be additional features or elements other than the listed ones. Identifiers such as "first", "second", "third", and so on, are used merely as labels, and are not intended to impose numerical requirements on their objects, nor construed in a manner imposing any relative position or time sequence between limitations.

[0037] The term "crop holder" and related terms may include references to a receptacle for holding the crops as well as to crops and crop-growing medium contained in the receptacle.

[0038] The term "coupled" and related terms are used in an operational sense and are not necessarily limited to a direct physical connection or coupling. Thus, for example, two devices may be coupled directly, or via one or more intermediary devices. Based on the present disclosure, a person of ordinary skill in the art will appreciate a variety of ways in which coupling exists in accordance with the aforementioned definition.

[0039] In accordance with some embodiments, a mechanised crop farming system 10 is shown in Figures 1A and 1B, and comprises a multi-level frame 11, a closed loop conveyor 12, a plurality of crop holders 20, a fluid reservoir 13, and a drive unit.

[0040] The multi-level frame 11 provides a vertically-stacked arrangement for multi-level or vertical crop farming. The frame 11 includes a length defining a lateral direction (x direction as shown in Figures 1A and 1B), a height defining a vertical direction (y direction as shown in Figures 1A and 1B) which is transverse to the lateral direction, and a width defining an orthogonal direction (z direction as shown in Figures 1A and 1B) which is transverse to both the lateral direction and the vertical direction. Each level of the frame 11 includes a lateral frame section and a non-lateral frame section, e.g. vertical frame section, connected thereto. Each level is stacked in the vertical direction and the lateral and non-lateral frame sections are connected to provide a zig-zag arrangement in which the lateral frame sections and the non-lateral frame sections are alternating. The zig-zag arrangement is in turn connected to a return frame section. At least some of the lateral frame sections are longer than at least some of the lateral frame sections.

[0041] The closed loop conveyor 12 traverses the multi-level frame 11, particularly the multiple levels of the frame 11, and is operable to move crop holders 20 among the multiple levels of the frame 11. The closed loop conveyor 12 is operably mounted on or coupled to the zig-zag arrangement and the return frame section to provide a closed loop or endless path. Since the path of closed loop conveyor 12 generally conforms to the multi-level frame 11, the closed loop conveyor 12 likewise includes alternating lateral and non-lateral conveyor paths, and a return conveyor path; at least some of the lateral conveyor paths are longer than at least some of the lateral conveyor paths. In other words, lengths of at least some of the lateral conveyor paths are greater than lengths of at least some of the non-lateral conveyor paths. The multiple-level frame 11 and closed loop conveyor 12 may be non-helical.

[0042] The lateral conveyor paths may include a first subset of the lateral conveyor paths (may alternatively referred to as the first subset), a second subset of the lateral conveyor paths (may alternatively referred to as the second subset), and optionally one or more subsequent subset of lateral conveyor paths. The term “subset” may refer to one or more lateral conveyor paths, or one or more portions of one or more lateral conveyor paths. These subsets will be described in later paragraphs.

[0043] The closed loop conveyor 12 may be implemented as a pair of conveyor chains operably coupled to at least one drive unit, e.g. one or more motors, via gears and configured to move synchronously. Linking members 15 or rods may be coupled between the pair of conveyor chains. Other implementations of a closed loop conveyor known to persons skilled in the art are also possible.

[0044] The crop holders 20 are removably coupled to the conveyor 12 at intervals thereof or spaced apart from one another.

[0045] A crop holder may comprise a receptacle 21 and an engagement mechanism coupled thereto or integrally formed therewith. The receptacle 21 is configured to retain crops, and crop-growing medium, e.g. soil, fluid. The engagement mechanism may include a hook 22 or loop or other arrangement configured to engage with or couple to the conveyor 12. In an example, the engagement mechanism may be one or more hanger-like attachments which are configured to be hung onto a linking member 15 coupled between the pair of conveyor chains. In another example, the engagement mechanism may be one or more loops which are configured to be hung onto one or more hooks provided at a linking member 15 coupled between the pair of conveyor chains.

