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FARMING SYSTEMS

Field of the Invention

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The present invention relates to a system of growing vegetables and an apparatus for use in said system. The system finds particular use where the available area for growing is limited, and especially on a rooftop of a building.

Background to the Invention

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Given an increasing need to produce more food crops from a decreasing area of available land, and also to use as little as possible fossil fuel-derived energy as possible in that production, many different techniques have been developed which improve yield per m² with minimal energy input. Additionally, techniques have been developed enabling previously unusable areas to support crops.

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For example, particularly in urban environments, roofs of buildings are increasingly being used to grow crops. Where the rooftop is capable of supporting the weight, conventional greenhouses can be erected. Alternatively, containers or raised beds are located on a strong flat roof and growing carried out in a manner used in conventional rural market gardens.

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In attempting to utilise roof space, then for an enterprise to be run commercially, one problem which needs to be addressed is that of tending and harvesting the crop. Many supermarkets have rooftop areas available. In a recent calculation, there were 2160 supermarkets, each having in excess of 5000 m² available. The use of this area could be exploited by utilising modern polytunnel structures with a potential capacity of such a supermarket to grow crops to value of £3 million per year. The process would benefit from directing the heat and carbon dioxide from boiler flue gases into the polytunnels so improving conditions for growth.

However, simply to utilise polytunnels as part of commercial rooftop farming enterprise retains the problem of land-based enterprises in that access is still required for farming machinery and for the workforce. The need for access removes a relatively large area from availability for cultivation. Additionally when working in a rooftop environment, safety measures need to be undertaken to minimise the risk of falling from the rooftop, particularly of personnel, but also of equipment and materials. Moreover, the use of polytunnels is not suitable where the rooftop is pitched and is not a horizontal flat roof.

One solution to the access problem uses hydroponics to deliver water and nutrients to the plants. There are two basic variants of hydroponics. In the first variant, individual pots containing plants are linked to an array of pipes which delivers what is required by the plant for growth. Due to the time required to set the pipework up, this variant is more advantageous for plant crops with a long growing period such as tomatoes. However, because of the need for access, not just to the crop but also to the pipework, a relatively large access area is still required. The second variant, which is often used for crops with a short growth cycle, such as salad leaf crops, utilises polystyrene trays which float in tanks holding nutrient enriched water. The tanks are usually relatively long, with the trays floating adjacent to each other from a first end when the plants are young, to a second end where the plants are grown and can be harvested. The nature of this second variant restricts growing crops to a single layer.

The present invention seeks to address the above problems by providing a system for growing crops suitable for use on a rooftop, which improves space utilisation and also safety of personnel. The system is also suitable for use in conjunction with sloping roofs.

5 Summary of the Invention

According to a first aspect of the invention there is provided an apparatus for use in growing a plant crop, the apparatus comprising a structure enclosing a volume in which a crop can be maintained in a controlled environment during the growth of a crop,

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the structure housing two endless belts in spaced-apart parallel relationship and mounted for synchronous motion about a closed path,

a trough to removably retain a nutrient solution for a crop,

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suspension means to enable a container holding a crop to be suspended between and move with the belts,

the paths of the belts being such as to at least partially immerse the container in nutrient solution and feed a crop at least once on a complete belt circuit.

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The apparatus enables a crop to be grown within a relatively small volume, with minimal input from an operative.

25 Optionally, the suspension means includes a framework to hold one or more containers which enables the crops to be removed, together with the container for further transportation and for a new crop to be relatively easily added to pass through the apparatus. Further optionally, the suspension means includes a bar or axle attached to and extending between the belts to provide a secure support.

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Conveniently each belt is mounted to a drive sprocket, yet further conveniently the path of the or each belt is defined by a plurality of idler cogs which additionally provide support

to the belts. Further conveniently, the drive sprockets are located within the structure.
The drive belts are preferably chains.

5 The apparatus preferably includes sensors, such as temperature or humidity sensors said sensors being connected to a display enabling an operative to control the environment within the structure. Optionally, the sensors are linked to a processing means and a control means to enable the environment within the structure to be controlled automatically.

