METHOD AND DEVICE FOR GROWING A CROP

For generating a desired climate for a crop (12) a method in which air flows in a circuit (20) around crop container (14) in a greenhouse (10a) provided. The circuit runs from above the crop along the container, underneath the container and through the bottom of the container to above the crop. Little or none of the still air present above a level (22) mixes with the air in the circuit. The circuit furthermore runs through an air treatment device (42) for conditioning the air, such as cooling, heating, dehumidifying and/or humidifying. In this way relatively little air is displaced and little power is needed to displace the air, and little power is needed for heating and/or cooling the air, while growth of the crop is stimulated by the air flowing along the crop.
Title: Method and device for growing a crop

The present invention relates to a method and a device for growing a crop in a protected climate.

Growing crops in an environment with a protected climate, such as in a greenhouse, is known. Such a protected climate is intended to create good conditions for the crop to grow quickly and well. These conditions are largely formed by a quantity of light and an air condition.

The air condition is determined, inter alia, by the temperature of the air, the relative humidity of the air and a CO₂ concentration in the air. Furthermore, it has been found that air flowing along the leaf of the crop stimulates the growth of the crop.

A known technique is to place a tube with apertures underneath a crop container, so that air flows out of a central air treatment device from underneath the crop container upwards along the crop so as to create a good climate for the growth of the crop.

It is, however, a disadvantage of the known technique that after passing along the crop the treated air flows freely into the protected area, i.e. the greenhouse. This means that an air circulation occurs in the protected area in the case of which in particular warm air present under the roof of the protected area becomes distributed in the protected area, which then requires additional cooling, particularly in the summer, in order to provide a good air temperature for the crop.

It is an object of the present invention to provide a method and device in which air flows along the crop and in this case to ensure that the flowing air is mixed as little as possible with warm air under the roof, in order to generate a conditioned air layer in the environment of the crop.

The object is achieved by a method according to claim 1. In the method the crop is placed in a container with a gas-permeable bottom. Such a container is known per se. The bottom is formed by mesh, for example, and the crop is in a pot or tray in a nutrient medium. The container is at least partially filled with a number of such pots and/or trays. Air can therefore flow from underneath the container through the mesh and along the pots or trays upwards along
the crop.

In the method according to the invention an air flow is generated in a circuit, in which the air flows from underneath the container upwards along the crop and from above the crop along the container back down underneath the container. A relatively short circulation circuit around the container and the crop is produced in this way. This circuit is advantageously used, because in this way a separate layer of air can be produced in the environment of the container and the crop. Said layer of air does not mix with the relatively warm air present directly under the roof of the protected environment.

The air flow circuit furthermore runs through an air treatment device for controlling a condition of the air. By this means, the condition of the air can be controlled locally. The air can be conditioned by cooling, heating, dehumidifying and/or humidifying. If various crops, or the same crops in various stages of growth, are placed in the same environment, the desired air condition can be generated locally for each individual type of crop.

In one embodiment the air treatment device has a low air resistance to the air flow. The circuit described above has a low resistance to the air flow, owing to the fact that, for example, pipes are not used for the conveyance of air. The generation and maintenance of the circuit therefore requires little energy, for example electrical energy. A suitable air treatment device therefore preferably has a low resistance. The low resistance can be the result of, for example, the use of special materials, a large flow-through surface for the air, and other measures that are known in the prior art, in particular the measures known from flow dynamics.

In one embodiment the condition to be controlled in the air comprises the temperature of the air. The air treatment device in that case can comprise a heating device for heating passing air and/or a cooling device for cooling passing air.

In one embodiment the condition to be controlled in the air comprises the relative humidity of the air. The air treatment device in that case can comprise a humidifying device for increasing the relative humidity and/or a dehumidifying device for reducing the relative humidity.

The method can furthermore comprise controlling a CO₂ concentration in the air and/or controlling a quantity of light.
Other parameters that have an influence on the growth of the crop can also be controlled.

In a further aspect the present invention provides a device for growing a crop in a protected climate, for example in a greenhouse. The device comprises a container with a gas-permeable bottom for holding the crop; an air displacement device for generating an air flow; and means for guiding the air flow. The air displacement device and the means for guiding the air flow are positioned relative to each other and relative to the container in such a way that in operation the air flow circulates in a circuit, which circuit runs from above the crop along the container, then underneath the container and through the bottom of the container to above the crop. The device is therefore suitable for carrying out the method according to the invention.