[0046] The receptacle 21 may include a top opening, e.g. open-top, and one or more sidewalls. In an example, a cylindrical sidewall may be coupled to a bottom wall. In another example, the receptacle 21 may be open-top and include a pair of opposed first sidewalls 23, a pair of opposed second sidewalls 24, and a bottom wall 25 coupled to the first and the second sidewalls 23, 24. In yet another example, the second sidewalls 24 may be shorter than the first side walls 23.

[0047] The receptacle may provide at least one flood opening 26 and/or at least one drainage opening 27. In an example, a flood opening 26 may be the same or integral with the top opening. In another example, the flood opening 26 may be separate from the top opening, e.g. arranged at the sidewall. In yet another example, a plurality of flood openings include a flood opening 26 integral with the top opening and another flood opening (not shown) separate from the top opening.

[0048] The drainage opening 27 may be another opening arranged at the sidewall 23, 24 or the bottom wall 25. In an example, the drainage opening 27 may be arranged nearer to the bottom wall 25 than the flood opening 26. In other words, a vertical distance or height of the flood opening 26 from the bottom wall 25 is greater than a vertical distance or height of the drainage opening 27 from the bottom wall 25. In an example, the drainage opening 27 may be arranged at a predetermined distance, e.g. 1 cm, 1.5 cm, or other distance, from the bottom wall 25, instead of at the bottom wall 25, to allow at least some fluid retention in the crop holder, e.g. to maintain roots of the crops in a moist condition.

[0049] In an example, at least a portion of the crop holder 20 may be pink colour and/or blue colour to cause growth light, e.g., red and blue, to be reflected onto the crops in order to enhance growth.

[0050] In an example, the crop holder 20 may be made from polyvinyl chloride (PVC) pipe.

[0051] The fluid reservoir 13 includes fluid, e.g. water, and optionally nutrients for crop-growth. The fluid reservoir 13 may be implemented in one of various ways.

[0052] In an example, the fluid reservoir 13 includes a fluid-holding tank having a top opening, e.g. open top, and a length which may both be associated with a length of a first subset of the lateral conveyor paths or the lateral conveyor paths. The fluid reservoir 13 may be located under a lateral conveyor path, e.g., bottom most of the lateral conveyor paths or any one thereof. Accordingly, crop holders 20 which are arranged along the first subset of the lateral conveyor paths are within an operational

reach of the fluid reservoir 13, i.e., arranged at a predetermined distance and/or orientation to be able to receive fluid from the fluid reservoir 13. In particular, due to the relative arrangement of the open-top tank under the first subset, the crop holders 20 which are arranged along the first subset are at least partially immersed in the fluid of the fluid reservoir 13 to allow these crop holders 20 to receive the fluid through their flood openings. Additionally, transporting these crop holders 20 along the first subset moves these crop holders 20 through the fluid reservoir 13 to cause the crop holders 20 to receive the fluid through their flood openings 26 and at least partially drain the fluid through their drainage openings 27, thereby creating fluid circulation within these crop holders 20.

[0053] The drive unit, e.g. at least one motor, is operably coupled to the conveyor 12 and operable to move the conveyor 12 relative to the frame sections to cause transportation or movement of the crop holders 20, which are coupled to the conveyor 12, along the conveyor 12, e.g. successively along the alternating lateral and non-lateral conveyor paths, and the return conveyor path, in a closed loop path or parts thereof in one or both directions.

[0054] In particular, the drive unit is operable to cause transportation of crop holders 20 to a first subset of the lateral conveyor paths such that these crop holders 20 are within an operational reach of the fluid reservoir 13. Figure 1C shows an example of crop holders 20 arranged at the first subset of the lateral conveyor paths. The drive unit is further operable to cause transportation of these crop holders 20 along the length of the first subset of the lateral conveyor paths, thereby transporting or moving these crop holders 20 through the fluid reservoir 13. In Figure 1C, an arrow shows a lateral direction in which the crop holders 20 may be transported along the first subset and thereby through the fluid reservoir 13.

[0055] The drive unit is further operable to cause transportation of these crop holders 20, which have been irrigated with fluid from the fluid reservoir 13, to outside the operational reach of the fluid reservoir 13, e.g. a second or subsequent subset of the lateral conveyor paths, or to the return conveyor path.