10 Optionally, one or more cameras are located within the structure to provide a visual image and/or record of the growth of the plants.

Preferably, one or more lasers are mounted within the structure to enable growth control of plant materials within the structure and reduce the requirement for herbicides during
15 the growth of a crop.

The apparatus preferably includes a pump to respectively fill and empty the trough.

Preferably the floor of the structure consists of a building roof which can enable crops to
20 be grown close to a point of sale in an urban environment.

According to a second aspect of the invention there is provided a method of growing plants, the method comprising the steps of:

25 (i) placing a plant into a container;

(ii) freely suspending the container between two endless belts, said belts being arranged in spaced-apart parallel relationship and mounted for synchronised motion about a closed path,

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(iii) adding a nutrient solution to a trough,

(iv) the path of the belts being such as to at least partially immerse the container and the plant through a nutrient solution in the trough to feed and water the plant and then to remove the container and plant from a nutrient solution and trough,

- 5 (v) the path being confined within a space having a controlled environment.

Brief Description of the Drawings

- 10 The invention is now described with reference to the accompanying drawings which show by way of example only, one embodiment of a farming system. In the drawings:

Figure 1 is a diagrammatic illustration of a building including a rooftop farming system in accordance with the invention;

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Figure 2 is a side view of the building and system of Figure 1;

Figure 3 is a diagrammatic illustration, not to scale, of trays and a nutrient trough; and

- 20 Figure 4 illustrates a tray suspended between drive chains.

Detailed Description of the Invention

- Referring to figures 1 and 2, these illustrate a modular system located on the rooftop of a
25 building. The building rooftop is of design which is common for modern warehouses and also supermarkets, especially those constructed as part of a purpose-built industrial retail park. In such buildings a basic steel frame is erected and cold-rolled steel purlins bolted thereto. The purlins are then covered with the insulated steel profile sheets. Larger buildings can be put together with several low pitched bays.

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The modules erected on the roof 11 of the building 10 can be installed to suit the frame of the building 10 and with minimal disturbance of the frame either during construction or

subsequently. In addition, it is intended that the weight of a module be borne, where possible by that building frame. A basic module, generally referenced 12 therefore comprises a steel framework having walls and a roof made of a plastics material. The plastics material is known in the art and is already widely used for the construction of conventional polytunnels. Moreover, the plastics material is available as a roll,
5 approximately two metres in width and the modules can be constructed using the known Keder method. In this method the framework of the module is erected, and includes regularly spaced arches across which the plastics material is attached to form a roof of the module. A roof can therefore be constructed from several strips of plastics material going
10 across the width of the module or alternatively a single length of plastics material running the length of the module.

Within the module, an almost completely automated process enables the growing plant to be monitored, watered and fed, and harvested. Additionally, means are optionally
15 included to control weeds and pests.

Within the internal volume of the module generally referenced 12, and defined by the building roof 11, module walls 13a, 13b and module roof 14a, 14b is maintained a controlled environment in which the crop is grown. A pair of parallel endless drive belts, or as herein exemplified, chains, approximately two metres apart, only one of which
20 chains 15 is shown in Figure 1 for convenience, are utilised to transport plants through the module 12. The chain 15 is driven by a main drive cog 16 and the path of the chain is effectively determined by the idler sprockets 17. The drive cog 16 is driven by a motor located where shown in Figure 1. At spaced intervals along the chain 15, bars or axles 18
25 (see Figure 4) extend between and are fixed at either end to the chain 15. In an alternative embodiment, not illustrated, a cable or chain can replace the bar or axle.

In use, containers 19 in which plants are retained are suspended by cables 19a from the axles 18. In an advantageous embodiment, not illustrated the containers 19 are held in a
30 common framework, enabling a container 19 to be removed, the crop harvested, a new crop planted in the container 19 and the container 19 then put back into a framework. In order to reduce costs therefore, it is envisaged that the framework is so sized as to accept

an integer number, especially three, industry standard-sized containers. Such containers are available in a wide variety of shapes and sizes and can themselves carry smaller trays or pots. By using industry standard containers the costs are kept to a minimum. In particular, certain trays are available which hold potted plants such that the potted plants
5 do not fall over and which fit into Danish trolleys, used within a supermarket or horticultural outlet. Although normally single use, trays can be reused with the present invention which again reduces costs.

