SUMMARY OF THE DISCLOSURE

[0011] The present disclosure is directed to facility layouts and configurations for an automated crop production system for controlled environment agriculture. In some implementations, the facility layouts establish consolidated utility and plant production zones that achieve a variety of operational and cost efficiencies. In particular implementations, the core of the facility comprises a controlled growth environment and a central processing system. The controlled growth environment includes systems for exposing crops housed in modules, such as grow towers, to controlled environmental conditions. The central processing system may include various stations and functionality both for preparing crop-bearing modules to be inserted in the controlled growth environment, for harvesting crops from the crop-bearing modules after they have been extracted from the controlled growth environment, and for cleaning or washing crop-bearing modules for re-use. The remaining aspects of the crop production facility--such as seeding stations, propagation facilities, packaging stations and storage facilities--are arranged to achieve one or more desired efficiencies relating to capital expenditures or operating costs associated with an automated crop production facility.

[0011a] According to a first aspect of the present invention, there is provided a crop production facility for controlled environment agriculture, comprising: a nutrient and thermal corridor; an array of one or more grow rooms adjacent to the nutrient and thermal corridor, the array having a first end and a second end, the array extending substantially parallel to the nutrient and thermal corridor; a conveyance mechanism that injects and ejects grow structures from a side of the one or more grow rooms opposite the nutrient and thermal corridor; a propagation space adjacent to the first end of the array and interfacing with the nutrient and thermal corridor; and a central processing system comprising one or more grow structure processing systems adjacent to the array of grow rooms and opposite the nutrient and thermal corridor; wherein each of the grow rooms comprises: one or more grow lines, each of the one or more grow lines comprising a grow conveyance mechanism; and a plurality of grow towers, each of the plurality of grow towers vertically attached to, and moveable along, a respective one of the one or more grow lines; wherein each of the one or more grow lines comprises a first path section, a second path section, and a

return mechanism operative to transfer grow towers from the first path section to the second path section; wherein the grow conveyance mechanism conveys grow towers along the first path section in a first direction, and along the second path section in a second direction opposite the first direction; wherein one of the one or more grow structure processing systems is a harvester station, and wherein the crop production facility further comprises a post-harvest processing facility located adjacent to the central processing system and proximal to the harvester station; and wherein the harvester station comprises a crop harvesting machine, and a feeder mechanism to receive a grow tower in a horizontal orientation and feed the grow tower through the crop harvesting machine in a horizontal orientation; and wherein the crop production facility further comprises an automated laydown station comprising a first robot including an end effector adapted to releasably grasp a grow tower, and control logic operative to cause the first robot to pick the grow tower from a pick location in a vertical orientation, rotate the grow tower to a horizontal orientation and place the grow tower on a conveyor for loading into the harvester station.

[0012] The present disclosure is also directed to a vertical farming structure having vertical grow towers and associated conveyance mechanisms for moving the vertical grow towers along one or more grow lines through a controlled environment, while being exposed to controlled conditions, such as lighting, airflow, humidity and nutritional support. The present disclosure describes a return transfer mechanism that creates a return or u-shaped path for each grow line. The present disclosure also describes an automated crop production system for controlled environment agriculture that selectively routes grow towers through various processing stages of an automated crop production system.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Figure 1A is a functional block diagram illustrating an example controlled environment agriculture system; and Figure 1B is a functional block diagram illustrating a second example controlled environment agriculture system.

CLAIMS

What is claimed is:

1. A crop production facility for controlled environment agriculture, comprising:

a nutrient and thermal corridor;

an array of one or more grow rooms adjacent to the nutrient and thermal corridor, the array having a first end and a second end, the array extending substantially parallel to the nutrient and thermal corridor;

a conveyance mechanism that injects and ejects grow structures from a side of the one or more grow rooms opposite the nutrient and thermal corridor;

a propagation space adjacent to the first end of the array and interfacing with the nutrient and thermal corridor; and

a central processing system comprising one or more grow structure processing systems adjacent to the array of grow rooms and opposite the nutrient and thermal corridor;

wherein each of the grow rooms comprises:

one or more grow lines, each of the one or more grow lines comprising a grow conveyance mechanism; and

a plurality of grow towers, each of the plurality of grow towers vertically attached to, and moveable along, a respective one of the one or more grow lines;

wherein each of the one or more grow lines comprises a first path section, a second path section, and a return mechanism operative to transfer grow towers from the first path section to the second path section;

wherein the grow conveyance mechanism conveys grow towers along the first path section in a first direction, and along the second path section in a second direction opposite the first direction;

wherein one of the one or more grow structure processing systems is a harvester station, and wherein the crop production facility further comprises a post-harvest processing facility located adjacent to the central processing system and proximal to the harvester station; and

wherein the harvester station comprises a crop harvesting machine, and a feeder mechanism to receive a grow tower in a horizontal orientation and feed the grow tower through the crop harvesting machine in a horizontal orientation; and

wherein the crop production facility further comprises an automated laydown station comprising a first robot including an end effector adapted to releasably grasp a grow tower, and control logic operative to cause the first robot to pick the grow tower from a pick location in a vertical orientation, rotate the grow tower to a horizontal orientation and place the grow tower on a conveyor for loading into the harvester station.