[0056] As shown in Figure 1B, the second subset of the lateral conveyor paths is arranged above the first subset of the lateral conveyor paths which in turn is arranged above the fluid reservoir 13, hence collectively a vertically stacked arrangement. Hence, a fluid drained from the crop holders 20 which are arranged at the second subset may return or fall back to the fluid reservoir 13 due to gravity action.

[0057] The drive unit may be further operable to cause intermittent repositioning of each of the crop holders 20 among a plurality of distinct positions along at least one lateral direction defined by the second subset of the lateral conveyor paths, without repositioning the entire frame 11. In other words, the drive unit may be operable to cause advancement or repositioning of each crop holder 20 along lateral direction(s) defined by the second subset of the lateral conveyor paths. The intermittent repositioning may include moving a crop holder 20 to a new position, maintaining the crop holder 20 in the new position for at least a first duration. Figure 1D shows an example of crop holders 20 arranged at the second subset of the lateral conveyor paths. A crop holder 20 may be intermittently repositioned at consecutive positions 1211, 1212, 1213, 1214, 1215, 1216, 1217 in the lateral direction, or non-consecutive positions thereof.

[0058] The drive unit may be further operable to cause intermittent repositioning of each of the crop holders 20 among a plurality of distinct positions along at least one vertical direction which is transverse to the lateral direction or second subset of the lateral conveyor paths, without repositioning the entire frame 11. In other words, the drive unit may be operable to cause the crop holders 20 ascend or descend to different levels of the frame 11, thereby causing the crop holders 20 to be repositioned along vertical direction(s) defined by the non-lateral conveyor paths and/or the vertically stacked lateral conveyor paths. Referring to Figure 1D, a crop holder 20 may be intermittently repositioned at consecutive positions 1221, 1222, 1223, 1224, 1225 in the vertical direction, or non-consecutive positions thereof. By intermittently repositioning each crop holder 20 at multiple positions along at least one lateral direction and/or at least one vertical direction, this ensures that crop holder positions are not fixed and that crops in different crop holders 20 receive an adequate or predetermined light exposure, e.g. sunlight, over a second duration, e.g. crop life, which is longer than the first duration for healthier growth and more even crop quality within the same crop batch.

[0059] A load and/or unload station 14 may be arranged along the conveyor 12, e.g. at the return conveyor path, or between the return conveyor path and a first subset of the lateral conveyor paths, or other one or more suitable positions, wherein the crop holders 20 are arranged within an operational reach of an operator, e.g. human, machine, human-controlled machine, for coupling to the conveyor 12 and/or decoupling from the conveyor 12. The drive unit may be operable to cause

transportation of the crop holders 20 at a lower speed or bring the crop holders 20 to a halt at or near the load and/or unload station 14. In an example, the load and/or unload station 14 may be arranged at a bottommost level of the multi-level frame 11. In another example, the load and/or unload station may be arranged at another level of the multi-level frame 11 depending on the operational height of the operator.

[0060] The mechanised crop farming system 10 may be convertible between different growing methods by interchangeably coupling and/or decoupling crop holders of different design or type to the conveyor 12. In an example, a crop holder for soil-based farming may have its drainage opening(s) arranged at a shorter vertical distance or height from the bottom wall than for a crop holder for hydroponics and/or aquaponics. In another example, a crop holder for hydroponics and/or aquaponics may not have drainage openings. Other variations are also possible.

[0061] From the above, it follows that the mechanised crop farming system 10 may optionally allow different crop growing methods simultaneously by employing crop holders of different designs or types for the different crop growing methods.

[0062] Various modifications may be made to embodiments of the invention, such as but not limited to the following.

[0063] In Figures 1A and 1B, a return frame 11 path and a return conveyor path are substantially vertical and connect between the top and bottom levels of the frame 11. In another example (not shown), the return frame 11 path and the return conveyor path may be non-vertical, e.g. zig-zag, step, or curve arrangement.