It will be noted therefore that as the main drive cog 16 turns, the chain 15 and the
10 containers 19 suspended therefrom are transported around the module 12 and the plants therefore are moved from one region of the module 12 to another. At defined points along this course, the light conditions, humidity et cetera can be monitored, and feeding and weed and pest control can be undertaken. The trays can be provided with RF tags or Bar/QR codes which can be read by sensors at various points, for example as a tray
15 approaches a watering trough or a transfer point (see below).

One advantage of the invention disclosed herein over prior art systems is that of being able to be installed on roofs of different shapes and dimensions, without needing to manufacture elements specifically for that roof or plant crop. The configuration of the
20 path of the chain 15 is determined by the idler sprockets 17 and therefore these can be positioned to suit the general roof shape and any other installations which maybe present on the roof 11.

The above system enables a much simplified watering and feeding regime to be
25 implemented. Unlike prior art systems which require a large number of pipes and branches to water individual plant-containing pots or which require the pots to be located on a capillary matting, the present system can comprise a single watering point consisting of a trough 20. The trough 20 can be filled with water and any nutrients for the particular plant and its stage of growth. Said trough can be filled either by hand or by utilising a
30 pump. As the plant is moved along its path by the chain 15 the plant is dipped into the trough 20 thereby watering and/or feeding the plants. Should the particular plant require it, the movement of the chain 15 can be paused to ensure thorough watering.

Once the watering and/or feeding is completed for that container, the trough 20 can be emptied, again optionally by means of a pump, ready to receive fresh water and nutrients. As the containers move on, any excess water dripping from the plants runs back into the
5 trough 20 and can be reused. An advantage of this method of watering is that as the water drains from the plant, air is sucked into the soil so enhancing the soil's ability to support growth.

In order to monitor the progress of the plants, sensors are installed at points within the
10 module 12 and also cameras so that the visual status of the plants can be observed. In Figure 1, a number of detectors is shown. Firstly, a temperature indicator is shown at 22 and second a humidity indicator at 23. It should be appreciated that said detectors can be positioned elsewhere within the system as best determined on setting the system up. Conveniently sensors can be located in the region of the trough 20. The sensors can in
15 particular include a barcode reader, camera or laser. The sensors are conveniently linked to a central processing and control unit which will be programmed to take the actions necessary to keep the values of various properties such as temperature within a preset range. Alternatively, the unit can simply provide read outs when it is required that the values be maintained manually.

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The use of sensors not only allows for conditions to be controlled but also to provide information to retailers which they can use as a marketing tool within that business. Firstly, the data can be accumulated and can be used to enable the grower to build a knowledge base to aid in their understanding of how to manage conditions within the
25 modules to ensure best growth.

Additionally, the data can be used to show customers either through labels on the goods or through screens throughout the store to show the provenance of the goods. A further use for the data would be as part of a smartphone app to enable customers/consumers to
30 receive direct camera feeds to determine when a crop is ready. Also, crops at different stages of development can be harvested and brought down for educational purposes to show students in the building below.

Finally, the images from the cameras can be used to give a time lapsed film showing growth of a plant.

The information from the cameras can also be linked to a processor which is linked to a
5 laser. The laser can be mounted at a convenient point within a module in line of sight of
the trays/containers and because all the plants within a module pass that point, all the
plants should at some time come within the line of sight of the lasers. The laser can then
be used, under the control of a processor for example, to remove weeds or to trim
unwanted roots, stems or leaves or perhaps to thin out plants in a tray. The requirement to
10 use herbicide is therefore reduced.

Where space allows, modules can be located side by side along a roof and, assuming
temperature requirements between adjacent modules allow it, share a common dividing
wall. Depending on the crops being grown, adjacent modules can either share a watering
15 trough or be provided with their own individual trough. In the former situation,
coordination between chain movement and delivery of a crop to the common trough can
be carried out to minimise the frequency of filling and emptying a trough, particularly
where the same solutions are used for both crops. The use of individual troughs would
of course remove the requirement for that level of coordination and would also enable the
20 growing conditions for each crop to be individually optimised.