~~2. The crop production facility of claim 1 wherein each of the grow rooms comprises~~

~~one or more grow lines, each of the one or more grow lines comprising a grow conveyance mechanism; and~~

~~a plurality of grow towers, each of the plurality of grow towers vertically attached to, and moveable along, a respective one of the one or more grow lines;~~

~~wherein each of the one or more grow lines comprises a first path section, a second path section, and a return mechanism operative to transfer grow towers from the first path section to the second path section;~~

~~wherein the grow conveyance mechanism conveys grow towers along the first path section in a first direction, and along the second path section in a second direction opposite the first direction.~~

~~3~~2. The crop production facility of claim 1 further comprising a seeding area adjacent to the propagation space.

~~4~~3. The crop production facility of claim 1 wherein one of the one or more grow structure processing systems is a harvester station, and wherein the crop production facility further comprises a post-harvest processing facility located adjacent to the central processing system and proximal to the harvester station.

~~5~~4. The crop production facility of claim ~~4~~ 3 further comprising a cold storage facility adjacent to the post-harvest processing facility.

~~6~~5. The crop production facility of claim ~~4~~ 3 further comprising a conveyor configured to carry bins or harvested product directly on the belt from the harvester station to the post-harvest processing facility.

~~7~~6. The crop production facility of claim ~~5~~ 4 further comprising a loading bay adjacent to the cold storage facility.

~~8~~7. The crop production facility of claim 1 wherein each of the grow rooms is substantially encapsulated and comprises one or more control systems for controlling one or more environmental variables.

~~9. The crop production facility of claim 2 wherein one of the one or more grow structure processing systems is a harvester station, and wherein the crop production facility further comprises a post-harvest processing facility located adjacent to the central processing system and proximal to the harvester station.~~

~~10. The crop production facility of claim 9 wherein the harvester station comprises a crop harvesting machine, and a feeder mechanism to receive a grow tower in a horizontal orientation and feed the grow tower through the crop harvesting machine in a horizontal orientation; and wherein the crop production facility further comprises~~

~~an automated laydown station comprising a first robot including an end effector adapted to releasably grasp a grow tower, and control logic operative to cause the first robot to pick the grow tower from a pick location in a vertical orientation, rotate the grow tower to a horizontal orientation and place the grow tower on a conveyor for loading into the harvester station.~~

~~11~~8. A crop production facility for controlled environment agriculture, comprising:

a nutrient and thermal corridor;

an array of one or more grow rooms adjacent to the nutrient and thermal corridor, the array having a first end and a second end, the array extending substantially parallel to the nutrient and thermal corridor; wherein each of the grow rooms comprises a substantially encapsulated growth environment containing a vertical grow tower conveyance system comprising

one or more grow lines, wherein each of the one or more grow lines comprises a first path section, a second path section, and a return mechanism operative to transfer grow towers from the first path section to the second path section;

a plurality of grow towers, each of the plurality of grow towers vertically attached to, and moveable along, a respective one of the one or more grow lines, wherein each of the plurality of grow towers includes a plurality of grow sites extending at least along one face thereof; and

a grow tower conveyance mechanism operative to convey grow towers along the first path section in a first direction, and along the second path section in a second direction opposite the first direction;

a central processing system, arranged adjacent to the array of one or more grow rooms and opposite the nutrient and thermal corridor, comprising

a harvester station comprising a crop harvesting machine, and a feeder mechanism to receive a grow tower in a horizontal orientation and feed the grow tower through the crop harvesting machine in a horizontal orientation;

a washing station comprising a second feeder mechanism to receive a grow tower in a horizontal orientation and feed the grow tower through the washing station in a horizontal orientation;

a transplanter station comprising a third feeder mechanism to receive a grow tower in a horizontal orientation and feed the grow tower through the transplanter station in a horizontal orientation;

a plurality of conveyors arranged to convey grow towers to and from respective ones of the harvester station, the washing station and the transplanter station, wherein the plurality of conveyors include a first conveyor arranged to feed a grow tower to the harvester station, a second conveyor arranged to feed a grow tower to the washing station, a third conveyor arranged to feed a grow tower to the transplanter station, and a fourth conveyor arranged to feed a grow tower from the transplanter station to a pickup location; and

an automated laydown station comprising a first robot including an end effector adapted to releasably grasp a grow tower, and control logic operative to cause the first robot to pick the grow tower from a pick location in a vertical orientation, rotate the grow tower to a horizontal orientation and place the tower on a conveyor for loading into the harvester station;

an automated pickup station comprising a second robot including an end effector adapted to releasably grasp a grow tower, and control logic operative to cause the second robot to grasp a grow tower from the pickup location in a horizontal orientation, rotate the grow tower to a vertical orientation for transfer to a select grow line of the plurality of grow lines; and

a propagation space adjacent to the first end of the array and interfacing with the nutrient and thermal corridor.

