SUMMARY OF THE DISCLOSURE

[0009] The present disclosure is directed to an automated crop production system for controlled environment agriculture that includes a horizontal-to-vertical interface between a vertical grow structure that includes vertical grow towers and associated conveyance mechanisms for moving the vertical grow towers through a controlled environment, and a processing system that performs one or more processing operations—such as harvesting, cleaning and/or transplanting—on the grow towers in a substantially horizontal orientation. 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. The present disclosure further describes tower buffers located at select locations in the processing path of grow towers to increase the overall efficiency of the system.

[0009a] According to a first aspect of the present invention, there is provided a crop production system for controlled environment agriculture, comprising: a vertical grow tower conveyance system comprising one or more grow lines; 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 move the plurality of~~one or more~~ grow towers along a respective grow line from a first end to a second end; a horizontal conveyor to convey grow towers to one or more processing stations; 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 the horizontal conveyor, wherein the end effector comprises a beam, a first gripper attached to a first end of the beam, and a second gripper attached to a second end of the beam, wherein the first and second grippers are configured to releasably grasp a grow tower.

[0009b] According to a second aspect of the present invention, there is provided a crop production system for controlled environment agriculture, comprising: a vertical grow tower conveyance system comprising one or more grow lines; 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; a grow tower conveyance mechanism operative to move the plurality of~~one or more~~ grow towers along a respective grow line from a first end to a second end; and a transfer mechanism adapted to attach a grow tower to the first end of a select grow line of the one or more grow lines; a loading transfer conveyor comprising a plurality of carriages disposed on a track; and wherein the loading transfer conveyor is configured to convey carriages carrying grow towers releasably attached thereto from a stop location to the one or more grow lines; and an automated pickup 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 grasp a grow tower from a pickup location in a horizontal orientation, rotate the grow tower to a vertical orientation and transfer the grow tower to a carriage of the loading transfer conveyor, wherein the end effector comprises a beam, a first gripper attached to a first end of the beam, and a second gripper attached to a second end of the beam, wherein the first and second grippers are configured to releasably grasp a grow tower.

[0009c] According to a third aspect of the present invention, there is provided a crop production system for controlled environment agriculture, comprising: a vertical grow tower conveyance system comprising one or more grow lines; 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; a grow tower conveyance mechanism operative to move the plurality of~~one or more~~ grow towers along a respective grow line from a first end to a second end; a grow tower processing system comprising a harvester station comprising a crop harvesting machine, and a first 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 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, and a second conveyor arranged to feed a grow tower from the transplanter station to a pickup location; and a controller configured to control operation of the plurality conveyors to transfer grow towers among the harvester station, the washing station and the transplanter station; an automated laydown station comprising a first robot including a gripper adapted to releasably grasp a grow tower, and control logic operative to cause the first robot to pick the grow tower from the grow station in a vertical orientation, rotate the grow tower to a horizontal orientation and place the tower on the first conveyor; an automated pickup station comprising a second robot including a gripper 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 and transfer the grow tower to the vertical grow tower conveyance system; and one or more sensors configured to identify a grow tower from a plurality of grow towers, and wherein the controller is operative, for select identified grow towers, to cause the tower processing system to bypass the washing station and the transplanter station; wherein the plurality of conveyors comprises a third conveyor arranged to convey a grow tower from the harvester station to a second pickup location proximal to the automated pickup station, and wherein the control logic of the automated pickup station is operative to cause the second robot to selectively engage grow towers placed at the pickup location or second pickup location.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] Figure 1 is a functional block diagram illustrating an example controlled environment agriculture system.

[0011] Figure 2 is a perspective view of an example controlled environment agriculture system.

[0012] Figures 3A and 3B are perspective views of an example grow tower.

[0013] Figure 4A is a top view of an example grow tower; Figure 4B is a perspective, top view of an example grow tower; Figure 4C is an elevation view of a section of an example grow tower; and Figure 4D is a sectional, elevation view of a portion of an example grow tower.

[0014] Figure 5A is a perspective view of a portion of an example grow line; and Figure 5B is a perspective view of an example tower hook.

[0015] Figure 6 is an exploded, perspective view of a portion of an example grow line and reciprocating cam mechanism.

What is claimed is:

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

a vertical grow tower conveyance system comprising

one or more grow lines;

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 move the ~~one or more~~plurality of grow towers along a respective grow line from a first end to a second end;

a horizontal conveyor to convey grow towers to one or more processing stations; 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 the horizontal conveyor,

wherein the end effector comprises a beam, a first gripper attached to a first end of the beam, and a second gripper attached to a second end of the beam, wherein the first and second grippers are configured to releasably grasp a grow tower.

2. The crop production system of claim 1 further comprising a harvester station comprising a crop harvesting machine, and a first feeder mechanism to receive a grow tower in a horizontal orientation from the horizontal conveyor and feed the grow tower through the crop harvesting machine in a horizontal orientation.