It is pointed out that the air already flowing is more readily-drawn in towards an air displacement device than still air. Consequently, the air flowing upwards through the bottom will more readily be moved along the container and back through the bottom than the still air in the top of the greenhouse. In this way it is possible to generate a local air flow circuit.

The device furthermore comprises an air treatment device. The air flow circuit runs through the air treatment device for controlling a condition of the air. The air treatment device can comprise, for example, a heating device for heating passing air and/or a cooling device for cooling passing air.

In one embodiment the air treatment device has a low resistance to the air flow. For example, the air flow runs along one side of the container, and the air treatment device extends substantially-over the full length of the abovementioned side of the container. In this way a large flow surface through/along the air treatment device is obtained.

In one embodiment the air treatment device can comprise a number of tubular elements. The tubular elements are at least partially filled, preferably fully filled, with a medium, and the tubular elements are connected to a cooling and/or heating device for cooling and/or heating the medium. In operation, the air flow is guided along the tubular elements. The tubular elements can be designed with surface-enlarging elements, such as fins and the like, for a good heat exchange with the air flowing past. In this way the
air is cooled or heated by the tubular elements. The tubular elements and possible surface-enlarging elements are preferably designed in such a way that the air can flow along them with little resistance, while a good heat exchange can occur.

The cooling and/or heating device can be a relatively heavy central device, in which case only one device is needed for heating or cooling the greenhouse. The cooling and/or heating device can also be a relatively light device, in which case a number of such devices are used to achieve the desired temperature at each location.

In one embodiment the tubular elements are placed below a grille that is placed substantially next to the container, which grille is suitable for bearing a person. An aisle is generally provided on at least one side of the container, so that a grower can inspect the crops in the container from close up. When the tubular elements are placed below the grille air can flow through the grille, so that the desired circulation circuit is not disrupted. The grille is of such strength and of such a strong supporting construction that a person can walk over the grille. This means that the device does not take up any additional space compared with the known prior art.

In one embodiment a first container and a second container are placed on either side of the grille and the tubular elements. The containers on either side form a funnel shape into which the air flow can be drawn and fed along the tubular elements.

The air displacement device can be placed downstream relative to the tubular elements, a substantially tubular space being formed between the air displacement device and the tubular elements. Air is guided from above the container along the tubular elements into the tubular space, from which space the air is drawn in by the air displacement device and conveyed underneath the container.

Furthermore, the device can comprise an air treatment device comprising a humidifying device for increasing the relative humidity and/or a dehumidifying device for reducing the relative humidity.

In one embodiment the air displacement device is placed near a first side of the container. The air displacement device generates an air flow in the direction of a second side of the container situated opposite. The air displacement device in that case preferably has a throw substantially corresponding to a distance
between the first side and the second side. The air flow generated by the air displacement device is substantially parallel to the bottom of the container. The flow decreases with the distance from the air displacement device. Since the air has to flow through the bottom of the container, the flow parallel to the bottom of the container at the second side must be light, so that the air can flow through the bottom of the container and does not flow away along the second side of the container.

In one embodiment the second side of the container is placed along a closed wall. A sealing means is then preferably provided between the second side and the closed wall in order to prevent flow along the second side, or at least to make it as light as possible.

In this way the air is forced to flow through the bottom of the container.

In one embodiment the air displacement device is a fan.

The invention is explained further below with reference to non-limiting embodiments shown in the accompanying drawings, in which identical reference numerals refer to identical parts, and in which:

Fig. 1 illustrates a circulation circuit according to an embodiment of the method of the invention;

Figs 2A and 2B illustrate diagrammatically a cross section and a top view of an embodiment of a construction for bearing a number of crop containers;

Fig. 3 shows diagrammatically an embodiment of the device according to the present invention.

Fig. 4 illustrates diagrammatically the functioning of a fan in use in an embodiment of the present invention;

Fig. 5 shows diagrammatically an embodiment for a cooling and/or heating device;

Fig. 6 shows diagrammatically an embodiment of a device according to the present invention;

Fig. 7 shows diagrammatically an embodiment of a device according to the present invention.