[0064] In Figures 1A and 1B, the fluid reservoir 13 is provided under a first subset of the lateral conveyor paths such that crop holders 20 arranged at the first subset are at least partially immersed in the fluid reservoir 13. In another example (not shown), the fluid reservoir 13 may include a fluid-holding tank having a fluid release opening configured to release fluid from the fluid reservoir 13 into the crop holders 20 which are within the operation reach of the fluid reservoir 13. The fluid release opening may be a nozzle, sprayer, or other arrangements. In this example, an optional collection tank may be arranged under the first subset of the lateral conveyor paths and/or other appropriate sections to receive fluid drained from the crop holders 20.

[0065] In Figures 1A and 1B, the fluid reservoir 13 is provided under a first subset of the lateral conveyor paths such that fluid drained from crop holders 20 may be returned to or collected in the same fluid reservoir 13 provided the crop holders 20 are above the fluid reservoir 13. In another example (not shown), one or more collection tanks

may be arranged between the first subset and the second subset so that the drained fluid is collected in the additional collection tank(s).

[0066] Optionally, solar panels or photo-voltaic modules may be incorporated into the system to reduce energy consumption or electricity drawn from the power grid. For example, the system may further include photo-voltaic modules which may be operably coupled to at least one energy storage device which may be operably coupled to the drive unit either directly or via an inverter or other current or voltage conversion device. The drive unit may be powered by the photo-voltaic modules, via the energy storage device, and/or power grid.

[0067] Optionally, at least one timer module may be incorporated with the system to enable some of the automated functions such as crop light positioning and/or irrigation of the crops. For example, the drive unit may be operably coupled to a microprocessor which may be operably coupled to a timer module. An operator may preset one or more timing parameters via the timer module to operate the drive unit at preset times or intervals, e.g. to reposition crop holders along lateral and/or vertical conveyor paths, to move crop holders through the fluid reservoir.

[0068] In accordance with some embodiments, a method for mechanised crop farming is described with reference to the flow chart 300 of Figure 3.

[0069] In **block 302**, the above-described mechanised system for crop farming or at least some of its above-described components are provided.

[0070] In **block 304**, a plurality of crop holders are removably coupled to a closed loop conveyor at intervals along the conveyor. Coupling of the crop holders may be performed at a loading and/or unloading station which may be located at a predetermined position along the conveyor. Alternatively, this coupling may be performed at any accessible position along the conveyor.

[0071] In an example, coupling the crop holders to the conveyor may include engaging hooks of the crop holders with linking members coupled between the pair of conveyor chains. In another example, coupling the crop holders to the conveyor may include engaging loops of the crop holders with hooks of linking members coupled between the pair of conveyor chains.

[0072] In **block 306**, the crop holders are transported along the conveyor to a first subset of the lateral conveyor paths, thereby arranging the crop holders within an operational reach of a fluid reservoir. In other words, when the crop holders are arranged along the first subset, they are in appropriate proximity to receive a fluid from

the reservoir. Transporting the crop holders, in this and/or other blocks, may include operating the drive unit to cause the conveyor to transport or move the crop holders.

[0073] In **block 308**, the crop holders arranged along the first subset receives the fluid from the fluid reservoir. The fluid may be received through at least one flood opening of each of the crop holders. The received fluid may be at least partially drained through at least one drainage opening of each of the crop holders at this and/or later time. This receipt of fluid may be implemented in one or more ways.

[0074] In the above-described example wherein the fluid reservoir includes an open-top tank arranged below the first subset of the lateral conveyor paths, crop holders arranged at the first subset are at least partially immersed in the fluid reservoir. This partial immersion may cause the fluid to enter the crop holders through their flood openings. The crop holders may be further transported along the first subset of the lateral conveyor paths. Due to the relative arrangement of the fluid reservoir under the first subset, this transporting causes the crop holders to be moved through the fluid reservoir. This movement of crop holders through the fluid reservoir may cause the fluid to enter the crop holders through their flood openings, and at least partially drain from the crop holders through their drainage openings, thereby causing fluid circulation within each of the crop holders. Accordingly, the at least partial immersion of the crop holders in the fluid reservoir may cause irrigation of the crop holders with the fluid; the transportation of crop holders through the fluid reservoir may cause irrigation as well as fluid circulation through the crop holders.