When using a plurality of modules there is an increased need to maximise the growing
space available and also to enable the system to remain predominantly automated. To
achieve this and to enable as high a density of plant growth as possible, a number of
25 access points to a module is reduced to the minimum possible. Moreover, produce from
each module is brought to a single access point, from where it can be removed from the
roof to, for example, the supermarket floor. For convenience, an access point can be in
the region of a trough 20. This facilitates the process of watering, weeding, pruning etc,
as these actions can firstly be monitored visually in a control area, and secondly take place
30 whilst the plants are stationary. In order to minimise the requirement for physical labour
to be used to move produce, robotics and CNC machining techniques can be utilised to
lift plant trays/containers from frames and to place them on a transport frame. The

transport frame is then carried by means of a pair of chains that give a route across the roof to the access point. By suitable routing, a growing area of several thousand square metres can be accessed from a very small area, perhaps no larger than a lift shaft.

- 5 Again the use of a single access area provides a great deal of flexibility in respect of where said access area can be located within the building or whether even on the outside of the building. As long as the layout allows for an adequate corridor for the transport frame, the positioning of the access area to the ground floor can be anywhere on the corridor. Of course, where a system is installed at ground level, or on a rooftop on which
10 human access is not restricted, then a crawler frame may not be required.

CLAIMS

1. An apparatus for use in growing a plant crop, the apparatus comprising a structure
5 enclosing a volume in which a crop can be maintained in a controlled environment during
the growth of a crop,

the structure housing two endless belts in spaced-apart parallel relationship and mounted
for synchronous motion about a closed path,

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a trough to removably retain a nutrient solution for a crop,

suspension means to enable a container holding a crop to be suspended between and move
with the belts,

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the paths of the belts being such as to at least partially immerse the container in nutrient
solution and feed a crop at least once on a complete belt circuit.

2. An apparatus according to Claim 1, wherein the suspension means includes a
20 framework to hold one or more containers.

3. An apparatus according to Claim 1 or Claim 2, wherein the suspension means
includes a bar or axle attached to and extending between the belts to provide a secure
support for the container.

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4. An apparatus according to any preceding claim, wherein each belt is mounted to a
drive sprocket.

5. An apparatus according to Claim 4, wherein the drive sprockets are located within
30 the structure.

6. An apparatus according to any preceding claim, wherein the path of the or each belt is defined by a plurality of idler cogs which additionally provide support to the belts.

7. An apparatus according to any preceding claim, wherein the drive belt is a drive
5 chain.

8. An apparatus according to any preceding claim, wherein the apparatus includes sensors, such as temperature or humidity sensors said sensors being connected to a display enabling an operative to control the environment within the structure.

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9. An apparatus according to Claim 8, wherein the sensors are linked to a processing means and a control means to enable the environment within the structure to be controlled automatically.

15 10. An apparatus according to any preceding claim, wherein one or more cameras are located within the structure to provide a visual image and/or record of the growth of the plants.

11. An apparatus according to any preceding claim, including a pump to fill and
20 empty the trough of nutrient liquid.

12. An apparatus according to any preceding claim, wherein the floor of the structure consists of a building roof.

25 13. An apparatus according to any preceding claim, wherein one or more lasers are mounted within the structure.

14. An apparatus substantially as herein described with reference to and as illustrated by the accompanying drawings.

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15. A method of growing plants, the method comprising the steps of:

(i) placing a plant into a container;

5 (ii) freely suspending the container between two endless belts, said belts being arranged in spaced-apart parallel relationship and mounted for synchronous motion about a closed path,

(iii) adding a nutrient solution to a trough,

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(iv) the path of the belts being such as to at least partially immerse the container and the plant in a nutrient solution to feed and water the plant and then to remove the container and plant from the nutrient solution,

15 (v) the path being confined within a space having a controlled environment.