Fig. 1 shows a protected environment 10 with a protected climate, which environment is surrounded by a closed construction, preferably a glass construction such as a greenhouse 10A. A crop 12 is grown in the greenhouse 10A. The crop 12 is placed in pots on a container 14. The container 14 has a gas-permeable bottom, for example a mesh bottom or a bottom with suitable perforations. The
container 14 rests upon supporting elements, such as legs 16. Optionally, a sealing means 18, such as a partition or a sailcloth can be provided under one side of the container 14.

According to one embodiment of the method, an air circulation flow 20A - 20D is generated. Means for generating the air circulation flow are not shown in Fig. 1, but embodiments of such means are shown in Figures 3, 4 and 6 and are described further in relation to the abovementioned figures.

In accordance with the invention, air flows around the container 14 and the crop 12 in the container 14. In order to promote the growth of the crop 12, air 20A flows through the bottom of the container 14. The rising air 20B flows to one side of the container 14, after which the air flow 20C goes along the container 14. Underneath the container 14 the air 20D flows further in the direction of the bottom of the container 14. The optional sealing means 18 can prevent air from flowing along the bottom of the container instead of flowing through the bottom along the crop 12.

The air circulation flow 20A - 20D remains substantially below a level 22. There is therefore little or no mixing of the air above the level 22 with the circulating air below the level 22. Since the air above the level 22 is directly under the roof, and since warm air rises, the air above the level 22 is relatively warm. The temperature of the air is possibly even too high for a good development of the crop 12. Since this warm air does not flow along the crop 12, this air has little or no need for cooling if the air is warm or too warm. This means that less energy is needed for cooling.

Fig. 2A and Fig. 2B show another supporting construction for the container 14. The container 14 in the construction shown can be moved along rails 30 by means of wheels 32 in the direction of conveyance indicated by arrow P (Fig. 2B). In another embodiment other means for moving the container 14 can be provided. The rails 30 rest upon bearing bars 34. The bearing bars are supported by side posts 36 and middle post 38.

Two containers 14 are placed in the longitudinal direction of the bearing bar 34 and an aisle in the form of bearing panels 40 is formed between the containers 14. In the embodiment shown the width of the greenhouse 10A (or a greenhouse element) is equal to the length of the bearing bar 34.
In the construction according to Figs 2A and 2B there is an open space below the containers 14, which open space can advantageously be used for carrying out the method according to the invention.

Fig. 3 shows an embodiment of a device according to the invention for use in the construction of the type shown in Figs 2A and 2B. Two containers 14 are placed next to each other with an aisle formed by a wire floor 40 between them. The wire floor 40 is gas-permeable and preferably offers as little resistance as possible to an air flow 20C through it.

A cooling and/or heating block 42 is placed underneath the wire floor 40. The cooling and/or heating block 42 comprises a number of tubular elements 44, which are suitable for conveying a gaseous or liquid medium, for example water. The cooling and/or heating block 42 has an open structure, so that the air flow 20C - 20E encounters as little resistance as possible. However, the air flows along the tubular elements 44 and is heated or cooled in the process, depending on the temperature of the tubular elements 44, which temperature is determined by the temperature of the medium in the tubular elements 44.

The air flow 20C - 20E is generated by fans 46, which are provided as air displacement devices. The fans 46 are placed below one side of the container 14. The opening under the side of the container 14 is further sealed by the cooling and/or heating block 42 and a sealing means 48A or 48B, with the result that a tubular space is formed between the fans 46 and the block 42. Through the substantially closed space, the air 20E drawn in by the fans 46 from above the containers 14 goes through the block 42. The air 20E drawn in by the fans 46 is then blown by the fans 46 underneath the containers 14.

The sealing means 48A or 48B divide the spaces below the first and the second container 14, so that no undesirable air flow is produced. In a first embodiment the sealing means 48A is a sealing means hanging straight down or connected to the floor. In another embodiment the sealing means 48B is a flexible material such as a sailcloth, which may or may not be weighted, so that this material hangs down to the floor. An advantage of the second embodiment 48B is that a very good seal can be achieved, since the sealing means 48B can be in one piece.
An advantage of the embodiment shown is the relatively low air resistance in the air circulation circuit. Owing to the low air resistance, relatively little energy is needed to maintain the circuit. It has been found from calculations that up to approximately 80% less energy is needed for circulation of the air for climate control.

The connection of the wire floor 40 and cooling and/or heating block 42 to the containers 14 can be achieved in various ways. In an embodiment different from that shown the wire floor 40 is, for example, placed lower down and is broader, so that the wire floor 40 extends to below the sides of the containers 14. Suitable sealing means can also be provided with the connection, in order to prevent an undesirable air flow, or at any rate to make it as light as possible. A person skilled in the art is familiar with suitable sealing means for this purpose.