[0075] In the above-described example wherein the fluid reservoir may include a fluid-holding tank having a fluid release opening configured to release fluid from the fluid reservoir, crop holders arranged at the first subset of the lateral sections may receive the fluid, which is dispensed through the fluid release opening and received through the flood openings of the crop holders.

[0076] In **block 310**, the crop holders, e.g. those which are arranged at the first subset and have received fluid in block 308, are transported along the conveyor to a second subset of the lateral conveyor paths, thereby arranging the crop holders outside the operational reach of the fluid reservoir. In other words, when the crop holders are arranged along the second subset, they are outside appropriate proximity to receive a fluid from the fluid reservoir. At this time, fluid may also be at least partially drained from the crop holders through their drainage openings. The drained fluid may be

received by an open-top tank arranged below the first subset of the lateral conveyor paths.

[0077] In **block 312**, each of the crop holders arranged at the second subset may be intermittently repositioned among a plurality of distinct positions along at least one lateral direction defined by the second subset of the lateral conveyor paths. In other words, each crop holder may be advanced or repositioned along lateral direction(s) defined by the second subset of the lateral conveyor paths. At each position, each crop holder is maintained at the position for a first duration. For example, in Figure 1D, a crop holder may be intermittently repositioned at consecutive positions 1211, 1212, 1213, 1214, 1215, 1216, 1217 in the lateral direction, or non-consecutive positions thereof.

[0078] Furthermore, the crop holders arranged at the second subset may be intermittently repositioned among a plurality of distinct positions along at least one vertical direction which is transverse to the lateral direction or second subset of the lateral conveyor paths. In other words, as each crop holder ascends or descends the multi-layer frame, it may be advanced or repositioned along vertical direction(s) defined by the non-lateral conveyor paths and/or the vertically stacked lateral conveyor paths. For example, in Figure 1D, a crop holder may be intermittently repositioned at consecutive positions 1221, 1222, 1223, 1224, 1225 in the vertical direction, or non-consecutive positions thereof.

[0079] In **block 314**, the crop holders may be transported to the load and/or unload station arranged along the conveyor. At least some of the crop holders may be decoupled from the conveyor for purposes such as but not limited to harvesting crops from crop holders, maintaining growing medium, changing crop holders of different type.

[0080] In some examples, at least some of the crop holders may be interchanged or replaced with a plurality of second crop holders. In other words, at least some of the crop holders may be decoupled from the conveyor and the second crop holders may be coupled to the conveyor. In an example, the crop holders and the second crop holders may employ same growing method, e.g. same medium. In another example, the crop holders, the second crop holders, and optionally a plurality of third crop holders may employ at least two different growing methods selected from the list consisting of soil-based farming, hydroponics and aquaponics. Accordingly, the

conveyor may be converted from one growing method to another growing method or may support at least two different growing methods at the same time.

[0081] In conventional crop farming, various needs of crops, e.g., water, nutrients, are transported or moved to crop locations. For example, water piping may have to be installed to deliver water various crop locations to irrigate the crops; artificial light may have to be installed at/near multiple crop levels; an operator has to move among crop locations to harvest crops. In embodiments of the invention, crops are transported or moved to or towards various needs. This reduces capital investment and human labour, yet improves various efficiencies, and also provide several advantages at least as explained below.

[0082] In embodiments of the invention, crops may be transported to a fluid reservoir for receiving fluid or water by transporting the crop holders to the fluid reservoir. This obviates a need for fluid and nutrient delivery infrastructure across multiple crop levels yet provides for automation of irrigation, e.g. flood and drain irrigation, and nutrient delivery. In an example wherein the fluid reservoir is an open-top tank and arranged under a first subset of the lateral conveyor paths, fluid and nutrients are simultaneously delivered to crops; there is no need to provide additional equipment, e.g. pump, to circulate fluid in the crop holders as fluid circulation is generated when the crop holders are moved through the fluid reservoir; fluid and nutrients which are drained from crop holders are returned to the same tank for subsequent use. This reduces additional equipment for delivering fluid and nutrients, circulating fluid, and collecting excess fluid, and also reduces electricity usage for operating any such additional equipment. Accordingly, the reduced need for infrastructure and equipment allows the system to be easily deployed in various locations including, outdoor and indoor areas, dedicated and non-dedicated farming locations, e.g. containers, building roof top, etc.