~~12. A crop production system for controlled environment agriculture, comprising:~~

~~one or more grow lines, each of the one or more grow lines comprising a grow conveyance mechanism; and~~

~~a plurality of grow towers, each of the plurality of grow towers vertically attached to, and moveable along, a respective one of the one or more grow lines;~~

~~wherein each of the one or more grow lines comprises a first path section, a second path section, and a return mechanism operative to transfer grow towers from the first path section to the second path section;~~

~~wherein the grow conveyance mechanism conveys grow towers along the first path section in a first direction, and along the second path section in a second direction opposite the first direction.~~

~~13. The crop production system of claim 12 wherein the return mechanism comprises~~

~~a track;~~

~~a carriage attached to the track;~~

~~a controller;~~

~~an actuator configured to move the carriage along the track in response to signals from the controller;~~

a receiver coupled to the carriage, wherein the receiver is configured to releasably engage a grow tower.

14. The crop production system of claim 12 wherein each of the one or more of the conveyance mechanisms, for each path section of a grow line, comprises:

a common beam disposed in a track, the track extending in a direction parallel to the grow line;

an actuator attached to the common beam, wherein the actuator is operative to move the common beam along the track in a forward stroke and a back stroke; and

a plurality of cams pivotally attached at select positions along the common beam, wherein each cam is mounted to limit rotation of the cam during the forward stroke causing the cam to engage and push a first tower forward in a first direction during the forward stroke and to allow the cam to slide over a second tower during the back stroke; wherein the select positions of the plurality of cams are each configured such that in a forward stroke a respective cam engages a first grow tower during the forward stroke and ratchets over a second grow tower adjacent to the first tower during the back stroke.

15. The crop production system of claim 14 wherein the spacing of the select positions increase in the first direction such that spacing of the grow towers increases as such grow towers are pushed along the one or more grow lines with success cycles of the actuator.

16. The crop production system of claim 14 wherein the common beam has a u-shaped profile having first and second walls extending from a base, and wherein the plurality of cams are each mounted at the select positions along the first and second walls.

17. The crop production system of claim 12 wherein each of the plurality of grow towers comprises a hook attached to the top of the grow tower, wherein the hook is configured to engage the grow line.

18. The crop production system of claim 17 wherein each of the one or more grow lines includes a groove region to which the hook of a grow tower slidably attaches.

19. The crop production system of claim 12 further comprising an onloading mechanism comprising a powered and free conveyer and one or more carriages; wherein the one or more carriages are configured to releasably engage grow towers; and wherein the powered and free conveyer is configured to insert a grow towers on a selected grow line of the one or more grow lines.

20. A crop production system for controlled environment agriculture, comprising:

a controlled growth environment substantially encapsulating one or more grow lines, each of the one or more grow lines comprising

a grow conveyance mechanism; and

a plurality of grow towers, each of the plurality of grow towers vertically attached to, and moveable along, a respective one of the one or more grow lines;

wherein each of the one or more grow lines comprises a first path section, a second path section; wherein the grow conveyance mechanism conveys grow towers along the first path section in a first direction, and along the second path section in a second direction opposite the first direction;

a return mechanism operative to transfer grow towers from the first path section of a grow line of the one or more grow lines to the second path section of the grow line; wherein the controlled growth environment further comprises one or more grow tower interfaces along a first side; and

a transfer conveyor comprising a plurality of carriages disposed on a track and a control system, wherein the track extends into the controlled growth environment at the one or more grow tower interfaces; wherein each of the plurality of carriages is configured to releasably attach to a grow tower; and wherein the control system is configured to convey a carriage including a grow tower to an injection point of a select grow line and convey an empty carriage from an ejection point of a select grow line.

21. The crop production system of claim 20 wherein the one or more grow tower interfaces comprise a vertical slot in the first side and a moveable door that closes over the vertical slot in a first position and allows a grow tower to pass through the vertical slot in a second position.

~~22. The crop production system of claim 20 wherein the controlled growth environment is divided into physically separate sections.~~

~~23. The crop production system of claim 22 wherein the track and the transfer conveyor are configured to route carriages into select ones of the physically separate sections.~~