Instead of the two fans 46 shown, it is also possible to use only one fan 46, which fan 46 can then be placed underneath the cooling and/or heating block 42, in such a way that an air flow generated by the fan 46 runs through the cooling and/or heating block 42.

Instead of placing the two fans 46 opposite each other, as shown in Fig. 3, the fans 46 can also lie staggered in the direction indicated by the arrow P (Fig. 2B), so that a fan is provided on the left side or on the right side of the aisle 40 in each case.

Fig. 4 shows diagrammatical ly a fan 46, which is placed below a container 14, for example in accordance with the embodiment according to Fig. 3. The container 14 can be a single container 14, or can be formed by a number of containers placed next to each other. The fan 46 is placed on a first side of the container 14, while a second side of the container 14 situated opposite the first side is adjacent to a wall 10B. Below the second side of the container 14 the wall 10B closes off the space below the container 14, so that little or no air flows along the bottom of the second side. If desired, a sealing means can be provided between the second side of the container 14 and the wall 10B. A person skilled in the art is familiar with sealing means suitable for this purpose.

The fan 46 has a throw 50 which is indicated by means of a dashed line. The throw 50 of the fan 46 indicates up to what point an air flow arises as a result of the effect of the fan 46. The fan
is preferably selected in such a way that the throw \( \Delta t \) of the fan goes up to the second side of the container 14. In this way the fan 46 provides an air flow from the first side to the second side of the container 14, so that air that has to rise up through the bottom of the container 14 is distributed below the substantially full container 14.

A sealing means can also be provided below the third and the fourth side of the container 14, but such a sealing means is not essential, since the fan 46 blows in the direction of the second side; in particular, it is not essential if next to the third and/or fourth side of the container 14 yet a further container 14 with fan 46 has been placed, as shown in Fig. 2B.

Fig. 5 shows an embodiment of a cooling and/or heating device 51. The cooling and/or heating device 51 comprises a number of cooling and/or heating blocks 42, as shown in cross section in Fig. 3. The blocks 42 comprise a number of tubular elements (44, Fig. 3). The air flows along the tubular elements for cooling or heating. The medium that flows through the tubular elements is supplied through a supply line 52 and after heat exchange with the air, is discharged through a discharge line 54. The supply line 52 and the discharge line 54 are connected to a central cooling and/or heating device (not shown) for heating or cooling the medium.

The blocks 42 of the cooling/heating device 51 each have a connecting line to the supply line and a connecting line to the discharge line. In the block 42 each connecting line splits into the number of tubular elements. The device 51 shown ensures that at the beginning of the supply line 52, where the medium is still at a low or high temperature, the cooling or heating output is not significantly greater than it is towards the end of the supply line 52. In the device 51 shown each block 42 has the medium supplied at substantially the same temperature, so that along the device 51 the output is substantially the same everywhere.

Fig. 6 shows another embodiment of the device according to the present invention. In the embodiment shown a unit 60 is placed below a container 14. A sealing means 48 can also be provided below one or more sides of the container 14. The unit 60 comprises at least one fan 46, or at least one air displacement element, and a cooling and/or heating device 42. Such a unit 60 is commercially available in its entirety. The unit 60 can generate the desired circulation
flow 20C - 20D around the container 14 and also control the temperature of the passing air. The unit can in addition - or instead of the cooling and/or heating device - comprise a humidifying element, a dehumidifying element and the like.

Fig. 7 shows an aspect of the invention, which aspect can be used in any embodiment described above. As described in relation to Fig. 1, a separate air layer can be provided in the bottom of the protected environment, i.e. in the greenhouse, by the method according to the invention. If the relatively warm air can be used advantageously, for example for heating the circulating air in the winter, a separation means 56 can be placed vertically in line with the side of the container 14 along which the air flows. By means of the separation means 56, the circulation circuit 20B-20F-20C-20D will flow through the higher layer above the level 22 and in this way mix with the relatively warm air.