[0083] In embodiments of the invention, each of crop holders may be intermittently repositioned at multiple positions along lateral conveyor paths and/or non-lateral conveyor paths. By arranging each crop holder at different positions along lateral positions and non-lateral positions over a period of time, this staggering or rotating of crop holders among multiple crop locations enables crops in various crop holders to receive adequate light exposure over a period of time. This obviates a need to install additional artificial lights yet ensure the crops receive adequate light exposure to produce more even crop quality within the same crop batch.

[0084] In embodiments of the invention, the crop holders may be provided with flood openings and optionally drainage openings which are adapted for a selected growing method. The crop holders may be interchanged with second crop holders which are adapted for another growing method. This allows conversion of the system or conveyor to a different growing method by simply replacing crop holders without requiring major changes to the frame, conveyor, fluid reservoir, etc. This may also allow for the system or conveyor to employ different growing methods at the same time.

[0085] In some examples, drainage holes are arranged at the shorter edges of the crop holder so that the drained fluid would not fall onto leaves of crops arranged at level below to cause any potential damage to the crops.

[0086] In some examples, the crop holders are suitably coloured to cause reflection of only the growth light spectrum to the crops. This helps to reduce heat that may accompany other or non-growth light spectrums.

[0087] In embodiments of the invention, crops are brought to a designated location to be harvested by transporting the crop holders to the load and/or unload station. This reduces labour and time for harvesting, and also the footprint required by the multi-level frame as only the designated load and/or unload station has to be accessible to the operator.

[0088] In embodiments of the invention, the zig-zag loop vertical conveyor system can be configured and sized to fit both open sunlight and indoor systems (where environmental control is required) and increase land productivity for vegetable crops by more than two times depending on the height and the number of crop layers provided by the system.

[0089] It is to be understood that the embodiments and features described above should be considered exemplary and not restrictive. Many other embodiments will be apparent to those skilled in the art from consideration of the specification and practice of the invention. Furthermore, certain terminology has been used for the purposes of descriptive clarity, and not to limit the disclosed embodiments of the invention.

CLAIMS

[Claim 1] A mechanised crop farming system comprising:

- a frame having a plurality of levels stacked in a vertical direction;
- a closed loop conveyor traversing the levels and having alternating lateral and non-lateral conveyor paths, and a return conveyor path, wherein at least some of the lateral conveyor paths are longer than at least some of the non-lateral conveyor paths;
- a plurality of crop holders removably coupled to the conveyor at intervals thereof;
- a fluid reservoir having a fluid;
- a drive unit operably coupled to the conveyor and operable to cause transportation of the crop holders to a first subset of the lateral conveyor paths wherein the crop holders arranged along the first subset are within an operational reach of the fluid reservoir, and wherein the drive unit is further operable to cause transportation of the crop holders to a second subset of the lateral conveyor paths wherein the crop holders arranged along the second subset are outside the operational reach of the fluid reservoir.

[Claim 2] The system according to claim 1, wherein each of the crop holders which are arranged along the second subset is intermittently repositioned among a plurality of distinct positions along at least one lateral direction defined by the second subset.

[Claim 3] The system according to claim 1 or claim 2, wherein each of the crop holders includes at least one flood opening configured to receive the fluid therethrough when the crop holders are within the operational reach of the fluid reservoir, and wherein each of the crop holders includes at least one drainage opening configured to at least partially drain the fluid therefrom.

[Claim 4] The system according to claim 3, wherein the drive unit is further operable to cause transportation of the crop holders along the first subset to cause a movement of the crop holders through the fluid reservoir and a circulation of the fluid through the at least one flood opening and the at least one drainage opening.