3. The crop production system of claim 1 wherein the first robot comprises a robotic arm movable in six axes.

4. The crop production system of claim 1 wherein the vertical grow tower conveyance system is substantially encapsulated in a controlled growth environment.

5. The crop production system of claim 4 further comprising an unload transfer conveyor comprising a plurality of carriages disposed on a track; and wherein the unload transfer conveyor is configured to convey carriages carrying grow towers releasably attached thereto from the one or more grow lines in the controlled growth environment to a pick location reachable by the first robot of the automated laydown station.

6. The crop production system of claim 2 further comprising

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.

7. The crop production system of claim 6 further comprising

a loading transfer conveyor comprising a plurality of carriages disposed on a track; and wherein the loading transfer conveyor is configured to convey carriages carrying grow towers releasably attached thereto from a stop location to the one or more grow lines; and

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 and attach the grow tower to a carriage of the loading transfer conveyor at the stop location.

8. The crop production system of claim 6 further comprising a horizontal tower buffer disposed between the harvester station and the washing station, the horizontal tower buffer configured to buffer a plurality of grow towers processed by the harvester station and to provide a buffered grow tower to the washing station to thereby operationally decouple the harvester station from the washing station.

9. The crop production system of claim 6 further comprising a horizontal tower buffer disposed between the washing station and the transplanter station, the horizontal tower buffer configured to buffer a plurality of grow towers processed by the washing station and to provide a buffered grow tower to the transplanter station to thereby operationally decouple the washing station from the transplanter station.

10. The crop production system of claim 1 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.

11. The crop production system of claim 1 wherein each of the plurality of grow towers comprises a first plurality of plug containers arranged along a first face of the grow tower.

12. The crop production system of claim 11 wherein each of the plurality of grow towers comprises a second plurality of plug containers arranged along a second face of the grow tower, wherein the second face is opposite to the first face.

13. The crop production system of claim 5 wherein the unload transfer conveyor is operative to selectively route grow towers to a select one of a plurality of pre-harvest buffers for pick up by the automated laydown station.

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

a vertical grow tower conveyance system comprising

one or more grow lines;

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;

a grow tower conveyance mechanism operative to move the ~~one or more~~plurality of grow towers along a respective grow line from a first end to a second end; and

a transfer mechanism adapted to attach a grow tower to the first end of a select grow line of the one or more grow lines;

a loading transfer conveyor comprising a plurality of carriages disposed on a track; and wherein the loading transfer conveyor is configured to convey carriages carrying grow towers releasably attached thereto from a stop location to the one or more grow lines; and

an automated pickup 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 grasp a grow tower from a pickup location in a horizontal orientation, rotate the grow tower to a vertical orientation and transfer the grow tower to a carriage of the loading transfer conveyor, wherein the end effector comprises a beam, a first gripper attached to a first end of the beam, and a second gripper attached to a second end of the beam, wherein the first and second grippers are configured to releasably grasp a grow tower.

15. The crop production system of claim 14 further comprising a transplanter station comprising a transplanting machine, and a feeder mechanism to receive a grow tower in a horizontal orientation and feed the grow tower through the transplanting machine in a horizontal orientation, and a conveyor for conveying the grow tower from the transplanter station to the pickup location.

16. The crop production system of claim 14 wherein the first robot comprises a robotic arm movable in six axes.

17. The crop production system of claim 14 wherein the vertical grow tower conveyance system is substantially encapsulated in a controlled growth environment.

18. The crop production system of claim 17 wherein the loading transfer conveyor is configured to convey the carriages carrying grow towers releasably attached thereto from the stop location outside of the controlled growth environment to a select grow line of the one or more grow lines.

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

a vertical grow tower conveyance system comprising

one or more grow lines;

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;

a grow tower conveyance mechanism operative to move the plurality of~~one or more~~ grow towers along a respective grow line from a first end to a second end;

a grow tower processing system comprising

a harvester station comprising a crop harvesting machine, and a first 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

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, and a second conveyor arranged to feed a grow tower from the transplanter station to a pickup location; and

a controller configured to control operation of the plurality conveyors to transfer grow towers among the harvester station, the washing station and the transplanter station;

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

an automated pickup station comprising a second robot including a gripper 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 and transfer the grow tower to the vertical grow tower conveyance system; and

one or more sensors configured to identify a grow tower from a plurality of grow towers, and wherein the controller is operative, for select identified grow towers, to cause the tower processing system to bypass the washing station and the transplanter station;

wherein the plurality of conveyors comprises a third conveyor arranged to convey a grow tower from the harvester station to a second pickup location proximal to the automated pickup station, and wherein the control logic of the automated pickup station is operative to cause the second robot to selectively engage grow towers placed at the pickup location or second pickup location.