A method and a device for generating a desired climate for a crop are shown and described above, in which method and device air flows in a circuit around a crop container 14 in a greenhouse 10A, which provides a protected climate. The circuit runs from above the crop 12, along the container 14, underneath the container 14 and through the bottom of the container 14 to above the crop 12. The circuit furthermore runs through an air treatment device for conditioning the air, such as cooling, heating, dehumidifying and/or humidifying. Little or none of the still air present above a level 22 mixes with the air in the circuit. In this way relatively little air is displaced and little power is needed to move the air, and little power is needed for heating and/or cooling the air, while growth of the crop is stimulated by the air flowing along the crop.
Claims

1. Method for growing a crop (12) in a protected climate, in which the crop (12) is placed in a container (14) with a gas-permeable bottom, which method comprises:
   • generating an air flow (20) in a circuit, in which the circuit runs from above the crop (12), along the container (14), underneath the container (14) and through the bottom of the container (14) to above the crop (12),
   • the air flow furthermore running through an air treatment device (42) for controlling a condition of the air.
2. Method according to claim 1, in which the air treatment device has a low resistance to the air flow.
3. Method according to claim 1 or 2, in which the condition to be controlled in the air comprises the temperature of the air, and in which the air treatment device (42) comprises a heating device for heating passing air and/or a cooling device for cooling passing air.
4. Method according to one of the preceding claims, in which the condition to be controlled in the air comprises the relative humidity of the air, and in which the air treatment device comprises a humidifying device for increasing the relative humidity and/or a dehumidifying device for reducing the relative humidity.
5. Device for growing a crop (12) in a protected climate, the device comprising:
   • a container (14) with a gas-permeable bottom for holding the crop (12);
   • an air displacement device (46) for generating an air flow;
   • an air treatment device (42) for controlling a condition of the air; and
   • means for guiding the air flow;
   in which the air displacement device (46) and the means for guiding the air flow are positioned relative to each other and relative to the container (14) in such a way that in operation the air flow circulates in a circuit, which circuit runs from above the crop (12) along the container (14), underneath the container (14) and through the bottom of the container (14) to above the crop (12), and in which the circuit of the air flow furthermore runs through the air treatment device.
6. Device according to claim 5, in which the air treatment device
has a low resistance to the air flow.

7. Device according to claim 5 or 6, in which the air flow runs along one side of the container, and in which the air treatment device extends substantially over the full length of the abovementioned side of the container.

8. Device according to claim 5, 6 or $I_1$ in which the air treatment device comprises a heating device for heating passing air and/or a cooling device for cooling passing air.

9. Device according to claim 8, in which the air treatment device comprises a number of tubular elements (44), which tubular elements are at least partially filled with a medium and are connected to a cooling and/or heating device for cooling and/or heating the medium, and in which in operation the air flow is guided along the tubular elements.

10. Device according to claim 9, in which the tubular elements are provided with means for enlarging a surface of the tubular elements.

11. Device according to claim 9 or 10, in which the tubular elements are placed below a grille (40) that is placed substantially next to the container, which grille is suitable for bearing a person.

12. Device according to claim 9, 10 or 11, in which the air displacement device is placed downstream relative to the tubular elements, and in which a substantially closed space is formed between the air displacement device and the tubular elements, air being drawn in from above the container along the tubular elements by the air displacement device.

13. Device according to one of claims 5 - 12, in which the air treatment device comprises a humidifying device for increasing the relative humidity and/or a dehumidifying device for reducing the relative humidity.

14. Device according to one of claims 5 - 13, in which the air displacement device (46) is placed near a first side of the container and generates an air flow in the direction of a second side of the container situated opposite, and in which the air displacement device has a throw (50) substantially corresponding to a distance between the first side and the second side.

15. Device according to claim 14, in which the second side is placed along a closed wall (10B), and in which a sealing means is provided between the second side and the closed wall.
16. Device according to one of claims 5 - 15, in which the air displacement device is a fan (46).

17. Air treatment device for conditioning air in an air flow, in which the air treatment device has a low resistance to the air flow.

18. Air treatment device according to claim 17, in which the air treatment device comprises a number of tubular elements.
### A. CLASSIFICATION OF SUBJECT MATTER

**INV.** A01G9/18 A01G9/24 A01G7/02

According to International Patent Classification (IPC) or to both national classification and IPC

### B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

AOIG

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database consulted during the international search (name of database and, where practical, search terms used)

EPO-Internal

### C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X Further documents are listed in the continuation of Box C

X See patent family annex

### Date of the actual completion of the international search

5 July 2007

Date of mailing of the international search report

18/07/2007

Name and mailing address of the IGA

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