[Claim 5] The system according to claim 4, wherein each of the crop holders includes a pair of opposed first sidewalls, a pair of opposed second sidewalls which are shorter than the first sidewalls, and a bottom wall coupled to the first sidewalls and the second sidewalls, wherein the at least one drainage opening is arranged on at least one of the second sidewalls at a distance from the bottom wall to cause retention of at least some of the fluid in each of the crop holders.

[Claim 6] The system according to claim 1 or claim 2, wherein the fluid reservoir includes at least one fluid release opening configured to release the fluid into the crop holders which are within the operational reach of the fluid reservoir.

[Claim 7] The system according to any one of claim 1 to claim 6, wherein the drive unit is further operable to cause transportation of the crop holders to a load and/or unload station arranged along the conveyor wherein the crop holders arranged at the load and/or unload station are within an operational reach for coupling to the conveyor or decoupling from the conveyor.

[Claim 8] The system according to any one of claim 1 to claim 7, wherein at least some of the crop holders are replaceable by a plurality of second crop holders, wherein the at least some of the crop holders and the second crop holders are respectively configured for at least two different growing methods selected from the list consisting of soil-based farming, hydroponics and aquaponics.

[Claim 9] The system according to any one of claim 1 to claim 8, wherein the conveyor is non-helical.

[Claim 10] A method for mechanised crop farming, the method comprising:

removably coupling a plurality of crop holders to a closed loop conveyor at intervals thereof, the conveyor having alternating lateral and non-lateral conveyor paths, and a return conveyor path, wherein at least some of the lateral conveyor paths are longer than at least some of the non-lateral conveyor paths, wherein the conveyor traverses a plurality of layers of a frame which are stacked in a vertical direction;

transporting the crop holders to a first subset of the lateral conveyor paths, thereby arranging the crop holders within an operational reach of a fluid reservoir having a fluid;

receiving, by the crop holders which are within the operational reach of a fluid reservoir, the fluid from the fluid reservoir; and

transporting the crop holders to a second subset of the lateral conveyor paths, thereby arranging the crop holders outside the operational reach of the fluid reservoir.

[Claim 11] The method according to claim 10, further comprising:

intermittently repositioning each of the crop holders, which are arranged at the second subset, among a plurality of distinct positions along at least one lateral direction defined by the second subset.

[Claim 12] The method according to claim 10 or claim 11, wherein receiving, by the crop holders which are within the operational reach of the fluid reservoir, the fluid from the fluid reservoir, includes: receiving the fluid through at least one flood opening of each of the crop holders, wherein the method further comprising: at least partially draining the fluid through at least one drainage opening of each of the crop holders.

[Claim 13] The method according to claim 12, wherein receiving, by the crop holders which are within the operational reach of the fluid reservoir, the fluid from the fluid reservoir, includes:

transporting the crop holders along the first subset, the transporting including moving the crop holders through the fluid reservoir and causing the fluid to circulate through the at least one flood opening and the at least one drainage opening of each of the crop holders.

[Claim 14] The method according to claim 12 or claim 13, wherein each of the crop holders includes a pair of opposed first sidewalls, a pair of opposed second sidewalls which are shorter than the first sidewalls, and a bottom wall coupled to the first sidewalls and the second sidewalls, wherein the at least one drainage opening is arranged on at least one of the second sidewalls at a distance from the bottom wall to cause retention of at least some of the fluid in each of the crop holders.

[Claim 15] The method according to claim 10 or claim 11, wherein receiving, by the crop holders which are within the operational reach of the fluid reservoir, the fluid from the fluid reservoir, includes:

releasing the fluid, through at least one fluid release opening of the fluid reservoir, into the crop holders which are within the operational reach of the fluid reservoir.

[Claim 16] The method according to any one of claim 10 to claim 15, further comprising:

transporting the crop holders to a load and/or unload station arranged along the conveyor; and decoupling the crop holders from the conveyor.

[Claim 17] The method according to any one of claim 10 to 16, further comprising:

interchanging at least some of the crop holders with a plurality of second crop holders, wherein the at least some of the crop holders and the second crop holders are respectively configured for at least two different growing methods selected from the list consisting of soil-based farming, hydroponics and aquaponics.

[Claim 18] The method according to any one of claim 10 to 17, wherein the conveyor is non-helical.